Response probabilities and "same-different" reaction times

BRUCE D. DOWNING
Kent State University, Kent, Ohio 44240

A "same-different" reaction-time (RT) task with multidimensional stimuli was used with a 50:50 and a 75:25 proportion of "different" to "same" response. The "different" RTs to each dimension were similar for the two proportions. However, the "same" RT in the 50:50 condition was faster than the "same" for the 75:25 condition and faster than the slowest "different" RT. Interpretations of the results in terms of response bias and processing criteria are offered.

Several recent studies have been concerned with the information processing involved in multidimensional stimulus discriminations. Egeth (1966) constructed nine possible processing modes that could be used by Ss in a same-different reaction-time (RT) task, with stimuli varying on one, two, or three binary dimensions. These models were based upon such factors as parallel vs serial processing, random vs fixed order of processing, self-terminating vs exhaustive search and template matching. His results narrowed the alternatives to two possible modes: serial/self-terminating/random order of search or parallel/self-terminating/statistically distributed search time.

Hawkins (1969) reported a series of three experiments using a task similar to Egeth's. However, the dependent measure (RT) in Hawkins's study was based upon a Donder's Type c reaction, in which only one kind of response (either same or different) was made on a block of trials, rather than a Type b reaction, in which both responses were made within a block of trials. Hawkins reasoned that a Type b reaction may cause response bias and result in the finding of Nickerson (1967) that same judgments for three trinary dimensions were faster than the different judgments for differences along one dimension. If a search is exhaustive, then Ss should test all three dimensions before making the same judgment, and the same RT should be at least as slow as the slowest different RT.

Hawkins concluded that his findings were totally consistent with none of Egeth's (1966) models, but that the findings were consistent with a model incorporating the following assumptions: (1) stimulus dimensions are interrogated simultaneously (parallel processing), (2) decision time for any dimension is distributed from trial to trial as a random variable, (3) self-terminating comparisons, and (4) the time required to determine the state of a given dimension covaries with the average time required to determine the

state of other dimensions present within a stimulus deck (correlated criteria).

Downing and Gossman (1970) conducted a series of three experiments using a slightly different technique with a multidimensional same-different RT task. They used three dimensions which differed significantly in terms of the mean RT for different judgments, when only one dimension would be different on a single trial. That is, Ss would have to monitor all three dimensions, but only one at a time (if any) would differ, thus eliminating the possibility of interference from irrelevant differences. Downing and Gossman reasoned that if the dimensions were tested serially, removal of a quickly judged dimension would lower the RTs for other dimensions, whereas, removing slower dimensions would have no effect on faster dimensions. On the other hand, if processing was parallel and the difference between dimensions on RT were due to discriminability differences, then removal of a dimension would produce no RT changes. The results showed no changes comparing conditions with three dimensions to monitor and two dimensions to monitor. Therefore, processing was concluded to be parallel. Furthermore, same RTs were slower than the slowest different RT, whereas previous investigators have found same to be faster.

Bamber (1969) tested the predictions of a serial self-terminating model that assumed processing and efferent isochronality. Processing isochronality means that the processing time for a dimension is independent of whether it is same or different, and efferent isochronality indicates that the time between the decision to respond and the response is independent of whether the response is same or different. If both types of isochronality hold, then the same response should be slower than the different response, regardless of whether processing is serial or parallel.

Bamber's data failed to support the serial self-terminating model, and the

greatest evidence of this failure was the inability of the model to predict same RTs. The obtained same RTs were consistently faster than obtained different RTs and faster than the predicted same RTs.

Bamber proposed a two-process model to explain his results. The two processes are a relatively slow difference analyzer, which works in series, and a faster identity analyzer. The difference analyzer emits either a "same" or a "different" signal, whereas the identity analyzer emits only a "same" signal. A match between the "same" of the identity analyzer and the "same" of the difference analyzer results in a fast "same" response, whereas only the "different" signal from the difference analyzer produces a "different" response. When the test stimulus is "same," both analyzers emit "same" signals, but, since the identity analyzer is faster, it has already initiated a "same" response by the time the difference analyzer emits a "same." Therefore, the "same" response is faster than the "different" and faster than would be expected by the serial self-terminating model.

It is interesting to note that Egeth (1966), Nickerson (1966, 1967), and Bamber (1966) have found same judgments faster than difference judgments, whereas Downing and Gossman (1970) did not obtain this result. One major difference between the Downing and Gossman study and the other studies was that Downing and Gossman used a 75:25 proportion of "different" to "same" stimuli, whereas the other investigators used a 50:50 proportion. It is possible that these proportion differences can account for the relative speeds of "sames" and "differents." Consider, for example, the Downing and Gossman (1970) situation with three relevant dimensions that differ in the RT for "different" judgments. With a 75:25 proportion of different to same stimuli, the initial probability of a "different" is .75. After sufficient time for detecting a difference on the first dimension and no difference is found, the probability of a difference on the remaining two dimensions (assuming an equal number of differences on each dimension) is .66. If no difference is detected after sufficient time for analyzing the first two dimensions, there is still a .50 probability that the third dimension is different. As long as the finishing time for the analysis of each dimension was different—it would not matter if the process was parallel self-terminating or serial self-terminating—the above probabilities would hold. However, if there were a 50:50 proportion of "same" to "different" stimuli, then the initial probability of "different" would be .50.

After one dimension, it would reduce to .40 and would be .33 for the final dimension. Therefore, the probability of a "same" becomes much higher toward the end of the total processing time, and there may be a bias toward "same" which develops over time and accounts for the fast same judgments for 50:50 proportions.

The following study was designed to test the hypothesis that the manipulation of the proportion of "same" and "different" responses would influence the RTs for these responses. More specifically, the hypothesis is that same judgments will be faster for a 50:50 proportion than for a 75:25 proportion of "different" to "same" responses.

METHOD

Subjects

Eight introductory psychology students (six males) served for a 1-h session in which they received all experimental conditions. Course credit was given for participation. All Ss had normal vision.

Stimuli and Apparatus

The stimuli were the same as those described by Downing and Gossman (1970). They consisted of simultaneously presented pairs of triangles which could vary on the binary dimensions of color (red or green), vertical displacement of a dot (up or down), and the number of borders inscribed on the edge of the triangles (one or two).

The pairs of triangles were rear projected on a frosted-glass screen by a Kodak Carousel projector. The opening of a shutter on the projector started a Hewlett-Packard electronic clock, which was stopped by the S's buttonpressing response. Reaction times to the nearest millisecond, along with the S's responses, were printed automatically on a Hewlett-Packard printer.

Procedure

Each S was run under two conditions, the order of which was counterbalanced. Both conditions had three relevant dimensions, but under one condition there was a 50:50 proportion of sames and differences, and under the other condition there was a 25:75 proportion of sames to differences. In the 50:50 condition there were 33 sames and 11 of the differences on each dimension. In the 25:75 condition there were 16 sames and 16 of each of the differences.

Ss were seated at a table directly in front of the projection screen. A platform with two buttons, labeled "same" and "different," was on the table. Ss were instructed to push the buttons with their index fingers, and the left-right position of

the same and different buttons was counterbalanced. Instructions emphasizing speed and accuracy were given, and a \$10 prize was offered for the person with the fastest overall RTs corrected for errors. All Ss served in both the 50:50 and 75:25 conditions, with half of the Ss receiving each condition first. After an example of stimulus pairs exhibiting the three dimensions was shown, Ss were given 40 practice trials on the condition they were to receive first.

RESULTS

The geometric mean RTs for "different" RTs on each dimension and for "same" RTs for each proportion condition are presented in Table 1. An analysis of variance was computed with the mean RT of each S for all conditions as the dependent measure. This analysis contained one between (order) and two within (proportions and dimensions, considering "same" along with "different" RTs for dimensions) variables. The main effect of dimensions is significant ($F = 26.66$, $df = 3/18$, $p < .01$), but the main effect of order and the main effect of proportions are not significant. Also, none of the interactions are significant. However, Newman-Keuls analyses indicate that the difference in same RTs for the two proportions is significant ($p = .05$).

There were 8% errors in the 50:50 condition and 6% in the 75:25 condition. Since the "same" RT for the 50:50 condition was faster than the slowest different RT, one might expect more false "same" responses in this condition than in the 75:25 condition. Indeed, there were twice as many false sames for the 50:50 condition, although the number of false sames are too few for statistical analysis (6.8% in the 50:50 condition, 3.4% in the 75:25 condition).

DISCUSSION AND CONCLUSIONS

The results of this experiment indicate that sames can be initiated faster than the slowest "different" RT when there is a high probability of a same response. This seems to be accomplished without a great number of errors, and only the RTs for sames are affected by the proportion of sames and differences.

These results pose difficulties for some of Bamber's (1969) assumptions. First of all, it is doubtful that both processing and efferent isochronality hold, since the time for initiating a response was dependent on whether the response was same or different. Secondly, the Bamber two-process explanation of fast same responses does not predict changes in the speed of the identity analyzer with changing response probabilities.

Table 1
Mean RTs for "Different" and "Same" Responses as a Function of Response Proportions

		Different RTs			
		Color	Dot	Border	Same
50:50	.733	.936	1.028	.957	
25:75	.725	.932	1.052	1.051	

A more parsimonious explanation would be a single detection of identity or difference, coupled with a response bias toward "same," with increases in the probability of an identity detection. However, this explanation might predict slower "different" RTs as the bias toward "same" increases. That is, a correct "different" response on the slowest dimension would be made by overcoming the bias toward "same" in the 50:50 condition. Therefore, one would expect an increase in the RT for different on the slowest dimension in the 50:50 condition when compared to the 75:25 condition, where there would be less bias toward "same." The fact that the data of the present experiment demonstrate no such changes in "different" RTs, may indicate that this explanation is too simple.

Another explanation for the difference in "same" RT with the proportion change might be in terms of changing processing criteria. That is, a high proportion of "same" responses may lower the time a S will continue processing the stimuli looking for a difference. Ss may be able to initiate a correct "same" judgment with minimal information if there is a high probability of being correct, but would wait for a longer time to be sure of their judgments if the probabilities are equal. Again, the 50:50 condition presents a situation in which there is a .66 probability of "same" after sufficient time has passed for "different" responses on the first two dimensions, whereas the comparable probability is .50 for the 75:25 condition. Nothing in the present data suggests a means of choosing between the response bias or processing criterion explanations.

The Bamber (1969) serial self-terminating model may have provided a better fit to the "same" RT data of his study if a different proportion of sames to differences were used. He used a 50:50 proportion and the obtained "same" RTs were lower than the predicted. The present study indicates a lowering of sames with a 50:50 proportion. At the very least, this study indicates that the interpretation of parallel or serial processing from "same" responses must be made with caution because of the possibility of response bias.

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