Repetition within and across missing scan trials¹

HERMAN BUSCHKE² AND RICHARD LENON
DIVISION OF NEUROLOGY, STANFORD UNIVERSITY

Random sequences containing six repeated and six un-repeated numbers were repeated for two trials, on each of which Ss reported the four numbers missing from the set 1-16. Both intratrial and intertrial repetition were effective, and repetition in the first trial affected retention in the second trial. This shows learning in the missing scan, involving item information about individual events presented.

A modification of the missing scan has recently been used to show differential impairment of learning with intact short term storage for "item information" in patients with cerebral disease (Buschke, 1967). Random sequences containing 12 of the numbers 1-16 were generated jointly by experimenter (E) and subject (S), so that short term retention could be evaluated by S's report of the four missing numbers. Ss were required to say the next higher number immediately after each number said by E. Numbers presented by E were chosen randomly so that when E and S had both said eight numbers, the set of numbers 1-16 was partitioned into four said only by E, four said only by S, four said by both (E-S repetition), and four said by neither. The major result was that although patients with cerebral disease did benefit from such repetitions, their retention of repetitions was significantly impaired, compared to controls, while their retention of un-repeated items was not. Such impaired learning of item information within trials parallels the finding by Caird (1964), with the method used by Hebb (1961) and Melton (1963), that learning across trials of "order information" in permutations of a set of numbers may be impaired when short term storage of un-repeated permutations is not impaired.

The present experiment uses repetition of sequences containing repetitions for two successive missing scan trials to show that demonstration of such intratrial learning depends upon repetition (rather than some interaction of input and output), that such learning within trials is also effective across trials, and to confirm that retention for the missing scan concerns item information about each individual event presented (rather than, e.g., a list of events not yet presented, or information about the presentation as an organized whole).

Method

The 12 Ss were college students paid for their participation, and were tested in a group.

Twelve of the numbers 1-16 inclusive were read aloud by E in random sequence at 1/sec. After each sequence Ss wrote down the four numbers missing from the set of sixteen. Six of the 12 numbers were

presented only once (S=single) in each sequence, while the other six were presented twice (R=repeated) at random in each sequence. The same 12 numbers were then presented again in random order for a second trial, so that three of the five singles had been presented once in the first trial (SS), three of the six singles had been repeated in the first trial (RS), three of the six repetitions had been presented once in the first trial (SR), and three of the six repetitions had been repeated once in the first trial (RR). Ss reported the missing numbers on both Trials 1 and 2, so that retention of S and R might be evaluated within trials by analysis of errors of commission, and across trials by comparison of such errors for SS, SR, RS, and RR in Trial 2. Each S was tested with 32 sets, each presented for two trials. Ss had 15 sec to write their responses, a 5 sec warning before each trial, and were reminded whether the next sequence was Trial 1 or Trial 2 of a set.

Results

Table 1 gives the results for each S, expressed as total correct (M=missing) over the 32 sets of Trial 1 and Trial 2, and total errors (in all four responses) for single (S) and repeated (R) items in Trial 1 and for SS, SR, RS, and RR in Trial 2.

It is apparent that there were about half as many errors for items repeated within each trial as for items presented once, for all Ss and both trials ($p < .003$, binomial test). For first errors only (regardless of response position) in Trial 1 only the ratio of R (92) to S (274) errors of almost 1:3 was significantly less than the R:S ratio for other than first

Table 1. Number correct (M) and number of errors of commission on single (S) and repeated (R) items in missing scan Trials 1 and 2.

SUBJECT	TRIAL 1			TRIAL 2				
	M	S	R	M	SS	RS	SR	RR
1	61	44	23	83	14	18	5	8
2	73	35	20	84	16	13	8	7
3	75	35	18	78	15	16	13	6
4	77	41	10	95	14	8	6	5
5	67	50	11	91	22	8	1	6
6	77	31	20	86	18	8	9	7
7	62	49	17	70	19	19	9	11
8	75	42	11	92	14	11	5	6
9	78	34	16	89	16	16	5	2
10	67	39	22	96	9	10	5	8
11	77	37	14	82	18	11	11	6
12	60	43	25	60	24	22	10	12
MEAN	70.8	40.0	17.3	83.8	16.6	13.3	7.3	7.0

errors ($p < .008$, Wilcoxon test). Learning across trials is demonstrated by the significant increase in correct responses in Trial 2 ($p < .006$, binomial test).

The interaction of intratrial and intertrial repetition is shown by previously planned comparison of errors of commission for SS, RS, SR, and RR items in Trial 2, evaluated by one sided Wilcoxon signed ranks tests. Smaller scores indicate better retention, since these are error scores. There were fewer errors for those items presented once in Trial 2 which had been repeated in Trial 1 ($RS < SS$, $p = .032$). For items repeated in Trial 2, repetition in Trial 1 had no demonstrable effect, probably because of the strong effect of intratrial repetition in Trial 2: $SR < SS$ ($p < .0005$); $RR < RS$ ($p < .0005$); and $SR < RS$ ($p < .001$).

The effect of repetition across trials may also be seen by comparison of *decrease* in errors for items in Trial 2. Improvement scores were obtained by taking the difference between twice the number of SS or RS errors and number of S errors, and between twice the number of SR or RR errors and number of R errors. Significant improvement occurred for SS, which involves learning only across trials ($p = .01$), as well as for RS ($p < .005$) and RR ($p = .021$), but not for SR. Comparisons of *improvement* also show a significant effect of repetition in Trial 1 on items presented once in Trial 2 ($RS > SS$, $p = .032$), but not on items repeated in Trial 2: $SR = RR$, $RS > SR$ ($p = .006$), and $RS > RR$ ($p = .034$). The mean decrease in errors of 13.33 for RS is about twice the improvement of 6.64 for SS.

Discussion

These findings show clearly that both intratrial

and intertrial repetitions of individual items presented by E lead to significantly greater short term retention for the missing scan, and that the effect of intratrial repetition is not restricted to that trial but carries over to at least one subsequent trial. It has been shown elsewhere, using input-output repetitions in single missing scan trials, that such intratrial repetition implicates a learning process as well as short term storage per se in short term retention (Buschke, 1967). The present results show that the effect of such intratrial repetition is due to repetition itself rather than to interaction between input and output. This experiment confirms that learning may occur in the missing scan, and that what is retained in the missing scan is information about individual items presented.

References

- BUSCHKE, H. Learning impairment and input-output storage in short-term retention. Presented at the 19th Annu. Meet. Amer. Acad. Neurol., San Francisco, April, 1967.
- CAIRD, W. K. Reverberating activity and memory disorder. *Nature*, 1964, 201, 1150.
- HEBB, D. O. Distinctive features of learning in the higher animal. In J. F. Delafresnaye (Ed.) *Brain mechanisms and learning*. London and New York: Oxford University Press, 1961. Pp. 37-46.
- MELTON, A. W., Implications of short-term memory for a general theory of memory. *J. verbal Learn. verbal Behav.*, 1963, 2, 1-21.
- Notes
1. Supported by USPH Research Grant MH-08556 to Herman Buschke from the National Institute of Mental Health.
 2. Supported by USPH Research Career Development Award K3-MH-23, 796 to Herman Buschke from the National Institute of Mental Health.