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Secondary memory and very rapid forgetting

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Studies of recall in the absence of expectancy (e.g., Muter, 1980) have suggested that forgetting from primary memory is much more rapid than previously assumed. Two experiments examined the role of secondary memory, as reflected by encoding strategies, in determining this rate of forgetting. Experiment 1 demonstrated that the type of encoding specified by orienting tasks can influence recall in a traditional Brown-Peterson task. Experiment 2 demonstrated a similar pattern of effects of orienting task in the Muter task when recall was not expected, despite much more rapid forgetting. The type of encoding engaged by the orienting tasks did not account for Muter's results. Expectancy and orienting task appear to have separable influences on resource allocation during encoding. The presence of secondary memory influences at even the shortest retention interval indicates that forgetting from primary memory may be even more rapid than has been proposed.

Until recently, psychologists have estimated the duration of short-term memory to be roughly 18 sec. This estimate, first obtained by Daniels (1895), was given prominence by Brown (1958) and Peterson and Peterson (1959). The Brown-Peterson task, as it is commonly called, requires subjects to recall a small number of items after a variable length retention interval. To prevent rehearsal, subjects are required to perform an interfering task (e.g., counting backwards) during the interval. Numerous replications consistently show a gradual decline in recall until an asymptote is reached after approximately 18 sec (e.g., Murdock, 1961). These results are typically described in terms of the theoretical model of Waugh and Norman (1965). Performance at asymptote is assumed to provide one measure of secondary memory, whereas the declining slope between stimulus presentation and recall serves as a measure of primary memory.

There have been, however, serious questions about the extent to which the slope of the Brown-Peterson curve actually provides an adequate measure of primary memory. Because subjects typically know that they are going to be requested to recall presented items, they are likely to attempt to form a more lasting secondary memory trace, even during brief intervals (e.g., Jacoby & Bartz, 1972; Watkins & Watkins, 1974). Responding to this potential confound between expectancy and rate of forgetting, Muter (1980) argued that actual loss from primary memory could only be assessed under conditions in which the subject did not expect a recall test. Muter therefore devised a technique in which subjects would rarely, if ever, expect to be asked to recall after a filled interval. This was accomplished by inserting only a few critical Brown-Peterson trials among many instances of three other trial types: (1) *Maintenance* trials, on which subjects were required to recall the stimulus, used an *unfilled* retention interval; (2) *counting* trials, which did have a *filled* interval, required backwards counting, but did not require recall; (3) additional *irrelevant* trials were used to distract subjects concerning the purpose of the task. Presumably, these trials set up the expectation that recall would be required after an unfilled, but not after a filled interval. Using this approach, Muter found that recall was dramatically reduced after a retention interval of only 2 to 4 sec.

These results suggest that forgetting from primary memory is substantially faster than commonly believed. It remains an open question, however, whether this methodology has produced a clear separation between primary and secondary memory. In Muter's terms, we have a measure of primary memory that is "less contaminated by secondary memory involvement" (p. 178). This paper examines whether or not the Muter task has eliminated effects of secondary memory on short-term recall. More specifically, we evaluate one hypothesis advanced by Muter—that the differences in the Brown-Peterson and Muter tasks represent different encoding strategies under different conditions of expectancy.

To avoid confusion between performance measures and theoretical mechanisms, we will observe the following terminological conventions, following Crowder's (1976)

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suggestion. *Short-term* and *long-term* memory will be used to refer to the task situations in which subjects are requested to recall presented items after either a brief or a long delay, respectively. To account for observed performance, *primary* and *secondary* memory will be used to refer to underlying memory systems that are hypothesized. In that context, this paper attempts to determine whether or not differences between Brown-Peterson and Muter estimates of short-term memory duration can be ascribed to changes in encoding strategies resulting from different contributions of primary and secondary memory.

A PRELIMINARY STUDY: PROACTIVE INHIBITION

Before examining the specific types of encoding that subjects may be using in the Muter task, however, it is important to consider a potential methodological confound. Given the large number of trials that are required for the Muter task, it is possible that the noncritical trials are increasing the interference or proactive inhibition (PI) on critical trials. Following Keppel and Underwood (1962), numerous studies have shown that recall is optimal on the first Brown-Peterson trial and that subsequent trials show a relative decrement in performance. Decreases in performance over trials or over time, in this view, represent the consequences of interference (PI) from previous trials.

In the typical Brown-Peterson study, the average number of trials can be relatively small since each trial provides relevant recall data. In Muter's experiments, however, in order to set subject expectancy, critical trials either were placed late in the test sequence or were randomly distributed throughout a long test sequence. As a consequence, it is possible that, as Muter noted, PI may play a role in very rapid forgetting. We tested this hypothesis in two experiments by controlling the locations of critical trials within a modified Muter task and then comparing the results to those for a more typical Brown-Peterson task. (Results for these studies were reported in Seamon, Schooler, Sklar, & Sebrechts, 1987.)

The first experiment was designed to provide a baseline measure of recall under full expectancy using a procedure similar to that used by Muter. For this experiment, subjects' recall was tested on a series of 20 short-term recall trials. The procedure was similar to that for critical trials in Muter's second experiment. On each trial, subjects were presented with a consonant trigram for 1 sec, followed immediately by a 4-sec distractor task, and then a recall prompt. The distractor task consisted of the presentation of four groups of four words; each group was displayed for 1 sec. Subjects were instructed to read the words aloud and to try to remember them. The results from this experiment are depicted in Figure 1 for strict (how many complete trigrams were recalled) and lenient (how many individual letters were recalled) criteria. Recall dropped rapidly after the first trial and became relatively stable thereafter. These results are consistent with other reports in the literature using different procedures (e.g., Keppel & Underwood, 1962).

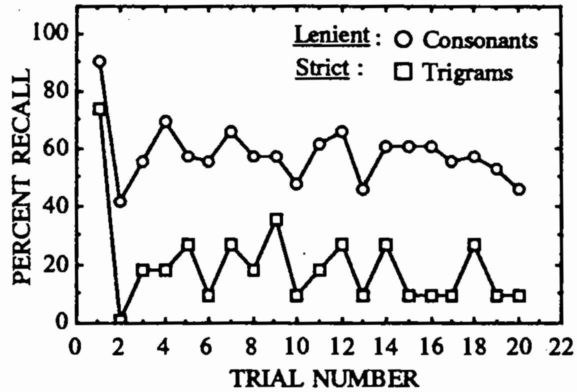

Figure 1. Mean percent recall of trigrams and words by trial for a series of Brown-Peterson trials with a 4-sec distractor. Recall was expected and required on every trial.

The second experiment examined how this pattern would be changed when expectancy was eliminated. Subjects were presented with 100 trials, the majority of which were used to set subjects' expectancy. On most trials, recall was required only after a blank retention interval; when subjects were given the same distractor reading task as in the first experiment, no recall was required. However, on three trials, recall was required after the distractor task, and these served as critical trials identical to those in our first experiment.

In Muter's study unanticipated critical trials were randomly distributed throughout the test sequence, whereas, in our second experiment, critical trials could occur only as the 1st, 5th, 25th, 75th, or 90th trial. Three groups of 20 subjects differed with respect to the specific location of the 1st critical trial: For one-third of the subjects, the 1st trial was also the 1st critical trial; for another third, the 5th trial was the 1st critical trial; and for the final third, the 25th trial was the 1st critical one. Within each of these three groups, half of the subjects received a 2-sec distractor task on critical trials and the other half received a 4-sec distractor task.

The results suggest that recall was determined by location of the critical trial within the trial sequence and not by the the specific order of critical trials (i.e., recall on the 25th trial was approximately the same whether it was the 1st or the 3rd critical trial in the sequence). The results, depicted in Figure 2,[1] were therefore collapsed across the three groups of subjects who received different critical trial locations. The top two curves indicate the number of consonants recalled (the lenient criterion), the bottom curves indicate the number of trigrams recalled (the strict criterion). As with typical PI studies, performance drops from the first to all subsequent trials, and the amount of the decline is greater for the longer retention interval (4 sec) than for the shorter interval (2 sec).

For our purposes, the central issue is the effect of expectancy. In general, performance is worse in the absence

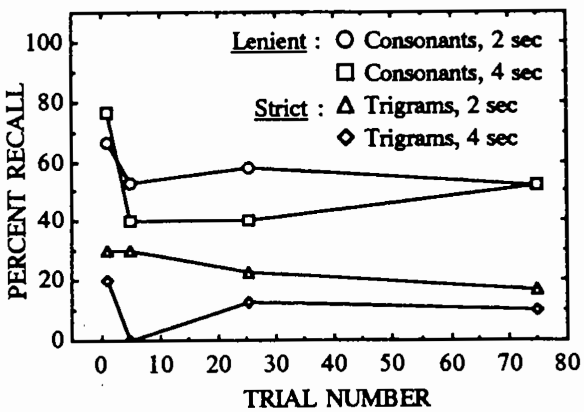

Figure 2. Mean percent recall for critical trials using a Muter task in which recall was not expected. One group had a 2-sec distractor task; the other group had a 4-sec distractor.

of expectancy, as can be seen by comparing the results from Figure 1 with the results from the comparable (4 sec) condition in Figure 2. This effect is present on earlier as well as later trials in the sequence; it is particularly striking on the first trial, which occurs prior to the buildup of experimentally induced PI. Thus, it appears unlikely that very rapid forgetting is primarily a function of differential PI buildup.

TYPE OF ENCODING

Having ruled out PI as the explanation for Muter's very rapid forgetting results, we now consider the central issue of this paper—type of encoding. According to the *levels of processing* view proposed by Craik and Lockhart (1972), differences in primary and secondary memory can be accounted for by different encoding strategies. Repetition of an item at a particular level of processing will prolong the accessibility of an item but will not lead to the formation of a more permanent trace. Deeper, more elaborative, analysis of the stimulus will produce an improved long-term trace.

Differences in the Brown–Peterson and Muter results may reflect differences in the use of these encoding strategies. In the Brown–Peterson paradigm, subjects expect a recall test after a filled interval, so they may engage in some form of elaborative rehearsal that will produce a more enduring trace. In contrast, in the Muter paradigm, subjects are not expecting a recall task and, therefore, may fail to engage in appropriate elaboration. As a consequence, recall in the Muter task will show substantially less influence of secondary memory. The studies described here examine this hypothesis by using different orienting tasks to manipulate the subjects' encoding strategies in the two short-term paradigms.

Experiment 1 used a modified Brown–Peterson paradigm to determine whether effects of elaborative encoding that have been found in long-term memory (Cermak & Craik, 1979) can also be found in short-term memory. Because elaborative encoding involves access to secondary memory, such encoding can be used as a probe to evaluate secondary memory effects in short-term memory tasks. Normally, the asymptotic portion of the recall curve is taken as specifying secondary memory effects. In this case, orienting task can provide a separate way to manipulate secondary memory involvement, so we compared asymptotic performance with performance on a final free-recall test.

Experiment 2 uses similar orienting tasks in the context of the Muter paradigm. By comparing effects of encoding with those in the Brown–Peterson task, we should be able to determine whether or not the experimentally induced encoding strategies are mediating the effects of expectancy on recall.

EXPERIMENT 1

Although it is reasonable to assume that secondary memory characteristics do influence short-term memory tasks (e.g., Shulman, 1972; Wickens, Born, & Allen, 1963), to our knowledge, no study has reported the effects of different orienting tasks within the Brown–Peterson paradigm. Experiment 1 addressed this issue explicitly. In this experiment, we used a typical Brown–Peterson task in which three words were presented, followed by a distractor of varying delay, which was followed by a recall test. The paradigm was modified to include three orienting tasks: (1) a semantic encoding task, (2) an acoustic encoding task, and (3) a reading task that served to assess performance in the absence of a specified orienting task.

Method

Subjects. Thirty Wesleyan University students, 18–24 years old, served as paid volunteers, or were awarded course credit for their participation, in Experiment 1. The subjects were divided evenly among three orienting task groups: semantic, acoustic, and reading. None of the subjects had participated in any prior experiments on memory.

Design. The experiment utilized a 3×7 mixed factorial design. The first factor was the orienting task that was manipulated between subjects. In the semantic condition, the subjects decided if the presented words represented something animate; in the acoustic condition, they decided if the words contained a long "e" sound; in the reading condition, they merely read the words aloud. The second factor specified the retention interval used for critical trials (0, 1, 2, 3, 4, 8, or 16 sec) and was manipulated within subjects.

Materials and Apparatus. Three-hundred common nouns were chosen from Thorndike and Lorge's (1944) word list; half of the words represented animate objects and half represented inanimate objects. The animate–inanimate criterion was crossed orthogonally with a second criterion, the presence or absence of a long "e" sound; thus, half of the words contained a long "e" sound and half did not. Because of a limited number of words that fulfill both criteria, the following number of words were contained in the four groups: animate/long "e" present, 50; inanimate/long "e" present, 100; animate/long "e"absent, 100; inanimate/long "e" absent, 50. Ten orderings of the 300 words were then constructed by random sampling without replacement. Each order was used for a single subject in each orienting task group. The subjects viewed the stimuli in the center of a 12-in. black-and-white monitor, under the control of software developed for a DEC Rainbow 100 computer.

Procedure. Each trial consisted of a preparatory tone, followed by a 0.5-sec delay, and then the sequential presentation of three words for 1 sec each. The subjects in the semantic and acoustic conditions said either "yes" or "no" to each word, according to previously given task instructions; the subjects in the reading condition merely said the word aloud. Immediately after the offset of the last word, the subjects saw a computer-generated random three-digit number for 1 sec. For a period specified by the retention interval (0, 1, 2, 3, 4, 8, or 16 sec), this number was decremented by threes on the screen at a rate of one decrement per second (e.g., 606, 603, 600, 597, 594, etc.). The subjects had been instructed to count backward by threes as quickly as possible from the time they saw the first number, trying to report the result before it appeared on the monitor. At the conclusion of the retention interval, the subjects were presented with the prompt "WORDS?" The subjects were instructed to recall the three words in their presented order when they saw this prompt and to guess if they could not remember a word.

Each subject viewed a total of 100 trials that had retention intervals of 0, 1, 2, 3, 4, 8, or 16 sec. The retention interval for any given trial was assigned randomly under the constraint that 16% of the trials occurred at each of 0, 1, 2, 3, and 4 sec, and 10% occurred at each of 8 and 16 sec.[2]

Upon conclusion of the final trial, the subjects were given a surprise final free-recall test. They were instructed to take a minimum of 5 min to write down all the words they had seen in the experiment.

Instructions. Prior to beginning the experimental trials, the subjects were given examples of the component tasks. Each subject was given one practice trial consisting of the initial portion of a trial (i.e., preparatory tone and the presentation of the three words); the subjects were asked to respond to each word according to the orienting task condition to which they had been assigned. Each subject was then given five practice trials on counting backwards. Finally, the prompt "WORDS?" was shown and the subjects were queried about critical aspects of the procedure.

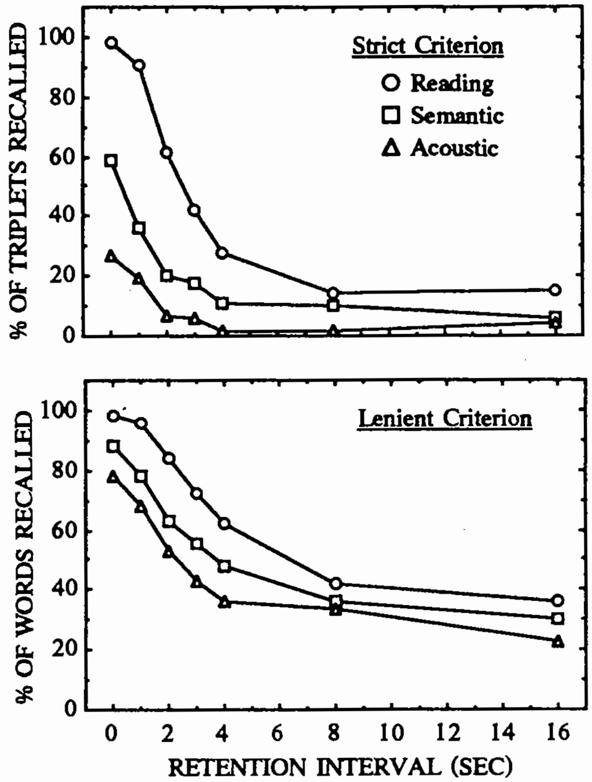

Figure 3. Mean recall by retention interval and orienting condition in the Brown–Peterson task in Experiment 1. The top portion presents the strict criterion, indicating the percent of word triplets recalled; the bottom portion presents the lenient criterion, indicating the percent of words recalled.

Results and Discussion

Short-term memory. Immediate recall was scored in two ways. Under a strict criterion, a response was considered correct only if the subject reported all three words in the correct order (i.e., both item and order information were correct). Under a lenient criterion, words were counted as correct without regard to order. The results for orienting task and retention interval are shown for these two criteria in Figure 3.

There were reliable differences in recall among the three orienting tasks [strict, $F(2,27) = 25.38$, $MS_e = 0.116$, $p < .001$; lenient, $F(2,27) = 10.18$, $MS_e = 0.089$, $p < .001$]. The reading group consistently showed the best retention, followed by the semantic group, and then the acoustic group. The planned comparison between semantic and acoustic groups across retention intervals showed a significant difference in recall by the strict criterion [$t(18) = 2.66$, $p < .05$], with the semantic task producing better retention. Scoring by the lenient criterion yielded similar marginally significant results [$t(18) = 1.88$, $p = .08$].

As shown in Figure 3, the rank order of recall results (reading first, then semantic, followed by acoustic) was consistent throughout the retention intervals tested and appears to have been preserved even in the asymptotic portion of the curves. Recall decreased substantially with increasing retention interval for all three orienting tasks [strict, $F(6,162) = 81.56$, $MS_e = 0.015$, $p < .001$; lenient, $F(6,162) = 156.25$, $MS_e = 0.009$, $p < .001$]. The rate of decrease, however, differed across orienting task, as reflected in an interaction between retention interval and orienting task [strict, $F(12,162) = 11.79$, $MS_e = 0.015$, $p < .001$; lenient, $F(12,162) = 2.40$, $MS_e = 0.009$, $p < .01$].[3]

In sum, each task produced a typically shaped recall function that decreased monotonically with retention interval of the counting task. The height of the recall function and the rate of decrease, however, were determined by the orienting task. To our knowledge, this is the first demonstration of such effects in a short-term memory task. Type of encoding and the related memory strategies usually ascribed to secondary memory are important for short-term memory.

Long-term memory. To give equal weight to each retention interval, the percent of critical trials correctly recalled during the final test was computed separately for each subject at each retention interval. Each subject's final free recall was then computed as the mean of the percent correct at each retention interval. Since final recall was not constrained to any order, there was only a single lenient criterion in this case. The overall differences in long-term recall were small and nonsignificant (semantic, 9%; reading, 8%; acoustic, 7%; $MS_e = 0.005$). However, a planned comparison reveals the characteristic advantage of the semantic over the acoustic group in long-term recall [$t(18) = 2.43, p < .05$]. The pattern of results is different from that in short-term memory; the reading group has lost its reliable advantage. This difference is also reflected by the fact that final free-recall data show a different ordering from the asymptote data obtained during immediate recall. This suggests that the influence of secondary memory as reflected in orienting task is not measured equivalently using these two forms of recall. At asymptote, recall is presumably based primarily on the activation state of the presented words, because knowing the category (e.g., animate vs. inanimate) does not distinguish the current trial from previous trials. At final recall, category can serve as a more useful retrieval cue because the subject does not need to differentiate presented words according to time of presentation.

EXPERIMENT 2

Experiment 1 established that encoding strategies induced by orienting tasks can influence short-term memory. Experiment 2 examined whether or not those results could be extended to conditions in which recall was not expected. In addition, we were interested in whether the *pattern* of results would be similar for the three orienting tasks under conditions of expectancy and nonexpectancy.

The same orienting tasks were used as in Experiment 1. However, in Experiment 2, we followed Muter's (1980) strategy for eliminating the subject's expectancy of a recall task. A few critical recall trials, similar to those in a Peterson task, are embedded in a number of other types of trials designed to control the subject's expectancy. Since only a few critical trials can be presented without changing expectancy, only three retention intervals were used.

Method

Subjects. Fifty subjects from Wesleyan University served as paid volunteers, or were awarded course credit for their participation, in Experiment 2. No subject had participated in Experiment 1. Ten subjects were randomly assigned to the reading group, and 20 subjects were randomly assigned to each of the semantic and acoustic orienting task groups.

Design. Experiment 2 utilized a $3 \times 3 \times 2$ mixed factorial design. As in Experiment 1, three levels of the orienting task (semantic, acoustic, and reading) were varied between subjects. The second variable, retention interval, was varied within subjects; since Muter's data suggested decay of short-term memory within 4 sec, only 0-, 2-, and 4-sec intervals were used. The third variable determined two alternate between-subjects orders in which the 2- and 4-sec critical trials were presented as described below.

Materials and Apparatus. The materials and apparatus were identical to those used in Experiment 1. Twenty new orderings of the 300 words were constructed by random sampling without replacement. Each order was used for a single subject in the semantic and acoustic orienting task groups; each of the 10 subjects in the reading condition was also randomly assigned uniquely to 1 of the 20 orderings.

Procedure. Each subject viewed a total of 100 trials consisting of 75 maintenance, 20 counting, and 5 critical trials (see Figure 4). The initial portion of each trial was identical to that in Experiment 1: Each trial consisted of a preparatory tone, followed by a 0.5-sec delay, and then the presentation of three words sequentially for 1 sec each. The subjects in the semantic and acoustic conditions said either "yes" or "no" to each word, according to previously given task instructions; the subjects in the reading condition merely read each word aloud. The next portion of the trial differed according to the trial type as illustrated in Figure 4.

The critical trials were identical to trials with matching retention intervals in Experiment 1. Maintenance trials were similar to critical trials except for the fact that there was no intervening counting task during the retention interval. The unfilled retention interval for all maintenance trials was 2 sec. Counting trials were identical to critical trials except for the fact that no "WORDS?" prompt appeared and no recall was required. The retention interval for these trials was always 6 sec.

There were five critical trials at three retention intervals: two at 4 sec, two at 2 sec, and 1 at 0 sec. Since a 0-sec trial has no delay, it cannot have an intervening task and therefore constitutes a special type of critical trial. To minimize the effect of the 0-sec trial on expectancy for other critical trials, it always appeared as the last trial. The remaining critical trials were located at Trials 20, 40, 60, and 80. The locations of the 2- and 4-sec trials were varied, using two between-subjects orderings in which a critical trial was never followed by one of the same duration. Consequently, one group received a sequence of critical trial durations of 2, 4, 2, and 4 sec across the four positions from 20 to 80, and the other group received the reverse order: 4, 2, 4, and 2 sec.

Upon conclusion of the final trial, the subjects were given a surprise final free-recall test identical to that in Experiment 1.

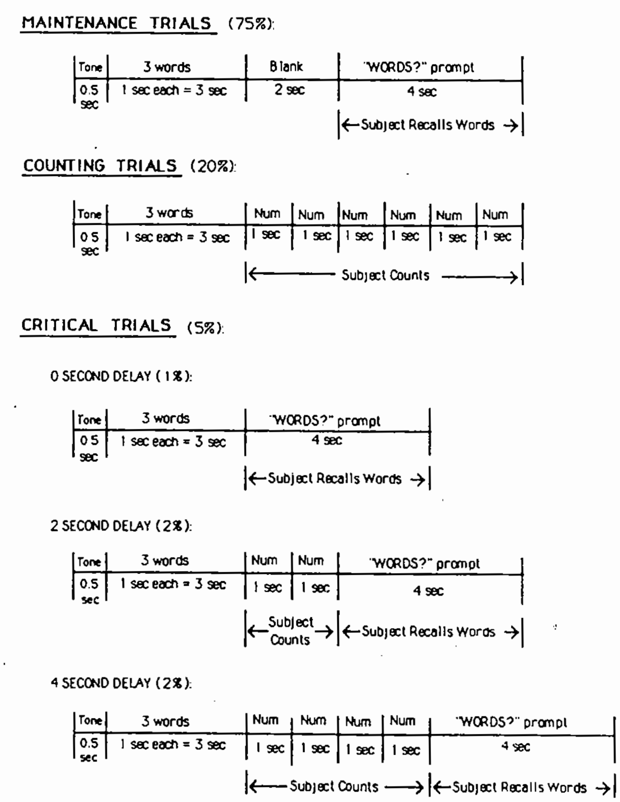

Figure 4. Different trial types and percent of each type presented in Experiment 2.

Results and Discussion

Short-term memory. As in Experiment 1, recall was scored by both strict and lenient criteria. The proportions of words recalled using these two criteria are plotted in Figure 5.

Initial analyses showed no effect of critical trial order; consequently, the data were collapsed across different orders in all subsequent analyses. The orienting condition significantly affected recall after very short intervals [strict, $F(2,47) = 9.60$, $MS_e = 0.084$, $p < .001$; lenient, $F(2,47) = 6.98$, $MS_e = 0.086$, $p < .01$]. Across the three retention intervals of 0, 2, and 4 sec, the reading group showed the best performance, followed by the semantic group, and then the acoustic group. Although the mean recall was very much higher for maintenance trials, they showed the same general effects of orienting task. Reading was best (strict, 97%; lenient, 99%), semantic was next (strict, 70%; lenient, 91%), and acoustic was worst (strict, 48%; lenient, 81%) [strict, $F(2,47) = 39.20$, $MS_e = 0.013$, $p < .001$; lenient, $F(2,47) = 33.08$, $MS_e = 0.004$, $p < .001$]. The similarity of results indicates that the effects of orienting task were general within the experiment and not confined to critical trials.

There also was a dramatic drop in recall with increasing retention interval, as shown in Figure 5 [strict, $F(2,94) = 74.14$, $MS_e = 0.078$, $p < .001$; lenient, $F(2,94) = 146.64$, $MS_e = 0.031$, $p < .001$]. By 4 sec, recall had reached levels comparable to those reported by Muter (1980): 29% ($SEM = 0.03$) for the lenient criterion and 1% ($SEM = 0.01$) for the strict criterion.

The differences among orienting task change with increasing retention interval [strict, $F(4,94) = 4.31$, $MS_e = 0.078$, $p < .01$; lenient, $F(4,94) = 2.75$, $MS_e = 0.031$, $p < .05$]. Differences among orienting task at 0 and 2 sec are almost eliminated by 4 sec. As shown in Figure 5, performance might have reached a minimum asymptote by 4 sec.

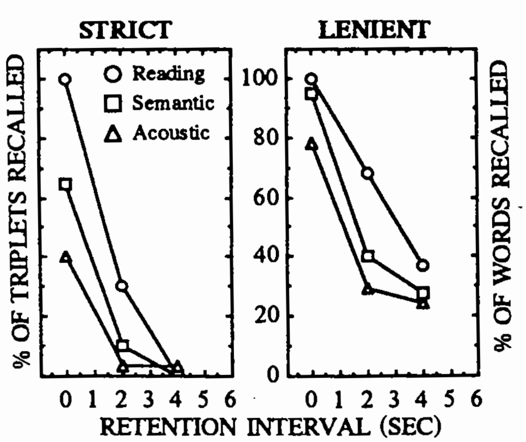

Figure 5. Mean recall by retention interval and orienting condition in the Muter task in Experiment 2. The left panel presents the strict criterion, number of word triplets recalled; the right panel presents the lenient criterion, number of words recalled.

Long-term memory. As in Experiment 1, for each subject, final free recall was proportionately adjusted for each retention interval. Because the 0-sec response interval was fixed at the last trial just prior to final free recall, it may have reflected short-term rather than long-term recall. This was suggested by the fact that recall for items at that interval (mean of 53%) was disproportionately higher than was recall for items from the 2- and 4-sec intervals (mean of 5%). The 0-sec interval was therefore excluded from the analyses. As expected from previous research on type of encoding, orienting tasks had a significant effect on recall from long-term storage [$F(2,47) = 6.17$, $p < .01$]. Performance was best for the semantic group (7%), poorest for the acoustic group (2%), and intermediate for the reading group (6%) ($MS_e = 0.004$). In these analyses, the most important difference is between semantic and acoustic conditions, and again the expected advantage for the semantic condition is reflected in a significant planned comparison [$t(38) = 4.06$, $p < .001$]. These results support many previous findings, including those of Experiment 1, that semantic encoding will yield better long-term retention than will acoustic encoding.

The same pattern of results was present for the maintenance trials. Recall for the semantic group was the highest (10%), followed by the reading group (6%), and then the acoustic group (5%) [$F(2,47) = 21.82$, $MS_e = 0.001$, $p < .001$].

For both the critical and the maintenance trials, the pattern for long-term retention is different from that for short-term retention. The reading group was best in the short term, whereas the semantic group was best in the long term. These results, again, suggest different processing consequences for the same orienting task in short- and long-term memory.

ORIENTING TASK AND EXPECTANCY: COMPARING EXPERIMENTS 1 AND 2

The effects of orienting task appear similar in the two experiments. These results suggest that the effect of encoding as manipulated by orienting task (within experiment) may be similar for different conditions of expectancy (between experiment). To examine this relationship more directly, we conducted analyses using comparable trials from the two experiments. We excluded the 0-sec interval because of its fixed position as the final item in Experiment 2. In addition, we focused on the lenient criterion in order to avoid potential floor effects that appeared to be present using the strict criterion. The data for this analysis are shown in Table 1 ($MS_e = 0.068$). Under these conditions, there are significant differences in recall due to both expectancy [$F(1,74) = 20.26$, $p < .001$] and to orienting task [$F(2,74) = 12.52$, $p < .001$]. These data support the notion that lack of expectancy results in poorer short-term recall or faster forgetting (Muter, 1980). They likewise indicate that orienting task can influence short-term retention with or without expectancy.

Table 1
Proportion of Words Recalled Under Expectancy (Experiment 1) and Nonexpectancy (Experiment 2) at the 2- and 4-Sec Retention Intervals Using a Lenient Criterion

Orienting Task	Expectancy	Nonexpectancy
Reading	.73	.52
Semantic	.55	.35
Acoustic	.44	.27

In addition, the effects of these two variables appear to be independent since they do not reliably interact [$F(2,74) = 0.08$, $p > .10$]. At both the 2- and 4-sec retention intervals, performance is consistently worse using the Muter paradigm than using the Brown–Peterson paradigm, on each of the three orienting tasks. In our studies, the relative utility of an encoding strategy did not depend upon the expectation of its use for retention.

GENERAL DISCUSSION

The results of the experiments reported here add evidence to the very rapid nature of forgetting in the absence of expectancy. Using differing procedures and materials, we find forgetting comparable to that described by Muter (1980). Within 2 to 4 sec, recall decreased to levels normally obtained after 18 sec in more traditional tasks. In addition, the data indicate that such rapid forgetting is not easily modified by slight changes in the paradigm or by inducing alternative strategies.

Our data also suggest that type of encoding can influence short-term memory. These results suggest that the role of secondary memory in short-term retention goes beyond the well-established consequences of proactive inhibition (Wickens et al., 1963). In addition, these effects have not been eliminated even in the case of very rapid forgetting. Such secondary memory effects are evidenced in two ways. First, the rapid forgetting described by Muter persists even when secondary memory processes ought to be engaged by the orienting task. This suggests that the type of encoding per se is not the central determinant of very rapid forgetting. Second, the pattern of the effects is similar for expectancy and nonexpectancy: The rank order of performance on orienting tasks is similar in the two conditions. The reading condition is best, followed by the semantic condition, and then the acoustic condition.

The role of secondary memory, however, is not the same for short-term recall as it is for long-term recall. The semantic condition was best for long-term memory, whereas the reading condition was best for short-term memory. These results are consistent with arguments concerning the distinction between rehearsal and elaboration (Craik & Lockhart, 1972). Rehearsal shows a relative advantage at short intervals, whereas elaboration is more helpful at longer delays. Since the reading condition is best at short, but not long, delays, this condition may represent a rehearsal condition. However, since the task was to read the words aloud, it is also possible that the subjects engaged in some form of elaboration. To test this alternative, we ran an additional study with two groups of 8 subjects in the Peterson task of Experiment 1. One group was assigned a semantic orienting task; the other group was told to rehearse the items overtly until the counting task began. Performance for these groups replicated the effects for the semantic and reading groups in Experiment 1. Thus, it seems reasonable to view the difference between reading and semantic groups as differences between rehearsal and elaboration.

The utility of an encoding strategy is dependent upon the character of the recall task. Semantic elaboration may help long-term retention, but it appears to hurt short-term retention relative to reading or rehearsal conditions. One explanation for these results is the different degree of resource allocation to primary and secondary memory. Semantic encoding uses relatively more resources to process the words in a way that is useful for long-term retention, but, as a consequence, it diverts resources away from short-term retention. The reading group, in contrast, allocates more resources to processing that aids short-term retention, with a relative disadvantage at longer intervals. Finally, the acoustic task tends to divert resources from rehearsal that might otherwise improve short-term retention. However, since the acoustic task does not provide a form of elaboration that produces useful retrieval cues, it also fails to improve long-term retention.

This functional dissociation between primary and secondary memory provides additional evidence for similar hypotheses emerging from different paradigms. For example, Mazuryk and Lockhart (1974; Mazuryk, 1974) found a similar pattern of recall using four different processing strategies in serial-list learning. Reading the words aloud or "trying to memorize" them resulted in the best initial free recall. Generating word associations produced the best final free recall. The rhyming condition in which subjects generated rhymes for the words showed no relative advantage at either immediate or final free recall. Presumably reading produces little elaboration to help final free recall, but also produces little processor load, thus facilitating initial free recall. Generating associates requires processor resources for elaboration, thus increasing final free recall at the expense of initial free recall. Rhyming likewise requires processor resources, without providing beneficial elaboration, resulting in neither an initial nor a final free-recall benefit.

Another study (Smith, Barresi, & Gross, 1971) showed a similar differential between imagery and rehearsal in serial-list recall. Subjects who were instructed to form visual images showed a recall advantage on secondary memory components, whereas subjects who were instructed to repeat the nouns showed an advantage on the primary memory components. Smith et al. argued that the information was sent in parallel to primary and secondary memory. However, since processing resources are limited, there is some tradeoff between using these two memory systems.

Our data suggest that such resource competition is present even at extremely short intervals. Although type of encoding can influence measures of short-term retention, those effects appear to be a consequence of the relative amount of available resources that are devoted to primary memory. Expecting a recall task or changing the orienting task can shift the allocation of those resources.

On the basis of our results, however, the effect of expectancy appears to be separable from the effect of orienting task. Expectancy appeared to shift the overall probability of recall, whereas orienting task changed the relative performance in short- and long-term tasks. It may be that expectancy of recall influences the level of available resources, whereas the orienting task specifies how those resources are distributed. When a subject knows that recall will be required (as in Experiment 1), more processing resources may be devoted to stimulus encoding. Likewise, if the subject is informed which subset of presented items will be tested by a precue (e.g., Healy, Fendrich, Cunningham, & Till, 1987), resources during encoding may be allocated selectively to the relevant portions of the presented material.[4]

The orienting task in our experiments and in the studies reviewed above may then shift the distribution of those resources to different processes, influencing the relative effectiveness of short- and long-term recall. The effectiveness of the resultant encoding will depend upon the degree to which resource allocation is relevant to subsequent task demands.

Insofar as the very rapid forgetting in the Muter task provides a measure of relative resource allocation, it does not provide a "pure" measure of primary memory. Recent simulations of memory (e.g., Barnard, 1985; Schneider & Detweiler, 1987) have suggested that primary memory may in fact be best characterized in terms of process. If so, variability in resource allocation would make it difficult to provide any single pure measure of primary memory duration. However, to the extent that primary memory processing has some associated "decay," the influence of secondary memory in the present studies indicates that it may be even more rapid than the Muter task suggests.

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NOTES

1. Since some of the subject data was missing for the 90th trial, that point is not plotted in Figure 2.

2. These percentages were chosen to provide a total experiment time comparable to that for Experiment 2 in which the mean retention interval was approximately 2 sec.

3. The interaction suggests that conditions that produce greater initial learning result in less rapid forgetting. Loftus (1985) has suggested that statistical interactions may not be the best way to evaluate rate of forgetting. However, in this case, the same conclusion follows if we use the alternative measure proposed by Loftus: Given an orienting task that produces greater initial recall, it takes longer for memory performance to fall from a given level to a lower level.

4. We are grateful to an anonymous reviewer for pointing out the parallel between *cuing* and recall *expectancy*.

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