

A comparison of the study-recall and anticipation methods in steady state paired-associate learning*

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Steady-state paired-associate learning was investigated, using both study-recall and anticipation procedures. In both conditions, an item was dropped from the list and replaced with a new item upon its first correct recall. This steady-state paradigm was a logical extension of Battig's (1965) "correction"-adjusted learning procedure and, in the study-recall condition, equated the degree of learning across items for individual Ss. The results also gave strong evidence that the anticipation procedure disrupted the learning and responding processes as compared to the study-recall procedure.

Battig (1965) has criticized the anticipation method common in paired-associate learning on two points: (1) the occurrence of learning is confounded with the measurement of performance, and (2) the individual items within a list are inevitably learned to unequal degrees. Battig felt that the first deficiency could be overcome by use of the study-recall or study-test method in place of the anticipation method. However, according to Battig, the second deficiency is only slightly less evident in study-recall than in anticipation. Consequently, he modified the study-recall procedure by removing items from the list as they were recalled correctly. In this "correction"-adjusted learning technique, the list continued to be presented until all items had received one correct response. Since, at the end of a trial, each pair had been correctly recalled exactly once, the degree of learning should have been more nearly equal across items than in a noncorrection technique.

Wearing & Montague (1970) tested Battig's procedure, using response latency on the solution trial as a measure of item strength. If the procedure were completely effective, there should have been no relation between response latency and item difficulty (measured by the number of presolution errors). However, strength of learning did vary significantly with item difficulty. Even though all items had reached the same criterion, the response latencies of more difficult items were significantly longer than latencies of easier items.

A confounding factor in Battig's procedure may have been responsible for Wearing and Montague's negative

findings. The easier items were learned early in the task, while the more difficult items were learned later. As the task progressed, however, items were being removed from the list, decreasing its length. This systematic change in the background condition could have affected the degree of learning of the easier and the more difficult items differentially.

It seems essential, then, that the learning of all pairs be carried out against a background which is not varying in any systematic manner. Such conditions of a steady-state learning environment can be achieved for individual Ss in the reverse of the paradigm developed by Rock (1957). This procedure was investigated in a number of studies (Alwitt & Rouse, 1962; Battig, 1962; Friedman & Clark, 1967). As each item was recalled correctly, it was dropped from the list and replaced by a new item. The list length did not vary and, for each S individually, there was essentially a constant number of unlearned items in the list at all times. This steady-state procedure, then, appeared to be a logical improvement on Battig's technique for equating the degree of learning across items.

The present experiment investigated the "reverse Rock" procedure in both study-recall and anticipation paradigms. The same stimulus and response materials were used in both conditions, and the duration of the study and test intervals were similarly equated.

A comparison of the responding processes in the two conditions was made on two measures. On presolution trials, Ss either responded incorrectly within the 3-sec test interval (a presolution response) or entered no response at all (a presolution nonresponse). Hence, presolution response latencies and the proportion of presolution responses to nonresponses in the two conditions

were compared to determine the effect of the procedures on the readiness of the S to respond, and, by inference, to learn.

In investigating the homogeneity of learning across items, two questions were asked. First, what relation obtained between item strength and item difficulty? Specifically, was the mean solution latency for an item (pooled across Ss) correlated with its mean number of presolution errors?

Even if the result of such an analysis were affirmative, it might still be possible to achieve homogeneity of item strengths; that is, by reducing the variability in item difficulty, the heterogeneity of item strengths should similarly be reduced. The trend of solution latencies over fixed categories of item difficulty would then answer the second question: Was a practical homogeneity of learning achieved in either experimental condition? This second analysis was comparable to that used by Wearing and Montague, as in both cases solution latencies were classified by the number of presolution errors.

In the present study, however, we attempted to correct for a potentially confounding effect neglected by Wearing and Montague in their use of this measure. That is, while each S may perhaps achieve an equal degree of learning across items, slow responders may be making more errors than fast responders are. Therefore, in classifying latencies by number of presolution errors, the slow responders may be overrepresented at the higher error levels, resulting in an apparent increase of latency with item difficulty.

This effect could have been controlled by standardizing the latency-error scores for each S. Such an approach was therefore used in the present investigation.

METHOD

The 59 Ss were drawn from an introductory psychology course and were given course credit for participation. The 27 Ss assigned to the anticipation condition were run approximately 1 month before the 32 Ss assigned to study-recall.

Stimuli and responses were identical in the two conditions. The stimuli used were 54 high-meaningfulness CVCs drawn from a list prepared by Noble (1961) and were subject to the constraint that any two items could have at most only one letter position in common. Most of these CVCs formed common words. The stimuli were paired randomly with unique two-digit responses (from 11 to 99, excluding any that included zeroes), and these pairings remained constant throughout the experiment.

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The stimulus and response items were displayed on a video monitor. Ss typed their responses, one digit at a time, on a small keyboard whose layout resembled that of a typewriter. Latencies were timed from the onset of the stimulus until the first digit of the two-digit response was typed. List presentations and recording of responses were handled by a DDP-116 real-time computer.

The lists in both conditions consisted of 12 stimulus-response pairs. The order of items was randomized on each trial. As soon as an item received its first correct response, it was dropped from the list and replaced by a new item drawn randomly from the remaining pairs in the item pool.

In the anticipation procedure, stimuli were displayed for 3 sec (during which time a response could be entered on the keyboard), followed by the stimulus and response together for another 3 sec. After a 2-sec interval, the next stimulus was presented. The intertrial interval was 5 sec, and a total of 15 trials were run for each S.

In the study-recall condition, stimulus-response pairs were displayed for 3 sec during the study period, with a 2-sec interval between pairs. After a 5-sec pause, the stimuli were presented alone for 3 sec each, during which time the two-digit responses were accepted. The interstimulus interval was 2 sec and the intertrial interval, 5 sec. A total of eight study-recall trials were run for each S. Ss were instructed to respond as "quickly and accurately as possible" and were warned that new stimulus-response pairs might appear in the list during the course of the experiment.

RESULTS AND DISCUSSION

Substantial evidence was found for a significant effect of the anticipation procedure on responding processes. The presolution response latency was significantly higher in the anticipation procedure—2,206 msec—than in the study-recall—2,077 msec— $[t(57) = 3.69, p < .001]$. The proportion of responding on presolution trials was lower in anticipation [49% vs 66% in study-recall, $t(57) = 3.166, p < .005]$.

It is fairly clear that these results can be attributed to the difference in procedure as opposed to the differences in apparent difficulty of the items. In an earlier study of steady-state learning (Parkman & Cavanagh, 1970), where difficulty was directly manipulated through meaningfulness, no relation was found between difficulty and response readiness.

Solution latencies were substantially higher in anticipation [1,845 msec vs

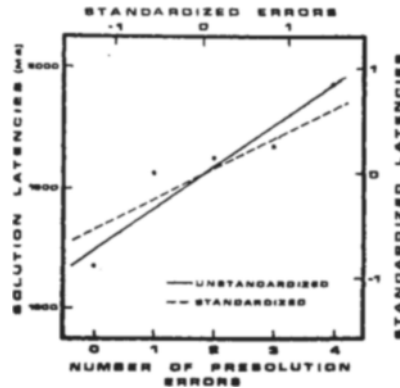


Fig. 1. Mean solution response latencies as a function of number of presolution errors for the anticipation condition. Linear regressions are shown for standardized and nonstandardized data.

1,617 msec in study-recall, $t(57) = 6.65, p < .001]$, while the number of presolution errors was greatly increased. Ss made an average of 3.33 errors in the anticipation condition (excluding the initial presentation) and 1.08 in study-recall $[t(57) = 3.35, p < .001]$.

These results strongly supported Battig's criticism of the anticipation method. The interleaving of learning and performance measurement appeared to have greatly reduced S's response readiness and learning rate in comparison to the study-recall procedure.

For individual items, the mean solution latency and number of presolution errors were correlated in both conditions ($r = .52$ in anticipation, $r = .36$ in study-recall). The regression coefficients were quite similar, being 69.1 ms/error in

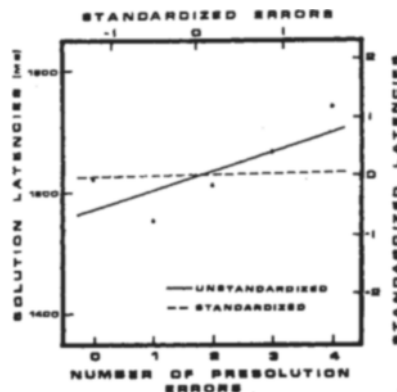


Fig. 2. Mean solution response latencies as a function of number of presolution errors for the study-recall condition. Linear regressions are shown for standardized and nonstandardized data.

anticipation $[t(25) = 4.38, p < .001]$ and 75.5 ms/error in study recall $[t(30) = 2.91, p < .01]$. The significant relation between item difficulty and solution latency for individual items in both conditions supported Underwood's (1954) contention that items reaching criterion sooner also reach a higher level of suprathreshold strength.

As this relationship seems inherent in the learning process as opposed to the experimental procedure, homogeneity of learning strength across items may only result through homogeneity of item difficulties. Since the standard deviation of presolution errors was greatly reduced in study-recall ($s = 0.55$) as compared to anticipation ($s = 1.40$), substantial homogeneity of learning may have been possible in the study-recall condition.

To study this possibility, the analysis comparable to that of Wearing and Montague was performed. Response latencies were classified by the number of presolution errors for items receiving zero through four errors. S averages were used to obtain homoscedasticity. Consistent with the findings of Wearing & Montague (1970), a significant trend of increasing latencies with increasing errors was found in both anticipation and study-recall conditions. The regression coefficients were 64.8 ms/error $[t(114) = 3.24, p < .001]$ and 30.4 ms/error $[t(138) = 2.24, p < .001]$, respectively.

When latency-error scores were standardized for each S independently, the trend remained significant in anticipation, yielding a regression coefficient of .34 $[t(114) = 3.89, p < .001]$. However, contrary to Wearing and Montague, the trend disappeared in study-recall. The regression coefficient of .03 was not significant $[t(138) = .397, p > .50]$, indicating that homogeneity of learning across items had been achieved. The data for anticipation are shown in Fig. 1 and those for study-recall in Fig. 2.

The steady-state study-recall procedure thus appeared to promote homogeneity of strength of learning across items for individual Ss. This effect was presumed to be a consequence of the attenuated variability of item difficulties produced by the procedure.

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tone increased the degree of learning of that tone in short-term memory but had no effect on the forgetting rate for the short-term memory trace.

In a study which varied rate of presentation, Norman (1966) found that increased rates of presentation (up to 10 digits/second) decreased the initial level of acquisition of the items in short-term memory but that the forgetting rate was not affected by these differences.

The purpose of the present study was to determine whether or not the invariance of the forgetting rate over different levels of acquisition (degrees of learning) in short-term memory holds true when the degree of learning is manipulated by varying the number of repetitions of a verbal item (three-digit number).

PROCEDURE

The Ss heard a 1-sec ready signal, followed after 2 sec by a list of eight different three-digit numbers, followed by a three-digit test number, followed by 4 sec in which Ss were to decide if the test number had appeared earlier in the list on that trial and to state their confidence on a scale from 1 (least) to 4 (most). On some trials each of the items (three-digit numbers) was presented once; on other trials, one of the items in the list was presented two, three, four, or six times in immediate succession. There was never more than one repeated item in a list. All presentations of an item occupied a period of 1 sec. No time elapsed between the end of the decision period for one trial and the ready signal for the next trial.

DESIGN

There were 10 types of lists: 1 type with no repetitions of items, 6 types with one item presented three times (repeated item being in Position 1, 2, . . . , or 6), and 3 types with the item in Position 2 being presented two, four, or six times. For each of these 10 types of lists, there were six conditions where one of the items in the list was tested for recognition (Position 1, 2, . . . , or 6, counting from the beginning of the list), and three (identical) conditions where a new item (not in the list) was tested for recognition. In addition to these 10 x 9 = 90 conditions, there were two (identical) conditions where the item in Position 7 was tested and two (identical) conditions where the item in Position 8 (last item) was tested. All four of the latter conditions were in lists with no repeated items. Thus, there were 94 trials/block. Four practice trials preceded each block. After two practice blocks, there were 10 different blocks taken six times each in the experiment, for a total of 62 blocks. Ss did no more than six blocks in any 1 day.

Invariance of forgetting rate with number of repetitions in verbal short-term recognition memory*

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Ss listened to a list of eight different three-digit numbers, presented at the rate of one three-digit number per second. In many of the lists, one of the three-digit numbers was repeated three times in immediate succession (in a 3-sec period) before going on to the next number. At the end of the list of eight different three-digit numbers, one three-digit number was presented as a recognition test item. The test item could have appeared at any of the eight serial positions or be a new item. Ss were instructed to rehearse only the current item in the list, not previous items. Under these conditions, repetition of an item led to greater degree of learning in short-term memory, but the forgetting rate appeared to be invariant with number of repetitions.

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Wickelgren & Norman (1966) found that items presented in the initial positions of a short list of three-digit numbers were learned better in short-term memory than items presented in later positions in the list, but the forgetting rate was the same for items in all serial positions.

In a series of studies on memory for pitch, using the delayed comparison procedure, Wickelgren (1969) found that increasing the study time for a