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Number of Items presented and recalled as Determinants of Short-term Recall

THE percentage of items correctly recalled from a sequence of items decreases as the number of items in the sequence increases[1,2]. Two factors normally vary directly with increasing sequence length: number of items presented and number of items to be recalled. When a twelve-item sequence was presented, Anderson[3] found that increasing the number of items to be recalled from four to eight to twelve increased the rate of error. Further investigation is necessary to determine if this is true substantially above the memory span. The importance of the number of items presented, independent of the number of items to be recalled, has never been adequately investigated. The following experiments on short-term recall of sequences beyond the memory span were designed to determine the independent effects of both these factors.

Using a Wollensak (model *T*-1515-4) tape recorder, 24 subjects were given sequences of digits presented approximately at 1/sec. Subjects had a 25-sec interval between the end of one sequence and the beginning of the next sequence in which to record the digits in order in the appropriate boxes. They were encouraged to guess; but they were not allowed to write down more items than the sequence contained. Subjects were run in two conditions. In condition *P*16-*R*12, 16 digits were presented, but only 12 were to be recalled. The first, fifth, ninth, and thirteenth items were already typed in the appropriate boxes. There were no repeats among the items that were typed-in. In condition *P*12-*R*12, 12 items were presented; and all 12 were to be recalled. Each sequence in condition *P*12-*R*12 was obtained by using the 12 digits to be recalled in a corresponding sequence in condition *P*16-*R*12. A one-second pause in presentation was used in place of each of the four deleted items. Thus, both conditions had the same number of items to be recalled and the same total time of presentation for the 12 items to be recalled. Sequences were randomly selected subject to the constraints that there were no runs of any digit, no forward or backward numerical sequences longer than two, and in *P*16-*R*12 the first, fifth, ninth, and thirteenth items were different from each other. All subjects received 24 sequences in one condition followed by 24 sequences in the other condition, counter-balanced for order. Two alternative sets of both length-16 and length-12 were used so that no subject recalled the same sequences of 12 digits in both conditions.

Table 1. ERROR RATES FOR *P*12–*R*12 AND *P*16–*R*12 (PER CENT)

Condition	Trials	Ordered recall	Item recall	Position recall
*P*12–*R*12	1–12	26·71	12·70	16·04
	13–24	19·07	10·10	9·98
	Total	22·88	11·40	12·97
*P*16–*R*12	1–12	43·63	22·77	27·01
	13–24	41·63	20·63	26·47
	Total	42·63	21·70	26·73

The data were analysed for ordered recall, item recall, and position recall for items. A subject's report of an item is correct by an ordered recall criterion if, and only if, the correct item is recalled in the correct position. A subject's report of an item is correct by an item recall criterion if, and only if, it appears anywhere in his report of the sequence in question. When a digit is repeated in a sequence, a subject must report all occurrences of the item to obtain the maximum item recall score. Position recall, independent of item recall, is obtained by subtracting the item recall errors from the ordered recall errors, reducing the total number of possible errors by the same amount when computing the error rate for position recall.

Table 1 reports the error rates for ordered recall, item recall, and position recall for the first 12, second 12, and total 24 sequences in each condition. The number of errors in condition *P*16-*R*12 was approximately twice as large as the number of errors in condition *P*12-*R*12 for ordered recall, item recall, and position recall. All differences between the two conditions were significant at well beyond the 0·001 level using a χ^2 test. Comparing the first 12 sequences with the second 12 sequences in each condition, there were significant practice effects in ordered recall, item recall, and position recall for condition *P*12-*R*12 ($P < 0{\cdot}001$, χ^2 test), but in condition *P*16-*R*12 only the practice effect in item recall was significant ($P < 0{\cdot}05$, χ^2 test). Items in condition *P*16-*R*12 were analysed into two categories: items identical to any of the items typed-in and items different from the items typed-in in any given sequence. The error rates for ordered recall, item recall, and position recall were computed separately for each of the two item categories in both *P*16-*R*12 and *P*12-*R*12. As expected, in *P*12-*R*12 there were comparable practice effects in both categories of items. However, in *P*16-*R*12, the only significant practice effect was in item recall of items identical to any of the typed-in items. When the number of items to be recalled is held constant, beyond the memory span, it appears that increasing the number of items presented increases the number of errors substantially and diminishes improvement with practice.

Anderson[3] established significant differences in short-term memory when four, eight, or twelve items were to be recalled out of twelve items presented. The following experiment was performed to determine if there is a difference in error rate between recall of 12 and 16 items when 16 items are presented. 24 additional subjects were run in

condition $P16$-$R16$ in which 16 items were presented and all 16 were to be recalled. Half the subjects in condition $P16$-$R16$ were given 24 practice sequences before being given condition $P16$-$R16$ in order to make $P16$-$R12$ equivalent in amount of practice to $P16$-$R12$ in the previous experiment. Subjects were instructed to divide the sequence into four groups since division into four groups was achieved by the pauses in $P12$-$R12$ and the typed-in items in $P16$-$R12$. This experiment was identical to the previous experiment in all other respects.

In $P16$-$R16$ the ordered recall rate of error for all 16 items was 44·20 per cent; the ordered recall rate of error for the 12 items identical to the 12 recalled in $P16$-$R12$ was 45·13 per cent. Neither of these rates of error was significantly different from the rate of error in $P16$-$R16$. In $P16$-$R16$ the item recall rate of error for all 16 items was 26·04 per cent; for the comparable 12 items it was 22·61 per cent. The former figure was significantly greater than the item recall error in $P16$-$R12$ ($P < 0·05$, χ^2 test); the latter figure was not. In $P16$-$R16$ the position recall error rate for all 16 items was 24·55 per cent; for the comparable 12 items it was 29·10 per cent. Neither figure was significantly different from the position recall error rate in $P16$-$R12$. No significant improvement occurred with practice in $P16$-$R16$. Increasing the number of items to be recalled from 12 to 16 increased the rate of error, but not very much.

Serial position curves for ordered recall, item recall, and position recall were obtained by dividing the number of errors of each type at each position by the total number of errors of each type. In all three conditions, primacy and recency effects were obtained, with the point of maximum difficulty being the position immediately prior to the middle of the sequence. Superimposed on this overall serial position effect were four smaller serial position effects corresponding to the four groups into which subjects divided the long sequences in each condition. This grouping was the result of the pauses in presentation in $P12$-$R12$, the typed-in items in $P16$-$R12$, and instructions in $P16$-$R16$.

The first item to be recalled (second item presented) in $P16$-$R12$ had an error rate more comparable with the second item to be recalled (second item presented) than to the first item to be recalled (first item presented) in both $P12$-$R12$ and $P16$-$R16$. It appears that the overall primacy effect in $P16$-$R12$ was influenced more by presentation position than by recall position and was therefore greatly reduced. The primacy and recency effects within each group were consistently greater in $P12$-$R12$ than in $P16$-$R12$, presumably resulting from the additional item presented before and after each group in $P16$-$R12$.

Increasing the number of items presented from 12 to 16 doubles the error rate; increasing the number of items to be recalled from 12 to 16 has a much smaller effect. Practice effects, the overall serial position curve,

and within-group serial position curves are affected more by the number of items presented than by the number of items to be recalled, when the number of items presented and recalled is well beyond the memory span as it is in the experiments reported here. These findings suggest the general conclusion that the number of items presented is a more important determinant of short-term memory above the memory span than the number of items to be recalled.

The decrement in short-term recall produced by increasing the number of items presented and the relatively small improvement with practice suggests that human beings are not able to ignore an item that need not be remembered when it is embedded in a sequence of items that are to be remembered. Perhaps the item before the item that need not be remembered is automatically associated to the item that need not be remembered, and this unnecessary association competes with the necessary association between the two items surrounding the item that need not be remembered. Alternatively, subjects may not even attempt to learn 12 item sequences in $P16$-$R12$ and may rehearse and recall these sequences the same as ordinary 16 item sequences. In either case it appears that the human short-term memory system is unable to ignore the extra items.

The relatively small effect of increasing the number of items to be recalled from 12 to 16 contrasts sharply with Anderson's findings for increases from four to eight to twelve[3]. It appears that the number of items to be recalled is a much more important variable below or in the vicinity of the memory span than it is above the memory span. Subjective reports suggest that there are two stages in short-term recall: first, a rapid ordered recall output of those items of which one is surest and, then, a slower free recall output of those items which one thinks were probably in the sequence. The ordered recall mechanism is assumed to be more accurate than the free recall mechanism. If there are these two semi-independent mechanisms for short-term recall, then the findings concerning the importance of the number of items to be recalled suggest that the ordered recall mechanism is much more vulnerable to interference from the recall of prior items than is the free recall mechanism.

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