A test of the cluster hypothesis of serial learning

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The cluster hypothesis of serial learning was investigated with a two-test design. Test 1 (paced anticipation) measured acquisition. Test 2 presented a cluster of two adjacent items from the serial list and S tried to supply the immediately succeeding item. If out of all the serial order cues available to S during acquisition, he used only a cluster of items as a cue, then performance should be the same on both tests. One hundred and fifty-six Ss were tested after 3, 6, 9, 12, 15, and 18 trials of practice with a 13-word list of highly meaningful words. Performance on the two tests was the same for most of the serial items at each level of practice. The cluster hypothesis was supported statistically for the entire list on the 12-, 15-, and 18-trial tests.

In any serial-learning task, a large number of potential serial-order cues are available. It is generally assumed that the learner uses only one, or at most several, of these cues to learn the serial sequence. The cluster hypothesis (Horowitz & Izawa, 1963) maintains that the learner uses a cluster of adjacent serial items as a cue for recalling the adjacent succeeding item. In the present study, a two-test design was used to test the hypothesis. In Test 1, S was tested for acquisition by the paced anticipation method. In Test 2, S was presented with two adjacent serial items in succession and then asked to recall the immediately succeeding item in the serial list. In Test 1, S could use any of the many serial order cues present in the paced anticipation situation, but in Test 2 he could use only a cluster of two preceding items as a cue for recall. If the cluster hypothesis is correct, then for each S recall on the two tests should be identical over the entire list and over successive levels of acquisition.

METHOD

Subjects were 156 students from an introductory psychology course at the University of Kansas. None of them had any previous experience in serial-learning experiments. They learned a 10-word practice list and a 13-word experimental list. The words (from Johnson, 1961) were high in Thorndike-Lorge frequency (L count 34 to 99) and high in meaningfulness (7.50 to 9.20). The experimental list consisted of: orchid, dentist, baggage, warden, litter, gallop, hammock, mustard, sermon, frontier, pigeon, revolt, and essay.

Interaction of S and E was reduced by a screen between them and by presenting instructions with a tape recorder. S sat facing two memory drums placed side by side. He was given paced serial-anticipation instructions followed by three trials with the practice list on the left memory drum. Each word was presented for 2 sec with a 4-sec intertrial interval. Then S was told that a cluster of words taken at random from the list would be presented on the right memory drum one word at a time, followed by a red "X." He was to read each word, then when the "X" was presented he was to guess what word came at that position in the list. Two clusters from disparate locations in the list were presented. First, two adjacent words from the list were presented at a 2-sec pace, then a red "X" was presented for 2 sec. There was a 4-sec interval and then another cluster was presented. This training procedure was repeated twice, then S opened a different window on the memory drums and the procedure was repeated six times with the experimental list. There was approximately a 5-sec delay between tests as one memory drum was turned off and the other was turned on.

The first word in the list was used as a starting cue, so S was tested on only 12 words. In the second test (the succeeding-item recall test), the "X" which was substituted for the first anticipation word was preceded by a blank space and the starting cue; all of the other "X"'s were preceded by two words. Each S was tested after 3, 6, 9, 12, 15, and 18 trials. By the end of the 18-trial test, he had been tested for each word in the series. Thus every S produced 12 two-test recall pairs. Each S's results on the succeeding-item recall (SIR) test were compared with his results for the same words at the same levels of practice on the paced anticipation test.

There were three different arrangements of the experimental list with an appropriate set of 12 clusters of words for each arrangement. The starting point for each of the sets of clusters was offset by one cluster for successive Ss so that it was possible to test every word in the list both as the first cluster tested and as the second cluster tested on each of the six SIR tests. The results were pooled for a given word tested as the first and as the second cluster at a particular level of practice. The results were also pooled for words at the same serial position from the three list arrangements at each practice level. For the 156 Ss, there were 1872 pairs of two-test observations. With the pooling, there were 26 pairs of observations for all of the 12 serial positions at each of the six tested levels of practice. In actual practice, all combinations of list arrangements and SIR-test starting points were randomized before assigning combinations to successive Ss.

To be correct on an SIR test, a correct response had to be given during the 2 sec the "X" was exposed. To be correct on an anticipation test, the word had to be correctly anticipated on either one of the last two trials before an SIR test. This two-trial criterion was necessary because of the tendency of some Ss to occasionally stop anticipating items for an entire trial.

The cluster hypothesis was tested by performing binomial tests at each serial position at successive levels of practice. The binomial tests on the change/no-change data were performed on all two-test pairs which had a correct anticipation on Test 1. Assuming $p = q = \frac{1}{2}$, the null hypothesis predicts that one-half or less of the pairs will be correct-correct pairs. The cluster hypothesis predicts that a number of the pairs significantly larger than one-half will be no-change pairs.

RESULTS AND DISCUSSION

Figure 1 shows the total number of correct anticipations (CA) on Test 1 and the total correct succeeding item recall (CSIR) on Test 2 for each word at each level of practice. If Ss performed the same on both tests as the cluster hypothesis predicts, then the two curves should be similar at each level of practice. Figure 1 shows that recall using a cluster of two preceding items as a cue does in fact approximate the acquisition data over most of the serial list at each successive level of practice.

Binomial tests were performed on the CA-SIR pairs at each serial position. If the number of no-change pairs observed in the CA-SIR pairs at any position was so large that it could only have occurred by chance with a probability of 5% or less, then the null hypothesis was rejected. For the 12-, 15-, and 18-trial tests, the null hypothesis was rejected at every serial position. The null hypothesis was also rejected at all positions for the nine-trial test except for Positions 6 and 8. For the six-trial test, the null hypothesis was not rejected for Positions 3, 6, 7, 8, and 9. For the three-trial test, the null hypothesis was only rejected at the two positions at either end of the serial list. Unfortunately the three- and six-trial tests do not afford a good statistical test of the cluster hypothesis because the number of CA-SIR pairs at each position was so small that in many cases it was not possible to reach the 5% level of significance even though all of the pairs were no-change pairs.

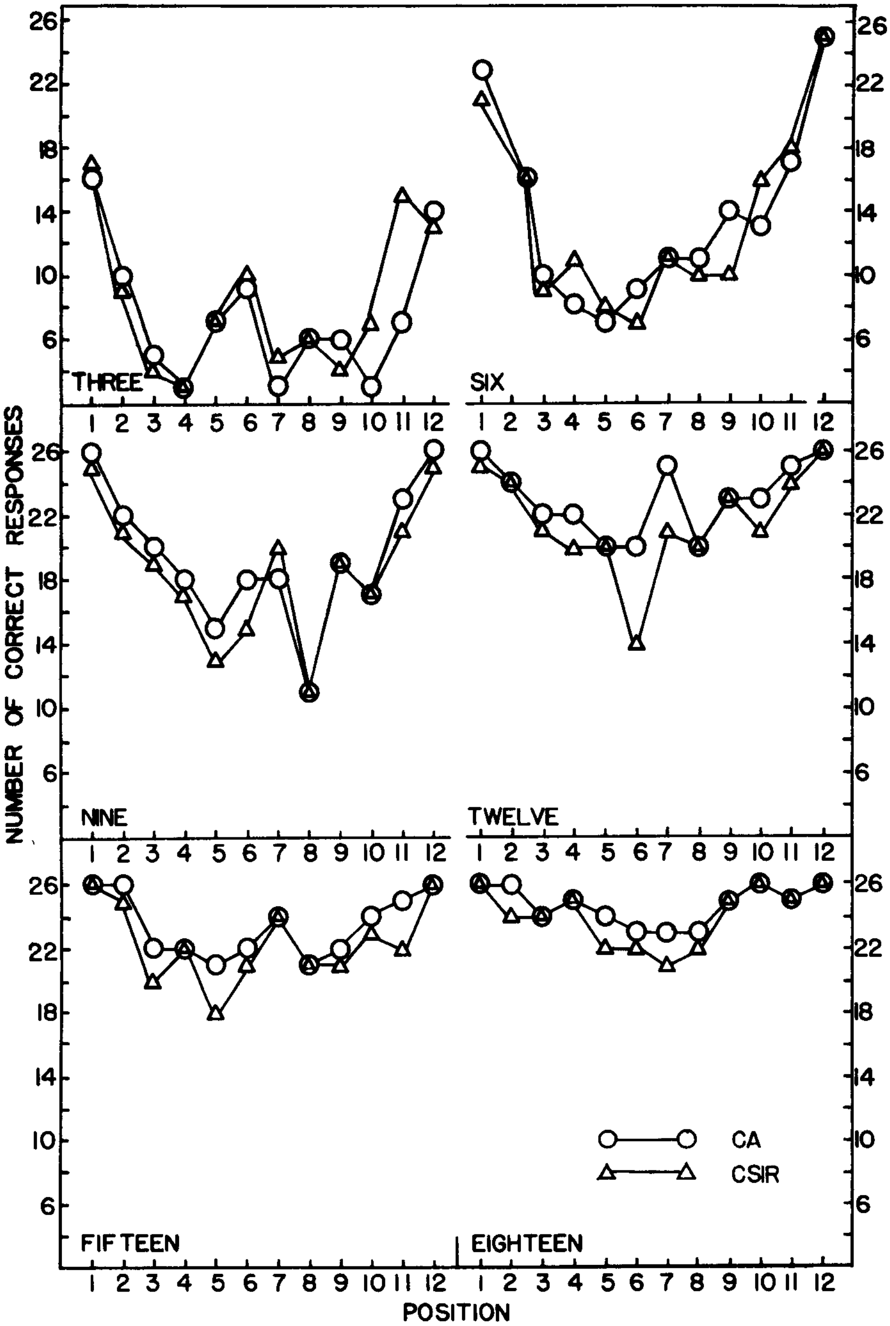

Fig. 1. Correct anticipations (CA) and correct succeeding item recall (CSIR) for each serial item at 3, 6, 9, 12, 15, and 18 trials of practice.

However, for all of the positions at various test levels where at least 20 Ss correctly anticipated the word on Test 1, the binomial tests clearly support a cluster hypothesis interpretation of the serial acquisition.

One hypothesis which is often proposed to account for serial learning is the ordinal-position hypothesis (Young, Hakes, & Hicks, 1967). This hypothesis maintains that Ss associate the serial items with a corresponding sequence of numbers. Serial recall then involves covert counting and overt emission of the appropriate serial associates. In the present study, this hypothesis was easily tested because every S correctly anticipated the last item in the list by the end of practice. If S was using numbers as cues and he was able to correctly anticipate the last item, then he would know how many items there were in the list. Each S was asked at the completion of testing how many words there were in the list including the starting word. The correct answer was 13. Guesses ranged from 7 to 15; 71 Ss guessed the number 10, 57 Ss guessed the numbers 8 and 9, but only one S guessed the number 13. These findings do not support the ordinal position hypothesis.

The results of the present study do, however, show that recall with a cue composed of two preceding items is sufficient to account for much of the serial acquisition in the situation that was studied. However, an earlier study (Heslip & Epstein, in press) has shown that cues with less information are also sufficient to account for acquisition at the ends of a serial list. Therefore, it cannot be maintained that a compound cue consisting of a cluster of preceding items is a necessary cue throughout all of serial acquisition. These conclusions are

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Table I
Extinction Probabilities (in Blocks of Nine Trials)

Block	1	2	3	4	Means
Long Run Sequence	.22	.22	.19	.18	.20
Short Run Sequence	.50	.15	.11	.11	.22
Means	.38	.19	.16	.15	

stimulus light for that trial was turned on for a duration of 2 sec. The interval between stimulus light and the onset of the ready light for the next trial was 1 sec. A piece of wood, 18 x 4 x 2 in., painted black, was placed in each booth and used as a base on which to mount the response buttons. On each board a button was mounted 2 in. from each end on the centerline of the 4-in. surface. The response buttons actuated snap-action spring-return switches.

PROCEDURE

Subjects were assigned randomly to one of two stimulus sequences and were run in groups of seven to nine depending on how many Ss showed up for a given session. Twenty-four Ss were run on the short-run sequence, 26 on the long-run sequence. The instructions were paraphrased from Estes & Straughn (1954).

STIMULUS SEQUENCES

Each of the stimulus sequences will be described by giving a list of numbers. Each number in the list represents the length of a run of lights on the same side. If the number is underlined, it means a run of right (coded A_1 for all Ss) lights; if the number is not underlined, it means a run of left (coded A_0) lights.

Short run sequence: 1, $\underline{1}$, 1, $\underline{4}$, 1, $\underline{2}$, 3, $\underline{1}$, 1, $\underline{1}$, 2, $\underline{2}$, 2, $\underline{2}$, 1, $\underline{1}$, 1, $\underline{1}$, 3, $\underline{1}$, 1, $\underline{1}$, 1, $\underline{3}$, 4, $\underline{3}$, 2, $\underline{1}$, 1, $\underline{1}$, 1, $\underline{2}$, 1, $\underline{1}$, 1, $\underline{1}$, 2, $\underline{2}$, 2, $\underline{1}$, 1, $\underline{1}$, 2, $\underline{1}$, 2, $\underline{2}$, 3, $\underline{2}$, 1, $\underline{1}$, 1, $\underline{1}$, 1, $\underline{1}$, 1, $\underline{1}$, 1, $\underline{1}$, 1, $\underline{1}$, 1, $\underline{2}$, 1, $\underline{2}$, 1, $\underline{3}$, 2, $\underline{1}$, 2, $\underline{1}$, 1, $\underline{1}$, 1, $\underline{1}$, 1, $\underline{1}$, 36

Long run sequence: 2, $\underline{1}$, 6, $\underline{4}$, 3, $\underline{4}$, 5, $\underline{2}$, 4, $\underline{6}$, 6, $\underline{1}$, 7, $\underline{5}$, 2, $\underline{7}$, 1, $\underline{6}$, 5, $\underline{3}$, 1, $\underline{2}$, 4, $\underline{5}$, 3, $\underline{3}$, 7, $\underline{7}$, 36

Thus a short run sequence started LRLRRRRL . . . , and the long run sequence started LLRLLLLLLRRRR . . . .

For each sequence there were 112 "acquisition" trials and 36 "extinction" trials (the last run of 36 lefts being regarded as the extinction trials). At the end of acquisition, Ss in the short-sequence group had seen 25, 9, 3, and 1 runs of Lengths 1, 2, 3, and 4, respectively, for both left and right. The long-run group had seen two runs of each length from 1 to 7 for both left and right.

RESULTS AND DISCUSSION

It was predicted that the group which had seen the short run sequence would start with a higher probability of predicting an A_1, but extinguish more rapidly than the group which had seen the long run sequences. Figure 1 displays the observed proportions of Ss predicting an A_1 on each of the 36 extinction trials for each of the two groups. The experimental hypothesis is confirmed.

For greater statistical stability (and to provide greater homogeneity of variance) mean proportions for blocks of nine trials are given in Table 1. Here the prediction concerning the course of extinction is borne out more smoothly. In the analysis of variance for the extinction data the blocks effect with 3 deg of freedom had an F of 17.81 and the Blocks by Runs interaction with 3 deg of freedom had an F of 14.20, both of which were significant at the .001 level.

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NOTE

1. This paper is based on work submitted to the University of Illinois in partial fulfillment of the requirements for the Ph.D. degree. The author is particularly grateful to Dr. Raymond W. Frankmann, Mr. Scott Krueger, and Dr. Lawrence Stolurow for their kind assistance in this endeavor. The IBM 1710 Control System at the Training Research Laboratory of the University of Illinois was utilized in the execution of this study. This system is supported by funds from the Office of Naval Research (ONR), from the Advanced Research Projects Agency (ARPA), and from the National Defense Education Act (NDEA).

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consistent with those of an earlier study (Battig, Brown, & Schild, 1964) which used a transfer design to test the cluster hypothesis.

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