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# The perception of identity in simultaneously presented complex visual displays*

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Two experiments were conducted in order to examine the information processing in a visual matching task, using digit sequences of varying complexity as the stimuli. Traditionally, reaction times for "same" judgments do not fit into a single-process self-terminating feature testing model, while those for "different" judgments do. Bamber (1969) proposed a two-stage model to account for the data, and the results of these experiments support this type of model. Strong evidence implying that Bamber's "identity reporter" has a limited capacity in terms of stimulus complexity was also found. This complexity seems to be defined by stimulus discriminability and the number of "chunks" of information rather than by "bits" of information being transmitted (Miller, 1956).

This report describes two experiments designed to investigate the nature of the information processing involved in complex visual discriminations. Ss were presented with pairs of digit strings varying in length, discriminability, and the size of the set from which the digits were drawn, and they were required to indicate, as rapidly as possible, whether the two strings were physically the same or different. The major dependent variable was same-different RT.

The experiments were intended to supplement the evidence implying the inadequacy of any of the one-process feature testing models to account for the data in the type of matching task (cf. Nickerson, 1970). These analytic models can be divided along several binary classes concerning: (a) whether features are processed simultaneously (*parallel*) or temporally (*serial*), (b) whether the processing must continue until the entire feature set is processed (*exhaustive*) or can end when the minimum information needed to reach a decision is obtained (*self-terminating*), (c) whether the order of the processing of features in the case of a serial model is *fixed* or *random*, (d) whether the time necessary to process a single dimension is *distributed* or *fixed*. (For a detailed description of these various models and their implications for the visual matching task, see Hawkins, 1969.) To summarize the results of many studies (Bamber, 1969; Beller, 1970; Cohen, 1969; Downing & Gossman, 1970; Egeth, 1966; Grill, 1971; Krueger, 1970; Nickerson, 1970; Sekular & Abrams, 1968; Smith & Nielsen, 1970; Snodgrass, 1972; Tversky, 1969), the RT data collected when Ss responded to a difference between pairs of stimuli fit into a self-terminating feature testing model, while the latencies obtained when Ss were responding to an "identical" stimulus pair seemed to fall into a template matching process (Neisser, 1967). The main reason for this incompatibility lies in the widespread finding that $\overline{RT}_{same} < \overline{RT}_{diff}$ (when one dimension differs), even though the "same" decision requires exhaustive processing, while the "different" response can be initiated before all stimulus features are fully processed.

Proponents of one-process models have attempted to explain this finding by reference to artifacts built into the procedure. Hawkins (1969) pointed out that one possible artifact is found in the probability of occurrence of the various stimulus types. If the stimuli are multidimensional, half requiring a "same" response and the remainder a "different" response, the total set of different pairings must be divided among the various difference levels (ranging from minimal to maximal difference). When this is done, the probability of occurrence of any one type of different pairing is less than the probability that a same slide will appear. $\overline{RT}$ is related to stimulus probability (Smith, 1968) and this could account for the data. When the stimulus set is changed from

$$p(S_{same}) = p(\sum_{\iota}^{N} S_{\text{different type } \iota}) \qquad (1)$$

to

$$p(S_{same}) = p(S_{\text{different type } \iota}) \qquad (2)$$

in order to equalize the probabilities of identical and minimally differing stimuli, the $\overline{RT}_{same}$ becomes greater than $\overline{RT}_{diff}$ (with one dimension differing), conforming to the single-process model's prediction. Hawkins, however, pointed out that this procedure introduces a possible artifact of response biasing because $p(R_{same}) < p(R_{diff})$, making these results difficult to interpret reliably. Further, when the response bias was removed by using a Donder's Type c task (Sternberg, 1969), the occurrence of a "same" response became so infrequent that the S was performing a vigilance task (Mackworth,

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1970), again making a clear interpretation of the data difficult.

Other possible artifacts discussed were: (a) a simple bias toward the "same" response, (b) a speed for accuracy tradeoff operating to favor the "same" response, (c) a priming mechanism where the "same" response is prepared for initiation before the processing terminates. The first of these possibilities is straightforward; Ss simply preferred to make a "same" response and, rather than reflecting a difference in the information processing or matching stage, the faster $\overline{RT}_{same}$ was due to a difference in the response initiation stage (Sternberg, 1969). The second alternative postulates that S could ignore the most difficult dimensions without a significant increase in error rate (as the probability that only a specific single dimension is different is $1/(2N)^2$, where N is the number of dimensions.)[1]

This means that, if a stimulus is composed of three dimensions (cf. Hawkins, 1969), errors will be made on only 1/18 of the trials if the most difficult dimension is completely ignored and a "same" response is initiated when no difference is detected along the other dimensions. This error rate can be further reduced if the S samples this dimension occasionally when no other difference is detected, resulting in no significant increase in the overall error rate and a speed for accuracy tradeoff that is difficult to detect. The third possible artifact comes from the notion that, as the dimensions are processed and no difference is encountered, the conditional probability that the pairing will require a "same" response is increasing (Grill, 1971). This allows the S to "prepare" to make a "same" response, producing a priming effect. If, however, a difference is detected late in processing, the "same" response must first be inhibited before the "different" response can be initiated, accounting for the relative speed of the $\overline{RT}_{same}$.

Ellis (1972) has suggested another one-process model that utilizes the response bias notion. He has postulated that if: (a) the stimulus pair can be processed as a single chunk (Miller, 1956), (b) each chunk is processed exhaustively, and (c) processing can self-terminate after any chunk is completed, the explanation for the relative speed of $\overline{RT}_{same}$ may simply lie in some response mechanism. Supportive data can be found where more complex patterns (Bamber, 1969; Eichelman, 1970; Hoch, 1971) containing more than a single chunk as conventionally defined are used as stimuli and $\overline{RT}_{diff} < \overline{RT}_{same}$. However, data from trials requiring a "different" response suggest a self-terminating model, even with the simpler multidimensional patterns, calling this type of explanation into question.

As the attempts to explain the data within a one-process model become more intricate, it becomes clear that a one-process model has great difficulty explaining these data. Therefore, Bamber (1969) proposed a two-process model containing a self-terminating feature analyzer to account for the $\overline{RT}_{diff}$ data and a separate "identity reporter" that performed a template matching function to account for the $\overline{RT}_{same}$ data. But the notion of an identity reporter, which only signals the presence of identity, is intuitively displeasing. It is illogical to assume that the failure of this reporter to signal does not signal nonidentity and that such a specific mechanism should have evolved in the human organism, as it is extremely uncommon that a discrimination of this type is necessary in normal everyday activity.

Conceding the possible objections that are voiced against Bamber's (1969) formulation, it seems more productive at this time to accept a two-process model of some type and to further investigate what factors influence these processes than to attempt to dismiss the large body of data favoring a dual-process model on artifactual grounds. When the nature of the processes becomes clearer, a more appealing two-stage model might be formulated.

## EXPERIMENT I

Sekuler and Abrams (1968) and Hock (1971) investigated information processing in a visual matching task using more complex stimulus materials than those employed by Bamber (1969). Hock, using random dot patterns on an 8 by 8 grid, found $\overline{RT}_{diff} < \overline{RT}_{same}$, and Sekuler and Abrams, using a 4 by 4 grid, found that simple patterns (of one or two grid cells) showed $\overline{RT}_{same} < \overline{RT}_{diff}$ but more complex figures (of four grid cells) showed $\overline{RT}_{diff} < \overline{RT}_{same}$. Taken with the other matching task data, these results seem to imply that, if it exists, the "identity reporter" has a limited capacity.

In order to measure the processing capacity of any system, the units in which to measure this capacity must first be determined. This experiment was designed to determine if there is a quantitative limit on the ability to make "same" judgments inordinately quickly, and if this limit is determined primarily by the stimulus information content in bits as opposed to chunks (Miller, 1956), or the stimulus discriminability.[2]

Krueger (1971) pointed out that, given any set of units greater than two, the number of possible different pairs exceeds the number of possible same pairs. With a small set of units, a possible strategy for S is to encode the stimulus pair as a whole, determine which set of pairs it belongs to, and assign an appropriate response. This could explain why $\overline{RT}_{same} < \overline{RT}_{diff}$, as the set size defining a response is proportional to $\overline{RT}$ (Smith, 1968), and implies that the stimulus information content is a relevant factor in determining $\overline{RT}$ in the matching task. Krueger's (1971) data from an experiment in which the sets of presented same stimulus pairs and different stimulus pairs were of equal size and the $\overline{RT}_{same}$ was still less than $\overline{RT}_{diff}$ contradicted this explanation, but it is possible to explain this result by distinguishing between the actual alternatives and the alternatives considered by the Ss. Although the number of presented different stimuli was only a subset of those possible, the S may not have been able to limit his search to less than the entire possible set, and the S's subjective set of alternatives was larger than the set actually used in the study.

To investigate further the relationship between stimulus information content and $\overline{RT}$, an alternative method of manipulating information content, which avoids this confounding, was employed. The stimuli in this experiment were digit sequence pairs, with stimulus discriminability and information content varying independently.

Robinson, Brown, and Hayes (1964) have shown that matching two stimuli can occur at a stage prior to stimulus identification. If this is true, a memory search is not necessary for the match, and, therefore, the size of the set of possible stimulus values should be irrelevant. The first prediction, therefore, was consistent with Krueger's (1971) finding that information content in bits is irrelevant. In addition, since the nature of the task required two stimuli to be compared and since discriminability should influence the ease of this comparison, it was expected to have an effect. In order to measure this effect independently of any information effect, three conditions, differing in discriminability but transmitting a constant amount of information, were used.

The most critical part of this experiment was the nature of the "same"/"different" response interaction. It was predicted that the $\overline{RT}_{same}$ would be faster for short digit sequences, while the $\overline{RT}_{diff}$ would be faster for long digit sequences where the identity reporter was overloaded. Further, if the capacity of the identity reporter also depends on stimulus discriminability, this overloading should take place at a longer sequence length for the more discriminable stimuli.

## Method

*Design*

A 2 by 5 by 8 experimental design was employed, with two responses ("same" or "different"), five conditions varying in discriminability or information content as outlined above, and eight levels of stimulus complexity within each condition.

*Subjects*

Ten undergraduates with normal corrected or uncorrected vision participated in this experiment. All Ss were fulfilling a requirement of an introductory psychology course and were not otherwise compensated.

*Apparatus*

The stimuli were projected from a Kodak 900 carousel slide projector. A shutter mechanism fitted to the projector controlled the stimulus duration and interstimulus interval. The opening of the shutter triggered a Hichock timer, which was halted by the depression of one of the two response keys. S's response and the latency were recorded by a Hichock printer. The two keys were 2 in. apart and mounted on a table in front of the S. Each S used his preferred hand to operate the keys. The stimuli were projected onto a white cardboard screen 6 ft in front of the S.

*Stimuli*

Stimulus figures were constructed by photographing two lines of random digits, typed one above the other. The two lines were of equal length within a stimulus pair and varied in length from one digit to eight digits between pairs.

The stimuli were further divided into five groups. Three groups were designed as 1-bit conditions because they were constructed from a set of two digits. Group 1 contained only 0, 1, Group 2 contained 2, 3, and Group 3 contained 6, 7. These pairings were selected in order to vary digit discriminability, 0, 1 being most discriminable and 2, 3 least discriminable. Consecutive numbers were used in order to avoid any effects of intervening digits due to overlearned counting behavior. Group 4 was a 2-bit condition, as its stimulus members were constructed from the digit set 0, 1, 2, 3, and Group 5 was a 3-bit condition composed of the digits 0-7.

Within each condition, the stimuli of each length were equally divided between same pairs, in which the two numbers were composed of identical digits, and different pairs, composed of two numbers that differed only at a single position. In this manner, the artifact mentioned by Hawkins (1969) concerning the greater number of same stimuli than one-dimension different stimuli is avoided without changing the overall 1:1 ratio of sames to differents.

The stimuli were grouped by condition into five blocks of 64. Added to the 2-bit and 3-bit conditions were an additional 16 slides (1 same and 1 different for each length), which were identical copies of 16 slides in the 2, 3 and 6, 7 groups, respectively. This provided an additional check on the relevancy of digit uncertainty on the matching task performance. The slides within each block were random regarding appropriate response, the only constraint being that not more than five consecutive trials could require a similar response, and the various lengths were ordered by a Latin-square arrangement. The extra 16 slides in the 2- and 3-bit conditions were inserted into this order randomly. There were a total of 352 slides.

*Procedure*

All Ss participated in one experimental session lasting approximately 35 min, during which all stimuli were presented. A Donder's Type b task was used in order to compare $\overline{RT}_{diff}$ with $\overline{RT}_{same}$ within each S. The order of block presentation was counterbalanced by Latin square, with half of the Ss pressing the left key for "same" responses and the remainder using the right key to signal "same."

Ss were seated in a darkened room and informed of the exact nature of the stimuli. Before each block, S was told the digit set from which the stimuli were constructed. There was a short rest period between blocks that varied slightly, the next block starting when S indicated that he was ready. The intertrial interval within a block was 1 sec. A trial consisted of (a) stimulus onset, (b) Ss' response terminating stimulus presentation, and (c) a 1-sec blank interval. In this manner, the offset of the preceding trial served as a warning stimulus for the next trial. There was no feedback given during the experimental session.

## Results and Discussion

The $\overline{RT}$ results for both "same" and "different" responses for the various conditions are summarized in Table 1. The dependent measure was the mean of the medians of the individual Ss' $\overline{RT}$.

Table 1
Mean RT for All Groups in Experiment I

| | Stimulus Set | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.1 | | 2.3 | | 6.7 | | 0-3 | | 0-7 | | |
| Length | Same | Diff | Same | Diff | Same | Diff | Same | Diff | Same | Diff | Mean |
| 1 | 823 | 925 | 808 | 864 | 710 | 882 | 804 | 889 | 796 | 930 | 843 |
| 2 | 823 | 847 | 900 | 1012 | 844 | 990 | 901 | 978 | 834 | 921 | 905 |
| 3 | 961 | 946 | 1212 | 1171 | 1074 | 945 | 844 | 1210 | 886 | 994 | 1024 |
| 4 | 973 | 1030 | 1315 | 1474 | 1010 | 1071 | 1045 | 1122 | 1108 | 1216 | 1136 |
| 5 | 1056 | 1054 | 1496 | 1552 | 1194 | 1210 | 1103 | 1149 | 1228 | 1352 | 1239 |
| 6 | 1197 | 1312 | 1858 | 1669 | 1368 | 1239 | 1590 | 1564 | 1519 | 1470 | 1482 |
| 7 | 1254 | 1187 | 2200 | 1883 | 1490 | 1469 | 1864 | 1514 | 1707 | 1746 | 1635 |
| 8 | 1188 | 1520 | 2338 | 1788 | 1666 | 1670 | 1992 | 1591 | 2150 | 1576 | 1748 |
| Mean | 1034 | 1107 | 1516 | 1427 | 1169 | 1188 | 1268 | 1252 | 1278 | 1276 | |
| | 1070 | | 1471 | | 1179 | | 1260 | | 1277 | | |

*Main Effects*

The various conditions differed significantly [$F(4,36) = 27.23$, $p < .001$]. An orthogonal comparison between the five groups showed that there was no significant difference between the 2-bit and 3-bit conditions [$F(1,36) < 1.0$] and no significant difference between the mean of the 1-bit conditions and the mean of the 2- and 3-bit conditions [$F(1,36) = 1.21$, $p > .1$]. The 0, 1 group was significantly faster than the 2, 3 and 6, 7 groups combined [$F(1,36) = 54.0$, $p < .001$], and the 2, 3 group was significantly slower than the 6, 7 group [$F(1,36) = 53.6$, $p < .001$]. The lack of a significant effect of digit uncertainty is substantiated by the additional comparison of the 16 identical stimulus pairings from the 2- and 3-bit conditions and the 2, 3 and 6, 7 groups, respectively. Sandler's A was used as the test statistic; for the "same" responses $A(7) = 0.2951$ and $A(7) = 5561.0$ [Acrit ($0.05$) $\leqslant 0.281$) for the respective comparisons; for the "different" responses $A(7) = 0.5785$ and $A(7) = 0.7856$. This evidence strongly implies that discriminability and not uncertainty determines $\overline{RT}$ in a matching task. This result fits well with the Robinson, Brown, and Hayes (1964) finding that a discrimination can be made without stimulus identification. Further, since the task's minimal demands do not require a memory search as traditionally defined in order to maintain perfect performance, there is no intuitive reason to assume that the information content/item should predict $\overline{RT}$.

$\overline{RT}$ increased significantly with increasing stimulus length [$F(7,63) = 78$, $p < .001$], but there was no significant main effect for response ("same" vs "different") [$F(1,9) < 1.0$].

*A Comparison of Same and Different Reaction Times*

Figure 1 shows the relationship of the "same" and "different" responses averaged over the five conditions and plotted against sequence length. The response interaction is significant [$F(7,63) = 7.43$, $p < .001$], with an apparent advantage favoring the "same" response for stimuli up to Length 5 and then switching to the "different" responses for Lengths 6-8. To verify this observation, the data were divided into two parts, one for Stimulus Lengths 1-5, the other for Lengths 6-8, and reanalyzed. For Lengths 1-5, the "same" response was faster than the "different" response [$F(1,9) = 15.99$, $p < .01$], and there was no significant Response by Length interaction [$F(4,36) < 1.0$]. In contrast, for the Lengths 6-8 the "different" response was faster than the "same" response [$F(1,9) = 6.84$, $p < .05$], and there was a significant Linear by Linear/Response by Length interaction [$F(1,18) = 5.17$, $p < .05$]. Inspection of the data revealed that the slope of the "same" response function was twice that of the "different" response function (120 vs 57 msec, respectively), a result predicted by a one-process serial self-terminating model. This type of interaction was found in all conditions except 0, 1, where the "same" response maintained a faster $\overline{RT}$ for longer stimulus lengths.

There was, in addition, a significant Response by Condition by Length interaction [$F(28,252) = 5.69$, $p < .001$] that seemed to be due to variance in the crossover point of the two response curves; the groups of higher stimulus discriminability crossed over at a later point than the groups of lower discriminability.

In order to verify this point, regression lines were calculated for the two responses in the three 1-bit conditions. The crossover point of these lines should occur at a longer stimulus length for the more discriminable stimulus conditions. Figure 2 shows this effect clearly.

In addition to clarifying the triple order interaction, the variable crossover point suggests that any eye movement artifact cannot account for the data. The stimulus construction was such that, as the number of digit pairs increased, the stimulus size (i.e., the visual angle) also increased. It is possible that five digits can be processed without eye movement, while six digit sequences cannot. If this were the case, this artifact might be sufficient to explain the overall Response by Length interaction. However, an eye movement type

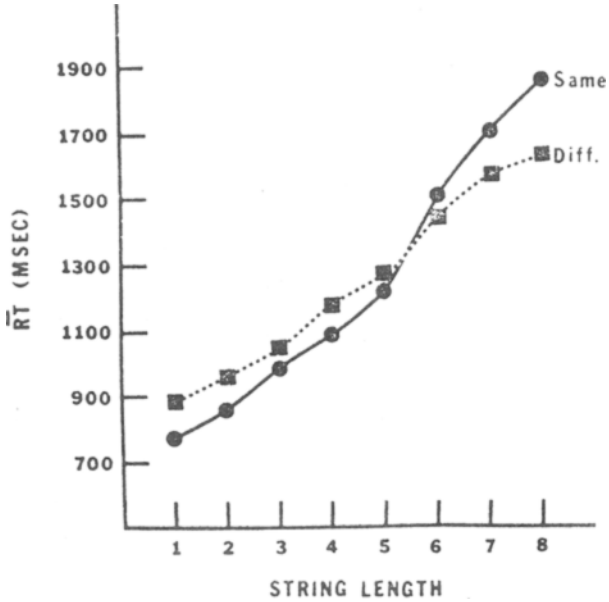


**Fig. 1. The response by length interaction of the RT data in Experiment I.**

explanation is untenable, because the 0, 1 condition shows that no crossover has occurred, even for eight digit sequences, and the digit size is constant across conditions. The data support the notion that the identity reporter function's limited capacity is affected by stimulus discriminability.

*Errors*

The overall error rate for Experiment I was 4.1%, with more false "same" responses than false "different" responses [$F(7,63) = 3.17$, $p < .001$].[3] The error data are given in Table 2, and inspection reveals that the difference in the response error rates is increasing from Stimulus Length 2 to Length 8. Since the data for Sequence Lengths 6-8 fit into a one-process self-terminating model with a simple response bias assumption and the difference in the error rates of the two responses for these stimuli are largest, reflecting the greatest amount of speed-accuracy tradeoff (Swenson, 1972), it is clear that a simple response bias notion is insufficient to explain the relationship between the two response functions for the shorter length sequences.

These findings seem to replicate previous work (cf. Hawkins, 1969) regarding the relative speed of the "same" judgments for simple tasks. Assuming some identity reporter mechanism (Bamber, 1969), it would seem that it has a limited capacity above which the same $\overline{RT}$s lose their advantage. This is demonstrated by the fact that (a) below Stimulus Length 6 the "same" responses are faster than the "different" responses, (b) the slope of these two functions show no interaction, and (c) above Stimulus Length 5 the data conform nicely to a single-process self-terminating feature testing model. It is difficult, however, to draw conclusions from these data contrasting the two response decision processes without obtaining a clearer picture of the nature of the different decision mechanism. Experiment II was designed for this purpose, and further discussion of this contrast will be postponed until after the results are reported.

## EXPERIMENT II

The purpose of the second experiment was to examine the nature of the different decision processing. Although much evidence has been reported indicating that this process is of a self-terminating nature (cf. Hawkins, 1969), verification for this particular type of stimulus arrangement is useful. Because only a single level (percent) of difference is used in Experiment I for each stimulus length, it is impossible to discern the nature of the different decision processing from this data. In this experiment, the selected stimulus lengths will vary with respect to difference level, allowing evidence for or against a self-terminating process to be observed. A self-terminating process model predicts that, as the level of pair difference increases, $\overline{RT}$ should decrease monotonically, while an exhaustive processing

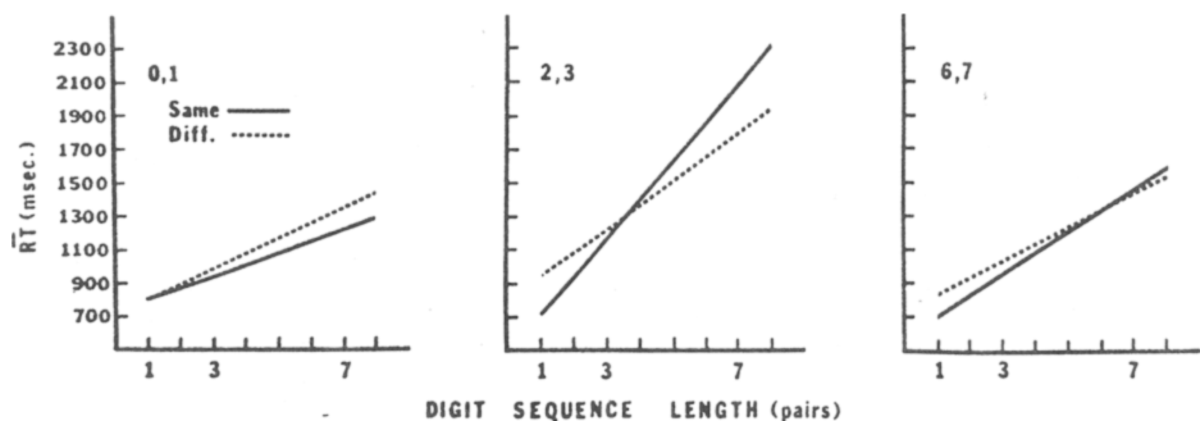


**Fig. 2. The Linear by Linear/Response by Length interaction of the RT data for the three 1-bit conditions in Experiment I. (Pearson r is greater than 0.9 around each of the regression lines plotted.)**

**Table 2**
**Error Rates (Percent) for the Various Groups in Experiment I**

| Stimulus Length | Condition 0.1 Same | 0.1 Diff | 2.3 Same | 2.3 Diff | 6.7 Same | 6.7 Diff | 0-3 Same | 0-3 Diff | 0-7 Same | 0-7 Diff | Mean Same | Mean Diff |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2.5 | 12.5 | 0 | 5 | 0 | 5 | 0 | 7.5 | 0 | 2.5 | 0.5 | 6.5 |
| 2 | 0 | 0 | 2.5 | 2.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0.5 | 0.5 |
| 3 | 0 | 5 | 2.5 | 7.5 | 0 | 0 | 0 | 2.5 | 0 | 5 | 0.5 | 4.0 |
| 4 | 2.5 | 2.5 | 0 | 12.5 | 0 | 7.5 | 0 | 7.5 | 0 | 12.5 | 0.5 | 8.5 |
| 5 | 2.5 | 7.5 | 2.5 | 7.5 | 0 | 12.5 | 0 | 5 | 5 | 7.5 | 2.0 | 8.0 |
| 6 | 2.5 | 10 | 0 | 7.5 | 5 | 5 | 0 | 12.5 | 0 | 2.5 | 1.5 | 7.5 |
| 7 | 2.5 | 2.5 | 2.5 | 17.5 | 0 | 12.5 | 2.5 | 2.5 | 2.5 | 10 | 2.0 | 9.0 |
| 8 | 0 | 12.5 | 0 | 15 | 2.5 | 17.5 | 7.5 | 10 | 0 | 5 | 2.0 | 12.0 |
| Mean | 1.56 | 6.56 | 1.25 | 9.06 | 0.94 | 7.5 | 1.25 | 5.94 | 0.94 | 5.62 | 1.19 | 7.0 |
| | 4.06 | | 5.16 | | 4.22 | | 3.60 | | 3.28 | | 4.06 | |

model predicts that there should be no effect of increasing the level of pair difference on $\overline{RT}$.

## Method

*Apparatus and Subjects*

The apparatus and general procedure for Experiment II were the same as for Experiment I. Ss were 12 volunteers from an undergraduate course in experimental psychology, all having 20/20 corrected or uncorrected vision.

*Design*

The overall design of this experiment can be most clearly described as the combination of two separate designs. The first contains stimuli of Length 2, with two responses ("same" or "different") and two levels of difference (one pair or two pairs differing). The second contains stimuli of Length 5, also with two responses, but with five levels of difference (one through five pairs differing).

*Stimuli*

Again pairs of random digit strings functioned as the stimuli, but only the 0, 1, 2, 3 group from Experiment I was used, selected because it was of both intermediate discriminability and information content. Two lengths of stimuli were employed, Length 2 and Length 5. For each length, half of the stimuli were same and the remainder different, the difference now varying over all possible degrees (percent) of difference. The Length 2 stimuli had either one or two pairings different, while the Length 5 stimuli could differ in one, two, three, four, or five positions. The different stimuli were divided equally between the various levels of difference and, within equal levels, all possible combinations of difference positions were used. The different pairings were used for each level of difference for both stimulus lengths, yielding a total of 70 different slides that were matched with 70 same slides.

**Table 3**
**Mean RT for All Groups in Experiment II**

| Stimulus Length | Percent Difference 0* | 20 | 40 | 50 | 60 | 80 | 100 |
|---|---|---|---|---|---|---|---|
| 2 | 711 | | | 808 | | | 776 |
| 5 | 882 | 1026 | 884 | | 883 | 821 | 771 |

**Same*

## Results and Discussion

The $\overline{RT}$ data from Experiment II is summarized in Table 3. A comparison of the $\overline{RT}_{same}$ and $\overline{RT}_{diff}$ shows that the "same" response is faster than the one item different judgments for both stimulus lengths [Sandler's $A(9) = 0.1999$, $p < .05$ for Length 5 stimuli and $A(9) = .2418$, $p < .05$ for Length 2 stimuli], replicating the results of Experiment I.

Although the Length 2 stimuli showed no significant difference between different pairs when one or two items differed [$F(1,9) < 1.0$], the difference is in the direction predicted by a self-terminating model, and the various levels of difference for the Length 5 items were significantly different [$F(4,36) = 7.35, p < .001$].

Further analysis shows the linear trend of this relationship to be highly significant [$F_{LIN}(1,36) = 26.38$, $p < .001$] and accounts for 89.7% of the total sums of squares between the level of difference groups. These data add to the existing evidence (Nickerson, 1970), which strongly supports self-terminating processing for the different comparison process, since any exhaustive model predicts that increasing the degree of stimulus difference should have no effect on $\overline{RT}$.

*Errors*

The overall error rate for Experiment II was 3.9%; the error data are given in Table 4. A comparison between the false "same" (with one digit pair different) and false "different" responses shows that there is no significant difference between them for the Length 2 stimuli [$A(9) = 0.5$, $p > .1$], but there was a difference for the Length 5 stimuli [$A(9) = 0.20$, $p < .05$]. Extension of this comparison to the Length 5 stimuli with two digit pairs differing does not show this difference [$A(9) = 3.4$, $p > .1$]. Taken with the $\overline{RT}$ data, these results add to the evidence from Experiment I demonstrating the inability of a response bias notion to explain the relationship between the two responses, since a one-process self-terminating model must predict that $\overline{RT}_{same} > \overline{RT}_{diff}$ (with two items differing) unless there is evidence favoring a strong response bias interpretation. This evidence is absent in the data.

## CONCLUSIONS

The results of these experiments strongly imply that the attempts to explain the identity reporter process within a one-process feature testing model have been inadequate. The simple response bias explanation fails because of its inability to predict the lack of a Response by Length interaction for the simpler stimuli in Experiment I. The difference in stimulus probabilities for the same and one item different stimuli is avoided in Experiment I, where $p(S_{same}) = p(S_{one\ item\ diff})$ and $\overline{RT}_{same} < \overline{RT}_{diff}$ for simpler stimuli. The "priming" of the "same" response, due to the change in the conditional probabilities that a stimulus pair is a same as processing progresses without the detection of a difference, does not seem to predict a discontinuity in the "same" response function as length increases analogous to the one observed in the Experiment I data. Finally, Krueger's (1971) postulation that stimulus set size may be relevant seems doubtful because of the lack of an effect of stimulus information content found in Experiment I. It seems unlikely that a variable that has no effect between conditions should influence the processing within a condition and, taken with Krueger's (1971) results, the data are strongly counter to this notion.

The results seem to necessitate the postulation of a two-process model, but there remain the strong intuitive arguments against Bamber's design, mentioned previously. While not conclusive, these are compelling arguments against a two-process model with a *separate* identity reporter. Therefore, a different two-process system shall be proposed that attempts to avoid the pitfalls inherent in Bamber's formulation.

### A Two-Stage Model

A model that can accommodate the matching task data need not postulate a *separate* identity reporter; the basis for such a model can be found in a Broadbent (1958) type formulation. Briefly, the original model describes the information flow within the nervous system as follows: (a) information comes from the environment to the senses; (b) it passes from the senses to some *short-term storage* (STS) area, where (c) a *filter* selects what information to pass on for further processing through considerations of perceptual set and expectancies to (d) a *limited capacity channel* (LCC) that handles detailed processing of the stimulus input in some appropriate form. The remainder of the model is not relevant to this discussion.

Once the notion of a selective filter is accepted, consideration must be given to how this filtering is accomplished. A process whereby the most relevant information or dimensions are selected implies a decision mechanism within the filter, and this decision must be based on expectancy, set, and what has already gone into the limited capacity channel (all as Broadbent's original model implies). In order for all this information to be considered, the filter must have some capacity to store information for brief periods. Conceptually, this store could take the form of a rapidly decaying memory trace that must serve to (a) guide the filter in picking out relevant dimensions and (b) prevent relevant dimensions already read into the limited capacity channel from being immediately and endlessly repeated.

**Table 4**
**Error Data (Percent) for Experiment II**

| Sequence Length | Percent Difference 0* | 20 | 40 | 50 | 60 | 80 | 100 |
|---|---|---|---|---|---|---|---|
| 2 | 2.0 | | | 6.0 | | | 2.0 |
| 5 | 3.27 | 15.0 | 5.0 | | 4.0 | 1.82 | 2.0 |

**Same*

It is conceivable that in the matching task, through instructions, the selective filter reads in the first item of the stimulus pair and then scans the second item for some incongruence. In order to perform this comparison, the filter must have available the set of features from the first item; the most efficient method of maintaining these features for reference would be to store them in the filter. As this storage area, as stated previously, is postulated to take the form of a set of rapidly decaying memory traces, only simple stimuli can be completely scanned by the filter before some of the original first-item information is lost.

If the stimulus pair can be compared without this information loss, the filter can report that (a) there is no incongruency, i.e., a "same" response is appropriate, or (b) there is an incongruency, i.e., a "different" response is appropriate. However, some information loss is always possible, and, because anything in the second stimulus item that is not in the set of first-item features now available to filter must be judged as an incongruency, requiring a "different" response, the different decision can never be made at the filter read-in level, even for simple stimuli. The filter can only read the feature in question into LCC, where a decision is made through a feature testing mechanism as to whether an actual stimulus difference exists or whether the observed incongruency was the product of filter trace decay. The filter can, however, simply report to the LCC that there are no new features in the second stimulus item and the LCC directs a "same" response to be made. This process is the functional equivalent of Bamber's identity reporter. If the stimulus material is complex and the filter cannot maintain the first item's feature set, the now novel features of the second stimulus item, although identical to those of the first stimulus item, will be read into the LCC and must be compared to the first-item feature set according to one of the feature testing models previously described in order to judge this identity. Thus, any decision to execute a "same" response with complex stimulus material becomes the end result of an exhaustive search within any of the self-terminating models, and the explanation of the data is completed.

It must be remembered that this system is not proposed as a definitive model to explain the matching task data but is postulated as a viable system, based on established principles, that avoids the pitfalls of Bamber's (1969) original formulation in which two completely different systems are responsible for the two response decisions. In the model proposed in this paper, the identity reporter function becomes a by-product of the more traditional information processing scheme.

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## NOTES

1. This is derived from the fact that (a) half of the stimuli are different, (b) the different stimuli are divided evenly between the various levels of difference (i.e., what fraction of the pair's dimensions differ), and (c) the specific dimension(s) differing is evenly distributed among the total dimensions on a given level.

2. The number of bits is defined in terms of the log (Base 2) of the number of possible outcomes, but chunks have no exact definition in the reduction of uncertainty. Typically, chunks refer to integrated stimulus units. For instance, a letter can be one chunk, although there are 26 possible letters. Letters represent more than 1 bit but constitute only one chunk.

3. A false "same" response occurs where a "same" response is erroneously given when a "different" response is appropriate.

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