Perceptual identification and encoding[1]

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Sequences containing 10 numbers from 1-20 were presented in serial-order or random-order at rates of 1/sec, 2/sec, and 4/sec for serial-order or same-order recall by eight Ss. Stimulus duration was constant, so that the interpresentation interval decreased as rate of presentation increased. Serial-order recall was greater for serial-order presentation than for random-order presentation. The decrease in recall as presentation rate increased was similar for both serial-order and random-order presentation. This result indicates that serial-order recall of random-order presentation does not involve reordering or repeated sequential scanning. It is consistent with the view that serial-order recall of serial-order presentation is greater because identification time is decreased, due to the decrease in the range of relevant alternatives, so that increased encoding time results in storage of more information.

A previous study concerned with the involvement of long-term storage in encoding for short-term storage showed that when numbers were *presented* in serial-order (either lowest to highest or the reverse) serial-order recall (lowest to highest) was greater than when presentation was in random-order (Buschke, 1968; Buschke & Mesibov, 1967). Greater recall of serial-order presentation was attributed to a decrease in the range of alternatives in long-term storage which are relevant for identification and encoding when presentation is in serial-order, so that more rapid identification might provide additional time for encoding more information.

The purpose of the present investigation was to evaluate that interpretation further by comparison of recall at increasing rates of presentation, as the interpresentation interval for identification and encoding decreases while stimulus duration remains constant. If greater serial-order recall of serial-order presentation (L→H/L→H) than of random-order presentation (Rand/L→H) were due to reordering or repeated sequential scanning of presentations in Rand/L→H, recall should decrease more in Rand/L→H than in L→H/L→H as rate of presentation increases. If the decrease in recall for Rand/L→H were similar to that for L→H/L→H it would indicate that Rand/L→H does not involve reordering or sequential scanning. If recall for L→H/L→H is greater because identification is more rapid, recall for L→H/L→H should not decrease as much as recall for Rand/L→H if identification and encoding are equivalent (so that identifying is encoding). However, if encoding followed identification and if mean identification time were constant, then recall for L→H/L→H should decrease as much as recall for Rand/L→H, since the amount of additional encoding time for L→H/L→H would be constant at all rates of presentation.

METHOD

Subjects

The Ss were eight college students who were paid for their participation in two 1-h test sessions.

Materials

There were 20 sequences of 10 numbers chosen randomly from the set 1-20 for each of the four conditions, at each of the three rates of presentation. The sequences were presented either in random-order or in natural serial-order (from lowest to highest number), for serial-order recall (from lowest to highest) or same-order recall (in order of presentation). The four conditions resulting from two kinds of presentation and recall were: L→H/L→H, Rand/L→H, L→H/Same, and Rand/Same. All numbers were presented equally often, and in random-order presentations each number occurred about equally often in each presentation position.

Procedure

Each S was tested individually in an IAC ACT-1202 sound room, viewing sequences of numbers through a glass window. The numbers were shown by an IEE Bina-View which was programmed by a teletype tape reader.

Each sequence was preceded by 3 sec of zeros presented at 4/sec and was followed by 20 sec of 4/sec blanks. At all rates of presentation each number was presented for 0.25 sec. At the 1/sec presentation rate each number appeared for 0.25 sec and was followed by three 0.25-sec blanks. At the 2/sec presentation rate each number appeared for 0.25 sec followed by one 0.25-sec blank. At the 4/sec presentation rate each number appeared for 0.25 sec without any intervening blanks. The actual presentation time for each number therefore remained constant, while the interval between presentations decreased as rate of presentation increased.

In the 120 sequences presented in each test session, L→H presentation and random-order presentation alternated in blocks of five sequences. The rate of presentation increased from 1/sec for the first two blocks through 2/sec for the next two blocks, to 4/sec for the next two blocks, and then was recycled again from 1/sec in this order through the 120 sequences. Thus both the kinds of presentation and the rates of presentation were balanced through each session.

The Ss were required to retrieve by either serial-order recall (L→H) or by same-order recall (in order of presentation). Only one kind of recall order was used in a test session. Half of the Ss used serial-order recall in the first session and same-order recall in the second, while the other half did the reverse. The Ss were instructed to write their responses either in order of presentation or from lowest to highest number in the appropriate blank from left to right on the response sheets during the 20 sec immediately after each sequence was presented. Although Ss were told to record their responses in the correct blank, while maximizing correct responses and giving 10 responses each time, they were not specifically required to actually output responses in their correct order. To insure that Ss would know what to expect, the rate and kind of presentation for each block were noted on the response sheets.

In order to provide a fair comparison of same-order recall and serial-order recall, responses were scored as correct if they occurred in the sequence presented, whether or not the response was recorded in the correct blank on the response sheet.

RESULTS

The overall results are presented in Fig. 1, which shows mean recall in each condition at each rate of presentation. Differences are evaluated by the binomial test unless otherwise indicated. Recall in L→H/L→H and L→H/Same, which are essentially identical conditions, did not differ significantly at any presentation rate ($p > .05$). At each rate of presentation, both L→H/L→H and L→H/Same were greater than Rand/L→H ($p \leq .035$) except at 4/sec where L→H/L→H was not ($p = .227$), and both also were greater than Rand/Same ($p \leq .008$). Rand/L→H was greater than Rand/Same at each presentation rate ($p \leq .05$, Wilcoxon signed-ranks test).

Total recall decreased in all conditions as presentation rate

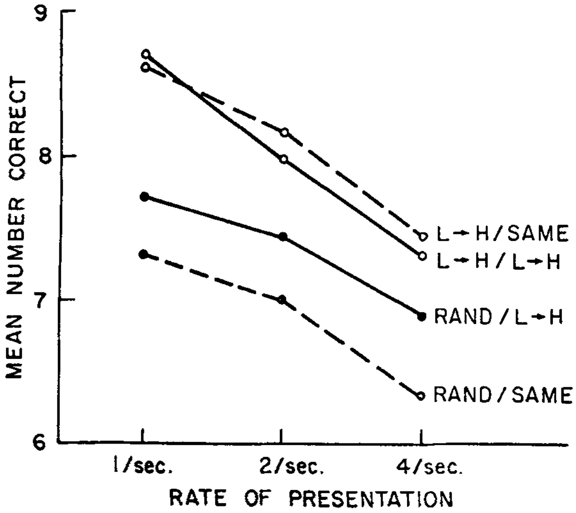

Fig. 1. Total serial-order and same-order recall with serial-order or random-order presentation, as rate of presentation rate increases.

increased from 1/sec to 4/sec ($p \leqslant .008$). As rate increased from 1/sec to 2/sec recall decreased significantly for L→H/L→H and L→H/Same ($p = .008$) but not for Rand/L→H or Rand/Same. When rate increased from 2/sec to 4/sec recall decreased in all conditions ($p \leqslant .008$). While retention of serial-order presentation remained greater than retention of random-order presentation for both serial-order and same-order recall, the decrease in recall of serial-order presentation as rate increased was at least as great as the decrease in recall of random-order presentation.

These changes in recall as rate of presentation increased are delineated more precisely in Fig. 2, which shows serial-position and response-order curves for all conditions except L→H/Same (which was similar to L→H/L→H). The decrease in recall seen in the recall-position curves across the bottom of Fig. 2 indicate that these curves approximate output-position curves, even though they actually show the number of items recalled in each recall blank. The Ss apparently output recall in the appropriate order from left to right, except for Recall Positions 10 and 9. As rate of presentation increases recall tends to decrease proportionately over output positions, so that the greatest decrease occurs in later positions where recall is least with slower presentation. The most striking aspect of these recall-position curves is the relative stability of recall in L→H/L→H as recall proceeds, so that the decrease in recall for L→H/L→H is clearly less than for Rand/L→H or Rand/Same.

The serial-position curves across the top of Fig. 2 are clearly different in each condition, and also show decreases in recall as rate increases which are proportional to recall in each presentation position at slower presentation. The serial-position curve for L→H/L→H shows a decline in recall to a relative asymptote which is less when presentation rate increases. The serial-position curve for Rand/L→H is relatively flat at 1/sec and tends to become more bowed as recall of middle items decreases. The curves for Rand/Same are increasingly bowed as rate increases.

It appears from these presentation and recall position curves that increasing the rate of presentation does not affect *relative* recall in each presentation or recall position, suggesting that the same processes continue to operate as rate increases. In interpreting these results it should be remembered that when the rate of presentation was increased, the interval between presentations for identification and encoding was decreased, since the actual presentation time for each item was the same for all rates of presentation in this study.

DISCUSSION

The major result of this study was that mean recall of serial-order presentation (L→H/L→H and L→H/Same) decreased as much as recall of random-order presentation (Rand/L→H and Rand/Same) when rate of presentation

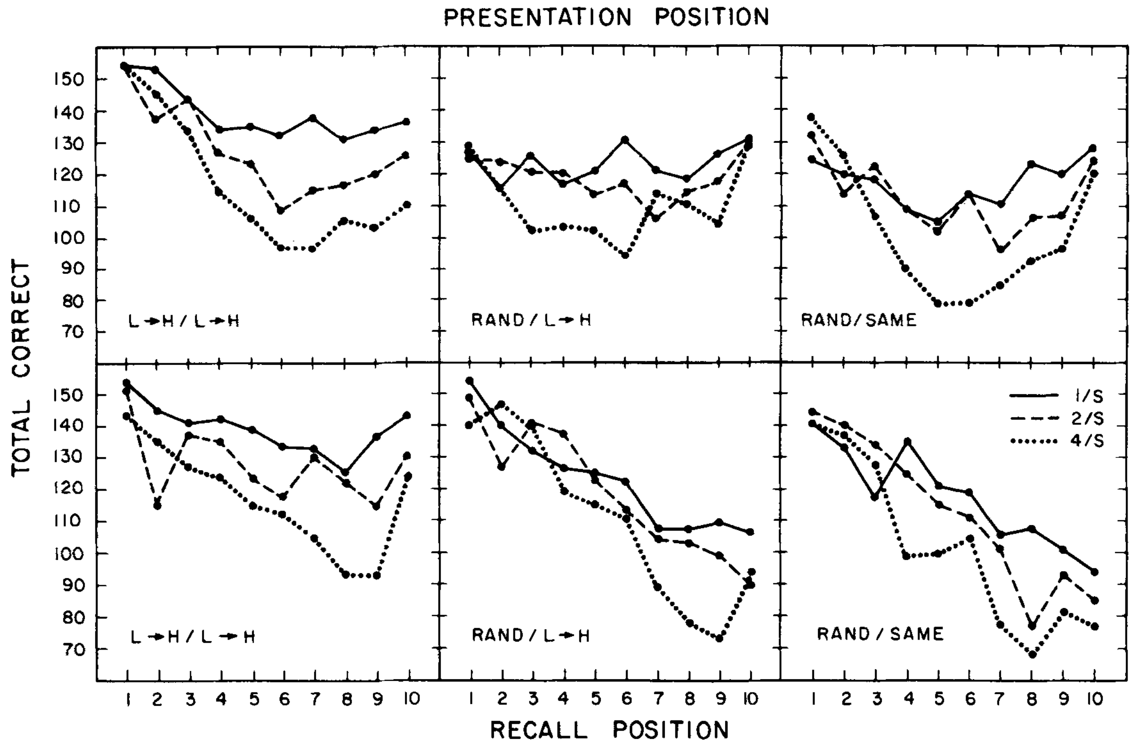

Fig. 2. Serial and output position curves at three presentation rates for serial-order presentation and recall, random-order presentation with serial-order recall, and random-order presentation with same-order recall.

increased, although recall of serial-order presentation remained greater than recall of random-order presentation. The decrease in recall as the interval between presentation decreased was similar in all conditions.

Aaronson (1967) has recently reviewed the evidence for a relatively greater effect of interpresentation interval than of presentation duration on two stages of perceptual processing for short-term memory. She has suggested that while stimulus duration may affect storage in a first stage sensory buffer, the interval between presentations may affect identification or encoding for a second stage limited-capacity slow-decay storage system. Because the presentation duration was kept constant in this study, the interval between presentations decreased as rate of presentation increased, so that the decrease in recall observed is presumably due to decreased time for identification and encoding when presentation rate was increased.

If identification and encoding were equivalent, recall of serial-order presentation should decrease less than recall of random-order presentation as identification time decreases if greater recall of serial-order presentation is due to more rapid identification because the range of alternatives is less for each presentation. The present finding that recall decreased as much in L→H/L→H as in Rand/L→H when the interval for identification (and encoding) decreased indicates either that identification is not the same as encoding or that greater recall of serial-order presentation is due to something other than more rapid identification.

It might be argued that L→H/L→H is greater than Rand/L→H simply because serial-order recall of random-order presentation requires either reordering of presentation or repeated sequential scanning from lowest to highest number while serial-order presentation does not. If this were the case, recall in Rand/L→H should have decreased more than recall in L→H/L→H as presentation rate increased. However, the observed decrease in recall was not greater for Rand/L→H than for L→H/L→H. Furthermore, the previous finding by Buschke and Mesibov (1967) that omissions in both Rand/L→H and L→H/L→H have similar bowed distributions over the ordinal sequence of Numbers 1-20 suggests that serial-order recall involves "marking" numbers in the ordinal sequence rather than repeated sequential scanning of numbers retained in order of presentation. Therefore, it does not appear that less recall in Rand/L→H than in L→H/L→H is due to sequential scanning or reordering in Rand/L→H, supporting previous studies which indicate that serial-order recall involves storage of different item-information than that retained for same-order recall (Buschke, 1967, 1968, in press; Buschke & Hinrichs, 1968).

The recall distributions shown in Fig. 2 suggest that presentation-position and recall-position affect recall. Although the mean interval between presentation and recall is the same in Rand/L→H and L→H/L→H, it might be argued that recall is less in Rand/L→H because the mean interval is longer for items presented first. Table 1 shows recall in Rand/L→H according to both presentation-position and recall-position, for all rates of presentation together. While a general decrease in recall is shown across the rows of Table 1, as the interval between presentation and recall increases up the columns of Table 1 no (progressive) decrease in recall is apparent. The possibility remains that presentation in serial-order may increase recall because faster identification permits encoding and retention of more information, implying that identification and encoding are different processes.

A reasonable interpretation of the present findings about serial-order recall of random-order or serial-order presentations may be provided by a model which assumes that for serial-order recall presented numbers are first identified (or located) in the ordinal sequence, and then encoded by "marking" that location in the ordinal sequence. More rapid identification may be achieved by presentation in serial-order,

Table 1
Correct Serial-Order Recall of Random-Order Presentation (Rand/L→H) by all Ss as a Function of Both Presentation and Recall Positions, for all Rates of Presentation Together

Presentation	Recall 1	2	3	4	5	6	7	8	9	10	Total
1	53	67	22	23	39	42	41	31	38	29	383
2	50	47	40	23	33	37	43	24	25	33	355
3	38	33	49	38	32	27	31	30	33	27	348
4	36	31	39	51	42	35	19	26	30	32	341
5	44	24	56	32	32	35	29	29	28	28	337
6	43	35	56	36	35	34	28	30	22	23	342
7	38	25	41	57	38	32	22	24	20	33	340
8	37	32	44	49	38	35	27	31	22	27	342
9	52	58	28	39	30	28	29	28	28	27	347
10	53	52	38	38	44	31	33	36	34	31	390
Total	444	414	413	384	363	346	302	289	280	290	3525

which restricts the range of alternatives relevant for identification of each number presented. More rapid identification would leave more time for encoding, increasing the strength of such "marker" traces for greater retention when the ordinal sequence is scanned in serial-order for recall of marked numbers. This would account for greater serial-order recall of serial-order presentation (L→H/L→H) than of random-order presentation (Rand/L→H).

If identification time were constant and less for serial-order presentation than for random-order presentation the decrease in encoding time would be the same for both when presentation rate increased so that the difference between encoding time for serial-order and random-order presentations would remain constant. This would account for the similar decrease in serial-order recall for both L→H/L→H and Rand/L→H.

Rehearsal time would be affected in the same way indicated for encoding time. If encoding time also were constant a similar interpretation of the major finding could be provided in terms of rehearsal rather than encoding. While the present interpretation may account for the finding that serial-order recall remains greater for serial-order presentation than for random-order presentation as both decrease similarly when rate of presentation increases, it does not account for the serial-position and recall-position curves which indicate the effects of both order of presentation and order of recall. A significant problem for further investigation raised by this experiment is whether identification and encoding for short-term storage are different or equivalent.

REFERENCES

AARONSON, D. Temporal factors in perception and short-term memory. Psychological Bulletin, 1967, 67, 130-144.

BUSCHKE, H. Two kinds of short-term storage. Psychonomic Science, 1967, 8, 419-420.

BUSCHKE, H. Perceiving and encoding two kinds of item-information. Perception & Psychophysics, 1968, 3, 331-336.

BUSCHKE, H. Interaction of long-term and short-term memory. Journal of Nervous & Mental Diseases, in press.

BUSCHKE, H., & MESIBOV, G. Encoding for short-term storage. Presented at the annual meeting of the Psychonomic Society, 1967, Chicago.

BUSCHKE, H., & HINRICHS, J. V. Controlled rehearsal and recall order in serial list retention. Journal of Experimental Psychology, 1968, 502-509.

NOTES

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