Manipulation of study trials in recognition memory¹

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Two experiments were performed for the purpose of ascertaining the effects of two processes in recognition memory: the Ss' actual viewing time of verbal material and the E's feedback. Recognition-memory performance was found to be superior for an E-induced feedback over the S's own "subjective," induced feedback (query loops), even though the time for total rehearsal was kept constant for each condition. The actual viewing time was not found to be a critical factor. Several hypotheses are advanced to account for this result.

Bugelski (1962) has shown that, with increased stimulus-presentation time (TP), the number of trials (N) needed to learn paired-associate lists decreased exponentially. Fischer (1966) has shown that a similar relationship existed for serial lists of nonsense syllables; both authors have shown that TP multiplied by N is a constant. Brewer (1967), using short exposure times (between 1 and 17 sec) for meaningful material, has also shown that the same relationship exists between TP and N. However, the quantity (TP), as Fischer (1968) has illustrated, may be made up of two time components: the first, which she calls the interstimulus interval (ISI), and the second, the *true* presentation time, the time the stimulus was actually *seen* by the S.

Thus, if six words are presented visually, there would be six presentation times and five interstimulus intervals. Fischer (1968) showed that if the TP was replaced by the *true* presentation time *plus* the ISI, then the constant learning-time formula was still true (in her experiment, a constant 2-sec rate of presentation was used with different ISI times).

This variation in viewing time has interesting possibilities for investigating the role of E-induced feedback in verbal learning. Consider, for example, the situation where the Ss view a list for a constant total time, K. By varying the speed of presentation of the stimulus items, groups of Ss may see the stimulus items more than once yet still see the total list for the same time K. Thus, for a constant ISI and a *variable* stimulus-presentation time (SPT), it is possible to have Ss viewing, and attempting to learn, lists of words with varying degrees of feedback or repetition. The learning of

verbal items may be facilitated not so much by time per se but by the number of repetitions, as Haber and Hershenon (1965) and Dainoff and Haber (1967) have shown in a different, but not too dissimilar, task (tachistoscopic presentation of words).

Thus, there are two active processes in this verbal-memory situation, the S's "rehearsal" time and the number of study trials.

The present study investigated the independent effects of rehearsal time and number of study trials in recognition memory.

EXPERIMENT 1

Subjects

In this experiment, the Ss were divided into three equal groups (A, B, and C), each consisting of 28 2nd-year university students. Some of the students volunteered to perform the experiment, while the others were paid for their participation. The paid Ss were divided equally between the three groups.

Materials and Procedure

Slides were made of 60 common words chosen from the Thorndike-Lorge word count (1944); each word possessed a frequency of 30 or more (for details, see Garton & Allen, 1968). Ten words were used for the inspection series and these, together with the other 50 words, comprised the subsequent test series; all words were projected onto a screen using a Kodak Carousel automatic projector (Model 550R). Each of the three groups of Ss viewed the 10 inspection words, after which there was a 2-min period during which the Ss read instructions that were printed on the first page of a test booklet. Then there followed the visual presentation of the 60 randomly allocated test words. Each word was presented on the screen at the rate of one every 3 sec, with the exception that, after every 10th word, the gap was 4 sec.

The S rated the confidence of each decision on a 5-point scale, ranging from absolutely sure present to absolutely sure absent. The task was thus E-paced, and the testing phase lasted the same period of time for each of the three conditions.

All Ss viewed the same 10 inspection words. However, the exposure time (SPT) varied for each of the three conditions, as

shown below. The ISI was 0.90 sec, as measured by a Tektronix No. 502A oscilloscope, for *all* inspection conditions in this experiment and in Experiment 2; thus, the ISI was a constant 0.90 sec. The three presentation conditions for the 10 inspection slides were as follows: Condition A, one presentation of each slide for 0.50 sec; Condition B, one presentation of each slide for 1.40 sec; Condition C, two presentations of each slide for 0.25 sec, which was achieved by repeating the list of 10 slides again, with an interlist interval of 0.90 sec.

The total possible rehearsal time for Conditions B and C was equal, that is, 22.10 sec. The slide-viewing times for Conditions A and C were equal (10 at 0.50 sec being equal to 20 at 0.25 sec). With 10 slide times of 0.50 sec plus nine ISIs of 0.90 sec, the total rehearsal time during viewing for Condition A was 13.10 sec. Consequently, it was possible to compare two types of timings. In the first (Condition A vs C), the slide-viewing time was a constant, though the rehearsal times varied for each list. For the second (B vs C), the rehearsal times during the inspection series were a constant, though the slide-viewing times were different. In summary, the inspection times consisted of the following: Condition A, $10 \times 0.5 \text{ sec} + 9 \times 0.90 \text{ sec} = 13.10 \text{ sec}$; Condition B, $10 \times 1.40 \text{ sec} + 9 \times 0.90 \text{ sec} = 22.10 \text{ sec}$; Condition C, $20 \times 0.25 \text{ sec} + 19 \times 0.90 \text{ sec} = 22.10 \text{ sec}$. The testing time for the 60 slides was constant for all three conditions, and all Ss viewed the same 60-slide test series.

EXPERIMENT 2

This experiment was designed to investigate the effects of the number of presentations upon the subsequent recognition performance of the Ss.

Subjects

Three equal groups of Ss were used for three experimental conditions, 1, 2, and 3. There were 16 Ss in each group, giving a total of 48 Ss, all of whom were paid for participation.

Materials and Procedure

An inspection series of 30 common words was used, and these words were later tested in a series of 60 words composed of the original 30 plus 30 additional new

Fig. 1. Operating characteristics on a double probability plot, where A, B, and C refer to the three conditions for Experiment 1. (See text for further explanation.)

words. The words were mixed randomly, and all Ss viewed the same test sequence of 60 words. The signal- (old words) to-noise (new words) ratio was 1:1; thus, guessing on the part of the S would not improve his performance, in general.

The testing procedure was exactly the same as for Experiment 1. The three initial presentation conditions were as follows: Condition 1, one presentation of the 30-word sequence for 2.9 sec for each slide (this plus 29 interstimulus intervals made the total viewing and rehearsal time 113.1 sec); Condition 2, two presentations of the slide series for 1.00 sec per slide and 59 interstimulus intervals; Condition 3, three presentations of the slides for 0.367 sec each and 89 interstimulus intervals. The total viewing and rehearsal

Fig. 2. Operating characteristics on a double probability plot for Experiment 2. The numerals 1, 2, and 3 refer to the number of stimulus presentations for each of the three conditions.

time was, thus, a constant for all conditions, being 113.1 sec.

RESULTS AND DISCUSSION

ROC curves for both experiments were constructed from the six sets of data. From the five decision categories used by the Ss, four points were plotted on a double probability plot to produce linear OCs (for details of the technique, see Sidowski, 1966, p. 235). The curves for Experiment 1 are shown in Fig. 1.

The worst recognition performance was clearly evident for Condition A. Perhaps this is not surprising, as a total time of 13.10 sec would not allow much rehearsal time, even for only 10 stimulus words. Of more interest are the results for Conditions B and C. In spite of the very long stimulus presentation time for B (1.40 sec), the performance was little better than that for Condition A. The best result was clearly for the double presentation of the stimulus items, i.e., for Condition C. On comparing B with C, C was superior ($d_s = 2.67$), and this superiority must be due to the E-induced feedback, as the time for rehearsal of items was a constant for both conditions, namely 22.10 sec.

The results of the second experiment are shown in Fig. 2. Recognition performance was directly related to the number of stimulus presentations. The use of a 1:1 signal-to-noise ratio for the three conditions under Experiment 2, though it does not necessarily eliminate response bias in the usual sense of the term, does assure that accuracy of performance is independent of response bias. The second experiment was run in order to better assess the generality of the results of Experiment 1 as well as to unconfound response bias and performance level.

It is clear from both experiments that the total-time law is not sufficient to account for the present results, although time does affect performance (Conditions A vs B of Experiment 1). The present findings are also pertinent to the time-honored law that spaced learning is superior to massed learning, for both experiments have shown that repeated study trials aid performance. There is no a priori reason to suppose that the Ss' own rehearsal strategies should be inferior to the feedback given by the E, for it must be remembered that the total time for rehearsal was identical for all three conditions in Experiment 2. Why is it easier to learn verbal material when it is presented in a multiple fashion, even when the presentation time is equated?

One important suggestion by Atkinson and Shiffrin (1968a), though related by them to paired-associate learning, seems plausible here; if, on a second or

subsequent presentation of the stimulus item, the item was correctly and easily retrieved from the long-term memory store, then the item would not need to be entered into a rehearsal buffer as the item was known already, the rehearsal buffer being a rehearsal span under the complete control of the S. Consequently, repeated presentations will allow the S to drop known words from the buffer and replace them with forgotten or partially remembered words. Thus, "easy" words will be "checked" and difficult ones will reenter the buffer for more "subjective" rehearsals. In the case of a single presentation, the S cannot assess in the absence of further study trials which items will be easy and which will be difficult.

The results of the current experiments show that the repeated feedback enables some comparisons to be made, which, in terms of Norman's (1968) synopsis, may highlight the role of multiple query loops, loops that return to the storage system (see Fig. 3).

Norman's (1968) outline of retrieval shows that a query of storage excited some combination of stored representatives. The decision process tests the item that received the greatest activation (the shaded item in Fig. 3) by reentering it into storage as if it were a query. If the output, used as a query, leads to the original query, the retrieval process is terminated (p. 532). This is akin to the TOTE mechanism of Miller, Galanter, and Pribram (1960).

The more efficient retrieval for repeated presentations of the stimulus may require, as Norman postulated, that the distance from the query to the stored information decreases with each cycle of interrogation of the storage system. This is analogous to Bruner's (1957) accessibility of categories for use in coding, or identifying, environmental events. A tentative categorization of the stimulus leads to a desire for a "trial and check," in Woodworth's (1947) terminology, or a "confirmation-check," in Bruner's terms (p. 135). Consequently, though study trials do not guarantee perfect performance, it does give the S extra opportunities to match his queries with the correct response.

However, one must agree with Atkinson and Shiffrin (1968b) when they state that a recognition test does not necessarily separate retrieval from storage effects in memory. The fact that repeated presentations of stimuli aid recognition performance seems to suggest, as Norman has implied, if not overtly stated, that retrieval of information does require a recursive query of storage until the decision process is satisfied.

Fig. 3. Norman's (1968) outline of retrieval.

REFERENCES

- ATKINSON, R. C., & SHIFFRIN, R. M. Some speculations on storage and retrieval processes in long-term memory. Institute for Mathematical Studies in the Social Sciences Technical Report No. 127, Stanford University, 1968a.
- ATKINSON, R. C., & SHIFFRIN, R. M. Human memory: A proposed system and its control processes. In K. W. Spence and J. T. Spence (Eds.), *The psychology of learning and motivation*. Vol. 2. New York: Academic Press, 1968b.
- BREWER, C. L. Presentation time, trials to criterion and total time in verbal learning. *Journal of Experimental Psychology*, 1967, 73, 159-162.
- BRUNER, J. S. On perceptual readiness. *Psychological Review*, 1957, 64, 123-152.

- BUGELSKI, B. R. Presentation time, total time, and mediation in paired-associate verbal learning. *Journal of Experimental Psychology*, 1962, 63, 409-412.
- DAINOFF, M., & HABER, R. N. How much help do repeated presentations give to recognition processes? *Perception & Psychophysics*, 1967, 2, 131-136.
- FISCHER, G. J. Relation between presentation time, serial learning, and the serial position effect. *Journal of Experimental Psychology*, 1966, 72, 153-154.
- FISCHER, G. J. On constant time to learn: A proposed modification of function. *Psychonomic Science*, 1968, 10, 357-358.
- GARTON, R. F., & ALLEN, L. R. Familiarity and word recognition. *Quarterly Journal of Experimental Psychology*, 1968, 20, 385-389.
- HABER, R. N., & HERSHENSON, M. The

effects of repeated brief exposures on the growth of a percept. *Journal of Experimental Psychology*, 1965, 69, 40-46.

MILLER, G. A., GALANTER, E., & PRIBRAM, K. H. *Plans and the structure of behavior*. New York: Holt, 1960.

NORMAN, D. A. Toward a theory of memory and attention. *Psychological Review*, 1968, 75, 522-536.

SIDOWSKI, J. B. (Ed.), *Experimental methods and instrumentation in psychology*. New York: McGraw-Hill, 1966.

SPENCE, K. W., & SPENCE, J. T. (Eds.), *The psychology of learning and motivation*. Vol. 1. New York: Academic Press, 1967.

THORNDIKE, E. L., & LORGE, I. *The teacher's word book of 30,000 words*. New York: Bureau of Publications, Teachers College, Columbia University, 1944.

WOODWORTH, R. S. Reinforcement of perception. *American Journal of Psychology*, 1947, 60, 119-124.

NOTES

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