非公開

TR－A－0064　　47

# Identification of Kanji and Kana characters within Japanese words

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1989 12. 7

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# 要約

日本語の単語認知における全体的処理と部分的処理との関係を調べるために、継時照合課題を用いて３つの実験を行った。継時照合課題とは、継時的に提示される２つの刺激が同じかどうかを判断するものである。英単語では、この照合課題を用いた実験から Word priority effect(Sloboda, 1977)、または、Whole-word advantage (Marmurek, 1986)と呼ばれる現象が報告されている。これは、実験課題として、２つの単語全体が同じかどうかを判断する全体照合と、単語内の１文字が同じかどうかを判断する部分照合の２種類を設けたとき、部分照合よりも全体照合の方が比較する文字数は多いにもかかわらず、反応時間は全体照合の方が短いというものである。そして、単語認知においては、必ず単語全体の処理がまず最初に行われ、単語を構成する文字の処理は必要があれば付加的に行われると解釈されている(Johnson, 1981)。

実験１では、２文字の漢字単語について調べた。実験の結果、全体照合と部分照合では、平均反応時間に統計的有意差はなく、英単語で報告されているようなWhole-word advantageは見られなかった。実験２では、漢字単語と比較するために、漢字非単語を用いた。その結果、部分照合の方が全体照合よりも75msec速く行われ、この差は統計的に有意であった。実験１、２の結果から、非単語中の漢字はシリアルに処理されるが、単語中の漢字は、パラレルに処理されていると考えられる。実験３では、４文字の仮名単語、非単語を用いた。その結果、実験１と同様、Whole-word advantageは見られなかった。一連の実験で、Whole-word advantageが見られなかったのは、漢字と仮名がアルファベット文字よりも大きな認知単位を形成していることによると思われる。

また実験１、２において、比較される刺激間の形態類似性（形態類似刺激対例：開店－閉店、温築－湿築）は、単語、非単語の両方に影響を及ぼしたが、刺激の音韻（同音韻刺激対例：照明－証明、局宙－曲宙）は単語にのみ影響した。このことから、漢字単語の照合は視覚的符号、音韻的符号、意味的符号を用いて行われ、漢字非単語の照合は視覚的符号を用いて行われていると考えられる。

# Introduction

When two words were presented successively, a decision about the identity of the two words was made more quickly than a decision about the identity of a single letter contained in a word (Johnson, 1975; Marmurek, 1986). This empirical phenomenon has been referred to as the *word-priority effect* (Sloboda, 1977) or the *whole-word* advantage (Marmurek, 1986), and has been interpreted as indicating that holistic word-level encoding precedes letter-level encoding.

The present experiments were designed to examine in detail the relationship between holistic and partial encodings in word recognition. Four new procedures were used to allow a variety of analyses.

First, Kanji characters and Kana characters, which are used for writing modern Japanese, were used instead of letters. A Kanji word which consists of more than two Kanji characters plays an important role in common Japanese writing. Kanji words also assumed to be perceptual units equivalent to English words, because the Kanji word-superiority effect was found (Yokosawa & Umeda, 1988). Kanji characters are ideographic scripts and usually multi-syllabic. Kanji characters play a role midway between that of words and letters. On the other hand, Kana characters are syllabic scripts, and the minimum unit in Japanese writing. One syllable consists of one Kana character in contrast with several letters in English. Thus Kana characters play a role midway between Kanji characters and letters. For example, the word *explanation* corresponds to the word *setsumei* in

Japanese. Written in Kana, "せつめい", and written in Kanji, "説明". "説" (setsu) is a larger unit than "せ" (se). The term whole-word advantage used in previous studies is simply the phenomenon that *explanation* is identified more quickly than *e*. In the present experiments the robustness of the phenomenon was investigated by comparing the Kanji word "説明" with the Kanji character "説", or comparing the kana word "せつめい" with the Kana character "せ".

Second, the similarity between two words presented successively was manipulated. Umansky & Chambers (1980) manipulated the similarity of items in "different" trials by using words which differed in only the first letter (e.g., BLAME/FLAME) or which differed completely (e.g., BOUND/FRAME). Johnson, Turner-Lyga, and Pettegrew (1986) also manipulated the similarity of items by dividing the letters of the alphabet into three classes. However, those definitions of similarity were ambiguous. Kanji characters are more complex than letters. Furthermore, many characters are similar. In this experiment, similarity of words was defined as the identity of a peripheral feature manipulated using a quantitative measure.

Third, pronunciation of two words was manipulated. As there are many homonyms in Japanese, it is easy to examine the role of pronunciation. The present experiments investigated how the identity of pronunciation affects the visual comparison task.

Fourth, type of comparison was specified by an auditory cue within a single session. Previous studies of the whole-word advantage (Johnson et al., 1986; Marmurek, 1986) have tested holistic and partial comparisons in separate sessions. Because

the subjects knew which comparison was required they seemed to change their strategies in each session. Umansky & Chambers (1980) claimed that subjects make word-level decisions for holistic comparisons and letter-level decisions for partial comparisons. Marmurek (1987) used a visual cue which signaled the type of comparison required so that both types of comparison could be tested within a single session. In this experiment, the type of comparison required was signaled by an auditory cue in the interval between the first stimulus and the second stimulus, rather than a visual cue, in order to avoid the visual masking effect.

In experiment 1 identification of Kanji words and Kanji characters were examined. In experiment 2 Kanji nonwords were used as a check on experiment 1. In experiment 3 identification of Kana words and Kana characters was examined.

## Experiment 1

### *Method*

*subjects.* The subjects were 25 adults, 12 men and 13 women. All subjects reported having normal or corrected-to-normal vision and were native readers of Japanese.

*design.* Each subjects participated in the whole experiment. There were two types of comparison: holistic and partial. In the "same" holistic comparisons there were 60 identical pairs. In the "different" holistic comparisons, (1) 30 pairs differed in the first character and (2) 30 pairs differed in the second character. In the "same" partial comparisons there were (1) 30

identical pairs and (2) 30 pairs which had only their first characters in common. In the "different" partial comparisons, there were (1) 30 pairs which differed in the first character and (2) 30 pairs differed in all characters. Moreover, the "same" trials in partial comparison and the "different" trials in both types of comparison had three levels: control, similar shape, and homophony.

In the previous studies, different stimuli were used for different types of comparison, or the same stimuli were repeated. In this experiment to compare holistic comparison with partial comparison using the same stimuli without repetition, the following operation was performed: Identical pairs were divided into three groups. Two of these groups were used in the holistic comparison and the other was used in the partial comparison. The first character-different pairs and the second character-different pairs were each divided into two groups. One was used in the holistic comparison and the other was used in the partial comparison. The type of assignment was evenly distributed between subjects. Throughout the whole experiment a stimulus pair appeared in both types of comparisons, but was never given to the same subject twice.

*materials.* A total of 390 Kanji words consisting of two kanji characters were used in this experiment. All Kanji characters were used in standard in modern Japanese writing, called "Jyoyo Kanji". All words were nouns. In the similar shape condition, stimuli were selected with the following procedure. First, 50 pairs of similar Kanji characters was selected. Then 50 pairs of Kanji words were picked up from a

Japanese dictionary. They included the selected similar Kanji characters as either first or second character. As a measure of similarity, "the peripheral direction contributivity feature" (Umeda, 1989) was used. In the homophony condition, paired words were homonyms having the same number of syllables. Moreover, the difference in the number of strokes in the first and second characters of paired words were the same ± three strokes so that the complexity of paired characters would be essentially equal. In the control condition, on basis of the measure mentioned above, neither the first or second characters of paired words were similar. But the difference in the number of strokes remained ± three. For pairs with all characters the same, jyoyo-kanji were used. A character had a visual angle about 0.8° wide and 0.8° high. A word had a visual angle about 1.8° wide and 0.8° high. No character was given to the same subject twice.

*apparatus.* A CRT tachistoscope controlled by a mini-computer was used for the experiment. This draws a pattern using a random scan method, and is characterized by high scanning speed and low remaining luminosity.

*procedure.* Each subject was tested under all conditions. The actual experiment was preceded by instruction and 40 practice trials. Instruction stressed the need to attend both the first and second stimuli and both the first and second characters. Subjects were required to respond as quickly and precisely as possible. There was a follow-up sequence in each trial. (1) Two fixation points were presented at the center of the display for 1,000ms. (2) A Kanji character replaced each fixation point and these two Kanji characters, presented for 1,000ms, constituted

the first Kanji word. (3) There was no display for 1,500ms. Beep tones were presented in the middle of this interval. The beep tones informed subjects of the type of comparison required. One beep tone signaled a partial comparison and two beep tones signaled a holistic comparison. The first beep tone was presented for 200ms, 800ms after the first stimulus disappeared. In the holistic comparison there was a delay of 100ms and the second beep tone was presented for 200ms (Fig. 1). (4) The second Kanji word was presented until subjects pressed a button. Half of the subjects were required to press the right button if response was "same", the left button, if "different". The remaining subjects were instructed to do the inverse.

As regards the whole-word advantage, the identical pairs in the same trials were critical. If word-level processing precedes component-level processing, the mean latency of the holistic comparisons was less than the partial comparisons.

Result

Analyses were carried out on the mean of the correct latencies and the mean error rates. Data deviating more than 3sd from the mean of all latencies per subject were eliminated. The error rates was low in all conditions; those conditions that yielded longer correct latencies tended to produce more errors. Because the "same" and "different" trial responses were generated by different processes, they were analyzed separately.

*same trials.* The mean correct latencies are shown in Table 1. Analyses of identical pairs were carried out. A one-way ANOVA showed that the means were not significantly different

($F(1, 24) = 2.8$, $p < .1$).

*different trials.* The mean correct latencies are shown in Table 2. Analyses of the first character-different pairs were carried out. A two (type of comparison) by three (type of stimulus) ANOVA showed that main effect of type of stimulus was significant ($F(2, 24) = 20.26$, $p < .001$), but main effect of type of comparison and interactions of type of comparison and type of stimulus were not significant ($F(1, 24) = 1.13$, $p < .3$, $F(2, 24) = 1.45$, $p < .25$, respectively). Tukey's studentized range test showed that latencies of each type of stimulus were significantly different. A one-way ANOVA was separately carried out for each type of stimulus. In both the control condition and homophony condition, type of comparison made no difference. In the similar condition, partial comparisons yielded latencies 29ms faster than holistic comparisons but this difference was not significant ($F(1, 24) = 3.21$, $p < .09$).

*Discussion*

For the "same" trials no whole-word advantage was found, and although partial comparisons were made 27ms faster than holistic comparisons, that difference was statistically insignificant. This means that Kanji word encoding does not precede Kanji character encoding. However, since difference was insignificant, there is a possibility that word-level processing takes almost the same latency as the character level processing.

For the "different" trials, results varied widely according to the type of stimulus. It is suggested that in successive same-different matching tasks, both visual and phonological

encoding occurred.

For "same" trials in partial comparison, if the decision was made based on only the first character, there was no difference between the identical pairs and the first character-same pairs. As a result, in the homophony condition a slight but statistically insignificant difference was found, and in the control condition a relatively larger but still statistically insignificant difference was found. This suggests that the decision about the first character was affected by other information. That is, in the homophony condition a "same" response for the first character-same pairs was interfered by the visual mismatch information from the second character but was facilitated by phonological match information from the second character and whole-word. In the control condition, a "same" response for the first character was interfered by both the visual and phonological information from the second character and whole-word. It is assumed that this conflict would increase when a "different" response would likely be made from the second character or whole-word. For that reason, the difference in the control condition was larger than in the homophony condition. There was no difference in the similar shape condition. This is interpreted to mean that the second character were processed so roughly with the visual feature that the identical pairs and the first character-same pairs were equivalent.

As for "different" trials in the partial comparison, there was no difference between the first character-different pairs and the all characters-different pairs in the control condition. In the similar shape condition, however, the first character-

different pairs were processed 43ms faster than the all characters-different pairs. In the homophony condition, however, the all characters-different pairs were processed 29ms faster than the first character-different pairs. These results suggested that even in the partial comparisons decisions were based not only on information about the first character but also on information about the second character or whole-word. If it is assumed that visual match information from the second characters and whole-word interfered with the "different" response, the all characters-different pairs might be processed faster than the first character-different pairs. However, the results for the similar shape condition were inconsistent. The results for the homophony condition was interpreted as indication that the phonological match information from the second character and whole-word and the visual match information from the second character interfered with the "different" response for the first character of the first character-different pairs. These interferences were more stronger than the interference caused by only the phonological match information from the second character and whole-word for the all characters-different pairs.

From these results it is suggested that there are three levels of processing, whole-word, first character, and second character and that all three influenced decisions. We assumed that whole-word, first character, and second character processing occurred in parallel. In experiment 2, the assumption was tested through comparison with nonword processing.

## Experiment 2

To compare the word processing with nonword processing, Kanji nonwords were used in experiment 2.

### *Method*

*subjects.* The 25 adults who participated in experiment 1.

*materials.* 390 nonwords of in the following types: In the all characters-same pairs, the first character-different pairs, and the all characters-different pairs, the second character only was replaced with another character so as not to constitute a word. In the first character-same and the second character-different pairs, only the first character was replaced. Thus in experiments 1 and 2, the target characters which the subjects were required to compare were common. All nonwords were certified as such by consulting a Japanese dictionary (Sanseido, 1979). Moreover, in the homophony condition, pronunciations of nonwords were different form that of any word. Kanji-nonwords corresponding to pseudwords in English; pronounceable, regular nonwords.

*procedure.* Procedure was same as experiment 1. Subjects were informed in advance that all stimuli were nonwords.

### *Result*

As experiments 1, data deviating more than 3sd from the mean of all latencies by subject were eliminated. "Same" trials and "different" trials were analyzed separately.

*"same" trials.* The mean correct latencies and error rates

are showed in Table 3. The error rate was low in the all condition. Analyses of identical pairs were carried out. Partial comparison yielded latencies 75ms faster than holistic comparison. This difference was significant ($F(1, 24) = 16.73$, $p < .001$).

*"different" trials.* The mean correct latencies and error rates are shown in Table 4. The conditions that yielded longer correct latencies tended to produce more errors. Analyses of the first character-different pairs were carried out. A two (type of comparison) by three (type of stimulus) ANOVA showed that only the main effect of the type of stimulus was significant ($F(1, 24) = 31.71$, $p < .001$) and that the main effect of the type of comparison and the interactions of the type of comparison and the type of stimulus were not significant ($F(2, 24) = 2.17$, $p < .15$, $F(2, 24) = .32$, $p < .73$, respectively). Tukey's studentized range test showed that difference between the control and similar conditions and between similar and homophony condition were significant, but that the difference between the control and homophony conditions was not significant. A one-way ANOVA was carried out for each stimulus type separately. In the homophony condition, the partial comparison 32ms faster than the holistic condition though that difference failed to be significant ($F(1, 24) = 4.22$, $p < .05$). For the control and similar shape conditions, the difference between the partial and holistic comparisons was not significant.

*words and nonwords.* Analyses were carried out by mixture the results of experiments 1 and 2 in order to compare word processing with nonword processing. For the "same" trials, a two

(lexicality) by two (type of comparison) ANOVA of the identical pairs showed that main effect of the type of comparison and the interactions were significant ($F(1, 24) = 11.39$, $p < .01$; $F(1, 24) = 10.6$, $p < .01$, respectively). Main effect of the type of stimulus was not significant ($F(1, 24) = .45$, $p < .5$). As for the "different" trials, no difference was significant.

*Discussion*

As expected, for the "same" trials, partial comparison was made much faster than holistic comparison. This result supports the assumption that nonwords are processed on character-by-character basis.

For the "different" trials subjects could make a different response when they were given only one mismatch. Then in the holistic comparison, the first character-different pairs were decided faster than the second character-different pairs, and in the partial comparison, there was no significant difference between the first character-different pairs and all the characters-different pairs. On the other hand, for the "same" trials subjects checked the second character even after they received match information from the first character. Thus, match information from the first character and mismatch information from the second character competed. Therefore, in the control condition in which pairs were different in shape and pronunciation, the difference between the identical pairs and the first character-same pairs was larger than in the similar shape and homophony conditions. However, this difference in the type of stimulus was smaller than in experiment 1. This suggests that

in experiment 1 a "same" response for the first character was interfered by the information from the second character and whole-word. On the other hand, in experiment 2 only the information from the second character interfered with a "same" response.

For the "different" trials, the difference between the control and homophony conditions was not significant. However, for the similar shape condition decisions were made more slowly than for the other two conditions. Thus it is suggested that the phonological code did not have an affect on a decision but the visual code had an effect on the comparisons.

Comparing words with nonwords, it is obvious that there were different ways of processing words and nonwords. It is suggested that characters within words were processed in parallel rather than serially.

## Experiment 3

In experiment 3 we examined the relationship between Kana words and Kana characters which are units midway between Kanji characters and letters.

### *Method*

*subjects.* The 25 adults who participated in experiments 1 and 2.

*materials and procedure.* In experiment 3 Kana words and Kana nonwords were used. Kana words which consists of four Kana characters were selected taking into account the latencies and

error rates of a preliminary experiment in which a lexical decision task was given to five subjects. Nonwords were generated in the following way; two nonsense syllables, each consisting of two Kana characters whose association value was 0-50 from Hayashi's(1976) norm, were combined so as to become nonwords consisting of four characters. As experiments 1 and 2, each subject participated in all condition. There were two sessions per subjects; a session of 80 word trials and a session of 80 nonword trials followed a session of 20 practice trials. The order of the session was counterbalanced across the subjects.

In the "same" holistic comparisons there were 20 identical pairs. In the "different" holistic comparisons, (1) 10 pairs differed in the first character and (2) 10 pairs differed in the third character. In the "same" partial comparisons there were 10 identical pairs and (2) 10 pairs which had only their first characters in common. In the "different" partial comparisons, there were (1) 10 pairs which differed in the first character and (2) 10 pairs differed in the first and third characters. The same stimulus appeared in both holistic and partial comparisons across the subjects without repetition as in experiments 1 and 2. That is, 30 identical pairs were divided into three groups, two for holistic comparison and one for partial comparison. 20 pairs which differed in the first character were divided into two groups, one for holistic comparison and the other for partial comparison. The procedure was same as in experiments 1 and 2 with one exception: a row of four, rather than two, fixation points was presented. The subjects were informed whether stimuli were words or nonwords before a trial session began.

*Result*

As experiments 1 and 2, data deviating more than 3sd from the mean of all latencies by subject were eliminated. The error rate was low in the all conditions. Analyses for words and nonwords were carried out separately.

*words.* The mean latencies and error rates for words are shown in Table 5. For the "same" trials, the identical pairs were analyzed. A one-way ANOVA showed that the difference between types of comparison was not significant ($F(1, 24) = 1.21$, $p < .3$). For the "different" trials, the first-character different pairs were analyzed, and no difference between types of comparison was shown.

*nonwords.* The mean latencies and error rates for nonwords are shown in Table 6. The same analyses were carried out. As for the "same" trials, partial comparison yielded latencies 158ms faster than holistic comparison. This difference was significant ($F(1, 24) = 49.97$, $p < .001$). For "different" trials, also, partial comparison yielded latencies 40ms faster than holistic comparison. This difference was significant ($F(1, 24) = 5.1$, $p < .03$).

*words and nonwords.* To compare words and nonwords a two (lexicality) by two (type of comparison) ANOVA was carried out for "same" and "different" trials separately. The "same" trials showed main effect for lexicality, and the type of comparison. The interaction of lexicality and comparison type was significant ($F(1, 24) = 4.86$, $p < .04$; $F(1, 24) = 23.24$, $p < .001$; $F(1, 24) = 23.44$, $p < .001$, respectively). The "different" trials showed no significant main effect or interaction.

*Discussion*

The results for Kana words and Kanji words were similar. For "same" trials the difference between holistic comparison and partial comparison was statistically insignificant; no whole-word advantage was found. As for nonwords, partial comparisons were made much faster than holistic comparisons. Comparing the identical pairs with the first character-same pairs in partial comparison, words showed a significant difference and nonwords showed no difference. This suggested that when the stimuli were words, the information from the second, third, and fourth characters affected the decision. However, when nonwords were presented, the subjects made decisions based on only the first character. The results of the "different" trials also showed the same tendency as in experiments 1 and 2.

In Japanese orthography, nouns written in Kanji characters are common. On the other hand, Kana characters are used to write particles as well as adjective and verb endings. In experiment 3, all the words were nouns. Thus their configurations as whole-words may not have been familiar one. However, a difference between words and nonwords for the "same" trials was shown, that is, Kana words were processed in a different way from nonwords. Since there was no difference between words and nonwords in terms of visual information, it is suggested that Kana words were also encoded phonologically and lexically and accessed to word-units in long-term memory.

## General discussion

These three experiments were conducted using four new procedures. First, and primarily, given that Kanji and Kana characters were assumes to play a role midway between that of words and letters, examining the robustness of the whole-word advantage. Second, testing the effect of similar stimuli. Third, examining the role of pronunciation in visual matching tasks. Fourth, devising alternative way to present stimuli, such as auditory cues.

As a result of using the first and the fourth new procedures, no whole-word advantage was found for either Kanji and Kana. Therefore, it is suggested that the whole-word advantage occurred only when word-level processing preceded processing as the simplest level, i.e. letter-level processing. In experiments 1 and 2, comparing Kanji words with Kanji nonwords in "same" holistic comparison trials, word-superiority was shown; Kanji words were processed 81ms faster than Kanji nonwords. For Kanji nonwords, because both partial and holistic comparison were made character by character, partial comparison was 75ms faster. On the other hand, for Kanji words partial comparison was only 27ms faster than holistic comparison. These differences were statistically insignificant. In experiment 3, i.e. the "same" holistic comparison trials, Kana words were processed faster than Kana nonwords. These results suggest that the processing of two characters within words occurred in parallel. However, attention is more likely to be directed to the first character (Marmurek, 1987). If the processing of the two characters began

simultaneously, the processing of the first character was completed before that of the second.

As regards the second and third new procedures, it is clear that similarity affected both words and nonwords, but pronunciation affected only words. In addition, words showed superiority to nonwords. Therefore, it is concluded that when the stimuli were words, decisions were made based on visual, phonological, and lexical codes. When stimuli were nonwords, decisions were made based only on visual code.

Johnson (1981) proposed the pattern-unit model of visual information processing. Its most basic assumption was that whenever a small visual pattern is presented, the subject's initial attempt is to encode it into memory is based on holistic pattern-level encoding, and that component-level processing occurs only after several such attempts at unitary encoding had failed (Johnson et al., 1986). In addition, the critical assumption underlying such holistic encoding is that this assignment of a pattern-level cognitive representation is not mediated by any analogous but prior cognitive encoding of the pattern's components (Johnson, 1986). It has been predicted that word-level decisions will always be made faster than letter- or character-level decisions. Obviously, this prediction is inconsistent with this series of experiments.

Nevertheless, there are models in which the encoding process is viewed as occurring at the feature-, letter-, and word levels simultaneously. These models are the race models (Drewnowski & Healy, 1977; Healy & Drewnowski, 1983; Chambers & Forster, 1975). In these models it is assumed that the level of encoding which is

completed first is the ultimate one and is available for response. Healy & Drewnowski (1983) proposed the unitization model, a kind of the race models. They assumed that the processing of components of a word and the processing of units larger than the components are conducted in parallel. The critical assumption of this model is that once a given word is identified, even if its components have not yet been identified, the reader will move on to process the next word of the text. In English, word-level processing is normally completed before letter-level processing. However, it is assumed that in Kanji words or Kana words these two levels of processing are completed at about the same time. Chambers & Forster (1975) claimed that the level which provides sufficient information to respond is completed first. When holistic comparison and partial comparison were tested in separate session, the level which provided sufficient information to respond changed in each session. This was because the subjects decided that in holistic comparison session their response would be based on the whole-word level, and in partial comparison session, would be based on the first letter. However, in the present experiments an auditory cue signaled the type of comparison. The subjects were instructed to look carefully at both the first character and the second character. Thus the subjects' strategy was foiled and the first stimuli were always processed in a holistic way. Accordingly, the results of the present experiments are not based on experimental artifacts, but are consistent with the race models.

## Acknowledgment

We are grateful to Dr. Yodogawa for his support and encouragement. We also would like to thank all members of ATR Auditory and Visual Perception Research Laboratories for their valuable discussion.

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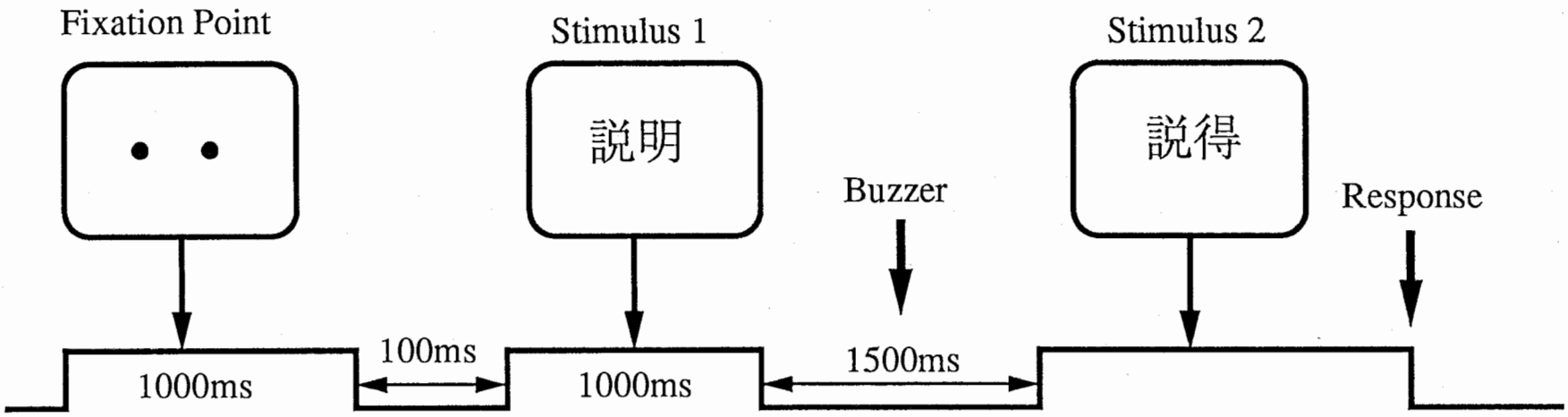


Fig.1 The procedure of a trial

Table 1. Mean correct latencies (ms) and error rates for "same" trials in Experiment 1

| holistic | partial | | |
|---|---|---|---|
| identical | identical | first only | |
| 647 (.02) | 620 (.02) | control | 654 (.04) |
| | | similar | 616 (.05) |
| | | homophony | 639 (.08) |

Table 2. Mean correct latencies (ms) and error rates for "different" trials in Experiment 1

| | holistic | | partial | |
|---|---|---|---|---|
| position of difference | 1 | 2 | 1 | 1,2 |
| control | 600 (.008) | 690 (.05) | 603 (.008) | 603 (0) |
| similar | 705 (.05) | 753 (.18) | 676 (.06) | 719 (.07) |
| homophony | 636 (.008) | 715 (.04) | 631 (.02) | 602 (.01) |

Table 3. Mean correct latencies (ms) and error rates for "same" trials in Experiment 2

| holistic | partial | | |
|---|---|---|---|
| identical | identical | first only | |
| 691 (.02) | 616 (.02) | control | 677 (.04) |
| | | similar | 661 (.05) |
| | | homophony | 662 (.08) |

Table 4. Mean correct latencies (ms) and error rates for "different" trials in Experiment 2

| | holistic | | partial | |
|---|---|---|---|---|
| position of difference | 1 | 2 | 1 | 1,2 |
| control | 650 (1.2) | 759 (2.5) | 627 (0) | 637 (0.8) |
| similar | 733 (10.2) | 823 (2) | 724 (5.7) | 728 (12.7) |
| homophony | 669 (2) | 745 (5.8) | 640 (2.4) | 616 (0.8) |

Table 5. Mean correct latencies (ms) and error rates for words in Experiment 3

| | holistic | partial | | |
|---|---|---|---|---|
| same | identical | identical | first only | |
| | 610 (.02) | 578 (.02) | 625 (.05) | |
| | position of difference | | | |
| different | 1 | 3 | 1 | 1,3 |
| | 633 (.004) | 750 (.07) | 640 (0) | 636 (.03) |

Table 6. Mean correct latancies (ms) and error rates for nonwords in Experiment 3

| | holistic | partial | | |
|---|---|---|---|---|
| same | identical | identical | first only | |
| | 769 (.03) | 611 (.02) | 636 (.11) | |
| | position of difference | | | |
| different | 1 | 3 | 1 | 1,3 |
| | 689 (.02) | 866 (.09) | 648 (.02) | 613 (.02) |

Appendix 1　Kanji-words stimuli in experiment 1

All characters-same pairs

症状－症状、孤独－孤独、炭坑－炭坑、工作－工作、郊外－郊外
肖像－肖像、屈折－屈折、推薦－推薦、訴訟－訴訟、洗浄－洗浄
虚飾－虚飾、答申－答申、掌握－掌握、障壁－障壁、郵便－郵便
溶液－溶液、訪問－訪問、多忙－多忙、粘膜－粘膜、往復－往復
操縦－操縦、順延－順延、脈絡－脈絡、徹底－徹底、批判－批判
個展－個展、警鐘－警鐘、頭髪－頭髪、美徳－美徳、武装－武装
評論－評論、転覆－転覆、興奮－興奮、潔癖－潔癖、常識－常識
贈与－贈与、渋滞－渋滞、非難－非難、忍耐－忍耐、確認－確認
派閥－派閥、薄弱－薄弱、階段－階段、注釈－注釈、膨張－膨張
沈黙－沈黙、伴奏－伴奏、夢中－夢中、跳躍－跳躍、斜陽－斜陽
携帯－携帯、吸盤－吸盤、比較－比較、助命－助命、継承－継承
紹介－紹介、品種－品種、軍隊－軍隊、極端－極端、構築－構築
哀愁－哀愁、圧倒－圧倒、安易－安易、衣類－衣類、英雄－英雄
酒宴－酒宴、縁談－縁談、応援－応援、許可－許可、果汁－果汁
課題－課題、干渉－干渉、基準－基準、風紀－風紀、偽善－偽善
穀物－穀物、砂丘－砂丘、儀礼－儀礼、錯覚－錯覚、奉仕－奉仕
参考－参考、畜産－畜産、闘志－闘志、支流－支流、歴史－歴史
写真－写真、静寂－静寂、狩猟－狩猟、群衆－群衆、獣医－獣医

The first-character different pairs

control

遺影－撮影、守衛－防衛、経済－救済、幸福－祝福、希望－有望
週末－歳末、充満－肥満、再婚－初婚、彫刻－遅刻、灯油－石油
概要－需要、食欲－無欲、法律－戒律、侵害－阻害、倉庫－宝庫
打撃－目撃、佳境－秘境、懐疑－嫌疑、破壊－崩壊、隠滅－撲滅

similar shape

運休－連休、通用－適用、金額－全額、苦手－若手、署名－著名
温度－湿度、敬意－敵意、期日－朝日、総計－統計、鋭角－鈍角
開店－閉店、慢性－慣性、固形－図形、列記－別記、重心－童心
遠視－透視、酵素－酸素、周期－同期、創業－副業、返却－退却

homophony

述語－術語、仮設－架設、焼失－消失、伸長－身長、証明－照明
序幕－除幕、季刊－既刊、採決－裁決、請願－誓願、協調－強調
局面－曲面、新式－神式、分化－文化、幹部－患部、飼料－資料
香水－降水、漢和－緩和、奇跡－軌跡、修了－終了、私営－市営

The second-character different pairs

control

音楽－音符、 加算－加盟、 空席－空腹、 予想－予報、 誘導－誘惑
放射－放送、 変革－変更、 標的－標高、 条例－条約、 整備－整然
提起－提案、 猛烈－猛毒、 野菜－野蛮、 優雅－優勝、 政策－政略
収益－収納、 爆弾－爆笑、 貧困－貧血、 本籍－本職、 豪華－豪遊

similar shape

小鳥－小島、 追究－追突、 教義－教養、 在住－在任、 電車－電卓
人造－人道、 出勤－出動、 着眼－着服、 夜露－夜霧、 短縮－短編
火災－火炎、 登校－登板、 製菓－製薬、 民謡－民話、 自治－自活
集会－集合、 回数－回教、 解説－解読、 断絶－断続、 硬貨－硬質

homophony

体型－体系、 悪習－悪臭、 必死－必至、 単価－単科、 議員－議院
受信－受診、 投棄－投機、 競走－競争、 混声－混成、 前掲－前傾
公園－公演、 高給－高級、 学者－学舎、 下弦－下限、 保険－保健
余罪－余財、 時候－時効、 実験－実権、 入城－入場、 愛称－愛唱

All characters-different pairs

control

陥落－逸脱、 捕球－探索、 残念－根拠、 告示－海岸、 厳格－慰留
依頼－雨量、 映画－快挙、 栄冠－現象、 座敷－封鎖、 審査－商社

similar shape

徒労－従事、 客観－容器、 官僚－宮殿、 天気－夫妻、 熟練－熱湯
綿密－締結、 宇宙－字典、 横領－模範、 抜粋－技能、 雑草－稚拙

homophony

帰省－規制、 師弟－指定、 委細－異彩、 方位－包囲、 過程－家庭
原則－減速、 犯行－反抗、 敗戦－配線、 好感－交換、 偉功－威光

Appendix 2　Kanji-nonwords stimuli in experiment 2

All characters-same pairs

圧画－圧画、英夜－英夜、酒速－酒速、応密－応密、許粋－許粋
果底－果底、課追－課追、干爆－干爆、基競－基競、風部－風部
偽回－偽回、脈性－脈性、携善－携善、孤縦－孤縦、炭社－炭社
工徳－工徳、郊像－郊像、砂在－砂在、儀集－儀集、錯制－錯制
警外－警外、奉調－奉調、参明－参明、畜単－畜単、闘加－闘加
支抗－支抗、沈手－沈手、歴能－歴能、写認－写認、安格－安格
静冠－静冠、狩介－狩介、群解－群解、獣入－獣入、順展－順展
助学－助学、掌猟－掌猟、紹製－紹製、症了－症了、肖流－肖流
洗論－洗論、虚殿－虚殿、答業－答業、往小－往小、屈用－屈用
穀感－穀感、推実－推実、障意－障意、訴壊－訴壊、操望－操望
贈医－贈医、衣撃－衣撃、渋変－渋変、極株－極株、構志－構志
階判－階判、注結－注結、継料－継料、常訟－常訟、膨出－膨出
哀電－哀電、徹形－徹形、個作－個作、頭練－頭練、美憲－美憲
非航－非航、忍収－忍収、確量－確量、派識－派識、薄類－薄類
伴下－伴下、吸記－吸記、軍球－軍球、比失－比失、批火－批火
評害－評害、縁器－縁器、品奏－品奏、武高－武高、転援－転援
興隊－興隊、潔時－潔時、郵心－郵心、訪考－訪考、多聖－多聖
粘談－粘談、夢式－夢式、跳気－跳気、溶中－溶中、斜受－斜受

The first charcter-different pairs

control

遺帯－撮帯、守産－防産、経題－救題、再水－初水、彫紀－遅紀
倉端－宝端、打敷－目敷、佳発－秘発、懐刊－嫌刊、法豪－戒豪
侵種－阻種、破独－崩独、灯愛－石愛、概妻－需妻、食留－無留
幸線－祝線、希脱－有脱、週挙－歳挙、充戦－肥戦、隠断－撲断

similar shape

苦放－若放、署投－著投、温築－湿築、敬短－敵短、期装－朝装
固僚－図僚、列汁－別汁、遠雄－透雄、酵自－酸自、周庫－同庫
開硬－閉硬、運和－連和、通象－適象、金念－全念、慢耐－慣耐
総宴－統宴、鋭混－鈍混、重典－童典、創提－副提、返真－退真

homophony

分拠－文拠、幹絵－患絵、飼央－資央、述影－術影、仮貿－架貿
序判－除判、私頻－市頻、季黙－既黙、漢準－緩準、奇陸－軌陸
局宙－曲宙、新必－神必、香瀬－降瀬、請絡－誓絡、協羃－強羃
修空－終空、採語－裁語、焼他－消他、伸勉－身勉、証落－照落

The second character-different pairs

control

人楽－人符、 疑算－疑盟、 境席－境腹、 化例－化約、 民備－民然
飾起－飾案、 期弾－期笑、 標困－標血、 倒籍－倒職、 難華－難遊
程威－程毒、 日菜－日蜜、 店雅－店勝、 幕想－幕報、 面導－面惑
計射－計送、 衆革－衆更、 衛的－衛高、 液策－液略、 跡益－跡納

similar shape

坑鳥－坑島、 視災－視炎、 湯勤－湯動、 耕眼－耕服、 髪説－髪読
陽会－陽合、 細数－細教、 範縮－範編、 換絶－換続、 折貨－折質
庭菓－庭薬、 油謡－油話、 索治－索活、 額住－額任、 省車－省卓
愁校－愁板、 条究－条突、 滞義－滞養、 婚露－婚霧、 弟造－弟道

homophony

膜死－膜至、 則価－則科、 礼員－礼院、 差信－差診、 忙棄－忙機
段者－段舎、 釈弦－釈限、 延険－延健、 渉罪－渉財、 較候－較効
寂験－寂権、 覚城－覚場、 滅称－滅唱、 音走－音争、 査声－査成
躍型－躍系、 満掲－満傾、 却習－却臭、 度園－度演、 易給－易級

All characters-different pairs

control

陥申－逸公、 捕弱－探欲、 残問－根張、 告観－海盤、 厳囲－慰末
依丘－雨名、 映政－快状、 栄可－現仕、 座拙－封要、 審休－商位

similar shape

徒設－従彩、 客素－容厚、 官草－宮保、 天握－夫刻、 熟鎖－熱薦
宇承－字岸、 横済－模貧、 抜浄－技命、 綿登－締福、 雑　－稚長

homophony

帰噴－規奮、 師雷－指頼、 委盲－異猛、 方囚－包収、 過率－家律
原余－減予、 犯優－反誘、 敗労－配老、 好壁－交癖、 偉定－威呈

Appendix 3　Kana-words stimuli in experiment 3

All character-same pairs

かんとくーかんとく、もんだいーもんだい、こくみんーこくみん
ぬいしろーぬいしろ、さいばんーさいばん、くみあいーくみあい
せつめいーせつめい、うりあげーうりあげ、れんあいーれんあい
むらさきーむらさき、ともだちーともだち、ほうこくーほうこく
きんだいーきんだい、ほうめんーほうめん、にせものーにせもの
かいぐんーかいぐん、こうげきーこうげき、こくないーこくない
ゆうじんーゆうじん、てきとうーてきとう、はいゆうーはいゆう
こうかんーこうかん、しんようーしんよう、ふんいきーふんいき
こうさんーこうさん、しつもんーしつもん、れんらくーれんらく
かいはつーかいはつ、ふうけいーふうけい、まんぞくーまんぞく

The first character-same pairs

きりかえーきのどく、ついおくーつきあい、ぬいものーぬけあな
ふでいれーふくそう、まいにちーまえおき、みちくさーみなもと
わるくちーわくせい、おこないーおくゆき、めいあんーめかくし
ていこうーておくれ

The first character-different pairs

さくひんーやくひん、せいさんーかいさん、せんそうーえんそう
せいしんーすいしん、しんぱいーかんぱい、ないようーさいよう
けいさつーあいさつ、こうふくーおうふく、かんせいーはんせい
さいこうーけいこう、ひつようーかつよう、せいねんーれいねん
せいさくーたいさく、ろうじんーようじん、けんこうーおんこう
しんどうーかんどう、たいせつーかいせつ、そうだんーおうだん
らいひんーせいひん、かいけつーたいけつ

The third character-different pairs

こうえんーこうしん、さいきんーさいてん、けいかくーけいやく
さくせんーさくいん、はんたいーはんえい、せきにんーせきたん
せいかくーせいさく、とくべつーとくしつ、ゆうめいーゆうかい
ほうりつーほうふく

The first and third characters-different pairs

かんけいーにんたい、ほんとうーはんのう、おんがくーしんぼく
はいとうーたいおう、こくさいーにくたい、さつえいーしつれい
もくてきーはくしき、さいこうーすいそう、ほうしんーこうふん
けんせつーいんさつ

Appendix 4　Kana-nonwords stimuli in experiment 3

All characters-same pairs

けへてゆ－けへてゆ、　すゆぬせ－すゆぬせ、　たゆほぬ－たゆほぬ
るよえう－るよえう、　れわつお－れわつお、　わゆつそ－わゆつそ
くてりろ－くてりろ、　つぬろも－つぬろも、　にのわも－にのわも
けほろせ－けほろせ、　あぬやふ－あぬやふ、　つひれま－つひれま
わまはへ－わまはへ、　るちせて－るちせて、　えひられ－えひられ
とへわみ－とへわみ、　けよるて－けよるて、　よらえね－よらえね
なもみぬ－なもみぬ、　ねさめは－ねさめは、　いはみへ－いはみへ
めよえは－めよえは、　こにめゆ－こにめゆ、　そさらと－そさらと
よまけお－よまけお、　まおうぬ－まおうぬ、　むたきに－むたきに
よひすあ－よひすあ、　とはれね－とはれね、　なこれろ－なこれろ

The first character-same pairs

うひみあ－うほむと、　くほゆひ－くめむよ、　にふろり－にうのは
さこらそ－さへれあ、　つへわう－つすろに、　れうけく－れそたせ
てけろの－てちるほ、　もほえや－もきむる、　らあすほ－らとそさ
そいるふ－そひてみ

The first character-different pairs

ぬそろゆ－にそろゆ、　くこらな－つこらな、　こゆその－るゆその
すよぬに－ほよぬに、　ぬおるえ－ひおるえ、　てひわぬ－ねひわぬ
へよそぬ－ゆよそぬ、　めむねふ－わむねふ、　うこよぬ－らこよぬ
すせれむ－ひせれむ、　あへねら－かへねら、　きまみわ－ゆまみわ
そもわこ－ちもわこ、　こへらつ－そへらつ、　りいすは－のいすは
れみたあ－めみたあ、　そへれは－なへれは、　つはろひ－みはろひ
らうけそ－ちうけそ、　わはたほ－むはたほ

The third charcater-different pairs

あよへし－あよるし、　ゆせきへ－ゆせわへ、　すによゆ－すにれゆ
えかむふ－えかゆふ、　すひりな－すひけな、　けうゆも－けうねも
わふてほ－わふねほ、　りえすお－りえゆお、　ちあるつ－ちあへつ
ろねつに－ろねふに

The first and third characters-different pairs

いほやへ－めほむへ、　てせろふ－ひせみふ、　せへぬね－ひへゆね
そえるま－けえむま、　りたしえ－ちたらえ、　けはめほ－ひはつほ
れのせひ－なのらひ、　せうれへ－しうるへ、　れらつぬ－るらふぬ
ゆそいむ－ねそきむ