Effects of rewarded interpolated tasks upon short-term retention

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Eighty Ss were shown two separate nonsense syllables on a memory drum for 2 sec. Following this, the Ss performed various interpolated activities. Under one condition interpolated activity was rewarded monetarily; under the other, it was not. Analysis of the data indicated that Ss under the rewarded condition experienced poorer recall of the syllables than they did under the nonrewarded condition. Differences in retention could not be attributed to performance levels during the interpolated activity.

The present study examines the effect of rewarded interpolated activity upon retention. A short-term memory (STM) model based upon a limited capacity to process information suggests that the recall of verbal material can be affected by the activity which consumes the retention interval. Experimentation supporting this notion has examined several parameters of the interpolated activity. Bruning & Schappe (1965) and Kothurkar (1968) have demonstrated the adverse effects upon retention as the similarity between verbal stimuli and intervening activity increases, indicative of a retroactive interference mechanism responsible for poorer retention. More quantitative in its focus upon the interpolated activity is another area of research, exemplified by Posner & Rossman (1965) and Dillon & Reid (1969). These researchers have manipulated the difficulty of the interpolated activities, defined by the amount of information transformation demanded for successful completion of the task. An increase in difficulty, demanding more of the limited capacity to process the information given and asked for in the interpolated task, resulted in poorer retention. Therefore, more permanent stable storage and subsequent retention, involving a degree of processing, must compete with the demands of the interpolated activity.

Current experimentation involving the short-term retention of verbal material has attempted to prevent Ss from rehearsing, i.e., processing exposed stimuli by keeping the material within the short-term store through the use of rehearsal-preventing interpolated tasks. While the most famous of these has been counting backwards (Peterson & Peterson, 1959), activities have also included color naming (Wickens, Born, & Allen, 1963), number identification and transformation (Posner & Rossman, 1965; Adams, Thorsheim, & McIntyre, 1969), perceptual-motor performance (Crowder, 1968), choice reaction (Pylyshyn, 1965), and verbal manipulations (Kothurkar, 1968). Posner & Rossman (1965) and Crowder (1967a, b, 1968) underscore the need to place control upon such crucial variables as the nature of both the learned material and task activity, as well as prior experience with the interpolated activity. The present study examines the importance of incentive states during the interpolated activity.

Montague, Hillix, Kiess, & Harris (1970) employed monetary payoff for either retention or interpolated task performance or both. They found that payoff for correct trigram recall produced significantly better retention than payoff for interpolated activity. Incentive effects were viewed as being mediated by covert rehearsal, as inferred from both interpolated activity scores and Ss' reports of rehearsal. However, the interpolated task of digit reading was not paced. Ss were required to reread the same rows of digits, and Ss interrupted performance to report instances of covert rehearsal. Such factors could conceivably diminish the validity of employing task performance as an indicant of covert rehearsal.

Several issues, therefore, appear to be quite relevant for exploration within the context of an information processing model of STM. How will the presence of incentive during several commonly used interpolated activities affect retention? Consistent with the findings of others (Montague et al, 1970), we predict that productivity and accuracy of interpolated performance will increase under incentive conditions. Secondly, as demonstrated by Posner & Rossman (1965) and Dillon & Reid (1969), we expect retention will be reduced under incentive conditions because of increased productivity.

SUBJECTS

Eighty students enrolled in educational psychology classes at Temple University served as Ss for this experiment.

APPARATUS AND MATERIALS

The stimuli were presented on a Lafayette memory drum, Model 2323. The responses of each S were recorded on a Sony tape recorder, Model 260. The stimuli consisted of two consonant trigrams listed by Scott & Baddeley (1969). The particular stimuli (XSF anf TCP) were selected for their high acoustical confusability (above .51) and low associative value (below .43), both factors contributing to the difficulty of retention of the syllables, as discussed by Adams (1967).

The general experimental procedure included presentation of the stimulus for 2 sec, interpolated activity for 16 sec, and immediate recall of the stimulus with the offset of the interpolated activity. Four different interpolated tasks were used. Each S was assigned randomly to interpolated activity. The four interpolated activities were: counting backwards, color naming, number naming, and visual search. Counting backwards consisted of presenting the S with a three-digit numeral for 2 sec on the memory drum and having him count backwards by threes. When this interpolated activity was under the incentive condition, the S received 10 cents for each correct numeral.

Color naming required the S to identify squares of different colors. Eight different randomly ordered colors were presented to the S for a period of 2 sec. The S was instructed to name as many colors on each line in the order in which they appeared before a new line was exposed. As soon as the line changed, he was to begin naming the colored blocks of the exposed line, beginning on the left-hand side. Under the incentive condition, 5 cents/correct color was awarded.

Number naming required Ss to identify rows of digits. Rows of 15 random digits were exposed to the S for 2 sec. The S was told to name as many of the digits in order, beginning on the left side. When the row changed he was to begin on the next row and follow the same procedure. Under the incentive condition Ss were paid 3 cents for each correct digit identified.

The final interpolated task employed in this experiment was a visual search task which was devised by the Es. This task consisted of the S viewing a row of five figures for a period of 2 sec and determining the presence or absence of the last figure from the previous row. In the first row of figures, the S was instructed to look for a circle. When this interpolated activity was under the incentive

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Table 1
Cell Means for Retention, Productivity, and Number Correct Under Different Incentive and Interpolated Tasks

Incentive Condition	Counting Backwards	Color Naming	Number Naming	Visual Search	Incentive Condition
	Interpolated Activity				
			Retention		
Incentive	4.40	3.05	2.65	4.50	3.65
No Incentive	3.95	4.10	4.40	4.60	4.27
Task Means	4.18	3.58	3.53	4.55	
			Number Correct (Interpolated Activity)		
Incentive	6.35	22.50	54.65	5.35	22.21
No Incentive	7.05	21.60	54.75	5.30	22.18
Task Means	6.70	22.05	54.70	5.33	
			Productivity (Interpolated Activity)		
Incentive	8.25	25.00	55.70	6.95	23.98
No Incentive	8.30	25.10	55.10	6.85	23.84
Task Means	8.28	25.05	55.40	6.90	

condition, Ss were paid 15 cents for the first three correct answers and 50 cents for any other correct answers. The rates of incentive for all interpolated tasks were selected in such a way that the payoff per S ranged between $1.50 and $2.50.

PROCEDURE

Each S was seated in front of the memory drum, where the directions were read and explained to him. The S was then given a practice trial consisting of presentation of the practice stimulus BPK for 2 sec, one of the four interpolated activities for a period of 16 sec, and a signal to recall the syllable. After the practice trial, each S was informed that his performance on the interpolated activity would be recorded along with his recall of the syllable. On the first trial, certain Ss were told that they would be paid according to their performance on the interpolated task, as described previously. Since each S participated in two experimental trials, if he received the incentive on the first trial, he did not receive the incentive on the second trial, and vice versa. Random assignments determined the order of the incentive condition and interpolated task.

Three dependent measures were taken on each S for each trial: a retention score for the syllable, a productivity score, and number correct score for the interpolated activity. Retention scores ranged from 0 to 6, with 2 points given for each correct letter in its correct position, and 1 point for a correct letter in an incorrect position.

RESULTS

Three two-way analyses with repeated measures were run using the Biomedical Series Program (BMDO8V).[1] The three dependent variables were retention, productivity, and number correct. The cell means of the three 4 by 2 analyses are shown in Table 1. The results of the analysis of variance for retention scores indicate a significant main effect of incentive ($F = 4.05$, $df = 1,76$, $p < .05$).[2] Retention of the syllables was greatest when interpolated activity was not rewarded. Although the data in Table 1 shows the largest differences occur with number naming and color naming, a significant interaction was not found. Of equal importance was the clear absence of an effect due to incentive for either productivity or accuracy during the interpolated activity.

A significant main effect of task for both productivity and number correct was obtained. This, however, was expected because of the nature of the interpolated tasks. Number naming, for example, had a possible total score of 120, while the visual search had a maximum score of 8.

DISCUSSION

With respect to accuracy and productivity of interpolated activity, our findings show these variables to be unaffected by treatment conditions. While retention was reduced under incentive conditions, in no way was this attributable to increased productivity on the interpolated task. In fact, accuracy of interpolated activity was also unaffected by incentive conditions. These data partially contradict results found by Montague et al (1970), where differences in retention were attributed to changes in productivity on the interpolated tasks.

There are several possible alternative explanations for these data. For both the Montague study and the present study, it is possible that the different instructions to the Ss may have resulted in varying degrees of learning of the trigrams. The fact that Ss were told they would be paid for success on interpolated activity may have resulted in their learning the trigrams to a lesser degree than those Ss under the nonincentive conditions. It is also conceivable that Ss may not have consumed their capacity to process information during the interpolated activity. Their performance was not paced. Consequently, Ss with nonincentive instructions may have utilized the remaining portion of processing capacity for trigram rehearsal. The latter explanation applies also to the Montague study.

There may be at least two important variables interacting within experiments using incentives for interpolated tasks. Greater or lesser degrees of activity (naming numbers or colors, etc.) involved in the interpolated tasks may interact with high- or low-incentive conditions to prevent rehearsal. Our data suggest it may be possible to prevent rehearsal without increasing these activities. Since our data showed no differences in productivity under differing incentive conditions, reduced retention associated with rewarded interpolated tasks could not be explained by differing levels of interference within the retention interval.

One possible explanation concerns the actual subjective effects of incentive upon Ss. Many Ss refused to believe they could actually keep the money. Consequently, the effects of incentive may have been attenuated in these Ss. While productivity and accuracy of interpolated tasks is unchanged by reward, the incentive instructions may have been sufficiently disconcerting so as to produce the obtained retention decrement. Further experimentation is needed to clearly describe the effects of incentive in studies of short-term memory.

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NOTES

1. Data were run on Temple University CDC 6400 computer.
2. Our data meets the assumption of symmetry and equality of the covariance matrices associated with repeated measures (Greenhouse-Geisser method, Winer, 1962).

Scanning strategies and differential sensitivity in a visual signal detection task: Intrasubject reliability

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Four Ss (two of each sex) were run on 960 trials of a 16-alternative forced-choice visual signal detection task. Analysis of variance of d′ values indicated the usual practice effects, as well as differential sensitivity to different target locations, and three significant interactions. Despite the significant changes in magnitude of d′, each S demonstrated consistency in the ordering of sensitivity as a function of target location across blocks of 320 trials (W = .51, .76, .85, and .81). The data imply extremely strong scanning biases which existed prior to the experimental task and further suggest that less than 400-500 trials is quite sufficient for reliable estimation of differential sensitivity among all 16 target locations in a 16-AFC task.

Normal visual perception requires selective processing of the information available at any given time. An analysis of the selection process may be approached in the laboratory by presenting a visual display with more elements than can be processed during the presentation duration. Subsequent hypotheses are generated which attempt to describe the characteristics of those elements which will be processed. As the elements attended to on any trial are not randomly drawn from the display (Taylor, 1970), any consistency in relative sensitivity to parts of the display increases the information concerning the processing rules and/or scanning strategies used by a given S.

One measure of relative sensitivity to visual stimuli is d′, the sensitivity index of signal detection theory. If a number of elements occur in a visual display, for example, and the S is required to specify the location of a particular target element, d′ values for different locations could be most descriptive of the scanning or processing strategy in use by the S. Unfortunately, stable estimates of d′ in a two-alternative forced-choice (2-AFC) task require from 500 to 2,500 observations (Green & Swets, 1966; Swets, 1964). For larger numbers of alternatives, the number of trials required for stable estimates of sensitivity to each alternative could become staggering. One of the major reasons for such high numbers of trials is a well-documented practice or learning effect, which may continue for as long as 10-12 h in a visual detection task (Blackwell, 1953). If, however, there is stability in the ordinal sensitivity to different target locations during the learning or practice effect, and if this differential sensitivity is of primary importance, it should be possible to obtain reliable estimates of differential sensitivity in fewer trials than would be necessary to obtain reliable estimates of the absolute magnitude of the sensitivity. Estes & Taylor (1966) have shown that test-retest reliability is high for the elements sampled by a S from a particular display, and this would suggest stability in relative sensitivity to parts of a display.

This study was preliminary to a series of studies concerning the factors influencing scanning strategies in a visual signal detection task. In this context, scanning refers to the method of processing a single visual image displayed for an interval too brief for actual physical scanning (no multiple fixations). A 16-AFC task was used, and the intent was to determine if a rather small number of trials might provide reasonable estimates of differential sensitivity for the 16 possible target locations.

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METHOD

Each stimulus contained 16 circles, in a 4 by 4 array, with 15 of the circles having an inscribed "upright" equilateral triangle (base down), and the 16th circle containing an "inverted" triangle (base up). For purposes of analysis (but not during the experiment), the circles were numbered consecutively, beginning with the upper left corner and progressing from left to right in each row. The data in Tables 1 and 2 are presented in a spatial arrangement similar to that of the original target locations. Stimuli were on 35-mm slides and were projected by means of a Lafayette two-field projection tachistoscope, with a blank frame identical in size to the stimulus frame projected at all times other than during stimulus presentation. Ss were seated approximately 3.4 m from the projection screen, and the projected stimulus frame measured 30.5 cm on a side. Each projected circle measured 4.6 cm in diam and contained a centered equilateral triangle, 2 cm on a side. The visual angle subtended by the 16 circles was approximately 4 deg, with each circle subtending an angle of about 48 min and each triangle subtending an angle of about 20 min.

Four Ss (two male, two female) were used in the experiment, each run individually for a total of 960 trials. Each trial consisted of presentation of a stimulus slide for 200 msec, with about 6 sec between trials. During the intertrial interval, Ss recorded the location of the target (inverted triangle) on a schematic drawing of the stimulus, together with a confidence rating concerning the judgment. Confidence ratings were made by means of a check mark on a horizontal line with the statements "sure" and "???" at opposite ends. For purposes of analysis, the line was divided into three equal segments, and all confidence ratings were coded as one of three values (1 = not sure, 2 = moderately certain, 3 = highly certain). The experiment was run in one 2½-h session, with brief rest periods after blocks of 40 trials and longer rest periods after blocks of 240 trials. Stimuli were presented in a pseudorandom order, with the target occurring in each location five times in