RESPONSE AVAILABILITY AS A FUNCTION OF MASSED AND
DISTRIBUTED PRACTICE AND LIST DIFFERENTIATION

by

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CHAPTER I

INTRODUCTION

Research has supported the conclusion that retention is largely a function of degree of learning, and variables which produce large differences in learning such as meaningfulness, similarity, and individual differences have little influence upon the rate of forgetting (Underwood, 1964). One exception to this conclusion is the facilitative effect on retention of distributing the practice (DP) during learning. The retention of the last in a series of paired-associate lists, having the same stimulus but different response terms (A-B, A-C, A-D), was found to be greater when the last list was learned by DP (Underwood, Keppel, & Schultz, 1962; Underwood & Schultz, 1961).

Underwood (1961) has defined the basic operations employed in most studies of paired-associate massed practice (MP) or DP learning. A trial is described as being a single presentation of all items in a list of verbal units. The central variable is the length of the interval between trials. If the interval is short, 2 to 8 seconds, learning is defined as being by MP. If the interval is longer, 15 seconds or more, learning is said to be by DP.

The anticipation method is often employed in learning. The stimulus is presented alone, then the stimulus is presented with the response item.

Although research has supported the conclusion that DP training on the last in a series of paired-associate lists facilitates retention, the mechanism which operates to produce such superior retention has not been identified. Three explanations have been advanced to explain the superior retention of DP training.

Underwood et al. (1961, 1962) explained the superior retention of DP training in terms of extinction and recovery of competing associations. During A-C acquisition, A-B associations are subjected to the damaging effects of A-C learning. However, MP and DP training on A-C have different effects on the previous associations. Distributing the practice on the A-C list results in greater extinction of B responses. The DP condition allows competing A-B associations to recover in strength during each intertrial interval. The competing associations undergo a series of extinction and recovery cycles.

Massed training on the A-C list suppresses the A-B associations. However, the effect is not as permanent as DP due to the lack of opportunity for A-B associations to recover during A-C learning. After A-C learning, the

suppressed A-B associations began to recover in availability interfering with recall of B responses.

The A-B associations which have been subjected to a series of extinction recovery extinction trials do not recover as fast and/or to the degree as associations which have been suppressed. The MP suppressed associations are at greater strength and produce greater interference at recall of A-C associations than the extinguished items. Distributed training results in less interference at recall and thus, superior retention.

The learning of paired-associate items has been found to occur in two stages. The first stage is the response learning stage during which the subject acquires the response items as responses; response items must become readily recallable units. The second stage is the associative stage during which the response term is connected to the stimulus term (Underwood & Schulz, 1960; Underwood, Ranquist, & Schulz, 1959).

Underwood et al. (1962) found that DP training resulted in superior retention (DP retention effect) with the A-B, A-C situation but not with the A-Br paradigm in which the same stimuli and the same responses are re-paired in successive lists. Underwood et al. concluded that DP training facilitated recall only when interference occurred in the response learning stage. Keppel (1964) did obtain the DP

retention effect with the A-Br paradigm. The major difference in the design of the two studies was the length of the DP interval. Underwood et al. used intervals of less than 3 minutes while Keppel used 24 hour intervals. The longer DP intervals resulted in the DP retention effect with interference in the associative stage of learning.

In the A-B, A-C transfer paradigm, the first list response is extinguished (or unlearned) during the learning of the second list response (Barnes & Underwood, 1959; Briggs, 1954). The result of the extinction process is such that the B response is not available to the subject at the time of recall as a consequence of the second list learning (Barnes, 1960; Barnes et al., 1959).

Extinguished responses recover (become available) following cessation of second list practice (Adams, 1961; Briggs, 1954; Underwood, 1948). For a constant degree of prior learning, the amount of recovery is a direct function of the length of the recovery interval (Underwood et al., 1962). The extinction recovery explanation of superior DP retention in paired-associate learning was derived in part from those data.

It has been found that a greater number of prior list intrusions (interlist intrusions) occur during last list DP training (Keppel, 1964). Such evidence is consistent with the extinction recovery position that greater extinction

of prior associations occurs in DP learning. But Keppel (1964) also found that there were no consistent differences in recall as a function of the occurrence of interlist intrusions in learning.

Houston and Reynolds (1965) expressed the notion that the superior recall of DP training is a function of list differentiation (Houston, 1966). According to the differentiation position, the employment of different training methods on the critical list serves to differentiate it from the other list(s). In the situation where all prior lists are learned by MP and the training method is varied on only the last list (MP or DP), list differentiation occurs for the DP but not for the MP group. The MP subjects, because they learned all of the lists by the same method, are subject to a greater degree of list confusion than DP subjects. Because of reduced list confusion, DP training results in superior retention.

Keppel (1967) stated that the superior retention of DP is a function of the development of superior mediational devices. During acquisition the subject engages in a search for a linkage or mediational device between the stimulus and response. Mediational devices vary in strength and stability. The intertrial interval of the DP condition results in the loss of function of the weak or unstable devices. Faced with the failure of the mediators, the subject

has a new opportunity to establish more satisfactory devices. A strong association, one which is resistant to forgetting for whatever reason, will survive the DP interval and be maintained throughout the remaining acquisition trials.

What is critical is that the subject, by his failure, is given another chance to replace an unstable association with a potentially stronger and more stable one.

It is assumed that considerably less forgetting occurs over the relatively short MP intervals. The MP subject acquires a collection of associations which represent the full range of associative strength, while the DP subjects will have acquired a collection of relatively strong and stable associations. Such a difference in associative strength accounts for the superior retention of materials learned by DP.

At recall, Keppel (1964) failed to find less prior list retention for last list DP training. However, prior list recall was taken following relearning of the last list, a procedure which may have eliminated any difference in prior list availability present at the time of recall. In a later study Keppel and Schwartz (1965) found no differences in prior list availability following MP and DP acquisition of the last list. Such a result indicates that the degree of extinction or suppression of prior associations is the same for last list DP and MP training.

Prior associations learned by DP do not seem to enter into an extinction relationship in the same way that associations learned by MP (Underwood & Ekstrand, 1967). First list DP associations interfered less with second list associations. The first list DP associations were more resistant to extinction during second list learning.

Underwood and Ekstrand (1966) reported that retention of first list DP items in an A-B, A-C transfer paradigm was not a function of different degrees of learning. By employing DP on the first list, it was found that A-B retention was the same for 80 and 12 acquisition trials.

In Keppel's (1964) study the magnitude of the DP retention effect with 24 hour DP intervals was impressive. Subjects that were trained by DP correctly recalled 89, 72, and 34% of the response items after 1, 8, and 29 days respectively. Recall was 31% after one day and only 7% after eight days for the MP group.

Studies have found that the rate of acquisition is slower under DP. The DP inferiority was especially notable at the beginning of training but approaching the level of MP toward the end of acquisition (Keppel, 1964; Underwood et al., 1962). One exception was when interference was generated which impeded the learning of response items as responses, such as the use of low meaningful units as response terms (Underwood et al., 1961).

The present study was designed to evaluate the three explanations of the superior retention of DP learning. Subjects were trained on both lists of an A-B, A-C situation by both MP and DP, forming MP-MP, MP-DP, DP-MP, and DP-DP groups. In order to test the facilitative effects of list differentiation on retention, half of the subjects in each cell learned lists which were differentiated by concept, while the other half learned nondifferentiated lists. Two recall tests were given, the first immediately after second list acquisition and the second seven days later.

Differentiation

The differentiation theory supposes that the DP retention effect is a result of list differentiation and not the training method per se. If such is the case, then any technique which differentiates the lists should result in superior retention. In a situation where DP training does not enhance list differentiation, the DP retention effect should not be evident.

The group learning lists differentiated by concept should be superior in recall to the group learning nondifferentiated lists. Groups learning lists differentiated by training methods (MP-DP, DP-MP) should be superior in recall to groups that learn by the same method (MP-MP, DP-DP). The retention of DP-DP and MP-DP groups should

not be superior to the MP-MP and DP-MP groups in recall of second list items. The retention of DP-MP and DP-DP groups should not be superior to the MP-DP and MP-MP groups in recall of first list items.

Extinction Recovery

The extinction recovery position contends that DP training on the last list extinguishes or suppresses prior associations to a greater degree than MP training. The lower availability of prior competing associations at recall results in greater recall of the DP trained items.

If DP training extinguishes prior list items to a greater degree, there should be less availability of prior associations under second list DP training on the first and second recall tests. However, if MP and DP training on the second list suppresses competing responses to the same degree but the recovery is greater for MP, prior list availability should be the same for both conditions on first recall but greater on second recall for the MP condition. Distributed practice on the second list should result in decreased availability of first list items. Distributed practice on the first list should not result in the DP retention effect for first list response items.

Mediational

The mediational theory contends that the DP retention effect is a result of the superiority of the training method

itself. Therefore, DP training should result in the DP retention effect for both first and second list items.

Because of the greater stability of the DP trained associations, there should be a greater loss of response availability for second list MP trained items than for DP trained items.

CHAPTER II

METHODS AND PROCEDURES

Design

The design was a 2 x 2 x 2 factorial; the first factor consisted of a variation of the conditions of list one learning, either MP or DP. The second factor consisted of a variation of the conditions of list two learning (MP or DP). The third factor consisted of list differentiation or nondifferentiation. List differentiation was achieved by employing names of things alive (A-items) as the response terms on list one and names of things not alive (NA-items) on list two. In the nondifferentiation groups, list one consisted of 6 A-items and 6 NA-items. List two was constructed of the 12 remaining response items.

Materials

The stimulus terms in all lists were nonsense syllables taken from Glaze (1928) with zero percent associative value. The response terms were 24 one-syllable nouns taken from Thorndike's 500 most common words (Thorndike, 1931). Twelve of the response terms were A-items and 12 were NA-items. Four orderings of the pairs were constructed. The eight 12 pair lists were presented in the same order to all subjects, having the same stimuli and different responses,

forming the A-B, A-C paradigm with list differentiation by concept on 4 cells and no differentiation by concept on the remaining 4 cells.

Procedure

All lists were presented on a Carousel projector at a 2:2 second rate. Each subject was seated facing a screen. The projector and experimenter were positioned behind the subject. Each stimulus term was presented on the screen for a period of two seconds followed by the stimulus paired with the response term for two seconds. Subjects were instructed to state verbally the correct response term each time the stimulus appeared alone. All subjects received 15 anticipation trials on each list. Under MP conditions the 15 trials were presented at one experimental session. Under DP conditions 3 anticipation trials were presented each day for 5 days. A 48 hour interval occurred between the last training trial on the first list and the first training trial on the second list for all treatment conditions. In the concept groups the subjects were informed that all responses on list one were the names of things alive. The information was given immediately before training on the first list. Immediately before list two acquisition, the concept groups were informed that all responses on list two were the names of things not alive. In the no concept group, subjects

were informed that the response terms were the names of something.

Two recall tests were given to all subjects. The first recall test was given immediately after the fifteenth training trial on the second list. The second recall test was given 7 days after the first recall test. Since availability of first list responses was important in this study, it should be noted that a time differential existed for some groups between the fifteenth training trial on first list acquisition and the recall tests. Subjects that learned list two by MP had an interval of 3 days from the fifteenth training trial on list one until first recall and 10 days until second recall. Subjects that learned list two by the distributed training method had an interval of 7 days from the fifteenth training trial on list one until first recall and 14 days until second recall.

The modified modified free recall technique was employed in recall testing. Each stimulus term was projected singly on the screen. Subjects were instructed to state verbally the first response term that they could remember that went with the stimulus term projected, and to state to which list the response term belonged, after which they were to attempt to recall the other response term that belonged with that stimulus. Unlimited time was allowed on each stimulus presentation. Attention was given only to the

term that was presently on the screen; subjects were not allowed to return to an earlier stimulus or to change a prior response. Subjects were not informed concerning the correctness of a response.

A response was scored correct only if it was paired with the correct stimulus term and assigned to the proper list.

Subjects

Each of the 8 experimental conditions contained 12 subjects. Subjects were drawn from introductory psychology classes at Texas Tech University. In certain classes service in experiments was either a requirement or students were granted extra class credit for such service. Subjects were assigned to the particular experimental conditions in order of appearance at the laboratory. Subjects who did not complete training or return for recall were replaced by the next subject to report for the experiment.

CHAPTER III

RESULTS

Acquisition of List One

During the early training trials the performance of the DP group was inferior to that of the MP subjects, but approaching their level by the last few acquisition trials. The learning curve of the DP condition was saw-toothed in appearance due to a reduction in the performance level on the first trial following each DP intertrial interval. The loss became progressively less as training progressed.

Acquisition of List Two

The learning curves on list two were much like those on the first list. Again the saw-toothed effect was observed on the DP learning situation. Other studies have found similar results on last list acquisition (Keppel, 1964, 1965; Underwood et al., 1962).

A greater number of interlist intrusions is predicted for DP subjects by the extinction recovery theory. Although the number was small, the data supported that prediction. The DP subjects had a total of 43 such intrusions and MP had 16.

The concept and no concept groups correctly anticipated a mean of 9.85 and 9.88 items respectively on the fifteenth

training trial. List differentiation did not facilitate acquisition although the concept group had only 3 interlist intrusions and the no concept group had a total of 53.

The subjects that learned lists differentiated by training method, correctly anticipated 9.85 items on the fifteenth training trial. Subjects that learned the lists by the same training method anticipated a mean of 9.88 items on the fifteenth training trial.

Recall

A $2 \times 2 \times 2 \times 2 \times 2$ analysis of variance was performed on the data. The factors were MP or DP on list one (first list training), MP or DP on list two (second list training), list differentiation or nondifferentiation by concept (concept differentiation), recall test one or two (test), and recall of items from list one or two (list).

As was expected, a significant main effect was found for the list factor. A mean of 7.62 and 9.06 items were recalled from the first and second lists respectively, $F(1,88)=38.85$, $P<.001$. The expected superior recall of second list items was confirmed.

A mean of 8.98 items were correctly recalled on the first test and 7.70 items on the second test. The main effect of the test factor was significant, $F(1,88)=117.23$, $P<.001$.

The interaction of first list training and second list training was not significant, $F(1,88) < 1.0$. Neither was a significant main effect found for concept differentiation, $F(1,88) < 1.0$. The interaction of first list training, second list training, and list was not significant, $F(1,88) < 1.0$. The failure of list differentiation either by concept or training method to result in significantly superior retention is damaging to the differentiation position.

The interaction of second list training and test was significant, $F(1,88) = 20.95$, $P < .001$. The DP retention effect was obtained. Distributed practice on the second list (Figure 1) resulted in superior retention of second list items on second recall.

A significant interaction of test and list was found, $F(1,88) = 156.00$, $P < .001$. There was considerable loss of availability of second list items (Figure 2) and some recovery of first list items between recall tests.

There was a significant interaction of second list training and list (Figure 3), $F(1,88) = 17.77$, $P < .001$.

The interaction of second list training, test, and list was significant, $F(1,88) = 60.10$, $P < .001$. The interaction is shown in Figure 4.

A separate analysis of recall scores was performed. The first recall of second list items probably gives an indication of the degree of second list learning as the

Fig. 1.--First and second recall with MP or DP training on the second list.

Fig. 2.--First and second recall of lists one and two.

Fig. 3.--Recall of lists one and two with MP or DP training on list two.

Recall of List One

Recall of List Two

Fig. 4.--Recall of list one and list two with MP or DP training on list two.

test was given immediately following second list acquisition. There was no significant difference in MP and DP training in that recall situation. Mean recall scores of 12.21 and 10.35 were recorded for MP and DP respectively, $F(1,88)=1.14$, $P<.10$.

The difference in first list response availability as a function of second list DP or MP training was not found on first recall test, $F(1,88)<1.0$. These data are consistent with Keppel's (1964, 1965) findings that DP training did not produce greater extinction of prior associations.

On the second recall of second list items the facilitative effects of DP training on the second list are evident (Figure 4). The mean recall scores for DP and MP were 9.04 and 6.29 respectively. The difference was significant, $F(1,88)=23.45$, $P<.001$.

The availability of prior associations was significantly less on second recall of first list items for subjects that learned the second list by DP, $F(1,88)=8.84$, $P<.05$. In Figure 4 it can be observed that prior list recovery and a considerable portion of second list response loss was a function of second list MP training. Such results are consistent with the interpretation that extinction recovery means equal suppression of prior associations under second list MP and DP but greater recovery of those associations under MP suppression (Keppel, 1967).

A significant interaction of first list training and list was found, $F(1,88)=10.42$, $P<.01$. A plot of the interaction is shown in Figure 5.

In a separate analysis of first list recall scores, it was found that on first recall first list MP and DP trained groups recalled a mean 6.65 and 8.17 items respectively. The difference was significant, $F(1,88)=9.80$, $P<.01$. There was no significant difference in first recall of second list items (Figure 6) as a function of training method on the first list, $F(1,88)<1.0$.

Distributed practice was again superior in retention on second recall of first responses. The DP and MP groups recalled a mean of 8.58 and 7.19 first list items respectively, $F(1,88)=5.84$, $P<.05$. There was no significant difference in retention of second list items on second recall as a function of first list MP or DP training, $F(1,88)<1.0$. A plot of the results is shown in Figure 7.

A significant interaction of concept differentiation and list was found, $F(1,88)=7.73$, $P<.01$. List differentiation by concept facilitated recall of first list items, but resulted in somewhat inferior second list recall.

All other interactions in the analysis of variance were not significant.

Fig. 5.--Recall of lists one and two with MP or DP training on list one.

Fig. 6.--First recall with MP or DP training on list one.

Fig. 7.--Second recall with MP or DP on list one.

Response Errors

Three types of errors were made by subjects in recall. The type of error that occurred with the greatest frequency was the response omission (failure to make any response on presentation of a stimulus term). The type error that ranked second in rate of occurrence was the intralist intrusion (assigning a response term to the correct list but pairing it with the incorrect stimulus). Least frequent was the interlist intrusion (assigning a response term to an incorrect list).

Table 1 shows that the recovery of first list DP trained items during the retention interval resulted in a decrease in only one type of response error, omissions. The recovery of first list MP trained items during the retention interval resulted in a decrease in intralist intrusions (11) and omissions (4). In both situations there was an increase in interlist intrusions.

The loss of response availability of second list items during the retention interval resulted in an increase in all three types of response errors. However, the increase in response omissions was the greatest. Of the 205 responses that became unavailable to the second list MP group, 149 became omissions. The second list DP group lost availability of 63 items and had an increase of 45 omissions.

TABLE I
TYPES OF RESPONSE ERRORS IN RECALL

	Correct Responses	Intralist Intrusions	Interlist Intrusions	Response Omissions
	<u>First Recall</u>			
DP-(MP) (DP)	392	62	1	121
MP-(MP) (DP)	328	70	10	168
(MP)-DP (DP)	497	35	2	42
(MP)-MP (DP)	507	33	2	34
	<u>Second Recall</u>			
DP-(MP) (DP)	406	66	3	101
MP-(MP) (DP)	335	59	18	164
(MP)-DP (DP)	434	43	12	87
(MD)-MP (DP)	302	81	10	183

CHAPTER IV

DISCUSSION

Differentiation

The data from the present study offer little support for the differentiation theory. The advantage of DP training in superior retention was not a function of list differentiation either by concept or different training methods.

The failure of differentiation of lists by concept or training method to result in superior retention is damaging to the differentiation position.

Extinction Recovery

Distributed training on the second list resulted in significantly superior retention of second list items on the second recall situation. The extinction recovery position predicted such results. However, the superior retention of first list DP on both recall tests was not anticipated by the extinction recovery position.

Distributed practice on list two did not result in less availability of first list items on the first recall test. On the second recall test there was significantly lower availability of first list items. The change in availability of first list items during the retention interval seems to have been the result of a recovery of first list items

under second list MP and no such recovery for second list DP. These data are consistent with the extinction recovery position.

Second list DP did not result in greater extinction of first list responses. If extinction means, as Keppel (1967) suggested, that the rate of recovery of previous associations is the factor effected rather than the depth of extinction, then the failure of DP training on list two to result in inferior first list recall is not particularly damaging to the theory.

Greater second list availability is not a direct function of lower prior list availability. Although there was lower availability of first list MP items, it did not result in greater availability of second list items.

Mediational

The expectation that DP training would result in superior retention of first list items as well as second list items was confirmed.

The prediction that there would be greater loss of response availability during the retention interval for MP training was confirmed for the second list items but not for first.

Implications

The data from the present study indicate that in paired-associate learning there is less or slower recovery of prior list associations when the last list is learned by the DP method. Massed practice on the last list suppressed prior list associations to the same degree as DP, but allowed greater recovery of those suppressed response items. The data did not support the position that the greater retention of DP is a direct function of the lower availability of previously learned associations.

It is concluded that the focus of attention in paired-associate learning should be the mediational device which links the stimulus and response terms.

There seems to be suppression and recovery of the mediational devices that connect the stimulus and response terms. Strong mediational devices which are developed during training are resistant to suppression. Distributed practice provides for the development of more stable mediators which resist suppression. Massed practice results in a greater number of weak mediational devices which are more susceptible to the effects of interference from competing mediational devices.

Distributed practice on the last list was more successful than MP in permanently suppressing prior mediators. The prior mediational devices recover in strength interfering

with the operation of the weak last list devices. Such a situation results in a decrease in last list recall for the MP condition.

The superior recall of the DP condition is a function of the establishment of strong mediational devices which survive interference. The greater number of weak mediators established by MP do not remain functional. Increases in interference interrupt unstable devices resulting in inferior recall.

CHAPTER V

SUMMARY

Three hypotheses which offer different explanations for the facilitation in retention following distributed practice of the last in a series of A-B, A-C lists were tested. The differentiation hypothesis explains the facilitation as being a function of the different training methods employed on the critical list and prior list(s). The extinction recovery hypothesis explains the facilitation as being a function of greater extinction and/or suppression and less recovery of prior, competing associations. The mediational hypothesis supposes that DP acquisition results in the development of superior mediational devices. To test the theories, subjects were trained by MP and DP on both lists of an A-B, A-C paradigm. Also subjects were trained on differentiated and nondifferentiated lists.

The differentiation hypothesis was not supported since superior DP retention was not a function of list differentiation. The suppression and recovery of prior associations was evident, but superior retention was not a direct function of reduced competition at recall. The data gave support to the notion that DP training establishes superior mediational devices which facilitate retention.

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