JOURNAL OF VERBAL LEARNING AND VERBAL BEHAVIOR 15, 479–490 (1976)

The Role of Rehearsal in Long-Term Memory Performance

VERONICA J. DARK AND GEOFFREY R. LOFTUS

University of Washington

In each of two experiments, subjects were given 48 Brown–Peterson trials, using word lists as stimuli, followed by an unexpected final free recall test on the words. Of interest was the influence on final performance of (1) the length of the original Brown–Peterson retention interval and (2) whether the subject overtly rehearsed the word list or performed a rehearsal-preventing task during the Brown–Peterson retention interval. To avoid confoundings involving the influence of initial recall on final recall, initial recall was required on only half the trials and analysis of final performance was restricted to data from the other half of the trials (referred to as *no-recall* trials). Results were consistent over the experiments: Items rehearsed during the Brown–Peterson retention interval showed better delayed recall than did items for which rehearsal was prevented. Also, delayed performance increased monotonically with retention interval for items that the subject had rehearsed but remained fairly constant over retention interval for items whose presentation was followed by a rehearsal-preventing task. It is argued that earlier studies indicating that overt repetition will not increase performance on a delayed test have failed to consider that overt repetition is a nonunitary phenomenon which may show either maintenance or elaborative properties in different situations.

The importance of rehearsal as an explanatory concept stems from its central role in multistore models of memory (e.g., Atkinson & Shiffrin, 1968; Waugh & Norman, 1965). Such models identify rehearsal as the central mechanism by which information is transferred from a transient short-term store to a more permanent long-term store, and (principally for the purpose of mathematical tractability) these models have formally defined rehearsal simply in terms of repetition. The power of rehearsal, characterized in this way, has been demonstrated in several studies by Rundus and his colleagues (Rundus, 1971; Rundus & Atkinson, 1970; Rundus, Loftus, & Atkinson, 1970). These studies have demonstrated (1) that memory performance for an item is a positive monotonic function of the number of overt repetitions accorded that item and (2) that a number of free-recall phenomena (e.g., the primacy effect, the Von Restorf effect, and the Melton spacing effect) may be accounted for simply in terms of the number of overt repetitions accorded individual items.

More recently, theorists have concerned themselves with broadening the scope of the term "rehearsal" to encompass more than just rote repetition. Currently, "rehearsal" is

This research was supported by National Science Foundation Grants GB 39615 and BMS 75-10450 to G. Loftus. We would like to thank Earl B. Hunt, Marcy Lansman, Colin M. MacLeod, Thomas O. Nelson, and Steven Poltrock for their very useful comments on this paper and on the research reported herein. We also thank Phil Lewis, Debbie Pittson, and Laurie Woods for their assistance in data collection. The respective contributions of the two authors were as follows: V. Dark was responsible for the original ideas, and expended the majority of the effort involved in experimental design, data analysis, theoretical interpretation, and writing. V. Dark also did all the work involved in supervising the data collection. G. Loftus was responsible to a lesser extent for experimental design, data analysis, theoretical interpretation, and writing. Requests for reprints should be sent to Veronica J. Dark, Department of Psychology NI-25, University of Washington, Seattle, WA 98195.

applied as a label to any active processing that keeps information available in consciousness such that the information can be immediately and accurately recalled at any time during which it is being rehearsed.

Craik and Lockhart (1972) suggest that rehearsal be subdivided into two classes: "...Type I processing does nothing to enhance memory for the stimulus; ...Thus, the concept of processing has been split into Type I or same-level processing and Type II processing which involves further, deeper analysis of the stimulus and leads to a more durable trace" (p. 681). Craik and Watkins (1973) have coined the now commonly-used labels "maintenance" and "elaborative" to characterize the two processing modes: "Following Craik and Lockhart (1972), it is suggested that rehearsal can be usefully broken down into its 'maintaining' function and its 'elaborating' function. To the extent that the subject uses the rehearsal time to enrich and elaborate the memory trace, subsequent retention will be enhanced. If the time is used merely to maintain the trace in some simple form (a phonemic representation, for example), then further repetitions or a prolonged stay in the short-term store will not lead to better learning and long-term retention" (p. 606).

In discussing the maintenance vs. elaborative dichotomy, it has been implicitly assumed that classification of rehearsal mode may be applied *a priori* because the classifications are based on an elaboration scale. As yet, however, elaboration or deeper processing of the trace has not been defined independently of the predicted effect of the processing on some delayed memory test. The dichotomy is applicable, in practice, only when applied *a posteriori* based on performance on a delayed test. Because of the *a posteriori* applicability of the dichotomy, maintenance rehearsal is defined in this paper to occur when there is no correlation between duration of the rehearsal period and memory performance on a subsequent test of the rehearsed information. Likewise, elaborative rehearsal is defined in this paper to occur when there is a positive correlation between duration of the rehearsal period and subsequent test performance.

Methodological Problems

The focus of the present set of experiments is on the relationship between the nature of some initial processing of a set of items and delayed memory performance on these items. A number of previous studies have used this initial test/final test paradigm and have produced conflicting results (to be discussed below). However, these studies have, for the most part, been beset by a number of procedural flaws.

Unobservable events. The first procedural problem is the failure to use any measure of observable rehearsal. Many recent experiments addressing the issue of rote rehearsal did not control the subject's strategy during the rehearsal period. Craik, Gardiner, and Watkins (1970), Jacoby and Bartz (1972), Meunier, Ritz, and Meunier (1972), Modigliani and Seamon (1974), and Woodward, Bjork, and Jongeward (1973) all draw conclusions concerning effects of rehearsal on final free recall and/or final recognition. In all of these studies, the subject was assumed to have covertly repeated the stimuli during a variable silent period. In none of the studies, however, was the subject explicitly instructed to covertly repeat items, nor was the subject's rehearsal behavior observed. For the most part, these studies find no increase in final performance when the rehearsal period is increased, and covert repetition of items is thus claimed to be maintenance rehearsal. The general conclusion, that covert repetition is a form of maintenance rehearsal, is therefore based on assumed, not observed, behavior.

Sometimes the lack of observable measures is claimed to be procedurally beneficial; for example, Kellas, McCauley, and McFarland (1975) have suggested that overt rehearsal is not natural and should not be used because it limits the strategies available to the subject.

We argue, however, that control of strategies is precisely the goal of an investigator interested in relating rehearsal to memory performance. Requiring overt rehearsal in the form of repetition, production of associates, production of rhymes, etc., reduces strategy variance across subjects and frees the experimenter from having to infer what type of behavior the subject is engaged in during a processing period.

Dependence of final test upon initial tests. The studies mentioned above also suffer from a second procedural flaw: The critical final test was preceded by an earlier initial test on the same items. The processing required during the initial test may influence delayed-test memory strength, obscuring the effects of the processing during the rehearsal period. This is because the effect of some initial processing variable (e.g., number of rehearsals) on a delayed test may be composed of two things. First, the variable may have a direct effect on delayed performance. Second, the variable may have an indirect effect in that it may affect short-term recall which in turn may influence long-term recall. If interest focuses only on the direct effect it is necessary to partial out the indirect effect. Examination of final performance conditionalized on initial recall introduces the possibility of confounding due to item selection effects (cf. Loftus & Patterson, 1975). Modigliani (in press) discusses this problem in detail and demonstrates that final free recall probability in an initial test/delayed test situation is heavily influenced by the probability of initially recalling the item.

Present Experiments

Jacoby and Bartz (1972) introduced a new problem for models that incorporate rehearsal/repetition as a mechanism for transferring information to long-term store. Their data showed that the delayed recall of items initially followed by a rehearsal-preventing task (subtraction) was better than the delayed recall of items initially followed by a silent interval during which the subject was assumed to have been rehearsing. Jacoby and Bartz suggested that subjects in the subtraction condition attempted to encode the items using elaborative codes that would survive the subtraction delay, whereas subjects in the silent delay condition encoded the words in a superficial fashion and covertly rehearsed them in a maintenance mode. Going a step further, Götz and Jacoby (1974) manipulated the subject's awareness of whether there would be a filled delay or no delay at all after list presentation and also found support for the influence of coding strategies on final performance. When subjects received only initial recall trials, their final recall performance showed a greater delayed recall superiority of filled delay items over no-delay items when precued about delay than when not precued. In a second experiment, half of the trials were initial no-recall trials. On these no-recall trials, precued subjects again showed better final recall of filled-delay items, but there appeared to be no difference between filled-delay and no-delay final free recall for subjects not given precues.

Unfortunately, interpretation of the findings in these studies is not clear-cut. Jacoby and Bartz did not use no-recall trials to examine effects in delayed recall. Götz and Jacoby confounded length of the retention interval with task during the interval: They used only a 0-sec delay and a 15-sec distractor-filled delay.

The general purpose of the experiments to be reported here was to examine delayed memory performance as a function of (1) how much processing time was initially accorded the items, (2) whether overt repetition was initially required or prevented, and (3) whether or not there was a precue before item presentation informing the subject whether rehearsal would be required or prevented. Each of the experiments consisted of two phases. The first phase involved a series of Brown–Peterson trials (Brown, 1958; Peterson & Peterson, 1959) using three-, four-, or five-word lists as stimuli. The second phase consisted of an unexpected delayed test on

the words presented in the first phase. To circumvent the possible confoundings between initial recall and final test performance discussed above, a random half of the initial Brown–Peterson trials for each subject in each experiment were "no-recall" trials. A no-recall trial was identical to a normal (recall) trial except that at the end of the retention interval, the subject was instructed to number-shadow for the "recall period" rather than to use the period attempting to recall the to-be-remembered items for that trial. Final test performance on items from the no-recall trials is thus relatively free from effects of initial recall and/or item selection. Such performance may therefore be viewed as primarily reflecting initial processing differences.

Two pilot experiments were run, followed by the two main experiments. The design and results of the pilot experiments will be described briefly. The two main experiments will then be reported in detail.

General Method

The methodology common to all experiments is described here.

Apparatus

Stimulus presentation was controlled by an on-line Data General Nova 800 computer driving two Tektronix 602 cathode-ray tubes (CRTs). The CRTs were in separate rooms, each located approximately 42 cm from the subject at eye level. The subject's responses (always oral) were recorded on a cassette tape recorder.

Stimuli

The stimulus word pool consisted of 288 relatively unrelated, common nouns occurring from 1208 to 38 times in the total word count of Kučera and Francis (1967). Stimuli were presented in capital letters 0.51 cm high. In Experiment 1 and the pilot experiments, the list length was three words. List length in Experiment 2 varied from three to five words. In each experiment, the stimulus lists were created randomly from the overall pool.

Procedure

The paradigm used in all experiments included two phases. Phase 1 consisted of 48 Brown–Peterson trials in which both the length of the retention interval and the nature of the task performed during the retention interval were manipulated. The possible retention interval tasks were (1) overt repetition of the stimulus list, (2) shadowing of visually presented digits, and (3) subtraction.

Table 1 depicts the sequence of events that took place during each Brown–Peterson trial along with the duration of each event. Each trial began with a cueing signal (to be described below) followed by a ready signal. The stimulus list items were then presented at a rate of 1 sec per word with no interword interval. Over the course of the experiments, retention interval

TABLE 1

Summary of Trial Events and Time[a] per Event for all Experiments

	Cueing signal	Ready signal	Stimulus list word 1	2	3	4	5	Retention interval	Recall Period
Pilot A	2	2	1	1	1	0	0	0, 5, or 20	10
Pilot B	3	2	1	1	1	0	0	0 or 15	10
Experiment 1	1.5	.75	1	1	1	0	0	1, 5, or 20	7.6
Experiment 2	.75	.75	1	1	1	1 or 0	1 or 0	5 or 20	10

[a] In seconds.

varied from 0 to 20 sec. The recall trials ended with a period of attempted recall while no-recall trials ended with an equivalent period of time filled with number shadowing.

Half of the Brown–Peterson trials in each experiment involved a repetition task during the retention interval while the other half of the trials involved a distractor task. The repetition task was signaled by the CRT display "rehearse out loud". During repetition intervals subjects were required to rehearse aloud the words just presented in any order and at any speed. The nature of the distractor tasks varied across experiments and is described in later sections.

As noted, for each subject a random half of the trials were no-recall trials and the other half were recall trials. On recall trials, the CRT message "recall once" was displayed immediately following the end of the retention interval, and the subject attempted to orally recall the words presented on that trial. On no-recall trials, subjects shadowed randomly chosen digits displayed one at a time at a rate of three per second under the message "shadow—no recall". Subjects did not know until the end of the retention interval whether a given trial was to be a recall or a no-recall trial. In each experiment, the recall/no-recall variable was factorially combined with all other independent variables.

Tape-recorded instructions explained the various possible conditions to each subject in detail. The instructions emphasized that responses on the 48 trials were to be tape-recorded, so it was essential that the subject read the words aloud on presentation. Furthermore, it was emphasized that all rehearsal, subtraction, and/or shadowing were also to be performed aloud. Each subject went through four practice trials with the experimenter present. After the practice trials, the subject was again reminded to do all tasks out loud and then was left alone for the 48 experimental trials. The total time for these trials was approximately 25 min.

Phase 2 of each experiment followed the last Brown–Peterson trial. In Phase 2, subjects received an unannounced final test on all the words just seen in Phase 1.

Final Test Data

As noted in the discussion above, any final test data involving items from initial recall trials are plagued with potential confoundings. Therefore, only final test data from initial no-recall trials are reported in this paper.

Pilot Experiments

The rationale for the two pilot experiments stemmed directly from the work of Jacoby and associates as discussed above. The experiments were designed (1) to replicate the finding of Jacoby and Bartz (1972) that final recall after a distractor delay was superior to final recall after a repetition delay and (2) to examine the effect of initial precueing on final test performance (cf. Götz & Jacoby, 1974). Unlike the Götz and Jacoby study, however, the present experiments factorially combined retention interval and the nature of the retention interval task.

Method

Each pilot experiment involved a factorial combination of four variables during the Brown–Peterson phase. These variables were:

1. The retention interval on a trial was varied from 0 to 15 sec in one experiment and from 0 to 20 sec in the other.

2. The retention interval activity consisted of either overt repetition of the stimulus items or a distractor task (shadowing of visually presented digits in one experiment and a subtraction task in the other).

3. Subjects were either precued (given information) or not precued (not given information) as to the nature of the retention interval task via the cueing signal that began the trial. The precue/no-precue factor was manipulated within-subjects in one experiment and between-subjects in the other.

4. A random half of the trials were recall trials while the other half were no-recall trials.

All subjects received an unexpected delayed test on all items.

Results

Although somewhat noisy, the general trend of the delayed test data was as follows: Delayed recall of items from distraction trials was independent of the retention interval. Conversely, delayed recall of items from repetition trials increased as a function of retention interval and was consistently *superior* to recall of items from distractor trials. There was no main effect of precueing in either study, nor were any interactions involving precueing significant.

Discussion

The Jacoby and Bartz (1972) finding of better performance after a rehearsal-preventing delay was not replicated in either of the pilot experiments. Final recall of items from rehearsal trials was significantly better than final recall of items from distractor trials. Overt repetition appeared to function as a form of elaborative rehearsal: The more overt repetition there was the better was subsequent performance.

Considering the precueing variable, there was no evidence that informing the subject as to the nature of the retention interval task led to a differential initial encoding strategy as suggested by Götz and Jacoby (1974). Precueing had no effect on delayed test performance either when manipulated between-subjects or within-subjects.

Experiment I

The pilot experiments suffered several flaws in design. First, a 0-sec retention interval was used in a large proportion of the Brown–Peterson trials in both experiments. Subjects precued to expect either a rehearsal or distractor delay may have been confused by these zero-delay trials, since, of course, a zero-delay trial in fact involved no retention interval activity at all. Second, the tape recordings of subjects in the pilot experiments suggested a qualitative change in the subjects' performance from the beginning to the end of the 48 Brown–Peterson trials as the subjects became practiced at the subtraction and/or shadowing tasks. Possibly subjects did not begin using the precue information until after they were thoroughly familiar with all the tasks at hand. (This possibility is also suggested by Götz and Jacoby (1974).)

Experiment 1 was designed to examine possible precueing effects without the design deficiencies present in the pilot experiments. In Experiment 1, subjects participated in two sessions of 48 trials each. The first session was considered practice; a final recall test was given only after the second session on only the items from the second session. Zero-second delay intervals were not used.

Method

Experiment 1 involved a $2 \times 2 \times 2 \times 3$ factorial design in which all variables were manipulated within-subjects during the Brown–Peterson trials. The variables were as follows:

1. Each trial was either a recall trial or a no-recall trial as discussed above.

2. The retention interval activity during each trial consisted of either a subtraction task or overt rehearsal (repetition) of the stimulus words. The subtraction task was a speeded-up, visual version of the auditory subtraction task used by Jacoby and Bartz (1972). A random two-digit number was presented under the CRT display "subtract one". The subject read the number aloud, subtracted one from the number, then reported the result aloud. A new two-digit number was displayed every second. During rehearsal, subjects simply repeated the words just presented at any speed and in any order they wished.

3. At the beginning of a trial, the subject was either precued (i.e., told via the cueing signal whether the trial would be a subtraction or a

rehearsal trial) or not precued. On a no-precue trial the cueing signal consisted of the words "new trial".

4. Retention interval was either 1, 5, or 20 sec.

The list length on each trial was three words.

Subjects were run in two sessions 2 days apart. During each session, the subject went through 48 Brown–Peterson trials. Different words were used on the 2 days—the original pool of 288 words was randomly divided in half, the two halves corresponding to Day 1 and Day 2 presentation.

When the 48 trials of Day 1 ended, the subjects were told that the experimenter was interested in practice effects on the various tasks and that they would go through another series of 48 trials with different words when they returned on Day 2. There was no final recall on Day 1, nor were any indications given that there would be such a test on Day 2. When the Brown–Peterson trials ended on Day 2, the subjects were asked to move to a nearby room and to complete a rating form concerning the difficulty of the tasks in the experiment. After approximately 2 min needed to complete the form, the subjects were given final recall instructions and instructed to recall words from Day 2 only. They were required to take a minimum of 5 min to complete final recall.

Subjects were grouped into sets of four for counterbalancing purposes. The 24 within-subject conditions were randomly assigned to the 48 Brown–Peterson trials for a given counterbalancing group with the restriction that each condition appear once in the first 24 trials and once in the second 24 trials. Assignment of words to triads across trials was constant within a group but was rerandomized for each new group. The distractor/rehearsal and recall/no-recall factors were interchanged across the four subjects within a group so that a given trial (and word triad) was assigned to all four combinations of the two variables. Length of retention interval and the precue/no-precue condition remained constant for a given trial within a group but were randomized across groups, subject to the restrictions noted above.

Thirty-two students from introductory psychology classes served as subjects and received extra credit for participation.

Day 1 data were discarded as practice. Only Day 2 data were included in the analysis.

Results

Initial recall performance. The means for initial recall performance from Phase 1 are presented in Table 2. The results were as expected: Rehearsal trial performance was near perfect for all conditions while subtraction trial performance dropped over retention interval. There was no effect of precueing, $F < 1$.

TABLE 2

PROPORTION CORRECT IN INITIAL RECALL AS A FUNCTION OF DELAY INTERVAL, TASK, AND CUEING INFORMATION FOR DAY 2

		1 sec	5 sec	20 sec
rehearsal	precue	.98	.99	.98
	no precue	.99	1.00	.99
subtraction	precue	.97	.65	.39
	no precue	.98	.67	.41

Final test performance. Figure 1 shows final recall performance as a function of retention interval. Items from initial rehearsal trials show better final performance than do items from initial subtraction trials, $F(1, 31) = 4.48$, $p < .05$. Length of retention interval, and the Task × Retention Interval interaction are both significant, $F(2, 62) = 9.66$, $p < .01$, and $F(2, 62) = 6.02$, $p < .01$, respectively. Neither the precueing effect nor any other interaction approached significance, all Fs < 1.

A planned comparison was performed to test the hypothesis suggested by the pilot data that final test performance on items from rehearsal trials would show a monotonic

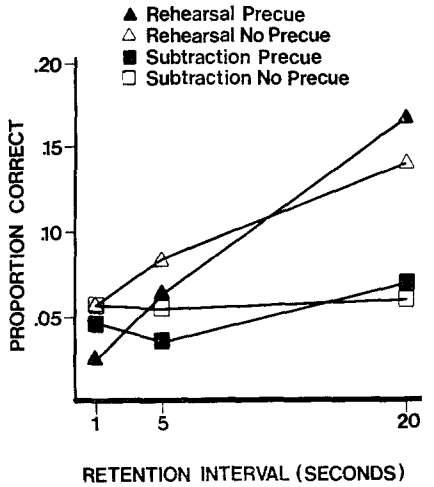

FIG. 1. Experiment 1, final free recall. Proportion correct as a function of retention interval, retention interval task, and precueing. Day 2, Phase 1 no-recall trials only.

increase over retention interval while performance on items from distractor trials would remain constant at a level equal to that of the one-second rehearsal items. The comparison yielded a highly significant result, $F(1, 341) = 32.61$, $p < .001$, and accounted for 91.2% of the variance due to treatments.

Discussion

As in the two pilot experiments, performance on the final test was significantly higher for rehearsal items than for distractor items and the performance on rehearsal items increased monotonically with longer retention intervals whereas performance on subtraction items was independent of retention interval. Overt repetition again acted as a form of elaborative rehearsal. The longer the repetition interval, the better the delayed test performance. Practiced subjects in the present study showed no effect at all from the precueing manipulation for either rehearsal or subtraction trials. There is no evidence for the differential encoding suggestions of Götz and Jacoby (1974) or Jacoby and Bartz (1972). There is, however, corroboration of the Modigliani (in press) data showing a flat function when final recall performance from no-recall distractor trials are plotted as a function of retention interval.

EXPERIMENT 2

Interest in Experiment 2 shifted away from precueing effects to the finding that rehearsal trials produced better final performance than did distractor trials in apparent contrast with the results of the studies reported by Jacoby and his associates. One difference between Experiment 1 and the experiments reported by Jacoby involves the use of three-word lists in the present experiment as contrasted to the five-word lists in the Jacoby studies. Three words is well within most subjects' immediate memory span while five words may be at the limit (Mandler, 1967; Watkins, 1974). Subjects rehearsing three words may find the task sufficiently easy that they can engage in extra, "elaborative" processing along with the "maintenance" rehearsal. Conversely, subjects rehearsing five words may need to use all their potential processing capacity for maintenance alone. To investigate this possibility, list length was manipulated across subjects in Experiment 2. If subjects with the longer five-word lists can, in fact, perform only maintenance repetition, then rehearsing a five-word list would not, by definition, lead to higher levels of final recall than would a distractor task.

Method

The two retention interval tasks, distraction (number shadowing) and rehearsal, and two retention intervals, 5 and 20 sec, were manipulated within subjects. Subjects were not informed of task type; each trial simply began with the CRT signal "new trial". List length was manipulated between-subjects. A given subject received either a three-, four-, or five-word list per trial on all 48 trials. Each three-word and four-word list was obtained by deleting the last one or two words from the end of a five-word list.

A random assignment of the eight within-subject conditions to the 48 Brown–Peterson trials was obtained for each of four, 12-subject counterbalancing groups with the restriction that each condition appear once in each sequence of eight trials. A 12-subject counterbalancing group was then subdivided into three subgroups of four subjects per subgroup. The three subgroups were identical in all respects except for list length; each subgroup corresponded to one of the three list length conditions. The rehearsal/shadowing and recall/no-recall factors were interchanged across the four subjects within each subgroup so that a given trial (and word list) was assigned to all combinations of the two factors. The ordering of retention interval and the composition of the lists were randomly determined for each group of 12 subjects.

All subjects received an unannounced final recall test. As a filler before final recall, the subject completed a rating form concerning the difficulty of the various treatment procedures. Subjects were required to take a minimum of 5 min for final recall.

Forty-eight introductory psychology students participated as subjects and received extra course credit. There were 16 subjects in each list length group.

Results

Initial recall performance. As indicated in Table 3, initial recall data conformed to expectations. Near ceiling performance was maintained over delay interval for rehearsal trials whereas performance dropped over delay interval for shadowing trials. There was also a decrease in initial performance on rehearsal trials as list length increased from three words to five words.

TABLE 3

PROPORTION CORRECT IN INITIAL RECALL AS A FUNCTION OF DELAY INTERVAL AND DELAY TASK FOR ALL LIST LENGTHS

		5 sec	20 sec
3-word	rehearsal	1.00	.96
	shadowing	.69	.37
4-word	rehearsal	.97	.97
	shadowing	.54	.30
5-word	rehearsal	.89	.88
	shadowing	.57	.32

Final test performance. Final recall data from no-recall trials, presented in Figure 2, were analyzed first with list length as a factor. There was no significant effect of list length, $F(2, 45) = 1.62$, nor did any interactions involving list length approach significance, all $ps > .10$. Data from all list lengths were therefore combined for further analysis.

As in the previous two experiments, rehearsal led to significantly better final performance than did the distractor-task, $F(1,45) = 22.10$, $p < .01$. There was also a significant retention interval effect, $F(1, 45) = 21.20$, $p < .01$, and a significant Task × Retention Interval interaction, $F(1, 45) = 4.85$, $p < .05$.

The planned comparison testing for an increase in final performance over retention interval on rehearsal items with constant performance over retention interval for shadowing items yielded a highly significant result, $F(1, 180) = 31.22$, $p < .001$, and accounted for 82.5% of the total treatment variance.

Discussion

The final recall data are fairly straightforward. List length had no effect on the pattern

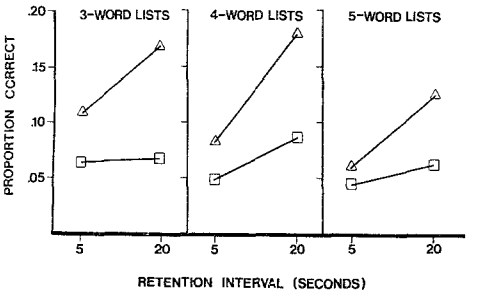

FIG. 2. Experiment 2, final free recall. Proportion correct for all three list lengths as a function of retention interval and retention interval task. Phase 1 no-recall trials only. △, rehearsal; □, shadowing.

of results. Performance was somewhat lower for five-word lists but did not differ qualitatively from performance on three- and four-word lists. The hypothesis suggesting different kinds of processing for lists shorter than vs. equivalent to immediate memory span was not supported.

As in the previous experiment, rehearsal items were recalled at a significantly higher level than distractor items. Also, as in the first experiment, there was a significant increase in final performance for rehearsal items as the overt rehearsal interval increased to 20 sec; this increase obtained for all list lengths. Overt repetition again displayed the properties of elaborative rehearsal. Final recall data from shadowing trials showed no significant increases as delay interval increased, again corroborating Modigliani (in press).

General Discussion

Data from the present set of experiments indicate that allowing overt repetition leads to better performance on a delayed memory task than does preventing rehearsal. Thus there is support for the conception of repetition as a mechanism that results in transfer of information to a more permanent long-term memory store. There is also evidence of a positive monotonic relationship between number of repetitions (controlled by the length of the overt rehearsal interval) and final test performance, corroborating the data of Roenker (1974) and Meunier, Kestner, Meunier, and Ritz (1974).

Modigliani (in press) has suggested that much of the reported beneficial effects of a rehearsal-preventing task on final recall results from the initial recall. The effect is attributed to more than just item selection. When subjects received only distractor-filled no-recall trials (Modigliani, Experiment 2), final performance remained unchanged as a function of the retention interval and was significantly below the final performance resulting from an initial recall procedure. The data reported in the present paper were from no-recall trials only. It was therefore possible to examine the effects of the rehearsal and rehearsal-preventing tasks on delayed performance without the contamination introduced by initial recall. The present data (reflecting a combination of distractor-filled and rehearsal-filled trials) follow the pattern established by Modigliani: Final performance on items initially followed by a rehearsal-preventing task was independent of the length of the delay interval. However, final performance increased as a function of delay interval for rehearsal items. These data suggest that there is no further processing of items during the distractor delay itself while processing continues during rehearsal.

There is no evidence in the present experiments to support the hypothesis of differential encoding of stimuli based on whether the subject is aware or not aware of the type of retention interval task that will follow stimulus presentation. There was no cueing effect for either rehearsal or filled-delay items as would be anticipated from the data of both Götz and Jacoby (1974) and Jacoby and Bartz (1972). Various attempts to control differences between the above studies and the present studies did not change the pattern. When the subject is alternating between an overt rehearsal task and a distractor task, precues providing information corresponding to the task type are apparently not used in any beneficial manner.

The present data indicate that "rehearsal" can be classified according to either experimental procedure or according to results on a delayed test and that the two classifications are not redundant. Recent studies fall into each cell of a factorial combination of these two dimensions, as shown in Table 4. The row dimension in the table is classification by procedure. Experimentally, the subject can overtly or covertly process the stimuli. Overt processing may be either rote repetition or it may be processing in a manner not requiring item repetition, e.g., production of rhymes or

associates of the stimuli. The column dimension in Table 4 is the *a posteriori* classification made, as discussed above, on the basis of performance on a delayed test. Studies in the same procedural division can involve either maintenance or elaborative rehearsal. Overt repetition, a procedural classification, should not be confused with maintenance rehearsal, a delayed test effect classification. Overt repetition may lead to either maintenance rehearsal effects (e.g., Jacoby, 1973; Mazuryk, 1974) or to elaborative rehearsal effects (e.g., Rundus et al., 1970, and the present experiments) depending upon the experimental conditions under which the rehearsal is performed. Not all modes of overt repetitive rehearsal are the same. Just as rehearsal per se can be broken into various subcategories (e.g., maintenance rehearsal and elaborative rehearsal), overt repetitive rehearsal can be subdivided along the same lines.

Darley and Glass (1975) make a related point in suggesting that long-term performance depends not on the depth to which an item is encoded but on the degree to which the subject attends to the item, where attention is related to the individual's allocation of central processing capacity (cf. Posner & Boies, 1971; Kahneman, 1973; Keele, 1973). Whenever rote, overt repetition involves attention, there will be an increase in long-term performance. Attention might be the underlying dimension relating experimental procedure to performance on a delayed test. Attention may define an "elaboration" dimension independent of delayed test performance, but until experimental procedures are defined upon an attention–elaboration dimension, procedural and *a posteriori* delayed test classifications should remain independent.

References

Atkinson, R. C., & Shiffrin, R. M. Human memory: A proposed system and its control processes. In K. W. Spence & J. T. Spence (Eds.) *The psychology of learning and motivation.* New York: Academic Press, 1968. Vol. 2.

Brown, J. A. Some tests of the decay theory of immediate memory. *Quarterly Journal of Experimental Psychology*, 1958, **10**, 12–21.

Cooper, E. H., & Pantle, A. J. The total-time hypothesis in verbal learning. *Psychological Bulletin*, 1967, **68**, 336–343.

Craik, F. I. M., Gardiner, J. M., & Watkins, M. J. Further evidence for a negative recency effect in free recall. *Journal of Verbal Learning and Verbal Behavior*, 1970, **9**, 554–560.

Craik, F. I. M., & Lockhart, R. S. Levels of processing: A framework for memory research. *Journal of Verbal Learning and Verbal Behavior*, 1972, **11**, 671–684.

Craik, F. I. M., & Watkins, M. J. The role of rehearsal in short-term memory. *Journal of Verbal Learning and Verbal Behavior*, 1973, **12**, 599–607.

Darley, C. F., & Glass, A. L. Effects of rehearsal and serial list position on recall. *Journal of Experimental Psychology: Human Learning and Memory*, 1975, 453–458.

Götz, A., & Jacoby, L. L. Encoding and retrieval processes in long-term retention. *Journal of Experimental Psychology*, 1974, **102**, 291–297.

TABLE 4

Classification of Selected Studies along Two Dimensions of Rehearsal

Rehearsal as type of experimental procedure	Did "rehearsal" lead to better delayed-test performance?	
	Yes (elaborative)	No (maintenance)
overt repetition	Rundus, Loftus, & Atkinson (1970) Meunier, Kestner, Meunier, & Ritz (1974)	Jacoby (1973) Mazuryk (1974) (overt repetition group)
overt nonrepetition	Mazuryk (1974) (association group)	Mazuryk & Lockhart (1974) (rhyming group)
covert	Cooper & Pantle (1967)	Craik & Watkins (1973) Jacoby & Bartz (1972) (silent group) Craik, Gardiner, & Watkins (1970)

JACOBY, L. L. Encoding process, rehearsal, and recall requirements. *Journal of Verbal Learning and Verbal Behavior*, 1973, **12**, 302–310.

JACOBY, L. L., & BARTZ, W. H. Rehearsal and transfer to LTM. *Journal of Verbal Learning and Verbal Behavior*, 1972, **11**, 561–565.

KAHNEMAN, D. *Attention and effort*. Englewood Cliffs, New Jersey: Prentice-Hall, 1973.

KEELE, S. W. *Attention and performance*. Pacific Palisades, California: Goodyear, 1973.

KELLAS, G., MCCAULEY, C., & MCFARLAND, C. E., JR. Reexamination of externalized rehearsal. *Journal of Experimental Psychology: Human Learning and Memory*, 1975, **1**, 84–90.

KUČERA, H., & FRANCIS, W. N. *Computational analysis of present-day American English*. Providence: Brown University Press, 1967.

LOFTUS, G. R., & PATTERSON, K. K. Components of short-term proactive interference. *Journal of Verbal Learning and Verbal Behavior*, 1975, **14**, 105–121.

MANDLER, G. Organization and memory. In K. W. Spence & J. T. Spence (Eds.) *The psychology of learning and motivation*. New York: Academic Press, 1967. Vol. 1.

MAZURYK, G. F. Positive recency in final free recall. *Journal of Experimental Psychology*, 1974, **103**, 812–814.

MAZURYK, G. F. & LOCKHART, R. S. Negative recency and levels of processing in free recall. *Canadian Journal of Psychology*, 1974, **28**, 114–123.

MEUNIER, G. F., KESTNER, J., MEUNIER, J. A., & RITZ, D. Overt rehearsal and long-term retention. *Journal of Experimental Psychology*, 1974, **102**, 913–914.

MEUNIER, G. F., RITZ, D., & MEUNIER, J. A. Rehearsal of individual items in short-term memory. *Journal of Experimental Psychology*, 1972, **95**, 465–467.

MODIGLIANI, V. Effects of delaying an initial recall on a later recall. *Journal of Experimental Psychology: Human Learning and Memory*, in press.

MODIGLIANI, V., & SEAMON, J. G. Transfer of information from short- to long-term memory. *Journal of Experimental Psychology*, 1974, **102**, 768–772.

PETERSON, L. R., & PETERSON, M. J. Short-term retention of individual items. *Journal of Experimental Psychology*, 1959, **58**, 193–198.

POSNER, M. I., & BOIES, S. J. Components of attention. *Psychological Review*, 1971, **78**, 60–68.

ROENKER, D. L. Role of rehearsal in long-term retention. *Journal of Experimental Psychology*, 1974, **103**, 368–371.

RUNDUS, D. Analysis of rehearsal processes in free recall. *Journal of Experimental Psychology*, 1971, **89**, 63–77.

RUNDUS, D., & ATKINSON, R. C. Rehearsal processes in free recall: A procedure for direct observation. *Journal of Verbal Learning and Verbal Behavior*, 1970, **9**, 99–105.

RUNDUS, D., LOFTUS, G. R., & ATKINSON, R. C. Immediate free recall and three-week delayed recognition. *Journal of Verbal Learning and Verbal Behavior*, 1970, **9**, 684–688.

WATKINS, M. J. Concept and measurement of primary memory. *Psychological Bulletin*, 1974, **81**, 695–711.

WAUGH, N., & NORMAN, D. A. Primary memory. *Psychological Review*, 1965, **72**, 89–104.

WOODWARD, A. E., BJORK, R. A., & JONGEWARD, R. H. Recall and recognition as a function of primary rehearsal. *Journal of Verbal Learning and Verbal Behavior*, 1973, **12**, 608–617.

(Received March 29, 1976)