

# On Distinctive Attributes in Character Recognition —Some Evidence from Reaction-time Measurements—

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One general approach to pattern recognition problem is feature detection. The class membership is determined by the presence or absence of essential attributes. Primary concern of the present study is to provide psychological evidences on the number and type of relevant attributes involved in a particular set of letters by use of reaction-time measurements.

One general approach to pattern recognition problem is feature detection [1]. It embodies the notion that class membership is determined by the presence or absence of essential properties or attributes. If patterns are composed of a number of well-defined attributes, the presence or absence of each of the attributes can determine whether the two patterns are the same. When a subject is asked to determine whether two patterns are the same or different, the time taken to arrive at a response (reaction-time) depends on whether the attributes can be examined in serial or in parallel and reflects the number of differing relevant attributes involved [2].

Primary concern of the present study is to provide psychological evidences on the number and the type of relevant attributes involved in a particular set of letters by use of reaction-time measurements.

**Experiment:** At first two groups of four letters; C, F, O, P (group 1) and 5, 6, 8, 9 (group 2) are found, see Fig. 1. The letters in group 1 are hypothesized to involve two relevant attributes; LEG and CLOSURE, and those of group 2 to involve one relevant attribute; CLOSURE.

Experiment 1: We have the following four conditions for the letters in group 1: (1) The identical condition (no attribute differing); C-C, F-F, O-O, P-P, (2) The CLOSURE condition (one attribute differing); C-O, F-P, (3) The LEG condition (one attribute differing); C-F, O-P, (4) The redundant condition (two attributes differing); C-P, F-O.

Experiment 2: For the letters in group 2, (1) The identical condition; 5-5, 6-6, 8-8, 9-9, (2) The TOP-CLOSURE condition (two letters differ only in the state of the CLOSURE in the upper half of the letters); 5-9, 6-8, (3) The BOTTOM-CLOSURE condition (two letters differ only in the state of the CLOSURE in the lower half of the letters); 5-6, 9-8, (4) The redundant condition (they differ on both the CLOSURE state and its location); 5-8, 6-9. TOP and BOTTOM are con-

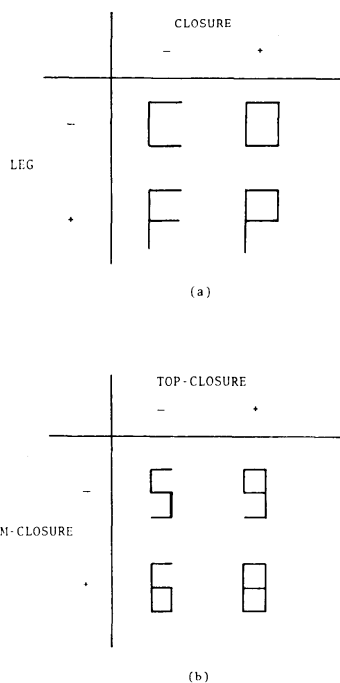


Fig. 1 Two groups of four letters. The actual style of the letters presented to the subjects was the same as that shown in this figure.

sidered as location modifiers associated with the attribute CLOSURE.

**Experimental Method:** The stimuli were presented in pairs by using a tachistoscope. The letters were drawn carefully, 3.8 cm height  $\times$  2.5 cm width, and placed side by side with a separation of 5 cm. The viewing distance was approximately 57 cm. The subjects (Ss) were 5 university students. They took part in the experiment 10 times each over 10 successive week days. The events of a single trial of the experiment were as follows. After the signal given by the experimenter, the subject pressed the start button, triggering the exposure of one of the

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stimulus pairs for 300 msec. and starting a counter for measuring the reaction-time. The voice response given by S, either SAME or DIFFERENT, stopped the counter.

**Results and Discussions:** The principal data are mean reaction-times (RTs) in milliseconds and data are combined across the 10 sessions.

Experiment 1: We can summarize the data obtained for Experiment 1 as shown in Fig. 2a. We have calculated t statistics to test the significance of the difference in mean RT. between letter pairs or groups of letter pairs for each subject. The results\* are as follows. (1) For the case of no attribute differing (SAME response), there is observed almost no significant difference in RTs among four letters. (2) For the cases of the DIFFERENT response, there are no significant differences in RTs between C-O and F-P, C-F and O-P, F-O and C-P, however, we have strong significant difference between the group of letter pairs; (C-O, F-P) and (C-F, O-P). These results are common to all 5 Ss. There may be considered two possible models of visual processing which help to understand the obtained data.

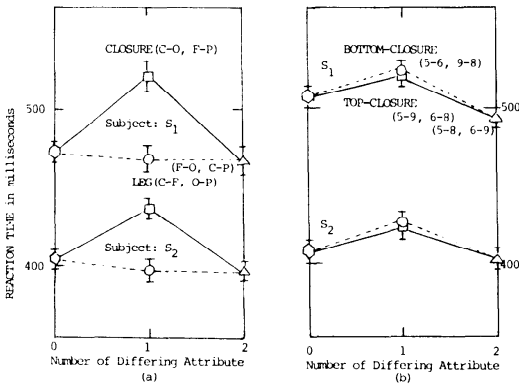


Fig. 2 Mean RTs versus N (number of differing attributes) for 2 Ss.

**Explanation by serial self-terminating model (Fig. 3a):** S compares one attribute at a time and responds DIFFERENT as soon as a difference is detected. Consider the case shown in Fig. 3a1, in which S compares the LEG attribute at the first stage. If no difference is detected, S goes into the next stage for CLOSURE comparison, otherwise S responds DIFFERENT. If no difference is detected again, S responds SAME, otherwise DIFFERENT. Fig. 3a2 shows another possible case in which S compares the CLOSURE at the first stage and the LEG at the second stage. The results obtained for S<sub>1</sub>, for example, are quite consistent with

\*For the SAME response, our data show significantly shorter reaction-times than expected. The same situations were reported also by many authors<sup>(2)</sup>.

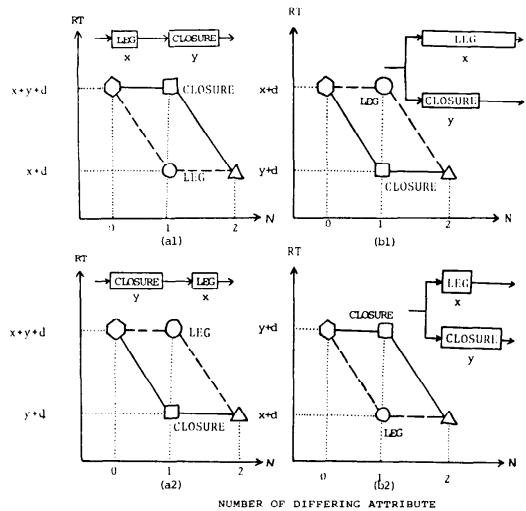


Fig. 3 Serial and parallel self-terminating models.

the model shown in Fig. 3a1 if we set  $x + d = 469$  msec. and  $y = 53$  msec.

**Explanation by parallel self-terminating model (Fig. 3b):** The term self-terminating means that all attributes of the first pattern can be compared simultaneously with all attributes of the second pattern and S responds DIFFERENT as soon as a difference is detected. These situations can be illustrated as shown in Fig. 3b1 for  $x > y$  and in Fig. 3b2 for  $x < y$ . The results obtained for S<sub>1</sub> are consistent also with the model shown in Fig. 3b2 if we set  $x + d = 469$  msec. and  $y + d = 522$  msec.

Experiment 2: In this experiment, the attribute CLOSURE is investigated along with its location. The data obtained are summarized as shown in Fig. 2b. We have also calculated t statistics to test the significance of the difference in RTs between letter pairs or groups of the letter pairs for each subject as before. The following results are obtained regardless of Ss. (1) For the case of no attribute differing, almost no significant difference in RTs is observed among four pairs of the same letters. (2) For the cases of the DIFFERENT response, there are no significant differences between 5-9 and 6-8, 5-6 and 9-8, 5-8 and 6-9, and we have little significant difference between the group of letter pairs (5-9, 6-8) and (5-6, 9-8), but significant difference between (5-9, 6-8) and (5-8, 9-6). It may be helpful to interpret the obtained data to introduce two assumptions as follows. (1) Comparison time of TOP-CLOSURE,  $y_t$ , is equal to that of BOTTOM-CLOSURE,  $y_b$ , that is,  $y_t = y_b = y$ . As far as this assumption goes we cannot explain the results by the parallel model because the result (2) mentioned above incurs a direct contradiction to the parallel model. (2) If the serial model is the case, the order of comparison of TOP-CLOSURE and BOTTOM-CLOSURE is not specified because they are

modifiers associated with the *same* attribute CLOSURE. This assumption indicates that the probability with which two comparisons are carried in one order is equal to that in the reversed order, see Figs. 4a, 4b. Thus it follows that comparison time for TOP-CLOSURE is equal to that for BOTTOM-CLOSURE.

**Explanation by mixed serial self-terminating model:** The two assumptions introduced above lead to the model illustrated in Fig. 4c. The data obtained for  $S_1$

are quite consistent again with this model if we set  $y = 55$  msec.

**Conclusions:** The two experiments reported here provide evidences for the following: (1) The group of four letters; C, F, O, P, involves at least two relevant attributes. (2) The group of four letters; 5, 6, 8, 9, involves one relevant attribute. (3) The modifiers TOP and BOTTOM are not processed in parallel. The conclusion (3) is in agreement with the results by Marcel [3], who found that although two conjunctions of different attributes may be processed in parallel, two conjunctions of modifiers on the same attribute may not be.

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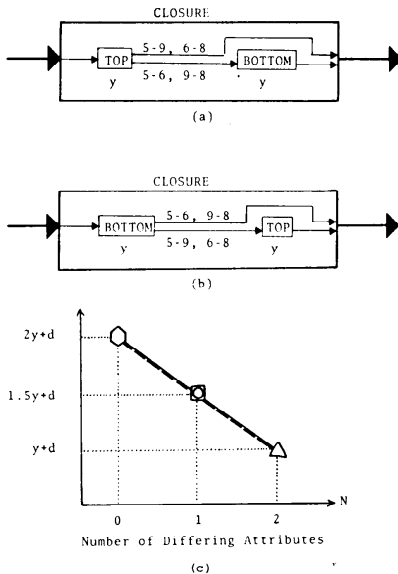


Fig. 4 Mixed serial self-terminating model.