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Effects of Sentence Constraint on Processing of Auditorily Presented Words in Chinese Intermediate Learners of the Japanese Language:

An Experimental Study with Manipulation of Orthographical and Phonological Similarities between Chinese and Japanese Kanji Characters

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The current study investigated the effects of sentence contextual constraint on auditory processing of Japanese *kanji* words in intermediate learners of the Japanese language whose native language was Chinese. In the current experiment, the degree of contextual constraint (high vs. low) of a preceding Japanese sentence (with a blank as a placeholder for a target word) and orthographical and phonological similarities of *kanji* words (i.e., the target words) were manipulated as independent factors. The response time of correctly performed trials in an auditory lexical decision task using the target words was measured. Similar to a previous study in advanced learners of the Japanese language (Fei & Matsumi, 2013), the results of the current experiment demonstrated that cognitive processing of Japanese *kanji* words that were presented auditorily varied depending on the level of contextual constraint of the preceding Japanese sentence. However, the effects of orthographical and phonological similarities on word processing were different from those observed in advanced learners. In addition, the results in both high and low sentence constraint conditions were different from those in the study of Fei (2015) who used a single word presentation paradigm. The effects of orthographical and phonological similarities on lexical information processing of Japanese *kanji* words that are presented auditorily appear to be impacted by context regardless of the degree of contextual constraint.

Key Words: Sentence Context, Japanese *Kanji* Words, Auditory Word Recognition, Chinese Intermediate Learners, Orthographical and Phonological Similarities

1. Introduction

In the fields of psycholinguistics and second language acquisition, research on word recognition by bilingual speakers has been actively conducted. In particular, with regard to Indo-European languages, the cognitive processes not only for target words in a single-word presentation paradigm but also for target words presented within a sentence are being elucidated. On the other hand, there are few studies examining the cognitive process for target words presented within a sentence in Chinese and Japanese *kanji*, both of which are ideograms. Therefore, in the current study, we examined the influence of a sentence on the processing of a target word in learners of the Japanese language whose native language (synonymous with first language, hereinafter, L1) was Chinese. We aimed to clarify the influence of sentence constraint on the cognitive processing of *kanji* words.

The relevant past literature on these two languages has shown that the Chinese language (L1) influences the process of acquiring the Japanese language as a second language (L2) in speakers of Chinese as the L1 language (for example, Cai et al., 2011, Fei & Matsumi, 2012, Matsumi et al., 2012; Fei, 2013, 2015). Many of these past studies used a single-word presentation paradigm in order to elucidate the mutual influence of the Chinese and Japanese languages. Single-word presentation studies enable rigorous examination of the structure of the learner's mental lexicon and activation of the languages. On the other hand, in everyday situations, words are usually used in context except in rare occasions. When an individual processes a word in a sentence, the constraint of the sentence context (i.e., how much a target word is constrained by the context of the sentence that the word is a part of) may have an impact on word processing.

In addition, many studies used visual presentation to study word recognition, while studies using auditory presentation are scarce. Examining the process of word recognition using auditory presentation that lacks a direct input of morphological information of characters in speakers of Chinese as L1, who typically rely on morphological information of *kanji* characters to process them, would be meaningful as it better clarifies the relationship of orthographical and phonological information between *kanji* characters in Chinese and Japanese. Therefore, the current study aimed to clarify the effects of sentence constraint on processing of *kanji* words in listening comprehension of Japanese sentences.

2. Overview of the Past Literature

2.1. The Past Literature on Phonograms

With regard to Indo-European languages that use phonograms, research studies on word recognition in bilinguals and L2 learners have been conducted since the 1960's. The past literature (in studies using a single word presentation paradigm) has shown that the language information of L1 that is similar with the orthographical and phonological information of L2 words, had an influence when an individual processed the L2 words that were visually presented (for example, Dijkstra et al., 1999; Marian et al., 2008; Schwartz, et al., 2007; Shafiro & Kharkhurin, 2009; Sunderman & Kroll, 2006; Sunderman & Schwartz, 2008; Szubko-Sitarek, 2011; van Hell & de Groot, 1998). It was found that cognates with high orthographical and phonological similarities were processed faster than non-cognates with low similarity, indicating that cognates had facilitation effects on the speed of processing.

Many studies focusing on two Indo-European languages have manipulated the degree of sentence constraint and compared word processing that occurs within a sentence with that observed in studies that used a single-word presentation paradigm. In those studies, the effects of cognates and non-cognates in high- and low-constraint sentences were examined (e.g., Jordan & Thomas, 2002; Duyck, et al., 2007; Schwartz & Kroll, 2006; van Hell, 2005; van Hell & de Groot, 2008).

van Hell (2005) & van Hell and de Groot (2008) examined processing of L2 words in Dutch-English bilinguals where a sentence was presented first with the location of the target word marked with a placeholder (and the target word was subsequently presented). In those experiments, the attribute of words (cognate vs. non-cognate) and sentence context restriction (high vs. low) were manipulated, and the

reaction times for correct responses in a lexical decision task and an oral translation task were measured. The results demonstrated cognate facilitation effects in low-constrained sentences, while weak (oral translation task) or no (lexical decision task) cognate facilitation effects were seen in sentences with high context constraint. This suggests that the context constraint of the preceding sentence affected the semantic processing of the target word.

Schwartz & Kroll (2006) examined the influence of sentence constraint on word processing in Spanish-English bilinguals using an overt reading task. Comparing the results of high and low sentence constraint, latency for cognate reading was shorter in sentences with low constraint while no such effect was seen for sentences with high constraint. The study confirmed the effects of sentence constraint in an overt reading task where a vocal output was required.

Recently, studies using eye movements as a measurement have made contributions to this field (for example, Duyck et al., 2010; Libben & Titone, 2009; Van Assche et al., 2011). Unlike studies using a conventional experimental method where a preceding sentence is presented followed by a target word, those studies examined processing of target words as an individual read aloud a sentence containing a target word.

Libben & Titone (2009) examined the processing of L2 words in French-English bilinguals using overt reading of L2 sentences (where a target word was presented simultaneously with a sentence containing it). In their experiment, the attribute of words (cognates vs. interlingual homographs) and sentence constraint were manipulated. The results demonstrated a facilitation effect of cognates and interference by interlingual homographs in sentences with low constraint. In the high constraint condition, a facilitation effect of cognates and interference of interlingual homographs were observed in the early stages of word comprehension (e.g., first fixation duration, gaze duration), but these effects were not present in the later stages of word comprehension (e.g., go-past time and total fixation duration). These results are partially inconsistent with the results of Schwartz & Kroll (2006), suggesting that the facilitation effect of cognates can be observed even in highly constrained sentences.

The previous studies, regardless of their use of a traditional or more recent eye movement methods, have shown that the context constraint of a preceding sentence influences processing of a subsequently presented target word, confirming the effect of sentence constraint on processing of a word.

2.2. Studies on Ideograms

Following the trend of experiments examining two Indo-European languages, research studies that examine processing of Chinese and Japanese *kanji*, which is an ideogram, have started to emerge. Studies using a single word presentation paradigm found facilitation effects by orthographical and phonological similarities (Cai et al., 2011; Matsumi et al., 2012) in visual processing of target words, and a facilitation effect by orthographical similarity and suppression effect by phonological similarity in auditory recognition of those words (Fei, 2013, 2015).

On the other hand, only a few studies have examined the processing of *kanji* words within sentences using Chinese and Japanese *kanji* words which are ideograms.

Cai (2009, 2011) examined the effects of sentence constraint on processing of Japanese *kanji* words that were presented visually or auditorily, respectively, to advanced learners of the Japanese language who resided in China. The results demonstrated shorter response times for target words in sentences with high constraint relative to sentences with low constraint regardless of the modality of presentation, indicating facilitation effects of sentences with high constraint. In addition, an interaction between sentence constraint and word attributes (orthographical vs. phonological similarity) was not observed for target words presented visually, but this interaction existed for words presented auditorily where suppression effects were seen for words with high orthographical similarity (i.e., words with low phonological similarity) in sentences with high constraint.

In those studies, however, either orthographical or phonological similarity was manipulated, and it is unclear how orthographical and phonological similarities interact to affect word processing, and whether the effects would be different between sentences with high or low constraint. In order to address these unresolved research questions, Fei & Matsumi (2013) manipulated the degree of sentence constraint of preceding Japanese sentences that were presented auditorily and examined the processing of Japanese *kanji* words (i.e., target words) that were presented following the sentences in advanced learners of the Japanese language who were residing in China. Orthographical and phonological similarities of target words between the Japanese and Chinese languages were treated as independent variables and manipulated simultaneously. The results showed that the processing of auditorily presented Japanese *kanji* words differed between sentences with high or low constraint, and that the interaction of orthographical and phonological similarities on *kanji*-word processing was observed only in sentences with high constraint. This is different from the processing of *kanji* words that were presented in isolation (Fei & Matsumi, 2012) in terms of facilitation and suppression effects by orthographical and phonological similarities. Those recent studies showed that the effects of orthographical and phonological similarities on *kanji*-word processing varied depending on the degree of sentence constraint during listening comprehension of Japanese sentences.

3. Research Questions and the Purpose of the Current Study

Compared to the studies on Indo-European languages, there are three limitations in the existing research study on Chinese-Japanese *kanji*.

First, there are many research studies using single-word presentation trials. However, few studies have investigated how *kanji* words are processed in relation to sentences. *Kanji* words in sentences are processed by seeing and/or listening to sentences that contain *kanji* words. Therefore, we need to conduct studies that examine word processing within the context of Japanese sentences, which would lead to further research on understanding the processes of reading and listening comprehension.

Second, many studies have used a visual presentation method, while only a few studies have used an auditory presentation method. Given the characteristics of *kanji,* it is important to elucidate how a *kanji* word is processed when a learner of the Japanese language sees a word. However, it is conceivable that speakers of Chinese as L1 who tend to rely on orthographic information of *kanji* words may have difficulty processing Japanese *kanji* words phonologically. Therefore, it is necessary to investigate the nature of processing that occurs when a word is auditorily presented.

Third, there have been many research studies on advanced learners of Japanese, while there are fewer studies on learners at lower proficiency levels. It is possible that how *kanji* words are processed may change as intermediate learners become more advanced, since intermediate learners would be at different levels of L2 acquisition and have different patterns of L1 usage than advanced learners. Therefore, in order to elucidate the change in the nature of *kanji* processing, it is essential to investigate how intermediate learners of the Japanese language process kanji words.

Therefore, the current study examined the *kanji*-word processing of intermediate learners of the Japanese language who spoke Chinese as L1, using auditory presentation of target words with preceding sentences.

We used a lexical decision task of the target words in order to be able to compare our results with the results of Fei (2015) who utilized a single-word presentation paradigm in intermediate learners of Japanese, and with the results of Fei & Matsumi (2013) who utilized a sentence presentation paradigm in advanced learners. The order of presentation of sentences and words was in accordance with Fei & Matsumi (2013), where a Japanese sentence with a blank (for the location of a target word) was presented first, followed by a target *kanji* word. Based on the study of Fei & Matsumi (2013), we sought to add

another component to the analysis. When a learner listens to a Japanese sentence with a blank, it can be expected that the conceptual representation of an appropriate word (hereinafter referred to as a blank word) to fill in the blank would be activated based on the context. It can be expected that the activation would affect the processing of the target *kanji* character word that is presented next. Therefore, the response time for the lexical decision task would reflect activation of the representation when listening to the Japanese sentence *and* the target *kanji* word. In particular, under the high constraint condition, it is highly likely that the blank word and the target word would be identical. Therefore, the outcome is expected to be different from that of the low constraint condition.

Based on the above, the following hypotheses were generated.

[Hypothesis 1] Hypothesis 1 is with regard to the condition where the preceding sentence has high constraint. Because the conceptual representation and the lexical representation of the target word (identical with the blank word) are thought to be activated early by abundant contextual information in this condition (Fei &Matsumi, 2013), the effects of orthographical and phonological similarities would be different from those observed in the study of Fei (2015) who used a single-word presentation paradigm. However, it has been shown that the effects of orthographical and phonological similarities do not completely disappear even when the orthographical and phonological information of the target word are first activated by the contextual information of the preceding Japanese sentence (Fei & Matsumi, 2013).

Based on these two previous studies, we expected shorter response times for words with high orthographical similarities regardless of phonological similarities, indicating facilitation effects by orthographical similarities (Hypothesis 1-1). On the other hand, longer response times were expected for words with high phonological similarity regardless of orthographical similarity, suggesting suppression effects by phonological similarities (Hypothesis 1-2).

Furthermore, it was expected that orthographical and phonological similarities would interact to affect the processing of the target word because orthographical and phonological information of the target word would be activated by the contextual information of the preceding Japanese sentence. Thus, we hypothesized that we would observe a significant interaction of orthographical and phonological similarities (Hypothesis 1-3).

[Hypothesis 2] Hypothesis two is with regard to the condition where a preceding sentence has a low contextual constraint. In this condition, it is unlikely that the contextual information of the preceding sentence would activate orthographical and phonological information of the target word (Fei & Matsumi, 2013). Therefore, we expected that the processing would be similar to that in single-word presentation experiments. Therefore, based on the study of Fei (2015), we expected shorter response times for words with high orthographical similarities, suggesting facilitation effects by orthographical similarity (Hypothesis 2-1). On the other hand, longer response times were expected for words with high phonological similarity, suggesting suppression effects by phonological similarity (Hypothesis 2-2).

However, as there can be small effects of a preceding sentence on the processing of the target word as the learner processes the meaning prior to target word presentation (Fei & Matsumi, 2013), the nature of the interaction of orthographical and phonological similarities may be different in the current study than that observed in the study of Fei (2015) who used a single-word presentation paradigm (Hypothesis 2-3).

4. Methods

4.1. Participants

Twenty-nine (22 women and 7 men) intermediate learners of the Japanese language whose L1 was Chinese participated in the current study. Fourteen (10 women and 4 men) and fifteen (12 women and 3 men) participants were assigned to high or low constraint conditions, respectively. All participants were sophomore students

who were enrolled at a Chinese university and were taking classes in the Japanese language department. They spoke standard Chinese in their daily lives. The participants did not have a prior experience of taking Japanese proficiency examinations. The participants were administered a Japanese proficiency examination and their Japanese proficiency was equivalent to the N2 level of the Japanese Language Proficiency Test. All participants were in their second year of learning Japanese, but they had no experience of visiting and staying in Japan.

4.2. Experimental Design

A two-factorial design was used for each of the two conditions where the preceding sentence had either high or low constraint. The first factor was orthographical similarity of *kanji* words and it had two levels (high vs. low). The second factor was phonological similarity of *kanji* words and it had two levels (high vs. low). Both factors were within-subject factors.

4.3. Materials

<Word Materials> The *kanji* words used in the experiment (i.e., the target words used in the lexical decision task where the correct response was "Yes") were identical to the ones used in the study of Fei & Matsumi (2013). All words came from the words in levels 3 and 4 of an earlier version of the Japanese Proficiency Test (Japan Foundation & Japan Educational Exchanges and Services, 2002). Four categories were created and they were: (1) words with high orthographical and phonological similarities with Chinese words, (2) words with high orthographical and low phonological similarities with Chinese words, (3) words with low orthographical and high phonological similarities with Chinese words, and (4) words with low orthographical and phonological similarities with Chinese words. Forty-eight words, with 12 words in each category, were used. The words in the four categories were controlled in terms of the level of frequency based on Amano & Kondo (2000). One-way analysis of variance (ANOVA) on the frequency of the words in each category revealed no statistically significant main effect (F (3, 44) = 0.16, p = .923, η2 = .01). All statistical tests were conducted at an alpha of .05 in the current study. We considered the frequency to be equal among the four categories of words. For non-word stimuli (i.e., words used in the lexical decision task where the correct response was "No"), we created words that did not exist consisting of two *kanji* characters. Similar to the target words, we created 30 non-words (read with Japanese pronunciation) considering orthographical and phonological similarities with Chinese words. Table 1 shows examples of words and non-words used in the experiment.

< Sentence Materials > The materials used as the preceding sentences were identical to those used in the study of Fei & Matsumi (2013). The following steps were used in selecting the sentences. First, using the vocabulary and sentence structures in levels 3 and 4 and some level 2 words in the previous Japanese Proficiency Examination, 142 sentences were created consisting of 15 to 21 syllables. These 142 sentences were examined by four speakers of Japanese as L1 who had experience in teaching Japanese and majored in Japanese language education, specifically paying attention to the length and level that may be difficult for intermediate learners of the Japanese language. None of the 142 sentences was judged to be inappropriate for students at the intermediate level.

Next, we carried out an investigation to measure the extent of sentence constraint in each of the 142 sentences. We followed the process used in research studies on Indo-European languages. Specifically, we administered a fill-in-the-blank writing task to 15 learners of the Japanese language majoring in Japanese and 3 speakers of Japanese as L1. These 18 individuals did not participate in any other tasks or experiments in the current study. These individuals were given sentences such as "My father [ ] in the park near our house every morning" and were asked to fill in the blank with the first word that came to their mind. The sentences in which more than 14 people (including more than one Japanese L1 speaker)

provided an identical word were considered to be "high constraint" sentences, and those in which fewer than 5 individuals provided an identical word were considered to be "low constraint" sentences. We selected 48 high constraint sentences and 48 low constraint sentences, resulting in a total of 96 sentences (Table 1).

The difficulty level of the 96 sentences as assessed using "Reading Tutor" [1] revealed that all sentences had a "very easy" vocabulary level.

The 48 high-constraint and 48 low-constraint sentences were each divided into 4 categories, taking into consideration the sentence length and difficulty level (12 sentences per category). ANOVAs on the number of syllables in these sentences in the 8 lists revealed that the main effect was not significant in the high constraint（$F(3, 44)=1.74$, $p=.331$, $\eta^2=.07$）, or low constraint （$F(3, 44)=0.48$, $p=.701$, $\eta^2=.03$）sentences, indicating that there was no statistically significant difference among the lists within each condition. The ratios of words from level 2 of the Proficiency Examination were 6% and 4% among the high- and low-constraint conditions, respectively. Therefore, the difficulty levels of the sentences were equivalent among the 4 lists, and were judged to be appropriate for intermediate learners. Table 2 shows examples of high- and low-constraint sentences, and the corresponding target *kanji* words.

4.4. Apparatus

A personal computer (SOTEC N15 WMT02) and peripheral devices were used for auditory presentation of the Japanese sentences and target *kanji* words, and for automatic measurement of response times in the lexical decision task. The experimental program was created using SuperLab Pro (Cedrus Corporation, Version 4.0). A set of headphones was used for auditory presentation.

Table 1: Examples of Words and Non-words Used in the Experiment

	High Orthographical/ High Phonological	High Orthographical/ Low Phonological	Low Orthographical/ High Phonological	Low Orthographical/ Low Phonological
Words	散歩（san bu） 安心（an xin）	作文（zuo wen） 正月（zheng yue）	財布（cai bu） 心配（xin pei）	泥棒（ni bang） 台所（tai suo）
Non-Words	面臨（men rin）余額（yo gaku）湾絡（wan raku）号定（gou sada）			

※Chinese pronunciations are shown in the parentheses.

Table 2: Examples of High Constraint and Low Constraint Sentences and Target *Kanji* Words Used in the Experiment

High and Low sentence constraint (top and bottom) and target kanji words			
My father takes a (　) in the park near our house every morning.	walk	There is only 100 yen in my (　).	wallet
Our grandmother's hobby is to take a (　).		I bought a new (　) at a supermarket yesterday.	
I wrote an (　) with my dream as a theme.	essay	A (　) stole my money yesterday on the bus.	Thief/thieves
My older brother criticized my (　).		There were many (　) in this town three years ago.	

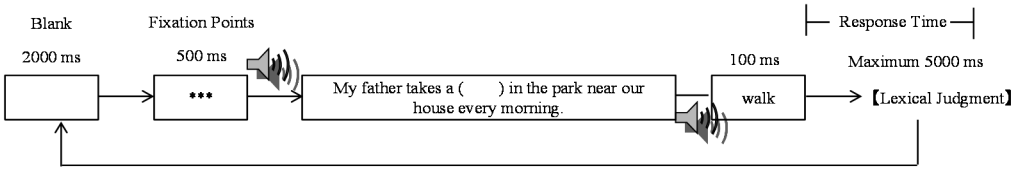


Figure 1: A Diagram of one Trial of the Current Experiment

4.5. Procedures

The experiment was performed individually. There were 5 practice trials prior to commencing the main trials. Figure 1 shows the flow of one trial. Fixation points were visually presented in the middle of the computer screen for 500 ms to signal the auditory presentation of a sentence. Immediately following presentation of the fixation points, a Japanese sentence was presented with a blank (with 2 knock sounds) auditorily through the headphones, which was immediately followed by auditory presentation of the target word. The participant was to judge as fast as possible whether the *kanji* word presented immediately after the sentence was a word or non-word in Japanese. The participant was to press the "yes" key if he or she thought that the word existed, and the "no" key if he or she thought that the word did not exist in the Japanese lexicon. The presentation order of the pairs of a sentence and a word was randomized, and the latency from the onset of the auditory presentation of the word stimulus until the yes or no key was pressed was automatically measured as the response time. The maximum duration of response latency was 5000 ms. If there was a response by the participant within that time window, the next trial started 2000 ms later. If there was no response by the participant, the next trial started automatically after the 5000 ms interval elapsed. After completion of the task, the participant answered a written survey that asked about words that they did not know, as well as their history of learning Japanese.

5. Results

Only the response times of the trials that required a "yes" response were analyzed. Trials with no response, those with a response error, and those with target words that were unknown to the participant, were excluded from the analysis. For each participant, the mean response time (mean and standard deviation) was calculated, and trials with a response time that was 2.5 *SD* longer or shorter than the participant's mean response time were excluded as outliers. In the high- and low-constraint conditions, 9.23% and 14.58% of the trials were excluded, respectively.

5.1. High Sentence Constraint Condition

Two-way ANOVA (Figure 2) showed that the main effect of phonological similarity approached statistical significance ($F(1, 13)=4.16$, $p=.062$, $\eta^2=.01$). This indicates that words with high phonological similarity tended to require longer response times than those with low phonological similarity. The main effect of orthographical similarity was not significant ($F(1, 13)=0.09$, $p=.765$, $\eta^2<.01$). Given the significant interaction of orthographical and phonological similarities ($F(1, 13)=8.62$, $p=.012$, $\eta^2=.03$), tests of simple main effects were conducted and they indicated that words

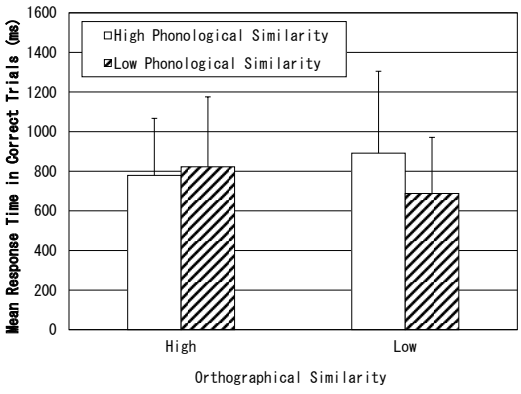


Figure 2: Response Times (Mean and Standard Deviation) in the High Constraint Condition

with high phonological similarity required longer response times relative to those with low phonological similarity in target words with low orthographical similarity ($F(1, 26)=12.54$, $p=.002$, $\eta^2=.04$), while no statistically significant difference was observed between words with high or low phonological similarities in words with high orthographical similarity ($F(1, 26)=0.58$, $p=.454$, $\eta^2<.01$). Furthermore, response times tended to be shorter for words with high orthographical similarity relative to those with low orthographical similarity in words with high phonological similarity ($F(1, 26)=4.07$, $p=.054$, $\eta^2=.01$), while response times were longer for words with high orthographical similarity relative to those with low orthographical similarity in words with low phonological similarity ($F(1, 26)=5.85$, $p=.023$, $\eta^2=.02$).

Two-way ANOVA performed on angular transformed error rates in the 4 categories of words (see Table 3) indicated that the main effect of phonological similarity approached statistical significance ($F(1, 13)=3.71$, $p=.076$, $\eta^2=.03$), indicating that the error rates tended to be higher for those words with high relative to low similarity. The main effect of orthographical similarity ($F(1, 13)=0.96$, $p=.345$, $\eta^2=.01$) or the interaction of orthographical and phonological similarity ($F(1, 13)=0.03$, $p=.874$, $\eta^2<.01$) was not significant. There was no speed-accuracy tradeoff where higher error rates were observed for words with shorter response times and vice versa. Therefore, we believe that the response times obtained in the current study reflected the time required to make a lexical judgment.

Table 3: Error Rates (Mean and Standard Deviation) in the High Constraint Condition

	High Orthographical and Phonological Similarities	High Orthographical and Low Phonological Similarities	Low Orthographical and High Phonological Similarities	Low Orthographical and Low Phonological Similarities
Error rate (*SD*)	8.27 (9.03)	5.29 (7.23)	10.03 (11.10)	6.68 (7.92)

5.2. Low Sentence Constraint Condition

Two-way ANOVA (Figure 3) showed a significant main effect of phonological similarity ($F(1, 14)=7.80$, $p=.014$, $\eta^2=.01$), indicating that words with high phonological similarity had longer response times relative to those with low phonological similarity. The main effect of orthographical similarity ($F(1, 14)=0.64$, $p=.437$, $\eta^2<.01$) or the interaction between orthographical and phonological similarities ($F(1, 14)=0.02$, $p=.884$, $\eta^2<.01$) was not significant.

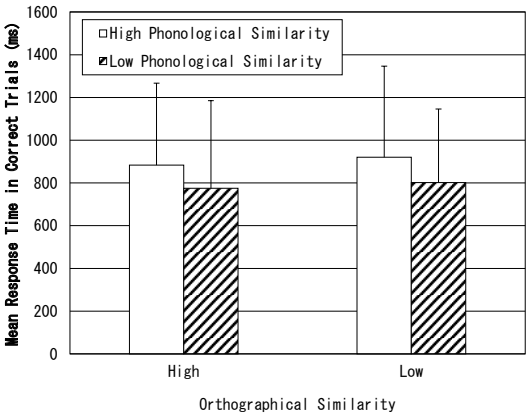


Figure 3: Response Times (Mean and Standard Deviation) in the Low Constraint Condition

Two-way ANOVA performed on angular transformed error rates in the 4 categories of words (see Table 4) demonstrated a significant main effect of phonological similarity ($F(1, 14)=4.15$, $p=.061$, $\eta^2=.01$), indicating that error rates were higher for words with high phonological similarity relative to those with low phonological similarity. The main effect of orthographical similarity ($F(1, 14)=0.48$, $p=.500$, $\eta^2<.01$) or the interaction between orthographical and phonological similarities ($F(1, 14)=0.00$, $p=.952$, $\eta^2<.01$) was not significant. We did not observe a speed-accuracy tradeoff. Therefore, we believe that the response times obtained in the current study reflected the time required to make a lexical judgment.

Table 4: Error Rates (Mean and Standard Deviation) in the Low Constraint Condition

	High Orthographical and Phonological Similarities	High Orthographical and Low Phonological Similarities	Low Orthographical and High Phonological Similarities	Low Orthographical and Low Phonological Similarities
Error rate (*SD*)	12.29 (9.75)	11.01 (9.78)	13.97 (8.54)	11.96 (9.25)

6. General Discussion

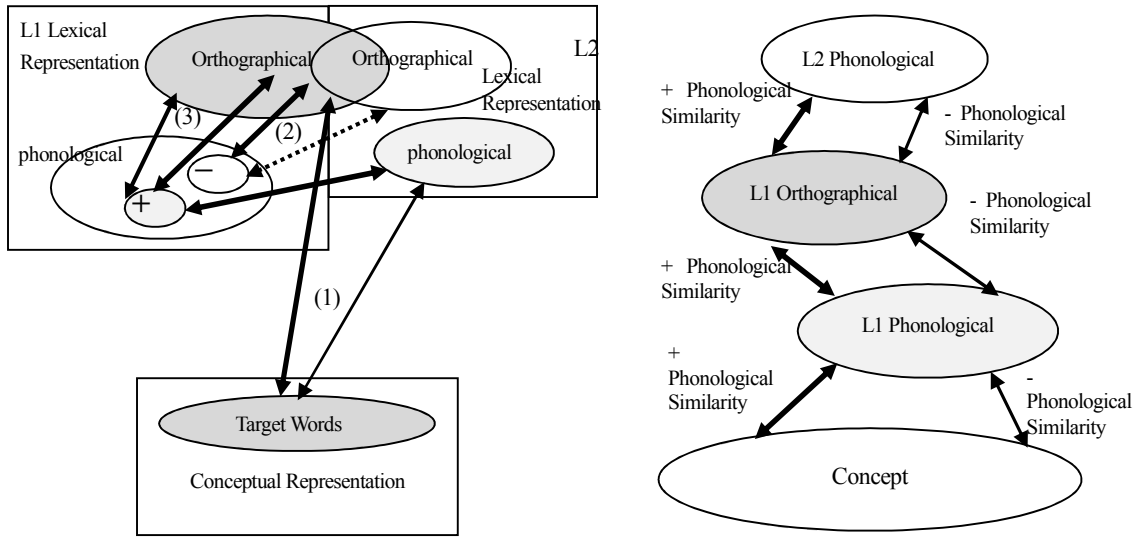
The current study examined the processing of Japanese *kanji* words in intermediate learners of the Japanese language whose L1 was Chinese, by using a sentence presentation paradigm. Specifically, we manipulated the degree of contextual constraint of the preceding Japanese sentence, and examined the effects of orthographical and phonological similarities between the Chinese and Japanese languages on processing of *kanji* words when the learner listened to the preceding sentences (i.e., blank words) as well as the *kanji* words (i.e., target words). Below, we organized the results of the experiment by hypotheses (1 and 2), and will compare the results with those of previous studies that used advanced learners and a single-word presentation paradigm, and discuss our finding related to the auditory processing of *kanji* words in intermediate learners of the Japanese language.

6.1. Word Processing in the High Constraint Condition

When the preceding sentence had high contextual constraint, the facilitation effect of orthographical similarity was not observed, while the suppression effect of phonological similarity was observed. Thus, our hypothesis 1-1 was not supported, while hypothesis 1-2 was supported. In addition, hypothesis 1-3 was supported as we observed a significant interaction between orthographical and phonological similarities, with a different nature of the interaction when compared with that obtained in the single-word presentation study of Fei (2015). Below we discuss word processing under high sentence constraint in intermediate learners of the Japanese language.

Similar to the study of Fei & Matsumi (2013), the current study indicated that the conceptual representation of the blank word was activated by presentation of a preceding sentence with high contextual constraint. Because it was highly likely that the blank word was identical to the target word, the conceptual representation of the target word was possibly already activated even before presentation of the actual target word. Here we interpret the effects of orthographical and phonological similarities on *kanji*-word processing seen in the current study. Figures 4 and 5 are schematic diagrams of proposed models for processing of Japanese *kanji* words.

We tended to observe a facilitation effect of orthographical similarity in words with high phonological similarity, and a suppression effect of orthographical similarity in words with low phonological similarity. Although the facilitation effect of orthographical similarity was reported by both Fei (2015) who used a single-word presentation paradigm in intermediate learners and Fei & Matsumi (2013) who used a sentence presentation paradigm in advanced learners, we found a suppression effect by orthographical similarity. We interpret this interesting finding in Figure 4.



(a) Activation of Various Representations by the Preceding Sentence (b) Processing of a Target Word Presented Subsequently

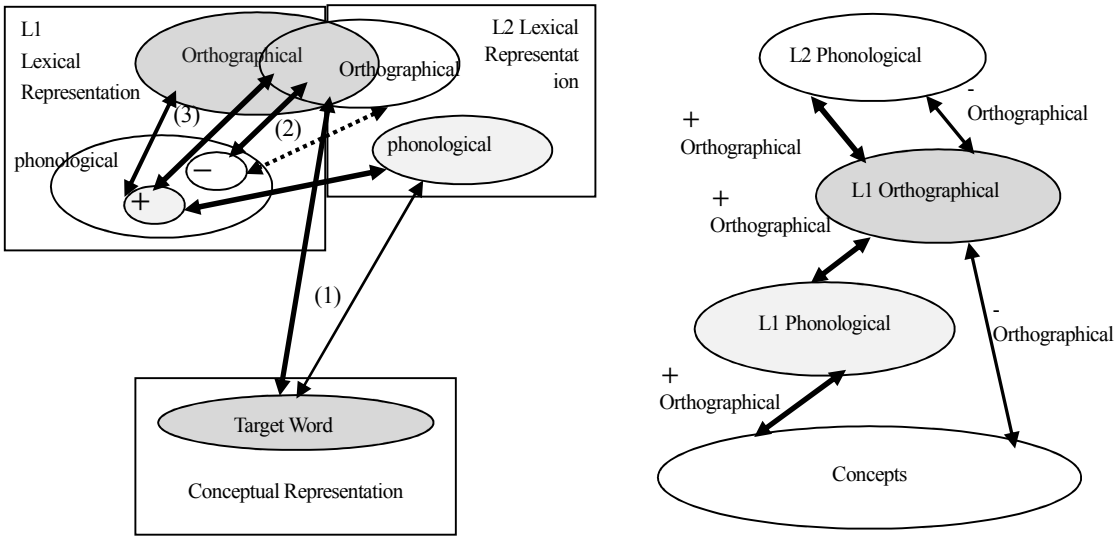
Figure 4: Word Processing in the High Sentence Constraint Condition in Intermediate Learners (Effect of Orthographical Similarity)

When learners listen to a Japanese sentence, it is expected that a conceptual representation of the target word gets activated by rich contextual information. Simultaneously or immediately following activation of the conceptual representation, the lexical representation of the target word is activated. We speculate that different from advanced learners in the study of Fei & Matsumi (2013), the orthographical representation gets activated more strongly as the phonological representation becomes activated (Figure 4(a), line labeled (1)). For words with high orthographical similarity, the Chinese phonological representation gets activated regardless of phonological similarity between Japanese and Chinese (Figure 4(a),the solid line labeled (2), and the bold connecting line labeled (3)). For words with low orthographical similarity, it can be speculated that the Chinese phonological representation gets activated for words with high phonological similarity (Figure 4(a), the thin line labeled (3)), but not for words with low phonological similarity (Figure 4(a), the dotted line of (2)). Because words with high orthographical similarity (Figure 4(a), the bold line labeled (3)) share orthographical representation between the two languages, the degree of activation of the Chinese phonological representation may be greater relative to words with low orthographical similarity (Figure 4(a), the thin line labeled (3)). This activation by the preceding sentence is thought to affect access to the lexicon based on the Japanese sound of the target word (see Figure 4(b)). That is, we speculate that words with high phonological similarity (Figure 4(b), three connections with the plus sign) were affected by the activated Chinese orthographical representation, and that the response time tended to be shorter than the response time to words with low orthographical similarity (Figure 4(a), the thin line labeled (3)). On the other hand, words with low phonological similarity (Figure 4(b), three connections with minus sign) were affected by the Chinese phonological representation that was activated by activation of the Chinese orthographical representation (Figure 4(a), dotted line labeled (2)), and the response times were longer for words with high relative to low orthographical similarity.

With regard to the effects of phonological

similarity, we observed some suppression effect in words with low orthographical similarity, but no effect was seen for words with high orthographical similarity. In the study of Fei (2015) where a single-word presentation paradigm was used, a suppression effect of phonological similarities was seen in words with high orthographical similarity but not in words with low orthographical similarity. We interpret these inconsistent effects in Figure 5.

When learners listen to a Japanese sentence, the conceptual representation of the target word gets activated by rich contextual information. Simultaneously or immediately following activation of the conceptual representation, the lexical representation of the target word is activated. We speculate that, different from the advanced learners in the study of Fei & Matsumi (2013), the orthographical representation gets activated more strongly as the Japanese phonological representation gets activated (Figure 5(a), (1)). For words with high orthographical similarity, the Chinese phonological representation gets activated regardless of phonological similarity between the Japanese and Chinese words (Figure 5(a), the solid line labeled as (2) and the bold line labeled as (3)). For words with low orthographical similarity, it can be speculated that the Chinese phonological representation gets activated for words with high phonological similarity (Figure 5(a), the thin line labeled as (3)) but not for words with low phonological similarity (Figure 5(a), the dotted line labeled as (2)). This activation by the preceding sentence is thought to affect the lexical access based on the Japanese sound of the target word (see Figure 5(b)). That is, for words with high orthographical similarity (Figure 5(b), three connections with the plus sign), the Chinese phonological representation gets activated regardless of the degree of orthographical similarity (Figure 5(a), bold lines labeled as (2) and (3)), and thus there was no effect of phonological similarity. On the other hand, words with low orthographical similarity (Figure 5(b), two connections with the minus sign) were affected by activation of Chinese phonological representations due to high phonological similarity (Figure 4(a), the thin line labeled as (3)), and the response times were longer for words with high relative to low orthographical similarity (Figure 5(a), the dotted line labeled as (2)).



(a) Activation of the Representations by a Preceding Sentence (b) Processing of a Target Word

Figure 5: Word Processing by Intermediate Learners of Japanese in the High Sentence Constraint Condition (Effect of Phonological Similarity)

6.2. Processing in the Low Sentence Constraint Condition

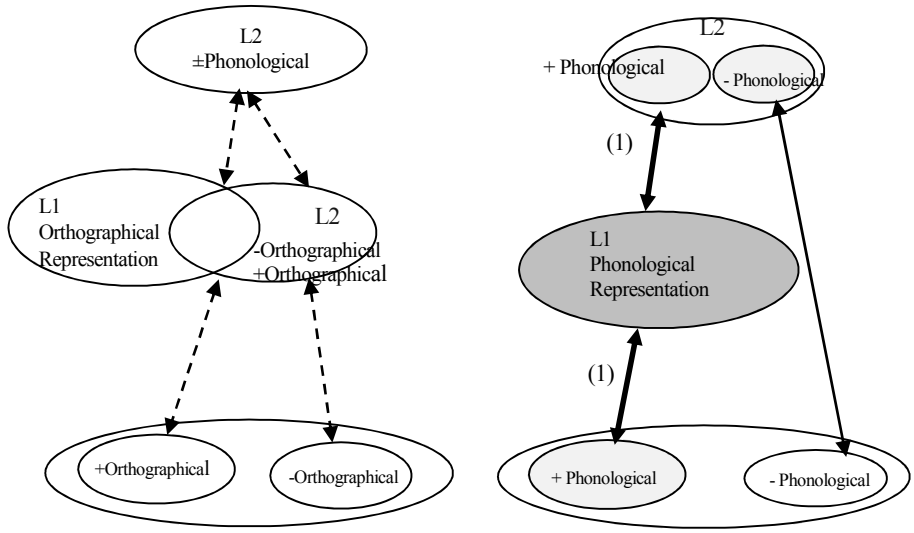
When the preceding sentence had low contextual constraint, the facilitation effect of orthographical similarity was not observed and the suppression effect of phonological similarity was observed. Thus, our hypothesis 2-1 was not supported, while hypothesis 2-2 was supported. There was no significant interaction between orthographical and phonological similarities; therefore, our hypothesis 2-3 was not supported. These results were different from those of Fei (2015) where a single-word presentation paradigm was used.

On the other hand, in advanced learners, similar results were obtained between a study using preceding sentences with low contextual constraint (Fei & Matsumi, 2013) and a study using a single-word presentation paradigm (Fei & Matsumi, 2012). We will present below our model for interpreting this common interesting finding among advanced and intermediate learners.

We propose a model for Japanese *kanji* word processing in intermediate learners under low sentence constraint, which is depicted in Figure 6.

As shown in Figure 6(a), there was no facilitation effect of orthographical similarity. This indicates that some semantic processing occurred at the time of presentation of a low-constraint sentence on the processing of the target word. Fei & Matsumi (2013) only mentioned the possibility of such an effect in advanced learners in their study, but the current study clearly showed the effect. It can be speculated that activation of the Chinese orthographical representation was suppressed by the processing of the preceding Japanese sentence in intermediate learners, and the participants accessed the conceptual representation directly from the auditory input of the Japanese word. As Figure 6(b) shows, one can interpret that the suppression due to phonological similarity occurred because the Chinese phonological representation got activated in the process of lexical access to the conceptual representation using the Japanese sound input. We speculate that words with high phonological similarity had longer response times than those with low similarity due to this mediation by Chinese phonological representation.

In intermediate learners of the Japanese language, it is possible that the workload was higher when processing the meaning of the preceding sentence, which in turn might have produced a different effect of sentence constraint compared to that in advanced learners.



(a) Facilitation Effect of Orthographical Similarity (b) Suppression Effect of Phonological Similarity

Figure 6: Word Processing by Intermediate Learners in the Low Sentence Constraint Condition

7. Conclusion

The current study investigated the processing of *kanji* words that were presented auditorily after a preceding sentence with high or low contextual constraint was presented in intermediate learners of the Japanese language residing in China.

The mean response time for the high constraint condition (705.23 ms) was shorter than that for the low constraint condition (845.22 ms), indicating that the manipulation of sentence constraint in the current study was successful. On the other hand, our results demonstrated differential effects of orthographical and phonological similarities depending on high and low sentence constraint conditions. The results of both high and low constraint conditions were inconsistent with the results of Fei (2015) who used a single-word presentation paradigm, and it was demonstrated that sentence constraint affected *kanji* word processing.

The current results demonstrated that Japanese *kanji* words were processed differently depending on high or low sentence constraint in intermediate learners of the Japanese language. Our results were different from the results of the single-word presentation study of Fei (2015) in the high constraint condition (i.e., the nature of the interaction between orthographical and phonological similarities was different), and in the low constraint condition (where no interaction between orthographical and phonological similarities was observed). The effects of orthographical and phonological similarities demonstrated in the study of Fei (2015) would have been different when sentence contextual constraint was manipulated such as in Fei & Matsumi (2013). In addition, the current results were different from the results of Fei & Matsumi (2013) where effects of sentence contextual constraint were examined in advanced learners of the Japanese language. The current study demonstrated that the effects of sentence constraint on processing of auditorily presented Japanese *kanji* words were different between intermediate and advanced learners of the Japanese language.

Note

1. Reading Tutor is a Japanese Language Reading Tutorial System, designed to help Japanese learners improve their reading skills in Japanese. (http://language.tiu.ac.jp/index_e.html)

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