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Functions of Graphemic Components of *Kanji* on Recognition of *Jukugo* [1]

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Abstract : This study aimed to examine functions of graphemic components of *kanji* on the recognition of *jukugo* (two-*kanji*-compound word). Kiriki (1986), in his study on *kanji*, suggested that *hen* (left-side radical of *kanji*) functioned as an indicator of meaning. Hirose (1992b) suggested that the first *kanji* of *jukugo* was used as a retrieval cue for *jukugo*. The present study investigated whether the activation of *hen* still remained as a predictor of meaning on the recognition of *jukugo*. The experiment was carried out using priming paradigms, the same method as used by Kiriki (1986) and Hirose (1992b) wherein the subjects were asked to give lexical decisions. The results of the experiment showed that some activation of *hen* remained in non-*jukugo* judgment, but not in *jukugo* judgment. It was noted that the activation becomes gradually focused with the progress of *jukugo* judgment. Considering the results of previous studies, it can be said that the present study synthetically considered the functions of components on the recognition of *jukugo*.

Key words : word recognition, *jukugo*, *kanji*, priming effect, lexical decision

The process of recognition of *kanji* has been investigated in many studies (See Saito, 1982; Kaiho & Nomura, 1983; Hirose, 1991, for reviews). Kaiho (1975, 1979) explained the process in terms of the relation of graphemic, phonemic, and semantic processings. Considering this explanation, the relation of the three processings has been examined in many other studies (e.g., Inoue, 1980; Saito, 1981; Wang, 1988). Saito (1981), for example, reported that in the silent reading of *kanji* the direct processing from graphemic codes to meaning was possible, whereas in *kana* (the Japanese syllabary) the relation of graphemic code to meaning was mediated by the phonemic system. The relation of the three processings in recognition of *kanji* is considered as follows: (1) after a little preceding of graphemic processing, phonemic and semantic processings are progressed in succession, (2) these three processings are progressed interacting with each other, and (3) semantic processing has an advantage over phonemic processing on the whole.

Generally speaking, one of the features of *kanji* is that it is an ideographic character in comparison with *kana* which is a phonetic symbol. The conclusions of Saito (1981) can be considered as reflecting this feature of *kanji*. *Kanji* as an ideographic character gives meaning directly. Another feature of *kanji* is that it is composed of some graphemic components. It is considered that each graphemic component has meaning or a phoneme in general. For example, the *kanji* 語 is composed of the *hen* 言 and the *tsukuri* 吾. The *kanji* character 語 means "word". 言 indicates a meaning as "something related with languages", and 吾 indicates a phoneme /go/. In Japanese, the left-side radical is called *hen*, and the right-side radical is called

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tsukuri. The *jukugo* 国語 which means "one's native language" is composed of the characters 国 and 語. 国 means "country", and 語 means "word". In the case of *jukugo*, linguistically referred to as a "two-*kanji*-compound word", most *jukugos* are composed of two *kanjis*. Inoue, Saito, & Nomura (1979) pointed out this feature related to *kanji* or *jukugo* recognition.

Kaiho (1975) in his research used *kanji* as stimulus materials. In this study, subjects were asked to judge whether 2, 3, 4, and 6 concrete nouns belong to an identical semantic class or not. Reaction time (categorization time) and correct or incorrect responses were recorded. The results indicated that the same radical does not accelerate the processing speed at all. It was then concluded that a radical does not function in indicating meaning. On the contrary, Kiriki (1986) suggested that a radical functions in indicating meaning. Kiriki's study was conducted by using priming paradigms. After seeing a prime stimulus, a target stimulus was presented. Then subjects performed a lexical decision task. The results showed that if the same *hen* was presented as prime stimulus, a lexical decision task for target stimulus was facilitated. As to the difference between Kiriki (1986) and Kaiho (1975), Kiriki (1991) suggested that it was a reflection of difference in task. He explained that the functions of graphemic components were fulfilled in the early stages of the cognitive process of *kanji* . Thus, Kiriki (1986) studied recognition of *kanji*, and Kaiho (1975) studied thinking and judgment in addition to recognition of *kanji* . As for the phoneme, Hirose (1992a) suggested that *tsukuri* was used for phonemic processing of characters.

A study using *jukugo* as stimulus material was conducted by Hirose (1992b). This study was carried out using priming paradigms in which subjects performed a lexical decision task. The results of Experiment 1 and Experiment 2 in this study showed that the first *kanji* was used as retrieval cue for *jukugo*, and the activation of the first *kanji* facilitated the identification of *jukugo* in terms of meaning. In Experiment 3, the lexicon of *jukugo* was formed in such a structure that several *jukugos* containing a common first *kanji* are tied together, based on the first *kanji* . For instance, consider the recognition process of 学歴 (for "school career"). *Jukugos* that have the first *kanji* (学) in common will be activated. Such *jukugos* are 学歴, 学校 (for "school"), 学習 (for "learning"), and so on. *Jukugos* which have the same *kanji* in the second position will not be activated. The *jukugos* 科学 (for "science") and 進学 (for "entrance into a school of higher grade"), for example, do not have any commonality in meaning. In the recognition process, the first *kanji* was used as retrieval cue. It was considered that the processing of *jukugo* which gave priority to the first *kanji* over the second was performed. The function as retrieval cue was also suggested in other research studies (Ohnishi, 1987; Saito & Tsuzuki, 1989). As a follow-up study, Hirose (1992c) examined the structure of the lexicon of *jukugo*.

As regards the relation of *kanji* and *jukugo*, Hirose (1994) investigated the problem in view of the attribute of words, independence words or combination words. For example, the *kanji* character 愛 (for "love") is used as an independence word, and is also used in a combination word (e.g., 愛着 for "attachment"). On the other hand, the *kanji* 観 is usually used only in a combination word (e.g., 観察 for "observation"). It is then considered that the prevailing activation to other *kanji* is not necessary in case of recognition of independence words, because a meaning is already assimilated. The study by Hirose (1994) supported this assumption. In this study it was presented that if the *kanji* used both as an independence word and in a combination word was presented as an independence word for prime stimulus, an activation to *jukugos* was not observed. However, activation was found if the *kanji* was used in a combination word. Then it was considered that the *kanji* used both as an independence word and in a combination word would be memorized separately according to their attributions. To be more precise, the *kanji* as an independence word was memorized independently, and the *kanji* in a combination word will be present at the center of the lexicon of several *jukugos* that have the same first *kanji* .

As for investigation of the relation of *kanji* and *jukugo*, the problem that needs to be solved is how graphemic components of *kanji* function in the recognition of *jukugo*. The present study was designed to decide whether prime *kanji* facilitates the target *jukugo* with the same *hen* as the prime in the first *kanji* or not, and to examine the function of the *hen* component in the recognition of *jukugo*. In a study using *kanji* as stimulus (Kiriki, 1986), it was suggested that the lexical decision for the target *kanji* was facilitated if the *kanji* with the same *hen* as the target *kanji* preceded. In the case of non-*kanji* target with the same *hen* as the prime *kanji* , the lexical decision was inhibited. In the study using *jukugo* as stimulus (Hirose, 1992b) the processing of *jukugo* gave priority to the first *kanji* over the second. In the present study, it was assumed that, if the semantic effect of the same *hen* is still existent, it will suggest that the *hen* functions as an indicator of meaning at the level of *jukugo*, too. It is also assumed that the activation is gradually focused with the progress of *jukugo* process. On the other hand, if the effect is non-existent, it will be considered that a unit of processing is perfectly translated into an upper *jukugo* level, or the activation of *jukugo* is different from the activation of *kanji*.

Method

Subjects

Twenty undergraduates or graduate students at Hiroshima University participated as subjects in this experiment. There were 8 males and 12 females, all of whom were native speakers of Japanese.

Apparatus

The stimuli were displayed on a 14 inch high resolution color CRT (NEC PC-KD853n) controlled by a personal computer (NEC PC-9801RX). Subject's yes or no responses were recorded from a response box connected with the personal computer. Time control and measurement of RT were carried out by using a timer chip contained in the personal computer.

Stimulus materials

First, thirty-two *jukugo*s and thirty-two non-*jukugo*s for target stimuli were selected. Non-*jukugo* is a two-*kanji*-compound character that is not actually used as *jukugo*. For the first *kanji* of target stimulus, a combination word composed of *hen* and *tsukuri* was selected. The classification of the words (independence words or combination words) was determined by using the classification of the National Language Research Institute (1976). Then prime stimuli (*kanji*) were selected according to the following conditions: same *kanji* , same *hen*, and different *kanji*. All prime stimuli were combination words and were composed of *hen* and *tsukuri*.

Table 1 shows the four experimental conditions. In same *kanji* condition the first *kanji* of target stimulus was presented as prime stimu-

Table 1
Examples of stimulus for each experimental condition (*jukugo* target)

Conditions	Examples of stimulus (Prime-Target)
Same *Kanji*: The first *kanji* of target is presented as prime stimulus.	設 － 設計
Same *Hen*: *Kanji* with the same *hen* as the first *kanji* of target is presented as prime stimulus.	浮 － 温度
Different *Kanji*: *Kanji* with *hen* different from the first *kanji* of target is presented as prime stimulus.	鋭 － 給食
Neutral: A sharp is presented for prime stimulus.	＃ － 限界

lus. In the same *hen* condition *kanji* with the same *hen* as the first *kanji* of target stimulus was presented as prime stimulus. In different *kanji* condition *kanji* with *hen* different from the first *kanji* of target stimuli was presented as prime stimulus. And, in the neutral condition a sharp sign (#) was presented as a prime stimulus, thereby making this condition as having no effect as a sensible *kanji* .

For filler stimuli, a filler stimulus set was prepared in the same fashion as the non-filler stimuli except that the second *kanji* of target stimulus was made as the point of variation in the making of the four conditions. There were thirty-two *jukugo*s and thirty-two non-*jukugo*s for target stimuli. Eight prime stimuli for each condition were selected as for *jukugo* or non-*jukugo* targets.

The 128 trials were separated into three blocks. Prime stimuli for target stimuli were counterbalanced across subjects. The order of lists was randomized in each subject.

Procedure

A fixation point (+) was presented for 1000 ms at the center of the CRT, followed by a 500-ms blank. Then the prime stimulus was presented, centered on the fixation point for a duration of 1000 ms. Subjects were instructed to see the stimulus. After a 500-ms blank, notice points of presentation (+ +) were presented for 1000 ms at the center of the CRT, followed by 500-ms blank. Then notice points of presentation were replaced by the target stimulus. Subjects were instructed to decide as rapidly and accurately as possible whether the target stimulus was or was not *jukugo*. Subjects responded yes by pressing the right response button with the thumb of their right hand and no by pressing the left response button with the thumb of their left hand. Reaction times which were measured from target onset until subjects' response were accurate to the nearest millisecond. Subjects received a series of 10 practice trials of the same type as the experimental trials before beginning the experiment.

Each subject was instructed in Japanese as follows: This is an experiment related to recognition of *kanji* . First, a fixation point that is a plus sign is presented at the center of the CRT. Focus your attention at the point. A *kanji* or a sharp is presented at the point in a few seconds. Then you will see the character. Next, notice points of presentation that are two abreast plus signs are presented. Again, focus your attention at the place. After noting the points of presentation, two *kanjis* are presented. Your task is to decide as rapidly and accurately as possible whether the target stimulus is or is not *jukugo*. If you think yes, press the right response button with the thumb of your right hand. And, in case of no, press the left response button with the thumb of your left hand. There are three blocks in this experiment.

Results

Mean reaction times for each condition are shown in Figure 1 (for *jukugo* targets) and Figure 2 (for non-*jukugo* targets). The reaction time data were submitted to an analysis of variance, considering the four conditions (same *kanji* , same *hen*, different *kanji* , and neutral) as principal factors. An analysis of variance was performed on both *jukugo* or non-*jukugo* targets. For the *jukugo* targets, the main effect was significant at $p<.001$ ($F(3,57)=10.03$). For the non-*jukugo* targets, the main effect was also significant at $p<.001$ ($F(3,57)=6.64$). To analyze the differences among conditions, Ryan's method was applied. For the *jukugo* targets, it revealed that there were significant differences at a level of $p<.05$ between same *kanji* condition and same *hen*, different *kanji* , and neutral conditions. For the non-*jukugo* targets, there were significant differences between same *kanji* condition and same *hen*, and neutral conditions. All of percentages of errors to target words were less than 10 percent.

These results can be summarized as follows: For *jukugo* targets, mean reaction time of same *kanji* condition is significantly shorter than in any other conditions. For non-*jukugo* targets, mean reaction time of same *kanji* condition is significantly shorter than different *kanji* and neutral conditions. As for same *hen* condition, it is considered that the condition is placed between same *kanji* condition and different *kanji* or neutral condition.

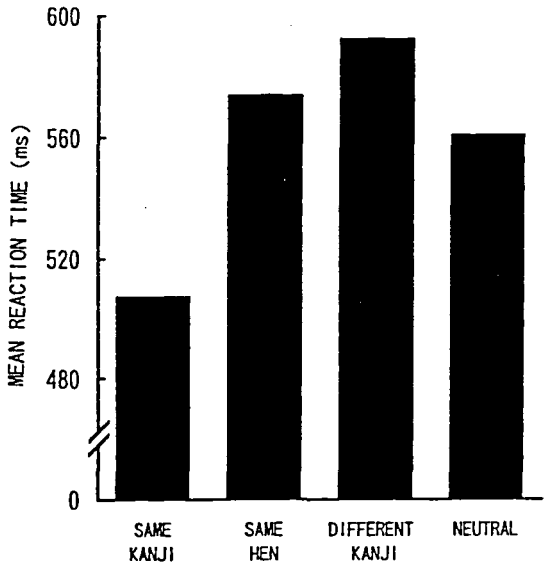

Figure 1. Mean reaction time for each condition (*jukugo target*).

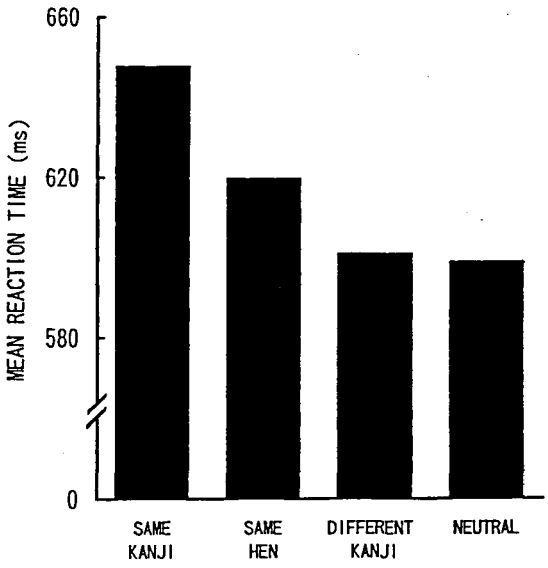

Figure 2. Mean reaction time for each condition (*non-jukugo target*).

Discussion

The results of *jukugo* targets indicated that the same *kanji* condition facilitated *jukugo* recognition. The results suggested that same *hen* condition does not facilitate *jukugo* recognition and that *hen* does not function as an indicator of meaning. As for non-*jukugo* targets, the results indicated that same *kanji* condition was inhibitory. These results can be explained by the fact that before the presentation of a target stimulus, activation for a prime stimulus had already prevailed. The activation covered *jukugos* that had the same first *kanji* . Due to this direct activation, the judgment on non-*jukugo* with the same first *kanji* was interrupted, thereby inhibiting the judgment.

Furthermore, some inhibition was observed in same *hen* condition (non-*jukugo* target). In this condition, if the stage is translated completely from the *kanji* level to the *jukugo* level, this inhibition would not be observed. Thus, this result suggests that some influence of *hen* still remained. It is considered that the activation gradually focused with the progress of *jukugo* process. In case of judgment of *jukugo*, target stimulus is finally identified as *jukugo*. It is considered that the activation at the *kanji* level does not remain in this case. But for non-*jukugo*, target stimulus is not identified as *jukugo* in the end. For this reason, it can be said that some activation of *hen* still remains.

Taking the results of previous studies into consideration, I will consider the issue on the functions of components on the recognition of *jukugo*. The first step of recognition of *jukugo* is to give priority to *hen* over *tsukuri* of the first *kanji* . The *hen* functions as an indicator of meaning. Then *kanjis* that have the same *hen* are activated. Therefore, the identification of the first *kanji* is facilitated and the *kanji* is identified. Then a unit of processing was translated to the upper level. The *kanji* functions as retrieval cue for *jukugo*. *Jukugos* that have the same first *kanji* are activated. Therefore the identification of the *jukugo* is facilitated. In effect, the *jukugo* is identified. Thus it is considered that the graphemic components are given the above-mentioned functions for recognition.

Then how are those functions given by those graphemic components? This question can be explained by interpreting the series of

processing as the process of limitation on meaning. For instance, consider the recognition of the *jukugo* 講義 for "lecture". The first step in the processing is given priority to *hen* (言) of the first *kanji* (講). The *hen* is also contained in 語 (for "word"), 話 (for "talk"), 評 (for "comment"), and so on. These are words related with talk. So, upon recognition of the *hen* (言), subjects understand the *kanji* as a word related to talk. Hence, the identification of the first *kanji* (講) is facilitated, and the *kanji* is identified. At the *jukugo* level, the *kanji* (講) is contained in 講堂, for "lecture hall", 講演, for "address", 講習, for "training course", and so on. Thus when they recognize the *kanji* (講), subjects understand the *jukugo* as a word related to detailed description. In effect the identification of the *jukugo* (講義) is facilitated and eventually the meaning of the *jukugo* is identified.

In conclusion of this study, some function of *hen* remains in non-*jukugo* judgment, but not in *jukugo* judgment. It is considered that the activation gradually focused with the progress of *jukugo* process. (It can also be considered as the process of limitation on meaning.) The *jukugo* process is divided broadly into two stages, the *kanji* level and the *jukugo* level. The first step is performed relating the first *kanji* to the *jukugo*, where the *hen* functions as a meaning indicator. The next step is using the first *kanji* to function as a retrieval cue for *jukugo*. In the case of non-*jukugo* judgment, *jukugo* processing is not performed in the end. That is why some function of *hen* remains.

In this study, the functions of the components of *kanji* or *jukugo* was investigated. Incidentally, the importance of whole information was indicated in concurrent with the importance of graphemic components' information (e.g., Hirose, 1992a; Hirose, 1992b). However, interaction between whole and part was not studied in detail. Recognition processing is often explained by both top-down and bottom-up processings (Kaiho & Nomura, 1983). In this viewpoint, the above-mentioned process is viewed as a detailed explanation for bottom-up processing on recognition of *jukugo*. Further studies on the function of graphemic information in *kanji* and *jukugo* recognition focused on the interaction between these two processings is necessary.

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