# REACTION TIME ANALYSIS OF SIZE, COLOR AND FORM INVARIANCE IN VISUAL PERCEPTION



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ABSTRACT

The effect of size and color on identical and different forms that share the same name was examined in a simultaneous matching task with reaction time as the dependent variable. Both experiments revealed an increase in reaction time as a function of size and color for identical forms. In contrast, different forms showed no such effect. These results are in general consistent with those of Posner and Mitchell (1967) and the notion of anonymous visual operations that are analog in nature.

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# INTRODUCTION

To the layman it is an absurd question to ask why the figures "A" and "a" are the same. Obviously they are because they share the same name. It is less easy, however, to specify the steps or transformations that a stimulus undergoes when being recognized as an "a" or identified as having the same name as another stimulus.

Posner and his co-workers (Posner and Keele, 1967; Posner and Mitchell, 1967; Posner and Taylor, 1969; Posner, Boies, Eichelman and Taylor, 1969; Taylor, 1969; Taylor and Posner, 1968) have with little ambiguity isolated at least three stages in the pattern recognition process. In one of their earlier papers (Posner and Mitchell, 1967) subjects were asked to respond "same" or "different" by pressing a key as quickly as possible to a pair of visual letters presented simultaneously. Items were either physically identical (as in "AA") or name identical (as in "Aa"), or physically and nominally different (as in "Af"). When asked to respond "same" if the letters had the same name, subjects produced reaction times which were approximately 70-100 msec faster to letters having the same form (e.g., "AA") than to letters which had different forms (e.g., "Aa"). The usual interpretation of this highly reliable finding is that subjects can match "AA" on the basis of pre-nominal visual contrast properties which is referred to as the "physical level". On the other hand, "A" and "a" do not share the same visual features, consequently a physical match is clearly impossible.

Instead, stimulus equivalence is achieved through the process of absolute identification of their respective names. This having been accomplished, a name match becomes possible. Two distinct levels of analysis have thus been established using the reaction-time technique for simultaneously presented pairs of stimuli.

REPRESENTATION

If a single letter is displayed visually for a short period, and followed shortly after its offset by a second letter, it is consistently found that RT to "A" followed by "A" is faster than to "A" followed by "a". Thus physical memory matches are faster than name memory matches (Posner and Keele, 1967; Posner et al, 1969). For this phenomenon to hold, the memory letter must be stored in some form that allows it to be physically matched to the second letter. If this was not so, then temporally delayed matches would be expected to have the same RT regardless of the physical specifications of the pair (AA or Aa).

An alternative explanation which might be utilized in this context is one by Paivio, Rogers and Smythe (1968). In discussing why pictures are better recalled and recognized than words, they entertained the possibility that pictures are dually represented in both visual and verbal form, while words are only stored verbally. The probability of recall is higher for pictures because retrieval from two independent stores is better than from one alone. Similarly, it is possible in the Posner paradigm that RT is mediated by the total amount of evidence available. Thus, physical matching is faster not only because it represents a different level of analysis which can be reached faster, but because physical evidence and name evidence provide more information than name matches alone. This describes a system in which response time is faster simply because two inputs are provided to the response system rather than one. The notion of combining evidence in this fashion is supported by experiments that have shown faster RTs to inputs when two separate modalities present simultaneous or overlapping signals (Todd, 1912; Hershenson, 1962; Bernstein, 1970; Taylor, 1973). Similarly, it has never been clear that the matching operations need terminate at the physical level if a match is indicated. Although it would seem to be a redundant operation, physical matches could serve to alter the state of readiness in a response buffer, while waiting for the output of a naming system (Sternberg, 1969).

If it can be demonstrated that certain operations affect physical matching but not name matching, or vice versa, then interpretations based on combining evidence or altering thresholds in the response system would be unconvincing since there would then be evidence for functionally independent stages of processing. Experimental evidence that bears upon this is readily available. Boies (1969) demonstrated that, with name instructions, RT for physical matches was unaffected by a concurrent verbal memory load held for later recall, while name matching time was significantly increased. Dainoff and Haber (1970) found that name matches involving acoustically confusable letters were slower and more error prone than name matches with letters that were not acoustically confusable. Matches at the physical level showed no effect of this manipulation. When physical level instructions are given, (respond "different" if the two letters do not have the same physical forms) same name stimuli (e.g., "Aa") were no slower to reject than different name stimuli (e.g., "AP"). Similar results were observed with Gibson forms that were assigned names (Posner and Mitchell, 1967). Thus, long term familiarity with the names has no effect on matching speed at the physical level. Of particular interest is Hochberg's (1968) finding that matching upright letters was no faster than matching upside down letters as long as the letters were adjacent. This breaks down when the letters are somewhat spatially separated. Posner (1969) interpreted this to mean that name information was being used, although it remains difficult to see why a physical match was still not possible. Recently, it has been found that if a pair of letters are presented in mirror image, stored, and then matched to a similarly oriented pair, RTs for both physical <u>and</u> name matches were significantly slower than for normally oriented stimuli (Kellicutt, Parks, Kroll and Salzberg, 1973). Finally, Eichelman (1970) using multi-letter strings found that familiarity decreased RT in a simultaneous matching task. He furthermore argued that this was a visual matching effect, not a name one.

Posner and Chase (1969) found that visual similarity had a marked effect on matching speed with circular arrays of letters in a search task, while auditory confusability had no effect. Posner and Taylor (1969) found that with single line multi-letter arrays stored in memory, visual confusability affected physical matches making them slower, but had no effect on name matches, while acoustic confusability slowed the name matches, but had no effect on the physical ones. It seems fair, therefore, to conclude as does Posner (1969) that matches at the different levels appear to be independent of one another.

VISUAL MEMORY

What has subsequently developed out of Posner's work has been primarily directed towards furthering the empirical base of visual short term memory. This reluctance on the part of experimental psychologists to accept the notion of a short term visual store à la Posner must be difficult for the layman to understand. For example, almost everyone has had the experience of recognizing a face but being unable to find the name that goes with it. Clearly, the realization that the face is familiar is independent of knowledge of the name. Thus, the stored memory of the face must have a large anonymous component. Furthermore, heavy reliance is placed on these cues. Why otherwise the difficulty in recognizing photographic negatives of friends and family? Laymen notwithstanding, the most widely cited system for human memory is a paper that is singularly striking for its omission of any discussion regarding visual memory other than the Sperling store (Atkinson and Shiffrin, 1968).

Several authors have attempted to rectify this situation. Kroll, Parks, Parkinson, Bieber and Johnson (1970), Salzberg, Parks, Kroll and Parkinson (1971), Parkinson, Parks and Kroll (1971), Parkinson (1972), Parks, Kroll, Salzberg and Parkinson (1972), Kellicutt, Parks, Kroll and Salzberg (1973), Phillips and Baddeley (1971) have all reported results supporting the existence of visual memory. All of these experiments, with the exception of the last, used auditory shadowing as a tool. The rationale was simple. Shadowing should be sufficient incentive to induce the subjects to maintain memory items in a visual form if possible. If it can be shown that auditory shadowing affects memory for letters presented aurally, but not visually, then one can infer that visually presented letters are stored differently. An obvious explanation would be that letters presented aurally are stored in a short term auditory store and hence are subject to interference from an auditory shadowing task, while letters which are presented visually are stored in a visual short term buffer and hence are impervious to auditory interference per se.

When a situation is contrived that makes verbal coding difficult, maintenance of a visual memory appears quite long lasting. Using a 5 x 5 matrix of squares, each with a .5 probability of being filled, Phillips and Baddeley found that subjects were able to recognize a change in the pattern made by the dots with better than chance accuracy up until nine seconds. Furthermore, this technique dispenses with the messy problems of processing capacity while shadowing, how to score accuracy of shadowing, and the like.

Taken as a whole, these experiments and others confirm and extend what Posner and Konick (1966) had already observed, namely, some form of visual memory is clearly available.

VISUAL MEMORY, ONE KIND OR TWO?

It should further be noted that the Posner visual memory is probably different from that of the Sperling "iconic" store. There are several reasons for supposing this.

Effects of a mask

Interpolating a black and white random noise field between memory and test letters has no effect relative to a blank interval other than to increase the absolute times for both physical and name matches by about 24 msec (Posner et al, 1969, Experiment 2). This is to be expected since the noise mask acts to decrease the signal to noise ratio of the second letter, much like Sternberg's (1967) finding for the first day of testing. Thus, while the mask has an effect, it is non-selective since it does not reduce the difference between a physical and a name match, which should be the case if the function of the mask is to erase or degrade the visual memory of the original letter. In contrast, forward and backward masking typically produces large and selective recall decrements when exposed with multi-letter single line arrays of short duration (Merikle, Coltheart and Lowe, 1971; Merikle and Coltheart, 1972). While caution is indicated when comparing different dependent measures such as RT and recall, it seems clear that the effects of masking in a recall task cannot be attributed to changes in the signal to noise ratios, since there was not a general effect of the mask. Indeed, items in the end positions remain completely unaffected under backward masking, a result that is difficult to reconcile with a strictly serial left to right encoding strategy.

Time course of the codes

Estimates of the duration of the icon have ranged from 250 msec to 5 seconds (e.g., Sperling, 1960; Averbach and Sperling, 1960; Averback and Coriell, 1961; Mackworth, 1963). All of these estimates, however, were based upon the difference between partial and full report. Several critiques of the partial report procedure have since emerged that suggest that the superiority of partial report is largely an artifact attributable to output interference (Anderson, 1960; Dick, 1971; Holding, 1970, 1971, 1972). Fortunately, other methodological innovations which do not involve the use of partial report have also supported the notion of a short-lived sensory trace which lasts from 250 to 500 msec (Eriksen and Collins, 1968; Haber and Nathanson, 1968; Haber and Standing, 1969; Haber and Standing, 1970).

While the early Posner papers (Posner and Keele, 1967; Posner et al, 1969) suggested a time course that was surprisingly similar to the Sperling estimates for iconic memory, there is good reason to believe that this was mainly a result of strategies that the subjects utilized, i.e., there was no compelling reason to attempt holding a visual image.

Finally, Coltheart (1972) and Scarborough (1972) have both argued that readout from the icon is at least partly based on visual coding rather than exclusively on visual to auditory recoding as Sperling (1963, 1967) had envisioned. Furthermore, Coltheart has argued that iconic memory is characterized by fast passive decay, maskability, and large capacity, while visual memory is non-maskable, has a flexible decay rate, and a limited capacity of not more than three or four items. This last point is of some interest since Posner and Taylor (1969) failed to find evidence for physical matches for some of the items when they used a multi-letter array stored in memory. Again, it is not clear to what extent recall and recognition reaction time measures tap similar processes, so the comparison is tenuous at best. In particular, the limited capacity notion is hard to reconcile with repeated demonstrations of highly accurate recognition for pictures, (Shepard, 1967; Standing, 1972; Standing, Conezio and Haber, 1970) as well as the recent finding that physical match superiority is still evident after several minutes with 100 words in storage (Hintzman and Summers, 1973).

It seems reasonable to conclude that there are at least two separate and distinct visual codes, the first an evanescent image, the second a durable storage medium that maintains information without recourse to verbal labels. Indeed, without such codes..."it would be most difficult to explain such diverse phenomenon as delayed matching to sample in nonverbal organisms, eidetic imagery, or the unusually good human ability to retain a visual location in space." (Posner, 1969).

ANALOG MATCHING

A third discrete stage of processing, intermediate between physical and name matching has been tentatively identified. This stage involves the effects of relative size. Posner and Mitchell noted that such letters as Cc share the same form, although they obviously differ in size. Since "AA" represents a physical match stage, while "Aa" represents a name match stage of processing, it is an empirical question whether under name match instructions subjects yield RTs to Cc which are similar to a name match (Aa) or to a physical match (CC). This is of considerable interest because, if the RTs are close to the physical matching times, subjects are presumably exhibiting size invariance, a phenomenon well documented in the perception literature and a feature crucial to any theory of pattern recognition (Sutherland, 1969). It has been found, however, that RTs to Cc were approximately 19 msec longer than to CC or cc, a time difference much less than that for a name match (70-100 msec). Beller (1970) confirmed this when he used Oo and Cc in a visual search task. Thus, the extraction of size is a process which takes a measureable amount of time. This process may occur in addition to those which are normally responsible for physical matching, but be much faster than processing of stimulus names. But these conclusions must be regarded as strictly tentative, because of certain methodological problems. The comparison of RTs to Cc with those to CC and Aa is difficult because there is no name match for C in which the forms differ physically in the same way as "A" and "a". Thus, the logic of being able to attribute faster "AA" RTs to a pre-nominal stage of processing because we can compare them to "Aa" RTs does not generalize well to inferences about Cc and analog processes. For instance, if the RT to Aa (same size) was <u>less</u> than to Aa (different size) could this be considered an analog process? It is a simple matter, however, to construct stimuli which satisfy the necessary requirements. Examples of these stimuli can be seen in Figures 1 and 2. Notice that there is both a physically similar pair differing in size as well as pairs that are physically dissimilar, but have same and different sizes, all with the same name. Using stimuli of this type ought to enable us to establish clearly whether Posner's reaction time methodology can be analytic with respect to the existence of a stage of processing intermediate between name and gross physical matching. It ought to also enable us to make inferences concerning specific types of anonymous visual operations. If, for example, the naming operation does not commence until after a physical match has been rejected, then any operation that prolongs the physical matching stage, such as size normalization, will affect the time taken to arrive at the name. Alternatively, if, in some sense the naming and anonymous visual operations occur in parallel, it may be possible to discover complex visual operations which take <u>longer</u> than name matching. By varying size alone then, it is possible to examine the notion of "analog" visual operations.

Differently colored letters which are otherwise the same are not confusable as to case. Thus, by varying color alone it is possible to determine if discrimination of letter

| | | | |
|---|---|---|---|
| BB | BB | BB | BB |
| 1 | 2 | 3 | 4 |

1 White letters on a black background, same size

2 White letters on a black background, different size

3 White letter on a black background and a black letter on a white background, same size

4 White letter on a black background and a black letter on a white background, different size

Figure # 1 Examples of size and color variations with physical match stimuli

| Bb | Bb | Bb | Bb |
|---|---|---|---|
| 1 | 2 | 3 | 4 |

1 White letters on a black background, same size

2 White letters on a black background, different size

3 White letter on a black background and a black letter on a white background, same size

4 White letter on a black background and a black letter on a white background, different size

Figure # 2 Examples of size and color variations with name match stimuli case type contributes to the differences in RT between AA and Aa. The latter is normally confounded with name and physical matching in the Posner paradigm.

## EXPERIMENT 1

### Stimulus Materials

The basic stimuli consisted of different forms, sizes and colors (black and white) of the letters B, F, O and C. Two populations were constructed, one of which contained only the letters F and C and the other only B and O. The various forms and combinations of F and C were presented to half of the Ss, and B and O to the others.

The individual stimuli used over the entire experiment were B, $\bar{B}$, B, $\bar{B}$, b, $\bar{b}$, b, $\bar{b}$, O, $\bar{O}$, o, $\bar{o}$, F, $\bar{F}$, F, $\bar{F}$, f, $\bar{f}$, f, $\bar{f}$, C, $\bar{C}$, c, $\bar{c}$, where the bar denotes a white stimulus on a black background. Otherwise the stimuli are black on a white background (see Figures 1 and 2).

Stimuli were presented in pairs subtending a horizontal angle of 1° for two small, and 1.7° for one large and one small pair. The vertical angle subtended by a large pair was 1.6° and for a small pair .8°. Within the B & O (or F & C) population there were 144 possible pairs, all of which were used at least eight times over the course of the experiment.

Of the 144 possible pairs, 80 had the same name and 64 a different name. Of the 80 same name pairs (Table 1) 12 had the same form, size and contrast, and therefore will be specified as FSC stimuli (Row 1). A further 12 had the same form and size but a different contrast (Row 2, FSC-), 12 had the same form and contrast but a different size, (Row 3, FS-C) and 12 had the same form but different size and contrast (Row 4, FS-C-).

Table 1

Description of stimuli requiring "same" response, for the (B & O) group. Comparable stimuli were used for the (F & C) groups.

| Description | Specification | Stimuli |
|---|---|---|
| FSC | XX | BB, $\bar{B}\bar{B}$, BB, $\bar{B}\bar{B}$, bb, $\bar{b}\bar{b}$, bb, $\bar{b}\bar{b}$, OO, $\bar{O}\bar{O}$, oo, $\bar{o}\bar{o}$ |
| FSC- | $X\bar{X}$ | $B\bar{B}$, $\bar{B}B$, $B\bar{B}$, $\bar{B}B$, $b\bar{b}$, $\bar{b}b$, $b\bar{b}$, $\bar{b}b$, $O\bar{O}$, $\bar{O}O$, $o\bar{o}$, $\bar{o}o$ |
| FS-C | Xx | BB, BB, $B\bar{B}$, $\bar{B}B$, bb, bb, $\bar{b}\bar{b}$, $\bar{b}\bar{b}$, $O\bar{o}$, $\bar{o}\bar{O}$, Oo, $\bar{o}\bar{O}$ |
| FS-C- | $X\bar{x}$ | $B\bar{B}$, $\bar{B}B$, $\bar{B}B$, $B\bar{B}$, $b\bar{b}$, $\bar{b}b$, $\bar{b}b$, $b\bar{b}$, $O\bar{o}$, $\bar{o}O$, $\bar{O}o$, $o\bar{O}$ |
| F-SC | XX | Bb, bB, $\bar{B}\bar{b}$, $\bar{b}\bar{B}$, Bb, bB, $\bar{B}\bar{b}$, $\bar{b}\bar{B}$ |
| F-SC- | $X\bar{X}$ | $B\bar{b}$, $\bar{b}B$, $\bar{B}b$, $b\bar{B}$, $B\bar{b}$, $\bar{b}B$, $\bar{B}b$, $b\bar{B}$ |
| F-S-C | Xx | Bb, bB, $\bar{B}\bar{b}$, $\bar{b}\bar{B}$, Bb, bB, $\bar{B}\bar{b}$, $\bar{b}\bar{B}$ |
| F-S-C- | $X\bar{x}$ | $B\bar{b}$, $\bar{b}B$, $\bar{B}b$, $b\bar{B}$, $B\bar{b}$, $\bar{b}B$, $\bar{B}b$, $b\bar{B}$ |

A further four stimulus classes differed in form. Since C's small upper and lower case forms are identical, the number of stimuli in these different form populations were fewer. Thus, eight stimuli differed in form, but were identical in size and contrast (F-SC), eight differed in form and contrast (F-SC-), eight differed in form and size (F-S-C), and eight differed in form, size and contrast (F-S-C-). All eight classes of stimuli required a "same" response, and they constituted the eight major conditions of the experiment. Table 1, in the second column, defines a more convenient code to specify each of the eight conditions.

Since "same" responses exceed "different" responses (80/64) the actual populations used in a given session on a given day were selected such that the response probabilities were equal. Thus in a given experimental session, 320 stimuli were presented, a half of which required the response "same" and a half "different". Since there were 80 stimuli of the same name, and 64 with a different name, each of the same name stimuli were presented twice in the course of a session. The stimuli chosen for "different" responses within a session consisted of all 64, plus a further 16 chosen at random.

Apparatus

Stimuli were presented for 1.5 seconds in a Scientific Prototype model GB tachistoscope, with intertrial intervals of 2.5 seconds. Two micro switches served as response keys, these were set three inches apart and operated by the index finger of one hand. One key indicated a "same" response and the other "different". Half the subjects in each sub-group responded "same" with their dominant hand and half with their non-dominant hand. RTs were recorded on a Hewlett-Packard time-printer system to the nearest millisecond.

## Subjects

Subjects (Ss) were 4 male and 4 female undergraduates; 2 male and 2 female Ss served in each of the sub-groups, (B & O) and (F & C). They were paid at a rate of $2.00 an hour.

## Procedure

Each S received a practice session of 80 slides, on the day prior to the experiment. Each S then received 320 stimuli per day for two days. Rest intervals of about a minute were introduced after every 80 responses. Ss were requested to respond "same" when the two letters had the same name, but otherwise to respond "different". Fast and error-less performance was requested. All Ss within a sub-group received the same stimulus pairs except that the order of tray presentation was varied across Ss.

Results

Data from the practice sessions were not tabulated, those from the experimental sessions are summarized in Appendix A, Tables 3 through 14. Less than 4% of the responses were incorrect, overall, and these were not analyzed.

Since the letter pairs "CC" and "OO" do not have corresponding name match forms, the data were analyzed initially only for physical matches. Median "same" responses were subjected to a three way analysis of variance (Letters (B, F, O, C) x Size (same or different) x Color (same or different). The detailed results of that analysis can be seen in Appendix A, Table 1.

The main effects of size and color were both significant, with same size RTs (544 msec) being faster than different size (556 msec), $F_{(1,12)}=8.14$, $p<.025$, and same color RTs (537 msec) being faster than different color (564 msec), $F_{(1,12)}=10.97$, $p<.01$.

The only other significant result was a letter x size interaction, $F_{(3,12)}=5.23$, $p<.025$. A multiple comparison test by the Newman Keuls procedure revealed that the letter "O" produced a disproportionately large difference between same and differently sized "same" RTs, while the letter "C" showed a reversal. The results for the letter x size interaction is summarized in Figure 3. Each point plotted is the mean across median RTs for that condition.

A further analysis was undertaken for those letters whose physical forms made name matches possible. These letters were subjected to a four way analysis of variance, Letters

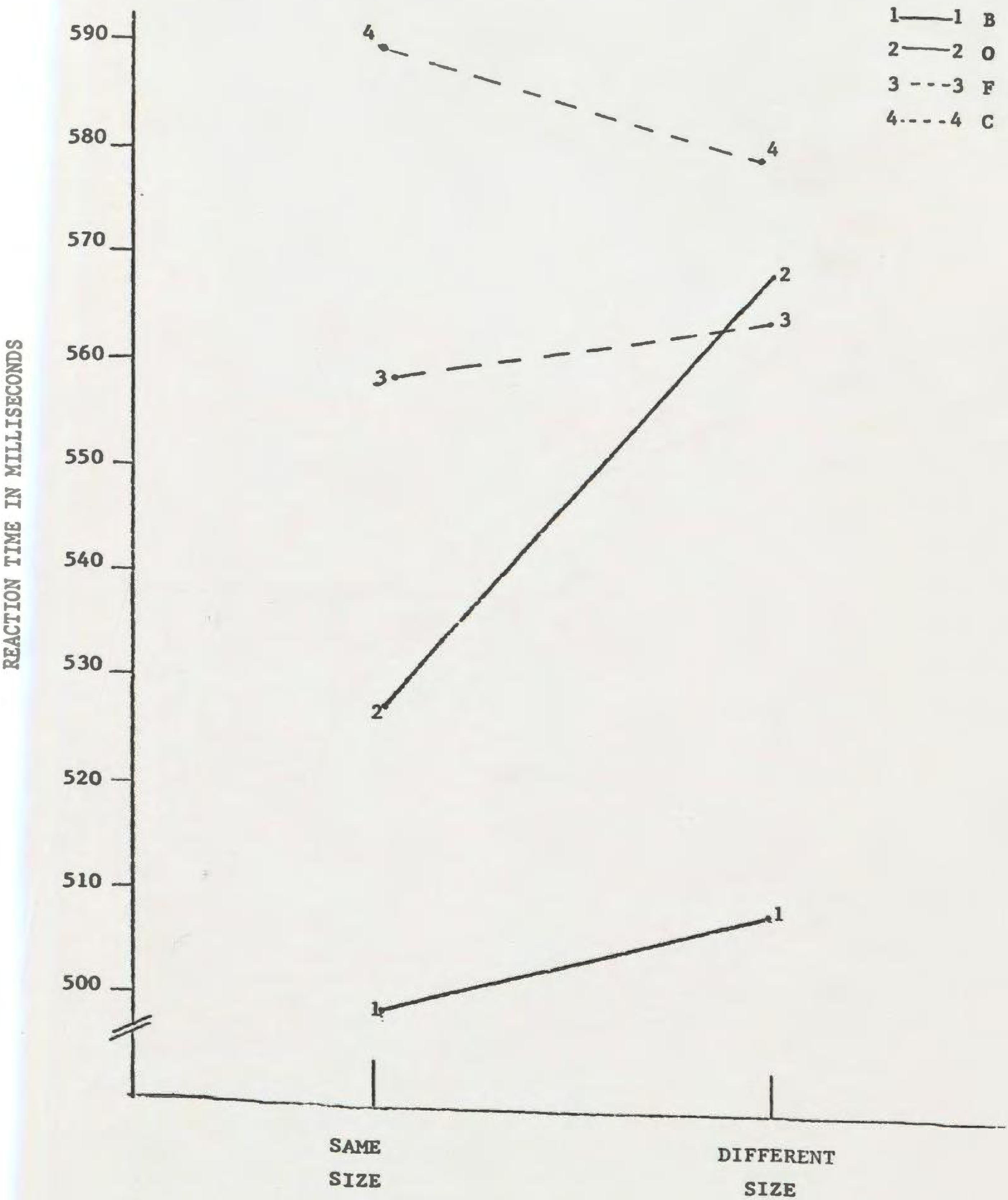


Figure # 3 Letter x Size interaction

(B, F) x Match type (name or physical) x Size (same or different) x Color (same or different). The details of that analysis can be found in Appendix A, Table 2.

The only effect that was significant in that analysis was the match type x color interaction, $F_{(1,6)}=7.80$, $p<.05$. This interaction is shown in Figure 4. Multiple two way comparisons revealed that only the same color physical match point differed from all the others ($p<.05$).

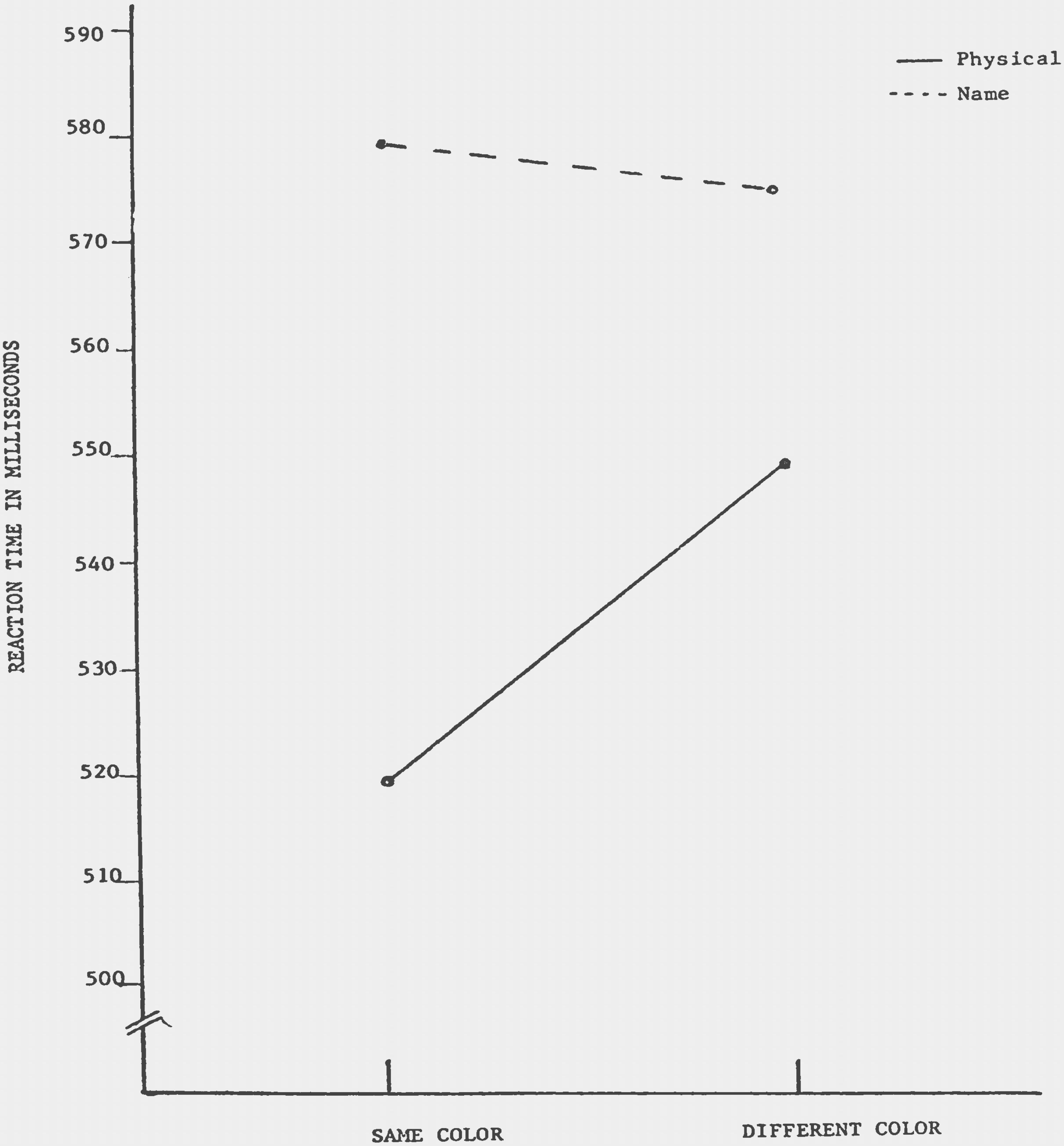


Figure # 4 Effects of Color on Name and Physical Matching

# EXPERIMENT 2

A decision was made to replicate the essential features of Experiment 1 but to increase the overall sensitivity of the experiment by a) increasing the number of Ss, b) increasing the number of trials per S, and c) changing the task to one in which a S only responds when he makes a "same" judgement. These procedures can perhaps be expected to increase the relative effect variances within "same" responses, and thus may help clarify the trends evident in Experiment 1.

## Method

Apart from the changes specified below, all other procedures are identical with Experiment 1.

### Stimulus materials

The stimulus pairs used to which the S responds "same" are shown in Table 2. The total population of stimuli amounted to 100, of which 52 were "same" and 48 "different". This small difference allowed for stimulus and response probabilities to be very nearly equal without arbitrary selection of stimuli.

### Subjects

Six undergraduates (3 male and 3 female) were used as Ss.

### Procedure

Ss were tested on five consecutive days, receiving 200 stimuli in the morning and 200 in the afternoon of each day. Thus a total of 1040 responses per S were taken. In order to encourage Ss to search for identity rather than dissimilarity,

Table 2

Stimuli used in Experiment 2, which yield "same" responses

| Specification | Description | Stimuli |
|---|---|---|
| FSC | XX | BB, BB, $\bar{B}\bar{B}$, $\bar{B}\bar{B}$, bb, $\bar{b}\bar{b}$, CC, cc, $\bar{C}\bar{C}$, $\bar{c}\bar{c}$ |
| FSC- | X$\bar{X}$ | B$\bar{B}$, $\bar{B}$B, B$\bar{B}$, $\bar{B}$B, b$\bar{b}$, $\bar{b}$b C$\bar{C}$, $\bar{C}$C, c$\bar{c}$, $\bar{c}$c |
| FS-C | Xx | BB, BB, $\bar{B}\bar{B}$, $\bar{B}\bar{B}$, Cc, cC, $\bar{C}\bar{c}$, $\bar{c}\bar{C}$ |
| FS-C- | X$\bar{x}$ | B$\bar{B}$, $\bar{B}$B, $\bar{B}$B, B$\bar{B}$, C$\bar{c}$, $\bar{c}$C, $\bar{C}$c, c$\bar{C}$ |
| F-SC | XX | Bb, bB, $\bar{B}\bar{b}$, $\bar{b}\bar{B}$ |
| F-SC- | X$\bar{X}$ | B$\bar{b}$, $\bar{b}$B, $\bar{B}$b, b$\bar{B}$ |
| F-S-C | Xx | Bb, bB, $\bar{B}\bar{b}$, $\bar{b}\bar{B}$ |
| F-S-C- | X$\bar{x}$ | B$\bar{b}$, $\bar{b}$B, $\bar{B}$b, b$\bar{B}$ |

no responses were made to "different" stimuli. Ss wore earphones while participating, with a white noise level of approximately 55 db. Again, Ss' instructions were to respond "same" to letter pairs with the same name.

Results and discussion

Data from the practice sessions were not tabulated, while those from the experimental sessions are summarized in Appendix B, Tables 4 through 9. Less than 3% of the responses were incorrect, overall, and these were not included in the analyses.

Since the letter pair "CC" did not have a corresponding name match pair, an analysis based on those stimulus pairs which could be identical physically was carried out first.

Median "same" RTs were subjected to a three way analysis of variance, Letters (B or C) x Size (same or different) x Color (same or different). The detailed results of that analysis can be seen in Appendix B, Table 1.

Letter type was a significant main effect, $F_{(1,5)}=17.20$, $p<.01$, as were the effects of size, $F_{(1,5)}=60.11$, $p<.001$, and color, $F_{(1,5)}=406.02$, $p<.001$. Three interactions were also significant; letter x size, $F_{(1,5)}=15.42$, $p<.025$, size x color, $F_{(1,5)}=20.86$, $p<.01$, and the triple interaction of letter x size x color, $F_{(1,5)}=12.32$, $p<.025$.

The triple interaction can be seen in Figure 5. Two way multiple comparisons revealed that all points differed significantly ($p<.05$) with the exception of a) the letter B, same size, different color from B, different size, same color; b) the letter B, same size, same color from C, same size, same color; and c) the letter C, different size, different color from C, different size, same color, all ($p>.05$).

A further analysis was performed solely for the letter B, since form name matches were available. Median "same" RTs

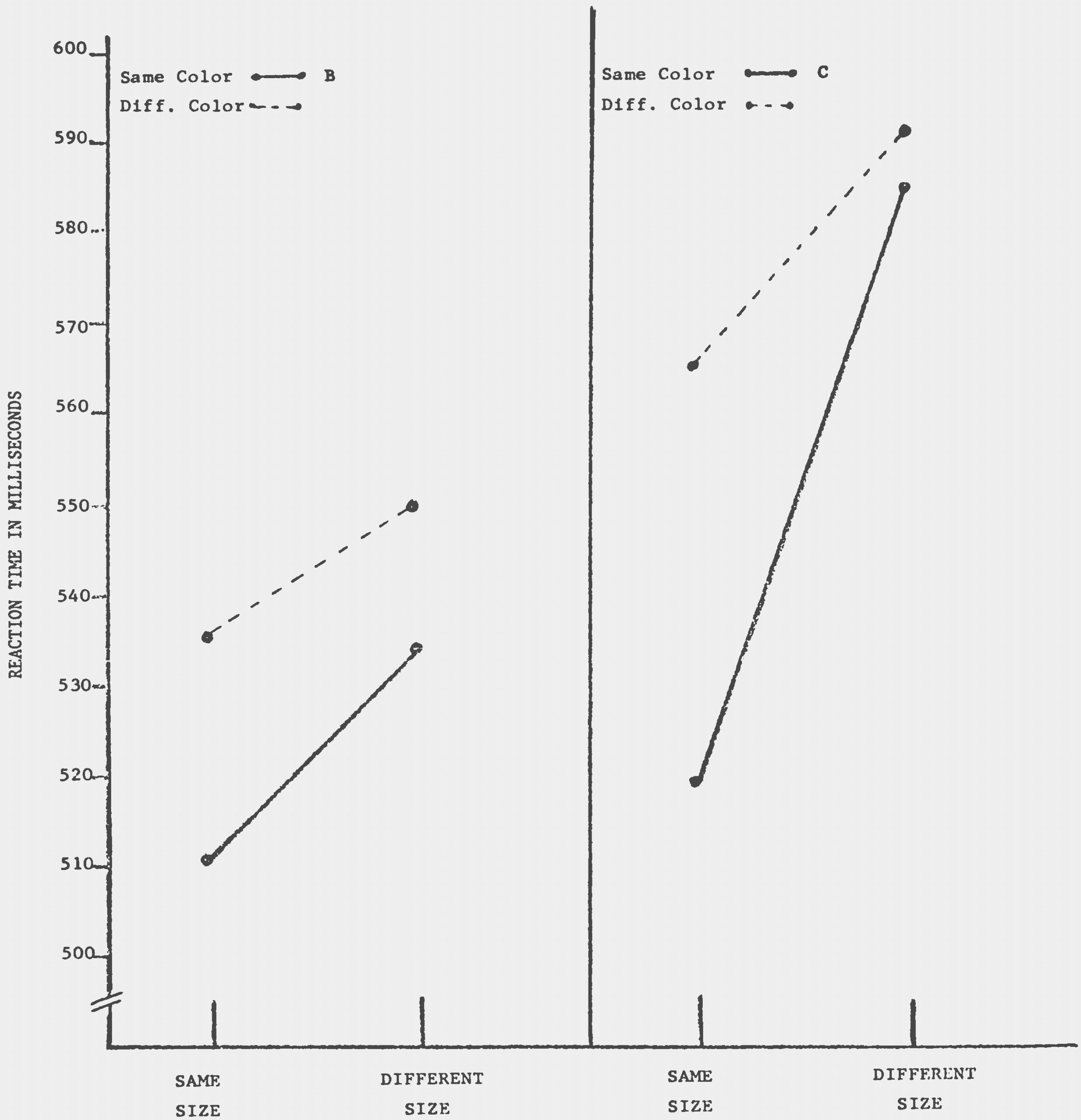


Figure # 5 Letter x Size x Color interaction were subjected to a three way analysis of variance, Match type, (name or physical) x Size, (same or different) x Color (same or different). The detailed results of that analysis can be found in Appendix B, Table 2.

Match type was a significant factor, $F_{(1,5)}=14.89$, $p<.025$, that is, different form matches were slower than same form matches. Size was not significant, $F_{(1,5)}=5.97$, $p>.05$, while color was a main effect, $F_{(1,5)}=9.38$, $p<.05$. None of the interactions approached significance.

Clearly, while size and color variables are highly effective in the physical analysis, the effects drop out when computed within a name-physical comparison. A look at Tables 4 through 9 (Appendix B), suggests that this is because these variables have no effect within the name match levels, however the large variations around these means is masking the small but highly consistent increase for the physical matches.

To check on this, the data from letter types that had name match forms as well as physical match forms were pooled from Experiments 1 and 2, and subjected to a three way analysis of variance, Match type (name or physical) x Size (same or different) x Color (same or different). Detailed results can be seen in Appendix B, Table 3.

Match type was a significant main effect, $F_{(1,13)}=7.78$, $p<.01$, that is, different form matches were slower than same form matches. Color was a main effect, $F_{(1,13)}=10.70$, $p<.01$, and the match x color interaction was also significant, $F_{(1,13)}=8.54$, $p<.01$.

The match x color interaction can be seen in Figure 6. Multiple comparisons confirm that name matches do not differ from each other ($p > .05$), but do differ from both physical matches ($p < .01$). Furthermore, physical matches having a difference in color present take longer than physical matches of the same color ($p < .01$).

Every single S shows an increase in RT for all comparisons used to compute the effects of size on physical matching for the letter B. This is significant on a two-tailed sign test, ($p < .02$). The comparable comparisons for the name matches (Table 4) reveal that 50% of the scores go in either direction. There is quite clearly no effect of size on name matching. Similar conclusions are evident for the effects of color.

Thus, it seems to be the case that both color and size lead to increases in RT when the same forms are present. However, when the physical forms differ, there is no such effect. Both of these findings are consistent with Posner and Mitchell's (1967) arguments as to the existence of an analog process. It would appear that the failure to find effects with name matches can be construed as supportive of the general Posner system, since if names are being matched physical features should be irrelevant. Indeed, if both same and different forms had shown similar effects it would have been possible to argue that it was localized at some stage prior to the matching operation. Thus, the increase in RT seems to be a post-perceptual effect.

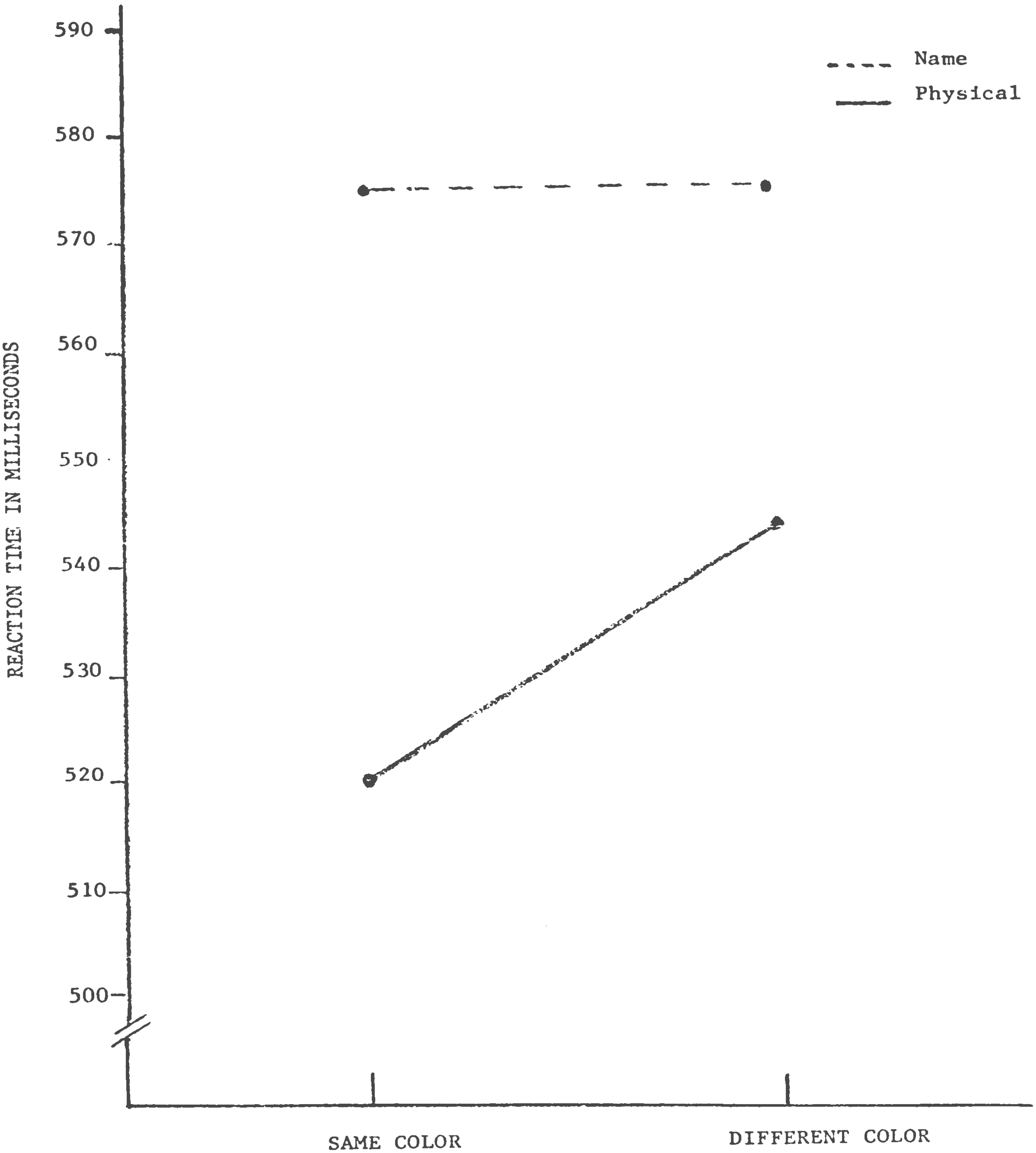


Figure # 6 Match type x color interaction

One problem concerns the source of the three way interaction between letter type, size and color. There are at least three possibilities.

This may simply be an effect that is due to the physical characteristics of different letters. While this is possible and should not be ruled out, it is nevertheless not apparent in the data that this interaction is present for other letters.

Another possibility is that stimulus attributes such as size and color are processed in a different fashion as a function of letter type. That is, if color and size are processed serially, then the time to respond to a pair that differs in both color and size should be an additive function of the difference in time between same size letters compared to different size letter pairs, plus the difference in time between same color pairs compared to different color pairs. On the other hand, if these features were handled in parallel, then the time to process a pair of letters that differ both in size and color should take as long as whichever of the two (size or color) takes the longest when processed separately, (i.e., $C\bar{C}$ vs CC). A look at Figure 5 indicates, roughly, that this would be true, if B was dealt with serially, while C was handled in parallel.

A final possibility is that Cc is not a long analog match, but a name match. Consider the following:

a) RT BB = RT CC    510 = 520

b) RT BB < RT BB < RT Bb    510 < 533 < 563

c) RT BB < RT Cc    533 < 584

d) RT Cc = RT Bb    584 = 563

e) $RT\ CC < RT\ C\bar{C}$ $520 < 566$

f) $RT\ BB < RT\ B\bar{B}$ $510 < 535$

g) $RT\ Cc = RT\ C\bar{c}$ $520 = 526$

h) $RT\ BB < RT\ B\bar{B}$ $533 < 550$

That is, we know that the increase for a size match is much longer for the letter C than for B even though initially response time to CC was no longer than to BB. Furthermore, Cc is approximately the same as a name match Bb. When there is no possible confusion as to case, i.e., when color is the variable of concern then both B and C show increases in RT that are also *not* different. However, when a size difference is already present, that is, when the comparison consists of different sized B's with colors the same compared to different sized B's with colors different, then we are looking at the effects of color since size varies within pairs, but not between, while color varies within one pair and not the other, thus it varies between pairs. In this case B shows an effect of color but C does not. This is because the presence of a size difference causes *S* to treat it as a name match. We have already observed that size and color have no effect on name matches. Therefore, if *S*s are treating Cc as a name match, color should have no effect, as is the case.

The question that remains then, is, if the above analysis is correct, why do *S*s treat Cc as a name match? One possibility is that *S*s make a case match in parallel with other operations. If a decision is made that the cases *differ*, the response system waits for the output of the naming system while ignoring input from visual matching operations. The logical difficulty with this conclusion concerns how it is possible to know when a letter is upper or lower case without identifying the letter name first. This is not necessarily impossible since Posner (1970) has argued that semantic classification is possible without going through the stimulus name. Indeed, while this is all highly speculative, Coltheart (1972) has noted that "different" responses in the Posner et al (1969) study show an effect of case over all delays. That is, it is quicker to respond "different" to "AB" than to "aB". Furthermore, the effect does not seem to vary in magnitude as a function of delay, unlike the physical-name difference, suggesting an operation that is digital in nature rather than analog. Thus, if the cases are the same, while the physical forms differ, there can be no match, and the decision is rapid, but if the cases differ, as well as the physical forms, there may be a name match.

Finally, if a case match is possible then the discrepancy between the data for the letters Cc in Experiment 2 and those of Posner and Mitchell (1967) for the letters Cc may perhaps be attributable to how large the size difference between C and c was in comparison. If there was only a slight difference, Ss could treat it as a same case match, and pursue an analog operation. The letter B is clearly not confusable as to case, and here the results mirror those of Posner and Mitchell.

General Conclusion

One of the important findings in the recent literature has been that Ss, when asked to judge if two stimuli have the same name, are reliably faster if the stimuli have the same form (e.g., AA) than if they have different forms (e.g., Aa). Since the two pairs of stimuli have identical names, the logical conclusion which seems warranted is that these faster RTs to same form pairs arises because Ss are able to make a decision based primarily on their visual properties. That conclusion has been supported by a number of studies which demonstrate that RTs can be manipulated independently within same or different form name decisions, and is the focus of a great deal of current research. The evidence from the experiments reported here suggest that in addition to form, variations in size and color can reveal something about anonymous visual processes.

A pair of stimuli having the same color are matched faster than a pair of different color, suggesting that the Posner technique can be generalized to variations in the physical properties apart from form.

A pair of stimuli of the same size are generally matched faster than if the two stimuli differ in size. A question arises as to whether stimuli of different size but the same form (Cc) are processed in the same way as stimuli of different size and form (Aa). This question is historically of interest because it has been suggested that the underlying processes by which a S is able to equate differently sized versions of the same form is analog in nature. In these experiments it was possible to independently manipulate size and form identity so that a general test of the question of whether these types of matches represent a special case could be undertaken.

In general, the results suggest that variations in size alone, when the forms are the same appear to result in the operation of an analog process. When the forms are confusable as to case, Ss appear to treat the stimuli as a name match. Finally, variations of size or color, or size and color appear to have no effect on different form stimuli. This was taken to be consistent within the Posner system, since presumably names are being matched and the differences in physical features between letters are irrelevant.

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APPENDIX A

Table 1

Three way analysis of variance based on Median "same" RTs Letters (B, F, O, C) x Size (same or different) x Color (same or different)

| Source | df | MS | F |
|---|---|---|---|
| Letters (L) | 3 | 19067.80 | 1.90 |
| Subjects (Subjs.) | 12 | 10026.20 | |
| Size (S) | 1 | 2639.39 | 8.15** |
| L x S | 3 | 1697.06 | 5.24** |
| S x Subjs. | 12 | 323.99 | |
| Color (C) | 1 | 11051.30 | 10.97*** |
| L x C | 3 | 2019.02 | 2.00 |
| C x S | 12 | 1007.27 | |
| S x C | 1 | 2058.89 | 3.96 |
| L x S x C | 3 | 815.71 | 1.57 |
| S x C x Subjs. | 12 | 519.50 | |

****p<.001
***p<.01
**p<.025
*p<.05

Table 2

Four way analysis of variance based on Median "same" RTs Letter type (B, F) x Match (Name or Physical) x Size (same or different) x Color (same or different)

| Source | df | MS | F |
|---|---|---|---|
| Letter (L) | 1 | 81011.40 | 4.27 |
| Subjects (Subjs.) | 6 | 18979.90 | |
| Match Type (M) | 1 | 30581.30 | 2.36 |
| L x M | 1 | 2340.13 | 0.18 |
| M x Subjs. | 6 | 12972.00 | |
| Size (S) | 1 | 0.39 | 0.00 |
| L x S | 1 | 489.50 | 0.78 |
| S x Subjs. | 6 | 631.00 | |
| Color (C) | 1 | 1753.52 | 3.22 |
| L x C | 1 | 415.13 | 0.76 |
| L x C x Subjs. | 6 | 545.04 | |
| M x S | 1 | 1396.89 | 1.20 |
| L x M x S | 1 | 221.25 | 0.19 |
| M x S x Subjs. | 6 | 1167.53 | |
| M x C | 1 | 4080.02 | 7.80* |
| L x M x C | 1 | 26.19 | 0.50 |
| M x C x Subjs. | 6 | 523.00 | |
| S x C | 1 | 199.52 | 0.50 |
| L x S x C | 1 | 14.94 | 0.04 |
| S x C x Subjs. | 6 | 400.57 | |
| M x S x C | 1 | 2104.50 | 4.79 |
| L x M x S x C | 1 | 1550.50 | 3.53 |
| M x S x C x Subjs. | 6 | 439.72 | |

*$p < .05$

Table 3

The effects of size and color on physical matching (Experiment 1)

1. The effects of color on the letter B

| SUBJECTS | SAME SIZE SAME COLOR | SAME SIZE DIFFERENT COLOR | DIFFERENCE SCORE |
|---|---|---|---|
| 1 | 399 | 432 | +33 |
| 2 | 491 | 547 | +56 |
| 3 | 522 | 541 | +19 |
| 4 | 482 | 570 | +88 |

| SUBJECTS | DIFFERENT SIZE SAME COLOR | DIFFERENT SIZE DIFFERENT COLOR | DIFFERENCE SCORE |
|---|---|---|---|
| 1 | 432 | 453 | +21 |
| 2 | 494 | 541 | +47 |
| 3 | 540 | 539 | - 1 |
| 4 | 547 | 526 | -19 |

Table 4

The effects of size and color on physical matching (Experiment 1)

2. The effects of size on the letter B

| SUBJECTS | SAME COLOR SAME SIZE | SAME COLOR DIFFERENT SIZE | DIFFERENCE SCORE |
|---|---|---|---|
| 1 | 399 | 432 | +33 |
| 2 | 491 | 494 | + 3 |
| 3 | 522 | 540 | +18 |
| 4 | 482 | 547 | +65 |

| SUBJECTS | DIFFERENT COLOR SAME SIZE | DIFFERENT COLOR DIFFERENT SIZE | DIFFERENCE SCORE |
|---|---|---|---|
| 1 | 432 | 453 | +21 |
| 2 | 547 | 541 | - 6 |
| 3 | 541 | 539 | - 2 |
| 4 | 570 | 526 | -44 |

Table 5

The effects of size and color on physical matching (Experiment 1)

1. The effects of color on the letter F

| SUBJECTS | SAME SIZE SAME COLOR | SAME SIZE DIFFERENT COLOR | DIFFERENCE SCORE |
|---|---|---|---|
| 1 | 533 | 544 | +11 |
| 2 | 642 | 635 | - 7 |
| 3 | 446 | 491 | +45 |
| 4 | 575 | 605 | +30 |

| SUBJECTS | DIFFERENT SIZE SAME COLOR | DIFFERENT SIZE DIFFERENT COLOR | DIFFERENCE SCORE |
|---|---|---|---|
| 1 | 523 | 554 | +31 |
| 2 | 606 | 642 | +36 |
| 3 | 497 | 508 | +11 |
| 4 | 588 | 612 | +24 |

Table 6

The effects of size and color on physical matching (Experiment 1)

2. The effects of size on the letter F

| SUBJECTS | SAME COLOR SAME SIZE | SAME COLOR DIFFERENT SIZE | DIFFERENCE SCORE |
|---|---|---|---|
| 1 | 533 | 523 | -10 |
| 2 | 642 | 606 | -36 |
| 3 | 446 | 497 | +51 |
| 4 | 575 | 588 | +13 |

| SUBJECTS | DIFFERENT COLOR SAME SIZE | DIFFERENT COLOR DIFFERENT SIZE | DIFFERENCE SCORE |
|---|---|---|---|
| 1 | 544 | 554 | +10 |
| 2 | 635 | 642 | + 7 |
| 3 | 491 | 508 | +17 |
| 4 | 605 | 612 | + 7 |

Table 7

The effects of size and color on physical matching (Experiment 1)

1. The effects of color on the letter C

| SUBJECTS | SAME SIZE SAME COLOR | SAME SIZE DIFFERENT COLOR | DIFFERENCE SCORE |
|---|---|---|---|
| 1 | 518 | 609 | +91 |
| 2 | 603 | 609 | + 6 |
| 3 | 571 | 568 | - 3 |
| 4 | 613 | 625 | +12 |

| SUBJECTS | DIFFERENT SIZE SAME COLOR | DIFFERENT SIZE DIFFERENT COLOR | DIFFERENCE SCORE |
|---|---|---|---|
| 1 | 576 | 561 | -15 |
| 2 | 670 | 581 | -89 |
| 3 | 549 | 511 | -38 |
| 4 | 588 | 615 | +27 |

Table 8

The effects of size and color on physical matching (Experiment 1)

2. The effects of size on the letter C

| SUBJECTS | SAME COLOR SAME SIZE | SAME COLOR DIFFERENT SIZE | DIFFERENCE SCORE |
|---|---|---|---|
| 1 | 518 | 576 | +58 |
| 2 | 603 | 670 | +67 |
| 3 | 571 | 549 | -20 |
| 4 | 613 | 588 | -25 |

| SUBJECTS | DIFFERENT COLOR SAME SIZE | DIFFERENT COLOR DIFFERENT SIZE | DIFFERENCE SCORE |
|---|---|---|---|
| 1 | 609 | 561 | -48 |
| 2 | 609 | 581 | -28 |
| 3 | 568 | 511 | -57 |
| 4 | 625 | 615 | -10 |

Table 9

The effects of size and color on physical matching (Experiment 1)

1. The effects of color on the letter O

| SUBJECTS | SAME SIZE SAME COLOR | SAME SIZE DIFFERENT COLOR | DIFFERENCE SCORE |
|---|---|---|---|
| 1 | 428 | 487 | +49 |
| 2 | 497 | 614 | +117 |
| 3 | 504 | 561 | +57 |
| 4 | 579 | 567 | -12 |

| SUBJECTS | DIFFERENT SIZE SAME COLOR | DIFFERENT SIZE DIFFERENT COLOR | DIFFERENCE SCORE |
|---|---|---|---|
| 1 | 498 | 512 | +14 |
| 2 | 520 | 650 | +30 |
| 3 | 566 | 593 | +27 |
| 4 | 596 | 631 | +35 |

Table 10

The effects of size and color on physical matching (Experiment 1)

2. The effects of size on the letter O

| SUBJECTS | SAME COLOR SAME SIZE | SAME COLOR DIFFERENT SIZE | DIFFERENCE SCORE |
|---|---|---|---|
| 1 | 428 | 498 | +70 |
| 2 | 497 | 520 | +23 |
| 3 | 504 | 566 | +62 |
| 4 | 579 | 596 | +17 |

| SUBJECTS | DIFFERENT COLOR SAME SIZE | DIFFERENT COLOR DIFFERENT SIZE | DIFFERENCE SCORE |
|---|---|---|---|
| 1 | 487 | 512 | +25 |
| 2 | 614 | 650 | +36 |
| 3 | 561 | 593 | +32 |
| 4 | 567 | 631 | +64 |

Table 11

The effects of size and color on name matching (Experiment 1)

1. The effects of color on the letter B

| SUBJECTS | SAME SIZE SAME COLOR | SAME SIZE DIFFERENT COLOR | DIFFERENCE SCORE |
|---|---|---|---|
| 1 | 662 | 616 | -46 |
| 2 | 400 | 430 | +30 |
| 3 | 516 | 481 | -35 |
| 4 | 609 | 568 | -41 |

| SUBJECTS | DIFFERENT SIZE SAME COLOR | DIFFERENT SIZE DIFFERENT COLOR | DIFFERENCE SCORE |
|---|---|---|---|
| 1 | 581 | 605 | -24 |
| 2 | 454 | 489 | +35 |
| 3 | 512 | 560 | +48 |
| 4 | 543.5 | 535.5 | - 8 |

Table 12

The effects of size and color on name matching (Experiment 1)

2. The effects of size on the letter B

| SUBJECTS | SAME COLOR SAME SIZE | SAME COLOR DIFFERENT SIZE | DIFFERENCE SCORE |
|---|---|---|---|
| 1 | 662 | 581 | -81 |
| 2 | 400 | 454 | +54 |
| 3 | 516 | 512 | - 4 |
| 4 | 609 | 543.5 | -65.5 |

| SUBJECTS | DIFFERENT COLOR SAME SIZE | DIFFERENT COLOR DIFFERENT SIZE | DIFFERENCE SCORE |
|---|---|---|---|
| 1 | 616 | 605 | - 9 |
| 2 | 430 | 489 | +58 |
| 3 | 481 | 560 | +79 |
| 4 | 568 | 535.5 | -32.5 |

Table 13

The effects of size and color on name matching (Experiment 1)

1. The effects of color on the letter F

| SUBJECTS | SAME SIZE SAME COLOR | SAME SIZE DIFFERENT COLOR | DIFFERENCE SCORE |
|---|---|---|---|
| 1 | 640 | 593.5 | -46.5 |
| 2 | 660.5 | 690 | +29.5 |
| 3 | 571.5 | 516 | -55.5 |
| 4 | 675 | 675.5 | +.5 |

| SUBJECTS | DIFFERENT SIZE SAME COLOR | DIFFERENT SIZE DIFFERENT COLOR | DIFFERENCE SCORE |
|---|---|---|---|
| 1 | 618 | 579.5 | -38.5 |
| 2 | 634.5 | 680 | +55.5 |
| 3 | 516.5 | 529 | +12.5 |
| 4 | 678.5 | 636 | -42.5 |

Table 14

The effects of size and color on name matching (Experiment 1)

2. The effects of size on the letter F

| SUBJECTS | SAME COLOR SAME SIZE | SAME COLOR DIFFERENT SIZE | DIFFERENCE SCORE |
|---|---|---|---|
| 1 | 640 | 618 | -22 |
| 2 | 660.5 | 634.5 | -26 |
| 3 | 571.5 | 516.5 | -55 |
| 4 | 675 | 678.5 | + 3.5 |

| SUBJECTS | DIFFERENT COLOR SAME SIZE | DIFFERENT COLOR DIFFERENT SIZE | DIFFERENCE SCORE |
|---|---|---|---|
| 1 | 593.5 | 579.5 | -14 |
| 2 | 690 | 680 | -10 |
| 3 | 516 | 529 | +13 |
| 4 | 675.5 | 636 | -39.5 |

APPENDIX B

Table 1

Three way analysis of variance based on Median "same" RTs Letters (B, C) x Size (same or different) x Color (same or different)

| Source | df | MS | F |
|---|---|---|---|
| Letters (L) | 1 | 13101.00 | 17.20*** |
| L x Subjects (Subjs.) | 5 | 761.51 | |
| Size (S) | 1 | 11875.50 | 60.11**** |
| S x Subjs. | 5 | 197.56 | |
| Color (C) | 1 | 6745.02 | 406.02**** |
| C x Subjs. | 5 | 16.61 | |
| L x S | 1 | 1912.70 | 15.43** |
| L x S x Subjs. | 5 | 123.99 | |
| L x C | 1 | 99.20 | 0.70 |
| L x C x Subjs. | 5 | 141.54 | |
| S x C | 1 | 1837.68 | 20.86*** |
| S x C x Subjs. | 5 | 88.09 | |
| L x S x C | 1 | 808.52 | 12.33** |
| L x S x C x Subjs. | 5 | 65.59 | |
| Subjs. | 5 | 84473.10 | |

****$p<.001$
***$p<.01$
**$p<.025$
*$p<.05$

Table 2

Three way analysis of variance based on Median "same" RTs Match type (Name or Physical) x Size (same or different) x Color (same or different)

| Source | df | MS | F |
|---|---|---|---|
| Match Type (M) | 1 | 21590.10 | 14.89** |
| M x Subjects (Subjs.) | 5 | 1449.82 | |
| Size (S) | 1 | 1496.33 | 5.98 |
| S x Subjs. | 5 | 250.43 | |
| Color (C) | 1 | 2700.00 | 9.39* |
| C x Subjs. | 5 | 287.65 | |
| M x S | 1 | 690.09 | 3.13 |
| M x S x Subjs. | 5 | 220.29 | |
| M x C | 1 | 396.75 | 1.03 |
| M x C x Subjs. | 5 | 384.36 | |
| S x C | 1 | 341.33 | 3.80 |
| S x C x Subjs. | 5 | 89.78 | |
| M x S x C | 1 | 14.09 | 0.07 |
| M x S x C x Subjs. | 5 | 214.03 | |
| Subjs. | 5 | 87535.60 | |

**$p<.025$

*$p<.05$

Table 3

Three way analysis of variance based on Median "same" RTs Match (Name or Physical) x Size (same or different) x Color (same or different)

| Source | df | MS | F |
|---|---|---|---|
| Match Type (M) | 1 | 52332.50 | 7.78*** |
| M x Subjects (Subjs.) | 13 | 6724.81 | |
| Size (S) | 1 | 627.01 | 1.28 |
| S x Subjs. | 13 | 491.75 | |
| Color (C) | 1 | 4312.72 | 10.72*** |
| C x Subjs. | 13 | 402.47 | |
| M x S | 1 | 2065.71 | 3.23 |
| M x S x Subjs. | 13 | 640.25 | |
| M x C | 1 | 3783.94 | 8.52*** |
| M x C x Subjs. | 13 | 443.91 | |
| S x C | 1 | 2.01 | 0.01 |
| S x C x Subjs. | 13 | 262.24 | |
| M x S x C | 1 | 1026.05 | 2.10 |
| M x S x C x Subjs. | 13 | 489.72 | |
| Subjs. | 13 | 48687.30 | |

***$p<.01$

Table 4

The effects of size and color on physical matching (Experiment 2)

1. The effects of size on the letter B

| SUBJECTS | SAME COLOR SAME SIZE | SAME COLOR DIFFERENT SIZE | DIFFERENCE SCORE |
|---|---|---|---|
| 1 | 501.5 | 519 | +17.5 |
| 2 | 407 | 431 | +24 |
| 3 | 524.5 | 547.5 | +23 |
| 4 | 628 | 634 | + 6 |
| 5 | 624 | 653 | +29 |
| 6 | 380 | 419 | +39 |

| SUBJECTS | DIFFERENT COLOR SAME SIZE | DIFFERENT COLOR DIFFERENT SIZE | DIFFERENCE SCORE |
|---|---|---|---|
| 1 | 523 | 528 | + 5 |
| 2 | 427.5 | 443.5 | +16 |
| 3 | 547 | 560.5 | +13.5 |
| 4 | 644.5 | 659 | +12.5 |
| 5 | 663 | 678 | + 5 |
| 6 | 409.5 | 434 | +24.5 |

Table 5

The effects of size and color on physical matching (Experiment 2)

2. Effects of color on the letter B

| SUBJECTS | SAME SIZE SAME COLOR | SAME SIZE DIFFERENT COLOR | DIFFERENCE SCORE |
|---|---|---|---|
| 1 | 501.5 | 523 | +21.5 |
| 2 | 407 | 427.5 | +20.5 |
| 3 | 524.5 | 547 | +22.5 |
| 4 | 628 | 644.5 | +16.5 |
| 5 | 624 | 663 | +39 |
| 6 | 380 | 409.5 | +29 |

| SUBJECTS | DIFFERENT SIZE SAME COLOR | DIFFERENT SIZE DIFFERENT COLOR | DIFFERENCE SCORE |
|---|---|---|---|
| 1 | 519 | 528 | + 9 |
| 2 | 431 | 443.5 | +12.5 |
| 3 | 547.5 | 560.5 | +13 |
| 4 | 634 | 659 | +25 |
| 5 | 653 | 678 | +25 |
| 6 | 419 | 434 | +15 |

Table 6

The effects of size and color on physical matching (Experiment 2)

1. Effects of size on the letter C

| SUBJECTS | SAME SIZE SAME COLOR | DIFFERENT SIZE SAME COLOR | DIFFERENCE SCORE |
|---|---|---|---|
| 1 | 513 | 581 | +68 |
| 2 | 436 | 493 | +57 |
| 3 | 510 | 590 | +80 |
| 4 | 659 | 695 | +36 |
| 5 | 623 | 706 | +83 |
| 6 | 381 | 445 | +64 |

| SUBJECTS | SAME SIZE DIFFERENT COLOR | DIFFERENT SIZE DIFFERENT COLOR | DIFFERENCE SCORE |
|---|---|---|---|
| 1 | 566.5 | 598 | +31.5 |
| 2 | 486 | 507 | +21 |
| 3 | 579.5 | 575 | - 4.5 |
| 4 | 704 | 717 | +13 |
| 5 | 638.5 | 701 | +62.5 |
| 6 | 429 | 448 | +19 |

Table 7

The effects of size and color on physical matching (Experiment 2)

2. Effects of color on the letter C

| SUBJECTS | SAME SIZE SAME COLOR | SAME SIZE DIFFERENT COLOR | DIFFERENCE SCORE |
|---|---|---|---|
| 1 | 513 | 566.5 | +53.5 |
| 2 | 436 | 486 | +50 |
| 3 | 510 | 579.5 | +69.5 |
| 4 | 659 | 704 | +45 |
| 5 | 623 | 638.5 | +15.5 |
| 6 | 381 | 429 | +48 |

| SUBJECTS | DIFFERENT SIZE SAME COLOR | DIFFERENT SIZE DIFFERENT COLOR | DIFFERENCE SCORE |
|---|---|---|---|
| 1 | 581 | 598 | +17 |
| 2 | 493 | 507 | +14 |
| 3 | 590 | 575 | -15 |
| 4 | 695 | 717 | +23 |
| 5 | 706 | 701 | - 5 |
| 6 | 445 | 448 | + 3 |

Table 8

The effects of color and size on name matching (Experiment 2)

1. The effects of size on the letter B

| SUBJECTS | SAME COLOR SAME SIZE | SAME COLOR DIFFERENT SIZE | DIFFERENCE SCORE |
|---|---|---|---|
| 1 | 598 | 552 | -46 |
| 2 | 426.5 | 433 | + 6.5 |
| 3 | 623.5 | 654 | +30.5 |
| 4 | 623 | 683 | +50 |
| 5 | 681 | 695 | +14 |
| 6 | 441 | 437 | - 4 |

| SUBJECTS | DIFFERENT COLOR SAME SIZE | DIFFERENT COLOR DIFFERENT SIZE | DIFFERENCE SCORE |
|---|---|---|---|
| 1 | 573 | 553 | -20 |
| 2 | 475.5 | 472 | - 3.5 |
| 3 | 640 | 637 | - 3 |
| 4 | 695 | 686 | - 9 |
| 5 | 667 | 681 | +14 |
| 6 | 436.5 | 442 | + 5.5 |

Table 9

The effects of size and color on name matching (Experiment 2)

2. The effects of color on the letter B

| SUBJECTS | SAME SIZE SAME COLOR | SAME SIZE DIFFERENT COLOR | DIFFERENCE SCORE |
|---|---|---|---|
| 1 | 598 | 573 | -25 |
| 2 | 426.5 | 475.5 | +49 |
| 3 | 623.5 | 640 | +16.5 |
| 4 | 623 | 695 | +72 |
| 5 | 681 | 667 | -14 |
| 6 | 441 | 436.5 | - 4.5 |

| SUBJECTS | DIFFERENT SIZE SAME COLOR | DIFFERENT SIZE DIFFERENT COLOR | DIFFERENCE SCORE |
|---|---|---|---|
| 1 | 552 | 553 | + 1 |
| 2 | 433 | 472 | +39 |
| 3 | 654 | 637 | -17 |
| 4 | 683 | 686 | + 3 |
| 5 | 695 | 681 | -14 |
| 6 | 437 | 442 | + 5 |