Same-different reaction time as a function of familiarity
by Patrick Jay Davis

A thesis submitted in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in Psychology
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Abstract:
Subjects were required to discriminate identical or non-identical pairs of Japanese characters over a period of ten days. With this methodology it was possible to observe trends of reaction time (RT) from a state of unfamiliarity with the stimuli to one of relative familiarity. It was hypothesized that initially "same" RT would be longer than "different" RT, but with practice "same" RT would come to be shorter than "different" RT. A second hypothesis predicted that once subjects were familiar with the stimuli, if they were then requested to process the characters in a holistic fashion, there would be no difference between "same" and "different" RT. A trend analysis revealed that neither hypothesis was supported, although trends were in the predicted direction. The results are discussed in terms of various models of discrimination.

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Date Jan 19, 1981

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ABSTRACT

Subjects were required to discriminate identical or non-identical pairs of Japanese characters over a period of ten days. With this methodology it was possible to observe trends of reaction time (RT) from a state of unfamiliarity with the stimuli to one of relative familiarity. It was hypothesized that initially "same" RT would be longer than "different" RT, but with practice "same" RT would come to be shorter than "different" RT. A second hypothesis predicted that once subjects were familiar with the stimuli, if they were then requested to process the characters in a holistic fashion, there would be no difference between "same" and "different" RT. A trend analysis revealed that neither hypothesis was supported, although trends were in the predicted direction. The results are discussed in terms of various models of discrimination.

INTRODUCTION

In Gibson's (1969) exposition of a differentiation theory of perceptual learning, she noted that a serial-process, feature-comparison model of letter discrimination was not an adequate model. This conclusion was based on the observation that the reaction time (RT) data associated with judgments of identity of members of a pair of stimuli did not conform to the predictions of the serial model. Since this time, the issue of constructing a model that will fit the data has become a rather provocative topic.

A self-terminating, serial-process, feature-comparison model assumes that in a discrimination task the observer compares the features of the paired objects one at a time. If a difference is discovered the search terminates. Search time is assumed to be a function of the number of feature differences between the pair of stimuli. That is, RT should be longer for a pair differing on only one feature than for a pair differing on several features. Indeed, Gibson (1969), and others who have used various kinds of stimuli--letters (Bamber, 1969), geometric forms (Nickerson, 1967), faces (Smith & Neilsen, 1970), and random shapes (Cooper, 1976)--have established rather convincingly that the serial process model is a good predictor of RT for the "different" responses in a discrimination task. The problem arises when we consider the RT data for the "same" responses. The serial-process model predicts that it will take longer to make a "same" judgment than it will to make a "different" judgment. This difference is predicted because the observer must compare every single feature of the stimulus pair before he can make the "same" response. However, the research cited above indicates that this model is not a good predictor of RT for "same" judgments. Instead of taking more time than the longest "different" responses, mean RT for "same" responses tends to fall somewhere between the mean RT for the longest and shortest "different" responses.

These results have led Bamber (1969) and Cleaves (1977) to suggest that a type of dual-processing is involved. That is, when presented with a discrimination task, two types of processing are initiated simultaneously. One process is the serial process described above, while the other is a faster identity-finding process based on some type of holistic or pattern processing. Blake and Beilin (1975) investigated the developmental aspects of "same"-"different" RT and interpreted their results as supporting such a dual-process model. Lachman, Lachman, and Butterfield (1979) suggest that rather than a dual-process model, support should go to a model which is seen as having two stages. The first stage consists of pattern recognition processes that are considered to be automatic--i.e., not requiring conscious attention--and to operate in parallel. A second stage, which occurs later in the information processing sequence, is seen as being under conscious control--i.e., requiring attention--and as operating in a serial fashion.

The two-stage model can be seen as consistent with Gibson's (1969) notion of a higher-order structure if we assume that the faster pattern-recognition process is developed commensurate with experience. That is, we can make the assumption that the pattern-recognition process--and hence a pattern-discrimination process, a comparison based on the patterns of the stimulus pair--is useful to the observer only if that observer is already familiar with the stimuli to be discriminated. If this is the case, then we would expect the serial-process model to fit the data when unfamiliar stimuli are used, and the two-stage model to better explain the data when familiar stimuli are used. Indirect support for this position can be gained from the research of Kellogg (1931) and Bindra, Williams, and Wise (1965). Respectively, the tasks consisted of discriminating the relative darkness of two sides of a circular disk and discriminating two tones that varied by 60 cps. Both of these experiments employed stimuli with which the subjects were relatively unfamiliar, and both found RT for "same" judgments to be slower than RT for "different" judgments, hence conforming to the predictions of the serial-process model. On the other hand, when we consider the research that has found "same" RT to be faster we find that the stimuli used in these experiments were familiar objects such as faces, letters, and geometric forms (Bamber, 1969; Nickerson, 1967; Smith & Neilsen, 1970). Since "same" RT was faster than "different" RT in these cases, the data from experiments using familiar stimuli seem to support a two-stage model. To describe the relationship between familiarity of stimuli and relative RT we can suggest that when a subject is exposed to an unfamiliar stimulus pattern, the subject does not have a stored memory representation for that pattern and hence must resort to the serial process to make both "same" and "different" judgments. However, once the subject has established a memory representation for the stimulus pattern, then that individual can begin to make comparisons based on the overall patterns rather than relying on the serial process. If uncertainty remains after completion of the pattern-discrimination process, however, then in the interest of uncertainty reduction the subject may proceed with the serial process in order to make a confident response. This could explain why the "different" response takes longer than the "same" response once the subject is familiar with the stimuli. It might be that when a subject is presented with a pair of familiar stimuli, the subject may be able to base a confident "same" response on the pattern-discrimination process simply because no differences are detected. However, when presented with a "different" pair, the pattern-discrimination process may only tell the subject that there is a difference, but not what the nature of that difference is. In order to make a confident response--that is, to be sure that the response is correct--the subject will have to resort to the serial process, which will allow feature examination and hence uncertainty reduction. This strategy would make sense, since subjects are generally asked to respond as fast as possible while keeping error rates low.

LaBerge and Samuels (1974) found a familiarity effect in which subjects became faster at discriminating unfamiliar letter pairs over a period of five days. They interpreted their results as supporting an automatic-processing theory which holds that the reduction in RT is due to less attention being required to process familiar stimuli than unfamiliar stimuli. LaBerge favored a hypothesis emphasizing the emergence of a higher-order structure in which unitization of the features of a letter takes place, creating a meaningful unit that can then be processed much faster as a pattern. LaBerge's automaticity theory is consistent with the two-stage model of discrimination, since once unitization has taken place a memory representation for that letter as a pattern has been established, and RT is facilitated. This study did not consider the effects of familiarity on RT for "same" and "different" responses. An experiment by Ambler and Proctor (1976) however, attempted to investigate the familiarity effect for "same" and "different" responses. "Same" and "different" RT was measured for American and Japanese subjects on both English and Japanese letters. The authors found a significant effect of familiarity, but no significant effect of response type (same vs. different). An examination of the mean RTs, however, reveals that both Japanese and American subjects responded faster to identical pairs than to non-identical pairs and that this effect was more pronounced with familiar letters than with unfamiliar letters. The authors asserted that the effect obtained by the Japanese subjects could not be safely called a familiarity effect since these subjects had had 11 years of experience with the English language. Looking only at the data of the American subjects we find that for unfamiliar stimuli RT was only 12 msec faster for "same" responses than for "different" responses, while for familiar stimuli mean RT was 52 msec faster for "same" responses.

With these observations in mind, it seems that the relative speed with which subjects can make "same" vs. "different" responses might be a function of familiarity. That is, when presented with pairs of unfamiliar stimuli, subjects use a strictly serial process for making both "same" and "different" responses. However, when presented with familiar stimuli, identity pairs are compared by a holistic pattern-discrimination process and a decision can be made before the serial process is initiated. The serial process is used only in making the "different" responses. This explanation would predict a relatively slower "same" RT when the stimuli are unfamiliar and a relatively faster "same" RT when the stimuli are familiar. If this is the case, then the Ambler and Proctor data should have shown slower RT for the "same" responses relative to the "different" responses for the unfamiliar stimuli. The fact that this was not the case might be explained by the observation that the data from four blocks of 32 trials were combined before being analyzed. It might be that 128 trials provided sufficiant practice for the subjects to establish memory representations of the Japanese characters, thus enabling them to base their "same" responses on a discrimination of the character patterns, hence obscuring the differential RT predicted by the two-stage model.

Thus, the initial hypothesis of the present experiment is that if American subjects are presented with unfamiliar stimulus pairs (Japanese characters) and are required to make "same"-"different" discriminations over a period of days, the initial sessions will show slower RT for "same" responses relative to "different" responses. However, as subjects become familiar with the stimuli this pattern of results should change such that "same" responses will come to be faster relative to "different" responses.

A second hypothesis predicts that once subjects are familiar with the Japanese stimuli, if they are requested to base all responses on a comparison of the overall patterns of the stimulus pair and to avoid looking for feature differences, then the difference between

RT for "same" and "different" responses should disappear. The rationale behind this prediction is that subjects should be able to base "different" responses on the pattern-discrimination process just as they do the "same" responses. The reason subjects do not do this naturally is assumed to be because there is too much uncertainty involved in making a "different" response based on the limited information availible from the pattern-discrimination process. If the experimenter specifically requests this type of comparison, however, subjects may be more inclined to make pattern comparisons, since this type of comparison is emphasized while accuracy becomes secondary.

METHOD

Subjects

The subjects were 10 volunteers from upper division psychology courses at Montana State University. They were each paid $15.00 for participating in the experiment. Only individuals who were right handed and who had normal or corrected-to-normal vision were allowed to participate. The subjects ranged in age from 19 to 36 years; the mean age was 23.8 years. Half the subjects were male and half were female.

Stimuli

Sixteen Japanese characters were used in the experiment. The stimuli were obtained from the Ambler and Proctor (1976) article. The selection of 16 characters yielded 16 identity pairs. Sixteen non-identity pairs were randomly constructed with the constraint that no single character could appear more than twice in the non-identity portion of the deck. The Japanese characters were photographically enlarged and then made into rubber stamps which were then used to create the stimulus cards. The stimulus pairs subtended a visual angle of 40' vertically at a distance of 56.4 cm. Members of a pair were placed on either side of a fixation point, and the center of each member was displaced from the fixation point by a visual angle of 56'. A 32-card deck of practice stimuli was constructed in a similar fashion using English letters.

Apparatus and procedure

The stimuli were presented using front illumination in a Gerbrands two-channel tachistoscope. Two telegraph keys were used to register responses, and RT was measured using a Hunters 120C Klockcounter. Subjects were required to make a "same"-"different" response following stimulus presentation. Half the subjects used the right hand for the "same" responses, while the other half of the subjects used the left hand for "same" responses. Subjects were asked to respond as fast as possible while keeping the error rate low. Subjects observed a fixation point until onset of the one-sec stimulus presentation. A 32-trial block of practice stimuli was presented at the beginning of each session. Following the practice stimuli two complete, randomly ordered, blocks of 32 trials each were run using the experimental stimuli. Each block consisted of 16 identity pairs and 16 non-identity pairs. Subjects were run for 10 days, with a two day break between days 5 and 6. The order of the experimental stimuli was randomized before each session each day. Each session took about 20 min to complete, including instructions and practice trials. On the ninth and tenth days the subjects were given the following instructions:

> There are two ways to conceive of what is going on in this task. One is that you process the letters as a whole, that is, based on their overall patterns. The other is that you compare the letters in terms of their features, that is, the separate parts of the letters. What I want

> you to do today is to try and respond entirely on the basis of a comparison of only the patterns of the letters. This means that you will not make comparisons by checking the individual features or parts of the letters, but rather you will make your decision purely on the basis of a comparison of the overall patterns of the letter pair. I would still like you to respond as rapidly as possible.

If these instructions were not clear to the subject, further explanation was offered.

RESULTS

Figure 1 shows mean RT across sessions for both "same" and "different" responses. The data obtained for each subject were averaged for each session, resulting in a single mean "same" RT and a single mean "different" RT. Eight planned comparisons were made using an analysis-of-variance test for the analysis and comparison of trends across repeated measures. The first hypothesis--that familiarity would interact with the relative RT for "same" and "different" responses--was tested with two comparisons. In the first, "same" and "different" trends were compared across the first eight days of the experiment. This comparison was not significant, $F(1, 9) = 1.44$, $\underline{MS}_e = 1867.5$, $\underline{p} > .05$. In the second, "same" and "different" trends were compared only across the first four days of the experiment. This comparison revealed an interaction that approached significance at the .05 level, $F(1, 9) = 5.07$, $\underline{MS}_e = 2504.2$, $\underline{p} < .051$. The second hypothesis--that the instructional manipulation on the ninth and tenth days would result in "different" RT approximating that of "same" RT--was tested by a comparison of "same" and "different" trends over the last three days of the experiment. This comparison was not significant, $F(1, 9) < 1$, $\underline{MS}_e = 1567.7$.

A significant effect of familiarity was revealed by three comparisons. A comparison of combined "same" and "different" responses revealed a significant linearly decreasing trend across the first

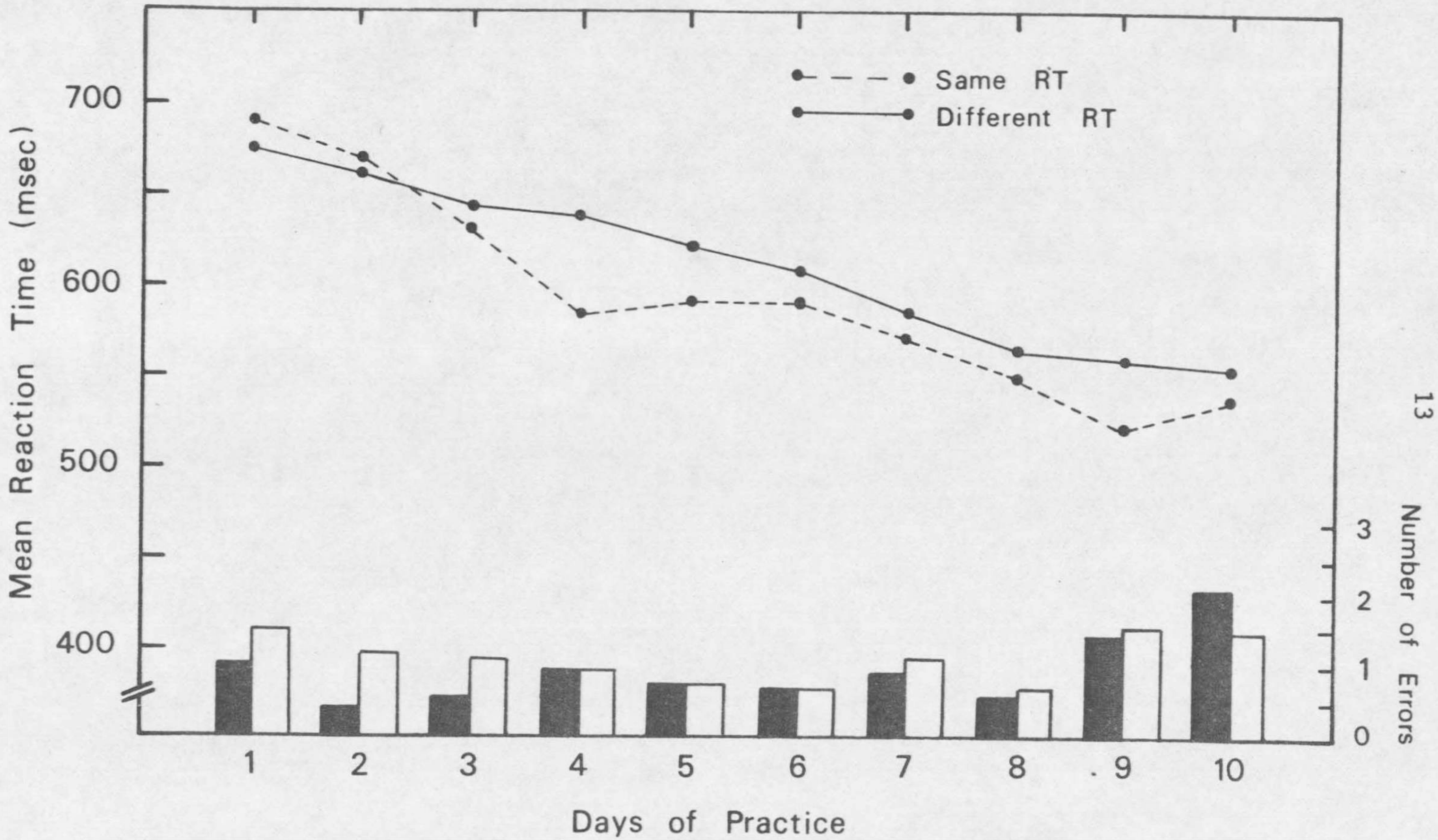

Figure 1. Mean "same" and "different" reaction time as a function of familiarity (number of days of practice). Mean error data are shown at the bottom of the figure for both "same" (shaded), and "different" (unshaded) comparisons.

eight days of the experiment, $F(1, 9) = 11.08$, $\underline{MS}_e = 21980.8$, $\underline{p} < .01$. A comparison of "same" responses only revealed a similar significant trend, $F(1, 9) = 10.72$, $\underline{MS}_e = 13870.5$, $\underline{p} < .01$, as did comparison of "different" responses only, $F(1, 9) = 9.78$, $\underline{MS}_e = 9977.8$, $\underline{p} < .05$.

Two additional comparisons compared the mean "same" and "different" RT on both Day-1 and Day-8 of the experiment. Neither comparison revealed a significant difference, $F(1, 9) = .40$ and 1.02, $\underline{MS}_e = 2700.5$ and 974.8, respectively.

Error rates are shown at the bottom of Figure 1. Error rates for the "same" responses are shown by the shaded columns, while error rates for "different" responses are shown by the unshaded columns. As can be seen, error rates in general decreased slightly over the first eight days and then increased on days 9 and 10.

Cooper (1976) has suggested that there may be two types of subjects, each of which uses somewhat different processes when presented with the "same"-"different" task. Type I subjects appear to use only a holistic comparison process, while Type II subjects seem to use both holistic and serial processes. It was decided that additional light might be shed on the matter if the subjects were separated according to the Type I-Type II classification scheme. Mean RT was computed for the individual subjects, with RT for "same" and "different" responses combined, over the first two days of the experiment. This procedure allowed separation of the Type I and

Type II subjects on the basis of clusters of mean RT points. Type II subjects should show a greater mean RT than Type I subjects since Type II subjects are assumed to be using the slower serial process. It should be noted that only two subjects seemed to fit the Type II catagory while seven subjects were classified as Type I. One subject was not included in this analysis because his mean RT was intermediate and hence could not be easily placed in either catagory. Mean RT for Type I subjects was 600 msec and mean RT for Type II subjects was 933 msec. Figure 2 shows mean RT of "same" and "different" responses for both Type I and Type II subjects as a function of familiarity. Mean error rates are shown at the bottom of the figure. These error rates are for "same" and "different" responses combined. As can be seen, the two types of subjects yielded two quite different trends across days of practice. Type I subjects showed little or no reduction in RT for either "same" or "different" responses, while Type II subjects showed a rather pronounced downward trend. In addition, Type I subjects seemed to have consistently faster "same" RT relative to "different" RT throughout the entire experiment. For Type II subjects, "different" RT was an average of 29 msec faster than "same" RT for the first three days of the experiment. On the fourth day this pattern reversed itself, and on the ninth day RT dropped to the level of the Type I subjects. Over the entire ten days of the experiment Type II RT dropped a total of 385 msec.