Invariant repetition structure and the Ranschburg effect*

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Two experiments concerned the Ranschburg effect (RE), the poorer short-term recall of repeated elements than recall of corresponding control elements in strings near span in length. Experiment 1 showed an RE of the usual size, even when 50% of the strings contained repeated elements that always occupied a fixed pair of serial positions. Experiment 2 showed that as the percentage of strings in a set of 40 that contained repetition in an invariant structure increased from 20 to 90 (and perhaps from 0 to 100), there was no corresponding change in the magnitude of the RE.

Errors of immediate memory associated with the presence of a repeated element in the stimulus string define the Ranschburg effect (RE). One aspect of the RE is the poorer recall of the repeated elements, as compared to nonrepeated elements occupying corresponding serial positions in control strings. The boundary conditions for this aspect of the RE are not fully known. However, successful studies of the RE have made use of strings of letters or digits near span in length, and the occurrences of the repeated elements have been separated by two or more different elements (e.g., Crowder, 1968; Crowder & Melton, 1965). Vocabularies of digits or letters are limited in size; since each S ordinarily is presented a sizable number of stimulus strings for recall, it follows that interserial repetition of elements must then be high. It now appears that concurrent intra- and interserial repetition is a necessary condition for the RE (Jahnke, 1971).

A standard technique in studies of the RE is to present to the same S, on different trials, both control strings (all different elements) and experimental strings (all different elements but one, which is repeated once). For any single S, the locus of the repeated elements in experimental strings is varied (e.g., Crowder, 1968; Jahnke, 1969). It has, perhaps, been assumed necessary to vary the locus of the repeated elements in order to prevent S from discovering a simple patterning of repetition and improving his performance thereby. This assumption was tested in Experiment 1. In this experiment, Ss in each of three different groups were always presented equal numbers of experimental and control strings. However, in two of these groups, repeated elements always occupied a given pair of serial positions. In the third group, repeated elements occupied, in an unpredictable manner, either of two different pairs of serial positions. It was hypothesized that the magnitude of the RE would be a function of the ease with which Ss could detect a repeated element, detection having been assumed to be easier in strings with repeated elements occupying predictable positions than in strings in which the positions were unpredictable.

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EXPERIMENT 1

Subjects

The Ss were 59 female undergraduates enrolled in the introductory psychology course at Miami University; participation in experiments fulfilled a course requirement. None had previously participated in any study of short-term memory.

Apparatus and Materials

Stimuli were strings of seven digits, presented at a rate of 2 digits/sec on a Bina-View display cell operated by a paper-tape reader. A total of 52 strings was presented to each S individually in each of three conditions. The first four of the strings were practice (control) strings, and the data from these were discarded. In Condition S, half the strings were control strings and half, experimental. In half of the latter, the digit in SP 2 was repeated in SP 5, and in the remainder, that in SP 3 was repeated in SP 6. In Conditions 2 and 3, also, half of all strings were control strings, but the remainder were experimental strings with repeated elements only in either SPs 2 and 5 or SPs 3 and 6, respectively. The order of the strings was random, subject to the restrictions that the last digit of one string was not the same as the first of the next and a particular digit did not occupy the same SP in two successive strings. Also, ascending, descending, or alternating series greater than length 2 were not permitted, nor were there more than three control or two experimental strings in a row.

Procedure

The Ss were assigned at random to each of the three experimental conditions. For Condition S, N = 19, and for Conditions 2 and 3, N = 20 each. The S read each digit aloud as it appeared on the Bina-View screen. Immediately after the last digit had been presented, a cue light signaled S to recall the digits from memory in the order in which they had appeared. If S could not recall a given digit, she was instructed to say "blank" in place of that digit. A 5 x 8 in. card with seven evenly spaced squares on it was in front of S as an aid in placing the digits in the proper position during their oral recall. An item given in recall was scored correct only if given in correct SP. The intertrial (interstring) interval was about 6 sec.

Results

Serial-position curves are shown for each experimental condition in Fig. 1. Each of the three panels of Fig. 1 shows that performance was poorer for experimental than for control strings. Most importantly, Fig. 1 shows that performance was poorest, relatively or absolutely, at the positions of the repeated digits. Wilcoxon matched-pairs signed-ranks tests showed that performance on combined repeated digits was significantly poorer than on corresponding control digits (the Ranschburg effect) in each of the three conditions of repetition structure ($T = 5$, $N = 18$, $p < .01$ and $T = 19$, $N = 19$, $p < .01$ for digits in SPs 2 and 5 in Conditions S and 2, respectively, and $T = 26$, $N = 18$, $p < .01$ and $T = 42$, $N = 19$, $p < .05$ for digits in SPs 3 and 6 in Conditions S and 3, respectively). The magnitude of the RE (the absolute difference between recall of control and experimental items) was not significantly different when repetition structure of experimental strings was variable and unpredictable (Condition S) and when it was not (Conditions 2 or 3) [$t(57) = .68$ and .58, $p > .05$, for the comparisons based on critical digits in SPs 2 and 5 combined and SPs 3 and 6 combined, respectively].

At the end of the experimental session, each S was asked whether she had observed any pattern of the digits in the strings and then, specifically, whether she had noticed any repeated elements. Each question was stated once and then rephrased in an attempt to insure that the questions were understood. In Condition S, 16 Ss reported that some of the strings contained repeated elements; corresponding numbers for Conditions 2 and 3, respectively, were 17 and 15. No S in any condition reported anything about the serial positions in which the repeated elements occurred.

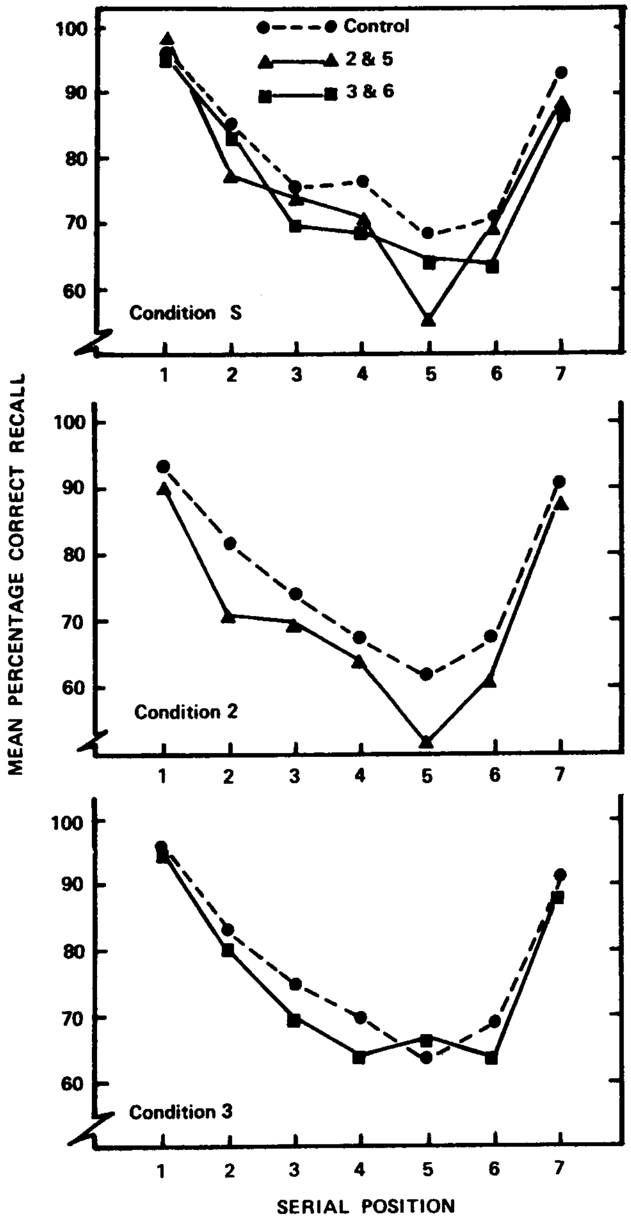

Fig. 1. Serial-position curves for the conditions of Experiment 1.

Discussion

The magnitude of the RE was found not to differ when experimental strings contained repeated elements in only a single pair of SPs or when they occupied either of two pairs of SPs in an unpredictable manner. Furthermore, even though all Ss were presented 24 control and 24 experimental strings, about 19% of the Ss failed to report that any of the strings contained repetitions; none reported the SPs of occurrence of the repeated elements.

When the data from Ss who failed to detect repeated digits were examined apart from those of the Ss who did, it was found that the former performed less well than the latter at each SP in all three conditions. However, the absolute magnitudes of the RE appeared not to be related in any systematic way to the detection (awareness) of repeated elements. While this result is not in accord with our hypothesis, the number of Ss who failed to report awareness of repeated digits was relatively small. Further, the method of the present study does not provide a false positive rate, nor is it known at what point in practice awareness of repetition developed for the remaining Ss. All these factors would seem to obscure a relation between awareness of repetition and magnitude of the RE.

Taken together, present data are not inconsistent with the view that the RE results, at least in part, from S's failure to detect the occurrence of repetition in a string of otherwise all-different items (Jahnke, 1969; Wickelgren, 1965, 1966). If this be accepted, then what becomes surprising is that it is apparently so difficult for S to recognize the structure of repetition in Conditions 2 and 3 and to profit from that information.

EXPERIMENT 2

Contrary to expectation, strings in which the repeated elements occupied only a single pair of SPs did not lead, in Experiment 1, to performance different from that obtained when the locus of repetition was unpredictable. This result leads to the interesting question of whether, when there is a single locus of repetition, there is some ratio of experimental-to-control strings that will alter performance on the critical digits. Experiment 2 addressed this question.

Subjects

The Ss were 157 undergraduate students enrolled in the introductory psychology course at Miami University. The data of 17 of these students were discarded, without known bias, in order to achieve seven equally sized groups of Ss, each composed of 10 men and 10 women. Participation was in fulfillment of a course requirement. None had served previously in any study of short-term memory.

Apparatus and Materials

Stimuli were tape-recorded strings of 7 digits presented aurally at the rate of 1 digit/sec. Each S was presented a total of 44 such strings; the first 4, however, were practice (control) strings, and the data from these were discarded. In the seven different experimental conditions, the percentage of the 40 strings that contained a repeated digit was either 100, 90, 80, 70, 60, 20, or 0. Thus, in Condition 100, each of the 40 strings was an experimental string; in Condition 90, 9 strings in each successive block of 10 were experimental strings, and so on, down to Condition 0, in which all 40 strings were control strings. The choice of which strings became control strings in each block in each condition was determined randomly. Repeated digits in experimental strings occupied only SPs 3 and 6.

Procedure

In Experiment 2, Ss were tested in small groups ranging in size from 2 to 15. Each S wrote the digits he could recall in the order they had been presented on an answer sheet containing seven blanks for each string. If a digit could not be recalled, the corresponding space on the answer sheet was to be left unfilled. Each string was preceded by a verbal "ready" signal, and the interstring interval was about 6 sec.

In order to minimize the possibility that the nature of the experiment would be divulged to others who might subsequently serve in the experiment, Ss were asked not to discuss the experiment with anyone. The data for Conditions 0, 60, 80, and 100 were collected within the space of 2 consecutive days. The data for Conditions 20, 70, and 90 were collected 2 weeks later, also within the space of 2 consecutive days. Within each of these two sets of conditions, there was random assignment of the Ss to the experimental conditions. Other details of procedure were the same as for Experiment 1.

Results

For Experiment 2, digits were scored correct, even if not recalled in correct SP. This procedure provides an appropriate measure of the RE, if somewhat less conservative than the measure of Experiment 1 (Wickelgren, 1965), since interest is directed here to the frequency of occurrence of critical digits in recall, rather than to their correct placement in recall. For this reason, only the overall recall data for the critical digits (repeated digits and digits occupying corresponding serial positions in control strings) are presented in Fig. 2. The recall of each occurrence of a critical digit contributed to these data.

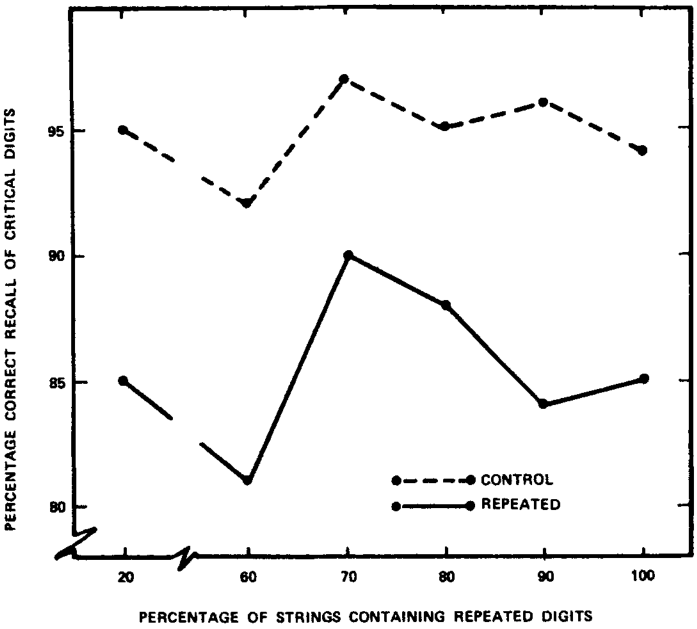

Fig. 2. Mean percentage correct recall of critical digits for the conditions of Experiment 2.

It is apparent in Fig. 2 that repeated digits were recalled less well than control digits in each condition. Wilcoxon matched-pairs signed-ranks tests performed separately for each condition in which S received both experimental and control strings showed that this difference was significant ($T = 11$, $N = 19$; $T = 9$, $N = 20$; $T = 3$, $N = 20$; $T = 18$, $N = 18$; and $T = 3.5$, $N = 18$ for Conditions 20-90, respectively, $p < .01$ in each case). (For this and all subsequent analyses, frequency of recall of control or experimental digits was corrected for opportunity when necessary.) Performance on repeated digits in Condition 100 was contrasted with that on corresponding control digits in Condition 0; this contrast was also significant [$t(38) = 2.41$, $p < .02$]. The lower curve shown in Fig. 2 is that for the repeated elements. An analysis of variance of the data on which this curve is based showed that performance did not differ significantly among the relevant conditions [$F(5,114) = 1.43$, $p > .05$]. Further, the magnitudes of the RE (absolute differences between performance on control and repeated digits) were not significantly different among Conditions 20-90 by related-measures analysis of variance [$F(4,95) = 1.11$, $p > .05$]. (Conditions 0 and 100 were excluded from this analysis because different Ss were assigned to them. Figure 2 shows, however, that the magnitude of the RE drawn from the comparison of these conditions seemed comparable to those magnitudes in the remaining.) The magnitude of the RE appears not to be influenced by the relative numbers of experimental and control strings, at least over the range of 20%-90% experimental strings and, perhaps, over the entire range.

Again, each S was interrogated at the end of the experimental session. Firstly, S was asked if he noticed a pattern of the digits within a string. The number of Ss who indicated that there were repeated digits occupying SPs 3 and 6 ranged from 0 to 3 in Conditions 20-100. Secondly, S was asked if he had heard repeated digits. From 15 to 20 Ss responded affirmatively in each of the conditions (20-100), and the rate overall was about 90%. For neither of these two questions were the frequencies in the various conditions significantly different among themselves [$\chi^2(5) = 5.41$ and 9.96 for the two questions in the order given, $p > .05$ in both cases]. Thirdly, S was asked to estimate the percentage of the strings in the experiment that contained repeated digits. Some Ss did not contribute data to this question, either because S did not respond or because he indicated that he did not know. The means and standard deviations, respectively, for responses to this question were: 24.7 and 20.6 ($N = 13$); 28.4 and 21.0 ($N = 17$); 39.4 and 30.4 ($N = 18$); 42.8 and 17.1 ($N = 19$); 42.6 and 32.6 ($N = 17$); and 42.5 and 28.2 ($N = 20$) for Conditions 20-100, respectively. While these condition means increased as might be expected, the increase was not large from Condition 20 to Condition 100, and the Kruskal-Wallis statistic corrected for ties indicated that these estimates did not differ significantly among themselves [$H(5) = 4.84$, $p > .05$]. Attention is directed to the fact that even when 100% of the 40 strings contained repeated digits, the group's average estimate was little more than 40%. Lastly, S was asked to indicate which serial positions the repeated digits occupied. Seven Ss in Condition 90 responded correctly. In the other conditions, the number of Ss responding correctly ranged from 0 to 4, but the six conditions did not differ significantly in terms of these frequencies [$\chi^2(5) = 7.85$, $p > .05$]. Although the data from Condition 0 could not be included in these analyses, they are of interest. There were no correct responses to the first question; to the second, five Ss reported hearing repeated digits; to the third, the same five gave estimates of 20%-40%; and, lastly, no S guessed SPs 3 and 6.

Discussion

It was considered possible that an increase in the proportion of strings that contained repeated elements in an invariant repetition structure would make more probable S's detection of the fact of repetition in the strings and, thereby, improve his memory for repeated elements and decrease the magnitude of the RE. This was not the case here. The data from both recall and the postexperimental questioning indicated that neither the magnitude of the RE nor awareness of repetition or its locus was a function of the independent variable of Experiment 2. These findings imply that the attempt to remember the stimulus strings occupies most, if not all, the information-processing capabilities of the average S; little, if any, opportunity seems left for S to pay attention to information in the string other than the items it contains and, perhaps, their order. Although 90% of the Ss receiving any experimental strings in Experiment 2 reported that some of the strings contained repetition (a figure that must be adjusted downward by the false positive rate for Ss in Condition 0), the number of Ss able to report the locus of repetition was very small and was, in fact, zero for Conditions 20 and 60. Present data show that some Ss will fail to detect repetition when repetition exists. It seems probable that any S might fail to detect repetition on at least an occasional trial. Such instances are likely to bias recall against the inclusion of a repeated element and in this way contribute to the RE. Other mechanisms, of course, may also figure in the RE (e.g., Jahnke, 1969; Wickelgren, 1965, 1966).

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