

Reading Words With Jumbled Characters in Japanese^{1,2}

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Reading Japanese With Jumbled Characters

Summary.— Rayner, *et al.* (2006) was replicated with 36 Japanese undergraduates who read Japanese sentences in which characters were transposed in one word at the beginning, middle, or end. The same pattern of reading delays in relation to transposition location was found but in smaller magnitude. Transposition of characters at the beginning of words caused the largest delay in reading.

Rayner, White, Johnson, and Liversedge (2006) demonstrated that British college students were able to read sentences in which about 40% of the words contained transposed letters relatively as easily as normal sentences. Reading speed decreased about 11% when internal letters were transposed, about 26% when ending letters were transposed, and some 36% when beginning letters were transposed.

It is not known if the ‘jumbled word effect’ is unique to English. To begin addressing this question, Rayner, *et al.*’s experiment was replicated with Japanese undergraduates and Japanese sentences. The Japanese language differs substantially from English in various aspects; it is an agglutinative language with subject-object-verb word order, is mora-timed with a lexically significant pitch-accent system, and has a unique orthographic system with a mixture of Chinese ideograms (kanji) and two types of Japanese phonograms (hiragana and katakana). Traditional Japanese orthography is vertical (reading top to bottom), but modern Japanese is predominantly horizontal and is read left to right. Such differences might affect reading jumbled words.

METHOD

Thirty-six Japanese undergraduates, 20 men and 16 women (19 to 23 years old), participated in the experiment individually. All the participants were native speakers of Japanese.

The participants were asked to read 80 sentences aloud at normal speed, each of which included one word with Hiragana characters (phonograms) transposed. The target words were selected from 4 to 6 words in Hiragana that were easy to read and common in daily usage. Short sentences were composed ($N=120$) with candidate target words, then 80 were chosen by means of pilot familiarity ratings by five psychology majors. For each critical word, three types of character-transposed words were created: Beginning-transposed, interchanging the first two characters, Intermediate-transposed, interchanging the second and third characters, and End-transposed, interchanging the last two characters. Some unchanged words were used (No-transposition; Table 1). Altogether, there were 320 sentences, or four versions of each of 80 sentences (17–32 characters long; $M=23.4$, $SD = 4.2$). Four sets of 80 sentences were created with 20 sentences from each of the four types, balancing the four different versions.

Each participant read *one* of the four sets of 80 sentences aloud in random order. The reading performances were video-recorded and reading speeds were measured sentence-by-

sentence from the video recording, using a stopwatch to time the reading from the outset to the end. Eye-tracking was not done as in Rayner, *et al.* (2006).

RESULTS AND DISCUSSION

The reading speed was converted into a reading rate score, yielding the number of characters read per minute (cpm). Since there are no spaces between words in written Japanese, a character (phonogram)-based counting system is generally used in Japan instead of word-based counting. The inter-rater reliability of reading speed was assessed as correlations between results of the experimenter and four other trained scorers (all $r \geq .98$). Table 1 shows the average reading speed for the four types of character transposition conditions. As Rayner, *et al.* (2006) found, reading rates decreased most when participants read sentences containing words with characters transposed at the beginning, and least for those whose target words had characters transposed in the middle. A one-way ANOVA indicated that the transposition effect was statistically significant ($F_{3,105} = 11.19, p < .01; \eta^2 = 0.32$). Tukey's *post hoc* test ($MSe = 220.5, p < .05$) indicated statistically significant differences between the No-transposition condition and the Beginning- and End-transposition conditions, but not between the No- and Intermediate-transposition conditions. The difference between Beginning- and Intermediate-transposition conditions was also statistically significant.

Eye movements of the participants were not recorded. The number of reading errors, including hesitations and interruptions, was recorded instead for each sentence. The average numbers of errors were 0.14 (No-transposition), 0.58 (Beginning-transposition), 0.38 (Intermediate-transposition), and 0.63 (End-transposition). This pattern was similar to the reading speed results. Setting aside the No-transposition condition, the least number of errors occurred in the Intermediate-transposition condition, and more errors occurred in the Beginning- and End-transposition conditions. An ANOVA and Tukey's test indicated that the errors in these two conditions were significantly more frequent than those in the No-transposition condition ($F_{3,105} = 4.42, p < .01; MSe = 0.41; \eta^2 = 0.13$).

Although the patterns of reading speed were similar to Rayner, *et al.*'s (2006) observations, effects were smaller (Table 1). In Rayner, *et al.* (2006), about 40% of words were transposed, while only about 20% were transposed in the present study, as only one transposed character was inserted ($M = 4.2$ characters) into each sentence (M length = 23.4 characters). The delaying effect of character transposition seemed much smaller in Japanese than in English, even taking into account the difference in the transposition rates.

Using an eye-movement recorder, Kajii, Nazir, and Osaka (2001) examined the gaze-direction distributions of the eyes during reading Japanese sentences consisting of Kanji and Kana characters. They found that Japanese readers' gaze tended to land at the word beginning only when the first character of the word is Kanji. It was because even in an ordinary unspaced Japanese text a Kana-Kanji string clearly indicates a word boundary. In other words, the initial Kanji in a Kana-Kanji string is the beginning of a word most of the time. However, they also found that the proportion of initial fixations did not differ between character positions for pure Hiragana words, such as used in the present study.

Hiragana characters are two-character consonant-syllable pairs or phonograms. The sounds of the consonant and vowel of a pair cannot be separated; they form a basic "sound." In this aspect, Hiragana characters are more independent as opposed to the alphabetical letters. Hiragana characters might provide some "built-in" context that might ease reading a jumbled word. It was these characters that were jumbled in the current study, not letters as in previous studies. This could explain why the effects were smaller.

As described above, the Japanese language is quite different from English in many aspects, in addition to the use of Hiragana as well as Kanji characters. It is noteworthy that the pattern of effects of jumbling characters or letters was found to be similar in two disparate languages. However, further examination concerning possible differentials between the delaying effects in various languages is needed.

REFERENCE

- Kajii, N., Nazir, T. A., & Osaka, N. (2001). Eye movement control in reading unspaced text: the case of the Japanese script. *Vision Research*, 41, 2503–2510.
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Table 1
Average reading rates (cpm) for the four character-transposition conditions

Transposition condition	Example [Although it looks real, this flower is fake.]	M	SD	Decrement compared to no transposition condition	
				This study	Rayner, <i>et al.</i> (2006)
No transposition	本物に見えるが、この花はつくりものだ。	526	57	--	--
Beginning transposition	本物に見えるが、この花はくつりものだ。	510	61	3.2%	36%
Intermediate transposition	本物に見えるが、この花はつりくものだ。	521	62	1.1%	11%
End transposition	本物に見えるが、この花はつくりのもだ。	515	63	2.1%	26%