Thirty-two subjects were tested in an experiment designed to investigate recency curves in single-trial free recall. One group of subjects was presented with five lists of common English words; the first four lists for delayed recall and the fifth for unexpected immediate recall. The second group was treated the same way except that following the fifth list two additional lists were presented for immediate recall. At the completion of all the recall tests and a distractor task, both groups were given an unexpected final recall test. In the final recall of the fifth list, positive recency was maintained by the first group whereas negative recency was produced by the second. These results seemed to indicate that given elaborative encoding of recency items, long-term recency may be obtained but that it may be so transient as to be wiped out by processing of additional lists. It was concluded that if initially tested in an immediate test, recency items would become less recallable than prerecency items in final recall, regardless of how deeply they were processed at encoding.

Key words: free recall, long-term recency, negative recency, spacing-of-tests effects, levels of processing, two-store theories.

In a single-trial free-recall experiment, subjects are first presented with a list of items and later asked to recall as many items as possible from the just-presented list in any order they wish. In immediate recall where a recall test is given immediately following the termination of list presentation, items from terminal input positions are usually best recalled. This is called the ”recency effect.” A few items from the earliest input positions are also well recalled (the ”primacy effect”), while items from the middle input positions are recalled with a roughly constant proportion.

When recall is delayed by a post-list task, the recency effect is wiped out with little change in the prerecency portion of the serial-position curve (Glanzer & Cunitz, 1966; Postman & Phillips, 1965). In final recall where subjects are unexpectedly asked to recall all the words from all the lists presented in a series of immediate recall, recency items, while best recalled in immediate recall, are now least recalled. This is called the ”negative recency effect” (Craik, 1970). Thus, there are three types of recency curves demonstrated in single-trial free recall; (1) positive recency with immediate recall, (2) zero recency with delayed recall, and (3) negative recency with final recall.

This trichotomy poses a problem for a two-store theory which divides nonsensory memory into a short-term store (STS) and a long-term store (LTS) (Atkinson & Shiffrin, 1968). Since output from STS is supposedly eliminated in delayed as well as final recall, the recency curves under these conditions should reflect output only from LTS and therefore be identical in shape. In this line of inquiry, Gardiner, Thompson, and Maskarinec (1974) conducted a series of experiments and demonstrated negative recency in delayed recall.
It should be noted, however, that in the Gardiner et al. study, negative recency was obtained only with auditorily-presented items; for visually-presented items zero recency was observed. Later, Roediger and Crowder (1975), Martin and Jones (1979, Exp. 1), and Richardson (1978) showed negative recency in delayed recall. However, list items were presented auditorily in all of these studies. Thus, for the two-store theory, negative recency has yet to be obtained with visually-presented items. One aim of the present study was to see whether negative recency could be obtained for visually-presented items in initial recall delayed by a substantially demanding post-list task.

Within the levels-of-processing framework (Craik & Lockhart, 1972), negative recency is thought to result from the application of shallow processing to recency items at encoding. A similar "quality-of-processing" account of negative recency was provided by Jacoby and Bartz (1972) who speculated that transfer of information to LTS might depend on the type or quality of processing which is under the subject's control. They found that recency items were as well recalled as pre-recency items (i.e., zero recency) in final recall when initial recall was delayed, while negative recency was obtained in final recall when initial recall was immediate. Jacoby and Bartz suggested that anticipating a filled delay preceding recall, subjects processed both recency and pre-recency items further for storage in LTS, which results in the absence of negative recency in final recall. It seems reasonable to assume that the type-of-processing notion is concerned only with the quality of processing at the time of list presentation and is independent of the test format of initial recall (i.e., either immediate or delayed). The second aim of the present experiment was to test the prediction that negative recency would not occur in final recall following immediate recall provided that subjects anticipate initial recall to be delayed by a rehearsal-preventing task.

It should be noted that negative recency has been found in final recall which follows presentation and immediate recall of several lists (Craik, 1970). Dalezman (1976) found that there was only zero recency in final recall for the last-presented list. He also observed that the magnitude of negative recency was inversely related to the recency of list presentation prior to final recall. These results, however, are incompatible with the Maskarinec and Brown (1974) results showing that negative recency in final recall developed over the course of trials. Lewis (1971) gave subjects a second recall test immediately following the first immediate test in order to assess the long-term retention of list items. Although recall of recency items was reduced from the first to the second recall, there was no indication of negative recency in the second recall. Bartz, Lewis, and Swinton (1972) further added a final recall test to the above procedure and found negative recency in final recall while observing zero recency in the second recall. The third aim of the present study was to investigate whether processing of subsequent lists was a necessary condition for the occurrence of negative recency in final recall.

Method

Subjects
Thirty-two subjects were recruited from introductory psychology classes at the University of California, Santa Barbara. They participated in the present experiment to fulfill a course requirement. Subjects were randomly assigned to one of two groups as they appeared to the experimental room, and were tested individually.

Materials and Equipment
Ninety-six concrete nouns were selected from the Paivio, Yuille, and Madigan (1968) norms to construct eight lists of 12
words with the restrictions that: (1) The mean concreteness score is higher than 6.00, (2) The Thorndike-Lorge frequency is from 20 to A, (3) The number of characters is from four to eight, and (4) No more than eight words begin with the same letter. Then, one practice and seven test lists were constructed with the restrictions that: (1) Obvious within-list acoustic and semantic associations were avoided, and (2) no two words within a list began with the same letter. Both the orders of the test lists and the within-list orders of words were so counterbalanced that no two subjects in the same group studied the words in the same sequence.

Thirty-six three-digit numbers were selected from a random number table. They were grouped together to form 12 sets of three numbers with the restriction that no two numbers within a set began or ended with the same digit. The orders of the sets were counterbalanced so that no two subjects in the same group would see them in the same order.

All the words and numbers were made into slides and presented individually via a Bell-Howell Ringmaster projector. Each word was printed in capital letters and each number was printed in the center with question marks on its right and left sides (e.g., ? 556 ?). All slides were automatically advanced by the instruction pulses pre-recorded on a cassette tape.

A separate page of an answer booklet was provided for the recall of each list so that subjects did not look at the words recalled on the previous trial. Also, extra pages were added to avoid any end-of-session spurt. Subjects were provided with a separate answer sheet for a final recall test.

Procedure

All the list words were presented one at a time for every three seconds. Initial recall was signaled by a slide showing three question marks in a row ( ??? ). For Lists 1–4 recall was delayed for 30 s by a "counting-with-alternation" task in which subjects were required to "alternately" count aloud forward and backward by threes from the number presented on the screen. For instance, seeing the number 556 on the screen, they had to count aloud 559, 553, 562, 550, 565, 547, and so on. It was noted that the counting-with-alternation task became increasingly difficult as counting went on, making it very difficult to continue counting for 30 s. Therefore, to save subjects from getting lost in counting, three three-digit numbers were presented one at a time for every 10 s. It was stressed that the important measures of the task were both speed and accuracy.

Preceding the test session, three counting-with-alternation trials and one delayed recall test were given as practice to familiarize subjects with the required tasks and the procedure. The test session was divided into Parts I and II. The "five-list" group was given a series of four delayed recall tests in Part I, and one immediate recall test and four counting-with-alternation trials in Part II. The "seven-list" group was treated in the same way as was the five-list group in Part I and then given three immediate recall tests and two counting-with-alternation trials in Part II. Both groups were informed that in Part I recall of list words and counting-with-alternation task would be tested with the counting task intervening between presentation and recall of list words and that the two tasks would be tested in "a slightly different context" in Part II. Subjects were not informed that the fifth list would be tested in the immediate-recall format. Nor were they informed of the number of trials in each part of the experiment. After the completion of Part II, all the subjects were given an unexpected final recall test.

Subjects in both groups were given one minute for initial recall. For final recall, the five-list group was given 8 min and the seven-list group 10 min. Each count-
ing-with-alternation task in Part II lasted for 30 s. Subjects were provided with a single-page answer sheet for final recall after their answer booklets for initial recall were collected. They read the written instruction on the answer sheet and began the test.

Results

Both groups were identically treated up to the fifth trial and therefore expected to reveal identical serial position curves for delayed recall and the first immediate recall. The results of 2 (groups) x 12 (serial-input positions) analysis of variance (ANOVA) confirmed that the two groups were nearly identical from List 1 through List 4; $F < 1$ for both group and interaction effects. There was a significant serial position effect for Lists 1-4: $F(11, 330) = 7.87, p < .001$. However, the recall data collapsed across the two groups indicated the absence of negative recency in delayed recall: $F(3, 93) < 1$ for the last four serial positions. See Fig. 1.

In final recall the five-list and seven-list groups did not significantly differ in the recall of Lists 1-4; $F < 1$ for a group effect and $F(11, 330) = 1.15$ for an interaction effect. There was a primacy effect which contributed to a significant serial position effect: $F(11, 330) = 5.09, p < .001$.

In analyzing the List-5 data, 12 serial-input positions (SPs) were grouped into six blocks of two SPs each; Block 1 consisted of SPs 1 and 2, Block 2 of SPs 3 and 4, and so on. The results of 2 (groups) x 6 (blocks) ANOVA indicated that the two groups showed nearly identical immediate-recall performance for List 5: $F < 1$ for both group and interaction effects. There was a significant block effect indicating both primacy and recency effects: $F(5, 150) = 5.25, p < .001$. The immediate recall data are shown in the left panel of Fig. 2.

In final recall, however, the two groups showed different serial position curves for List 5: $F(5, 150) = 3.55, p < .005$, for an interaction effect. See the right panel of Fig. 2. Neither group nor block effect

![Fig. 1. Mean proportion of recall in delayed recall as a function of serial input positions.](image-url)
was found to be significant: \( F < 1 \) for a group effect and \( F(5, 150) = 1.87, \ p > .10 \), for a block effect. The analyses of the simple main effects (Kirk, 1968) revealed that the five-list group outperformed the seven-list group at Block 6: \( F(1, 180) = 7.44, \ p < .01 \). While the five-list group also tended to surpass the seven-list group at Block 5: \( F(1, 180) = 3.30, .05 < p < .10 \), the seven-list group in turn tended to outperform the five-list group at Block 3: \( F(1, 180) = 3.30, .05 < p < .10 \). The trend analyses (Kirk, 1968) applied to the last four blocks indicated a significant linear relationship for both groups: \( F(1, 47) = 8.14, \ p < .01 \), for the five-list group, and \( F(1, 47) = 4.59, \ p < .05 \), for the seven-list group. These linear relationships represent positive and negative recency for the five-list and the seven-list group respectively.

To examine changes in the serial position curves from immediate to final recall, a 2 (immediate vs. final recall) \( \times 6 \) (blocks) within-subjects ANOVA was applied to the recall data for List 5. The five-list group showed similar serial position curves for immediate and final recall of List 5: \( F < 1 \) for an interaction effect. There were more items recalled in immediate than in final recall: \( F(1, 165) = 5.04, \ p < .05 \). A block effect, due to both primacy and recency effects, was found to be significant: \( F(5, 165) = 7.34, \ p < .001 \). In contrast, the seven-list group revealed different serial position curves for immediate and final recall of List 5, resulting in a significant interaction effect: \( F(5, 165) = 2.68, \ p < .05 \). As for the five-list group, more items were recalled in immediate than in final recall: \( F(1, 165) = 10.25, \ p < .01 \). However, a block effect was not significant: \( F(5, 165) = 1.71, \ p > .10 \).

**Discussion**

Despite its demanding nature, the counting-with-alternation task did not produce negative recency in initial delayed recall. Although the two-store theory might argue that the 3-s rate of presentation was slow.
Transient "long-term" recency enough to allow the transfer of recency items to LTS, this line of argument contradicts their claim that the rate of presentation affects the prerecency portion with little effect on the recency portion of the serial position curve (Glanzer & Cunitz, 1966; Murdock, 1962). The theory should hold that a slow presentation rate elevates the entire LTS component without changing the shape of the serial position curve. It should be noted that negative recency was observed with items auditorily presented at a relatively slow rate of one word for every 2.5 s (Gardiner et al., 1974) and at a slower rate of one word for every 5 s (Richardson, 1978).

The type-of-processing notion, on the other hand, has difficulty in accounting for the presence of such negative recency in initial delayed recall. The question here is why subjects could not process recency items as elaborately as prerecency ones. According to Jacoby and Bartz (1972), memory performance should depend on qualitative nature of processing which subjects determine according to the demand characteristics of the task. If negative recency is due to the application of shallow processing to recency items, zero recency should be predicted in initial delayed recall where subjects are aware of the necessity of applying elaborative processing to recency items.

Jacoby, Bartz, and Evans (1978) demonstrated that initial delayed recall led to higher final-recall performance than did immediate recall when list items were presented at a 3-s rate but that delayed recall and immediate recall produced equivalent final recall performance when items were presented at a 1-s rate. They argued that "manipulating the orienting task is likely to have an effect on retention only if subjects are given time to do additional processing that is appropriate for the task" (p. 332). This argument may be applicable to the Roediger and Crowder (1975) study in which items were presented at a 1.5-s rate. However, its applicability to the Gardiner et al. (1974) study is questionable and the argument is certainly untenable against the Richardson (1978) study which used a 5-s rate of presentation. Therefore, the question still remains as to why subjects would or could not apply elaborative processing to both middle and recency items. Taken together, it seems reasonable to state that both the two-store theory and the type-of-processing notion are in need of a modality-specific account of negative recency in initial delayed recall.

Neither the two-store theory nor the type-of-processing notion, as it is, has a theoretical basis to account for positive recency in final recall demonstrated by the five-list group for List 5. This positive recency is not attributable to output from STS or primary memory because of the presence of a 2-min filled interval between the initial recall of List 5 and final recall. The seven-list group, however, showed that this positive recency was so "transient" that it was to be wiped out by processing of two additional lists.

It is important to note that the interpretations of negative recency provided by the two-store theory and the type-of-processing notion do not explicitly refer to possible differential effects of initial recall on final recall of the list items. One important characteristic of Craik's (1970) final recall procedure is that each list is presented and immediately tested before final recall is given. It has been shown that initial recall enhances overall final-recall performance (Bjork, 1975; Bjork & Geiselman, 1978; Darley & Murdock, 1971) but that initial recall may be least beneficial to recency items (Bjork, 1975) and to the items initially tested with a shorter filled retention interval (Bjork & Geiselman, 1978). The latter is consistent with the "spacing-of-tests effect" found and so termed by Whitten and Bjork (1977).

The spacing-of-tests-effect notion might argue that immediate recall is not beneficial to recency items which are typically
output first. In contrast, prerecency items would always benefit from initial testing because of their positions in the input list and recall. The output order during the immediate recall of List 5 revealed that the recency items were, on the average, output earlier than the middle items. Therefore, it can be argued that in the present experiment the spacing-of-tests effect was selectively added to prerecency items during the immediate recall, though the recency items were also effectively processed during the list presentation.

When initial recall is delayed as it was for Lists 1-4, however, the spacing-of-tests effect may be nullified with the initial-testing effect evenly spread out among list items. For the "spacing effect" is usually valid up to 15 s of the retention interval (Hintzman, 1974). Then, it can be expected that with the spacing-of-tests effect nullified, the initial and the corresponding final-recall serial position curves resemble each other. This seems to be evidenced in the Jacoby and Bartz (1972) study showing that disregarding the overall recall levels, the final recall curve was identical to that of initial delayed recall.

Gardiner and Klee (1976) presented subjects with a series of lists for immediate free recall and then a "recall-recognition" memory test in which subjects were required to identify which items they remembered having recalled in initial recall tests. The major finding was that while fairly accurate in discriminating between previously recalled and not-recalled items, subjects' knowledge of recall of recency items was extremely poor. Gardiner and Klee (1976) pointed out that "this pattern of results is obviously akin to findings which show that recency items, though well recalled in an immediate test, on a delayed or a subsequent test are either recalled worse or no better than earlier list items" (p. 231). This recall-recognition performance for recency items has been shown to be inferior to that for prerecency items in the subsequent studies using serial recall instructions (Klee & Gardiner, 1976), various recall-response modes (Gardiner, Passmore, Herriot, & Klee, 1977), and different verbal materials (Klee & Legge, 1980). Interestingly, the recency items' deficiency in memory for previous recall was somewhat attenuated by serial recall instructions, and memory for previous recognition was found to be independent of serial input positions (Klee & Gardiner, 1976).

It might be that the spacing-of-tests effect is at least partially due to differences in the memory strength of the very act of recall. There may not be much qualitative difference between rehearsal and the act of recall, if rehearsal is considered as "the recall of a verbal item—either immediate or delayed, silent or overt, deliberate or involuntary" (Waugh & Norman, 1965, p. 92). Then, the act of recalling an item can be expected to be much less distinct when the item is still being rehearsed in primary memory than when it is to be retrieved from secondary memory. In the present study, the five-list group maintained positive recency for List 5 in final recall, whereas the seven-list group failed to do so. A similar result was reported by Glenberg, Bradley, Stevenson, Kraus, Tkachuk, Greiz, Fish, and Turpin (1980) who studied long-term recency in the "continuous distractor paradigm" (Bjork & Whitten, 1974; Poltrock & MacLeod, 1977). They found that out of eight lists presented, Lists 7 and 8 still maintained positive recency in final recall, while the earlier lists revealed zero recency (see also Maskarinec & Brown, 1974). It might be that in order for the spacing-of-tests effect to manifest in subsequent recall, initial recall of a particular list needs to be followed by processing and recall of additional lists before the list is recalled again.

According to the contextual-retrieval hypothesis (Glenberg et al., 1980; Glenberg, Bradley, Kraus, & Renzaglia, 1983), in standard free recall the "local" test context matches the stored encoding con-
Transient "long-term" recency of recency items, resulting in positive recency. In the present study it is suggested that while the act of recall for recency items fail to stand out against the background context due to the local contextual match between encoding and recall, that for prerecency items become distinguishable from rehearsal because of their local contextual mismatch. It is further suggested that memory for recall be readily interfered with by processing and recall of subsequent lists which produce their own memory for recall and that recall-memory of recency items be most vulnerable to such interference. Thus, provided that recency items are subjected to elaborative processing at encoding, positive recency may be maintained in final recall without subsequent list processing (the five-list group) but will be eliminated with processing of additional lists (the seven-list group).

It may be concluded that final-recall performance does not simply reflect original encoding operations carried out on items during the list presentation. Rather, it should be construed as a product of both differential encoding and item-strengthening effects of initial testing. Since the item-strengthening effect is actually the spacing-of-tests effect, recency items would not receive as much benefit from immediate recall as prerecency items. Consequently, as local contextual cues change, recency items become less recallable in final recall, regardless of how deeply they were initially processed at encoding.

References


Poltrock, S. E., & MacLeod, C. M. 1977 Primacy and recency in the continuous distractor paradigm. *Journal of Experimental Psychology: Human Learning and Memory, 3*, 560-571.


