The influence of irrelevant information on speeded classification tasks*

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Multidimensional stimuli, which could vary on one, two, or all three dimensions within a particular series, were presented to Ss who were required to classify each stimulus on the basis of its value on a specified dimension. The prior relevance of the irrelevant dimensions and the difficulty of the task were varied. Latency and error data indicated that Ss were unable to gate the irrelevant information effectively. It was further concluded that this lack of perfect gating cannot be simply attributed to competing responses learned during the experiment.

When complex stimulus material is to be sorted into categories, it is normally the case that this sorting is done on the basis of some particular aspect of this material, other aspects being ignored. In the literature dealing with the speeded classification of stimulus material, "gating" or "filtering" is said to occur when the presence and variation of irrelevant information (information in the display not necessary for the classification) has no noticeable effect on the performance of the classification.

Previous investigations of the extent to which it is possible to gate irrelevant information while performing a speeded classification task have produced results that seem not to be consistent. In particular, Gregg (1954), Hodge (1959), Montague (1965), Egeth (1966), and Morgan and Alluisi (1967) reported substantial interference effects due to variation along dimensions of the stimulus display that were supposedly irrelevant, while Archer (1954), Morin et al (1961), Fitts and Biederman (1965), and Imai and Garner (1965) reported no such interference. This literature has been reviewed in some detail by Egeth (1967).

While it is true that these studies have differed in the types of stimulus material used, in the prior relevance of the irrelevant information, and in the difficulty of the tasks in the absence of any irrelevant information, it is by

no means clear which of the respects in which these studies have differed are critical in determining whether or not interference will occur.

Hodge (1959) and Montague (1965) tested the hypothesis that irrelevant information impairs the processing of relevant information because it evokes competing responses. Both studies showed that the inclusion of irrelevant information which had previously been relevant during the experiment resulted in performance decrements. The results of Archer (1954), Morin et al (1961), and Fitts and Biederman (1965) are consistent with this competing-response (CR) hypothesis, since for no Ss were irrelevant dimensions ever relevant during the experiment. The results of Egeth (1966) are also consistent, since irrelevant dimensions were relevant in other conditions. Although the CR hypothesis seems strongly supported by the evidence cited above, it cannot account for the results obtained by Imai and Garner and by Morgan and Alluisi. Moreover, a careful analysis of the Hodge and Montague studies suggests that they may possibly not have been totally appropriate tests of the CR hypothesis.

The Montague study seemed to confound task complexity with response competition. Montague used "primary" dimensions to indicate which "secondary" dimensions were relevant in his "sometimes relevant" condition, whereas in the "never relevant" condition, the same secondary dimension was always relevant. In other words, in one condition Ss had first to process primary dimensions to determine which secondary dimension was relevant, whereas in the other condition Ss knew, even before the stimulus was presented, which secondary dimension would be relevant. There were performance differences between the two conditions, but it is not obvious that they can be attributed solely to response competition.

In the Hodge study, Ss were possibly forced into the strategy of trying to process all of the dimensions with which they were presented. The very complex (up to 10 binary dimensions) stimuli were presented for only 0.5 sec. Ss had to determine which secondary dimensions were relevant on the basis of the values of the primary dimensions. Latencies varied from about 4.0 sec on the first block of 128 stimuli in the maximum irrelevancy condition (with about 65% error) to about 1.5 sec on the last trial block in the condition of minimum irrelevancy. There was no condition in which irrelevant dimensions which were never relevant were varied. It is thus difficult to say whether irrelevant dimensions interfered because they had previously been relevant and hence evoked competing responses or because Ss attempted to encode as much of the stimulus as possible while it was still present before deciding which secondary dimensions were relevant.

The results of Imai and Garner seem to defy any explanation consistent with the CR hypothesis. Using a card-sorting task, Imai and Garner were able to demonstrate perfect filtering, even though there was ample opportunity for competing responses to be learned. Certain reservations about the implications of this study for the CR hypothesis have been expressed by Egeth (1967).

In the present study, stimuli similar to those used by Imai and Garner were employed in a discrete reaction-time classification task in an attempt to assess the role of competing responses learned during the experiment.

EXPERIMENT 1

The literature suggests that the extent to which irrelevant dimensions can be filtered is a function of the discriminability of the relevant dimensions and the previous relevancy of the irrelevant dimensions. Consequently, both factors were varied in Experiment 1. A discrete reaction-time task involving binary classification was employed. Stimuli similar to those of Imai and Garner were used, and discriminabilities were varied over a fairly wide range.

Method

Subjects. Eight female and seven male Ss were hired through the University of Oregon Employment Service and were paid at the rate of \$1.50 per hour. All Ss were less than 30 years of age.

Stimuli. Stimuli were generated by a PDP-9 computer and displayed on a Tektronix 503 oscilloscope. Stimuli were squares within which were displayed two dots. The 4 x 4 cm

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Fig. 1. Illustration of the dimensions D, P, and O in the stimuli used in Experiment 1.

squares consisted of 20 evenly spaced dots along each side and appeared 1 sec before the onset of the two inside dots. The three dimensions along which the stimuli could vary are illustrated in Fig. 1 and were as follows: (1) the distance between the inside dots (D); (2) the locations of the inside dots relative to the vertical axis of symmetry, SS' , of the square, as measured by the lateral displacement of a hypothetical vertical line, MM' , through the midpoint of the two dots from the vertical axis of symmetry (P); and (3) the orientation of the inside dots relative to one another, as measured by the angle made with the vertical of the hypothetical line joining the two dots (O). For Dimension P a positive displacement was to the right, and for Dimension O a positive angle resulted when the top dot was to the right of the bottom dot.

Each dimension had a "null" value, which it assumed when it was not varying within a block of trials, and six other possible values, which it could assume when it was varying, making up three levels of discriminability. The possible values of the stimuli on each of the dimensions are given in Table 1.

Presentation of stimuli. Ss were run individually and sat facing the oscilloscope such that they viewed the screen from a distance of about 1 ft. Stimuli were presented alternately at two fixed positions, one on the upper part of the screen and one symmetrically located on the lower

part. This method of presentation was adopted to prevent any interference resulting from the rather long persistence of the P7 oscilloscope phosphor.

The square always appeared 1 sec before the two inside dots. After a response, feedback as to the accuracy of the response was displayed for 2 sec. The offset of this display coincided with the onset of the square for the next trial.

Seven different sets of stimuli were used. Stimuli varied along only one dimension for each of Sets 1, 2, and 3; along two dimensions for Sets 4, 5, and 6; and along all three dimensions for Set 7. When a dimension was free to vary, it could assume any of its possible values except its null value, so that all stimulus sets contained stimuli at different levels of discriminability. Each block of trials using a particular stimulus set contained 54 stimuli, the particular stimuli being displayed being chosen randomly from the sets of possible stimuli.

Task. Ss were required to classify each stimulus into one of two categories by pressing one of two keys, each of which operated a microswitch. The keys were operated by the first fingers of each hand. Classifications were to be made on the following basis: (1) If D was the relevant dimension, Ss were to press the right key when one of the three larger distances occurred and the left key when one of the three smaller distances occurred. (2) If P was the relevant dimension, Ss were to press the right key when the two inside dots, taken together, were displayed to the right of the vertical axis of symmetry of the square, and the left key when they were displaced to the left. (3) If O was the relevant dimension, Ss were to press the right key when the top dot was to the right of the bottom dot and the left key when the top dot was to the left of the bottom dot.

A 2-kc clock was started when the two inside dots appeared and was stopped when a response was made.

In Condition 1, Ss were required to classify stimuli on the basis of different dimensions for different blocks of trials. Six Ss were assigned to Condition 1, three serving for 3 days and three for 5 days. Each session lasted about 1 h. The first day was a practice day during which Ss were

provided with 30 practice trials from each relevant-dimension/stimulus-set combination. For example, three blocks of 30 stimuli from Set 7 were presented, each block with a different dimension relevant. On each subsequent day, Ss were presented with nine blocks of 54 trials, one block from each of Sets 1-6 and three blocks from Set 7 (one block with each dimension relevant). As two dimensions were free to vary for each of Sets 4, 5, and 6, if one of these dimensions was relevant on one day, the other was relevant on the next. The orders in which sets varying on one, two, and three dimensions were presented were counterbalanced across Ss. For each block of stimuli, Ss were instructed as to which dimension was relevant, were given 10 practice trials, and then were given 54 trials from which data were collected.

In Condition 2, the same dimension was always relevant for each S. Nine Ss served for 2 days, three Ss classifying on the basis of each dimension. Stimuli from only four of the seven stimulus sets were presented to any S, since a particular dimension was free to vary in only four sets. The first part of Day 1 was used for practice, much as in Condition 1. Data were recorded from 12 blocks of trials, four each with one, two, and three dimensions varying. As in Condition 1, each block of 54 trials was preceded by 10 practice trials.

Instructions to Ss emphasized both speed and accuracy.

Results

Condition 1. The data collected during the first 2 experimental days are summarized in Fig. 2. Analysis of variance of the latency data¹ revealed significant effects for the number of irrelevant dimensions varying, $F(2,10) = 9.66$, $p < .01$, the level of discriminability, $F(2,10) = 12.29$, $p < .01$, and which dimension was relevant, $F(2,10) = 4.44$, $p < .05$. Significant interactions were found for Discriminability by Irrelevancy, $F(4,20) = 4.75$, $p < .01$, Discriminability by Relevant Dimension, $F(4,20) = 7.32$, $p < .01$, and Irrelevancy by Relevant Dimension, $F(4,20) = 3.17$, $p < .05$.

Condition 2. The data collected in Condition 2 are summarized in Fig. 3. Analysis of variance of the latency data showed a significant interference

Table 1
Specification of the Stimuli Used

Dimension	Null Value	Discriminability		
		Level 1	Level 2	Level 3
Distance	20 mm	20 ± 2 mm	20 ± 4 mm	20 ± 6 mm
Position	0 mm	± 1 mm	± 2 mm	± 8 mm
Orientation	0 Deg	± 1.5 Deg	± 5.0 Deg	± 25.0 Deg

Fig. 2. Mean RTs for correct responses and error percentages in Condition 1.

due to the irrelevant dimensions, $F(2,4) = 9.08$, $p < .05$. The effects of discriminability, $F(2,4) = 35.85$, $p < .01$, and relevant dimension, $F(2,4) = 7.59$, $p < .05$, were also significant, as was the Discriminability by Relevant Dimension interaction, $F(4,8) = 4.14$, $p < .05$.

Comparison of Conditions 1 and 2. Statistical analysis took the form of an unweighted means analysis of variance (Winer, 1962). Separate analyses were performed for each relevant dimension. In none of these did the condition effect approach significance, $F(2,7) < 1$. For each of these analyses, the irrelevancy and discriminability effects were significant.

Practice. Since three Ss in Condition 1 had served for 4 experimental days, an analysis to determine the effects of practice on the performance of these Ss was conducted. The main effect of days of practice was significant, $F(3,6) = 5.29$, $p < .05$, but none of the interactions with practice were significant.

Errors. In general, the error data were fairly consistent with the latency data, those situations having greater mean latencies also tending to have higher error rates. As there were relatively few errors, however, the error data were less stable than the latency data. When error data were subjected to analysis of variance (after the appropriate arcsin transformation), the only significant effects for Condition 1 were those of irrelevancy, $F(2,10) = 4.92$, $p < .05$, and discriminability, $F(2,10) = 68.23$, $p < .01$. For Condition 2, only discriminability was significant,

$F(2,4) = 76.97$, $p < .01$. Of course, less power was available for Condition 2, since relevant dimension was here a between-Ss rather than a within-Ss variable.

Discussion

The results of Experiment 1 both contradict those of Imai and Garner (1965) and are highly inconsistent with the CR hypothesis. Ss were able to classify on the basis of a particular dimension most efficiently when that dimension was the only one varying throughout a block of trials. It did not seem to matter whether irrelevant dimensions had previously been relevant or not.

Since the stimuli employed in Experiment 1 were very similar to those of Imai and Garner, the different results must have been caused by other features of the two experiments. In the Imai and Garner card-sorting task, stimulus cards were held face-up by Ss, thus allowing some "preview" of a particular card while completing the process of sorting the previous card. Clearly, however, the additional processing time made available to Ss in this fashion was not sufficient for them to choose the correct response, since sorting time was a function of the level of discriminability. The discrete reaction-time task used in Experiment 1 was, however, probably more sensitive to interference effects than would be a card-sorting task. In addition, the two studies differed in their basic designs. In Experiment 1, equal numbers of trials were given at each level of irrelevancy, each block containing stimuli at all three levels of discriminability. In the Imai and Garner study, equal numbers of trials were given at each discriminability level of both the relevant and irrelevant dimensions, a particular deck of cards containing stimuli at only a fixed level of discriminability for both relevant and irrelevant dimensions. This means that in the Imai and Garner study much more practice was given when three dimensions were varying than when one dimension or two dimensions varied. Even though Experiment 1 did not show a significant Practice by Irrelevancy interaction, such an interaction may well have been important in the Imai and Garner study, since their Ss were given so much practice (150 decks of 32 cards each). Perhaps because of variation of discriminability within each trial

Fig. 3. Mean RTs for correct responses and error percentages in Condition 2.

Fig. 4. Examples of "agree" and "disagree" situations in Experiment 2. The L or R under each stimulus indicates whether the correct response was the pressing of the left or right key.

block, error rates were relatively high in Experiment 1 (exceeding 10% for Discriminability Level 1). Imai and Garner did not report error data, stating that the number of errors made was too small to allow detailed analysis.

It actually would have been quite surprising to be able to report perfect filtering in Experiment 1 since in a very real sense the "irrelevant" dimensions employed (as in the Imai and Garner study) were not strictly logically independent of the relevant dimensions. It should, for instance, be easier to judge whether a dot lies to the right or left of another dot if their vertical separation is small.

The absence of any significant condition effect or Condition by Irrelevancy interaction argues against the CR hypothesis. While there was ample opportunity for competing responses to be learned in Condition 1, interference effects were also large in Condition 2, where no irrelevant dimensions were previously relevant.

A second analysis to assess the effects of any possible competing responses was also made. As Ss were always required to make one of two possible responses, it was possible to compare performance for those situations in which (1) all of the dimensions would have called for the same response had S been attending to them (the "agree" case) and (2) the relevant dimension called for one response and the other two dimensions would have called for the other response had S been attending to them (the "disagree" case). Were competing responses built up to the irrelevant dimensions when they were relevant, one would expect to find smaller latencies and fewer errors for the "agree" case than the "disagree" case

in Condition 1, but not in Condition 2.

Unfortunately, the results of this analysis were somewhat ambiguous. Better performance occurred in the "agree" case than in the "disagree" case for both Conditions 1 and 2. This was almost certainly a result of the particular assignments of responses to stimuli in Experiment 1, which were such as to confound S-R compatibility effects with the effects of competing responses learned during the experiment. Whenever, for instance, the correct response was the pressing of the right-hand key and D or O were relevant, the dots were displaced toward the left edge of the square for "disagree" situations and toward the right for "agree" situations.

EXPERIMENT 2

Experiment 2 was designed to provide a more stringent test of the CR hypothesis than had been provided in Experiment 1. While Experiment 1 did not provide any evidence to support the CR hypothesis, it could be argued that the design of the experiment was biased against uncovering such evidence, in that (1) stimuli were presented in blocks of 54, for each of which a particular dimension was always relevant, and (2) each block was preceded by 10 practice trials. In addition, no data were collected on the first day, so that the experiment would not have been sensitive to a CR effect that diminished rapidly with practice. Finally, Experiment 1 was somewhat unsatisfactory in that the assignment of correct responses to stimuli was such as to confound the effects of S-R compatibility with those of competing responses learned during the experiment, thus precluding any unambiguous direct analysis for the effects of competing responses.

For Experiment 2, it was decided to rotate the stimuli that had been used in Experiment 1 through 90 deg and to change the response assignments so that there would not be any confounding of the effects of compatibility with the effects of competing responses learned during the experiment. The correct response assignments for Experiment 2 are shown in Fig. 4. Also in Experiment 2, data were collected after a minimum of practice on Day 1, the relevant dimension was free to change for each stimulus presentation, and practice trials on Days 2 and 3 were confined to a brief warm-up period.

Method

Subjects. Twelve female Ss were hired through the University of Oregon Employment Service and were paid at the rate of \$1.50 per

hour. Ss ranged in age from 17 to 22 years.

Description and presentation of stimuli. Stimuli were rotated 90 deg from those used in Experiment 1 so that the three dimensions along which stimuli could vary were as follows: (1) the distance between the inside dots (D), (2) the displacement of these dots relative to the horizontal axis of symmetry of the square (P), and (3) the inclination of the hypothetical line joining the two points from the horizontal (O). The possible values of the stimuli on each of the dimensions were the same as in Experiment 1 and are given in Table 1.

Whereas in Experiment 1 stimuli were presented alternately at two fixed positions, in Experiment 2 only the upper position was used. This was made possible by replacing the original P7 oscilloscope tube with a much faster P2 tube, so that there was no longer any danger of interference due to the persistence of the preceding stimulus.

When a stimulus was to be presented, a number (1, 2, or 3) was first displayed near the bottom of the screen to indicate which dimension was to be relevant. This number remained on for 3 sec. Two seconds after the number first appeared, the square came on, and 1 sec later the two inner dots were displayed. The square and the two inner dots remained on until a response had been made. After each response, accuracy feedback was displayed for 1 sec. The offset of this feedback coincided with the onset of the number for the next stimulus.

Stimuli displayed during the experiment were selected randomly from the set of possible stimuli, with the constraint that for one-third of the stimuli, one dimension was at its null value; for one-third, two dimensions were at their null values; and for the remaining one-third, no dimensions were at their null values. Stimuli were presented in blocks of 50 trials, after each of which the average reaction time for that block was displayed on the screen.

Task. As in Experiment 1, Ss were required to classify each stimulus into one of two categories by pressing one of two keys. The classifications were made on the following basis: (1) If D was relevant, Ss were to press the right key if one of the three larger distances occurred and the left key if one of the three smaller distances occurred; (2) if P was relevant, Ss were to press the right key if the inside dots, taken together, were displayed toward the top of the square and the left key if they were displaced toward the bottom; (3) if O was relevant, Ss were to press the right key if the right dot

was closer to the top of the square and the left key if the left dot was closer to the top of the square.

Three Ss were assigned to Condition 1, in which the relevant dimension could change on each stimulus presentation. Each S served for 3 consecutive days, each session lasting about 1 h. On Day 1, Ss were given five blocks of 20 practice trials, three blocks throughout which a particular dimension was relevant, followed by two blocks of mixed trials. After this practice, five blocks of 50 stimuli were presented with a 40-trial warm-up period at the beginning of the session, after which data were recorded from eight blocks of 50 trials. Thus, 1,250 responses were recorded for each S.

In Condition 2, the same dimension was relevant throughout the experiment for each S, three Ss being assigned to each dimension. Ss served for 3 days. On Day 1 they were given 40 practice trials before data were collected and on subsequent days were given 20 warm-up trials at the beginning of the session. As in Condition 1, data were recorded from five blocks of 50 trials on Day 1 and eight blocks on each subsequent day, making a total of 1,250 responses per S.

Instructions to Ss again emphasized both speed and accuracy.

RESULTS AND DISCUSSION

In Experiment 2 all dimensions varied throughout each trial block. It was possible to compare performance for those cases in which (1) all of the dimensions would have called for the same response had S been attending to them ("agree" case) and (2) the relevant dimension called for one response, and both irrelevant dimensions would have called for the other response had S been attending to them ("disagree" case). In Condition 1, competing responses learned during the experiment would be expected to cause poorer performance in the "disagree" case than in the "agree" case. If S-R compatibility effects were properly controlled, there would be no reason to expect any differences in performance for these two cases in Condition 2.

The appropriate data, pooled over dimensions, are summarized in Fig. 5. Each data point is based on approximately 200 responses for Condition 1 and 600 responses for Condition 2.

There were no significant differences between the "agree" and "disagree" cases in either Condition 1 or Condition 2. Despite the prior relevance of irrelevant dimensions in Condition 1, performance was about

Fig. 5. Mean RTs for correct responses and error percentages for "agree" and "disagree" situations in Experiment 2 (pooled over relevant dimensions).

the same whether relevant and irrelevant dimensions called for the same or different responses. The results of Condition 2 suggest that this absence of a difference in Condition 1 was not an artifact of compatibility differences between the "agree" and "disagree" cases. These results seem difficult to reconcile with the CR hypothesis.

It could be argued that the results are consistent with the explanation that prior relevance of the irrelevant dimensions interferes with the act of attending to the relevant dimension rather than with the overt responses to the relevant dimension. This explanation would predict equal performance decrements for the "agree" and "disagree" cases with previously relevant irrelevant dimensions. It was shown in Experiment 1, however, that interference effects occurred whether or not irrelevant dimensions were previously relevant. There was no evidence from either Experiment 1 or Experiment 2 to suggest that interference effects were necessarily enhanced by prior relevance of irrelevant dimensions during the experiment.

It was, then, not possible to reject the null hypothesis that there was no effect of competing responses. The criticism can be made, of course, that the effect may have been there and that the methods used were simply not sensitive enough to detect it. It should be emphasized, however, that fairly large interference effects were obtained in Experiment 1 and, in spite of the fact that Experiment 2 provided a situation which would be more likely to result in response competition than Experiment 1, there was no evidence

to support the CR hypothesis in either experiment.

There are, of course, situations in which competing responses are important. One need look no further for an example than the S-R compatibility effects encountered in Experiment 1. When, for example, the two dots were displayed near the left edge of the square, Ss were faster in making a correct left response than a correct right response. There are many other studies, such as those based on the Stroop (1935) color-word paradigm, which have demonstrated that previously learned responses can result in strong interference effects in certain situations. In most instances, however, the competing responses were highly overlearned, and were brought to, rather than acquired during, the experiment.

The results of the present study, then, merely suggest that providing the opportunity to develop competing responses does not necessarily result in performance decrements over and above those incurred by providing irrelevant information without prior relevance. As indicated earlier, the stimuli used in the present study (and by Imai and Garner) were such that the discriminabilities of relevant dimensions were not completely independent of the values of the "irrelevant" dimensions. This lack of independence seems to be the most likely source of interference in the present study.

Interference effects due to supposedly irrelevant information cannot simply be attributed to competing responses learned during the experiment, nor can they be attributed, in every instance, to any single factor. The effects of response

tendencies brought to the experiment, of differential practice, and especially of the nonindependence of dimensions must be considered.

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NOTE

1. The latency data referred to are the latencies for correct responses.

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