Familiarity of configuration vs discriminability of features in the visual identification of words[1]

FRANK SMITH,[2] Southwest Regional Laboratory, Inglewood, Calif. 90304

An experiment with 90 Ss failed to support a traditional theory of reading that the total configuration of a word is the dominant cue for word identification. Distortion of the total shape or structure of words did not interfere with reading unless discriminability of the relative size of lower-case letters was also obscured. It is concluded that feature discrimination rather than familiarity with the total configuration is critical for word identification.

How are words identified in reading? The traditional explanation that the familiar shape or structure of the entire word is recognized (Woodworth & Schlosberg, 1954, pp. 100-103) fails to account for the identification of many nonword sequences of letters as easily as words (Postman & Rosenzweig, 1956), or for the identification of words in typefaces or handwritten scripts completely novel to the reader.

It has been proposed that letters (Gibson, 1965), and also groups of letters and words (Smith, in press), are identified on the basis of "distinctive features" which reduce the set of alternatives that the total configuration might be. Combinations of distinctive features permit unique identification of the letter or word.

Gibson (1965) describes some properties of upper case letters, such as straightness, curvature and intersection, which could function as distinctive features. Similar features may be assumed for lower-case letters, alone or in sequences, with an additional cue of relative size to facilitate discrimination involving the presence or absence of ascenders, e.g., bad vs pad, h vs n.

We differ from the Gibson position in one critical respect, however. Gibson suggests that the fluent reader learns to identify some assumed canonical form of letters under different transformations; our proposal is that different combinations of features (criterial sets) may become "functionally equivalent" in that they lead to the same response. For example the feature combinations comprising the different configurations A, *a*, and *h*, or HAT, *hat*, and *h* are considered as functionally equivalent because they represent the same letter or word.

While opposing the "familiarity of configuration" point of view, we do not wish to suggest that words are identified letter by letter. It is proposed instead that criterial combinations of features are discriminated simultaneously in different areas of the configuration and integrated for identification of the whole. This "functional equivalence" point of view asserts that it does not matter if feature combinations within a configuration are not in the same alphabetic or typographic code, or even if they are not all discriminable, provided that sufficient criterial combinations are discriminable in different parts of the word. Such a view does not demand familiarity with the word shape as a whole.

Results apparently supportive of the whole-word view occur in a demonstration (Anderson & Dearborn, 1952) that text in which words are printed with alternating upper- and lower-case letters, as in Line 6 of Fig. 1, is more difficult to read than normal all-capital or capital and lower-case text. However, the alternation of case may do more than destroy the postulated cue of "total word form"; it may also interfere with the discrimination of the relative size of lower-case letters.

The present experiment was designed to determine whether the disruptive effect of the alternation of case is due to distortion of a familiar configuration or interference with the discrimination of features of lower-case letters. Feature discriminability would be shown to be the critical variable if: (a) the alternation of upper- and lower-case letters were not disruptive when the size of the capitals was reduced so that the ascenders of lower case letters were clearly discriminable (as in Line 3, Fig. 1), even though the configurations were quite unfamiliar; (b) variation in the size of letters were disruptive in text that was all lower case (except the first letter of sentences) (Line 5); (c) variation in the size of letters were *not* disruptive when the letters were all capitals (Line 4), despite unfamiliarity of the configuration, because relative size is not a distinctive feature for the identification of upper-case letters.

The experimental measure was the time taken by adults to read a 150-word, 18-line passage printed in the six styles shown in Fig. 1. Corresponding lines of each of the six versions contained the same words and were the same width. Ninety Ss were assigned randomly to read one of the six versions aloud at "normal reading speed." There were no special instructions with respect to comprehension. All Ss read with appropriate intonation.

RELATIVE SIZE CUE	CASE	EXAMPLE	MEAN READING TIME (secs)
Irrelevant	Upper	1. THE MEANINGFULNESS OF THE	53.38
Maintained	Lower	2. The meaningfulness of the	53.01
	Mixed	3. TnE meaNiNgFULnESS OF tHe	52.61
Irrelevant	Upper	4. THE MEANINGFULNESS OF THE	53.21
Disrupted	Lower	5. The meaningfulness of the	58.18
	Mixed	6. ThE mEaNiNgFuLnEsS oF tHe	66.82

Fig. 1. Examples of text and mean reading time for 150-word passages. *Differences significant at p < .05, **at p < .001, by the Mann-Whitney U test (Siegel, 1956, pp. 116-127).

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viewing conditions do have a differential effect on integrated output. These differences may be explained in terms of an intuitive ranking of the viewing conditions along an arousal continuum, somewhat in the manner of Daniel (1965). Daniel ranks five experimental conditions on an arousal continuum (final relief from task, pretask relaxation, attention, recovery from task and task hyperventilation) and obtains a good fit with a number of parameters. Our technique is inferior to that of Daniel in that low frequency analysis confounds prevalence with amplitude and fails to measure rhythmicity. Nevertheless, the results fit an arousal model.

Strictly speaking, stimulus complexity is not measured here; but rather, a comparison is made between eyes-closed, eyes-open without a stimulus and eyes-open with a stimulus. It might therefore be argued that reduced integrated output in the patterned condition is attributable to increased brightness, but this does not accord with Baker & Franken's (1967) finding.

The differences over all filters (eyes-open against eyes-closed) support the findings of Gengerelli & Parker (1966). They report that "when the eyes are opened and the S is in a state of perceptual alertness, the amplitude in this range (8-12 cps) clearly diminishes; but there is no corresponding enhancement of the amplitude in higher frequencies." Gengerelli and Parker obtain their results with briefer exposure times than our own (18 sec only). Consideration of the EEG distribution (as shown in Fig. 1) leads one to doubt the general assumption that "desynchronization" involves a *replacement* of alpha activity by beta activity (Thompson, 1967). This would call for a considerable skew in the distribution. Indeed, arousal differences appear *within* alpha rather than in terms of a contrast between alpha and beta; beta itself is not affected differentially by the two viewing conditions (plain against patterned). Failure to obtain an effect might be due to the gross character of the beta filter, which fails to discriminate among frequencies within beta; even so, there is no difference in overall beta output for the two conditions. Again, comparison of first and last eyes-closed trials shows that the differences lie in the high alpha and subalpha ranges rather than in beta. "Desynchronization" as such is normally said to be present as a short-term response and our EEG sampling technique is designed for long-term recording. Berlyne & McDonnell (1965) employ an alpha decrease measure rather than a beta increase measure. The absence of an effect in beta in the present study in relation to stimulus complexity (eyes-open conditions), given the association of beta with "arousal," is puzzling and merits further attention. We are undertaking further studies involving (a) a range of visual stimuli graded for complexity, and (b) an extension of the analyzer frequency range.

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RESULTS AND CONCLUSIONS

Mean reading time for the 15 readers on each of the six versions (Fig. 1) supports the view that feature discriminability rather than familiarity is the critical variable in word identification. Mixing upper and lower case is disruptive when capital letters are as tall as the ascenders of the lower-case letters (Line 6), otherwise the mixture (Line 3) is as easy to read as normal type. Varying the size of alternate letters disrupts reading when the text is all lower case (Line 5), but not when it is all capitals (Line 4).

The present results cannot be attributed to "generalization of response to variations of a stimulus pattern" (whatever the assumed conditioned or canonical form might be). It is difficult to see how one could generalize among forms as diverse as hat, HAT, *hat*, hAt, and so forth, each of which may be far more similar to other words in the same typographic style than to the different typographic styles of the same word.

The results are consistent with other evidence that we have obtained using the same material in a comprehension-free task (Smith, Lott, & Cronnell, in press). In the latter study, 240 Ss were required to search for target words in texts set in the different type mixes.

The most surprising outcome of the present study is perhaps not the fact that the most difficult version took 25% longer to read than the easiest. What is remarkable is the facility with which even the most bizarre passages were read. Adaptation to these mutilated texts was almost instantaneous, the number of words read in the first 10 sec correlating highly with the speed of reading the entire passage. Our daily experience is that quite unfamiliar handwriting becomes relatively legible once we have "cracked the code" of a few words, i.e., established a sample of feature equivalences. One of the most important skills of the fluent reader may be that of acquiring and mastering a wide variety of functional equivalences for a diversity of typographic and calligraphic forms. Familiarity with any particular form is irrelevant.

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NOTES

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2. Now at The Ontario Institute for Studies in Education, 102 Bloor Street West, Toronto 5, Ontario, Canada.