

FACTORS INFLUENCING THE MAGNITUDE OF) RECALL-ANTICIPATION
METHOD LEARNING) DIFFERENCE IN PAIRED-ASSOCIATE LEARNING

by

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INTRODUCTION

Since the time of Ebbinghaus psychologists have used list learning as a tool in the study of human learning and memory. Ebbinghaus used a serial learning procedure in his experiments. As investigators began to propose models of list learning processes they encountered problems with the serial learning method. Serial lists were found inadequate in that the stimulus and response characteristics of each item are confounded. That is, each item in a serial list must serve as both a stimulus for the subsequent word and a response to the previous word. In order to isolate the stimulus and response functions of list items, the paired-associate (PA) learning procedure was developed.

In PA learning each response item is presented with a stimulus item which functions only as a cue during the subsequent test trial. The stimulus item is presented alone during a test trial and the subject (S) is asked to respond with the associated response item. PA studies have commonly used one of two methods of presenting a list. The anticipation method is characterized by the presentation of a stimulus item immediately followed by the paired presentation of that item and its associated response (see Table 1b). A trial consists of the presentation of all N pairs of the list, each preceded by the presentation of the stimulus item alone. The S's task is to anticipate the correct response during the stimulus item presentation. The S is run until he has reached a specified criterion of performance, or until a predetermined number of trials have transpired. It is important to note that learning cannot be measured in this procedure until the second trial. In the recall method of PA learning all pairs are presented in a random sequence, followed by the presentation of all the stimulus items in a different random order

TABLE 1

Schematic Representation of the Recall and Anticipation
Methods of Presenting Paired-associate Lists

a. Recall Method			b. Anticipation Method		
<u>Trial</u>		<u>Lag</u>	<u>Trial</u>		<u>Lag</u>
1	S ₁ -R ₁		1	S ₁ -	
	S ₂ -R ₂			S ₁ -R ₁	
	S ₃ -R ₃			S ₂ -	
	S ₄ -R ₄			S ₂ -R ₂	
	S ₅ -R ₅			S ₃ -	
(Within-Trial Interval)				S ₃ -R ₃	
	S ₄ -	(1)		S ₄ -	
	S ₃ -	(3)		S ₄ -R ₄	
	S ₁ -	(6)		S ₅ -	
	S ₂ -	(6)		S ₅ -R ₅	
	S ₅ -	(4)	(Between-Trial Interval)		
(Between-Trial Interval)					
2	S ₃ -R ₃		2	S ₄ -	(2)
	S ₁ -R ₁			S ₄ -R ₄	
	S ₅ -R ₅			S ₃ -	(6)
	S ₂ -R ₂			S ₃ -R ₃	
	S ₄ -R ₄			S ₁ -	(12)
(Within-Trial Interval)				S ₁ -R ₁	
	S ₅ -	(2)		S ₂ -	(12)
	S ₄ -	(1)		S ₂ -R ₂	
	S ₂ -	(3)		S ₅ -	(8)
	S ₁ -	(6)		S ₅ -R ₅	
	S ₃ -	(8)	(Between-Trial Interval)		
(Between-Trial Interval)					

(see Table 1a). Thus, in this procedure, study of the pairs is temporally blocked and separated from retrieval of the responses during testing (i.e., the presentation of the stimulus items alone).

Both the recall and anticipation methods of list presentation were used early in the history of PA learning studies. During the late 1940's the anticipation method began to dominate the literature and became accepted as the "standard" method of presenting a PA list (McGeoch, 1942; see Fig. 1 in Battig, 1965). It was commonly assumed that the anticipation method resulted in optimal PA learning. However, as research problems demanded more analytical treatment of PA learning, many deficiencies of the anticipation method became apparent. In a major critique, Battig (1965) noted that it is impossible to determine how much S has learned at the end of any given trial since some learning immediately follows any measure of the learning state of S. Due to problems with the anticipation method such as this, the recall method made a noticeable resurgence in the verbal learning literature. The frequent use of both methods made it necessary to directly compare learning rates under the two methods in order to adequately evaluate the literature.

Studies Comparing Recall and Anticipation Learning

Battig and Brackett (1961) made the initial direct empirical comparison between the recall and anticipation methods. Their data indicated a large, statistically significant, advantage of learning by the recall method. However, subsequent recall-anticipation comparisons have yielded equivocal results, with some studies replicating Battig and Brackett's (1961) original finding (e.g., Battig, Brown, & Nelson, 1963, Exp. 4; Battig & Wu, 1965; Cofer, Diamond, Olsen, Stein & Walker, 1967, Exp. 1 & 2),

and others showing no significant effect of method on learning rate (e.g., Lockheart, 1962; Battig, et.al., 1963, Exp. 1; Bruder, 1969). In an extensive search of the literature I have found 31 studies which have compared the two learning methods directly. Of the twenty-three studies that used the standard recall and anticipation methods, only nine report significant recall superiority. Eleven of the studies that found no significant recall-anticipation method learning difference did show a small numerical advantage for the recall method, while only three studies showed the advantage to be in the other direction. Eight studies used variants of these methods, six showing the variant recall methods to be superior to the anticipation method. The existing literature therefore, poses two problems. Not only is it necessary to discover the factor(s) underlying recall superiority, but it is also necessary to isolate the factor(s) which produce the inconsistencies found in the literature. Many experiments comparing recall and anticipation have been attempts to isolate the factor(s) involved in producing these inconsistencies.

These studies can be divided into three groups. One set of studies has examined the effect of the characteristics of the material to be learned on the magnitude of recall-anticipation differences. A second set has examined the effect of manipulating task variables that are common to both methods. A third group of studies has focused on inherent procedural differences between the methods.

List Characteristics

In general, studies attempting to relate characteristics of the list to the superiority of the recall method have yielded negative results. For instance, many studies have shown that within and between pair similarity does not interact with method of list presentation

(Battig & Brackett, 1963; Behring & Zaffy, 1965; Goss & Nodine, 1965, Exp. 8 & 10; Cofer, et.al., 1967, Exp. 2 & 3). Similarly, most studies have shown that meaningfulness of stimuli and responses does not interact with method of PA learning (Battig, et.al., 1963; Goss & Nodine, 1965, Exp. 7, 9 & 11; Wright, 1967), although Elmes and Lovelace (1967) did find a small but significant effect of this variable. Despite the results of the latter study, it seems fairly safe to conclude that the meaningfulness of the material to be learned is not a strong factor in the magnitude of recall method learning superiority.

Task Variables

Varying procedures that are common to both methods of list presentation has also failed to show any significant interaction with the magnitude of the difference between rate of learning by the recall and anticipation methods. Cofer, et.al. (1967, Exp. 1) used three rates of item presentation (1, 3, or 5 seconds) in comparing the recall and anticipation methods. Although lengthening item presentation time facilitated performance, it did not interact with method of list presentation. Similarly, response familiarization (Cofer, et.al., 1967, Exp. 4) and constant list order (Battig, et.al., 1963, Exp. 1) aided learning equally under both methods of list presentation. Varying list length also does not appear to interact with presentation method (Goss & Nodine, 1965, Exp. 9; Cofer, et.al., 1967, Exp. 5).

Procedural Differences

The most productive approach to discover the variables underlying recall method superiority and the variation in magnitude of that superiority has been to isolate the inherent procedural differences between the recall and anticipation methods. That is, differences between methods

that result from the defining characteristics of each method. Three such differences shall be considered. They are (a) the temporal separation of study and test; (b) the mean number of items intervening between study and test (lag); and (c) the presence of a within-trial interval in the recall method.

The temporal separation of study and test in the recall method was first cited as a factor in recall method superiority by Battig and Brackett (1961). They proposed that the temporal blocking of input and output processes could facilitate learning by enhancing "the identification of the set of materials to be learned" and/or by separating "the two behavioral processes of producing a previously learned correct response and learning new stimulus-response associations (pp. 63-64)." Battig and Brackett (1963) tested this hypothesis by varying the percent occurrence of response members appearing with stimulus members ($\%ORM$) during the study segment of the recall method. When a test item (stimulus alone) appeared during study segment S was instructed to give the appropriate response. These responses were not scored. Thus, the 50% ORM condition approximates the anticipation method. They found that with total number of pair presentations equated, the 100% ORM group performed significantly better than the 50% ORM group, supporting a temporal separation of task effect. Battig and Wu (1965) mixed the recall and anticipation methods so that anticipation units (S_1 - followed by S_1-R_1) were interspersed among either recall method pair or test presentation. Performance was significantly better when recall pairs were isolated, leading the authors to conclude that temporal separation of the recall pairs is responsible for the superiority of this method. Cofer, et.al. (1967, Exp. 4) expected response familiarization to

counteract the facilitative effects of segregation of functions and therefore to decrease the magnitude of recall method superiority. No difference was found between recall and anticipation learning under response familiarization. However, no recall-anticipation learning difference was found under normal conditions either. Thus, although these studies offer support for the importance of the separation of tasks in recall method learning superiority, there are two problems with this formulation. First, it can only be tested by altering one of the methods of list presentation. Therefore, any empirical test of this factor can only be indirectly related to recall-anticipation comparisons. Second, the separation factor cannot account for the inconsistencies in finding recall method superiority since it is present to facilitate the recall procedure in all comparisons of methods.

Two other procedural differences have been incorporated into a model of recall and anticipation learning proposed by Izawa (1972). Her model proposes that performance will decrease as the mean retention interval between the studying and testing of items increases. The retention interval is equivalent to the duration of the time interval between presentation of the pairs and subsequent testing (i.e., the within-trial interval in the recall method and the between-trial interval in the anticipation method) plus the product of the mean lag (i.e., the mean number of items intervening between study and test of any given item) and the duration of item presentation. Formally, the mean absolute retention intervals for the recall and anticipation methods can be expressed as (Izawa, 1972, p. 18):

$$\text{Int}(R-T)_{\text{rec}} = (\underline{n}-1) \underline{d} + (\text{intercycle interval}) \quad (1)$$

$$\text{Int}(R-T)_{\text{ant}} = 2(\underline{n}-1) \underline{d} + (\text{intercycle interval}) \quad (2)$$

Where n represents the number of items in the list and d is equivalent to the duration of stimulus presentation. The intercycle interval is the interval that occurs between pair study and its subsequent testing. This interval will be called the study-test interval in this paper.

Since Izawa's formal model explicitly emphasizes the importance of lag and within- (or between-) trial interval factors in recall anticipation comparisons, it seems appropriate to assess each of these factors.

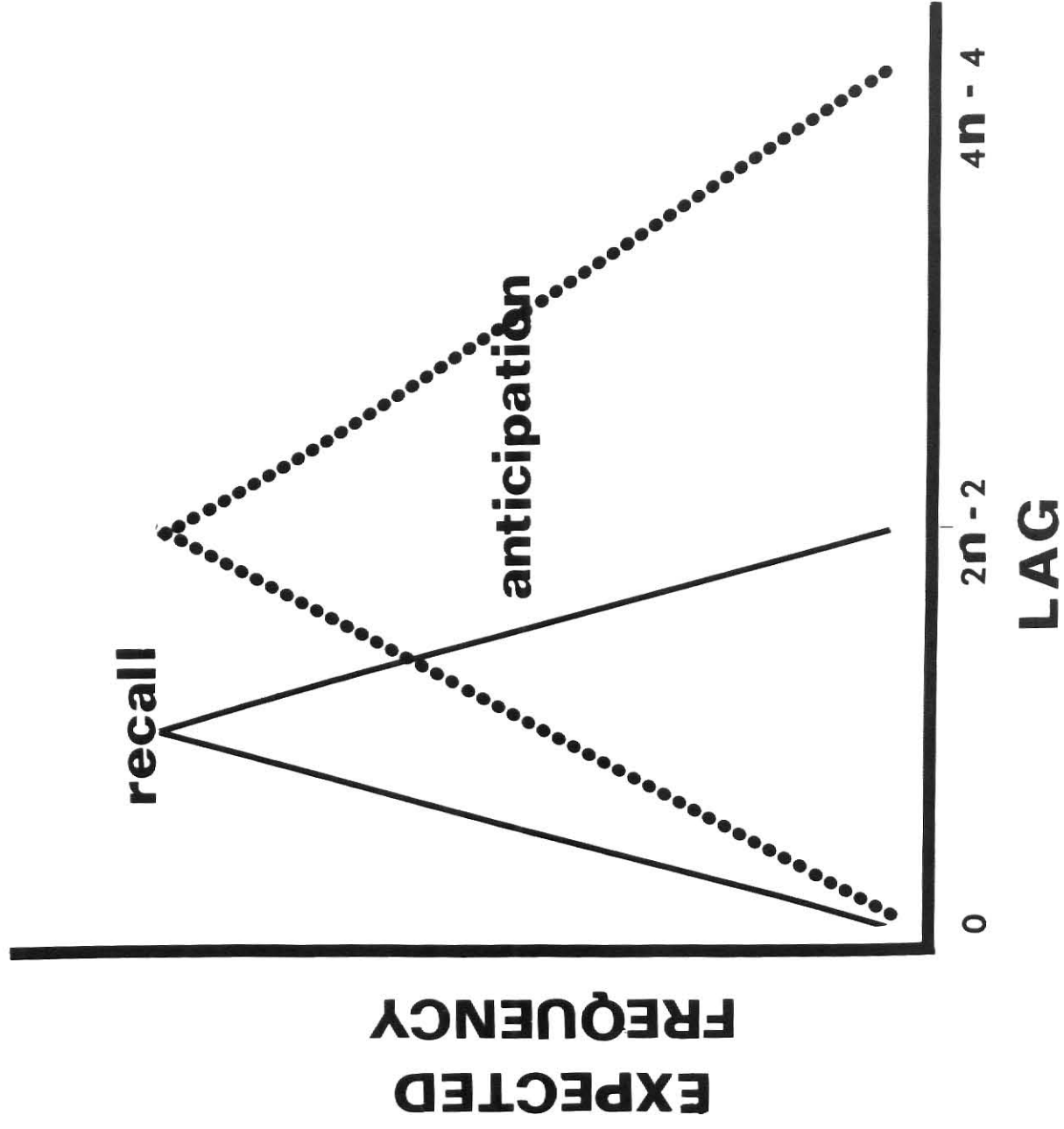
Lag

The difference in lag under the two methods could certainly account, at least in part, for the superiority of the recall method. Specifically, pairs are presented and tested during the same trial in the recall method whereas pairs are presented and then tested on the subsequent trial in the anticipation method. Hence, there are fewer tests occurring after short lags in the anticipation method. If performance deteriorates as lag increases in a multi-trial PA procedure, as it does both in single-trial PA learning (Tulving & Arbuckle, 1963) and continuous PA learning (Bjork, 1966), then it is clear that differences in lags between the two methods would produce faster learning under the recall method of list presentation. While it is obvious that the difference in lag between the two methods could account for the superiority of the recall method, it is not obvious how this difference could be used to explain the variation in the magnitude of the superiority of the recall method.

The expected frequency distributions of lags under the recall and anticipation methods for an infinite number of random orders of list presentations is shown in Figure 1. Despite the recall method's shorter mean lag and greater number of items falling into short lag positions, Izawa (1972) has argued that "the relatively large overlapping

Figure Caption

Fig. 1. The expected lag distributions for the recall and anticipation methods of learning a list of n pairs presented in random orders. It should be noted that the anticipation distribution is not actually a continuous function since odd numbered lags are impossible in this method.



area under both curves" indicates "the existence of some probability that the two methods may produce identical performances (p. 18)." However, she never explains how this is functionally possible. In fact, the previous inconsistencies can be explained only if the shapes of these distributions are assumed to vary from one experiment to another, thus allowing for a variation of the difference between methods in the number of items falling into short lag positions. Given the several random orders of list presentation typically used in PA studies, it is difficult (if not impossible) to imagine systematically skewing the expected distributions of lags so as to reduce (or increase) the advantage of the recall method. It is most unlikely, therefore, that changes in lag distributions for the two conditions is the essential factor in the variability in recall-anticipation comparisons.

Within- and Between-trial Intervals

The distribution of practice by the insertion of a long unfilled time interval between trials has been the subject of a plethora of studies in the past. A great bulk of the work in this area has been done by Underwood and his associates (see Underwood, 1961 for a review). Underwood used the anticipation method of list presentation and he distributed practice by lengthening the between-trial interval. The results of these studies generally indicated that the distribution of practice had little, if any, facilitory effect on PA learning. It should be noted, however, that while only the duration of the between-trial interval can be varied in the anticipation method, the duration of the within-trial interval as well as the between-trial interval may be varied in the recall method. Battig and Brackett used a 30 sec. within-trial interval in their 1961 study, but discounted this as a

possible reason for faster recall method learning because of Underwood's results. The generalization of Underwood's results to the recall method may not have been justified, however.

Izawa (1971), using the recall method, examined the effect of lengthening the within-trial interval, i.e., the study-test interval, on performance. She found significantly faster PA learning when this interval was lengthened from 0 to 24 seconds. Consistent with Underwood's results, no significant facilitation was produced by increasing the duration of the between-trial interval in either the anticipation method or the recall method. (Note that this is the study-test interval for the anticipation method but not for the recall method). Thus, the lengthening of the rest interval between study and test in the recall method (the within-trial interval) facilitated performance, while manipulation of the interval between study and test in the anticipation method (the between-trial interval) did not effect learning. Although Izawa did not directly compare the two methods, these data certainly suggest that increasing the study-test interval will result in superior performance under the recall method. The fact that all studies which have used substantial within-trial intervals in the past (Battig & Brackett, 1961; Battig & Wu, 1965; Cofer, et.al., 1967, Exp. 1) have found large and significant recall method superiority adds support to this notion.

Izawa's equations (1 & 2 above) suggest the importance of distribution of practice in determining the magnitude of recall method superiority. According to these formulas, increasing the within-trial interval would increase the mean retention interval and therefore worsen performance. However, Izawa discounts this factor completely since study-test rest

intervals are "held constant under both anticipation and RT (recall) methods. (p. 17)."

Her reasoning in discounting the effect of the study-test interval has two faults. First, Izawa's previous work (1971) indicates that even though interval lengths may be held constant in a single study, they can and do differentially influence learning. That is, longer study-test intervals facilitate learning by the recall method and have no effect on anticipation method learning rate. Secondly, the interval between study and test has not been held constant in past studies comparing the recall method with the anticipation method. While between-trial intervals have generally been equated between methods, the length of the study-test interval in the recall method (i.e., the within-trial interval) has varied, sometimes being equal to the study-test interval in the anticipation method (i.e., the between-trial interval), but often being shorter. Since the "intercycle interval" referred to by Izawa is equivalent to the study-test interval, it is apparent that her reasoning is questionable.

In summary, then, it seems most probable that the factors suggested by Izawa do contribute to the differential learning rates found for the recall and anticipation methods--but not in the way Izawa suggests. Specifically, while lag effects may contribute in part to the superiority of the recall method, it is unlikely that such effects could account for variations in the magnitude of that superiority. On the other hand, varying the interval during which no items are presented (i.e., the within-trial or between-trial interval) has differential effects on the two methods and such a manipulation could, therefore, account for the variation in the magnitude of recall superiority.

The primary goal of this study was to directly measure the effect that lengthening of the within-trial interval in the recall method has on the magnitude of the recall-anticipation learning difference. Hence, recall groups with short (3 sec.) and long (24 sec.) within-trial intervals were compared with an anticipation group. Because rehearsal during the within-trial interval may be the critical factor in facilitating subsequent recall, an additional recall group was added in which the 24-sec. within-trial-interval was filled with a rehearsal-preventing task.

METHOD

Subjects. Ninety Ss were drawn from the undergraduate student population at Kansas State University. Some Ss received extra-credit in their introductory psychology class, while others were paid for participating in the experiment. None of the Ss had participated in a PA study prior to this study.

Design. The Ss were assigned randomly to one of four groups. One group of 36 Ss learned the 12-item list under the anticipation method of list presentation (Group A). The three other groups of 18 Ss each were run under the recall method with the characteristics of the within-trial interval different for each group. The Ss in Group R_3 had a 3-sec. within-trial interval, while Ss in Group R_{24} had a 24-sec. interval added between the study and test segments of a trial to distribute practice. Group R_{24f} had a 24-sec. within-trial interval filled with a shadowing task meant to limit Ss opportunity for rehearsal.

Materials. The list consisted of 12 pairs. The S-terms of the pairs were CVC's of medium association value ($\bar{X} = 71\%$; Archer, 1960) chosen for ease of pronouncability ($\bar{X} = 2.7$; Underwood & Schultz, 1960). Two digit numbers of low association value ($\bar{X} = 1.06$; Battig & Spera, 1962) served as R-terms. The 12 S-and 12 R-terms were combined randomly to create the pairs. The stimuli were presented visually on the wall in front of S by means of a slide projector. The shadowing task, which filled the interval for Group R_{24f} consisted of a list of 2-syllable nouns, presented one per second auditorily by means of a tape recorder. Ss given the shadowing task were required to repeat (echo) each word and were led to believe that performance on the shadowing task was being monitored.

A different random order of list presentation was used for each S. Thus, it was very unlikely that any deviations from the expected lag distributions (Figure 1) would occur.

Procedure. Each S, tested individually, learned the same 12-pair list to a criterion of two successive errorless trials or to a maximum of ten trials, whichever came first. The Ss were instructed to vocalize the correct response during pair presentation and to respond verbally to the test stimuli if they thought they knew the response. Guessing was encouraged.

Stimulus presentation time was 3 sec. and all groups had a 6-sec. between-trials interval. The within-trial interval was varied in the recall method groups as described above. There is no within-trial interval in the anticipation method.

Since no learning measure is possible on Trial 1 in the anticipation method, a Trial 0 preceded Trial 1 in both methods. This trial consisted of a normal anticipation trial in the anticipation condition and was a presentation of the test stimuli alone in the recall conditions. Thus, testing on Trial 1 was preceded by one presentation of the test stimuli and one presentation of the pairs in both methods.

RESULTS

Effect of Within-trial Interval

The criterion of two successive correct trials was reached by 15 of the 90 Ss before Trial 10. The mean number of trials to criterion for these Ss was 6.93 trials, with no S reaching criterion in less than five trials. Twelve of these 15 Ss were in a recall group with a 24 sec. within-trial interval (7 in Group R_{24} ; 5 in Group R_{24f}), whereas only 2 of 18 Ss in Group R_3 and one S in Group A reached this criterion.

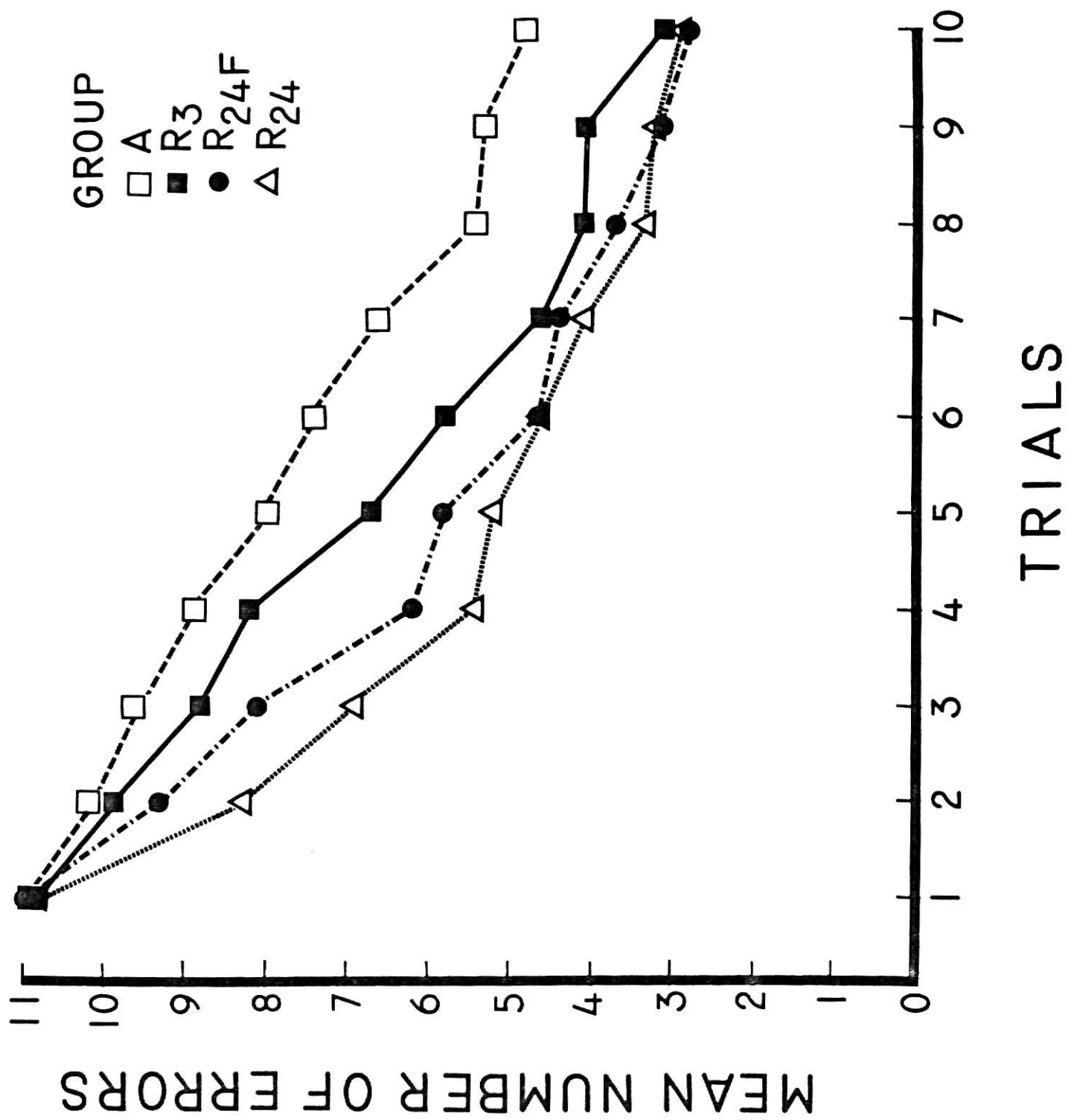
The mean number of errors made on each trial for the four groups is shown in Figure 2. As can be seen, performance was virtually equivalent for all groups at the outset of learning (Trial 1). However, the groups quickly diverged as learning progressed with overall performance being best for Groups R_{24} ($\bar{X} = 54.7$ errors) and R_{24f} ($\bar{X} = 59.2$), poorest for the A Group ($\bar{X} = 77.4$) and intermediate for Group R_3 ($\bar{X} = 66.1$). The analysis of variance performed on these data showed a significant main effect of Groups, $F(3,86) = 3.24$, $p = .05$, a significant main effect of Trials $F(9,774) = 256.76$, $p = .01$ and a significant Trials x Groups interaction $F(27,774) = 2.76$, $p = .01$. The interaction reflects that, as noted above, all groups start at the same error level on trial one and decrease at different rates. A Newman-Keuls post-test performed on the mean number of errors per group revealed that except for the comparison between Groups R_{24} and R_{24f} , all pairwise comparisons were reliably different.

Effect of lag

To determine whether lag had a reliable effect on performance, an analysis was done comparing the mean lag on the trial in which pairs were recalled correctly for the first time (first correct response) with

Figure Caption

Fig. 2. Mean number of errors as a function of trials for the four experimental groups.



the mean lag for the trials prior to the first correct response (before errors). If the probability of a correct response decreases as lag increases, then it would be expected that the mean lag on the trial of the first response would be reliably shorter than the mean lag of the before errors. The obtained means are presented in Table 2. As expected, the mean lag on the trial of the first correct response was shorter than the mean lag of the before error trials. Separate analyses were performed on the recall and anticipation data because the mean and variance of anticipation lags are theoretically (Figure 1) and empirically twice as great as recall lag means and variances. The analysis based on the anticipation group data showed a significant effect of Learning State (first correct response vs. before errors) $F(1,35) = 15.61, p .01$. The analysis based on the recall group data also indicated a significant main effect of Learning State, $F(1,51) = 37.03, p .01$, as well as a significant Learning State x Within-trial interval length interaction, $F(2,51) = 4.10, p .05$. This unexpected interaction was caused by the relatively small effect of lag in the R_3 condition. A post-analysis showed a significant effect of Learning State on lag for Groups R_{24} and R_{24f} , $t(17) = 3.97, p .01$. Learning State did not have a significant effect on lag in Group R_3 , $t(17) = 1.60$.

Another more traditional way of assessing the effect of lag is to plot the probability of a correct response as a function of lag. These data are presented in Figure 3 for each of the four groups and are based on before errors and first correct responses only. Subsequent trials were ignored because lag was assumed to effect the probability of a correct response prior to the first correct response, but to have little effect subsequent to the first correct response. As would be

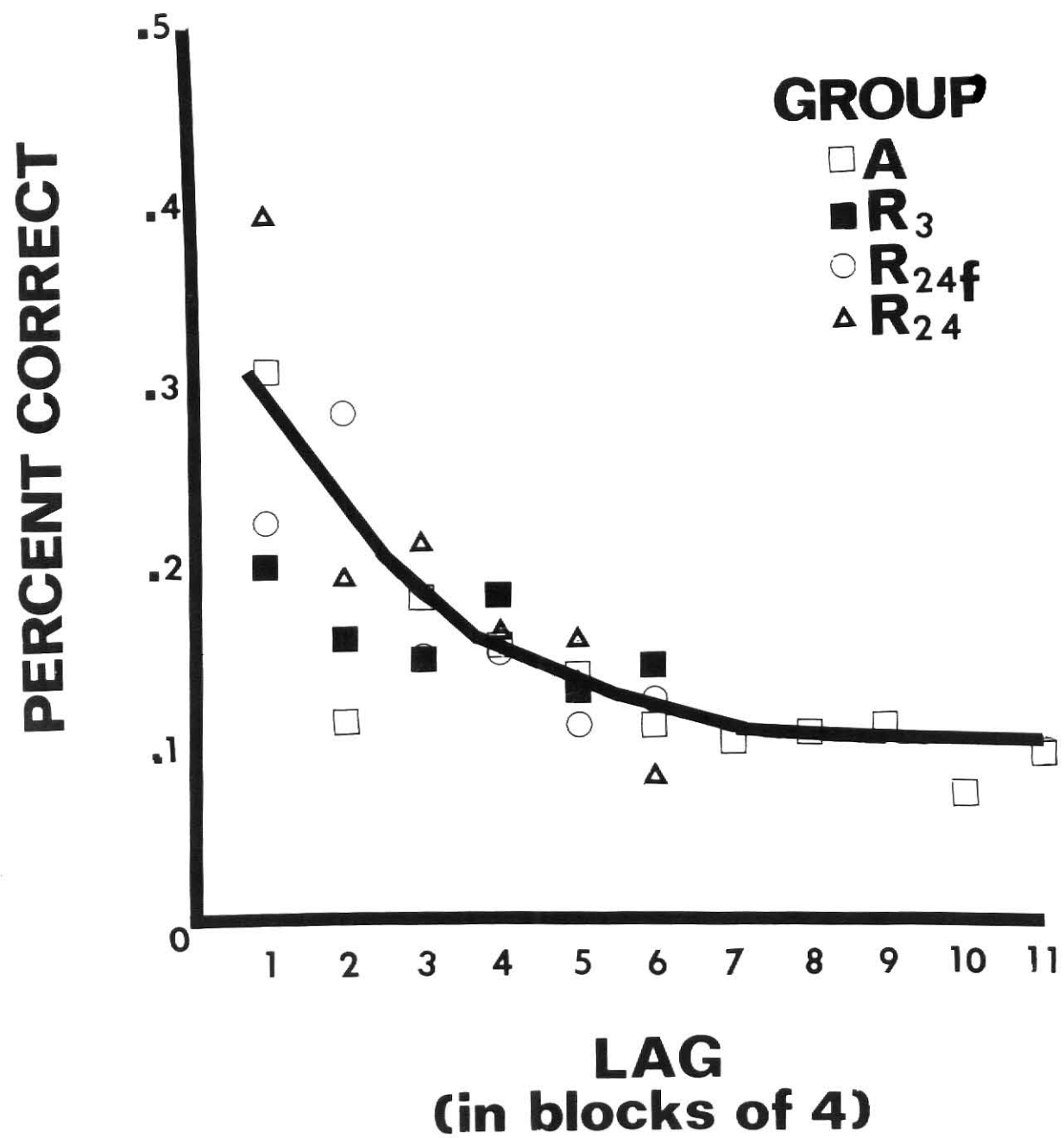
TABLE 2

Mean Lag on Trial of First Correct Response and on Trials
prior to the First Correct Response (Before Errors)
for all Learning Method Conditions

Learning Method Condition				
	R_{24}	R_{24f}	R_3	A
Before Errors	11.30	11.41	11.02	22.19
First Correct	9.84	9.46	10.54	19.15

Figure Caption

Fig. 3. Probability of a correct response (no. first correct/no. before errors + no. first correct) as a function of lag.



expected from the frequency distributions of Figure 1, the number of data points at each lag varies widely and these data are presented for descriptive purposes only. The curve drawn in Figure 3 is a smoothed approximation of the mean probability of a correct response averaged over all groups at each lag block. The expected decreasingly accelerated negative slope appears to be present in all groups, although the data contain a good deal of noise.

To determine whether the use of a different random order for each S eliminated biases in lag distributions, the proportion of items in short lag positions (arbitrarily defined as 0-6 intervening items), was calculated for each group. The proportions were .206, .198, and .196 of the items for the R_{24} , R_{24f} , and R_3 groups, respectively. The expected proportion derived from the hypothetical recall lag distribution in Figure 1 is .196 when $n = 12$. Since the proportion of items in short lag positions is virtually identical in all recall groups ($F = 1$) and these proportions were virtually identical to the expected proportion, it may be concluded that no lag bias was present. The expected and observed proportions of items in short lag positions in the anticipation group were .070 and .066 respectively. The obtained proportion was also extremely similar to its expected value in this group and, as expected, was much lower than that for the recall groups. As noted earlier, the recall condition yields many more items in short lag positions than does the anticipation method.

DISCUSSION

The results of this study clearly support the hypothesis that increasing the within-trial interval in the recall method will increase the difference between recall and anticipation PA learning rates. The 24-sec. within-trial interval produced reliably better recall than the 3-sec. interval. It is not particularly surprising, therefore, that studies which have used short within-trial intervals have not consistently shown the recall method to be statistically superior to the anticipation method. In fact, if the data of this study are reanalyzed as simple t-test comparisons between the anticipation group and each recall group, the anticipation group differs reliably from both of the 24 sec. interval recall groups, but not from the 3 sec. recall group. This becomes the fourth study comparing the methods which used a within-trial interval of substantial length and all four studies have found large and reliable differences in PA performance between the two methods.

Thus, it seems likely that the inconsistencies found in the literature are due to the failure of most studies to employ a study-test interval of substantial duration in the recall method (i.e., the within-trial interval).

While the evidence clearly indicates a major effect of lengthening the study-test interval on recall method performance, it is puzzling that no comparable effect is found in the anticipation method. Although there are no data in this experiment which speak directly to this problem, it is my belief that the solution may be related to the strong possibility that there are more correct pairs available at the onset of the study-test interval in the recall method than are available in the anticipation method. Recall method pairs should be more available upon entering this

interval for two reasons. First, there are, on the average, twice as many intervening presentations between pair study and study-test interval in the anticipation method. Second, only correct pairs directly precede the within-trial in the recall method whereas in the anticipation method incorrect test trials may directly precede the between-trial interval. Therefore, at the onset of the study-test interval in the anticipation method there is a high probability that S has paired a wrong response with a stimulus item. The substitution of incorrect responses would then lower the availability of correct pairs. The greater availability of correct pairs during the within-trial interval may account for the ability of Ss to use this interval to facilitate performance.

Given this basic difference in availability of pairs, there are at least four potential mechanisms which could be operating during the study-test interval to facilitate subsequent performance. The first is rehearsal. However, rehearsal can probably be eliminated as the primary causal agent because the recall group which was tested after a filled interval (R_{24f}) was not reliably different from the recall group which was tested after an unfilled interval (R_{24}). Although it is possible to argue that activity during the filled interval did not eliminate rehearsal, it would seem very likely that the intervening activity would greatly reduce rehearsal. Failure to find a reliable difference between the two groups, therefore, strongly suggests that rehearsal is not the critical mechanism. The second possible mechanism is consolidation--that is, facilitation dependent only on the passage of time. Again, consolidation can probably be eliminated as the critical mechanism on the grounds that the between-trial interval in the anticipation procedure

should provide as much opportunity for consolidation as the within-trial interval in the recall method. As pointed out in the introduction, changing the lengths of these two intervals does not produce equivalent effects. The third possibility is the temporal separation hypothesis proposed by Battig and Brackett (1961). Increasing the time during which no list-related task is performed could serve to further separate learning and testing into two distinct tasks and thereby facilitate performance. Unfortunately, that hypothesis is difficult to test without altering the methods of list presentation. A fourth possibility is that Ss change their strategy for encoding the material as characteristics of the within-trial interval vary. There is now developing considerable evidence that Ss change their strategy for recall as the conditions of retention change (e.g., Roenker, 1973; Craik & Watkins, 1973).

Although the present study was not designed to test either the differential encoding or separation hypotheses, both would seem to be plausible candidates for the mechanism underlying facilitation of recall through an extended within-trial interval.

Although the within-trial interval seems to be a likely candidate to account for the failure to replicate recall method superiority, there are eight studies which did not use lengthy within-trial intervals and yet report significant recall method superiority. Two of these studies contain severe methodological impurities which favor recall method learning. Behring & Zaffy (1965) used the standard anticipation procedure but presented all recall pairs simultaneously. This procedure allowed S to give unequal consideration to different subsets of the list in the recall condition. Cavanaugh & Parkman (1971) inserted a two second interval between the presentation of stimuli. This manipulation

has been shown to facilitate recall method learning, but to have no effect on anticipation method learning (Izawa, 1971). Therefore, it is not surprising that these studies find large recall-anticipation learning differences. However, the six remaining studies (Battig, et.al, 1963, Exp. 4; Cofer, et.al., 1967, Exp. 2; Goss & Nodine, 1965, Exp. 7; Izawa, 1972, Exp. 2; Schild & Battig, 1969, Exp. 1; Wright, 1967) all seem to be methodologically sound.

Evidence from these six studies, along with the fact that the majority of studies that found no significant difference between methods did show a numerical recall method advantage, suggest that other factors may contribute to recall method learning superiority. The present study indicates that lag is, at least in part, responsible for the small, but consistent, superiority of the recall method. The lag data show that performance declines in a negatively accelerated fashion as lag increases. This lag function favors recall method learning because a much higher proportion of items are tested after short lags in this procedure. The lag effect cannot be very robust however, since it is present in all studies which do not report significant recall method superiority.

The present experiment, taken together with the studies just discussed and all other previous recall-anticipation comparisons, provides conclusive evidence that lengthening the within-trial interval in the recall method increases the superiority of that procedure over the anticipation method of PA learning. Thus, it seems likely that the many failures reported in replicating Battig and Brackett's (1961) results can be attributed to the short within-trial intervals used in those studies. That is not to suggest that the magnitude of the within-trial interval is the only variable contributing to differences between recall and

anticipation PA learning. The results of this study indicate that there are multiple causes for superior recall method learning over the anticipation method with two of these causes being the inclusion of a within-trial interval to distribute practice in the recall method and the relatively high frequency of items tested after short lags in this method.

REFERENCES

- Archer, E. J. A re-evaluation of the meaningfulness of all possible CVC trigrams. Psychological Monographs, 1960, 74, (10, Whole No. 497).
- Battig, W. F. Evidence that recall-anticipation differences increase with increasing time intervals. Journal of Experimental Psychology, 1973, 100, 399-402.
- Battig, W. F. Procedural problems in paired-associate research. Psychonomic Monograph Supplements, 1965, 1, No. 1.
- Battig, W. F., & Brackett, H. R. Comparison of anticipation and recall methods in paired-associate learning. Psychological Reports, 1961, 2, 59-65.
- Battig, W. F., & Brackett, H. R. Transfer from verbal-discrimination to paired-associate learning: II. Effects of intralist similarity, method, and percentage occurrence of response members. Journal of Experimental Psychology, 1963, 65, 507-514.
- Battig, W. F., Brown, S. C., & Nelson, D. Constant vs varied serial order in paired-associate learning. Psychological Reports, 1963, 12, 695-721.
- Battig, W. F., & Spera, A. J. Rated association values of numbers from 0-100. Journal of Verbal Learning and Verbal Behavior, 1962, 1, 200-202.
- Battig, W. F., & Wu, R. D. Comparison of recall and anticipation paired-associate procedures within mixed aurally-presented lists. Psychonomic Science, 1965, 3, 233-234.
- Behring, D. W., & Zaffy, D. J. Study-test and anticipation methods in paired-associate learning of similar and non-similar lists. Psychological Reports, 1965, 16, 1237-1241.
- Bjork, R. A. Learning and short-term retention of paired-associates in relation to specific sequences of inter-presentation intervals. Report No. 106, Institute for Mathematical Studies in the Social Sciences, Stanford University, Stanford, 1966.
- Bruder, G. A. Effects of method of presentation on paired-associate learning. Journal of Experimental Psychology, 1969, 79, 383-384.
- Cavanaugh, J. P., & Parkman, J. A. A comparison of the study-recall and anticipation methods in steady state paired-associate learning. Psychonomic Science, 1971, 22, 361-363.
- Cofer, C. N., Diamond, F., Olsen, R. A., Stein, J. S., & Walker, H. Comparison of anticipation and recall methods in paired-associate learning. Journal of Experimental Psychology, 1967, 75, 545-558.

- Craik, F. I. M., & Watkins, M. J. The role of rehearsal in short-term memory. Journal of Verbal Learning and Verbal Behavior, 1973, 12, 599-607.
- Elmes, D. G., & Lovelace, E. A. Meaningfulness and presentation method in paired-associate learning. Journal of Verbal Learning and Verbal Behavior, 1967, 6, 296-297.
- Goss, A. E., & Nodine, C. F. Paired-Associate Learning, New York: Academic Press, 1965.
- Ingison, L. J., & Ekstrand, B. R. Effects of study time, methods of presentation, word frequency, and word abstractness on verbal discrimination learning. Journal of Experimental Psychology, 1970, 85, 249-254.
- Izawa, C. Massed and spaced practice in paired-associate learning: List versus item distributions. Journal of Experimental Psychology, 1971, 89, 10-21.
- Izawa, C. Retention interval hypothesis and evidence for its basic assumptions. Journal of Experimental Psychology, 1972, 96, 17-24.
- Lockhead, G. R. Methods of presenting paired-associates. Journal of Verbal Learning and Verbal Behavior, 1962, 1, 62-65.
- McGeoch, J. A. The Psychology of Human Learning, New York: Longmans-Green, 1942.
- Roemaker, D. L. The role of rehearsal in long-term retention. Unpublished doctoral dissertation, Kansas State University, 1973.
- Schild, M. E., & Battig, W. F. Directionality in paired-associate learning. Journal of Verbal Learning and Verbal Behavior, 1966, 5, 42-49.
- Tulving, E., & Arbuckle, T. Y. Sources of intratrial interference in immediate recall of paired-associates. Journal of Verbal Learning and Verbal Behavior, 1963, 1, 321-334.
- Underwood, B. J. Ten years of massed practice on distributed practice. Psychological Review, 68, 229-247.
- Underwood, B. J., & Schultz, R. W. Meaningfulness and Verbal Learning. Philadelphia: Lippincott, 1960.
- Wright, J. H. Effects of stimulus meaningfulness, method of presentation, and list design on the learning of paired-associates. Journal of Experimental Psychology, 1967, 73, 72-77.

FACTORS INFLUENCING THE MAGNITUDE OF RECALL-ANTICIPATION
METHOD LEARNING DIFFERENCE IN PAIRED-ASSOCIATE LEARNING

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ABSTRACT

The recall method in paired-associate learning has usually, but not always, been found to be superior to the anticipation method of presenting paired-associates. In this study the magnitude of this difference was shown to increase as the length of the within-trial interval increased in the recall method. It was noted that only those studies which used short within-trial intervals fail to consistently show the recall method to be statistically superior to the anticipation method. Recall method learning rate was not affected when the within-trial interval was filled, suggesting that rehearsal is not responsible for the facilitory effect of this interval. Alternate mechanisms were suggested.

The relationship between the lag between study and test of pairs and performance was also examined to determine the role of lag in recall method superiority. Performance was found to decline assymtotically as lag increased. It was concluded that the lag factor provides a small but consistent recall method learning advantage over the anticipation method.