Chapter II

Historical Resume

In the previous chapter it was seen that a fixed amount of time is necessary to learn a fixed amount of material regardless of the number of individual trials into which that time is divided. A large number of investigations have been conducted to study the tenability of this hypothesis.

Two studies were conducted by Hovland (1938 a, 1938 b) in which the effect of variation in the rate of syllable presentation (2 seconds and 4 seconds) on the number of trials required to reach the criterion was studied. Subjects learned a list of 12 nonsense syllables (N.S.S.) in a serial order. Although this investigation did not compute the total-time, his results indicate that while the total number of trials required to reach criterion varied greatly, variation in the total-time was negligible. Subjects required fewer number of trials to reach a criterion of 7/12 nonsense syllables at the 4 second rate than at the 2 second rate (3.28 vs 6.05 trials). Mean total-time per item was 13.12 seconds at the 2 second rate.

In the other investigation, subjects learned by the method of distributed practice. The mean number of trials required to achieve one perfect recitation was 6.32 at the 4 seconds rate and 13.04 at the 2 second rate. Mean total time per item was 25.28 seconds at the slow rate and 26.08 seconds at the fast rate.
Melton and Stone (1942) using the same method of learning reported that with an increase in the rate of presentation there was a subsequent increase in the number of trials required to learn a given material up to the same criterion. Subjects learned serial lists of 16 adjectives up to a criterion of 12 correct anticipations and were then given rest intervals for varying lengths of time, after which they relearned the lists up to a criterion of two successive errorless trials. However, the Total-Time spent in learning was not affected.

In 1949, Hovland conducted a similar experiment but he used pairs of nonsense syllables. Subjects learned nine pairs of nonsense syllables at either at a 1:1 second or a 2:2 second rate. The mean number of trials taken to reach the criterion at the 1:1 second rate was found to be 25.5, while that at the 2:2 second rate it was 15.0. In this study also the total presentation time per item was approximately the same (51.0 seconds vs 59.8 seconds).

A 2x2x2 factorial design with two degrees of meaningfulness (high and low), two intertrial intervals (6 seconds and 2 minutes) and two presentation rates (2 seconds and 4 seconds) was used by Braun and Heyman (1958). Mean trials to learn the high meaningful list in a serial order was 8.04 at the 4 second rate and 19.58 at the 2 second rate. Mean trials to learn the low meaningful list was 23.5 at the 4 second rate and 31.67 at the 2 second rate.
Like Hovland, Braun and Heyman did not compute Total-Time, however, when mean Total-Time is calculated from their data, it appears that Total-Time invariance holds for the high meaningful list, but not for the low-meaningful list. Mean Total-Time per item for the higher meaningful list was 39.16 seconds at the 2 second rate and 32.16 seconds at the 4 second rate, for the low meaningful list, it was 53.24 seconds at the 2 second rate and 94.00 seconds at the 4 second rate.

Goss, Morgan and Colin (1959) presented eight pairs of nonsense syllables at either a 2:2 second or a 3:3 second rate and manipulated percentage occurrence of response members. It took considerably fewer trials to learn the 100% occurrence of response members list at the 3:3 second rate then it did at the 2:2 second rate (16.4 vs 24.8 trials). Although the difference appeared to be quite large, computation of Total-Time per item indicated the 3:3 second rate had only a slight advantage (98.4 seconds vs 99.2 seconds).

The fact that this advantage holds even for free recall learning was demonstrated by Murdock (1960) who reported that immediate retention following a single presentation of a list of unrelated words ($R_1$) in a linear function of the Total-Time required for presentation time per item. He reported that if list length and presentation time per item were varied concomitantly so that they remained constant, recall would be remain constant. The mean values of $R_1$ for 4 lists: a 20 item
list presented at a rate of 3 seconds/item, 30 item list presented at a rate of 2 seconds/item, a 40 item list presented at a rate of 2 seconds/item, a 40 item list presented at a rate a rate of 1.5 seconds/item and a 60 item list presented at a rate of 1 second/item were 9.3, 9.3, 9.6 and 8.4 words, respectively were not significantly different. Murdock suggested the following equation as an approximation to the function relating $R_1$ to $t$:

$$R_1 = 0.6 t + 6.1$$

where $t$ is measured in seconds.

A number of earlier studies by Peters (1936), Bousfield, Sedgewick and Cohen (1954), Deese (1957) and Deeses and Kaufman support these results.

Peters (1936) used a 10 item list presented at the rate of 1 second/item. He found that the obtained $R_1$ was equal to 5.2 words. This was approximately equal to the predicted value of $R_1$ i.e. 6.7.

Bousfield, Sedgewick and Cohen (1954) used a 60 item list presented at a rate of 3 seconds per item. Predicted $R_1 = 16.9$ words; obtained $R_1$ at the end of 2 minutes = 16.2 words.

A 20 item list was presented by Deese (1957) at a rate of 1 second per item. Predicted $R_1 = 7.3$; and obtained $R_1 = 5.7$ words.

Deeses and Kaufman (1957) used a 32 item and a 10 item list, both presented at a rate of 1 second per item. For the
first list predicted $R_1 = 3.0$ words; obtained $R_1 = 3.5$ words, for the second list predicted $R_1 = 6.7$ words, obtained $R_1 = 5.8$ words.

Later in 1963, Cohen extended the domain of Murdock's function to the recall of categories of related words. Seventy words comprising of 10 exhaustive and 10 nonexhaustive categories were presented for free recall learning at a rate of 4 seconds per word. Whether category recall was inferred from word recall (i.e. subjects received credit for having represented a category in recall if at least one word of the category was recalled) or measured directly, between 10 and 14 categories were represented in recall. Using Murdock's formula, a recall of 10.9 words is predicted from a list of 20 unrelated words presented at a rate of 4 seconds per item.

If 20 categories are equated with 20 unrelated words the present findings are not at variance with this predicted value indicating that Murdock's formula predicts as well for categories of related words as it does for unrelated words.

Wilcoxen et al. (1961) used a 3x3x3 factorial design and demonstrated that manipulation of list ($4, 6, 8$ pairs), percentage occurrence of response members ($100, 50, 25\%$) and rate of presentation ($1:1, 2:2, 4:4$ seconds) does not effect the total time required to reach the criterion although increased rate of presentation does increase the mean number of trials taken.
Bugelski's (1962) study provides impressive support for the total-time hypothesis. The subjects learned eight pairs of nonsense syllables to a criterion of two successive correct anticipations of each pair. The stimulus presentation time was held constant at 2 seconds, as was the time between the occurrence of a stimulus–response pair and the presentation of the stimulus of a subsequent pair. However, there was not a significant difference in the total time required to learn when it was measured by multiplying trials by presentation time. Later Bugelski and Rickwood (1963) allowed a group of subjects to control their own stimulus–response exposure time. The mean total per item for this group was 65.5 seconds. This is not significantly different from the mean for the five groups of the previous study, that is, 61.5 seconds per item.

An experiment on bidirectional paired associate learning by Underwood and Keppel (1963) also confirms the Total-Time Hypothesis. The difference in time to learn the first list between experimental and control groups was almost perfectly matched by the difference in degree of learning (or number) of backward associations (25%).

In a later study by Newman (1964) subjects learned a six item paired associate list using a study-test procedure with 12 pairing trials, each followed by a test trials. The mean number correct on the respective tests for each group was
3.25 for group 24 and 4.10 for group 44. Neither of the two comparisons between the means were statistically significant.

An experiment by Johnson (1964) indicates that due to perceptual and motivational factors, upper and lower boundaries must be set on presentation rate, if the total-time hypothesis is to be held. Subjects learned an eight-item paired-associate list in which stimuli were CVC nonsense syllables and responses were digits one to eight. The design of this experiment was a 4x4 factorial. A subject's total learning time per item was fixed at either 10, 20, 40 or 80 seconds, and it was divided into either 1.5, 10 or 20 exposures. A 4 second intertrial interval was used. Upon completion of the learning trials, during which the stimulus and response of each pair were presented simultaneously, each subject was immediately given 15 test trials with the stimuli being shown alone.

A subject's score was the total number of correct responses made during the 15 test trials. An analysis of variance indicated that with Total-Time of exposure held constant, frequency of exposure did have a significant effect, amount learned increasing sharply between 5 and 20 trials. Most of the increase in the number of correct responses as a function of increases in number of exposures occurred during changes from one to five repetitions, indicating a boundary set by motivational factors.
Many repetitions with fast presentation rates resulted in deterioration of performance, indicating a boundary set by perceptual factors. There was, in general, a curvilinear relationship between presentation rate and number of correct responses, with a maximum at some point between 2 seconds and 4 seconds per item.

The Johnson experiment is, however, open to criticism. Johnson confounded frequency of exposure and total learning time by his use of 4 second intertrial intervals, for example, in the 10 second group, those subjects who had one exposures did, indeed, have only 10 seconds total learning time per item. But those subjects who had 5 exposures had 10 second + 5(4 second 8 = 12.5 seconds total learning time per item; those who had 10 exposures had 10 seconds + 10(4 seconds)/8 =15 seconds total learning time per item; those who had 20 exposures had 10 seconds + 20(4 seconds)/8 =20 seconds total learning time per item.

Postman and Goggin (1964) also tested the total time hypothesis by comparing total time required to master 10 item CVC serial lists, by the whole and pure part methods. A measurement of total learning time showed a small but statistically significant advantage for the pure-part method. The variations in meaningfulness and intralist similarity, which had major effects on speed of learning, did not influence the magnitude of the difference between the two methods.
A factorial design 4x3x2x2x3 with four list lengths (4, 8, 12, 20 pairs) three levels of meaningfulness, two levels of ability, two equivalent forms, and three rates of presentation (1.5:1.5, 2:2, 4:4 second) was employed by Carrol and Burke (1965) to investigate the effect of a number of variables on the total time required to reach the criterion. An analysis of variance performed for all data pertaining to acquisition of complete lists showed a significant effect of rate of presentation.

Nordine (1965) had subjects learn 16 consonant vowel consonant (CVC) trigrams to a 15/16 criterion. As stimulus response durations increased there were increasing numbers of correct responses on the first 20 trials, the effect being statistically significant. Total learning time showed a significant increase with increasing stimulus duration, but not with increasing stimulus response duration. Increasing stimulus response duration increased rate of learning and, therefore, did not increase total learning time.

In a study by Keppel and Rehula (1965), subjects learned serial lists of 14 adjectives up to a criteria of 5/14 and 10/14 at a 2-second or a 4-second rate of presentation. Although, the total number of correct responses was slightly higher for the 4 second group (13.31 vs 17.97), this difference was not significant.
Portman and Goggin (1966) replicated their earlier study (1964), but used paired associate instead of CVC items, to compare the total time required by whole and part methods. The difference in total learning time between the whole and part condition remained at or near zero. In experiment II, the whole, pure-part, and repetitive part methods were compared. The total learning time was substantially less in the repetitive-part condition than in the whole or pure-part conditions. However the total learning for the whole and pure-part methods were virtually identical.

Muhar and Shrivastava (1971) did not observe similar results. In their study, two hundred university students were equally divided into 4 groups on a random basis and were required to learn a list of N.S.S. having an association value of 20% four different methods were followed (massed, spaced, whole and part) for each group only one method was employed. The results showed differential learning by the four learning methods.

However, it was later demonstrated by Bhasker and Muhar (1972) that if N.S.S. of a higher association value are used, the total time hypothesis holds time except for the whole method of practice.

With this background we may now pass on to the next chapter dealing with the problem and hypothesis of the present investigations.