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The effects of irrelevant information on processing levels.

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THE EFFECTS OF IRRELEVANT INFORMATION ON PROCESSING LEVELS

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ON PROCESSING LEVELS

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Abstract

The present studies were designed to determine whether color as an irrelevant dimension would affect task performance based on different levels of information processing (Posner and Mitchell, 1967), and to try to assess whether the factors of response competition, response facilitation, and distraction contributed to these effects. It was expected that color, being a visual dimension, would have an effect on task performance based on a comparison of visual codes, and might also affect task performance based on name code comparisons. Experiments 1 and 2 were designed to determine whether, if Ss were asked to make same-different judgments about either the names of two letters presented to them (Experiment 1) or the forms of the two letters (Experiment 2), the varying of letter color on certain trials would affect task performance. According to Posner and Mitchell (1967), responses to physically identical pairs of letters are based on comparisons of visual codes of the letters; responses to name identical pairs are based on comparisons of name codes of the letters. The results indicated that irrelevant color affected responses based either on visual code comparisons or on name code comparisons. Since it seemed improbable that the matching of nominally coded information could be affected by visual factors (Posner and Taylor, 1969), it was suggested that perhaps irrelevant color affected not the comparison of the nominal information, but rather, other aspects of task performance preceding and following this comparison.

Experiment 3 investigated the possibility that the factors of

response competition, response facilitation, and distraction contributed to the effects of varying color. This notion was consistent with the observation that, in Experiments 1 and 2, "same" response latencies increased, but "different" response latencies appeared to be unaffected, when color varied. In Experiment 3, paired letters were to be judged nominally same or different. On certain trials, the colors of the letters were designed to cause both response competition and distraction (Condition SB). On other trials, the colors were designed to cause only distraction (Condition SS). The results indicated that Condition SB had a significant effect on task performance based on the visual code, and its effect on task performance based on the name code approached significance. Condition SS didn't have a significant effect on either kind of performance. It was suggested that Condition SS actually had not been a very distracting condition, and that distraction still may have been a factor contributing to the effects of irrelevant color. A difference between letters in color may be more important to causing distraction than the presence of a particular color value.

Some suggestions for separating the effects of response competition, response facilitation, and distraction, and for locating the effect of irrelevant color on task performance were given,

Introduction

The present study attempts to examine the effects of irrelevant stimulus dimensions on task performance based on different levels of information processing. Irrelevant stimulus dimensions are defined as those stimulus aspects which are present in the stimulus display, but which are not necessary to provide information for performance of some task. The literature is not consistent with respect to the effects of irrelevant stimulus dimensions. There is considerable evidence that irrelevant stimulus dimensions do affect a variety of speeded tasks, including an auditory discrimination task (Montague, 1965), a visual discrimination task (Hodge, 1959), speeded classification tasks (Egeth, 1966; Well, 1971), and absolute judgment tasks (Egeth and Pachella, 1969; Morgan and Alluisi, 1967). Other studies have not shown such effects (Archer, 1954; Fitts and Biederman, 1965; Imai and Garner, 1965; Morin, Forrin and Archer, 1961).

The response competition hypothesis is one explanation for the interfering effects of irrelevant dimensions, and is useful in explaining some of the inconsistencies between studies. According to this hypothesis, irrelevant information interferes with the primary response by producing competing responses which must be suppressed. Hodge (1959) and Montague (1965) have argued that in order to produce competing responses, a dimension irrelevant on a particular trial has to have been relevant on previous trials. Montague (1965) found that dimensions sometimes relevant to performance of a particular task caused more interference than dimensions never relevant to that task. If prior relevance is necessary for interference to occur, this would explain why no interference was seen in the Archer (1954), Fitts and Biederman (1965), and Morin, Forrin, and Archer (1961) studies, where irrelevant dimensions were never relevant to task performance. Several other studies, however, have indicated that prior relevance may not be necessary for response competition to occur. Well (1971) found interference effects of irrelevant information to be independent of prior relevance, although lack of dimension separability (Hyman and Well, 1968) may partially account for the interference observed in his study. Using multi-dimensional stimuli with independent dimensions, Green and Well (1971) also found interference effects of never-relevant dimensions. The interference of never-relevant dimensions in tasks requiring same-different judgments of paired stimuli (Green and Well, 1971), but not in tasks requiring classification of single stimuli (Archer, 1954; Fitts and Biederman 1965; Imai and Garner, 1965; Morin, Forrin and Archer, 1961) suggests that task requirements may determine whether response competition occurs. In same-different tasks, a judgment based on an irrelevant dimension may provide a basis for response that is in direct opposition to the same-different judgment based on the relevant dimension. In tasks involving the classification of single stimuli along a particular relevant dimension, the irrelevant dimension, except by virtue of its past relevance, usually offers no information about the category appropriate for a given stimulus.

Another explanation for the effects of irrelevant dimensions is the distraction hypothesis, which has been used to explain the interfering effects of irrelevant stimulus dimensions on several absolute judgment tasks (Egeth and Pachella, 1969; Morgan and Alluisi, 1967). According to this hypothesis, irrelevant dimensions, regardless of the response tendencies they elicit, cause interference simply by distracting S from primary task performance. Physiological measures normally correlated with attention, such as heart rate, indicate that, although over time, an individual becomes less responsive to an unchanging stimulus environment, he does respond to a change in that environment or to the introduction of a new stimulus (Sokolov, 1963). It is conceivable that the "orienting response" which is produced by such a situation could distract S from primary task performance. A particular dimension may thus be distracting if it represents a change in a stimulus environment to which S has become accustomed. Egeth and Pachella (1969) suggest that irrelevant dimensions, such as color, which are usually responded to in real life, may be particularly potent distractors.

There are other factors not mentioned in the previous explanations which may affect the extent to which irrelevant dimensions affect task performance. Egeth (1967) notes that where

Ss have the opportunity to preview upcoming stimuli, as in the Imai and Garner (1965) study, it may be easier to prevent irrelevant information from affecting responses based on relevant aspects of the stimuli. Both stimulus-response incompatibility (Gregg, 1954) and poor discriminability of the relevant stimulus values (Montague, 1965; Morgan and Alluisi, 1967; Well, 1971) may enhance the interfering effects of irrelevant dimensions. The integrality of stimulus dimensions, i.e., when one dimension can't occur without reflecting the value of another dimension, may be critical in determining the effects of irrelevant dimensions. Lockhead (1966) has described the dimensions of a visual stimulus as being integral if they are spatially coexistent. Garner and Felfoldy (1971) have found that irrelevant dimensions affected task performance only in stimuli having integral dimensions. Other studies using stimuli which could be described as either integral or non-integral (Egeth and Pachella, 1969; Morgan and Alluisi, 1967; Well, 1971) are consistent with this interpretation.

Another factor which may determine the effect of irrelevant dimensions is related to the processing requirements for task performance. Several studies (Posner and Mitchell, 1967; Murray, Mastronardi, and Duncan, 1972) have indicated that there is a distinction between the processing of word names and the processing of physical information. The Stroop task (Stroop, 1935), in which there is interference of color names with the naming of the ink color in which the color names are printed, is a classic example of how the requirements to process information in a certain way may cause irrelevant information to affect task performance. The interference is seen only when subjects must respond by naming ink colors, which results in the naming of the word as well (Egeth, Blecker and Kamlet, 1969). If the task can be performed on the basis of physical information alone, without name processing, there is no conflict between ink color name and word name. The effect has been eliminated in studies where Ss can discriminate ink color by counting the instances of a particular color (Derks and Calder, 1969) or by pressing response keys labeled with colored patches (Prichatt, 1968).

The problem of interest in this study is how irrelevant stimulus dimensions affect task performance based on the different levels of stimulus information processing. The notion that different kinds of stimulus information may be processed separately has recently been discussed by Posner (1969) and a series of co-workers. Posner and Mitchell (1967) presented Ss with pairs of letters, instructing them to judge the pairs as same or different either according to whether the letters were physically identical (Level I instructions) or according to whether they only shared the same name (Level II instructions). With Level II instructions, they found that "same" reaction times (RTs) to physically identical (PI) pairs of letters (e.g., "A A") were about 70 msec. faster than "same" RTs to pairs only nominally identical (NI, e.g., "B b"). In addition, when Ss were under Level II instructions, their "different"

RTs were about 70 msec. slower than "different" RTs to the same stimuli when under Level I instructions. Posner and Mitchell inferred that there exist at least two processing levels which can provide the basis for response. At one level, codes of visual information abstracted from the stimulus complex are compared and provide the basis for response. At another level, codes for name information, which take longer than the visual codes to abstract, provide the basis for response. Responses to PI and NI pairs differed in latency because the visual codes alone could be used in judging the nominal similarity of PI pairs, but name codes had to be abstracted to judge NI pairs.

A series of studies reviewed by Posner (1969) describe the relationships between the visual and name codes, and the factors that affect them. Several studies using sequential letter presentation have suggested that the efficiency of the visual code as a basis for response deteriorates rapidly over time (Boies, 1969; Posner and Keele, 1967; Posner, Boies, Eichelman, and Taylor, 1969), except where the task offers _S_ some incentive to maintain it (Posner et al., 1969). The efficiency of the visual code is especially reduced when processing capacity is diverted to another task, such as an addition task interpolated between stimulus and response (Posner et al., 1969). It appears that the visual and name codes may be abstracted and compared independently of one another, and their efficiency as a basis for matching may be influenced by different factors. Physical matches are affected by visual factors, such as form similarity (Chase and Posner, 1965; Posner and Taylor, 1969), but are not affected by factors related to name coding, such as auditory similarity, which does affect name matches (Boies, 1969; Tversky, 1969). Differences in the order of search through a stored array for visually or nominally coded stimuli (Taylor and Posner, 1968) also suggest an independence of the codes.

In the present study, the effects of color as an irrelevant dimension were studied by presenting Ss with pairs of colored letters to judge as same or different. For a particular study, the criterion for sameness could have been either the physical forms of the letters, disregarding color (modified Level I instructions) or letter names (Level II instructions). According to Posner and Mitchell (1967), with Level II instructions responses to PI pairs are based on comparisons of the visual codes alone, since physical identity implies name identity. Responses to pairs differing in form are based on name code comparisons. A difference of at least 70 msec. between "same" RTs to PI and NI pairs indicates that the responses are being based on different codes. Under Level I instructions Ss base responses to all pairs on comparisons of visual codes alone, so that "different" responses are at least 70 msec. faster here than under Level II instructions. By use of either Level I or Level II instructions, it was thus possible in the present study to manipulate the processing level on which task performance was based, and study the effects of irrelevant color on that level.

It was expected that color, as a visual dimension, would be included in the visual code, and would thus affect task performance based on this code either by simply distracting S from his comparison of the relevant aspects of the visual code or by eliciting responses competing with the response to the relevant dimension. Since, according to Lockhead's (1966) definition, color was an irrelevant dimension integral with form in this study, Garner and Felfoldy's (1971) work would predict that color would affect task performance. Egeth and Pachella's (1969) suggestion that color was a particularly distracting irrelevant dimension also supported this prediction. If irrelevant color did affect task performance based on visual code comparisons, then response latencies to PI pairs under either Level I or Level II instructions should have been affected by irrelevant color.

It was less clear how irrelevant color might affect task performance based on name code comparisons. As a visual dimension color would not be included in the name code, and therefore might not be expected to affect task performance based on comparisons of this code. But, interference could occur between color names and letter names if the processing of name information included the naming of both colors and letters. The lack of interference of incongruous ink colors with the naming of printed color names (Stroop, 1935) suggested that irrelevant colors, regardless of whether or not they were named, did not affect task performance based on the name processing of a relevant dimension. The present study investigated whether irrelevant color affected responses based on name processing, as indicated by changes in the latencies of "same" responses to NI pairs under Level II instructions.

Experiment 1

The purpose of Experiment 1 was to determine whether irrelevant color affected task performance based on the visual information and name information processing levels. In a task similar to that used by Posner and Mitchell (1967), subjects were required to judge pairs of letters as same or different according to name. The color of the letters, which was irrelevant to task performance, was varied on certain trials. It was expected that varying color would affect task performance based on visual code comparisons, as indicated by changes in the latencies of "same" responses to pairs identical in form. The effect of varying color on task performance based on name code comparisons, indicated by changes in the latencies of "same" responses to NI pairs, was also examined.

Method

Subjects

The subjects were ten undergraduates enrolled in psychology courses at the University of Massachusetts. Subjects volunteered for the experiment and received some course credit for their participation. All were unfamiliar with the Posner and Mitchell (1967) paradigm and findings.

Apparatus

The stimuli were rear-projected by two Kodak Carousel RA-950 slide projectors operated by a PDP-8I computor, which selected the stimulus display. Each projector projected one letter at a time, the two projections being superimposed to display two letters side by side on a screen. The computor recorded reaction times and also controlled a Grason-Stadler 901B tine generator and a Harmon Kardon A3000 amplifier, which produced the warning tone. The subjects' responses were made on two keys separated by five inches mounted on a twelve inch by twelve inch keyboard. Accuracy feedback was provided by lights next to the correct keys.

Presentation of Stimuli

The stimuli were simultaneously-presented pairs of letters chosen from a letter set including A, a, B, b, C, c, E, and e. The two letters as they appeared on the screen subtended a visual angle of 2.8 degrees. The relations between members of a pair could be classified on one of three ways as follows: 1) physically identical in form (PI pairs), e.g., "A A" or "b b;" 2) nominally identical but different in form (NI pairs), e.g., "a A" or "B b," 3) differing in both form and name (Diff pairs), e.g., "E a" or "b c." Within the restrictions of its definition, the composition of stimulus pairs was randomly determined. Stimuli were presented in blocks of 64 trials, each block containing 32 Diff pairs, 16 PI pairs, and 16 NI pairs. Each stimulus pair appeared to S as two colored letters on a dark background. Within each block of 64 trials, 24 Diff pairs, 12 PI pairs and 12 NI pairs (i.e., 75% of all trials) contained letters both printed in the same color, this color being referred to as the basic color (Condition BB). The basic color could be either red or green, and remained constant across all trials blocks for a particular S. On the remaining 25% of the trials (8 Diff pairs, 4 PI pairs, 4 NI pairs), one of the two letters was printed in the secondary color, which was green if the basic color was red, and red if the basic color was green (Condition SB). The secondary color was randomly assigned to either the right or left member of a pair.

Each day began with practice trial blocks which were of a composition similar to that previously described for test trial blocks. Practice blocks for Day 1 included 20 Diff pairs, 10 PI pairs, and 10 NI pairs. Practice blocks for Day 2 included 16 Diff pairs, 8 PI pairs, and 8 NI pairs. Secondary color was randomly assigned to 4 Diff pairs, 2 PI pairs, and 2 NI pairs.

The timing of the stimulus presentation was identical for practice and test trials. A trial began with presentation of a 0.5 sec. burst of white noise. One second after the onset of this warning tone, the stimuli appeared simultaneously on the screen. The stimulus pair remained visible until a response was made. There was an interval of about 7 sec. before the next trial began.

Procedure

Each S was tested individually on a total of six test blocks, three blocks being presented on each of two successive days. Each testing session took about one hour. The basic color of the stimulus pairs was randomly assigned to each S, with the restriction that one-half of the Ss had green as the basic color and one-half had red as the basic color. For a particular S, the basic color (and thus, the secondary color also) remained constant for all trial blocks.

Ss were run individually in a sound-damped room that was darkened except for a dim light. S was seated at a table, on which was placed the response keyboard, about eight feet from the screen on which the stimulus pairs appeared. S was instructed that he would be presented with pairs of letters which could be upper or lower case and could be colored red or green. His task was to press the left key with his left middle finger if the two letters presented had the same name and to press the right key with his right middle finger if the two letters presented had different names. This kind of instruction is similar to Posner and Mitchell's (1967) Level II instructions. Within a trial block, correct responses were thus one-half "sames" and one-half "differents." The method of feedback was explained to S. He was told that the order of responses was randomized, and that he was to respond as quickly as possible without making too many errors. S was asked to respond to several stimulus pairs before E left the testing room. S was then exposed to a practice block. His reaction times and error rate were checked to insure that he understood instructions. If S's RTs were above 600 msec. or his error rate was over 5%, he was instructed between trial blocks to try to modify his performance so as to maintain these standards.

On Day 1 S was exposed to three test blocks of 64 trials each, each block separated by a rest period during which the door to the testing room was opened, and S remained seated in the darkened room. Day 2 followed the same procedure as Day 1. S was reminded of his task, particularly that letter names were to be the only basis for his "same" or "different" response, and that he was to respond quickly without making too many errors. He was then presented with a practice block, followed by three test blocks, at the conclusion of which he was de-briefed.

Results

Analysis of variance was used to examine the effects of the four critical variables: Color (C), basic color, either red or green; Day (D), either Day 1 or Day 2; Irrelevancy condition (R), BB or SB; Pairs (P), PI, NI, or Diff.

Analysis of variance indicated that the D ($F=19.63$; d.f.=1,8; $p<.01$), R ($F=6.73$; d.f.=1,8; $p<.05$) and P ($F=63.86$; d.f.=2,16; $p<.001$) main effects were significant. The RP interaction approached significance ($F=2.11$; d.f.=2,16; $p<.20$). Collapsed over other variables, mean RTs were 514 msec. for PIs, 592 msec. for NIs, and 610 msec. for Diffs, and RTs decreased about 50 msec. from Day 1 to Day 2. Since neither the DPR nor CPR interactions were significant,

Table 1

Experiment 1: RTs as a function of R and P in msec.

	Levels of P		
Levels of R	PI	NI	Diff
BB	504	578	610
SB	524	606	610
SB - BB	20	28	0

results were collapsed over D and C, and are shown in Table 1. Latencies were longer under Condition SB than under Condition BB by 20 msec. for PI pairs and by 28 msec. for NI pairs. RTs to Diff pairs were identical under both conditions. Although the RP interaction was not highly significant, post hoc analysis revealed that R differed in its effect on Diff pairs, as compared to PIs and NIs combined ($F=5.85$; d.f.=1,9; $p<.005$). There was no significant difference in the effect of R on PIs and NIs.

An examination of error rates showed that, for PIs, there was 1% error under Condition BB, and 2% error under Condition SB; for NIs, 3% under Condition BB and 7% under Condition SB; for Diffs, 2% under Condition BB and 3% under Condition SB. Since Ss were instructed to maintain low error rates, the error rates were small, but there was a consistent trend for the error rate to be higher under Condition SB than under Condition BB.

Discussion

The 70 to 80 msec. difference between "same" response latencies to PI pairs and NI pairs under either Condition BB or SB replicated Posner and Mitchell's (1967) findings. This difference indicated that pairs identical in form were judged "same" on the basis of visual code comparisons, while pairs identical in name only were judged "same" on the basis of name code comparisons. The increase in "same" response latencies to PI pairs under Condition SB suggested that irrelevant color did affect task performance based on visual code comparisons. However, the exact magnitude of the effect was not clear from Experiment 1 since, under Level II instructions, the distributions of responses based on visual and name code comparisons may overlap. The increase in "same" response latencies to NI pairs under Condition SB indicated that task performance based on name code comparisons was also affected by irrelevant color.

Another finding was that irrelevant color affected "same" response latencies, but did not change "different" response latencies. This was consistent with predictions that could be derived from the previous explanations for the effects of irrelevant dimensions. In the case of "same" responses, the response competition hypothesis would have predicted that there would be interference between the "same" response on the basis of name or form, and the "different" response elicited by the difference between letter colors in Condition SB. "Same" response would also have been lengthened by the presence of secondary color, which was distracting. If a difference in color competed with a "same" response, it also seemed feasible that a difference in color could have facilitated a "different" response. Egeth (1966) found that "different" reaction times decreased as the number of relevant differences increased. Although Egeth's study differed from the present one in that the facilitative dimensions were relevant dimensions, it was not unreasonable to assume that irrelevant color, which was clearly being processed in the present study, might have had a facilitative effect on "different" responses. The facilitation effect, however, would have been counterbalanced to some extent by the interfering effect of distraction, thus resulting in little change in response latency under Condition SB, as observed. Thus, the observation that only "same" response latencies increased under Condition SB was consistent with the notion that response competition, response facilitation, and distraction contributed to the effects of irrelevant color.

Experiment 2

Experiment 2 attempted to more accurately assess the magnitude of the effect of varying color on task performance based on visual code comparisons. Subjects were instructed to base their same-different judgments on the physical forms (disregarding colors) of the letters. Such instructions presumably allow subjects to most efficiently make either a correct "same" or "different" response on the basis of visual code comparisons alone (Posner and Mitchell, 1967). Changes in response latencies when color varied would reflect an effect on task performance based on visual information processing.

Method

Subjects

The subjects were sixteen undergraduates from the same population as in Experiment 1.

Apparatus

The apparatus was identical to that used in Experiment 1.

Presentation of Stimuli

The stimuli were the same as those used in Experiment 1.

Procedure

The procedure was identical to that of Experiment 1, except that S was told to base his "same" or "different" response on the form of the letters, a physical characteristic, rather than on their names. These instructions were similar to Posner and Mitchell's (1967) Level I instructions, but modified in that S was instructed to disregard the physical characteristic of color in choosing his response. Letter form only was the criterion for response. Otherwise, Ss in Experiment 2 received the same instructions as did Ss in Experiment 1. Because Level I instructions were used in Experiment 2, correct responses within a trial block were one-fourth "same" and three-fourth "different."

Results

Analysis of variance was used to examine the effects of the same variables as in Experiment 1. The following effects were significant: D ($F=35.1$; d.f.=1,14; $p<.001$), R ($F=12.01$; d.f.=1,14; $p<.01$), P ($F=4.54$; d.f.=2,28; $p<.025$), DP ($F=5.63$; d.f.=2,28; $p<.05$), CP ($F=3.80$; d.f.=2,28; $p<.05$), and RP ($F=3.86$; d.f.=2,28; $p<.05$). Table 2 shows RTs as a function of levels of D and P. Over Days, RTs decreased by 29 msec. for PIs, by 60 msec. for NIs, and by 46 msec. for Diffs. Table 3 shows RTs as a function of levels of C and P. For PIs, mean RTs were only 3 msec. apart under the two levels of C. For NIs and Diffs, mean RTs were about 30 msec. faster when red was the basic color than when green was the basic color. Since neither the DPR nor CPR interactions were significant, results were collapsed over D and C and are shown in Table 4. Responses to PI pairs were longer by 30 msec. under

Table 2

Experiment 2: RTs as a function of D and P in msec.

	Levels of P		
Levels of D	PI	NI	Diff
Day 1	514	516	502
Day 2	485	456	456
Day 1 - Day 2	29	60	46

Table 3

Experiment 2: RTs as a function of C and P in msec.

	Levels of P		
Levels of C	PI	NI	Diff
Red	501	470	466
Green	498	502	493

Table 4

Experiment 2: RTs as a function of R and P in msec.

Levels of R	Levels of P: PI	NI	Diff
BB	484	486	476
SB	514	486	483
SB - BB	30	0	7

Condition SB than under Condition BB. Responses to NI pairs and Diff pairs were increased by an average of 4 msec. Post hoc analysis revealed that the effect of R was different for the NI and Diff pairs combined, as compared to the PIs ($F=13.97$; d.f.= 1,15; $p<.005$). There was no significant difference in the effect of R on NIs as compared to Diffs.

An examination of error rates indicated that for PIs, there was 3% error under Condition BB and 7% error under Condition SB; For NIs, there was 1% error under Condition BB and 3% error under Condition SB. For Diffs, there was 1% error under each Condition. There was a trend for error rates to be higher under Condition SB than under Condition BB.

Discussion

"Different" responses in Experiment 2 were over 100 msec. faster than "different" responses in Experiment 1, suggesting that the faster visual code comparison was the basis for response in Experiment 2. It should be noted that, since correct responses were three-fourths "different" in Experiment 2, Ss may have been set to respond "different," a factor which could partially account for the speed of "different" responses. However, in view of Posner and Mitchell's (1967) work, and the emphasis placed on speed of response, it seemed likely that responses in Experiment 2 were based on visual code comparisons.

The increase in "same" response latencies to PI pairs under

Condition SB, relative to BB, indicated that task performance based on visual code comparisons was affected by irrelevant information. As in Experiment 1, "same" response latencies were affected by irrelevant color, but "different" response latencies were not. This finding was consistent with the notion that response competition, response facilitation, and distraction contributed to the effects of irrelevant color.

Experiment 3

The effects of response competition, response facilitation, and distraction were confounded in Experiments 1 and 2. Condition SB could have caused both distraction and response competition or facilitation. The purpose of Experiment 3 was to separate the effects of these factors, and to try to assess their relative strengths. In contrast to Experiments 1 and 2, Experiment 3 included a third level of Irrelevance, known as Condition SS, in which the paired letters were colored the same, but the color was the secondary color, instead of the basic color. If the presence of an unusual color alone caused distraction, Condition SS would have been distracting, whereas the condition in which both letters were colored in the basic color (Condition BB) would not have been as distracting. This leads to the prediction that both "same" and "different" responses under Condition SS should have had longer latencies than under Condition BB. Since both response competition and distraction would have contributed to the effects of Condition SB on "sames," but only distraction contributed to the effects of Condition SS on "sames," the difference between these two conditions relative to BB should have indicated the relative strengths of distraction and response competition. Since only response competition contributed to the effects of Condition BB on "differents," but response competition and distraction contributed to the effects of Condition SS on "differents," the difference in response latencies under these two conditions should have provided a second measure of the strength of distraction.

Method

Subjects

The subjects were twelve undergraduates from the same population used in Experiments 1 and 2. All were experimentally naive with the exception of one subject.

Apparatus

The apparatus was identical to that used in Experiments 1 and 2, with the following exceptions. For reasons unrelated to the experiment, instead of pressing response keys, Ss' responses were made on two response switches about five inches apart which Ss pulled toward themselves with their middle fingers. Accuracy feedback was again provided by lights next to the correct switch.

Presentation of Stimuli

Each test block consisted of 72 trials, including 24 PI pairs, 24 NI pairs, and 24 Diff pairs. Each stimulus pair appeared as two colored letters on a dark background. Within each test block, 18 of each kind of pair appeared in the basic color (Condition BB), which again could be red or green, and was constant across all blocks for a particular S. Within each block, there were also 3 PI pairs, 3 NI pairs, and 3 Diff pairs in which secondary color was randomly assigned to one of the two letters (Condition SB). The remaining 3 PI pairs, 3 NI pairs, and 3 Diff pairs in the block consisted of letters both of which appeared in secondary color

(Condition SS).

Practice trial blocks for Days 1 and 2 were similar to those described for test trial blocks. Practice blocks included 15 PI pairs, 15 NI pairs, and 15 Diff pairs. Two of each kind of pair were under Condition SB and two were under Condition SS, the remainder being under Condition BB. The timing of the stimulus presentation was the same as in Experiments 1 and 2.

Procedure

The procedure was nearly identical to that described for Experiment 1, including the use of Level II instructions, which made correct responses two-thirds "same" and one-third "different." The performance standards for Experiment 3 were slightly modified because overall RTs were slower. Ss were instructed between blocks to modify their performance if the error rate exceeded 5% or RTs exceeded 800 msec.

Results

Analysis of variance was used to examine the effects of the same variables as in Experiments 1 and 2, with the exception that R now had three levels, BB, SB, and SS. The following effects were significant: D ($F=39.89$; d.f.=1,10; $p<.001$), P ($F=28.99$; d.f.=2,20; $p<.001$), and RP ($F=4.89$; d.f.=4,40; $p<.005$). RTs decreased about 50 msec. from Day 1 to Day 2. Since neither the DPR nor CPR interactions were significant, results were collapsed over C and D and are shown in Table 5. Differences between response latencies

Table 5

Experiment 3: RTs as a function of R and P in msec.

	Levels of P		
Levels of R	PI	NI	Diff
BB	512	621	671
SB	548	633	658
SS	514	637	680
SB - BB	36 $F(1,11)=13.70$, $p<.005$	12 $F(1,11)=3.60$, $p<.10$	-13 $F(1,11)=5.85$, $p<.05$
SS - BB	2 $p>.20$	16 $p>.20$	9 $p>.20$

Table 6

Experiment 3: Percentage of error as a function of R and P

	Levels of P		
Levels of R	PI	NI	Diff
BB	0	3	3
SB	2	4	4
SS	1	5	4

under Conditions BB and SB, and under Conditions BB and SS, as well as the significance of these differences are shown in this table. Responses to PI pairs were longer under Condition SB than under Condition BB. Responses to Diff pairs were shorter under Condition SB than under Condition BB. For NIs, the difference in the effects of Conditions BB and SB approached significance. Conditions BB and SS did not differ in effect for any kind of pair.

Table 6 shows the error rates for Experiment 3. As in previous experiments, the error rates were small, but there was a consistent trend for the error rates to be higher in Conditions SB and SS than in Condition BB.

Discussion

The difference in "same" RTs to PI and NI pairs under each irrelevancy condition indicated that these responses were based on the two different processing levels. "Different" response latencies were somewhat longer than "same" response latencies to NI pairs, a difference that may have been caused by Ss' hesitation to respond "different" in a task where the correct response was "same" two-thirds of the time.

Although RTs under Condition SS tended to be longer than under Condition BB, the failure of this effect to achieve significance for any kind of pair suggested that Condition SS was not very distracting. It would, however, have been difficult to explain why "different" response latencies in Experiments 1 and 2 were similar under Conditions BB and SB unless irrelevant color had caused some sort of distraction. Although the effects of distraction on "same" responses were confounded with the effects of response competition in Experiments 1 and 2, the failure of "different" responses to vary under levels of R suggested that Condition SB had produced distraction and response facilitation, which were separable, but opposite in effect. It seemed reasonable, therefore, to re-analyze the conditions necessary for distraction to occur. It was originally thought that if most of the letters were of the same color (the basic color), the presence of either or both letters in another color (the secondary color) would have provided distraction. The effect of Condition SS suggested that, if the presence of a particular color value had been distracting, this effect was rather small. Since the explanation for the difference in the effects of irrelevant color on "same" and "different" responses implied that Condition SB had been significantly distracting, it was reasonable to suggest that perhaps a difference between letters in color produced a stronger kind of distraction. In the present task, where letter color was irrelevant to task performance, <u>Ss</u> may have been able to prevent color from affecting responses on most trials, except when a difference between colors, as in Condition SB, violated their expectation that the letters would be similarly colored. <u>Ss</u>' comments indicated that they were more aware of differences between letter colors than of color values.

According to this interpretation of the conditions most important in causing distraction, the effects of distraction, response competition, and response facilitation were still confounded in Experiment 3. Since the color difference which caused distraction also elicited a "different" response that affected the primary response, it would have been difficult to separate the effects of response competition and distraction using the present task.

The results of Experiment 3 indicated that the effects of Condition SB were similar to those previously observed. The difference in "same" RTs to PI pairs under Conditions SB and BB was slightly, though not significantly, larger than in Experiments 1 and 2. This suggested that in Experiment 3 color may have interfered more with task performance based on visual code comparisons than in previous experiments. The difference in Experiment 3 between "different" responses under Conditions SB and BB was also slightly larger than in Experiments 1 and 2. In previous experiments, the lack of a difference between Conditions SB and BB was consistent with the suggestion that the effects of response facilitation and distraction counterbalanced one another, thus implying they had equal, but opposite effects. The slight decrease in response latencies under Condition SB in Experiment 3 suggested that the effect of response facilitation was larger than that of distraction.

The difference between "same" RTs to NI pairs under Conditions SB and BB only approached significance. The weakness of the effect of irrelevant color on task performance based on name code comparisons was puzzling in view of the significant effect observed in Experiment 1. In Experiment 3, however, "same" responses to NI pairs were, on the average, 109 msec. longer than "same" responses to PI pairs. Since Posner and Mitchell (1967) estimated that there was a 70 to 80 msec. difference between task performance based on visual and name code comparisons, the large difference between PI and NI "same" responses in Experiment 3 suggested that responses based on the name code were being produced more slowly than usual. If this were the case, there could have been two explanations for the reduced effects of irrelevant color. Responding more slowly would have enabled Ss to better filter out the effects of irrelevant color. An alternative explanation was that because they were trying to filter out color, Ss were responding more slowly. The present data could not distinguish between these two alternatives.

Although the effects of irrelevant color were only slightly and not significantly different from those observed in Experiments 1 and 2, it was interesting to speculate on their causes. One obvious difference between Experiments 1 and 2, and Experiment 3, was that letter pairs in Experiment 3 could have been colored in one of three, instead of only two, ways. It was possible that, as the number of irrelevant color conditions increased, Ss found the task more difficult and were less able to handle the effects of irrelevant color. Compared to previous experiments, Experiment 3 had a slightly higher error rate, which suggested that there was more difficulty with task performance. The increased effects of irrelevant color on responses based on visual code comparisons, and the possibility that responses based on name code comparisons were being made more slowly than usual, were also consistent with the idea that irrelevant color was strongly interfering in Experiment 3. The effect of irrelevant color on "different" responses suggested that increases in the effects of irrelevant color might have been more strongly reflected in increases in response facilitation, rather than in distraction.

General Discussion

The literature suggests that irrelevant information does affect the performance of a variety of tasks (Hodge, 1959; Montague, 1965; Egeth, 1966; Morgan and Alluisi, 1967). The present studies were designed to determine if irrelevant dimensions affected task performance based on different processing levels. The work of Posner and his co-workers (Posner, 1969) suggested that in tasks requiring Ss to compare two letters, the processing of the letters involved the independent coding and comparison of two kinds of stimulus information. Visual characteristics of the stimuli were coded and compared more quickly than were characteristics which pertained to the names of the stimuli.

The present studies examined whether color as an irrelevant dimension affected task performance based on comparisons of the visual and name codes. The results indicated that the irrelevant color dimension did affect task performance based on either code. In Experiments 1 and 3, the increase in NI "same" response latencies when color varied suggested that irrelevant color did affect task performance based on name code matches. In all three experiments, the increase in PI "same" response latencies when color varied suggested that irrelevant color also affected task performance involving visual code matches.

At first glance, the effect of a visual aspect of the stimulus on task performance based on name level processing seems to contradict Posner and Taylor's (1969) suggestion that visual factors do not affect such task performance. In their study, Ss had to perform a search task which could be based on comparisons of either visual or name codes. The effects of similarity of form and acoustic similarity on task performance were measured. Similarity of form, a visual factor, affected task performance which was based on visual code comparisons, but did not affect task performance based on name code comparisons. This study did not necessarily indicate, however, that visual information never interferes with task performance based on the name code. Since the requirement to judge pairs such as "A a" as "same" gave Ss experience in ignoring the dissimilarity of form in such pairs, it was not surprising that similarity of form did not seem to affect task performance based on the name code.

The present data suggested that color did affect task performance based on name information. Since Posner (1969) implies that the name code is independent of its visual context once it has been abstracted, it is difficult to imagine how visual information could have affected the actual name code comparison. It seems more possible that irrelevant color could have affected responses by disrupting aspects of task performance preceding or following the name code comparisons. If color were distracting, it could have delayed the initial encoding of name information from the stimulus, or the elicitation of the final response based on comparisons of the name codes. If a response was elicited on the basis of color, it might have affected the mechanism that makes the final same-different decision. It is possible that the final decision is reached only after same-different judgments based on both relevant and irrelevant stimulus aspects have been weighted and reviewed. Although relevant stimulus aspects were most important, and therefore most highly weighted in the choice of a response, responses based on irrelevant aspects may have delayed or facilitated the final response depending on their agreement with the decision based on the relevant dimension.

The present studies emphasize that there may be a distinction between effects of irrelevant information on comparisons of coded information, and effects on aspects of task performance preceding or following such comparisons. Sternberg (1969) has suggested one way to separate factors affecting the encoding of stimulus information from the factors affecting comparisons of that encoded information with an already encoded stimulus set. In a task requiring Ss to judge "yes" or "no" whether a target item was a member of a previously presented set of items, he found that "yes" RTs linearly increased as a function of the memorized set size, which he interpreted as evidence that Ss were responding after conducting an exhaustive search through memory for the target. According to his analysis, the y-intercept of the function reflected the time necessary for the initial encoding of the target stimulus, and the slope of the function indicated the time necessary for comparing the encoded target stimulus with each member of the memorized set. Thus, factors affecting stimulus encoding would be expected to influence the y-intercept; factors influencing the comparison stage would modify the slope.

The effect of irrelevant color on such a task might be localized by examining whether changes in the y-intercept or slope occurred when irrelevant color was present. If most target letters were colored the same, it would be expected that a change in letter color would produce an orienting response (Sokolov, 1963) that would affect task performance. Variance in the y-intercept when color changed would indicate an effect of irrelevant color on stimulus encoding; variance in the slope would indicate an effect on comparisons of coded information. It should be noted, however, that effects of a variable such as color on the comparison stage might have to be inferred from rather small, undramatic changes in slope, similar to the small changes found by Sternberg (1969).

Since it is not clear whether name codes or visual codes are being compared in such a task (Sternberg, 1969), it might be difficult to determine whether the location of the effect varies as a function of the kinds of codes being compared. In the usual Sternberg task where Ss must merely indicate whether the target was contained in the memorized set, there is evidence that the code of the target is not simply a name, but retains some physical features of a visual code. If, however, Ss were required to respond as to whether the memorized set contained a letter having either the same name or same physical form as the target, it might be possible to manipulate the processing level on which task performance was based. By manipulating processing level and examining where changes in the function relating RT and set size occurred when irrelevant color varied, the location of the effects of irrelevant color might be better assessed.

In the present studies, an irrelevant dimension that was never relevant to the task affected task performance. This is inconsistent with the notion than an irrelevant dimension has to have been previously relevant to the task in order to affect performance (Hodge, 1959; Montague, 1965). There are several possible reasons why prior relevance of the irrelevant dimension was not necessary in the present task. As suggested by Egeth and Pachella (1969), color may have been a particularly powerful irrelevant dimension because Ss were accustomed to attending to color. Less potent irrelevant dimensions might not have been attended to unless they had been previously relevant to task performance, and therefore had been previously attended to. The nature of the present task also may have reduced the importance of the irrelevant dimension's prior relevance. In the same-different task, Ss were able to judge stimuli as "same" or "different" either by comparing relevant or irrelevant dimensions of the paired stimuli. Never-relevant dimensions were able to provide a basis for the appropriate same-different response. However, in a classification task, there is no response associated with a dimension that has never been relevant. Prior relevance of the irrelevant dimension is necessary here in order for S to know a response to the irrelevant dimension that is appropriate for the classification task.

The results of the present experiments were consistent with the notion that response competition, response facilitation, and distraction contributed to the effects of irrelevant color. The increase in "same" RTs in Condition SB, relative to BB, could be interpreted as reflecting effects of distraction and response competition. "Different" RTs were similar under these two conditions because the effects of distraction and response facilitation counterbalanced each other. As previously discussed, it seemed likely that a difference between letters in color had been more important to causing distraction than the presence of a particular color value. If this were the case, then the effects of response competition and distraction on "same" responses were always confounded in Condition SB, since the difference in color responsible for distraction also elicited a competing "different" response. Although it would probably be difficult to separate the effects of distraction and response competition using the present same-different task, the effect of distraction could be isolated if the task didn't require a same-different judgment, thus making a same-different response based on color unrelated to the primary response. For example, Ss might be asked to classify appropriate stimuli as containing two vowels or two consonants. It seems improbable that in such a task the letterscolors could elicit a competing response that could interfere with the primary response. Thus, interference when the colors differed between letters might be attributed solely to effects of distraction.

Although the effects of response competition and distraction were confounded, the present experiments did provide some indication of the relative effects of response facilitation and distraction. In Experiments 1 and 2, "different" RTs under Condition SB were not significantly different from those under Condition BB, suggesting that the effects of response facilitation and distraction under Condition SB had counterbalanced each other by being nearly equal, but opposite, in effect. In Experiment 3, the significant decrease in "different" RTs under Condition SB suggested that the effects of response facilitation were outweighing any distraction that was occurring. The present experiments offer no explanation for the variance in the relative effects of response facilitation and distraction, and provide only rough estimates of their relative magnitudes. The effect of distraction could be isolated in a task not requiring same-different judgments, as previously described. The effects of response facilitation or response competition might be assessed in a task creating distraction on every trial, but response facilitation or response competition only on some trials. Comparisons of trials in which only distraction occurred with trials in which response facilitation or response competition also occurred might indicate the magnitude of the latter effects.

Another possible line of investigation might focus on whether response competition or facilitation can occur independently of distraction, or vice versa. In the present experiments, the effects of Condition SB were always interpreted as reflecting both distraction and response competition or response facilitation. There was no way to assess whether response competition/facilitation occurred under Condition BB, which supposedly was not very distracting. The classification task previously suggested might indicate whether distraction can occur without response competition/facilitation. It might, however, be more difficult to use designs similar to the present one to separate response competition/facilitation from distraction, since the establishment of the response competition/facilitation conditions usually necessitates a change in the stimuli that might distract S.

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