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A main processing unit in Japanese word recognition: Analysis from the recognition thresholds of moving characters

Koichi Kaketa*1

Abstract

This study examined whether a Japanese word is recognized as a whole unit or as a cumulative sequence of individual characters. The materials were designed to examine three variables: lexicality (word and nonword), script type (ideographic Kanji and phonogrammic Hiragana), and word length (2 and 3 characters). The participants' recognition thresholds for the materials were measured through the presentation of moving characters, in which the materials moved through a small visual window at varying speeds on a CRT. The variations in window size and moving speed of the materials were held constant across conditions. Our results

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supported the view that recognition threshold for words is lower than for nonwords. These results suggest that Japanese Kanji and Kana words are recognized in the same way as words in alphabetic languages, such as English. We conclude that Japanese words are recognized as whole units by matching lexical information with whole word representations in the mental lexicon.

In studies of visual word recognition, a recurring question has been whether a word is recognized as a whole unit or as a cumulative sequence of individual characters. One of the simplest ways to give an answer to this question is to examine and compare the recognition performances of word vs. nonword. If a word is recognized as a whole unit, the recognition performance of word will be better than that of nonword. If a word is recognized as a specific sequence of individual characters and not as a unit of meaning, however, the recognition performance of word will not be differentiated from that of nonword.

In the case of English and other alphabetic languages, a number of previous studies on visual word recognition have shown that the processing unit for recognizing a word is not each character, but a whole word. Some researchers, for example, have confirmed the word/nonword effect, which connotes that words are easier to recognize than nonwords, by using such experimental tasks as the recognition threshold task (Adams, 1979; Feustel, Shiffrin, & Salasoo, 1983; Hershenson & Haber, 1965; Salasoo, Shiffrin, & Feustel, 1985), the naming task (Besner, 1983; Forster & Chamber, 1973; Scarborough, Cortese, & Scarborough, 1977), and the lexical decision task (Besner, 1983; Forster & Chamber, 1973; Rubenstein, Garfield, &Millikan, 1970; Scarborough et al., 1977). This effect is said to suggest that each word is represented in a form of a whole word in the

mind. As a result, the word is recognized through a comparison of its input letter string with its internal word representation. The word superiority effect (e.g., Reicher, 1969), which connotes that a character within a word can be recognized more easily than the same character isolated from a word context, is also based on this theory. Marmurek (1986) described a similar phenomenon which he called, "whole-word advantage." In a comparison of identity between two words, presented successively, and two letters within each word, the decisions on the identity of the two words are made faster. Thus, the phenomena revealed in the studies of English word recognition have consistently suggested that whole words are the main processing units of word recognition.

Are Japanese words recognized in the same way as alphabetic words? Japanese has two qualitatively different types of characters, Kana and Kanji.*2 This feature is not found in the alphabetic languages or even in Chinese, where Kanji originated. The characteristics of Kana and Kanji characters are different from those of the alphabet, respectively. Kana characters are phonograms and each character mainly represents a syllable. If each Kana character of a Kana word is recognized, the phonological information of the whole of the Kana word can be obtained. Thus, it is possible that every Kana word is recognized based on its phonological information of constituent characters, rather than its whole word internal representation. The other Kanji characters are ideograms

*2 In Japanese, there are two scripts, syllabic Kana and logographic Kanji. Kana is subdivided into two groups of characters serving two different purposes. One form, Hiragana, is used to represent grammatical prefixes and suffixes, function words, and some content words. The other, Katakana, is used to represent "loanwords." Most Kanji characters have at least two pronunciations: a *Kun*-reading and one or more *On*-readings.

and mainly represent morphemes. Some Kanji characters are themselves words, and combinations of Kanji characters produce various words. Considering these characteristics of Kanji characters, each Kanji word may be recognized on the basis of each constituent character in a word, similar to Kana words, rather than on its whole word internal representation.

In the case of Japanese, although there have been many studies of Kana and Kanji word recognition, experimental results of recognition performances of words vs. nonwords were rather inconclusive. There is no convincing evidence which suggests that Japanese word recognition is a function of whole word units or individual characters, or a different mechanism that found for alphabetic word recognition.

Some studies have reported that Kana words are named faster than Kana nonwords in the naming task (Besner & Hildebrandt, 1987; Nomura, 1981; Usui, 1998). It has also been found that decision latencies of Kana words are shorter than those of Kana nonwords in the lexical decision task (Hirose, 1985; Kawakami, 1993; Usui, 1998; Yamada, Imai, & Ikebe, 1990). The word superiority effect has also been reported for Hiragana (Miura, 1978). However, no whole-word advantage has been found for Kana words (Shimomura & Yokosawa, 1991).

The results are considerably more inconclusive for Kanji than for Kana. There are no studies yet which clearly report a difference in recognition performance between Kanji words and nonwords. The naming task paradigm is not appropriate for Kanji because every Kanji character has more than one pronunciations. Therefore, the pronunciations of Kanji nonwords can not be determined. No whole-word advantage has yet been found for Kanji word recognition or for Kana word recognition (Shimomura & Yokosawa, 1991). The word superiority effect for Kanji words has been found in some cases but not in others

(Yokosawa & Umeda, 1988). If Kanji words are recognized by utilizing internal representation of whole words, then the word superiority effect and whole-word advantage should have emerged.

Thus, there is little evidence to support a difference in recognition performance between words and nonwords in Japanese compared to the alphabetic language. Therefore, the nature of the internal mechanism involved in Japanese word recognition remains unclear.

In the present study, I compared the recognition performance of Japanese words and nonwords, in order to demonstrate whether a difference between word and nonword recognition exists. I prepared words and nonwords as materials, each half of them of which were written in Kanji or in and half in Hiragana. I decided to use the recognition threshold as an index of recognition performance, rather than reaction latency for two reasons. First, I wished to examine all recognition performance of Kanji and Kana words with the same measure. Because it is difficult to examine the naming latency of Kanji nonwords, the reaction latency measure did not meet our needs. Second, it has been demonstrated that the reaction latency task tends to exaggerate the effect of response processes, and not the effect of recognition processes, more than the recognition threshold task.

My hypothesis was that if the recognition threshold of words could not be differentiated from that of nonwords using this measure, it should be taken as evidence that the Japanese word recognition main processing unit is not a whole word but rather, each character of a word. If the recognition threshold of words was demonstrated to be lower than that of nonwords, then it this would support the whole word processing unit theory of word recognition for the Japanese language.

In order to measure recognition thresholds of the materials, I presented the materials moving rapidly from the right side to the left side of a

limited viewing range. This method of presentation has been used to estimate the effective visual field in reading (e.g., Bouma & deVoogd, 1974; Chujyo, Notomi, & Ishida, 1993; Kaketa & Abe, 1996; Legge, Pelli, Rubin, & Schleske, 1985; Newman, 1966; as reviewed by Osaka & Oda, 1994, and Rayner & Pollattsek, 1989, in detail). Generally, recognition thresholds of words are measured by asking participants to read them under various limited situations, e.g., short exposure and spatial filtering. Ideally, to control for situation-specific limitation and biases, recognition performances should be measured under various methods and conditions, and the resulting data should be compared. In this experiment I decided to use of moving-material presentation, which has not previously been used to word recognition tasks, and to compare the results of this experiment with those of previous experiments using different methodologies. The threshold data obtained by this method has given us new insights into Japanese word recognition.

Method

Materials and Variables for Materials

Stimulus materials consisted of Japanese words and nonwords created according to the criteria of the two experimental variables of interest: lexicality (word or nonword), and script type (Kanji or Hiragana). Groups of Kanji word, Kanji nonword, Hiragana word, and Hiragana nonword were prepared. In addition, the effects of character number and window size were also studied. Half of these materials consisted of two characters and half consisted of three characters, since Japanese words mostly consist of two or three characters. Thus, eight types of material sets were prepared in all. The variables and all the experimental materials are shown in Table 1.

For each type of material set, four practice items and 20 experimental items were prepared. Each set was further divided into four subsets, each consisting of one practice item and five experimental items. Each subset was randomly assigned to one of four "window-size" conditions, which will be described later.

Table 1 Variables for Materials and All Experimental Materials Used in the Experiment

Variables			
Lexicality	Script Type	Word Length	Sample Materials
Word	Kanji	2 Characters	世界，政府，土地，保護，酸素，人間，生産，自由，農業，機能，生活，政治，地方，組織，理論，国民，気候，文化，種類，議会
		3 Characters	一年生，海水浴，自動車，英会話，看護婦，原子力，加速度，会社員，初任給，自衛隊，外国人，委員会，衣料品，温度計，不思議，青少年，小学校，化粧品，農作物，新聞紙
	Hiragana	2 Characters	いみ，いろ，うみ，ぎむ，おや，きた，じき，いし，かべ，かげ，かわ，むぎ，ちか，つき，こえ，ねつ，かず，やま，なつ，はる
		3 Characters	にほん，みなみ，こころ，たばこ，とけい，せかい，ふつう，ひだり，くるま，りかい，ひがし，じかん，こども，きけん，あたま，じぶん，ひかり，やさい，みどり，きかい
Nonword	Kanji	2 Characters	展胞，意個，立利，然企，長保，治細，題市，気大，民達，比現，動度，置発，加全，展状，定実，態地，通植，和地，温自，団動
		3 Characters	定中宇，究席可，念名能，作過指，温国浴，気的不，会圧専，高青自，商院枝，校所衆，手度民，古思速，地食医，衣海悪，門書植，企学少，住好映，委消安，運音社，記性営
	Hiragana	2 Characters	れみ，とこ，ちと，あろ，ねと，たわ，えな，ろみ，とあ，んい，たし，ほえ，えね，ねあ，ちも，つほ，まそ，ろい，はそ，むも
		3 Characters	ゆいあ，こかき，わふけ，しひき，りせけ，いはそ，きひさ，うふか，りなろ，そほい，せふあ，うかさ，みけふ，けほい，くりう，くしほ，こかお，くなう，こしい，んけそ

The materials were chosen to fit a wide range of familiarity and were balanced within each set and subset. The familiarity levels of the materials were determined according to their frequencies of usage in newspapers and books. For Kanji 2-character words and Hiragana 2-character words, the frequencies were based on the 1983 Kokuritsu Kokugo Kenkyujyo Report (National Language Research Institute, 1983). The range of their frequencies fell within 721 and 18 among 321,058 words, with a median frequency of 153. For Kanji 3-character words and Hiragana 3-character words, the frequencies were based on the 1973 Kokuritsu Kokugo Kenkyujyo Report (National Language Research Institute, 1973). The range of their frequencies fell within 1324 and 2 among 1,967,575 words, with a median frequency of 75.5. Although it was impossible to equalize the frequencies among all the types of materials perfectly on a common norm, the frequencies were arranged to be approximately equal within each set and subset. Other characteristics of the materials, such as the number of strokes within each Kanji character, were as evenly balanced among the subsets of each material type as possible.

The nonword materials were created by combining characters in an arbitrary way so that they might be meaningless as word units. However, the familiarity levels of the characters approximately matched those of the word materials.

Presentation Method and Apparatus

Each item was presented moving from the right side to the left side of a small window in the center of a CRT display, which was controlled by a personal computer (NEC PC9801 VX). Participants were able to see the material only in the window (see Figure 1). The window size was 1 character high, and 2, 3, 4, or 5 characters wide. Each character was 8.

75 mm high and 8.75 mm wide. The viewing distance was about 50 cm, so the visual angle of a character was approximately 1.0 degree. The presenta-tion speed was manipulated by changing both the duration of material presentation at the same location on a CRT display and the distance the material moved at a time. The distance and the duration were held constant within a particular presentation-speed condition. It is impossible to control the presentation speed accurately on a standard CRT display, since such a display cannot rewrite a screen faster than 17 ms. In addition, such a display has an inescapable negative feature of slow decay after stimulus offset. In the present experiment, therefore, we used a special CRT tachistoscope (Iwatsu Isel Co. Ltd., IS-701A) which features a fast decay and the precise control of material presentation to within 1 ms.

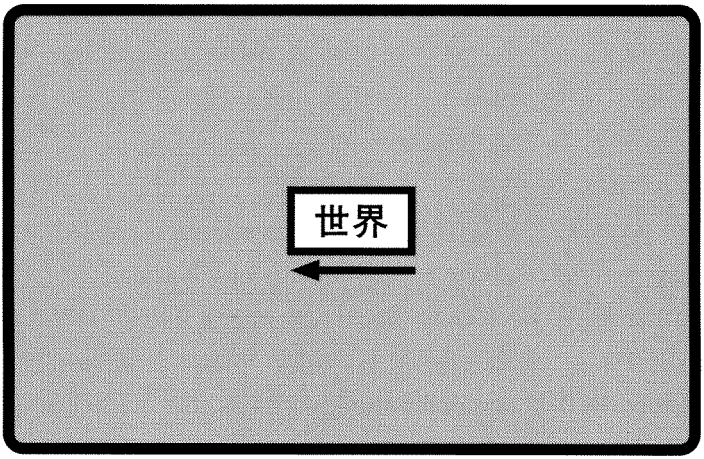

Figure 1. An Example of a material presentation. The figure exemplifies the presentation of a Kanji 2-character word, 世界, in the 3 character window-size condition. The word is seen moving from the right to the left within the window.

Variables for Material Presentation

The independent variable manipulated for the material presentation was window size, which could be 2, 3, 4, or 5 characters wide. These sizes are within the range of the functional visual field in reading, allowing participants to acquire the information adequately at one fixation within the range of the window (e.g., Rayner & Pollatsek, 1989, in detail). The dependent variable was recognition threshold as a function of presentation speed. The unit of the presentation speed was determined at even intervals by measuring the duration taken for one character to move across one character width on the screen. According to this unit, the fastest and the slowest speeds were 16 and 64 milliseconds per character width (8.75 mm), respectively, and items were separated by 13 speed interval steps of 4 ms/character-width. This unit was converted to another unit of speed, character-width per second. The character-width unit represents the number of characters that move a given distance during a one-second interval. The fastest speed, 16 ms/character-width, corresponded to 63 character-width/s and the slowest speed, 64 ms/character-width, to 16 character-width/s. According to this unit, the speed conditions were 63, 50, 42, 36, 31, 28, 25, 23, 21, 19, 18, 17, and 16 character-width/s in all. This range of presentation speeds was determined based on the results of our preliminary observation. At the fastest presentation speed, participants could not recognize materials at all, and at the slowest speed they could recognize materials almost perfectly. Also, I confirmed by preliminary observation that participants could recognize the material more easily in the wider window-size condition.

Procedure

The measurements of thresholds were determined separately for participant in each of the eight material sets. Participants were seated

in front of the CRT tachistoscope with their heads supported by a chin rest at a viewing distance of approximately 50 cm. Participants were asked to recognize a stimulus item and pronounce it aloud; if they could not recognize it, they were asked to say so. They were allowed to pronounce a Kanji character in either a *Kun*-reading and/or an *On*-reading.*3 They were also allowed to pronounce nonwords in any naming as long as the experimenter could ascertain that they were recognizing the nonwords as nonwords. Participants were informed beforehand what type of material they would see, but they were not told what any of the specific items were. A typical set of instructions would be as follows: "The stimulus materials that you will see are Kanji 3-character words. Namely, the script type is Kanji, the lexicality is word, and the number of characters is three."

The general procedure for each material set at each window-size condition was as follows: The presentation of materials began at the fastest speed (63 character-width/s) and then decreased step by step to the slowest speed (16 character-width/s). During these trials the speed at which participants correctly recognized the material for the first time was recorded as their initial recognition threshold. If they subsequently gave an incorrect response, their recognition threshold was recorded as the speed at which participants could correctly report the material for the second time. I refer to this procedure as "the uninformed decelerating series," since participants were uninformed as to the exact nature of the material, and since the presentation speed was decreased by degrees.

In the next set of trials, the presentation speed was increased step by

*3 *Kun*-readings are those of native Japanese origin. *On*-readings are those that were introduced into Japanese originally as Chinese borrowings (Jorden & Chaplin, 1977).

step from the slowest (16 character-width/s) to the fastest speed (63 character-width/s), and once again the participant's recognition threshold was recorded. I refer to this second procedure as "the informed accelerating series," since participants were informed as to the exact nature of the material, and since the presentation speed was increased by degrees.

In the final set of trials, the speed of presentation was decreased step by step to the slowest speed again and the same task was completed. I refer to this third procedure as "the informed decelerating series," since participants were informed as to the exact nature of the material, and since the presentation speed decreased by degrees.

Let us look at how a sample item was used in these experiments, such as this Kanji 3-character word, 自転車. In the uninformed series, participants were not told what the item was, but they were apprised of what kind of material type they would see. In the informed series, participants were also told what the specific item would be.

Participants were not informed as to whether or not their responses were correct, except when they could not recognize the material presented at the slowest speed in the uninformed decelerating series. In this case, the experimenter told the participants what the items were before the procedure shifted to the informed accelerating series.

The same procedure described above was repeated for one practice and five experimental items of each material type in each window-size condition. The window size was changed after the presentation of six items and then the same procedure was repeated for another item of the same material type. The window size could be increased from 2- to 5-character size or decreased from 5- to 2-character size. Half of the participants experienced a steady increase in window size, and the other half experienced a steady decrease in window size. Each of four subsets for the same type of material sets was assigned randomly to each of four

window-size conditions for each participant.

Participants

Twenty undergraduate, graduate, and research students of Hokkaido University participated in this experiment. Of these 20, 16 participants were evenly assigned to one of the four 2-character material sets. This was a between-subject design. The remaining 4 participants were exposed to each of the four 3-character material sets. This was a within-subject design. Ideally, I wanted to manipulate all variables as within-subject factors in order to reduce the effect of individual differences. However, I carried out a between-subjects design for the 2-character materials, since in the present experiment the within-subject design imposed a burden on the participants.

Results and Discussion

The main targets of the analysis were the effects of lexicality (word and nonword) and script type (Kanji and Hiragana) on recognition threshold. In addition I studied the effects of word length (2 and 3 characters) and window size (2, 3, 4, and 5 character size). The recognition threshold of each combination of window size and material type for each participant was defined as the fastest presentation speed at which 50 percent correct answers were attained. For each participant, the 50 percent correct answer for each condition was calculated from the data of his/her responses to the materials in each subset.*4

*4 In the uninformed series, in the 2 character window size, a 50 percent correct answer rate for Kanji 2-character nonword and Hiragana 2-character word was not attained by one participant. The loss of these data in the uninformed series caused the degrees of freedom for the uninformed series.

As stated in the Procedure, the participants were asked to recognize materials in three series; i.e., the uninformed decelerating series, the informed accelerating series, and the informed decelerating series. In the uninformed decelerating series, readers were told the type of an incoming item only. In the informed accelerating and informed decelerating series, readers were told exactly what the incoming item was. The difference between the uninformed series and the two informed series was whether or not participants knew the nature of the material in advance. Because our purpose was to define "recognition threshold," and not "identification threshold," in this study I chose to analyze the data from the uninformed decelerating series only.

A four-way analysis of variance (ANOVA) was carried out. The dependent variable was the recognition threshold as a function of presentation speed for each participant, and the independent variables were lexicality, script type, the number of characters, and window size. As expected, a significant main effect of window size was found. That is, as the window size increased, recognition threshold decreased, $F(3, 94)=59.19$, $p<.0001$. A multiple comparison test revealed significant differences between all window-size conditions ($p<.05$). There were no significant interactions between window size and other three variables. I, therefore, did not discuss anymore the effect of window size, which was not a main factor of this experiment.

Figures 2, 3, and 4 show the mean thresholds for the 8 material set. The ordinates of Figures 2, 3, and 4 represent the thresholds as a function of presentation speed, and the abscissas represent lexicality, script type, and the number of characters, respectively. I will discuss each of the effects in the following sections.

Effects of Lexicality and Script Type

A significant main effect of lexicality was found, $F(1, 94)=6.89$, $p<.011$, indicating that recognition threshold for words was lower than for nonwords (see Figure 2). A main effect of script type was also significant, $F(1, 94)=17.75$, $p<.0001$, indicating that recognition threshold for Hiragana was lower than for Kanji (see Figure 3). A significant interaction between lexicality and script type also emerged, $F(1, 94)=21.01$, $p<.0001$. A simple main effect test revealed that, for Kanji, the recognition threshold for words was significantly lower than for nonwords, $F(1, 94)=23.55$, $p<.0001$. For Hiragana, however, there was no significant difference between these recognition thresholds. In addition, the recognition

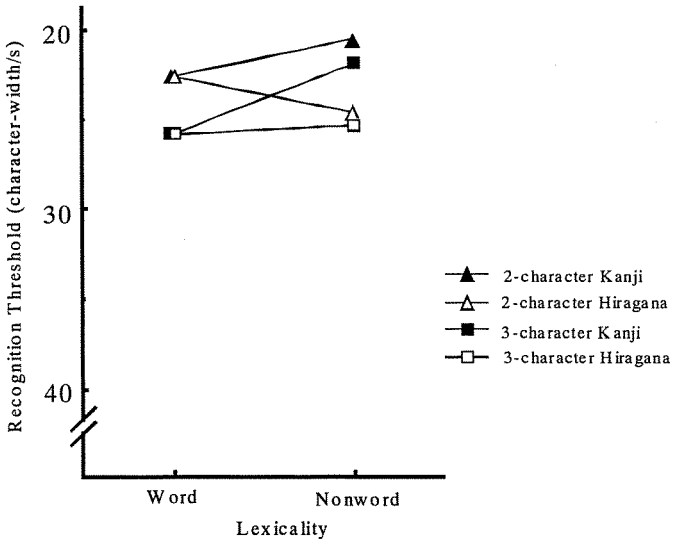

Figure 2. Mean recognition thresholds (presentation speed: character-widin/s) as a function of lexicality. The triangles and squares indicate 2-character and 3-character materials, respectively. The open and filled symbols indicate Hiragana and Kanji, respectively.

thresholds for Kanji and Hiragana words were not significantly different, but for nonwords, the recognition threshold for Hiragana was significantly lower than for Kanji, $F(1, 94)=38.38$, $p<.0001$ (see Figures 2 and 3).

These results suggest that Kanji words were easier to recognize than Kanji nonwords, but Hiragana words were not more easily recognized than Hiragana nonwords. This supports the idea that the main processing unit for Kanji word recognition is a whole word, but for Hiragana word recognition it may be each individual character. However, this supposition may be premature.

As previously stated, a number of studies investigating Japanese visual word recognition have reported a recognition superiority of Kana

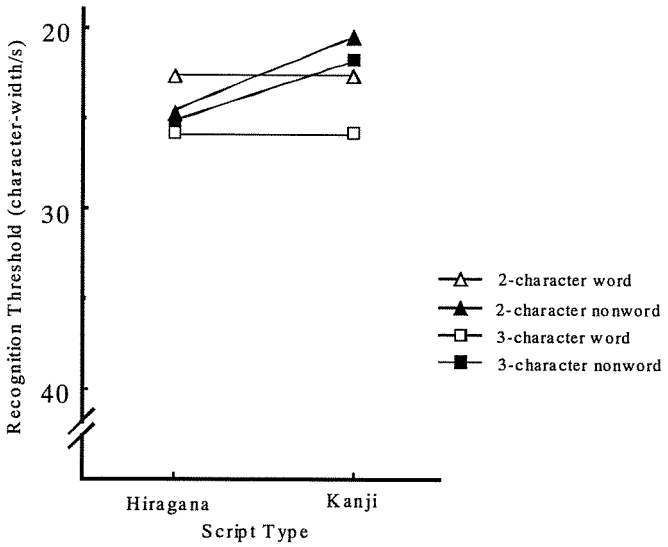

Figure 3. Mean recognition thresholds (presentation speed: character-width/s) as a function of script type. The triangles and squares indicate 2-character and 3-character materials, respectively. The open and filled symbols indicate words and nonwords, respectively.

word to Kana nonword, contrary to the result of this experiment. This may be due to differences in script-type familiarity, which, in our experiment, were not controlled. Here, *script-type familiarity* means the frequency of occurrence of each script type, Kanji, Hiragana, Katakana, or their combination, for each Japanese word. Most of the Hiragana words used in this experiment (e.g., "せかい") are usually written in Kanji (e.g., "世界") as they appear in Japanese daily life. Because this sort of script-type familiarity was not controlled in this experiment, participants may have been familiar with the meanings of the Hiragana words but unfamiliar with their orthographic appearance. This might confound the lexicality effect for the Hiragana materials.

Effect of the Number of Characters

A significant main effect of the number of characters was found, $F(1, 94)=22.82$, $p<.0001$, indicating that the recognition threshold for 3-character materials was lower than for 2-character materials. A marginally significant interaction between the number of characters and lexicality was also found, $F(1, 94)=3.75$, $p<.056$. A simple main effect test revealed that the recognition threshold for 3-character materials was significantly lower than for 2-character materials. This effect appeared to be clearer for words than for nonwords (words, $F(1, 94)=23.24$, $p<.0001$; nonwords, $F(1, 94)=4.17$, $p<.05$) (see Figure 4).

Although the effect of the character number was not the primary concern of the present study, this result was interesting. In view of the theory that the basic processing units of word recognition are individual characters, we would expect 2-character words to be recognized more easily than 3-character words. Instead our results appear to support the view that the main processing units of word recognition are whole words.

This interpretation is supported by additional data concerning the

threshold of single characters which were measured in Kaketa and Abe (1995). As this experiment used identical procedures to the present experiment, I was able to compare directly the recognition thresholds of Kanji single characters with those of Kanji words and Kanji nonwords (see Figure 4). The recognition thresholds for Kanji 1-character items were marginally higher than for Kanji 2-character words, $F(1, 21)=3.38$, $p<.081$, and significantly higher than for Kanji 3-character words, $F(1, 21)=26.45$, $p<.0001$. However, there were no significant differences in the recognition thresholds between Kanji 1-character items and Kanji

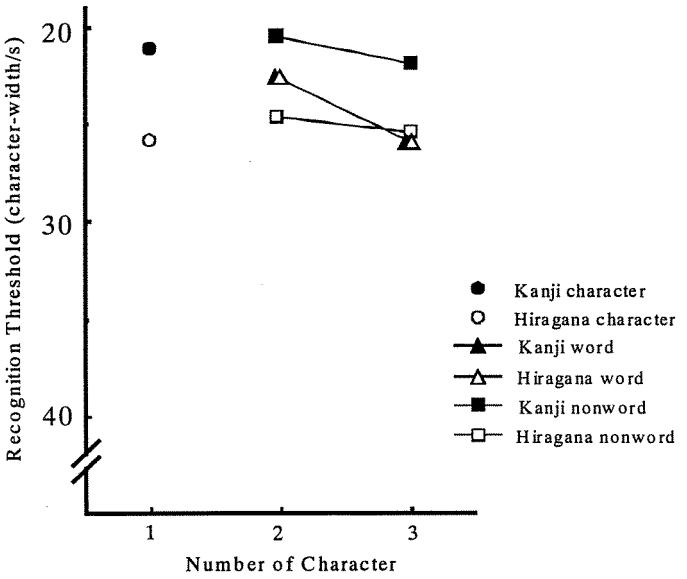

Figure 4. Mean recognition thresholds (presentation speed: character-width/s) as a function of the number of characters. The triangles and squares indicate words and nonwords, respectively. The open and filled symbols indicate Hiragana and Kanji, respectively. The circles indicate 1-character materials, which was carried out in our previous experiment.

2-character nonwords or between Kanji 1-character items and Kanji 3-character nonwords. That is, Kanji single characters were more difficult to recognize than 2-or 3-character Kanji words. If the main units of Kanji word recognition were individual characters, then this analysis should have produced the opposite result.

General Discussion

Previous studies of Japanese visual word recognition have reported that participants' recognition performance for Kana words is better than for Kana nonwords, but differences in recognition performance for Kanji words and Kanji nonwords are as yet unclear. In the present study, I examined the difference between participants' recognition performance for Japanese words and nonwords using both Kana and Kanji materials. The results of this study indicated that Kanji words were significantly easier to recognize than Kanji nonwords, but there was no significant difference in recognition between Hiragana words and nonwords.

The results of this study may be interpreted as follows. Kanji words seem to be recognized as a whole word unit. That is, Kanji words are represented in the form of a whole word in the mental lexicon and are then recognized through a matching process with existing whole word representations in the mental lexicon. In Kana word recognition, on the other hand, each character of a Kana word appears to be processed cumulatively until the whole word can be recognized: That is, whole words are not the basic unit of processing for Kana. However, in regard to Kana word recognition, this interpretation is speculative.

As described earlier, the Hiragana word materials of this experiment were of low script-type familiarity. This was due to the fact that the Hiragana words were transcribed from Kanji words of high script-type

familiarity. Some findings have indicated that script-type familiarity plays an important role in the reading of Japanese words. This suggests that low script-type familiarity of Hiragana words weakens the lexicality effect. For example, Hirose (1985) found that the lexical decision latency of Katakana loan-words, which were usually written in Katakana script, was shorter than that of Katakana words, which were usually written in Kanji or Hiragana. Besner and Hildebrandt (1987) also found that Katakana loan-words of high script-type familiarity yielded faster responses than other Katakana words of low script-type familiarity in the naming task. The low script-type familiarity of the Hiragana words in this experiment may have weakened the lexicality effect, resulting in a lack of difference in recognition performance between Kana words and Kana nonwords.

This interpretation of Kana word recognition is also supported by the reported effect of word length: That is, Hiragana 3-character words were easier to recognize than Hiragana 2-character words. If each individual character was processed in Hiragana word recognition, I would expect words consisting of more characters to be more difficult to recognize than those consisting of fewer characters. As this was not the case in the present experiment, this suggests that Hiragana words are also recognized as whole word units through the mechanism of feedback from word representations in the mental lexicon.

In summary, Japanese Kana words and Kanji words appear to be recognized in the same way as alphabetic languages, such as English. Japanese words appear to be recognized as whole word units by matching lexical information from whole word representations in the mental lexicon.

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