The word superiority effect in a case of *Hiragana* letter strings

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This paper is concerned with the effect of syllabification in the superior perceptibility of tachistoscopically presented Japanese *Hiragana* letter strings. The *Hiragana* letter is a phonetic symbol having an invariant one-syllable pronunciation. Controlling retention and guessing factors, an experiment replicated the original Reicher (1969) findings of a word superiority effect. Thus, the results suggest that letter unitization which depends upon syllable-like structures (the vocalic center groups; Spoehr & Smith, 1973) is not a prerequisite, but that orthographic regularity and meaningfulness may be important determinants of the word superiority effect.

It is certain that context plays an important role in our visual recognition. Ever since Cattell, 1886 (cited in Reicher, 1969), it has been known that with tachistoscopic presentation, more letters can be reported correctly if the letters form a familiar sequence, such as a word, rather than an unfamiliar sequence of unrelated elements. Although the effect of familiarity is highly reliable, an adequate explanation has proven elusive. Controversy surrounds the issue of whether familiarity affects the perception and identification of the letters, or the retention and verbal report of the letters (Neisser, 1967, Chap. 5).

Reicher (1969) and Wheeler (1970), controlling the retention and guessing factors, demonstrated that a letter is more accurately identified when it is presented in a word than when it is presented alone or in a nonword. Cattell and Reicher attributed the effect primarily to meaningfulness, but it has become apparent that many other factors play a role in conferring on a word its apparent unity. A word can be defined as a complex of features, a composite representation of information: graphic, phonological, orthographic, semantic, and syntactic (Gibson & Levin, 1975). A large number of investigators have examined the formation of higher-order perceptual units. Different researchers have stressed different properties. These could be classified into the lexical approach and the structural approach. The lexical approach is not concerned with structural relations among the component letters of an item but, rather, with the availability of the whole item in lexical

memory (Manelis, 1974; Morton, 1969). In the structural approach, the variables of interest are linguistic relations among component letters. In a large number of the studies of the perception of English nonwords, it has been shown that nonwords are encoded (or at least reported) more accurately if they are orthographically regular (Baron & Thurston, 1973; Mason, 1975), or if they are made up of subunits such as "spelling pattern units" (Aderman & Smith, 1971; Gibson, Pick, Osser, & Hammond, 1962; Gibson, Shurcliff, & Yonas, 1970) or "vocalic center groups" (Spoehr & Smith, 1973, 1975). (For general reviews, the reader is referred to Gibson & Levin, 1975; Krueger, 1975; and Neisser, 1967.)

In the structural approach, one of the issues seems to be the role of pronounceability (e.g., Baron & Thurston, 1973; Gibson et al., 1962; Spoehr & Smith, 1973, 1975). The vocalic center group (VCG), a syllable-like structure, has been proposed as a perceptual unit. This proposal, the VCG model, seems to be in line with the previous notion that items transferred from iconic storage to short-term memory are encoded acoustically or verbally (Conrad, 1964; Eriksen, Pollack, & Montague, 1970; Sperling, 1967). In the VCG model, letter strings are parsed into VCGs, each composed of a vowel and one or more consonants (unitization stage). If no vowels are present in a string, any vowel may be inserted where phonotactic violations occur. Then these VCG units are translated serially into a phonological code. Accuracy of the report of tachistoscopically presented letter strings is said to be predictable from the amount of processing necessary to generate phonetic representation. It was demonstrated that words having one syllable (e.g., PAINT) were easier to identify than those having two (e.g., PAPER) (Spoehr & Smith, 1973) and that pronounceable nonwords (e.g., ROST) were easier to

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identify than unpronounceable nonwords (e.g., RNOT) (Spoehr & Smith, 1975).

The present experiment attempted to test more directly the validity of the VCG model, using Japanese *Hiragana* letter strings. The *Hiragana* letter (*kana* letter¹), a phonetic symbol, has a fixed one-syllable pronunciation which contains a consonant and a vowel, or only a vowel. That is, a *kana* letter generates a vocalic center group, so unitization of the VCG kind cannot be expected in *kana* letter strings. From the assumption of the VCG model, the prediction follows that identification accuracy for words and that for nonwords (their anagrams) should be the same, and that it should be lower than that for single letters.

METHOD

Subjects

Ten undergraduate psychology students of the department participated in the experiment. All had normal or corrected vision.

Stimulus Materials and Apparatus

Three context types, words of four *kana* letters, anagrams of these (nonwords), and *kana* letters presented alone, were employed (see Table 1). Sixteen familiar word pairs were chosen so that two words differed in only one *kana* letter [e.g., *くだもの* (ku'da'mo'no'; fruit)—*けだもの* (ke'da'mo'no'; beast)]. Thus, one of the words of such a pair would be presented, followed by the two single-*kana*-letter alternatives that would form the two different words if inserted into the critical position. The critical *kana* letter occupied each of the four possible positions equally often. The nonword stimuli were generated from the word stimuli by leaving the critical *kana* letter in its position and changing the positions of the other *kana* letters to form a nonsense string of *kana* letters (e.g., *くのもだ* (ku'no'mo'da') — *けのもだ* (ke'no'mo'da')). The single-*kana*-letter stimuli were generated by leaving the critical *kana* letter in its position and removing the other *kana* letters. Thus, the list of stimuli contained 96 items (32 items in each type of context). The presentation order of all these stimuli was randomized.

The stimuli and alternatives were printed on 22 × 23 cm white cards using instant lettering (Letraset, No. JPN-5024). The stimuli were presented via a three-field tachistoscope at a viewing distance of 104 cm. *Kana* letters subtended approximately .20° of visual angle vertically and .14° horizontally. Four-character displays subtended approximately .90° horizontally. The distance between the horizontal center line of the stimuli and that of the

Table 1
Illustrative Stimulus Materials Where the Critical
Kana Letter is *く* or *け*

Context Type		Single <i>Kana</i> Letter
Word	Nonword	
くだもの (ku'da'mo'no') (fruit)	くのもだ (ku'no'mo'da')	く (ku)
けだもの (ke'da'mo'no') (beast)	けのもだ (ke'no'mo'da')	け (ke)

Table 2
Mean Percent Correct Decision for Words, Nonwords, and Single
Kana Letters in the Four Critical *Kana* Letter Positions

	Position			
	1	2	3	4
Words	88	84	85	83
Nonwords	76	74	68	70
Single <i>Kana</i> Letters	83	83	78	81

following alternatives was 1.7°. A rectangular visual noise mask was printed with instant lettering (Letraset No. 332, Screen-Tone). This mask was .45° high × 1.0° wide, covering the stimuli area. The luminance of the stimulus field was approximately 2.2 log fL and that of the masking field and the blank field 1.8 log fL.

Procedure

Following practice, the first session of the experiment determined the duration at which each subject performed at 75% accuracy in identifying single critical *kana* letters involved in four-*kana*-letter nonsense strings from two response alternatives. The alternatives appeared directly above the critical *kana* letter position with visual noise mask immediately upon the termination of the four-*kana*-letter nonsense string exposure. All stimuli in the experimental trials were run at this constant exposure duration. The mean duration averaged across subjects was 78 msec.

At the beginning of the experimental session, the experimenter explained the forced-choice task, and the random presentation both of the three context types and of critical *kana*-letter positions. Each subject was instructed to focus on the fixation point. In each experimental trial, after receiving a signal from the experimenter, the subject could initiate the stimulus display with a microswitch. The interval between pushing the microswitch and the onset of a stimulus exposure was 1 sec. The card with the masking field and response alternatives followed immediately upon termination of the stimulus exposure and remained on for 3 sec. The alternatives appeared directly above the position of a critical *kana* letter in the prior stimulus display. After the appearance of the response alternatives, the subject gave verbal reports of the critical *kana* letter and the context-type which he thought had appeared in the stimulus display. Then he recalled the other *kana* letters which he thought had appeared. No feedback was given.

RESULTS AND DISCUSSION

The results of the present experiment replicated those obtained previously by Reicher (1969), Wheeler (1970), and many others, showing the superiority of words to nonwords and single *kana* letters.

The mean percentages of correct decisions for words, nonwords, and single *kana* letters were 85%, 72%, and 81%, respectively. Table 2 displays the mean percentages of correct decisions for all subjects, broken down by the serial position of critical *kana* letters. These data were subjected to a 3 by 4 by 10 analysis of variance. The main effect of context type was significant [$F(2,18) = 10.46$, $p < .005$]. Neither the position effect nor its interaction with context type was significant. Words had a reliable advantage over single *kana* letters ($p < .01$) and single *kana* letters over nonwords ($p < .01$ by Tukey's test).

It is worth noting that even with the *kana* letters

which cannot be grouped into syllable-like structure (VCG), the word superiority effect (WSE) was obtained. According to the VCG model, for *kana letter* strings, the number of perceptual units which must be processed in the present experiment is the same for both words and nonwords, and is smaller for single *kana letters* than for words and nonwords. It follows that no superior perceptibility of words over single *kana letters* and nonwords is to be expected. Thus, the results of this experiment do not support the theory that the WSE depends on a *syllable-based grouping* of letters into higher-order perceptual units.

Spoehr and Smith (1975) argued that phonetic coding of words, though not an obligatory process, was a dominant strategy in word recognition experiments like theirs, and this was supported by their subjects' reports. However, they employed a 1-1.5-sec delay between stimulus offset and presentation of the alternatives, and it seems that, since experimental situations are different, subjects' processing strategies differ depending on whether alternatives are presented immediately after the offset of the stimulus exposure or whether there is a 1-1.5-sec delay. In the present experiment, where the alternatives were presented after 0-sec delay, subjects reported that they matched *kana-letter* strings with alternatives on the ground of visual shapes. Posner, Boies, Eichelman, and Taylor (1969) demonstrated that in the same-different judgment of successively presented single letters, visual matching was dominant with the short time intervals in the presentation of letters, and that verbal matching became gradually more effective than visual matching as they approached the lengthier 2-sec interval. Therefore, the discrepancy between the dominant decision strategies in the present experiments and those in Spoehr and Smith (1973, 1975) is not contradictory.² But what should be stressed here is that in the present task, where visual decisions seemed to be dominant, the WSE was nevertheless obtained. That is, it seems more reasonable to assume that the WSE occurs without phonetic encoding. This is also supported by the report of Gibson, Shurcliff, and Yonas (1970) that the same spelling pattern results are found with deaf perceivers who have never heard an invariant pronunciation of the spelling patterns. Baron and Thurston (1973) dismissed pronounceability as a source of facilitation on the basis of an experiment involving homophones. Bruder (1978) and Pollatsek, Well, and Schindler (1975) suggested a major visual component to the familiarity effect. McClelland (1976) also suggested the involvement of visual form information in word perception.

Thus, the account of the WSE in terms of the ease of formation of phonological representation has been proven dubious and the question arises as to what type of constraint the subject does utilize in

processing familiar letter strings. There are two major possible determinants left, that is, orthographic (or spelling) regularity on the one hand (Baron & Thurston, 1973; Gibson et al., 1962; Gibson et al., 1970; Mason, 1975; McClelland & Johnston, 1977) and meaningfulness on the other (Manelis, 1974; Morton, 1969).

As already indicated, from the results of the present experiment, it has been demonstrated that an orthographic rule system that specifies the construction of syllables is not a prerequisite for the WSE, because a *kana letter* has an invariant one-syllable pronunciation. Therefore, an orthographic regularity that specifies the structure of familiar *kana letter* strings should be considered.

Almost all investigations that support English orthographic regularity as a determinant of the WSE are based on the findings of the advantage of pronounceable pseudowords over unpronounceable unrelated letter strings (Aderman & Smith, 1971; Gibson et al., 1962; Krueger, 1970; McClelland, 1976). On the other hand, even though words have been found to be advantageous over pronounceable pseudowords, this advantage has received virtually no attention (McClelland & Johnston, 1977; Spoehr & Smith, 1975). [Manelis (1974) is one of the few to have considered this.] Perhaps this is because, as Coltheart (1972) pointed out, accounts which resort to meaning are thought to be inherently paradoxical. And there is no answer to the question of whether orthographic regularities within real words are reflected in perception of them. In the present experiment, a superiority of words over pronounceable nonwords was detected. However, the correspondence between nonsense *kana letter* strings and English pronounceable pseudowords is not clear, since we have no findings about the orthographic regularity of *kana letter* strings. And it seems reasonable that different writing systems which relate to language at different levels will involve attention to and abstraction of different aspects of the orthographic system (Gibson & Levin, 1975, p. 165). So orthographic regularity, as well as meaningfulness, seems to be a viable determinant of the WSE. [Baron and Pittinger (1974) suggested that semantic processing might occur in parallel with orthographic processing.] What we need is a precise specification of the nature of the orthographically constructed representation, its relation to meaningfulness, and the process of orthographic construction itself.

Conclusion

Findings of the present experiment with *kana letter* strings demonstrate that the word superiority effect can be obtained without unitization of parts of letter strings depending on syllable-like structure, and *could* be obtained without phonetic or verbal

encoding. So, it is possible that the WSE could be accounted for by a facilitation of visual encoding due to orthographic regularity, as well as to meaningfulness. It seems that knowledge of abstract properties of familiar stimuli or context can influence the process of visual recognition.

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NOTES

1. The Japanese language has Chinese logographs (ideographs) and two syllabaries: Hiragana and Katakana. Both of the latter two are referred to as *kana*. In order to distinguish the Japanese syllabic letter from the alphabetic letter, I designate the former "*kana letter*" and the latter simply "letter."
2. Most recently, Spoehr examined the effect of delay of alternatives (Spoehr, 1978, Experiment 3). She failed to obtain syllabic effect at below 250-msec delays, and suggested, as an explanation, subjects' visual matching strategy at short delay intervals.

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