Delay and the digit probe¹

A. D. BADDELEY,² *APPLIED PSYCHOLOGY RESEARCH UNIT, Cambridge, England*

The Waugh and Norman probe technique was used to study retention of a seven digit sequence after a delay of 0, 2, 4, 8, or 16 sec filled with letter copying. Results showed: (1) rapid forgetting reaching an asymptote at 15-20 sec (2) forgetting occurred at all serial positions, and (3) forgetting was a function of number of intervening items regardless of whether these were digits to be retained or letters to be copied.

Peterson & Peterson (1959) showed that serial retention of a sequence of items declines rapidly if rehearsal is prevented. In the case of paired-associate learning (PAL) however, only the last item presented shows this rapid decline. Retention of earlier items tends to improve over time, suggesting that PAL contains a much greater long-term component than does serial STM (Peterson 1966).

The present study is concerned with a technique that is intermediate between serial and PAL, the digit probe technique devised by Waugh & Norman (1965). In this, S is presented with a sequence of digits followed by the probe, a repetition of one of the digits at which point S attempts to say which digit followed the probe in the sequence presented. (e.g., Present 7082619, probe digit 2, correct R = 6). The presentation is therefore identical to that used in serial STM, while the test procedure resembles PAL first in asking for a single specific item, and secondly is requiring S to form associations between items, rather than between serial position and items as seems to occur in serial STM (Baddeley 1968). This experiment is concerned with the question of whether retention measured by the digit probe technique will show the rapid decline characteristic of serial STM or will show the stability characteristic of PAL.

Method

The Ss listened to and tried to retain sequences of seven digits, followed by a 1 sec pause and 0, 2, 4, 8, or 16 letters to be copied down as a rehearsal preventing task. After a further 1 sec pause one of the digits was repeated (the probe) and S was allowed 5 sec to write down the digit that had followed the probe. Digits and letters were read out at a 1 sec rate. Two observations were made at each of the six possible probe positions for each of the five delays, giving a total 60 sequences. Items from the various

conditions were presented in random order; two separate sets of material were used, 13 housewives being tested on each using a group testing procedure.

Results and Discussion

Figure 1 shows mean per cent correct recall as a function of delay, combining the results from all probe positions. Since it is clear from Fig. 1 that the two groups behave in the same manner they were therefore combined for analysis. A Friedman test showed the effect of delays to be highly significant ($X^2 = 68.7$, $df = 4$, $p < .001$). The function clearly resembles that found by Peterson & Peterson (1959) for serial STM in showing a rapid decline reaching an asymptote at about 15 to 20 sec. One unexpected feature of this result is the relatively low level of retention with no delay. Since seven digits is probably within the span of many of the Ss one would expect the probe technique which requires only one digit would give almost perfect performance on immediate test. It is possible that performance in the no delay condition was depressed because the S was expecting to have to copy letters, as he did on 80% of the tests.

Serial position curves after the various delays are shown in Fig. 2. The immediate recall condition shows both primacy and recency. The marked recency effect is characteristic of the digit probe technique (Waugh & Norman 1966), though the primacy effect was not found in their study, probably because it is limited to the first pair of digits, and these were not tested by Waugh and Norman. In contrast to the bowed serial position curve when the test is immediate, performance after 16 sec of digit copying seems to be independent of serial position. Unlike free recall (Glanzer & Cunitz 1966) and PAL (Peterson 1966), forgetting is not limited to the recency effect, but occurs at all positions. This implies that recall at all positions depends on STM.

A final point is made by Fig. 3 which shows retention as a function of number of intervening items, plotted separately for intervening digits and letters. The digit curve is based on the immediate recall condition, thus the zero point represents the score for Position 7, two intervening digits represents the score for Position 5 and four digits represents Position 3. The letter curve is based on the retention of Item 7 after 0, 2 or 4 intervening letters. Within the limits of the present data, the two are substantially the same, suggesting that number of intervening items is the crucial variable, rather than whether they are drawn from the same or different categories as might have been expected on the basis of

Fig. 1. Mean per cent correct Rs as a function of delay (all serial positions combined).

Fig. 2. Mean per cent correct Rs as a function of serial position and delay.

Fig. 3. Rate of forgetting digits as a function of number of interpolated digits and letters.

interference theory (Wickelgren, 1966; Wickens, Born, & Allen 1963).

REFERENCES

- BADDELEY, A. D. How does acoustic similarity influence short-term memory? *Quart. J. exp. Psychol.*, in press.
- GLANZER, M., & CUNITZ, A. R. Two storage mechanisms in free recall. *J. verbal Learn. verbal Behav.*, 1966, 5, 351-360.
- PETERSON, L. R. Short-term verbal memory and learning. *Psychol. Rev.*, 1966, 73, 193-207.
- PETERSON, L. R., & PETERSON, M. J. Short term retention of individual verbal items. *J. exp. Psychol.*, 1959, 58, 193-198.
- WAUGH, N. C., & NORMAN, D. A. Primary memory. *Psychol. Rev.*, 1965, 72, 89-104.
- WICKELGREN, W. A. Acoustic similarity and retroactive interference in short-term memory. *J. verbal Learn. verbal Behav.*, 1966, 4, 53-61.
- WICKENS, D. D., BORN, D. G., & ALLEN, C. K. Proactive inhibition and item similarity in short-term memory. *J. verbal Learn. verbal Behav.*, 1963, 2, 440-445.

NOTES

1. I am grateful to the British Medical Research Council for financial support, and to Denise Scott for assistance with data analysis.
2. Now at the Experimental Psychology Laboratory, University of Sussex.