JOURNAL OF VERBAL LEARNING AND VERBAL BEHAVIOR **11**, 561–565 (1972)

Rehearsal and Transfer to LTM

LARRY L. JACOBY AND WAYNE H. BARTZ

Iowa State University, Ames, Iowa 50010

Rehearsal has been viewed as serving to maintain items in short-term memory (STM) and transfer information to long-term memory. This experiment contrasted that position with one that assigns rehearsal the single function of maintaining items in STM. Lists were first recalled either immediately after presentation, after a 15-sec silent delay (which allowed the greatest amount of rehearsal) or after 15 sec of rehearsal-preventing activity (filled delay). Initial recall of words from terminal serial positions was lowest in the filled delay condition. Results were opposite on a final free-recall test; filled delay produced highest recall of terminal items. Encoding and retrieval interpretations of the results were considered.

Recent analyses (Atkinson & Shiffrin, 1968; Waugh & Norman, 1965) of the serial position effect obtained in free recall have involved the division of memory into two stores, short-term memory (STM) and long-term memory (LTM). Items from terminal input positions are said to be retrieved from STM while items from earlier positions must be retrieved from LTM. The STM is a temporary store in which items are maintained in a very accessible state for a brief period of time. Rehearsal serves the dual purpose of maintaining an item in STM and transferring information about the rehearsed item to LTM (Rundus & Atkinson, 1970). Rundus and Atkinson, instructing *S*s to rehearse aloud, provided evidence of the relationship between rehearsal and storage in LTM. Excluding the most recent items, which were rehearsed least, probability of recall was a direct function of number of overt rehearsals. The recency effect, again, was attributed to retrieval from STM.

Additional evidence for equating storage in LTM with number of rehearsals comes from the negative recency effect (Cohen, 1970; Craik, 1970; Madigan & McCabe, 1971). Since items from the last input positions are rehearsed less often than items from earlier positions, they should be less likely to enter LTM. Craik (1970) presented 15-word lists and required free recall of each list immediately following its presentation. Serial position curves from immediate recall were typical, showing a primacy effect and a pronounced recency effect. After ten lists had been presented and tested, *S*s were instructed to recall all of the words from all 10 lists. Final free recall (FFR) of items that had occupied one of the five terminal serial positions in a study list was lower than that of words from earlier input positions. Thus, there was a positive recency effect in immediate free recall and a negative recency effect in final free recall, a test of LTM.

Rather than serving as a means for transfer of information to LTM, rehearsal might be viewed as serving the single function of maintaining items in STM. Transfer to LTM would then depend on the processing of items held in STM. Type of processing is considered to be under the control of *S*, much like the control processes postulated by Atkinson and Shiffrin (1968), and dependent on the demand characteristics of the task. The immediate recall of an item or recall after an unfilled delay requires minimal processing; items need only be maintained in STM. However, if a delay interval is filled with rehearsal-preventing activity, further processing of the study material is required to allow recall after the delay, retrieval cues that will survive the retention interval must be generated. If rehearsal alone does not result in transfer to LTM, interpolating a silent delay between study and recall should not increase the amount of information stored in LTM. The only instance in which transfer to LTM will be increased by a silent delay is when *S* anticipates a later recall after a filled delay. Only then will the silent delay be used for additional processing of the rehearsed items.

In the present investigation, 10 lists of 20 words were presented with each list being recalled prior to the presentation of the next list. After recall of the last list, *S*s were instructed to recall all of the words from all lists. Three between-subjects conditions were differentiated on the basis of structure and initial testing of study-lists. Sets of five words within 20-word lists were (*a*) consecutive, (*b*) separated by a 15-sec unfilled interval, or (*c*) separated by 15 sec of engagement in a rehearsal-preventing task. The type of delay employed in structuring a list was also interpolated between the presentation of the last set of five words in that list and initial free recall. Three additional conditions were identical to those described above with the exception that words were presented as 40 five-word lists. Comparisons between the recall of a five-word list and recall of the corresponding five words in a 20-word list should yield additional information concerning the importance of rehearsal for storage in LTM.

Method

Materials. Two hundred words with A and AA ratings were selected at random from the Thorndike and Lorge word book and assembled into 40 groups of five words each. These words were presented, in the same order, as either 40 lists of five words each or as 10 lists of 20 words.

Words were tape recorded for auditory presentation at a 2-sec rate. The factorial combination of list length (5 or 20 words) and type of delay (no delay, 15-sec silent, or 15-sec filled) required six recordings; list length and type of delay were constant within each of the recordings. The task employed in the filled delay interval consisted of the auditory presentation of randomly selected two-digit numbers. Numbers were presented at a 2-sec rate with the first number occurring 1 sec after the last word, seven numbers were presented within the 15-sec delay interval. The *S* was to subtract one from each number and report the result aloud prior to the presentation of the next number. The word "Go" signaled the beginning of the recall interval in the delay conditions. Recall was spoken. The recall interval, for all conditions, was 1.5 sec per word; 7.5 and 30 sec for the 5- and 20-word lists. The recall interval was terminated with the word "Ready" which preceded the first word of the next list by 2 sec.

The 20-word lists in the delay conditions were presented as groups of five words separated by 15-sec filled or unfilled delay. Thus the 20-word lists with delays consisted of four alternations of five words and the 15-sec delay interval with the delay interval after the 20th word in a list preceding the 30-sec recall interval. That is, the 20-word lists with delays could be considered as four 5-word lists with a "final" recall after the fourth sublist. This procedure equated the 20- and 5-word lists in terms of total time of presentation.

Subjects and procedure. Sixty volunteer *S*s from psychology courses at Iowa State University were tested individually. They received extra course credit for participation. Ten *S*s were randomly assigned to each of the six conditions. Subjects were fully informed concerning the list length and delay intervals that they would encounter and instructed to recall aloud. Prior to the recall of the last list, *S* had no reason to expect a final free recall test. At that time, he was instructed to write down all the words he could remember from all lists. There was no time limit on this final free recall.

Analyses. For each *S*, words reported in the initial recall of the 20-word lists were categorized on the basis of study list serial position. Four input blocks were then formed by summing across serials positions 1–5, 6–10, 11–15, and 16–20. These data were analyzed by means of a 4 (input block) × 3 (delay condition) analysis of variance with repeated measures on the first factor. Recalled words that had occupied input positions 16–20 and the corresponding words from five-word lists were classified according to serial position and the number recalled from each position was entered into a 2 (list length) × 3 (delay condition) × 5 (serial position) analysis of variance. Since recall of the five-word lists included in the above analysis was characteristic of that of all the five-word lists, additional analyses of recall of the short lists are not included. Analyses of the final free recall data were identical to those described for initial recall.

RESULTS

Initial Free Recall—20-Word Lists

The initial free-recall results for the 20-word lists are summarized in Figure 1. The analysis of recall revealed significant main effects of delay condition, $F(2,27) = 8.12$, $p < .01$, and serial position block, $F(3,81) = 76.5$, $p < .001$. Recall in the silent delay condition (48%) was superior to that produced by either no delay (37%) or filled delay (32%). The last-presented block (63%) was better recalled than blocks 1–3 (34, 30, and 28%). The interaction of delay condition with input block was also significant, $F(6,81) = 7.37$, $p < .001$. Recall from input blocks 1 and 2 was highest after silent delay, recall from these blocks after filled delay was slightly higher than that produced by no delay. Across the first three blocks, recall declined in the silent delay condition while remaining relatively constant for the filled and no-delay conditions The superiority of block 4 recall, as compared to recall of the third block, was greater for the silent and no delay conditions. That is, filled delay resulted in an attenuation of the recall advantage of terminal list items.

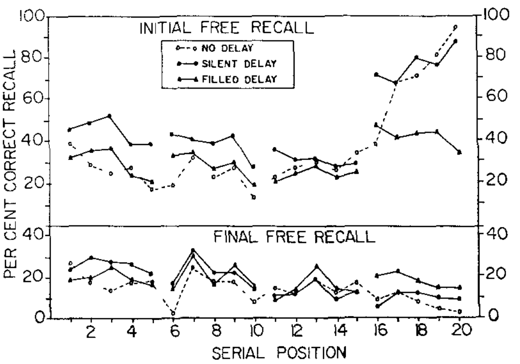

FIG. 1. Serial position effects in the initial and final free recall of 20-word lists.

Final Free Recall—20-Word Lists

The effect of serial position block, $F(3,81) = 14.50$, $p < .001$, and the interaction of delay condition with serial position block, $F(6,81) = 3.01$, $p < .025$, were significant. The significant interaction is shown in the lower panel of Figure 1. After silent delay, final free recall of words from the first input block was higher than that produced by other delay conditions, and then recall steadily declined across later input positions. Items from the third block were also better recalled than items from terminal input positions (block 4) in the no-delay condition. In contrast input position had little influence on final free recall after filled delay.

Initial Free Recall—5-Word Lists

Serial position effects for all five-word lists are presented in Figure 2 along with the serial position effects of the last five words of the 20-word lists. The analysis of the recall of the five-word lists corresponding to the last words in the longer lists revealed a significant interaction of list length with delay condition and serial position, $F(8,216) = 6.17$, $p < .001$. Regardless of list length, the silent and no-delay conditions produced higher recall than did filled delay. Recall increased as a function of serial position in the 20-word silent and no-delay conditions while remaining relatively constant across serial positions in the other conditions. In general, recall of a five-word list was higher than that of the last five words from a 20-word list. However, after either silent or no delay, recall of the last presented word was not influenced by list length.

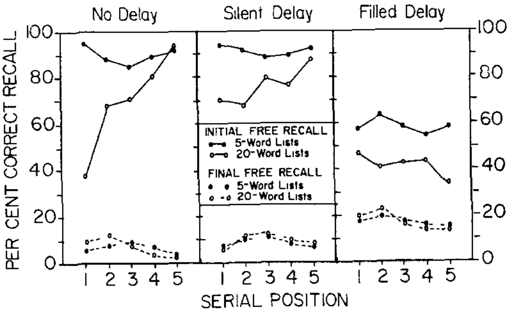

FIG 2. Serial position effects for five-word lists and the last five words of 20-word lists.

Final Free Recall—5-Word Lists

The analysis indicated significant effects of delay condition, $F(2,54) = 8.45$, $p < .005$, and of serial position, $F(4, 216) = 2.52, p < .05$. The effect of serial position was due to the superior recall of words from the second (or seventeenth) serial position. The mean percentage recall from serial positions 1–5 in the short lists or 16–20 in the long lists were 10.8, 15.0, 11.5, 10.8, and 10.8. Newman-Keuls tests of differences among delay conditions showed that filled delay resulted in higher recall than either no delay, $q(3, 54) = 5.74$, $p < .01$, or silent delay, $q(2, 54) = 3.70$, $p < .05$; the difference between the latter two conditions was not significant. Neither the main effect nor any interactions involving list length approached significance.

Discussion

Final free recall of the 20-word lists with interpolated silent delay lends support to a suggested (Rundus & Atkinson, 1970) relationship between storage in LTM and amount of study. There was an inverse relationship between FFR and serial position in the study list. This relationship may have been due to study of items during later delay intervals in addition to that during the interval closest to presentation. On the basis of other results, the additional study responsible for the observed difference does not, however, appear to have involved only rehearsal.

Recall results of 20-word lists with no delay replicate those reported by Craik (1970); words from the last input positions were better recalled on an immediate test but not recalled as well as items from earlier input positions on the final free recall test. If rehearsal alone results in transfer to LTM, an increase in FFR of terminal items should have been produced by the interpolation of a silent delay between study and test. This prediction was not confirmed by results of the present investigation. Considering recall of five-word lists and of terminal items from the longer lists, performance of the silent and no-delay conditions did not differ on the final free recall test. Thus, there was no evidence of an increase in LTM resulting from the extended presence of items in STM. The superior initial recall of five-word lists as compared to that of items from the last input positions in longer lists, implies a greater STM duration for items in the shorter lists. However, there was no effect of list length on FFR, again suggesting that LTM storage does not necessarily depend on length of an item's presence in STM.

Interpolation of a subtraction task attenuated but did not eliminate the recency effect observed in the initial recall of 20-word lists. Of greater importance for present purposes, initial recall after filled delay was less than that produced by silent delay for the last words in 20-word lists and all items in five-word lists. Contrary to predictions that would be made on the basis of this apparent differential rehearsal, FFR was greater after filled than silent delays. In this instance, then, there was an inverse relationship between length of stay in STM and storage in LTM.

Results of the present investigation allow at least two possible interpretations. As suggested in the introduction, processing may be influenced by the anticipation of a filled delay preceding recall. Retrieval cues that can survive the filled delay may be generated and stored when the delay is anticipated. If *S* expects recall to be immediate or after an unfilled delay, items are merely maintained in STM and not processed further for storage in LTM. As an alternative, the effect of delay condition on FFR might be attributed to the initial tests. Tulving (1968) has suggested that items recalled immediately after presentation differ from those recalled after a delay in terms of the type of retrieval cues employed. If this distinction is accepted, initial recall after a filled delay might employ retrieval cues that will also be available at the time of FFR. That is, a retrieval from LTM might be more effective than a retrieval from STM as a means of increasing final free-recall performance. Several investigations (e.g., Lachman & Mistler, 1970) have shown a facilitating effect of test trials; however, a comparison of the effectiveness of retrieval from STM with that from LTM has not been provided. Both the processing and type of initial retrieval interpretations ultimately attribute the effect of delay condition to differences in the storage of retrieval cues. The primary difference is that the first suggests that the difference was present prior to the initial tests while the latter states that the difference was produced by the initial tests. The present investigation does not allow a choice between these two alternatives. Both agree that continuous rehearsal alone need not increase storage in LTM.

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(Received January 3, 1972)