

Persistence of a briefly presented visual stimulus in sensory memory

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College students were given 12 trials in which two 4 by 4 matrices of letters were presented sequentially, each for 100 msec. On one-half of the trials, the second matrix was the same as the first, and on one-half of the trials, the second matrix differed from the first. Both the interval between the two presentations and the degree of difference between the second matrix and the first were manipulated systematically. Results indicated that when the difference between the second matrix and the first was either large or nonexistent, recognition was good. When the difference between the matrices was small, performance decreased significantly. The inter-stimulus interval variable was not significant. Results were discussed in terms of Sperling's (1960) findings and those of Cermak (1971) and Phillips (1974).

Sensory memory is thought to be the first stage in the information processing system and has three major characteristics. First, sensory memory has virtually unlimited capacity. That is, all sensory information impinging upon a certain sensory system is stored. Second, the information is held in sensory memory for a very brief period of time, usually less than 1 sec. Third, information in sensory memory is processed in terms of physical characteristics and is not categorized in terms of meaning until later. Evidence for these three characteristics comes from a series of experiments by Sperling (1960). In Sperling's paradigm, subjects were presented a matrix of letters for 50 msec and asked to recall the entire matrix, the whole-report procedure, or an identified portion of the matrix, the partial-report procedure. Under the latter procedure, recall was significantly better and indicated that most of the incoming sensory information is available for recall, for a brief period of time. In Experiment 6, Sperling presented his subjects a matrix consisting of letters and numbers. When asked to report just the letters, or the numbers, performance was not different from that in the whole-report procedure, indicating that information in sensory memory is stored precategorically.

Although performance under the partial-report procedure is quite good, it is still not perfect. In fact, with a 3 by 4 matrix of letters, subjects could report only 76% correct. It is possible that the lower percentage is attributable to the partial-report procedure itself. Before the subject can report the letter, the process of pattern recognition must take place, since

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information in sensory memory is precategorical. The invoking of another memory system complicates the task and may account for this finding. The present investigation was an attempt to remedy this situation by making the task one of recognition. Subjects were presented two slides, each for 100 msec, and were asked to press a response key that indicated whether the second slide was identical to or different from the first. With this method, since it is not necessary to invoke the process of pattern recognition, it may be possible to accurately assess the capacity of sensory memory proper. In this experiment, both the inter-stimulus interval (ISI) and the degree of difference between the two slides were systematically varied. It was hypothesized that as the ISI increased, performance would decrease. In addition, it was thought that the degree-of-difference variable would have no effect, since sensory memory is thought to be a high-capacity system and one in which even small differences should be detectable.

METHOD

Subjects

Fifty-eight male and female students enrolled in the introductory psychology course served. Students participated in order to meet course requirements.

Apparatus

The apparatus consisted of two Kodak Carousel projectors, each with a Lafayette (Model 43016) electronic tachistoscope attachment. In addition, a Lafayette repeat cycle timer (Model 51013) and two response keys (Model 58026) connected to a data recorder (Model 58004) were used. Subjects were presented a 4 by 4 matrix of white letters on a dark background. Two slides were presented sequentially in one of four ways: (1) The second slide was identical to the first, or (2) the second slide differed from

the first by 1 letter, either 1 of the 4 inside letters or 1 of the 12 outside letters, or (3) the second slide differed from the first by 4 letters, either the 4 inside letters or one entire outside row or column, or (4) the second slide differed from the first by 16 letters, with the positions filled first by the unused letters, then by the other letters, randomly assigned to different positions. During blank periods, the screen and room were dark.

Procedure

Subjects were randomly assigned to one of four groups; the groups differed only with respect to the ISIs, which were 100, 250, 500, or 5,000 msec. All subjects received six trials in which the second slide was the same as the first (same), two trials in which the second slide differed from the first by 1 letter (D1), two trials in which the second slide differed from the first by 4 letters (D4), and two trials in which the second slide differed from the first by 16 letters (D16). The duration of each slide was 100 msec. In addition, subjects were given two practice trials. The 12 nonpractice trials were randomly presented, and subjects were instructed that 50% of the trials would be "same" trials and 50% would be "different" trials. The subject's task was to press a key marked "SAME" if it was thought the second slide was the same as the first and to press a key marked "DIFFERENT" if it was thought the second slide differed from the first. The experimenter called out "ready" prior to each trial.

RESULTS

The percentages of correct responses for all subjects are presented in Figure 1 as a function of ISI and the degree of difference between the second slide and the first. A split-plot analysis of variance on these data revealed no effect attributable to ISI [$F(3,54) = 2.17, p > .05$], a strong degree-of-difference effect [$F(3,162) = 44.14, p < .01$], and a significant interaction [$F(9,162) = 2.29, p < .05$]. The degree-of-difference variable accounted for 35% of the variability, whereas the interaction accounted for only 5%. Since the same analysis on arcsin-transformed scores required an identical interpretation, only nontransformed data are reported.

The mean percentages of correct responses for the ISIs of 100, 250, 500, and 5,000 msec were 64%, 71%, 67%, and 75%, respectively. As mentioned, these means did not differ significantly. The mean percentages of correct responses for the four degrees of difference (same, D1, D4, and D16) were 80%, 43%, 60%, and 96%, respectively. A Newman-Keuls multiple-comparison test showed each of these means to be significantly different from each of the others. When all letters were different, performance was higher; when the first and second slides were the same, performance was also higher.

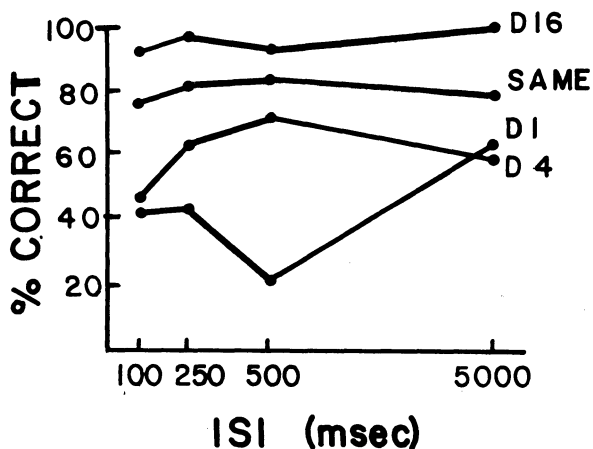


Figure 1. Percentages of correct responses as a function of ISI and degree of difference.

The D4 and D1 differences were the most difficult to detect and resulted in greatly reduced performance. Although the interaction was significant, a simple main effects test revealed that the differences were attributable largely to the degree-of-difference variable. The only significant difference among the ISIs occurred between 500 msec and 5,000 msec at D1.

Performance on D16 trials was excellent and may partially be explained by subjects' shifting to a more liberal criterion. Table 1 shows the hit rate (HR), false alarm rate (FAR), d' , and β as a function of ISI and degree of difference. FARs were determined by using two randomly chosen "same" trials for D1, two for D4, and two for D16. Table 1 shows the D16 subjects to be more liberal and more sensitive than the D1 and D4 subjects.

DISCUSSION

Performance on the D16 trials was nearly perfect and provides partial support for the hypothesis that a recognition task would show that all incoming sensory information is processed and is retrievable. The poorer performance in the D1 and D4 conditions poses a problem for this hypothesis. It should not matter whether part or all of the stimulus is changed, if 100% of the information is processed. Bartram (1978) and Wilton and File (1975) provide a possible explanation for this finding. These researchers demonstrated that subjects group information that is held in posticonic visual storage. Bartram presented tachistoscopically 10 disks randomly placed in a

Table 1
Hit Rate (HR), False Alarm Rate (FAR), d' , and β as a Function of ISI (in Milliseconds) and Degree of Difference

ISI	Degree of Difference											
	D1				D4				D16			
	HR	FAR	d'	β	HR	FAR	d'	β	HR	FAR	d'	β
100	.42	.15	.83	1.70	.46	.35	.29	1.08	.92	.23	2.15	.50
250	.43	.13	.95	1.86	.63	.30	.85	.92	.97	.13	3.01	.33
500	.21	.14	.27	1.32	.71	.21	1.36	1.17	.93	.14	2.56	.59
5000	.63	.22	1.10	.79	.59	.16	1.23	1.63	1.00	.25	4.38	.01

5 by 4 matrix and showed that the subjects generally recalled one or two chunks of spatially adjacent disks, consisting of three or four disks. It may be that such grouping also takes place in the sensory store. If the subject has only one or two groups of information in the sensory store, the probability of detecting a difference, or lack of difference, in the D16 and SAME conditions is better than in Conditions D1 and D4. This would account for the poorer performance in the D1 and D4 conditions and the better performance in the D16 and SAME conditions.

Perhaps the most surprising result concerns the negligible influence of the ISI variable. Performance for all four degrees of difference at 100 msec was not significantly different from performance at 5,000 msec. These results are not consistent with those of Sperling (1960), who found that recall declined sharply after 1,000 msec. The explanation for this discrepancy may lie in the procedure itself. The use of the same-different recognition task is not new. Cermak (1971) and Phillips (1974) both have used a similar procedure. Cermak presented subjects not easily described shapes and showed a 78% recognition rate with an ISI of 1.5 sec and 66% recognition rate with an ISI of 20 sec. The overall percentage of correct responses was 70%. Phillips, using a 4 by 4 matrix of light and dark squares, showed better than 75% recognition with an ISI of 9 sec. Although these researchers were not using letters, the percentages of correct responses for long ISIs compare favorably with the present findings. It is interesting that evidence for an extended sensory

memory only occurs when using the same-different recognition task. It was not shown in Sperling's recall paradigm. The higher performance at long ISIs found in the recognition forms of this task may simply reflect the different methodologies. It is well known that recognition tasks generally show greater retention for longer periods of time than do recall tasks.

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