Syllable Effects on Reaction and Recognition Times in Reading Letters in Japan

SYLLABLE EFFECTS ON REACTION AND RECOGNITION TIMES IN READING LFTTERS IN JAPAN*

By

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Three experiments were carried out to examine the syllabledependent effects on reading pronouciation latency (Exp. I and II), and the recognition-threshold (Exp. III) for Japanese alphabets and Chinese characters. The results indicated that significant effects on latency were observed in Japanese alphabets, i.e., words with a larger number of syllables required longer latency, but this was not necessarily true for Chinese characters. The recognition time was also affected by the number of syllables in 2-character words, but not in 1-character series. These findings were discussed in terms of the distinctive features between the "ideogram" such as Chinese characters and the "phoneme" like Japanese syllabaries, and also with respect to the level of grapheme-phoneme correspondence.

Recently, in the English speaking countries, there was an extensive interest on the role of vocal or acoustic factors in perception and memory (Neisser, 1967, Sperling and Speelman, 1970). These studies suggested an acoustic form of storage in some stages of word information-processing, transformed from the printed materials (Conrad, 1973, 1964, Wickelgren, 1965, 1966). Several lines of investigation demonstrated the role of vocal factors in perceptual stages, too. One experiment showed the superior perceptual accuracy of words and pronounceable trigrams to unpronounceable trigrams, reported by Gibson et al (1962, 1963). Another is the so-called Reading Pronounciation Latency (RPL) effect (Eriksen et al, 1970, Klapp, 1971, Klapp et al, 1973). "When Ss read single words or 2-digit numbers aloud, the latency from stimulus onset until the beginning of the overt vocalization increases as the number of syllables to be pronounced is increased" (Klapp et al, 1973, p. 368). This increment of latency was regarded as an evidence of the mediation of acoustic factors - like an implicit speech - in reading a word.

The present study was conducted in order to investigate the syllable-dependent effects in Japanese alphabets (KANA) and Chinese characters which are extremely different from English in transcription. Also it was the first attempt to examine the relationship between the visual and vocal aspects in reading printed materials in Japanese.

The main index of the present experiments was RPL or Reaction Time (RT) from the onset of the stimulus presentation to the initiation of pronounciation. Although

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RT should be measured as exactly as possible, it might be difficult to determine - in particular the onset of vocalization - as Eriksen et al also pointed out (1970). They said, "the effective triggering of the voice key might be due to different components of the sound spectrum at different latencies in the vocalization" (p. 503). Thus, a preliminary experiment was carried out to examine the triggering effectiveness of 53 Japanese syllables using 4 Ss. The outcome of the preliminary experiment indicated that the difference of the mean RT among 53 syllables exceeded 50 msec. This difference might be mainly a reflection of the different ways of pronounciation and articulation of each syllable, for example as shown in an envelope factor (Cole and Scott, 1974).

Experiment I

The purpose of Exp. I was to confirm the syllable-dependent effect, originally reported by Eriksen et al (1970), in Japanese alphabets. Thus, the hypothesis was that, if some vocalic factors such as an implicit speech played a certain role in reading letters, the more syllable words needed a longer RT than did the words of fewer. Even though the increment of the number of syllables accompanied the increment of the number of letters in the present experiment, the syllable-dependent effect could be inferred from the increment of RT as the number of syllables increased, RT being measured from the stimulus onset until the start of vocalization.

Method

Materials Seventeen 2- to 5- syllable concrete nouns, which were the names of either animals or plants and which contained one of the NA, MA, MU, MO, and YA syllables as an initial syllable, were selected from the *Word List by Semantic Principles* (1964). The total stimuli consisted of 22 words, 5 letters as 1-syllable stimuli being identical with the initial syllables in 17 nouns mentioned above. These initial syllables were selected according to the finding in the preliminary experiment that these syllables had the most stable triggering effects. The 22 stimuli were also controlled with respect to the frequency of usage according to the *Vocabulary and Chinese Characters in Ninety Magazines of Today Vol. 1* (1962). Five words per syllable were included in 1- to 4- syllable words and 2 words in 5-syllable. Each syllable was printed in a black, Mincho type alphabet on a white card. A stimulus letter subtended a horizontal and vertical angle of approximately 1°. Therefore the 1-letter subtended the same vertical and horizontal angle while 5-letter strings subtended the same vertical visual angle and a 5° horizontal angle when viewed through a tachistoscope.

Apparatus All stimuli were dispalyed in a three-field tachistoscope (TKK Transistor tachistoscope). A TKK Digitimer and a microphone (SONY ECM-23) for a vocie key device were used to determine RT.

Subjects The subjects were 12 Fukushima Paramedical School females. All *S*s

were naive with respect to an experiment of this kind.

Procedure At the beginning of the first experimental session, each *S* received several practice trials using different materials from those of experimental sessions. A session consisted of a random and continuous exposing to 22 words. A rest period of about 5 minutes was provided after each session. After the 3 sec prewarning signal of 1 KHz tone, a visual warning signal (a fixation point) of 1.5 sec appeared in the center of a viewing field. Its offset was immediately followed by the appearance of a stimulus which remained in view for 1 sec. *S*s were instructed to say each word as quickly as possible after presentation. The viewing field was kept blank (white) during the intertrial interval of approximately 10 sec.

Results

The data from the first of the 8 sessions, and the maximum and minimum RT among the remaining 7 trials were eliminated from the data analysis, so that the mean of the remained 5 values was a RT. A main result showed in Fig. 1 and Table 1. As can be seen in Fig. 1, RT was a function of the number of syllables and the plotted points seemed to be linear. A two way analysis of variance was performed for the 1- to 4-syllable items (the 5-syllable being eliminated), and revealed that the effect of the

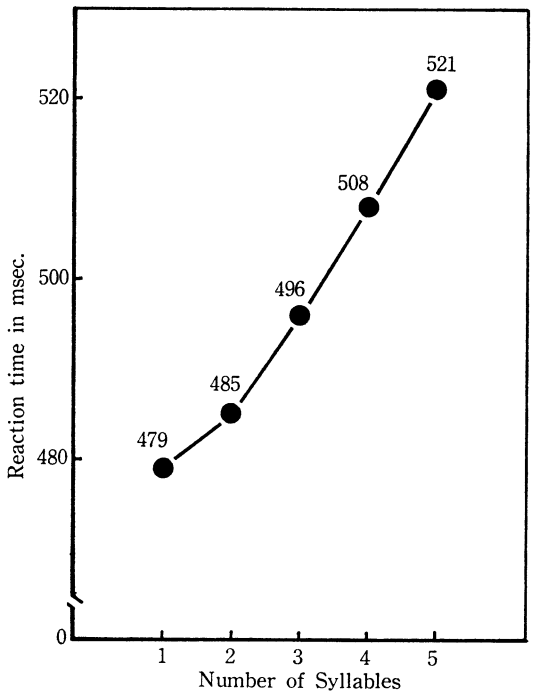

Fig. 1. Reaction time as a function of the number of syllables in Japanese alphabets.

Table 1. Mean reaction time in msec for 5 syllables in Japanese alphabets (N=12).

	Number of syllables				
	1	2	3	4	5
Reaction time	479	485	496	508	521

number of syllables was significant, F (3, 19)=12.451, $P<.01$, but the letter effect (the difference among 5 letters) was not significant, F (4, 19)=2.050, $P>.05$. In the present experiment, it was apparent that the relatively many syllables produced the delay of RT. This result might suggest the mediation of an acoustic process like an implicit speech in reading a printed letter.

The present experiment, however, failed to make clear whether the increment of RT might be due to either the number of letters as a visual factor or the number of syllables as an acoustic factor because in Japanese alphabets the number of letters may be almost perfectly correlated to the number of syllables. As Klapp et al (1973) pointed out, visual factors should be strictly distinguished from the vocalic or acoustic ones, because there may be a possibility that a part of the increment of RT should be attributed to the increased time reqiured for the visual discrimination as a function of the stimulus size. We should then determine whether the delay of RT might be due to either the discrimination or the other processes.

Experiment II

The purpose of the present experiment was to examine the syllable-dependendent effects on the discrimination or the implicit speech process, using Chinese characters in which we could separate the visual (the number of characters) from the acoustic factors (the number of syllables).

Method

Materials The stimuli consisted of 33 words selected from the *Vocabulary and Chinese Characters in Ninety Magazines of Today, Vol.* **1** (1962), meeting the following criteria that: (1) the frequency of usage be between .070 and .090 ‰; (2) the members of the corresponded items be closely correlated in the number of strokes *; (3) the initial syllable of each stimulus be composed of one of the n, m, and y series, and the vowel; (4) the pronounciation of 1-character items be a solitary ones. Generally speaking, a Chinese character has several pronounciations and it is very difficult to pick out the characters that have only one way of pronounciation. Indeed, this criterion was not perfect.

* It is well known that the number of strokes is one of the major factors which influence reading speed and accuracy (Murata, 1973). Our preliminary experiment also confirmed this finding that the larger the number of strokes, the longer the RT.

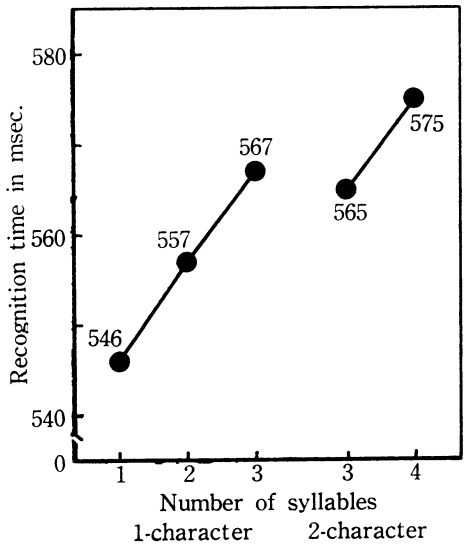

Fig. 2. Reaction time as a function of the number of syllables in two series of chinese characters, the 1- and 2-character. (N=10).

Apparatus Instrumental systems were almost the same as in Exp. I.

Subjects Ten females from the same school as those for Exp. I served as *S*s. They were all naive with respect to the purpose of the experiment.

Procedure The warning signal of 1 KHz tone was exposed for 1.5 sec, immediately followed by the stimulus for 1 sec. *S*'s task was to read the word presented aloud as quickly as possible. During the intertrial interval of 10 sec, the viewing field remained light. The stimuli were divided into 2 series, the 1-character (the A series) and the 2-character (the B series) in which were included 1, 2, and 3 syllables, and 3 and 4 syllables respectively.

Results

The major result of Exp. II was summarized in Fig. 2 and Table 2. As seen in Fig. 2, RT tended to increase as a function of the number of syllables in both the A and B series. The plotted points were roughly fitted by a straight line and its equation was approximately as follows; RT=535+10 msec per syllable. An analysis of variance, however, failed to achieve a significant difference between the syllables in the A series, F (2, 14)=1.769, $P>.10$. A tendency of the slightly significant difference was observed between the 1- and 3-syllable words, t=2.726, $.05<P<.10$. The t test also revealed that the difference between the 3- and 4-syllable words in the B series approximated to the level of 10 %, t=1.165. These results suggested the concern of a visual discrimination in Exp. I, but the factor of an implicit speech also could not be neglected. Comparing

Table 2. Mean reaction times in msec for 1- to 4- syllable words in 2 series of chinese characters.

Series \ Syllable	1	2	3	4
1-character	546	557	567	—
2-character	—	—	565	575

the result of Exp. II with that of Exp. I, the effect of a vocal factor seemed to be superior to that of the visual discrimination factor.

Experiment III

Exp. I and II examined the syllable-dependent effects of vocalization latency in reading Japanese alphabets and Chinese characters respectively. The result of Exp. II sugested that the delay of RT at the more syllable words might be due to the time required for some covert, implicit speech processes, rather than the time needed for the visual discrimination. The interpretations of this implicit speech process, however, seemed to be somewhat ambiguous. Two interpretations at least might be possible as Klapp et al (1973) suggested. One is the notion that the delay of latency should be attributed to the variations in perception or recognition of words (Eriksen et al, 1970, Klapp, 1971), and the other to the variations in response stages, i.e., "time needed to program the vocal apparatus prior to vocalization of the word" (Klapp et al, 1973, p. 368).

The analysis of this problem might be possible only in the tasks in which S indicates his understanding and perception of a word without pronouncing it. One of the tasks is the same vs. different decision design of Klapp (1971). This design, however, "seemed to be at odds with Posner's evidence (1969)", as Spoehr and Smith criticized (1973, p. 72). The other is the recognition threshold procedure of the present experiment, which aimed at the separation of the implicit speech as a mediator of word recognition from the variations in preparation of a vocal apparatus. If any differences were found in recognition time, it might be solely due to perceptual aspects rather than to the subsequent, acoustic or motor stages. Therefore, Exp. III was conducted to investigate the role of vocal or acoustic factors in perceiving or recognizing stages in reading letters by means of the recognition threshold for different syllables.

Method

The stimulus materials were identical with those of Exp. II. Twenty females from the same school as in Exp. I and II, having normal or corrected-to-normal visions, served as *S*s and were also naive with respect to the purpose of the experiment. Apparatus was a three-field tachistoscope identical with that of Exp. II. Stimuli

were displayed in a viewing field which was intervened by two pieces of half-transmitted mirrors using a 4 W fluorescent light. Stimulus size and viewing conditions were the same as in Exp. II. After presenting a warning signal of 1 KHz sound for 1.5 sec during which period a fixation point appeared in the center of the viewing field, stimulus words were presented for a certain duration. The recognition threshold was determined by a modified method of limits procedure according to Howes and Solomon (1951). The shortest starting point was 20 msec and this was increased by 5 to 7 msec steps.

Results

A principal outcome from Exp. III was shown in Fig. 3 and Table 3. The words with a larger number of syllables required the longer time for recognition in both of the A and B series. However, the plotted points were not necessarily linear in contrast to the results of RT in Exp. I and II. A two way analysis of variance in the A series revealed a significant difference among the characters (the number of strokes), $F(4, 14) = 6.766$, $P < .05$, but failed to indicate a significant difference among the syllables. The interaction of the number of syllables with that of strokes was also insignificant, while the mean threshold of the 4-syllable was significantly higher than for the 3-syllable in the B series, $t = 2.661$, $P < .05$.

Discussion and Conclusion

The results of Exp. I and II can be summarized as follows; in Japanese syllabaries RT varied significantly with the number of syllables (Exp. I), but did not so remarkablly change in Chinese characters (Exp. II). The data for KANA coincided well with the previous findings in English (Eriksen et al, 1970, Klapp, 1971, Klapp et al, 1973) but did not for Chinese characters. These results might be, first of all, due to the nature of written letters, i.e., the Japanese syllabaries are more closely akin to English alphabets than did Chinese characters. A KANA is a phonetic symbol like an English script in its nature except that it has a more simple grapheme-phoneme correspondence, while a Chinese character is a typical ideograph which has little grapheme-phoneme correspondence. The latter is more closely associated with semantics rather than with the phoneme.

A similar outcome was observed in recognition time data in Exp. III. Although the 1-character A series did not prove an obvious difference in perceptual sensitivity, the 2-character B series obtained a significant difference due to the number of syllables. It seems also possible to interpret these findings in terms of the degree of grapheme-phoneme correspondence. In general, the 1-character Chinese charcter is linked with "semantics" rather than with the phoneme and usually form a word by themsevles. For example, as mentioned above, 1-character has several pronounciations according to its meaning. Therefore, its linkage with the phoneme is relatively loose.

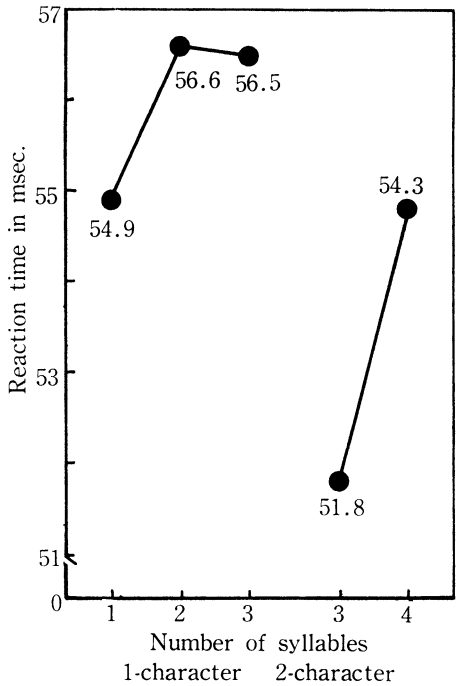

Fig. 3. Recognition time for 1- and 2-character words as a function of the number of syllables (N=20)

Table 3. Mean recognition times in msec for 1- to 4- syllable words in Chinese characters.

Series \ Syllable	1	2	3	4
1-character	54.9	56.6	56.5	—
2-character	—	—	51.8	54.3

Meanwhile the 2-character in the present experiment constituted a word and was tightly combined with a solitary pronounciation. Concerning this level, i.e., a level of words composed of two characters, Chinese characters could be compared with English words in that they also have a close grapheme-phoneme correspondence, contrary to the 1-character of the loose correspondence.

Finally, we will discuss our findings with respect to those of Spoehr and Smith (1973) who have examined the recognition accuracy for digit numbers and words. They demonstrated a similar effect of syllables on words, but found no effects on digit numbers. Hypothesizing three sequentially ordered stages in perceiving or recognizing a number or a word: (1) the Analysis stage, (2) the Translation stage, (3) the

Implicit Speech stage, they attributed this effect to the perceptual organization (the Analysis and Translation stages, which are the "true" perceptual stages), rather than to the Implicit Speech stage. According to their notion, the recognition of the digit number was not sensitive to the Implicit Speech in which the stimuli operated in phonological representation, while the recognition accuracy of words was partially affected by the perceptual stages in which stages the stimuli functioned in the graphemic representation, as well as by the vocalization. For, according to the present author's interpretation, the words could be analyzed in terms of the "Vocalic Center Group", whereas the digit numbers could not.

Since the Chinese character in the present study seems to be analogous to the digit number in Spoehr and Smiths' investigation from the view point of the VCG, so the VCG analysis may be impossible to apply to the Chinese character. Considering these discussions our results have not agreed with those of Spoehr and Smith (1973), because if their hypothesis was correct the data from Chinese characters should be equivalent for those of digit numbers in their experiments.

Further investigations would be necessary to examine this problem. Even the ideographic letters, like Chinese characters and digit numbers in English, have a certain pronounciation and thus are combined, tightly or loosely, with a certain vocalization. Although the reasoning by Spoehr and Smith is perhaps correct, it seems also adequate to infer that this vocal component closely correlated to the ideogram might play a certain role in any stage. A task in the future thus will be to examine the role of these grapheme-phoneme correspondences in the ideograph.

References

Cole, R.A. and Scott, B. **1974** Twoard a theory of speech perception. *Psychol. Rev.*, **81**, 348–374.

Conrad, R. **1963** Acoustic onfusions and memory span for words. *Nature*, **197**, 1029–1030.

Conrad, R. **1964** Acoustic confusions in immediate recall of sequences. *Brit. J. Psychol.*, **55**, 75–84.

Eriksen, C.W., Pollack, M.D., and Montague, W.E. **1970** Implicit speech: Mechanism in perceptual encoding. *J. exp. Psychol.*, **84**, 502–507.

Gibson, E.J., Pick, A.D., Osser, H., and Hammond, M. **1962** The role of grapheme-phoneme correspondence in the perception of words. *Amer. J. Psychol.*, **75**, 554–570.

Gibson, E.J., Osser, H., and Pick, A.D. **1963** A study of the development of grapheme-phoneme correspondences. *J. verb. Learn. verb. Behav.*, **2**, 142–146.

Howes, D.H. and Solomon, R.L. **1951** Visual duration threshold as a function of word-probability. *J. exp. Psychol.*, **41**, 401–410.

Klapp, S.T. **1971** Implicit speech inferred from response latencies in same-different decisions. *J. exp. Psychol.*, **91**, 262–267.

Klapp, S.T., Anderson, W.G., and Berrian, R.W. **1973** Implicit speech in reading, reconsidered. *J. exp. Psychol.*, **100**, 368–374.

Murata, K. **1974** *YOJI NO KAKIKOTOBA* (The written languages in infants). Tokyo; Baifukan. (in Japanese).

Neisser, U. **1967** *Cognitive Psychology.* New York: Appleton-Century-Crofts.

Sperling, G. and Speelman, R.C. **1971** Acoustic similarity and auditory short-term memory: Experiments and a model. In D.A. Norman (Ed), *Models of Human Memory.* New York: Academic Press.

Spoehr, K.T. and Smith, E.E. **1973** The role of syllables in perceptual processing. *Cognitive Psychology*, **5**, 71–89.

The National Language Research Institute (Ed), *Vocabulary and Chinese Characters in Ninety Magazines of Today*. (Vol. I). Tokyo: Syuei Syuppan, **1962**. (in Japanese).

The National Language Research Institute (Ed), *Word List by Semantic Principles*. Tokyo: Syuei Syuppan, **1964**. (in Japanese).

Wickelgren, W.A., **1965** Short term memory for phonemically similar lists. *Amer. J. Psychol.*, **78**, 567–574.

Wickelgren, W.A. **1966** Phonemically similarity and interference in shrot-term memory for single letters. *J. exp. Psychol.*, **71**, 396–404.

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