Memory for individual events in concept identification

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Subjects attempted six concept problems, each of which was soluble on the basis of information contained in six instances (positive and negative). In any problem, S inspected the six instances, presented successively, and then stated a hypothesis about the solution. After some problems S was asked to recall freely each instance and its category. The later in the problem series the first recall test was administered, the poorer recall was; with experience Ss learn that retention of the stimulus pattern and its category is unnecessary. Recall was better on the second and subsequent tests indicating that Ss can, if necessary, retain some of the information presented.

Trabasso & Bower (1964) evaluated S's memory for trial-by-trial stimulus and feedback events in a concept-identification problem. While their evidence indicated only limited retention at the end of a problem, overall recall was above chance and showed a marked primacy effect, patterns presented in the initial positions of a trial sequence being recalled with higher probability than patterns presented later. Both outcomes are inconsistent with recent quantitative models of concept identification (Bower & Trabasso, 1964).

There are at least two ways in which the procedures used by Trabasso & Bower might have been biased against the limited-memory theory. First, Ss were warned in advance that recall for stimuli and feedback would be tested, after each problem. The Ss were set to recall and undoubtedly attempted to memorize what was to be tested as well as to solve the conceptual problem. Thus, the measures probably do not reflect memory as it occurs naturally in concept identification but rather index S's ability to do two tasks concurrently. Second, recall tests were taken on the first problem and all problems thereafter. While Ss might indeed—even under conventional conditions—memorize the events of individual trials in the initial problems of a series (perhaps for lack of complete understanding of the conceptual task), this tendency should diminish with successive problems as it is repeatedly demonstrated that memorization of the entire stimulus and feedback on each trial is unnecessary. Familiarity with the general format of these problems might quite reasonably lead to an apparent

reduction in S's recall for single trial events. The routine of Trabasso & Bower, however, calling for recall after each problem, should counteract this process, once again giving spuriously high estimates of what S normally recalls.

One condition of the Trabasso-Bower study seems likely to have the opposite biasing effect. The Ss had to recall patterns and feedback in varying orders from problem to problem, as determined by E. Had S been allowed to produce the retained information in any order, then, in view of the general superiority after the first presentation trial of free over serial recall (e.g., Waugh, 1961), performance might have been better than it was.

The present experiment was designed to explore the effects of these procedural variables on the retention of individual events in a concept-identification problem.

SUBJECTS AND DESIGN

Forty-eight students from introductory psychology classes participated individually as Ss in one of four experimental groups. An equal number of Ss was assigned randomly to each group. Each S attempted to solve six successive concept-identification problems, requiring determination of the one relevant among six binary dimensions of stimulus patterns. Each of the six dimensions (color, number, shape, size, orientation, and position) was relevant to the solution of one of the problems. The order of problems for the 12 Ss within a group was determined by two 6 by 6 Latin squares. Groups of Ss differed in terms of the loci of memory tests within the series of six problems. The test required S to designate the six attributes (e.g., red or green) of each of the stimuli presented during a problem and the feedback corresponding to each stimulus. The S was free to describe these events in any order regardless of the presentation sequence. Group 1 was tested after each of the six problems; Group 2, after Problems 2 through 6; Group 3, after Problems 4 through 6; and Group 4, only after Problem 6.

TASK AND PROCEDURE

Each S was given oral instructions describing the general form of solutions, the six dimensions of the stimuli, and how to respond. No indication of impending retention tests was given.

In each problem, E presented a series of six stimulus patterns, one at a time, at the same time indicating the proper category, A or B. The S could inspect the pattern for 5 sec, after which it was replaced by the next. The six cards comprising each problem were selected so as to eliminate, logically, all but one dimension as a solution. After the six cards had been presented, and the last one removed, S was asked to indicate the one dimension which was consistent with the way the cards were classified. The S had 10 sec to supply an answer.

RESULTS

Where comparable measures were taken, the data were parallel to those reported by Trabasso & Bower (1964). Table 1 contains a summary of recall scores for stimulus attributes and feedback signals at the six presentation positions, averaged over all problems, attributes, and Ss. For convenience of comparison, the corresponding scores from Trabasso & Bower (1964) are reproduced. As in the earlier study, performance seems to follow the typical serial-position curve, with recall for attributes and feedback better at the initial and terminal presentation positions than in the middle. The only discrepancy detectable in the results of the two studies is the slight difference in probability of recall for attributes, favoring the earlier Ss at five of the six presentation positions. Other statistics computed in the present data—such as the probability of recall of relevant and irrelevant attributes and the joint probability of recall of relevant attribute and feedback, derived separately for solving and nonsolving Ss—while differing in some details, were generally consistent with the results of Trabasso & Bower (1964). Parenthetically, it can be noted that recall for trial-by-trial events was poor in both studies. In contrast, success in problem solving was respectably high, given that only a minimal amount of information was available to S. Overall, 76% of problems were solved. Per cent solutions

Table 1
Probability of Recall for Attributes and Feedback as a Function of Presentation Order

	Position					
	1	2	3	4	5	6
This experiment						
Attributes	.65	.54	.52	.50	.51	.58
Feedback	.62	.56	.54	.50	.51	.58
Trabasso & Bower (1964)						
Attributes	.66	.56	.51	.52	.54	.60
Feedback	.61	.55	.52	.51	.52	.62

Fig. 1. Recall probabilities for solving and nonsolving Ss as a function of locus of the recall test within the problem series.

for the six successive problems were 68, 79, 81, 85, 75, and 73.

The uniqueness of these results is revealed in analyses of measures of recall for the separate, successive problems and the separate groups of Ss. First, Fig. 1 shows two joint probability measures taken on the successive recall tests. Clearly recall improves with practice, on both solved and unsolved problems. The major change in probability of recall for the relevant attribute and feedback occurs between the first and second tests; performance is relatively stable thereafter. The differences between the first and second recall measures for solving Ss are probably reliable, $z(\text{pattern}) = 1.66$, $p < .05$, and $z(\text{relevant attribute}) = 1.61$, $p < .10$. Recall for the entire pattern plus feedback improves through the series of tests, at least on solved problems. Finally, there are clear differences between the recall probabilities on the solved and the unsolved problems for both measures on all tests after the first, $z = 3.49$ and $z = 2.73$, $p < .01$, for recall of the relevant attribute plus feedback and whole pattern plus feedback, respectively, with solving Ss able to recall more than failing Ss. Similar trends appear in three simple probabilities: recall of feedback, relevant attribute alone, and all irrelevant attributes. Once again there are sizeable increases in recall probability on Test 2; the probability is relatively steady throughout the remaining tests. In general, recall after solved problems is superior to recall after unsolved problems.

A detailed analysis of performance on the first recall test is presented in Table 2.

Recall probabilities for attributes and feedback are near chance regardless of the success of S in solving the conceptual problem. The only indication of better-than-chance recall appears in the first (primacy) and last (recency) presentation positions, with slightly (though in all cases significantly) higher probabilities in the initial slot.

Recall performance depends also on the locus, within the problem series, of the first recall test. Table 3 describes these data for a variety of performance measures. On the first recall, probabilities for those Ss who solved the problem generally decline as the locus of that test changes toward the end of the problem series. This trend is relatively consistent over all measures. Little or no change is apparent in the scores of nonsolving Ss. There is an overall improvement in recall from the first to the following tests in each group which, again, seems to be more stable for solving than for nonsolving Ss. While probabilities from the later tests decline over groups, the trend is less stable than that exemplified in the first test data.

DISCUSSION

In their general features, these results are

consistent with the findings of Trabasso & Bower (1964). Ss do remember some of the event-information given in a conceptual problem, despite the fact that its retention is neither logically necessary nor prescribed by some current theoretical models. The pattern of recall is a bow-shaped serial-position function with Ss retaining more of the initial and terminal patterns than of the middle-most.

This experiment permitted an examination of some of the conditions which might contribute positively to S's recall. First of all, if S knows about a forthcoming test of retention, it seems likely that he will attempt to memorize the pertinent events (stimulus and feedback) despite their essential irrelevance to the primary task. Better-than-chance recall in this and the earlier study might be attributable in part to S's set to "do two things at once," making the recall test something other than a measure of normal memory during concept learning. The results of Test 1 in the present experiment, a test of memory without advance warning, support this conjecture. Recall probabilities for the various individual events were close to chance and tended not to differ between

Table 2
Recall Probabilities for Various Events at Each Presentation Position on the First Test

	Presentation Position					
	1	2	3	4	5	6
Feedback						
Solved	.60	.54	.50	.52	.51	.54
Unsolved	.57	.49	.48	.53	.49	.54
Relevant attributes						
Solved	.63	.55	.48	.52	.47	.55
Unsolved	.56	.47	.49	.51	.50	.57
Irrelevant attributes						
Solved	.53	.47	.55	.49	.47	.53
Unsolved	.57	.53	.54	.51	.56	.57

Table 3
Recall Probabilities for Various Events on the First and All Subsequent Recall Tests as a Function of the Locus of the First Test

	First recall test Group				Combined subsequent tests Group ^a		
	1	2	3	4	1	2	3
Entire pattern plus feedback							
Solved	.10	.07	.06	.03	.23	.20	.17
Unsolved	.03	.03	.17	— ^b	.17	.06	.04
Feedback							
Solved	.57	.56	.50	.52	.61	.66	.57
Unsolved	.53	.52	.51	—	.68	.45	.52
Relevant attribute plus feedback							
Solved	.55	.42	.47	.39	.56	.52	.51
Unsolved	.33	.27	.32	—	.51	.30	.26
Relevant attribute							
Solved	.61	.46	.49	.55	.65	.63	.64
Unsolved	.48	.55	.52	—	.64	.54	.50
Irrelevant attribute							
Solved	.50	.49	.47	.59	.62	.52	.54
Unsolved	.51	.62	.46	—	.63	.45	.58

^a Only one recall test was administered to Group 4

^b All Ss solved this problem

solving and nonsolving Ss. These data, collected under reasonably unbiased conditions, are more nearly what one would expect, based on the assumptions of hypothesis-selection models of concept identification (Bower & Trabasso, 1964).

There is some evidence of a small amount of residual memory, however, even on the first recall test. Analyses of presentation positions indicate mild primacy and recency effects. If reliable, these effects would necessitate some elaboration of existing models, although they could probably be ignored for most practical purposes. The fact that solving Ss have a higher probability of recalling jointly the relevant attribute and the feedback for any trial than do nonsolvers on Test 1 presents no theoretical difficulties. That result appears to arise from the solving S's tendency to make the two events compatible. Having guessed the value of the relevant attribute on any particular trial, he proceeds to generate the corresponding feedback from the known solution.

Recall probabilities increase reliably on Test 2, and remain relatively stable thereafter. These probabilities are numerically closer to those reported by Trabasso & Bower. The fact that, overall, they are slightly higher than the earlier values is probably insignificant but might be attributed to the relaxed test procedure used in the present case, which allowed S to recall events in a self-determined rather predetermined order.

Finally, there is some evidence to suggest that the locus of Test 1 within S's

problem series is an important consideration. Specifically, as Test 1 is moved toward the end of the series (Groups 1 through 4) there is a general decrement in recall probabilities. This result is taken as an indication of changes in S's knowledge about and set toward the primary task, in effect a learning-to-learn phenomenon. In Problem 1, with no warm-up or task-relevant practice, S has only the preliminary instructions as a guide. He probably keeps track of a multiplicity of stimuli, including many that are irrelevant to problem solving. As he gains experience and familiarity with the general format of problems, he learns that successful performance depends on relatively narrowly-defined information and skills, which do not include the details of each pattern.

REFERENCES

- BOWER, G., & TRABASSO, T. Concept identification. In R. C. Atkinson (Ed.), *Studies in mathematical psychology*. Stanford: Stanford University Press, 1964.
 TRABASSO, T., & BOWER, G. Memory in concept identification. *Psychonomic Science*, 1964, 1, 133-134.
 WAUGH, N. C. Free versus serial recall. *Journal of Experimental Psychology*, 1961, 62, 496-502.

NOTE

1. This research was undertaken in the Institute for the Study of Intellectual Behavior, University of Colorado, and is Publication No. 4 of the Institute. The work was supported in part by Training Grant 5-T01-MH-10427 and Research Grant MH-14314 from the National Institute of Mental Health, Research Grant G-3404 from the National Science Foundation, and a grant-in-aid and faculty fellowship from the University of Colorado Council on Research and Creative Work.

p. 306), in discussing the persistence of lights of short duration, indicates that as early as 1740 the problem was studied by Seguer by whirling a glowing ember in the dark and measuring the time of persistence by the length of the circular arc that was visible, and that most estimates since then, derived by a variety of methods, have varied from approximately 100 to 200 msec.

Very recently Haber & Standing (1969), employing paradigms designed to provide direct measures of visual persistence, have found times ranging from approximately 250 to 400 msec. Since the 250- to 400-msec times are much longer than those obtained by Mayzner, Tresselt, & Helfer (1967b) and others [e.g., see Le Grand (1968, p. 306)], our earlier work has been partially repeated and three new experimental paradigms have been examined in order to obtain further evidence bearing on this issue.

SUBJECTS

Ten undergraduate male, experimentally naive Ss were employed, selected randomly at the University Heights campus of New York University.

APPARATUS

The stimulus material was presented on a Fairchild cathode-ray tube (CRT) display console, slaved to a 340 Master Display, driven by a PDP-7 digital computer. A complete description of this hardware system and its associated computer programs (software) may be found in two previous publications (Mayzner, 1968; Mayzner, Tresselt, & Helfer, 1967a).

PROCEDURE

Four different experimental tasks or paradigms were examined, with each of the 10 Ss receiving the four tasks in different random orders on four separate testing days, with a separation of at least 1 week between testing sessions. Each S was tested individually. In Task 1, Ss were shown two Xs sequentially side by side. Either the right or left X, selected randomly, was displayed first for 10 msec, then the other X was displayed, also for 10 msec. Interstimulus interval (ISI) times between the two Xs varied from 50 msec to 150 msec in 5-msec steps. Ten ascending, alternating with 10 descending, trials were used with each S. Each S was requested to indicate that trial on which he judged that the two Xs were totally separate visual experiences, i.e., the first X could no longer be judged present when the second X appeared. The average of the 20 trials for which this nonsimultaneity judgment occurred constituted S's threshold for Task 1.

In Task 2, the same paradigm was employed as in Task 1 with the same "on" times and ISI times, except that two Xs were displayed in exactly the same location on the CRT, rather than side by side. In this

Estimates of "SVE" processing time¹

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The present study examines four different experimental paradigms designed to provide estimates of input processing time in the "SVE" component of a model of visual information processing. Mean processing times vary from a low of 60 msec to a high of 120 msec for the four paradigms examined and the results are related to other time estimates in the literature concerning the visual persistence of short duration stimuli.

In a previous paper (Mayzner, Tresselt, &

Helfer, 1967b) a provisional model of visual information processing was described that had a data-processing component labeled "SVE" (subjective visual experience). SVE represents a S's actual subjective visual experience associated with visual inputs, and it was estimated that input processing time in SVE was on the order of 100 msec, if input duration or "on" time was short (i.e., in the range from 50 μ sec to approximately 50 msec).

The concept of SVE, as it relates to input processing time, is closely related to the concept of visual persistence. The time course of visual persistence is an old problem. For example, Le Grand (1968,