75-3300

EVANS, James David, 1946-
THE LAG EFFECT IN FREE RECALL: DIFFERENTIAL ENCODING OR DIFFERENTIAL REHEARSAL?

Iowa State University, Ph.D., 1974
Psychology, general

Xerox University Microfilms, Ann Arbor, Michigan 48106

The lag effect in free recall: Differential encoding or differential rehearsal?

by

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A Dissertation Submitted to the
Graduate Faculty in Partial Fulfillment of
The Requirements for the Degree of
DOCTOR OF PHILOSOPHY

Major: Psychology

Approved:

In Charge of Major Work

For the Major Department

For the Graduate College

Iowa State University
Ames, Iowa

1974

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INTRODUCTION

Perhaps no phenomenon in the field of memory possesses more theoretical significance or practical importance then the facilitating effect of distributed practice. On the practical side, the implications are obvious. If you desire to have someone retain some piece of information, does it make any difference whether you present this information several times in immediate succession or offer it on several different occasions that are relatively far apart in time? Relatedly, should repeated information be delivered in the same way (i.e., words, context) each time it is given, or would the learner benefit to a greater extent from varied presentations? These questions appear to possess considerable relevance for educators and applied psychologists in general.

On the theoretical side, psychological processes underlying the enhancing effect of repeated learning trials are at the very heart of theories of learning and memory (cf. Melton, 1963). The issue of massed (MP) *versus* distributed practice (DP) is of special significance for several reasons. To the extent that learning and memory are straightforward functions of total learning time, irrespective of how repetitions are distributed, the matter of relating performance to study time becomes psychologically trivial. If the slope of the performance function varies with certain conditions of practice, however, it becomes theoretically fruitful to ask why the permanence of memory traces varies with the distribution of repetitions. In fact, this consideration has been at the center of controversies regarding the psychological "morphology" of the memory trace (e.g., Bjork, 1970a; Melton, 1970). Specifically, the enhancing effects on recall of spacing repetitions (as opposed to "massing" them) have stimulated theorists to ask whether the memorial consequences of repetition can be adequately explained by a conventional "single trace" (monistic) orientation. Could DP result in better retention than MP if the main effect of repeating an item is to increment or strengthen a memory trace laid down by an earlier presentation? Single-trace theories might predict that the repeating of items at a certain point in time prior to the recall test would be "order-preserving" (e.g., Bjork, 1970a). That is, since a MP item has a higher probability of recall at the time of its second occurrence than does a DP item, a simple incremental conception would hold that the former would be better recalled than the latter after a retention interval of *x* minutes following the repetition. How can such a position account for the "strength paradox" (Bjork, 1970b) observed in the comparison of MP to DP -- viz, that the facilitating effect of a second presentation on later recall tends to increase as the probability of recall at the time of the second occurrence decreases? Could it be that increasing the time between presentations of an item enhances the likelihood that more than one retrieval cue (trace) will be attached to the item (Melton, 1970) or, perhaps, the probability that long-term rather than short-term processing will be expended on the second presentation (Glanzer, 1969)? Alternatively, are spaced items merely more likely than massed items to be processed on their second occurrence (Waugh, 1970)? Thus, the possible theoretical implications of the DP effect begin to avalanche.

The beneficial effect of DP on the retention of verbal material was first noted by Jost, a student of G. E. Muller. Jost's investigation of the spacing of presentations culminated in what came to be known as "Jost's law" (McGeoch, 1943): "...if two associations are of equal strength but of different age, a new repetition has a greater value for the older one (p. 140)." For many decades subsequent to Jost's pioneering endeavors, studies of MP versus DP were largely limited to the domain of perceptual-motor tasks (Melton, 1970). During the 1950's a rebirth of interest in the problem of how practice schedules might be optimally arranged in the verbal learning situation was almost single-handedly engineered by Underwood (for a review, see Underwood, 1961), who employed the paired-associates and serial-learning paradigms exclusively. Unfortunately, however, his patient work was repaid with a mere paucity of theoretical progress. After ten years of researching the matter, he was forced to conclude that the schedule of repetitions made little difference in terms of amount learned per unit of study time. His principal finding was that DP was superior to MP only when the response terms were of very low meaningfulness -- that is, only when considerable response learning was required. It should be noted, however, that he had restricted his work to the paired-associates and serial-learning tasks.

A new vigor was afforded the MP-DP issue in the field of verbal learning and memory when researchers began using innovative paradigms in lieu of the traditional paired-associates and serial learning techniques (Melton, 1970). Specifically, the Brown-Peterson paradigm (e.g., Peterson, 1963), the continuous paired-associates technique (e.g., Peterson, Saltzman, Hillner, & Land, 1962), and the free-recall method (e.g., Melton, 1967) have been successfully employed to demonstrate a marked superiority of DP over MP. Along with the trend toward general paradigmatic innovation, there emerged an interest in the effect of systematically varying the spacing between two presentations of an item. If DP resulted in better retention than MP, would a DP schedule with ten items intervening between occurrences of an item be superior to a DP schedule based on a spacing interval that was five items long? Would a 15-item schedule produce still higher performance? If so, at what spacing distance would the DP effect reach an asymptote? Of late, such questions have constituted "hot" issues in the psychology of learning and memory, and the "lag" effect -- systematic changes in level of recall with systematic increases in the interpresentation interval -- has come to overshadow the empirically simpler DP effect in theoretical priority. The lag phenomenon has proved to be more difficult to demonstrate than the DP effect (cf. Melton, 1970; Underwood, 1970). Moreover, its particular form (monotonic _versus_ nonmonotonic) and magnitude appear to depend upon the task demands imposed by the particular paradigm used, the retention interval, and, perhaps, the modality of presentation. This is not to say, however, that a single factor cannot be of primary importance within a particular experimental arrangement.

The present paper will review the major paradigms used in researching the DP and lag phenomena and will consider the two most tenable theoretical statements set forth to account for them. As the free-recall paradigm has been most widely employed in researching the lag effect, and has yielded the largest effect, it will be allotted primary consideration. The theoretical focus will be on Melton's differential encoding (multiple-trace) theory. Evidence for and against this position will be reviewed, and the accuracy of the differential encoding theory will be compared to that of a differential processing time view. Finally, three experiments bearing on the relationships among differential encoding, differential processing time, and the lag effect will be reported.

LITERATURE REVIEW

Lag Paradigms

Continuous paired-associates paradigm

A substantial advantage of DP over MP was first demonstrated by way of the continuous paired-associates (PA) task. Within this arrangement, word stimuli have been paired with number response terms and each pair presented to subjects either once or twice in an indefinitely long list consisting of a very large number of such pairs. At any time following the only or the second occurrence of a particular pair, the stimulus member is presented alone, and the subject is required to produce the corresponding response term. Thus, both the number of pairs intervening between successive presentations of a target pair and the number of pairs separating the last occurrence of a target item and its recall test can be varied separately or simultaneously in a very flexible manner to assess either the effect of lag, the effect of length of retention interval, or their interaction. Using the kind of continuous PA technique described above, where massed presentations occurred zero seconds apart and spaced occurrences were given eight seconds apart, Peterson et al. (1962) found that distributed repetitions resulted in better performance than massed repetitions. Further, this difference increased with the length of the retention interval, up to eight sec. In later studies, in which lag was systematically varied across more than two values of spacing, there was observed an orderly relationship between number of pairs occurring between respective presentations of an item and the probability of its recall (Peterson, Wampler, Kirkpatrick, & Saltzman, 1963; Young, 1970) up to seven or eight intervening items. In both the Young and the Peterson et al. (1963) investigations, a lag of 16 yielded a level of recall that did not differ from that associated with a lag of two items. The important point at present, however, is that a lag effect has been produced consistently with this technique.

Brown-Peterson paradigm

In the typical Brown-Peterson paradigm (e.g., Peterson & Peterson, 1959), a small stimulus array, usually a word or letter trigram, is presented for a sec. or two and is followed by a number. The subject is required to count backward from the number by some constant amount (e.g., 1's, 3's, 5's or 7's) until he receives a recall signal, at which time he is to attempt a retrieval of the stimulus array presented prior to the subtraction task. The advantage of this technique is its elimination of uncontrolled rehearsal of earlier items -- i.e., the subject need only be concerned with one stimulus array on each trial. When used in the investigation of lag, this method is modified so that the subject counts backward for varying periods of time until he receives a second presentation of the stimulus rather than a recall signal. Following the second study period, there is an additional interval of rehearsal-preventing activity that is terminated by a retention test. Greeno (1970) has summarized studies by Peterson (1963) and Pollatsek (1970) showing that recall probability increases regularly with lag in the Brown-Peterson retention task. Corroboratory data were provided by

Bjork and Allen (1970) and, more recently, by Tzeng (1973), who employed slight variations in this paradigm for the purpose of testing competing theories of lag. The real utility of the Brown-Peterson technique lies in its freedom from uncontrolled rehearsal, as certain time-sharing aspects of such rehearsal form the basis of one theoretical account of the DP effect.

It is worth noting that although a lag effect has been reported rather consistently in both the continuous PA and the Brown-Peterson situations, the magnitude of the optimal effect relative to the MP condition is not very large in these paradigms. The figures reported by Melton (1970) are 25% and 20%, respectively. This contrasts with the 80% to 90% improvement at the longest lags in the free-recall method. It is important to be mindful of the paradigmatic differences in this regard when attempting to sort out factors that may contribute to a lag effect. This point will be discussed in greater detail when theories of lag are considered.

Free-recall paradigm

In the free-recall method, subjects are given several items serially and, following presentation of the last item in a list, are required to recall as many of the words as they can without regard to order. Underwood (1969; 1970) and Waugh (1963; 1967; 1970) have used this paradigm to investigate the relation between presentation time and level of recall under conditions of MP and DP, respectively. Words typically were presented from one to four times within a list, either in immediate succession (MP) or with at least one other word occurring between repetitions (DP). As the MP *versus* DP issue has been their chief concern, Underwood and Waugh usually did not consider the effect of systematic spacing but, rather, averaged over the varying lags employed in order to assess an overall DP effect. Waugh (1963; 1967) reported several studies that consistently failed to show any advantage of DP over MP, thereby supporting the total-time hypothesis (cf. Cooper & Pantle, 1967). Underwood, however, has regularly found a DP effect using this method, while being unable to obtain an orderly effect of lag. Underwood has demonstrated a superiority of DP over MP under a wide variety of conditions, employing a range of stimulus material (e.g., sentences to CVC's), with children as well as adults, and with "unmixed" (i.e., some lists contain only MP items, others only DP items) schedules as well as with the usual "mixed" lists which contain both MP and DP items. A more recent experiment by Waugh (1970) showed a DP effect when words were presented at a relatively slow rate (4 sec. per word) but none when faster rates were used. No influence of lag was present in that study, however. In a second experiment reported in the same paper, Waugh obtained no DP effect when schedules were unmixed and items were presented at a 1-sec. rate. On the basis of her rather regular results, Waugh has reaffirmed her confidence in the total-time law. Interestingly, Underwood (1969) has rejected the total-time law on the basis of data garnered from essentially the same paradigm as Waugh used. The most conspicuous dissimilarities in method between the two researchers are the slower presentation rates and longer lists in Underwood's experiments.

Melton (1967; 1970) and his students have been quite successful in producing not only a substantial DP effect but also a systematic effect of lag in the free-recall situation. Presentation was generally via the visual mode, and words occurred either once or twice. Unlike the research of Underwood and Waugh, Melton's efforts have been aimed specifically at assessing the result of regular differences in spacing within a single list. In a typical experiment (Melton, 1970), each of three lists was comprised of 48 four-letter nouns. The first eight items served as a "primacy buffer," and the last eight words made up a "recency buffer," the purpose of the buffers being to minimize contamination of spacing effects with serial position effects. In the body of each list there were eight words that occurred once and four words that were presented twice at lags of 0, 2, 4, 8, 20, or 40 intervening items. Rate of presentation was also manipulated, some lists being delivered at 1.3, some at 2.3, and some at 4.3 sec. per word. The results were typical of this paradigm, showing a regular and significant effect of lag which did not interact with rate. Moreover, the increase in recall with lag had not reached an asymptote at a lag of 40 intervening items. This basic outcome has been replicated on numerous occasions by a host of investigators (e.g., Gartman & Johnson, 1972; Glanzer, 1969; Johnston, Coots, & Flickinger, 1972; Madigan, 1969). It should be noted, however, that these replications have invariably involved visual presentation. While a positive effect of lag under conditions of auditory delivery has been reported by Melton (1970), use of the aural mode does seem to result in an attenuation of the phenomenon.

Due to the obvious complexity of findings regarding the influence of spacing upon free-recall performance, no straightforward summary statement can be couched at the present time. Waugh's (1963; 1967; 1970) failure to obtain a DP effect in the majority of her studies and Underwood's inability to replicate the fundamental lag phenomenon probably stem from certain characteristics of their methods. Both of these investigators use aural presentation, which is known to diminish the lag effect in some circumstances. Both typically repeat several words within a list multiple times rather than only once. The absence of a DP effect in Waugh's experiments has regularly been associated with aural delivery in combination with a rapid rate of presentation. In addition to these considerations, Melton (1970) has pointed out that Waugh often uses "mixed" word classes (e.g., nouns, verbs, adjectives) in her studies, as well as relatively short lists containing easily discerned lag patterns (see Waugh, 1970, Experiment I). The matter of which of the above variables are integrally related to the lag effect and of theoretical importance and which ones are fortuitous covariates will have to await a better understanding of the lag phenomenon itself. The significant point for present purposes is that, under a particular set of parameters, the free-recall paradigm has been shown to be a powerful means of investigating the effects of spaced presentations on learning.

Theories of Distributed Practice and Lag

Of the four chief theoretical accounts of the lag effect, only two, differential encoding theory and differential rehearsal theory, have retained appreciable credibility in light of available data. Therefore, only these models will be reviewed in this paper. Excellent discussions of the "consolidation" and "memory-stores" accounts are available elsewhere (Bjork, 1970a; Bjork & Allen, 1970; Glanzer, 1969; Landauer, 1969; Melton, 1970).

Differential encoding

The most popular and vigorously researched theory of lag is Melton's (1967; 1970) encoding variability, or differential encoding, theory. Although Melton must be credited with formalizing this explanation of spacing effects, he was clearly riding the crest of the *Zeitgeist*. The idea of fluctuation in the stimulus situation dates back in its modern phase to Hull's "oscillation of reaction potential," was an integral part of Guthrie's theory, and has been brought to fruition in Estes' (1955) stimulus sampling theory. Indeed, stimulus encoding variability has become a very useful notion in diverse areas of verbal learning (e.g., Martin, 1968) and memory (e.g., Shiffrin & Atkinson, 1969).

Applied to the lag effect, the differential encoding hypothesis is quite uncomplicated. It is first assumed that encoding an item in more than one way enlarges the set of retrieval cues *or* routes which may be used by the subject to access the item at the time of recall. (It should also be pointed out that it is implicitly assumed that two retrieval cues are always better than one, regardless of strength.) The second assumption is that increasing the spacing between two presentations of an item reduces the overlap or similarity of the word contexts in which the respective presentations occur, thereby enhancing the likelihood that more than one retrieval cue (trace) will be attached to the item. Carried to its extreme, this hypothesis implies that in order to remember efficiently following a second exposure to a stimulus, we must forget how we encoded the first occurrence of that stimulus (Tzeng, 1973).

Although, or perhaps because, the differential encoding theory has an air of the paradoxical about it, it has received an enthusiastic and industrious audience of researchers. One of the earliest attempts to test the differential encoding theory of lag was engineered by Madigan (1969). Using common English nouns as stimulus words, Madigan constructed two types of list. Each type contained eight once-presented items and six each of items repeated at lags of 0, 4, 8, or 16 intervening items. In the same-cue (SC) lists, repeated words were always accompanied by the same adjectival modifier (e.g., speed-ENGINE, speed-ENGINE), while in the different-cue (DC) lists different modifiers occurred at the respective presentations of a target word (e.g., speed-ENGINE, valve-ENGINE). Including the buffer items at the ends of the lists, each list was 68 items long. Presentation of each list was visual and was followed by a written free recall, which, in turn, was succeeded by a cued-recall test. In the latter test, subjects were provided with two cues (adjectives) per presented word, even though they may have seen only half of these adjectives during presentation (i.e., in the SC condition).

Differential encoding theory makes two unambiguous predictions concerning the free-recall data of Madigan's investigation: (a) The DC lists should be free-recalled significantly better than the SC lists, since two retrieval cues are assumed to be more effective than one; (b) The lag effect should be eliminated or greatly attenuated in the DC condition, as different verbal contexts (i.e., the modifiers) have been induced independently of lag. Neither differential encoding theory nor any other extant theory of the spacing effect makes an unequivocal prediction with respect to the cued-recall data.

Madigan's results showed no overall recall differences between the cue conditions. That is, two cues were not better than one in this case. Furthermore, the lag effect was but minimally attenuated in the DC group, relative to the SC group's lag function. This interaction was statistically significant, however, and was due primarily to the increase of DC recall relative to SC recall of lag-0 words and the decrease of DC performance relative to SC performance with respect to lag-16 items. The spacing effect was eliminated by the DC treatment only when recall was cued. This finding is of meager relevance, however, since it is not specifically predicted by differential encoding theory and, in any case, tells us little regarding the effective processes in free recall.

Johnston et al. (1972) carried out an experiment which was very similar to Madigan's, except that lag was set at 0, 1, 3, or 7, and the cue-type manipulation was a within-subjects variable whereas this factor had been between-subjects in Madigan's study. Johnston et al. found neither a superiority of DC over SC recall nor a significant reduction of the lag effect in the DC condition. However, a strong tendency toward attenuation of the lag effect in the DC condition was visible in their data.

The only free-recall investigation that has been successful in showing an overall performance-enhancing effect of varying the verbal context across presentations was reported by Gartman and Johnson (1972). The target items were homographs -- that is, words with more than one meaning -- which followed two words from the same category (SC) on each of two presentations (e.g., leg neck foot, arm hand foot) or followed pairs of words that represented different categories (DC) at the respective presentations (e.g., leg neck foot, inch meter foot). There were only two classes of spacing, lag-2 and lag-8-18, and both lag and type of category biasing were within-subjects variables. The outcome of this experiment indicated both a complete elimination of the lag effect in the DC condition and a significantly higher level of recall in the DC condition than in the SC condition, as predicted by differential encoding theory. There was, however, a serious design problem in this experiment. Since the subjects were asked to attempt to recall all words presented, the nature of the biasing manipulation resulted in both an increase in effective category size and a decrease in the number of categories in the SC condition relative to the DC condition. These circumstances probably would work to augment the number of target words recalled in the DC treatment relative to the SC condition, irrespective of encoding variation _per se_ (see Tulving & Pearlstone, 1966). Hence, the higher level of performance in the DC condition cannot be accepted as unmitigated evidence for differential encoding theory. This is not to deny that the observed elimination of the lag effect is in line with that hypothesis. However, an alternative explanation of this outcome is possible and will be discussed in the next section of this paper.

Interestingly, the lag effect apparently can be produced and eliminated in a recognition memory task as well as in the recall situation. Winograd and Raines (1972) presented homographic nouns in a sentence context, and these nouns were repeated at a lag of 0 or 15 intervening sentences. Critical words were presented twice in the same context or once in a high frequency-of-usage context and, then, again in a medium frequency-of-usage context. As in the free-recall studies reviewed above (e.g., Madigan, 1969), forced-choice recognition performance showed a lag effect in the same-context condition, no lag effect in the different-context condition, and no overall difference between context conditions. That is, different-context words were better recognized than same-context words at lag-0, but the opposite result obtained for lag-15 words. The authors concluded that the beneficial result of distributed practice is due to the establishment of more than one trace of the item.

In spite of its current popularity, the differential encoding account of the lag effect is lacking on several counts. First, it runs counter to conventional conceptions of encoding and organization which hold that the establishment of <u>stable</u> higher-order units is essential for retention (Postman, 1972). By contrast, the differential encoding position holds that the efficient retention of verbal material depends upon the instability of codes. The conventional view is not without foundation, however, since performance in multitrial free recall paradigms improves faster if the words are presented in the same order on each trial than if the order is varied across trials (Postman, 1972). Second, the differential encoding hypothesis implicitly assumes that two weak codes are better than a single strong code. To the knowledge of the present writer, the only studies bearing on this question show either that two weak codes are equal to one strong code (Bower & Winzenz, 1969; Underwood, 1972; Wood, 1972; also the lag studies reviewed above) or that several weak traces yield lower performance than one strong one (Bower, Lesgold, & Tieman, 1969). Finally, the attenuation of the lag effect which has been shown to be associated with certain types of biased encoding (e.g., Madigan, 1969) may well be due to differential processing time factors, as is pointed out below.

Differential rehearsal

A parsimonious, and still viable alternative to the differential encoding theory of lag is the differential processing time, or differential rehearsal, hypothesis. This proposition was originally set forth to account for the DP effect rather than the lag effect, and it assumes two forms. Greeno (1967) and Waugh (1970) have proposed that subjects may not always use the second presentation of a massed item to further process that item. Rather, they may employ this "free" time to rehearse earlier, more "unique" items -- i.e., once-presented items or spaced items, which may be considered to be once-presented items by the subjects. However, more complete processing efforts are assumed to be expended on the repetitions of spaced items. It follows that the higher recall of spaced items may result from the fact that a greater amount of rehearsal has been allotted to them than to massed items.

A second way of looking at the differential rehearsal notion is to suppose that subjects simply "turn off" or reduce their processing activity upon the second occurrence of a massed or short-lag item (Greeno, 1970; Underwood, 1970). In this statement, the differential rehearsal effect is not held to be a positive one with respect to spaced items but a negative one regarding massed items. Either way of formulating the differential rehearsal hypothesis could account for the reduction of the lag effect with different-cue biasing. A different modifier accompanying the second appearance of a massed item may simply induce the subject to afford more attention to it than he would otherwise.

Waugh (1970) has reported data that are in line with the differential rehearsal notion. Using unmixed MP and DP lists in which items were presented 1, 2, 3, 4, 6, or 8 times, she found that MP yielded better free recall than DP at frequencies of 1, 2, and 3, was equivalent to DP at a frequency of 4, and was inferior to DP at frequencies of 6 and 8. That is, recall probability as a function of number of occurrences was a steep linear function intercepting at zero for DP lists and a linear function of lesser slope that did not intercept at zero in the MP case.

This outcome was a clear instance of time-sharing in which low-frequency items (i.e., items presented once or twice) were allotted more processing time in MP lists than in DP lists. In the MP condition, subjects apparently used the "free" time during the fifth, sixth, seventh, and eighth occurrences of massed items to rehearse the more "unique," less frequently presented items at the expense of words of greater frequency. This strategy probably occurs much less extensively under conditions of DP, where the frequency with which an item occurs is not readily apparent at later presentations.

There are two lines of evidence countering Waugh's claim that differential rehearsal by way of time-sharing may be responsible for the superior recall of DP items reported by several researchers. The major implication of Waugh's findings is that DP items are given extra rehearsals at the expense of MP items in situations where these two types of item are mixed together. This contention predicts no overall superiority of DP when MP and DP words occur in separate lists, which, in fact, is what Waugh found. To the contrary, however, Underwood (1969) has reported better recall of DP lists than of MP lists even when schedules were unmixed. In addition, as Melton (1970) has pointed out, the recall of once-presented items was no higher in Underwood's MP lists than in his DP lists, in contradiction of what Waugh's data indicated. It is important to consider, however, that Underwood employed a 5-sec. per-word rate of presentation whereas Waugh's rate was 1 sec. per word. Hence, Underwood's subjects may have found one presentation sufficient for processing an item, therefore foregoing the opportunity for extensive time-sharing. Moreover, lower recall of MP lists, relative to DP lists, may have stemmed from a reduction in the processing of repetitions of massed items presented at such a slow rate, without a concomitant increase in the rehearsal of once-presented words.

The second line of evidence against the differential rehearsal hypothesis consists of data showing a lag effect in the Brown-Peterson paradigm (Bjork & Allen, 1970; Peterson, 1963; Pollatsek, 1970; Tzeng, 1973). Since subjects subjected to this paradigm are required to retain only the stimulus presented on the current trial, a lag effect in this situation cannot be attributed to differential rehearsal of certain "unique" items that occurred earlier. Before being tempted to discard a differential rehearsal notion on the basis of these data, however, one should consider the following points. First, there is nothing about the Brown-Peterson lag paradigm that would preclude the possibility that subjects tend to "turn off" or reduce the processing of the second presentation of a short-lag word. Thus, this form of the hypothesis remains tenable even in this situation. Second, it has been noted that the largest increment due to spacing in the Brown-Peterson method is between 15% and 20%. This is to be compared with the 80% to 90% improvement that is often observed in the free-recall situation. Since it is likely that more than one process can contribute to the lag effect, it is quite possible that differential rehearsal is the predominant one in free recall whereas some other process may be largely responsible for the small lag effect observed in the Brown-Peterson paradigm. This "other process" may be the retrieval practice that the subject gets with the second presentation of an item. There is evidence that subjects recruit (i.e., retrieve) information about the first occurrence of an item when they are given that item a second time (Hintzman & Block, 1971; Hintzman, Block, & Summers, 1973). Further, since retrieval practice after a long delay benefits recall to a greater degree than retrieval practice following a short delay (Gotz & Jacoby, 1974), the lag effect in the Brown-Peterson task may be revealing the effects of only this limited process. By comparison, differential rehearsal may be a much more significant variable than retrieval practice in the case of free recall.

Evidence for the idea that varying rehearsal strategies may be central to spacing effects in free recall was recently provided by D'Agostino and DeRemer (1973). Their subjects were given a list of sentences repeated at lags of 0, 5, 10, or 20 intervening events and were instructed to free-recall object phrases. Phrases were either presented in the same sentence each time or in different sentences on respective occurrences. Rehearsal was either unconstrained or controlled by asking the subject to generate an image corresponding to the sentence and describe it during the entire 10-sec. presentation interval. It was found that controlling processing time alone eliminated the lag effect but not the MP-DP difference. Delivering the object phrase in two different sentences did eradicate the MP-DP difference, but only when rehearsal was controlled across lags. Accordingly, the authors concluded that differential rehearsal is the dominant factor in the free-recall lag phenomenon.

Indirect support for a differential processing time explanation of the lag effect was supplied by Hintzman et al. (1973). High frequency nouns were repeated at a lag of 0, 1, 5, or 15 intervening items in a situation that was described to the subject as a free-recall task. Within the list, a given event occurred in either the auditory (A) or visual (V) mode. At the end of the list, subjects were asked to indicate whether an item had occurred once or twice, and, given that an item had been presented twice, whether it had been presented in an AA, AV, VA, or VV sequence. It was found that when subjects erroneously rated twice-presented VA or AV items as once-presented words, there was a significant tendency to identify such items as having occurred in the modality of the first presentation (e.g., V in the case of VA words). Even more important was the finding that the tendency to identify these items with the first-occurrence modality decreased significantly as spacing between the successive occurrences of VA and AV items increased. Hintzman et al. concluded that their data were consistent with the hypothesis that the lag effect is due to a failure to either store or retrieve the second occurrence of items repeated at a short lag.

A somewhat novel approach to the study-time issue indicated that differential processing time may contribute substantially to the MP-DP effect in the free recall of conventional word lists. Shaughnessy, Zimmerman, and Underwood (1972) permitted subjects to pace themselves through a list of 90 words in which repeated items were presented 2, 3, or 4 times in either massed or distributed fashion. The usual MP-DP difference was found, and examination of study-time records indicated that this difference was nearly paralleled by differences in the study time devoted to MP *versus* DP items. A closer analysis indicated that only 12% of the DP recall was not accounted for by the study-time difference.

In an extension of the Shaughnessy et al. study, Maki (1974) asked subjects to pace themselves through a list of common nouns wherein items were presented once or repeated at a lag of 0, 2, 8, or 16 intervening items. In accordance with differential rehearsal theory, both free recall and study time increased with lag (with the exception of a slight dip at lag 8). These results were not conclusive, however, because viewing time was correlated with lag for first presentations as well as for second presentations. This aspect of her data suggests that lag categories may not have been properly counterbalanced for serial position, as study time has been shown to vary with serial position in this kind of paradigm (cf. Shaughnessy et al., 1972).

Overall, then, results of the investigations described above suggest that the differential rehearsal hypothesis deserves further examination as a possible alternative to the differential encoding explanation of the lag effect.

Purpose of the Present Experiments

Underwood (1970) has written: "...if learning is depressed under MP because of inattention by *S*, it would be trivial; learning cannot take place without input (p. 580)." The present writer could not disagree more with the first segment of Underwood's conclusion. Although it is almost tautologous to say that learning cannot occur without input, it can be by no means trivial to investigate and, eventually, understand conditions that influence the reduction in processing or the time-sharing which may relate to performance under MP. Furthermore, from a practical standpoint, as well as theoretically, it would behoove psychologists to discover situations which are capable of reversing, at least to some extent, any such tendency toward attenuation of attention.

It would be interesting if we are dealing with a cognitive-motivational phenomenon in the DP and lag effects. Walker (1964) has set forth an intriguing, general motivational theory based on the tenet that psychological processes are biased against repetition. That is, organisms tend to cease responding to the same stimulus situation in a very short time and attempt to "choose" alternative events that are most in line with a subjective standard of psychological complexity. The implications for the literature and issues reviewed herein are quite obvious.

Still, there are those who would reject a differential rehearsal notion out-of-hand. Melton (1970) has claimed that such a proposition is contraindicated by the orderly effect of lag on the probability of free recall. To date, however, only one attempt has been made to empirically evaluate study-time differentials under conditions of systematic lag variations (Maki, 1974); and, though the results of that investigation were in line with a differential rehearsal hypothesis, they were plagued by study-time differences associated with the first presentations of the respective lag instances. Furthermore, the effect of same *versus* different modifiers on study time has not been assessed. The three experiments reported in the present paper were aimed specifically at these areas of investigation. Experiment I looked at the effects of spacing of repetitions on retention in an incidental learning paradigm where large differences in study time and type of processing were obviated by the nature of the task. This task was also set up to assess the effects of same _versus_ different encoding at different lags. Experiment II employed the "free-looking-time" technique of Shaughnessy et al. to study the influence of orderly variations in lag on study time in the free-recall situation. Experiment III also used this method in a free-recall task where differential encoding was induced at various lags.

EXPERIMENT I

Several recent studies (e.g., Hyde & Jenkins, 1969; Jacoby & Goolkasian, 1973) have shown through incidental learning techniques that the type of processing (e.g., semantic *versus* acoustic) allocated to a list of words rather than intent to learn determines the level of free-recall performance. The advantage of using an incidental learning task in the present experiment was that the nature of the subject's task would tend to equalize the amount of processing time afforded each stimulus event, thereby providing an evaluation of lag and the interaction of lag with type of encoding (same or different) across repetitions, uncomplicated by differential rehearsal. A second advantage of this technique was that it ensured differential encoding of different-cue target words to a greater degree than had the more conventional techniques used in previous investigations (e.g., Madigan, 1969).

Subjects received an 80-event list wherein each event consisted of a pair of words presented visually for 6 sec. Each pair of words contained a "target" word and a set (code) inducing, biasing word. Some target words were presented only once, and others were presented twice at either a short or a long lag. Repeated target words of the same-cue type occurred both times with the same biasing word (e.g., staff rod, staff rod), whereas repeated target words of the different-cue variety were presented with biasing words that differed across occurrences (e.g., priest cardinal, robin cardinal). Incidental learning subjects were required to make semantic judgements about each pair, and reaction times of the judgements were recorded. An intentional learning (control) group was instructed to memorize all words for a free-recall test.

On the assumption that differential rehearsal has a substantial influence upon the lag effect in free recall and that the incidental learning task would minimize such differential treatment of items by subjects, better recall at the longer lag was predicted only for the intentional learning group. Additionally, attenuation (reduction in slope) of the lag effect was expected for the different-cue condition of the intentional learning group. To the extent that a lag effect might occur in the incidental learning group, it was expected to be paralleled by a reaction-time gradient showing longer reaction times at the longer lag. In short, the basic prediction was an instruction (incidental *versus* intentional learning) x lag x cue-type interaction. By contrast, a strict differential encoding position would predict the same outcome in both the incidental and the intentional learning groups -- viz, that the different-cue condition should result in higher recall than the same-cue condition, and that a lag effect should be evidenced in neither condition, as same or different encoding will be induced independently of lag.

Method

Lists and materials

In discussing list construction, it will prove useful to refer to "target" words (those of central interest) and "biasing" words (those that occurred with target words to induce a category set). It is also important to note that repeated pairs of words always occurred only twice and that an "event" consisted of the presentation of a pair of words, one of which was a target word and one of which was a code inducing, biasing word.

All subjects received an 80-event list consisting of five primacy-buffer (PB) pairs, 15 nonrepeated pairs, 15 pairs repeated at a lag of two to four intervening events (short-lag pairs), and 15 pairs repeated at a lag of ten to 12 intervening events (long-lag pairs). Within each repeated-pair type there were three kinds of biasing, divided equally among the 15 pairs. The five same-cue (SC) target words of each lag type (short or long) were accompanied by the same biasing word on their respective occurrences (e.g., staff rod, staff rod). The five different-cue (DC) target words, however, appeared with different biasing words across presentations (e.g., inch foot, hand foot). With DC pairs, then, the change in the biasing word across presentations altered the semantic relationship between the words in a pair, hence the way in which the target word was encoded, but, nevertheless, sustained a semantic, or category, match at both occurrences.

The third type of repeated pair was the match-nonmatch (M-N) type, which was also represented by five pairs within each class of lag. While the first occurrence of a M-N target word was always accompanied by a biasing word from a mutual category, thereby requiring a "same" judgement from incidental learning subjects, the second occurrence appeared with a word from an alien category, thereby calling for a "different" judgement (e.g., bus car, tree car). The chief purpose of including this kind of repeated pair was to discourage subjects from developing a strategy which might override the effects of lag and cue-type manipulations. If M-N pairs did not appear in the list, for instance, then a pair that was judged as being semantically "the same" on its first occurrence would always presage an identical judgement for a second presentation of either or both of the words comprising that pair. Thus, alert subjects in the incidental learning group could easily adopt a strategy of saying "same" to any word that they recognized as having occurred previously, without engaging in the type of semantic analysis required by the initial presentation.

Three other manipulations were included to offset tendencies toward the development of contaminating strategies in the incidental learning group. First, five of the 15 once-occurring pairs were of the nonmatch variety. Incorporating these items into the list would further lessen a general set to respond "same" on the basis of minimal processing. Second, neither the short lag nor the long lag was constant, the former varying between two and four intervening events and the latter ranging between 10 and 12 intervening events. This aspect of list construction should have reduced subjects' temptation to employ a list-structure strategy in responding. Finally, the relative position of the target word with respect to the biasing word (above *versus* below) was unsystematically determined in the construction of stimulus slides.

The 50 target words used in building the list were high-frequency nouns drawn from the Battig and Montague (1968) category norms and the Thorndike-Lorge (1944) wordbook. Ten of the items taken from the Battig and Montague norms were polysemous; of these, five were randomly assigned to short-lag-DC and five to long-lag-DC cells. Ten additional items, matched with the polysemous words in terms of frequency of usage, were used to fill the short-lag and long-lag cells of the SC condition. Of the remaining 30 target items, five were randomly assigned to each of the lag cells of the M-N pairs, 15 were randomly selected to be once-occurring items, and the last five were designated PB items.

All biasing words used in this experiment were high-frequency nouns. The biasing words of the SC pairs were selected from the Battig and Montague norms on the basis of their semantic relations with the SC target words. The ten biasing words selected for the first occurrence of DC pairs were also taken from the Battig and Montague norms and were chosen according to their semantic relations with DC target words. Second-occurrence DC biasing words were drawn from the Thorndike-Lorge wordbook and paired with individual target items so as to form category matches that were mediated by semantic relationships that differed from those of the first presentation. Biasing words for the nonrepeated, M-N, and buffer pairs were taken from both of the above mentioned sources and paired with target words such that 10 of the 15 unrepeated pairs represented semantic matches and two of the three buffer pairs represented semantic matches. An attempt was made to equate the frequency-of-occurrence-in-the-language of biasing words across SC, DC, M-N, nonrepeated, and buffer pairs.

The end result of list construction procedures was a basic test list comprised of five SC pairs to be repeated at a short lag (short-lag-SC; 10 events), five SC pairs to be repeated at a long lag (long-lag-SC; 10 events), five DC pairs to be repeated at a short lag (short-lag-DC; 10 events), five DC pairs to be repeated at a long lag (long-lag-DC; 10 events), five M-N pairs to be repeated at a short lag (short-lag-M-N; 10 events), five M-N pairs to be repeated at a long lag (long-lag-M-N; 10 events), ten nonrepeated pairs representing category matches (nonrepeated-match; 10 events), five nonrepeated pairs representing nonmatches (nonrepeated-nonmatch; five events), and five PB pairs, three of which were nonmatch events. (Word pairs comprising the basic list are shown, according to repetition type, in Appendix A.)

Two forms of the basic list, form A and form B, were used to minimize possible artifacts due to order of presentation. In each form, the order of the pairs from the respective pair types was determined by a random shuffling of cards, subject to the constraints imposed by the lag manipulation. In addition, pairs repeated as long-lag items in form A were repeated as short-lag items in form B, and vice versa.

All stimulus pairs were typed on acetate squares and mounted on Kodak Ready Mounts for visual presentation via a carousel projector. On each slide, one member of a word pair was positioned two typewriter spaces above the other member.

Subjects and design

The subjects were 60 undergraduate students taking psychology courses at Iowa State University. They received extra course credit for participating in the experiment.

There were two between-subject factors, learning instruction (incidental learning or intentional learning) and list form. Subjects were randomly assigned to one of the two learning groups and to one of the two list forms as they appeared at the laboratory. Each subject was tested individually.

The within-subjects factors were frequency type (once-presented, short-lag, or long-lag) and cue type (SC, DC, or M-N).

Apparatus and procedure

Presentation of the slides forming a list was paced by a Massey-Dickinson module sequence at a rate of one slide every .6 sec. The initiation of an impulse not only triggered the change of slides but also reset the dials of a Hunter Klockcounter. The Klockcounter automatically and instantaneously commenced its sequence following its reset. This sequence was terminated when the subject pressed a table button with his index finger. The subsequent impulse then renewed this chain of events. The reaction time to each slide was recorded by the experimenter on a prepared data sheet.

All subjects were told that they would view a long list of word pairs and that the members of each pair may belong to the same semantic category. Two examples were given by the experimenter. Subjects were not apprised of the distinction between target and biasing words but were informed that some of the pairs would be repeated.

Subjects in the intentional learning group were instructed to memorize the words for a written free-recall test that would be administered after the list had run its course. They were not required to engage in any orienting task or to manipulate the table button.

Incidental learning subjects were told that the experiment was concerned with the meaningful relations between different words and that the experimenter was interested in the accuracy with which different words are perceived as belonging to the same category. Thus, they were being asked to make "same" or "different" judgements about each pair of words. They were also asked to press the table button simultaneously with the oral response indicating their decision. It was explained that although this was for the purpose of timing their decision, the main concern was with the accuracy of their judgements.

To diminish the influence of warm-up and practice effect, all subjects were given a 20-event practice list containing four short-lag pairs, four long-lag pairs, and four nonrepeated pairs. Intentional learning subjects were asked to free-recall these words, whereas the incidental learning group was asked only to make category judgements.

Next, the test list was presented. At the end of this list, subjects in both groups were shown five additional pairs on cards that were presented by the experimenter at a 6-sec. rate. Immediately following the presentation of this "recency buffer," the subject was handed two sheets of paper bearing several columns of dittoed lines and was instructed to write down as many of the words as he could remember, in any order that he wished. Ten min. were allowed for completion of the recall task.

Scoring and analysis

Reaction times to each slide were categorized according to frequency type, cue type, and position within the repetition sequence (first occurrence or second occurrence). A 2 x 2 x 2 x 2 (List Form x Cue Type x

Lag x Position) analysis of variance, with repeated measures on the last three factors, was carried out on the reaction-time data. Data from once-presented, M-N, and buffer items were not included in this analysis.

Responses in free recall were scored correct if they were words from the test list or slight misspellings of those words. Responses which were target words were classified according to type of instruction, cue type, and frequency type. A 2 x 2 x 3 x 2 (List Form x Instruction x Cue Type x Lag) analysis of variance, with repeated measures on the last two variables, was performed on these free-recall data. Matched-pair *t* tests (cf. Snedecor & Cochran, 1967) were used to test specific, *a priori* hypotheses, and a Newman-Keuls procedure was employed to make *post hoc* comparisons of interest. Although the recall data of biasing words were not of central concern, analyses of interest were performed on these data.

Results

Recall of target words

As a result of constraints imposed by the design of the present experiment, there were only five observations per factorial cell per subject. This circumstance violates the assumption of a normal and continuous distribution of observations underlying the conventional analysis of variance procedure (see Kirk, 1968; pp. 42-43, 60-61). Perhaps because of the failure to meet this assumption, the cell means and variances of the free-recall data tended to be proportional. Consequently, each subject's recall score was subjected to the transformation,

$X' = \sqrt{X + .5}$ (Kirk, 1968), prior to the running of statistical analyses. Therefore, all references to the free-recall data should be read in terms of square-root values in lieu of raw scores, unless stated otherwise. Likewise, all tables containing means will present mean root values rather than means of raw scores.

Mean root recall of target words for the various conditions is shown in Table 1.

Table 1. Mean root recall of target words as a function of type of learning instructions, lag, and cue type, Experiment I

Cue type	Short lag (2 - 4)	Long lag (10 - 12)
	Intentional learning	
Same cue	1.412	1.578
Different cue	1.531	1.567
Match-nonmatch	1.318	1.244
	Incidental learning	
Same cue	1.615	1.461
Different cue	1.513	1.508
Match-nonmatch	1.206	1.272

A summary of the analysis of variance performed on these data is presented in Table 2. Data on once-presented items were not included in that analysis. As the exceedingly small $\underline{F}$ values indicate, there was no effect of learning instructions or list form; nor did their interaction have an effect. That recall under incidental learning instructions was

Table 2. Summary of analysis of variance of root recall of target words, Experiment I

Source of variation	Degrees of freedom	Mean squares	F values
A Learning Instructions	1	.014	.047
B List Form	1	.005	.016
A x B	1	.092	.292
C Subjects/A x B	56	.315	
D Lag	1	.003	.019
A x D	1	.124	.794
B x D	1	.743	4.777*
A x B x D	1	.659	4.234*
C x D	56	.156	
F Cue Type	2	2.770	21.808***
A x F	2	.069	.541
B x F	2	.030	.239
A x B x F	2	.240	1.882
C x F	112	.127	
D x F	2	.003	.031
A x D x F	2	.403	4.272*
B x D x F	2	.313	3.318*
A x B x D x F	2	.386	4.093*
Error	112	.094	

*P < .05

***P < .001

equivalent to that obtained under intentional learning instructions is in line with earlier findings by Hyde and Jenkins (1969) and Jacoby and Goolkasian (1973). Those investigators had reported that an orienting task which requires a semantic analysis of words results in a level of free recall that equals that produced by intentional learning.

There was no overall effect of lag. Unfortunately, however, lag interacted significantly with list form, and the three-way interaction of lag, learning instructions, and list form was also significant. The mean root values shown in Table 3 reveal the nature of these interactions. It can be seen that the long lag tended to yield higher recall than the short lag when subjects in the intentional learning group were given Form A of the list, but that the reverse trend was present in all but the SC condition when Form B of the list was employed. In the incidental learning group, however, the interaction of lag and list form appears to have been neither as pronounced nor as systematic as it was in the intentional learning group.

Cue type produced the largest effect of all and interacted with no other factor or combination of factors. A Newman-Keuls procedure indicated that the effect of cue type could be attributed to poor recall of M-N items relative to SC, $q\ (2, 112) = 7.769$, $p < .001$, and DC, $q\ (3, 112) = 8.181$, $p < .001$. SC and DC items, on the other hand, were recalled equally well, $q < 1.0$. This result is contrary to expectations stemming from differential-encoding theory, which predicts that DC target words should be more retrievable than SC target words.

Table 3. Mean root recall of target words as a function of type of learning instructions, list form, lag, and cue type, Experiment I

List form	Cue type	Short lag	Long lag
	Intentional learning		
	Same cue	1.452	1.654
Form A	Different cue	1.366	1.756
	Match-nonmatch	1.237	1.302
	Same cue	1.371	1.502
Form B	Different cue	1.695	1.377
	Match-nonmatch	1.400	1.186
	Incidental learning		
	Same cue	1.583	1.339
Form A	Different cue	1.575	1.507
	Match-nonmatch	1.132	1.366
	Same cue	1.647	1.583
Form B	Different cue	1.451	1.509
	Match-nonmatch	1.281	1.177

The three-way interaction of learning instructions, lag, and cue type is of central importance to evaluation of the present hypotheses. According to the differential rehearsal hypothesis, augmentation of recall at the long lag, over that at the short lag, should occur only for SC words studied under intentional learning instructions, where differential rehearsal strategies would be operative. The remaining lag functions should be flat, as neither incidental learning instructions nor DC (nor M-N) repetitions would be expected to result in a substantial attenuation of processing of repetitions at the short lag relative to the long lag. These predictions were supported, descriptively, by the values appearing in Table 1 and, statistically, by the significant instructions x lag x cue type interaction shown in Table 2.

Three additional considerations suggest caution in the interpretation of this interaction, however. First the magnitude of the interaction, albeit large enough to satisfy statistical significance, is small in a practical sense. Second, when the M-N level is removed from the analysis, the remaining three-way interaction falls short of significance, $F\ (1,56) = 3.188$, $p > .05$. Ideally, this interaction should stand on its own, as the M-N level was introduced as a strategy-control condition and was not an integral part of logical derivation of the central hypothesis. Third, the significant four-way interaction of learning instructions, lag, cue type, and list form shown in Table 2 indicates that support for the main hypothesis depends on which form of the list was employed. Perusal of Table 3 reveals the nature of the four-way interaction and shows that neither form of the list upheld the current hypothesis in a convincing fashion.

It is noteworthy that a lag effect was present, numerically, in the recall of SC target words under intentional learning instructions, regardless of the specific list form used. In a planned comparison,[1]

[1] All mean comparisons in this paper are two-tailed tests.

recall of short-lag SC items was contrasted with that of long-lag SC items via a matched-pair _t_ test (cf. Snedecor & Cochran, 1967). This test indicated that, under conditions of intentional learning, lag did have a (marginally) significant effect on the recall of SC items, $t\,(29) = 1.920$, $p = .06$. A Newman-Keuls procedure showed that lag had no significant influence on recall in any of the remaining cells represented in Table 1, all p's $> .05$.

Mean root recall of once-presented target words was 1.074 in the intentional learning group and .992 in the incidental learning group. Although free-recall data for once-presented words were not included in the main analysis, a subsidiary analysis employing Dunnett's test for comparisons involving a control mean (Kirk, 1968) revealed a significant effect of repetition -- i.e., repeated target words were better recalled than once-occurring target words -- in the SC, $tD(4, 112) = 6.364$, DC, $tD(4, 112) = 7.197$, and M-N, $tD(4, 112) = 3.136$, conditions of the intentional learning group, all p's $< .01$. A significant effect of repetition was also found in the SC, DC, and M-N conditions of the incidental learning group, $tD\,(4, 112) = 8.272$, 7.863, and 3.743, respectively, all p's $< .01$.

Recall of biasing words

As subjects in the current investigation were not apprised of the distinction between biasing words and target words, many of the items produced in free recall were biasing words. It is of theoretical interest to consider these data because they may shed some light on the locus of repetition effects. Hintzman et al. (1973) have pointed out that some theories stress the importance of the first presentation whereas others hold that how the later presentations are processed is all important. As individual DC target words were accompanied by different biasing words on their successive presentations, those biasing words may serve as "tracer attributes" in the search for the locus of repetition effects.

The mean root recall data (i.e., $X' = \sqrt{X + .5}$) for the various conditions of presentation of biasing words are shown in Table 4. Within each type of learning instructions, there were five biasing conditions: SC (same biasing item on both presentations), first presentation-DC, first presentation-M-N, second presentation-DC, and second presentation-M-N.

A 2 x 2 x 2 x 5 (Learning Instructions x List Form x Lag x Biasing Condition) analysis of variance, with repeated measures on the last two factors, was carried out on these data, and a summary of that analysis is given in Table 5. Of particular interest is the large effect of biasing condition. It can be seen in Table 4 that first-presentation biasing words were recalled at a higher level than their second-presentation counterparts. A Newman-Keuls analysis indicated that this trend was significant in both the DC condition, $\underline{q}$ (3, 224) = 3.928, $\underline{p} < .05$, and the M-N condition, $\underline{q}$ (3, 224) = 6.215, $\underline{p} < .01$. The small interaction of biasing condition with learning instructions reflects the fact that these differences were more pronounced in the intentional learning group than in the incidental learning group.

Table 4. Mean root recall of biasing words as a function of type of learning instructions, lag, cue type, and position of presentation (first *versus* second), Experiment I

Presentation	Cue type	Short lag	Long lag
	Intentional learning		
First	Same cue	1.150	1.286
	Different cue	.934	1.010
	Match-nonmatch	.858	.947
Second	Different cue	.883	.791
	Match-nonmatch	.553	.588
	Incidental learning		
First	Same cue	1.031	.904
	Different cue	1.145	1.016
	Match-nonmatch	.985	1.048
Second	Different cue	.978	.772
	Match-nonmatch	.780	.629

Table 5. Summary of analysis of variance of root recall of biasing words, Experiment 1

Source of variation	Degrees of freedom	Mean squares	F values
A Learning Instructions	1	.060	.069
B List Form	1	.289	.329
A x B	1	.971	1.104
C Subjects/A x B	56	.880	
D Lag	1	.072	.240
A x D	1	1.164	3.857
B x D	1	3.087	10.229**
A x B x D	1	3.457	11.456**
C x D	56	.302	
F Biasing Condition	4	3.961	13.750**
A x F	4	.732	2.542*
B x F	4	.869	3.017*
A x B x F	4	1.435	4.983**
C x F	224	.288	
D x F	4	.219	.837
A x D x F	4	.090	.343
B x D x F	4	.878	3.361*
A x B x D x F	4	1.778	6.804*
Error	224	.261	

*$p < .05$

**$p < .01$

In the M-N condition, superior recall of first-presentation biasing words over second-presentation items can be accounted for by the fact that first-occurrence M-N events consisted of semantically related words, whereas second occurrence M-N events involved unrelated words. A different explanation is required, however, to account for this outcome in the DC condition, a point which will be elaborated in the Discussion section that follows.

Reaction times

In the incidental learning group, each subject's reaction time (RT) to each event was recorded. In the scoring of these data, the subject's mean RT to each combination of cue type and lag magnitude was computed; these means were the units of analysis. Because some of the means represented extreme observations, the transformation, $X' = \log X$ was applied (see Kirk, 1968). Thus, any reference to RT should be read as "log RT."

The mean log RT's are given in Table 6, and a summary of the corresponding analysis of variance is presented in Table 7. Neither once-presented nor M-N events were included in this anslysis.

As expected, DC events were associated with longer RT's than SC events. However, neither the effect of lag nor the interaction of lag and cue type yielded significant differences. Although second occurrences of repeated events were associated with significantly longer RT's than were first occurrences, the effect of "position" is best considered in light of the sizeable interaction of cue type and position. A survey of the means in Table 6 reveals that the effect of position was almost entirely limited to the SC condition, where second occurrences were

Table 6. Mean log reaction time[a] as a function of cue type, lag, and position of event in repetition sequence (first or second presentation), incidental learning group, Experiment I

	Cue type			
	Same cue		Different cue	
Position	Short lag	Long lag	Short lag	Long lag
First	2.310	2.309	2.332	2.346
Second	2.255	2.252	2.337	2.335

[a]Untransformed reaction times were in hundredths of a sec.

Table 7. Summary of analysis of variance of log reaction time, incidental learning group, Experiment I

Source of variation	Degrees of freedom	Mean squares	F values
A list form	1	.00559	1.731
B Subjects/A	28	.03227	
C Cue Type	1	.18768	113.758***
A x C	1	.00093	.564
B x C	28	.00165	
D Lag	1	.0031	.205
A x D	1	.00612	4.101
B x D	28	.00149	

***$p < .001$

Table 7. (Continued)

Source of variation	Degrees of freedom	Mean squares	F values
F Position	1	.05326	39.452***
A x F	1	.00045	.333
B x F	28	.00135	
C x D	1	.00111	.854
A x C x D	1	.01336	10.285**
B x C x D	28	.00130	
C x F	1	.04254	32.270***
A x C x D	1	.00097	.740
B x C x F	28	.00132	
D x F	1	.00129	1.045
A x D x F	1	.00003	.023
B x D x F	28	.00124	
C x D x F	1	.00077	.748
A x C x D x F	1	.01047	10.148**
Error	28	.00103	

**$p < .01$

responded to faster than first occurrences. The three-way interaction of cue type, lag, and position was not significant.

Although RT's to second occurrences of DC events were longer than those to second-occurrence SC events, interpretation of this finding is clouded by the fact that RT's to DC and SC events also differed at the level of first occurrences, $\underline{q}$ (3, 56) = 64.368, $\underline{p} < .001$. The longer first-presentation RT's in the DC condition may be a function of the polysemous nature of DC target words. Because those items could be interpreted in more than one way, many subjects may have deliberated slightly over which interpretation to invoke before responding.

Summary of results

Free recall of target words afforded general support to the differential rehearsal hypothesis in that a significant lag effect obtained only in the SC condition of the intentional learning group. Interpretation of this finding was tainted by the interaction of list form with several variables and combinations of variables. A significant effect of repetition was found at all three levels of cue type.

Statistical analyses of the free recall of biasing words indicated that biasing words accompanying the first presentations of DC and M-N target words are better remembered than their second-occurrence counterparts. Lag was shown to have no significant effect whatsoever on the recall of biasing words.

Reaction times to events in various conditions of the incidental learning task failed to provide any useful information regarding the free-recall results. Second occurrences of repeated events did yield faster RT's than first occurrences, but this effect was limited to the SC condition. The lag manipulation did not influence RT's significantly.

Discussion

Recall of target words

The impetus for comparing the effect of lag in intentional learning to the effect of lag in incidental learning was twofold. First, it was reasoned that the semantic judgement entailed in the incidental learning task would ensure differential encoding of DC target words to a greater extent than had earlier attempts to induce differential encoding by merely presenting modifiers along with to-be-remembered words (e.g., Madigan, 1969). Second, on the assumption that differential rehearsal of short- versus long-lag events would be minimized by the incidental learning task, comparing lag functions of various cue types in the incidental learning group with those in the intentional learning group would, ideally, provide a crucial test of the differential rehearsal hypothesis.

The free recall of target words lent no support to differential encoding theory, as there was no difference between the SC and DC conditions in either the intentional or the incidental learning group. This result corroborates similar data reported by Madigan (1969), Winograd and Raines (1972), and Johnston et al. (1972). It would seem that proponents of differential encoding theory must either concede that the theory has clearly failed in the context of these studies or claim that this type of paradigm does not adequately test the theory -- and explain why this is so.

An overall evaluation of the free recall of target words might be that it provided mild support for the differential rehearsal hypothesis.

That hypothesis would forecast a lag effect only in the recall of SC words by subjects in the intentional learning group, which is what was found. As this hypothesis is based on rehearsal strategies linked directly to motivational factors pertinent to deliberate memorization of word lists, it clearly does not predict a lag effect under conditions of incidental learning.

The results, however, must be considered merely "mild support" for the theory, for at least two reasons. First, the lag effect in the SC condition of the intentional learning group was only marginally significant and accounted for very little of the variance in an absolute sense. Second, because many of the variables, including the lag manipulation, interacted with list form, almost any conclusion that is reached on the basis of these data must be tempered by a consideration of the list-form problem. Certainly, this consideration restricts the generality of the results.

Using a list structure similar to that employed in the present study, Gartman and Johnson (1972) also found a very substantial interaction of lag and list form, so that when data were summed across forms, the resultant lag functions were flat. They attributed their troublesome findings to the fact that the complexity of the lists "...may have been quite confusing for the subjects (p. 803)." For want of a better explanation, the present writer concurs with their conclusion. When list structure becomes extremely complicated, other factors may mute or override the effects of lag. It is suggested, therefore, that the type of list used here is, perhaps, not a very efficient instrument for investigating the lag phenomenon.

Recall of biasing words

No significant effect of lag was observed in the free recall of biasing words. Although a lag effect was numerically present in the SC condition of the intentional learning group, it failed to reach a conventional level of statistical significance. This finding, in particular, must be considered puzzling. As the subjects were not aware of the distinction between target and biasing words, and because both types of word were repeated in the SC condition, higher recall of items repeated at the long lag was expected for biasing as well as target items.

Perhaps the most fruitful finding emerging from the present investigation was that biasing words that accompanied the first occurrence of DC target words were recalled significantly better than those associated with the second presentations of DC target words. As both first- and second-occurrence biasing items were represented an equal number of times by the same words, the former type of item must have been subjected to more processing. One possible explanation of this result is that information about the first presentation of a twice-presented word is recruited (i.e., retrieved) at the time that that word is repeated (cf. Hintzman et al., 1973). Thus, first-presentation biasing words may have often received an additional presentation when the associated target words were repeated and would, therefore, be expected to be recalled better than their second-occurrence counterparts.

Alternatively, if subjects tend to attenuate the processing of repetitions in comparison to first occurrences, first-occurrence biasing words simply may have been studied longer than second-occurrence biasing words. This hypothesis will be rendered either more or less feasible than the first explanation by the results of Experiments II and III.

EXPERIMENT II

Shaugnessy et al. (1972) successfully employed a free-looking-time technique to show a relationship between study time and recall. In that study, the superior recall of DP items, relative to MP words, was associated with longer viewing times and, presumably, more rehearsal. In view of those results, it is quite possible that the orderly increment in free recall that is correlated with regular increases in lag is largely mediated by a parallel augmentation in effective study time. Although this proposition has been handily rejected by Melton, it has not yet been subjected to an adequate empirical test. The second experiment reported herein was designed to assess the possibility that study time covaries with lag in a fashion similar to the covariation of free recall with lag.

Subjects paced themselves through a visually-presented list of nouns that were to be free-recalled subsequent to study of the final item. The list consisted of 14 primacy-buffer and 10 recency-buffer items, three 8-item sets of repeated words, and 8 once-presented items -- 80 events in all. Twice-occurring words were repeated at lags of 0, 4, or 20 intervening items. The amount of viewing time allotted to each word was recorded.

It was hypothesized that both recall of repeated words and viewing time of second presentations would increase monotonically with lag. This prediction was derived from the differential rehearsal hypothesis. An unembellished differential encoding theory generates no expectation regarding the covariation of lag and viewing time.

Method

Lists and materials

A basic, 80-event list was constructed from a pool of common, one- and two-syllable polysemous nouns that had been gathered by staff of the Psychology Department at Iowa State University. Fourteen of these words were randomly selected to serve as primacy-buffer (PB) items, and 10 were randomly chosen to comprise the recency-buffer (RB) items. Eight additional words were selected on a random basis to be used in the body of the list as once-occurring items. Three sets of eight twice-presented items were also drawn from the pool via random selection. Items from a given set of twice-occurring words were repeated in the body of the list at a lag of 0, 4, or 20 intervening events. Three forms of the list were constructed such that words within a particular set of repeated items were presented at each of the three lags an equal number of times. A balanced latin-square sequence was employed in effecting this rotation of repeated-word sets through the three magnitudes of lag. The buffer and once-presented words were the same across all list forms. Serial positions of individual buffer items remained constant across list forms. However, the positions of the remaining items were randomly determined for respective forms, subject to constraints exacted by the lag manipulation. Stimulus words were typed on acetate squares and mounted in Kodak Ready Mounts for visual presentation via a carousel projector.

Subjects and design

The subjects were 39 introductory psychology students at Iowa State University who volunteered to participate in the experiment for extra course credit. Thirteen subjects were assigned to each of the list forms. Assignment to list forms was conducted on a random basis at the time that the subject arrived at the laboratory. Subjects were tested singly.

List form was considered a between-subjects variable. The within-subjects variable was lag magnitude: 0, 4, or 20 intervening items. With regard to the viewing-time data, there was the additional within-subjects factor or position of occurrence for repeated items (first or second).

Apparatus and procedure

Subjects were told that they would view a long list of words, some of which would be repeated, and that they were to try to retain as many of the words as they could without regard to order. They were apprised of the fact that there would be but one main list, which would be followed immediately by a free-recall test.

Each subject was told that he would be pacing himself through the list and that, as the words varied in difficulty, he could study each slide as long or as little as he desired. He was further informed that the exchange of slides could be accomplished by pressing a telegraph key that was located in front of him.

The self-paced presentation sequence was mediated by a Massey-Dickinson module sequence in which each impulse initiated by pressing the telegraph key triggered an exchange of slides. This impulse also reset the pen of an event recorder (Beckman Dynograph), which permitted the automatic recording of viewing time per slide. This record of viewing time, however, was used primarily as a checking device, as a series of two Hunter Klock-counters permitted the direct recording of time per slide. In this series, each impulse set up by pressing the telegraph key instantaneously stopped one counter while resetting and starting the other counter. If the accuracy of an experimenter-recorded time was in question, it could be checked against the automatically registered record provided by the event-recorder protocol.

To minimize the influence of warm-up and practice factors, subjects were given a 20-event practice list consisting of two items from each of the three lag magnitudes and eight once-presented items. The practice list was self-paced. After attempting a written free recall of these items, subjects were asked to commence viewing the 80-event test list.

At the end of the test list, the subject was handed a dittoed recall sheet bearing several columns of blanks and was instructed to write as many of the words as he could remember in any order that he liked. Each subject was given up to 8 min. to complete his recall.

Scoring and analysis

Words produced in recall were deemed correct if they were items from the test list or slight misspellings of those items. Responses were categorized according to location in the list (buffers or body of the list) and lag magnitude. Recall of once-presented items was also assessed.

Amount of time allocated to each event during study was categorized according to lag and position (first or second occurrence). Once-presented items were also scored in terms of viewing time.

A mixed analysis of variance (3 x 3), in which lag was the within-subjects factor and list form was the between-subjects variable, was carried out on the free-recall responses, buffer and once-presented items excluded. An auxiliary analysis included once-presented items. A mixed analysis of variance with the same factors was performed on the viewing-time data for second presentations. Again, buffer and once-presented items were excluded from this analysis. Study times associated with the first presentations of items were analyzed in a third, mixed analysis of variance, with once-presented items comprising a fourth level of the within-subjects factor. Dunn's test (Kirk, 1968) was used for testing specific, *a priori*, hypotheses.

Results

Recall

For the sake of logical and statistical consistency, the free-recall scores of this experiment were subjected to the same transformation as the recall data of Experiment I -- viz, $X' = \sqrt{X + .5}$. Therefore, any reference to recall in the discussion of these results should be construed in terms of root recall.

Mean root recall as a function of number of presentations and magnitude of lag is shown in Figure 1. The monotonically increasing function typically found in conventional, experimenter-paced lag paradigms

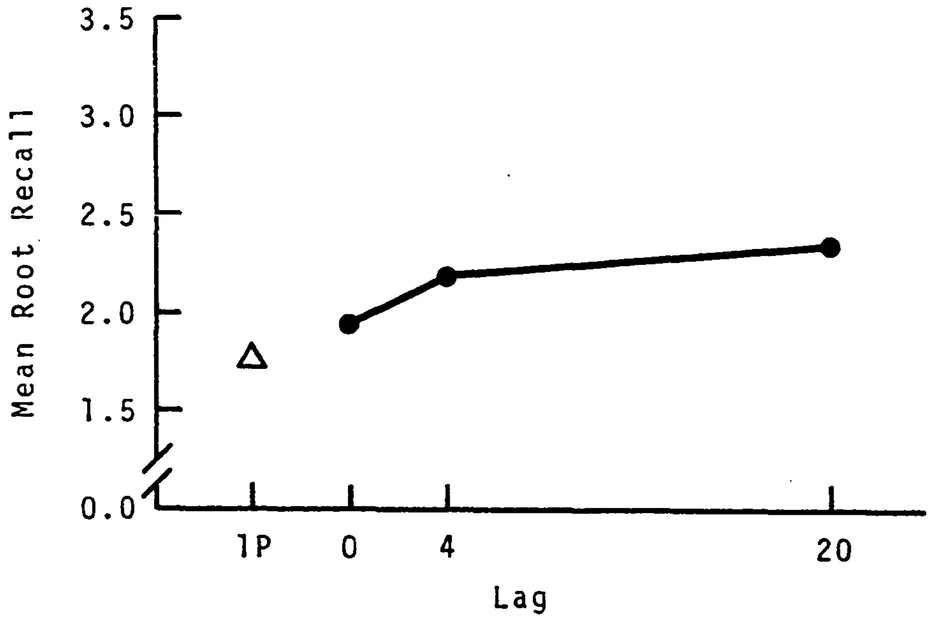

Figure 1. Mean root recall as a function of number of presentations and lag

is clearly in evidence. Moreover, relative differences in level of recall among the three magnitudes of lag appear to approximate those reported by earlier investigators who restricted themselves to experimenter-paced presentation (e.g., Madigan, 1969; Melton, 1970).

An analysis of variance of the root free-recall data, summarized in Table 8, revealed a highly significant effect of lag that did not interact with list form.

Application of Dunn's test for making nonorthogonal planned comparisons (Kirk, 1968) showed that, as expected, recall was better at lag 4 than at lag 0, $\underline{d}$ (2, 72) = 4.444, $\underline{p} < .01$, and higher at lag 20 than at lag 4, $\underline{d}$ (2, 72) = 2.433, $\underline{p} < .05$. Although recall of lag-0 items was just slightly higher than recall of once-presented words, a Newman-Keuls test indicated that this difference was significant, $\underline{q}$ (2, 108) = 3.361, $\underline{p} < .05$.

Viewing time

Subjects viewed first presentations for an average of 9.721 sec. (actual clock time), and second presentations for an average of 4.680 sec. (These figures include .8 sec. required for the exchange of slides.) The unit of analysis was the individual subject's mean viewing time at each lag. These scores were transformed to a log scale in order to "adjust" their distributions for some extreme observations (see Kirk, 1968).

Mean viewing time (in log sec.) as a function of presentation (first *versus* second) and lag is given in Figure 2. The analysis of

Table 8. Summary of analysis of variance of root recall, Experiment II

Source of variation	Degrees of freedom	Mean squares	F values
A List Form	2	.808	1.657
B Subjects/A	36	.488	
C Lag	2	2.132	23.926***
A x C	4	.122	1.365
Error	72	.089	

***$\underline{P} < .001$

variance of first-presentation viewing times, in which once-presented items were considered a fourth level of the lag variable, is presented in Table 9. As indicated in Figure 2, amount of viewing time allotted to first presentations was not related to lag category. This result was desirable in that no viewing-time differences would be expected at the level of first presentations if list construction procedures had been successful in randomizing the order of the various magnitudes of lag throughout the list. It will be recalled that results of a similar study reported by Maki (1974) were deemed equivocal because there had been viewing-time differences associated with initial presentations of repeated items.

The lower function in Figure 2 shows that the amount of viewing time afforded second presentations of repeated items increased

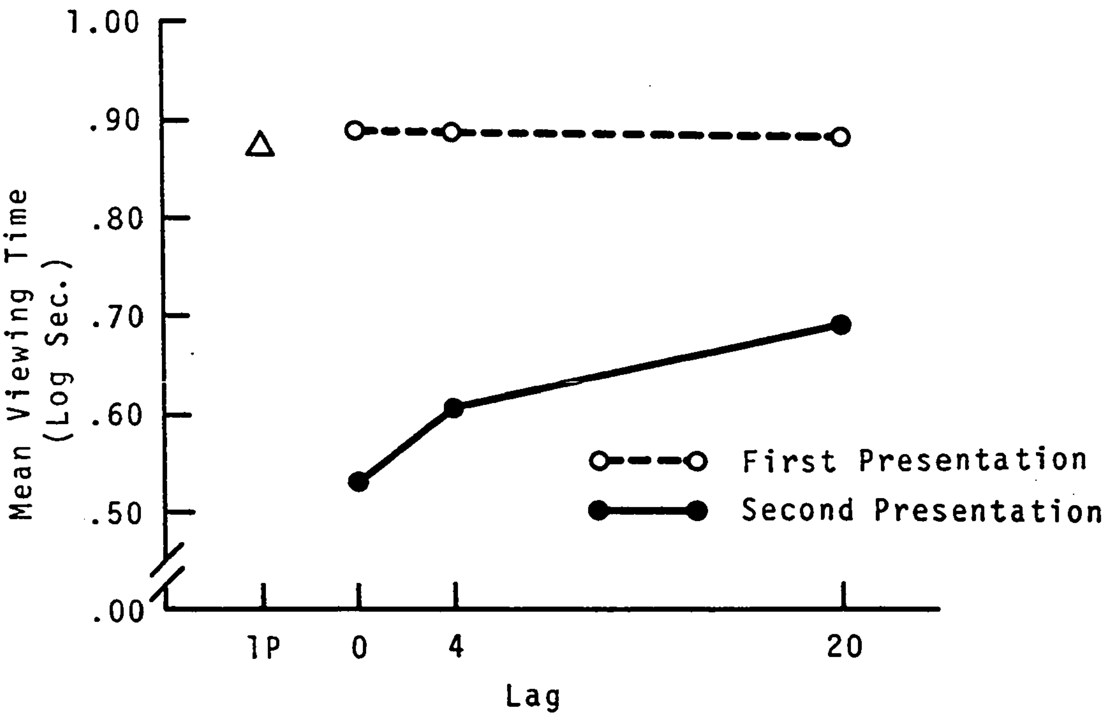

Figure 2. Mean viewing time (in log sec.) as a function of presentation and lag

Table 9. Summary of analysis of variance of mean viewing time (in log sec.), first presentation, Experiment II

Source of variation	Degrees of freedom	Mean squares	F values
A List Form	2	.15728	.456
B Subjects/A	36	.34473	
C Lag	3	.00241	.738
A x C	6	.00397	1.215
Error	108	.00327	

monotonically with the spacing of repetitions. This predicted effect was highly significant, as indicated in summary Table 10, and is consistent with the differential rehearsal hypothesis. It is noteworthy that subjects did not study second presentations as long as first presentations, even when the second presentation occurred after twenty intervening items.

Further analyses

The parallel between root recall as a function of lag and log viewing time as a function of lag may be largely fortuitous. Although both dependent variables may be responsive to the spacing of repetitions, the enhancing effect that longer lags have upon recall may not be *a result of* the tendency for study time to increase with lag.

Table 10. Summary of analysis of variance of mean viewing time (in log sec.), second presentation, Experiment II

Source of variation	Degrees of freedom	Mean squares	F values
A List Form	2	.27469	2.560
B Subjects/A	36	.10734	
C Lag	2	.24043	19.884***
A x C	4	.01367	1.130
Error	72	.01209	

***$\underline{P} < .001$

If an appreciable part of the lag effect is due to differential study times, subjects who show a large lag effect for study time should also exhibit a larger lag effect for recall than subjects whose study times are minimally influenced by lag. Therefore, 38 of the 39 subjects[2] were ranked according to the magnitude of their individual lag functions for second-occurrence viewing times, where "lag score" = [(viewing time at lag 4) - (viewing time at lag 0)] + [(viewing time at lag 20) - (viewing time at lag 4)], which reduces to (viewing time at lag 20)-(viewing time at lag 0). The top 19 subjects were labelled the "large-effect" group, and the remaining 19 subjects constituted the "small-effect" group. Viewing-time functions based on this median split are shown in Figure ?.

[2]One subject with maximum recall scores at all lags was excluded.

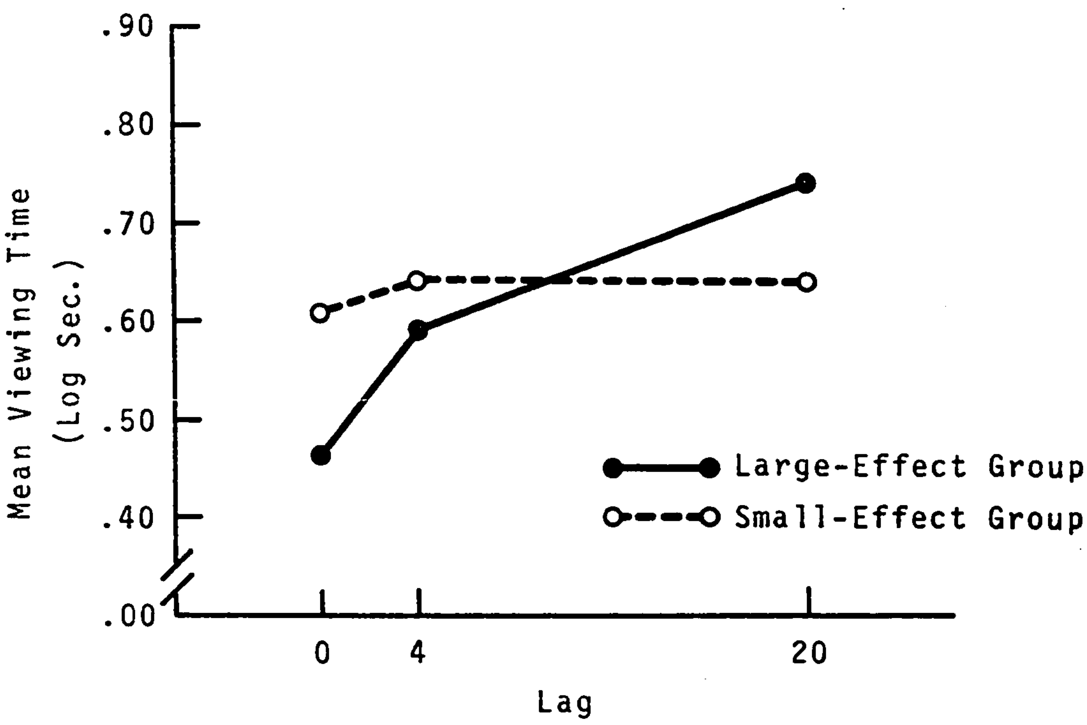

Figure 3. Mean viewing time (in log sec.) for second presentations as a function of lag and effect group

Mean root recall as a function of lag and effect group is given in Figure 4. A summary of the analysis performed on these data is presented in Table 1 . It can be seen that subjects with larger study-time lag functions also had larger recall lag functions; this interaction was statistically significant. The general correspondence between the recall and viewing-time data of the respective effect groups very strongly suggests that a differential study-time process contributes significantly to the lag effect. It is obvious, however, that the study-time data would lead one to expect higher relative recall in the lag-20 condition of the large-effect group than was observed. To some extent, recall in that condition may have been restricted by an effective recall ceiling, as 8 of the 19 subjects had lag-20 raw scores of 7 or 8, where a score of 8 was the maximum. Further discussion of the problem of partial noncorrespondence between the two dependent variables is presented below.

Each subject's linear component on the recall dimension was computed by "lag score" = (recall at lag 20) - (recall at lag 0). The Pearson $\underline{r}$ between this difference score and the one computed for viewing times was .42, $\underline{p} < .01$.

The outcomes of the present study corroborate those of Shaughnessy et al. (1972) and Maki (1974), and lend support to the differential rehearsal explanation of the lag effect. In both this investigation and the study reported by Maki, the amount of time subjects studied second presentations of repeated items increased monotonically with the spacing of repetitions and, thereby, paralleled the effect that lag had upon free recall.

There are two ways in which the present investigation was more informative than Maki's. First, Maki's results were difficult to interpret because the correlation between lag magnitude and study time tended to exist at the level of first presentations as well as for second presentations. This problem did not develop in the present data.

Table 11. Summary of analysis of variance of root recall, Experiment II

Source of variation	Degrees of freedom	Mean squares	F values
A Effect Group	1	.687	1.416
B Subjects/A	36	.485	
C Lag	2	2.457	23.398***
A x C	2	.423	4.032*
Error	72	.105	

*$P < .05$

***$P < .001$

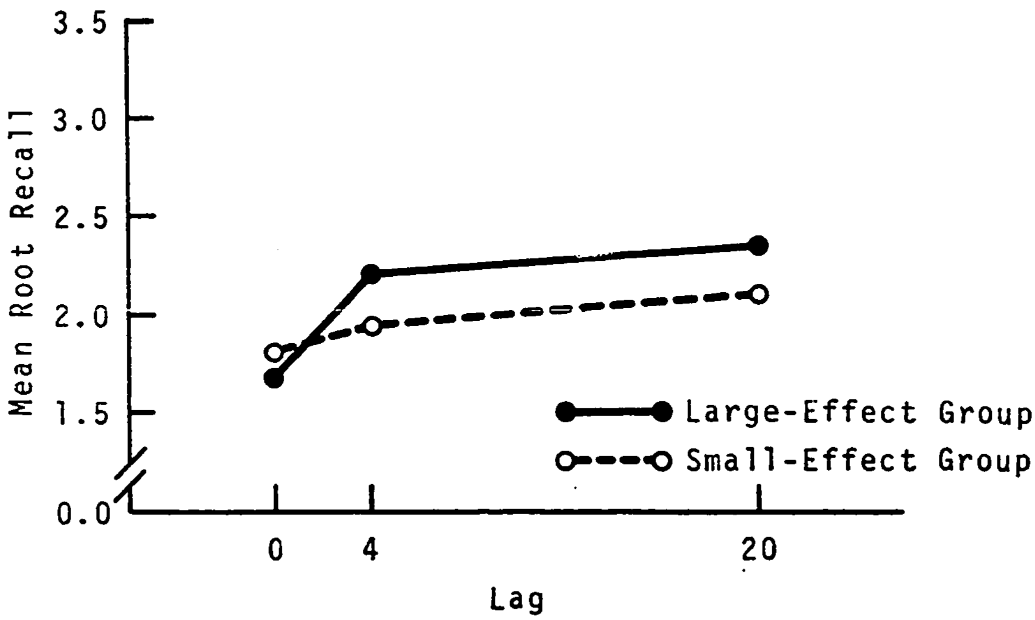

Figure 4. Mean root recall as a function of lag and effect group

Second, the correspondence between study time and recall reported by Maki may have merely represented a situation in which two psychologically independent processes happen to react in a similar fashion to a particular stimulus situation. Maki made no attempt at finer analyses that may have rendered the differential rehearsal hypothesis more credible. The median split of subjects in the present study, however, indicated that subjects who had steep viewing-time lag functions also showed steeper lag functions on the recall variable than did subjects whose viewing times were only minimally correlated with lag magnitudes. This relationship, while in no sense proving the differential rehearsal hypothesis, tends to augment confidence in the idea that recall increases with lag largely because massed and short-lag items tend to be processed less on their second occurrences than items repeated at longer lags. Moreover, the increment in processing time afforded second presentations of distributed items appears to be a regularly increasing function of the spacing of repetitions.

It should be noted, however, that while these data uphold the version of the differential rehearsal hypothesis asserting an <u>attenuation</u> of processing at short lags (e.g., Greeno, 1970; Underwood, 1970), they do not necessarily fit with Waugh's (1970) statement of the hypothesis. The latter version holds that earlier, more "unique" (i.e., once-presented or long-lag) items are rehearsed during the "free" time associated with second and later presentations of massed items. Hence, a strict interpretation of Waugh's hypothesis might predict that subject-controlled viewing times would be the same at all lags. That is, subjects might allocate an equal amount of time to each second occurrence, regardless of lag, but use the study time afforded second presentations of massed items to rehearse earlier items. Figure 2 shows, however, that when given an opportunity to control study time directly, subjects prefer to spend less time on second presentations than on first presentations, and that the tendency to attenuate processing of second occurrences decreases as the number of items intervening between first and second occurrences increases. Thus, it is concluded that the results are more supportive of differential rehearsal hypotheses that ascribe the lag effect to a negative factor regarding second presentations of massed items than of hypotheses that attribute the lag effect to a positive effect of rehearsal strategies on "unique" items in a list.

It was mentioned earlier that there was a degree of noncorrespondence between relative viewing time and relative recall. Specifically, lag-20 recall in the large-effect group was somewhat lower than their lag-20 viewing times would lead one to expect. While a recall "ceiling" may have affected recall performance in that cell, other explanations readily suggest themselves.

This particular aspect of relative noncorrespondence between viewing time and recall relates to a larger, and presently unanswerable, question of the accuracy of the study-time measure. As Shaughnessy et al. have pointed out, the appropriateness of the present procedure as a test of the differential rehearsal hypothesis rests entirely on acceptance of the assumption of a direct correspondence between the subject's termination of a slide exposure and the cessation of processing that might occur in connection with that slide under conditions of experimenter-paced presentation. Undoubtedly, this assumption is inaccurate to some extent, and the degree of inaccuracy may be related systematically to lag magnitude. For example, subjects occasionally may rehearse earlier items during the "viewing" of second presentations, and the likelihood of doing this may be greater at lag-20 than at shorter lags.

It should also be borne in mind that the median-split procedure was based on difference scores, which are notoriously unreliable.[3]

In conclusion, then, the results of Experiment II, while not disconfirming the differential encoding theory, indicate that a significant portion of the lag effect could be accounted for by study-time differences.

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[3]In any case, the conventional statistical regression model would generate the expectation of smaller differences between the "predicted" functions (i.e., recall data) than between the "predictor" functions (i.e., viewing-time data).

EXPERIMENT III

One of the principal predictions of differential encoding theory is that presenting a repeated item with different verbal modifiers on its respective occurrences should eliminate or greatly diminish the lag effect (Gartman & Johnson, 1972; Johnston et al., 1972; Madigan, 1969). Although several investigators have succeeded in showing a reduction of the lag effect with different-cue repetitions (Gartman & Johnson, 1972; Madigan, 1969; Winograd & Raines, 1972), the interpretation of this result is still open to question. It was suggested earlier in this paper that the flattening of the lag function found when different-cue modifiers are used may be a result of additional processing time afforded the second presentation of massed or short-lag items under these conditions rather than a product of the establishment of two different retrieval cues. That is, if the organism's bias against immediate repetition of psychological events (Walker, 1964) is at least partly responsible for lower recall at shorter lags, the altering of modifiers across repetitions of short-lag or massed items may release the organism from this bias by effectively changing the repetition of an event into a somewhat novel event. Hence, at short lags, more rehearsal time should be afforded different-cue repetitions than same-cue repetitions, thereby effecting an attenuation of the slope of the lag function. Experiment III investigated this hypothesis.

The basic design of the present experiment was similar to that of Experiment II, except that the stimulus words were accompanied by adjectival modifiers and only two magnitudes of lag, 0 and 8-12, were used. In addition, half of the repeated words had different modifiers on their respective occurrences, and the remainder of the repeated words occurred with the same modifier both times. As in Experiment II, subjects paced themselves through the list.

It was predicted that the free-recall lag effect would be attenuated in the different-modifier condition and that the slope of the viewing-time lag function of second occurrences would be smaller in the different-modifier condition than in the same-modifier condition. In other words, a lag x modifier type interaction was expected to be evident in both the free-recall data and the viewing time data associated with second occurrences. The planned comparison to be made on both dependent variables involved the difference between the means of same- and different-modifier conditions at lag 0.

Method

Lists and materials

A basic, 80-event list was constructed from the 56 polysemous nouns used in Experiment II. (These nouns and their modifiers are given in Appendix B.) There were two sets of 12 words each that were to be presented twice in the list, a set of eight once-presented words, 14 primacy-buffer (PB) items, and 10 recency-buffer (RB) items. Once-presented words were evenly distributed among instances of repeated words in the body of the list. Within each form of the list, 12 words were repeated at lag 0, and 12 were repeated at lag 8-12. Assignment of items to twice-presented, once-presented, and buffer categories was made on a random basis.

All target words and buffer items were presented with adjectival modifiers, with the modifier in the upper position and typed in lower-case letters and the target word in the lower position and typed in uppercase letters. Six target words in each lag set of 12 items were accompanied by the same modifier (SM) at each occurrence (e.g., baseball DIAMOND, baseball DIAMOND). The remaining six items in that set had different modifiers (DM) on their respective presentations (e.g., glee CLUB, billy CLUB). Target words and their modifiers were typed on acetate squares and mounted in Kodak Ready Mounts for visual presentation via a carousel projector.

Complete counterbalancing of all combinations of modifier type (DM and SM) and lag magnitude (0 and 8-12) across the 24 repeated items necessitated the construction of four forms of the list. The repeated items were broken down into four subsets of six items each. Then, each subset of repeated words was rotated through the four combinations of modifier type and lag magnitude such that, across four list forms, each subset represented each combination once. In addition, across all forms of the list, each modifier-target word combination occurred equally often at the first and second presentation position in the DM condition.

The same set of eight words served as once-presented items on all forms of the list. However, each of the two modifiers of each once-presented word was used and equal number of times across list forms. The same was true of the buffer items. With the exception of the buffer items, the order of words within a list was randomly determined for each list form, subject to constraints imposed by the lag manipulation. The order of buffer items was the same on all list forms.

Subjects and design

The subjects were 44 volunteers from psychology classes at Iowa State University. They received extra credit toward their course grades for participating in the experiment. Eleven subjects were assigned to each of the list forms. These assignments were carried out on a random basis at the time that the subject appeared at the laboratory. Subjects were tested one at a time.

List form was the sole between-subjects factor. The within-subjects variables were lag, type of modifier, position of occurrence (first or second), and number of presentations (one or two). Of course, the position of occurrence factor could not be analyzed on the free-recall dimension.

Apparatus and procedure

The apparatus and procedure were exactly the same as those employed in Experiment II. The instructions were similar also, with the exception that in the present study subjects were told that they would be asked to recall only the words typed in capital letters (i.e., target words). They were reminded of this at the time of free recall. To ensure orientation to the verbal context, however, subjects were instructed to pronounce each pair of words in top-to-bottom order at the time of its presentation. As in the previous study, subjects in the present experiment were given a practice list prior to the test list.

Scoring and analysis

Free-recall responses were deemed correct if they were target items from the test list or slight misspellings of those items. Responses were categorized according to location in the list (buffers or body of the list), lag, and type of modifier. To equalize cell frequencies, only six of the eight once-occurring items were used in the analysis; selection of these items was random.

Amount of time devoted to each event was extracted from the viewing-time records and classified in term of lag, modifier type, and position (first or second).

A 4 x 2 x 2 (List Form x Lag x Modifier Type) analysis of variance, with repeated measures on the last two factors, was performed on the free-recall responses, buffer items excluded. A 4 x 2 x 2 (List Form x Lag x Modifier Type) analysis of variance was executed on the second-occurrence viewing-time data, and a 4 x 5 (List Form x Repetition Type) analysis of variance was carried out on the first-occurrence viewing times. In the latter analysis, once-presented events were considered to be a fifth level of the repetition-type factor. Buffer-item data were also excluded from analyses of viewing time. Student's *t* test was used to test *a priori* hypotheses, and Dunnett's test was employed in making additional mean comparisons.

Results

Recall

Consistent with treatment of data in Experiments I and II, free-recall scores recorded in this experiment were subjected to the transformation, $X' = \sqrt{X + .5}$.

Mean root recall as a function of the four combinations of lag and type of modifier is shown in Figure 5, and a summary of the analysis carried out on the data is given in Table 12. List form neither had an effect nor interacted significantly with any other variable. Both lag and type of modifier were significant manipulations, with root recall being higher at lag 8-12 than at lag 0, and higher for different-modifier (DM) words than for same-modifier (SM) items.

The principal prediction for the recall data was a lag x modifier type interaction. Although higher recall at lag 8-12 than at lag 0 was expected for both types of modifier, it was predicted that the lag effect would be smaller in the DM condition than in the SM condition, such that recall of DM items should be higher than recall of SM items at lag 0 but not at lag 8-12. As indicated in Figure 5, this interaction obtained. Planned comparisons revealed that while retention of DM items was better than retention of SM items at lag 0, $t\ (80) = 4.145$, $p < .001$, the two types of modifier did not differ on the recall variable at lag 8-12, $t < 1.0$.

(Although the predicted interaction of lag and type of modifier was evinced both graphically and statistically, its interpretation poses some problems as a result of possible "scale differences" in the dependent

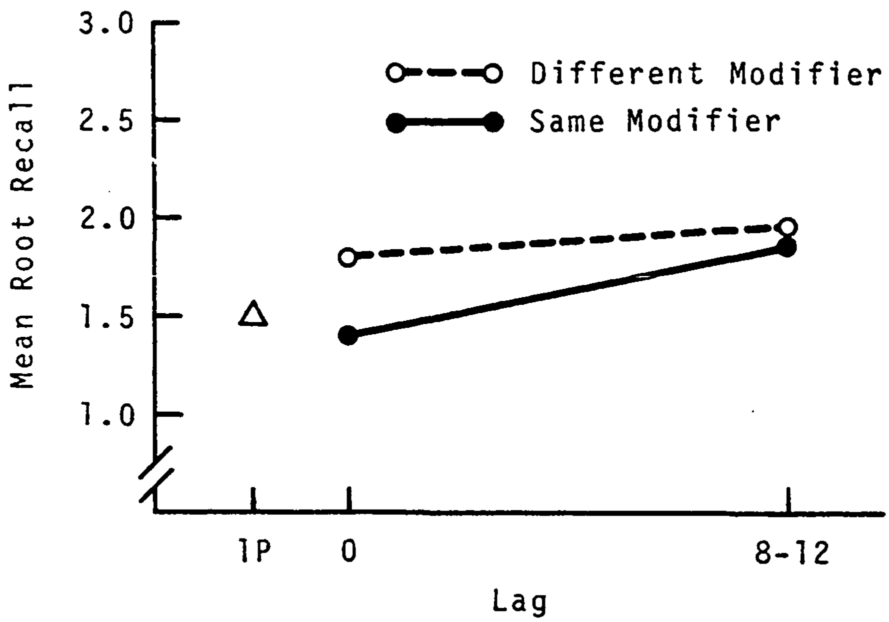

Figure 5. Mean root recall as a function of lag and type of modifier

Table 12. Summary of analysis of variance of root recall, Experiment III

Source of variation	Degrees of freedom	Mean squares	F values
A List Form	3	.733	1.295
B Subjects/A	40	.564	
C Lag	1	4.267	30.367***
A x C	3	.203	1.443
B x C	40	.140	
D Modifier Type	1	2.523	9.385**
A x D	3	.108	.403
B x D	40	.269	
C x D	1	1.357	6.496*
A x C x D	3	.076	.363
Error	40	.209	

***$P < .001$

**$P < .01$

*$P < .05$

variable (recall) at different points along the independent dimension (lag). Because the properties of the free-recall scale are unknown -- i.e., it cannot be ascertained that we are dealing with an interval scale -- the difference between the DM and SM conditions may represent the same number of "psychological units" at both lag magnitudes, if the units at lag 8-12 are smaller than those at lag 0. Thus, the interaction of interest may be more apparent than "real." This interpretive problem would have been averted, had the DM and SM lag functions "crossed" one another near lag 8-12; in that case, the respective functions would have been "sharing" a portion of the dependent dimension at a common point along the independent dimension, and the assertion of "no evidence of a difference" at that point could have been made unambiguously.

Because there was no crossover of functions in these data, caution must be exercised in drawing conclusions on the basis of this interaction. Fortunately, however, the predicted interaction has occurred with a crossing of lag functions in several other studies designed to examine the same variables (cf. Johnston et al., 1972; Madigan, 1969; Winograd & Raines, 1972). Therefore, considerable confidence probably should be placed in the reality of the interaction.)

Additional mean comparisons, using Dunnett's test, showed that DM words repeated at lag 0 were better recalled than once-presented items, $\underline{tD}$ (5, 160) = 3.549, $\underline{p} < .01$, and that recall of lag-0 SM items did not differ from that of once-presented words, $\underline{tD} < 1.0$.

Viewing time

The unit of analysis in statistical treatment of the viewing-time data was each subject's mean viewing time for once-presented items and for each cell resulting from the factorial combination of modifier type and lag. Subjects viewed first presentations for and average of 9.206 sec. (actual clock time), and second presentations for and average of 5.252 sec. (These figures include .8 sec. required for the exchange of slides.) Consistent with treatment of data in the first two experiments, the present viewing-time data were transformed to a log scale, where $X' = \log X$. Accordingly, any reference to viewing time should be construed in terms of log viewing time.

Mean viewing time (in log sec.) as a function of lag, type of modifier, and presentation (first *versus* second) is shown in Figure 6. A summary of the analysis of variance for first presentations is given in Table 13. In this analysis, the four cells resulting from the factorial crossing of two levels of modifier type with two levels of lag were treated as four levels of a single factor, and once-presented items were treated as a fifth level. As Figure 6 clearly suggests, viewing-time differences did not exist at the level of first presentations.

An analysis of variance of viewing times for second presentations, summarized in Table 14, indicated that both lag and modifier type produced highly significant effects. Figure 6 reveals that, as expected, second presentations were studied longer at lag 8-12 than at lag 0, and longer when the biasing word changed from the first to the second occurrence than when it remained constant across successive presentations. Because the viewing time functions were expected to parallel the recall functions,

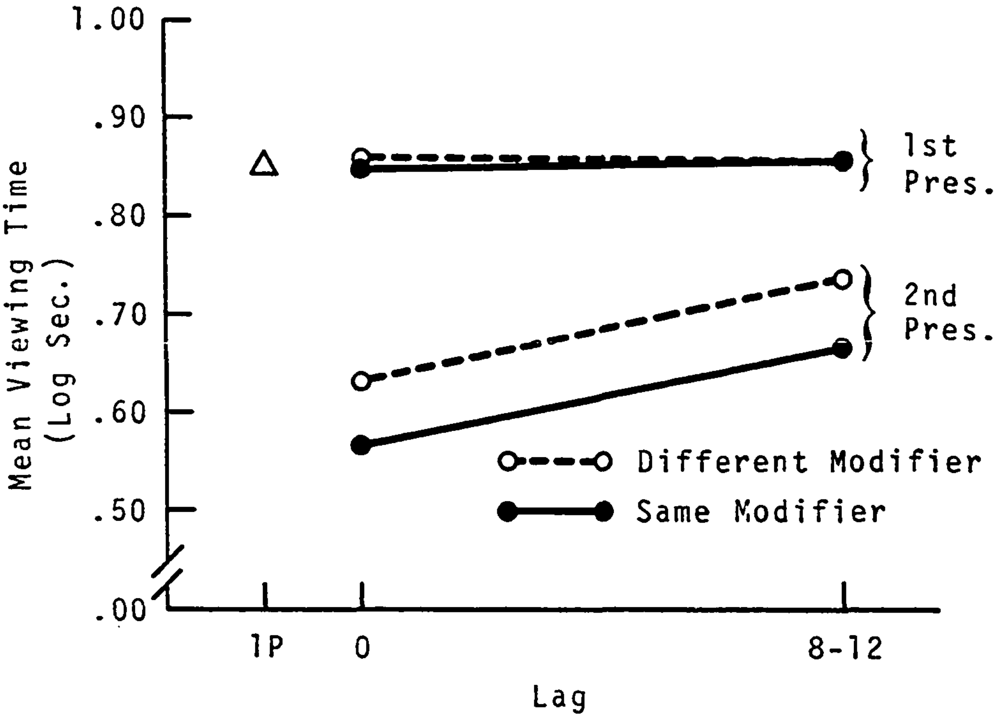

Figure 6. Mean viewing time (in log sec.) as a function of lag and type of modifier

Table 13. Summary of analysis of variance of mean viewing time (in log sec.), first presentation, Experiment III

Source of variation	Degrees of freedom	Mean squares	F values
A List Form	3	.13945	.329
B Subjects/A	40	.42439	
C Repetition Type	4	.00080	.219
A x C	12	.00445	1.211
Error	160	.00367	

an interaction of lag and modifier type was predicted. As indicated in Table 14, however, that interaction did not occur. Because the expected attenuation of lag in the DM condition would have had to be defined in relation to the SM lag function, it is difficult to ascertain whether the failure to obtain the interaction stems from too large a difference between DM and SM conditions at lag 8-12 or too small a difference between those conditions at lag 0. The large overall effect of modifier type, however, would suggest that the former alternative is the more correct one.

Further analyses

As in Experiment II, subjects in this study were divided into two groups based on the slope of their individual viewing-time lag functions: a "large-effect" group and a "small-effect" group, where "lag score" =

Table 14. Summary of analysis of variance of mean viewing time (in log sec.), second presentation, Experiment III

Source of variation	Degrees of freedom	Mean squares	F values
A List Form	3	.06575	.345
B Subjects/A	40	.19087	
C Lag	1	.44829	19.158***
A x C	3	.01695	.722
B x C	40	.02340	
D Modifier Type	1	.20048	25.705***
A x D	3	.00154	.198
B x D	40	.00777	
C x D	1	.00000	.000
A x C x D	3	.00178	.276
Error	40	.00645	

***$p < .001$

(SM viewing time at lag 8-12) - (SM viewing time at lag 0). Only the second-presentation viewing times of the SM condition were of interest in this particular analysis. This analysis was carried out principally as a check on the replicability of the results of a similar analysis performed in Experiment II.

Each effect group contained 22 subjects, assigned according to a median split based on the difference score described above. The viewing-time lag functions of the respective groups are presented in Figure 7. Interestingly, the figure indicates that, on the average, the small-effect group exhibited virtually no lag effect for viewing time. This was also the case for the viewing-time data of Experiment II.

Each group's lag function for the free-recall dimension is shown in Figure 8, and a summary of the analysis of variance of these data is given in Table 15. The present results replicated those of Experiment II. The significant effect group x lag interaction indicates that, once again, the recall lag effect could be predicted from the lag effect for viewing time. In fact, the Pearson _r_ between SM difference scores on the viewing-time dimension and corresponding difference scores on the recall dimension was .44, $p < .01$. The important point is that this analysis has further strengthened the hypothesis that differences in study time may contribute significantly to the effect of distributed practice.

The chief impetus for the design and execution of the present experiment was the contention that attenuation of the lag effect may result from subjects' simply allocating more attention (i.e., study time) to the second presentation of massed items in the DM condition than in the SM condition. Although the data of this study failed to

Table 15. Summary of analysis of variance of root recall, Experiment III

Source of variation	Degrees of freedom	Mean squares	F values
A Effect Group	1	.456	1.419
B Subjects/A	42	.318	
C Lag	1	3.860	42.041***
A x C	1	.374	4.078*
Error	42	.092	

*$P < .05$

***$P < .001$

uphold this idea in the sense that lag did not interact with modifier type on the viewing time dimension, more viewing time was given to DM items repeated at lag 0 than to SM items repeated at that lag. If the original hypothesis was to remain tenable, however, it had to be shown that differences between recall of DM items and SM items in the lag 0 condition were predictable from the corresponding viewing-time differences. When a median split of subjects into large- and small-effect

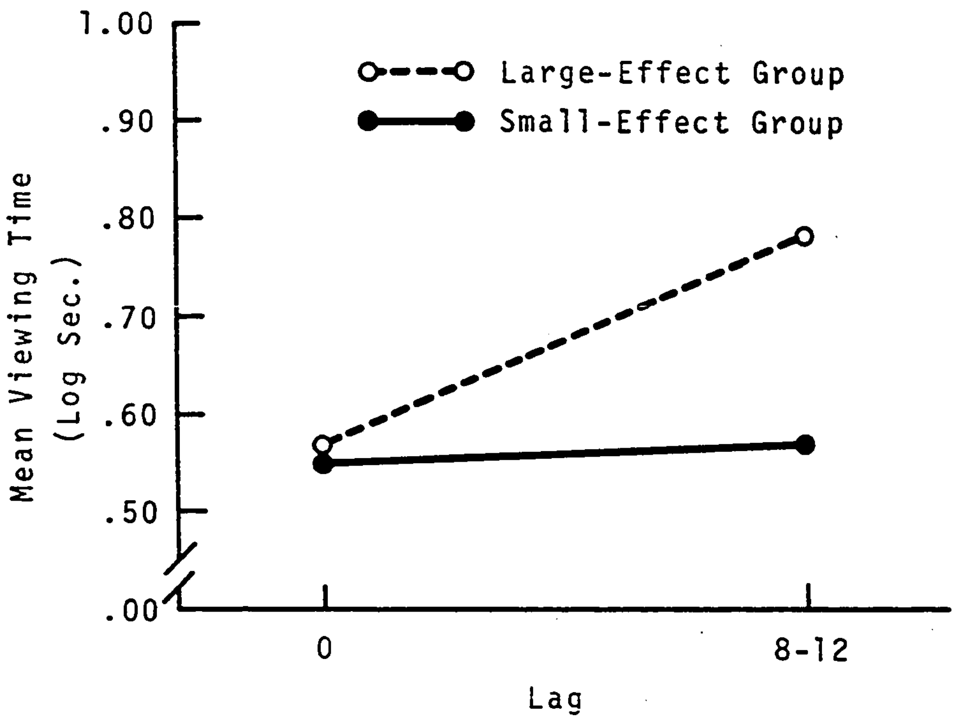

Figure 7. Mean viewing time (in log sec.) for second presentations of SM items as a function of lag and effect group

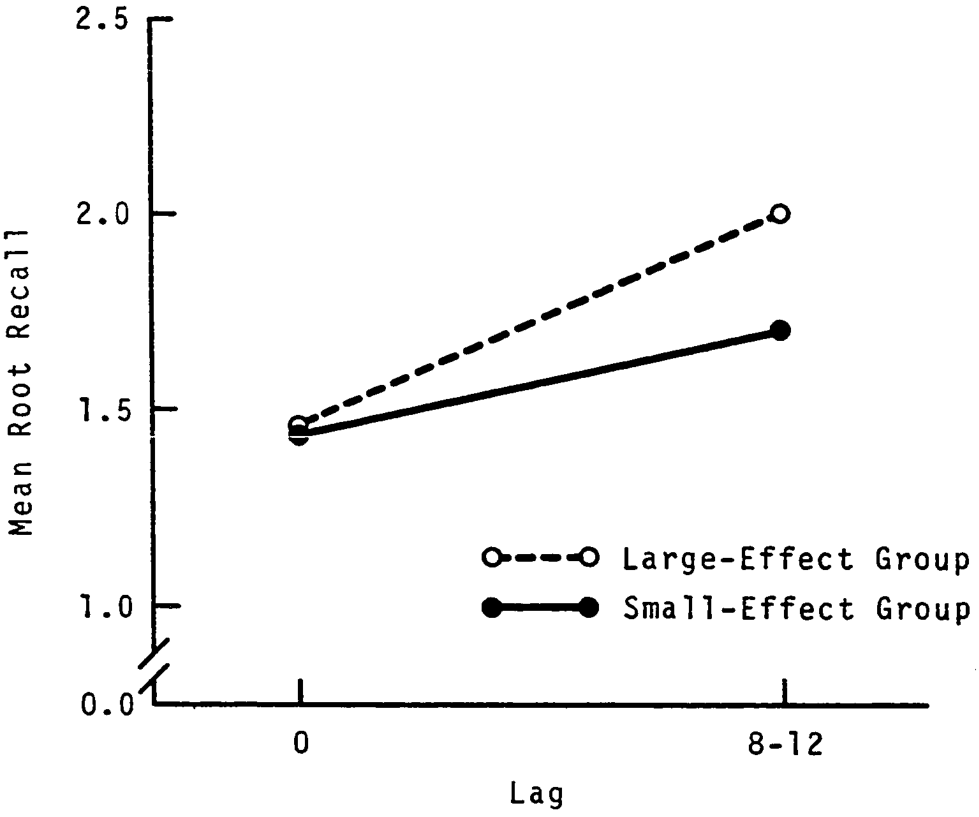

Figure 8. Mean root recall as a function of lag and effect group

groups was carried out to test this implication, however, the outcome, while in the proper direction, fell below statistical significance, F (1, 42) = 1.943, $p < .10$. The corresponding Pearson r was .15, $p = .17$. Thus, there is no hard evidence that the superior recall of DM items over SM items at lag 0 can be attributed to study-time differences.

An additional median-split analysis indicated that the superiority of overall DM-item recall over SM-item recall could not be predicted from corresponding viewing-time data, F (1, 42) $<$ 1.0.

Discussion

The results of this investigation upheld Underwood's and Greeno's differential rehearsal hypotheses as explanations of the lag effect but provided no unequivocal support for a differential rehearsal account of attenuation of the lag effect in the DM condition.

That second-presentation viewing times were smaller than the viewing times of first presentations but increased with the spacing of repetitions corroborates the data of Experiment II. The combined results of Experiments II and III suggest very convincingly that the inferior recall of massed items relative to distributed items in the free-recall situation may stem, at least in part, from the fact that the subjects give less study time to repetitions of the former items.

The significant interaction of lag and modifier type on the free-recall dimension replicates earlier investigations in which changing modifiers across presentations of repeated words produced an attenuation of the lag effect. The major differences between the interaction found here and those reported by other investigators were that in this study the DM and SM lag functions did not "cross," and, relatedly, DM words were recalled at a significantly higher level than SM words. In general, however, the present data appear to lend credence to the reliability of the lag-attenuation phenomenon.

The differential rehearsal hypothesis encountered problems in certain aspects of the viewing-time data. The chief hypothesis of this investigation was that DM words are better recalled than SM words in the lag-0 condition because subjects allocate more processing to massed repetitions of DM items than to massed repetitions of SM items. This assertion, however, forecasts a lag x modifier type interaction on the viewing-time dimension that parallels the interaction of these factors on the recall dimension. Not only did that interaction fail to emerge but, also, a median-split procedure showed that recall differences between massed DM and massed SM items were not predictable from corresponding viewing-time differences. It may be that the measure of study time was not valid, but this argument is mitigated by the fact that the degree of lag effect on the viewing-time variable in both Experiment II and the present experiment. Even when the unreliability of difference scores and the restricted range of difference scores on the recall dimension are considered, it must be concluded that the present data provide no unequivocal evidence that attenuation of the lag effect in the DM condition can be accounted for by study-time differences.

Higher overall recall in the DM condition than in the SM condition was the most unusual outcome of this experiment. To the knowledge of the present writer, this represents the only instance, in current memory literature, of multiple encodings resulting in better free recall than repetitions of the same encoding, save the study reported by Gartman and Johnson (1972). As mentioned earlier, however, same _versus_ different encoding was confounded with category size in the Gartman and Johnson investigation.

Superior recall of DM items over SM items is explicitly predicted by differential encoding theory, which holds that two retrieval cues are better than one when the subject is "searching" his memory at the time of recall. One possible problem in construing this result as support for differential encoding theory is that DM items were studied longer than SM items. Hence, better recall of DM words might be attributed to the study-time difference rather than to the existence of more retrieval cues. As a median-split procedure revealed that recall differences between DM and SM items could not be predicted from viewing-time differences, however, the parallel between viewing-time and free-recall differences, with regard to the modifier-type factor, appears to have been a fortuitous event. Consequently, the superior recall of DM words probably should be viewed as being more consistent with the differential encoding theory espoused by Melton than with a differential rehearsal hypothesis.

One question that arises immediately from the finding of a significant main effect of same versus different encoding is that of why this result has been so consistently absent in earlier investigations. The answer may lie in the fact that subjects in this study used an average of 5.252 sec. to study second occurrences. Bower (1972) has pointed out that complex coding strategies are "slow rate" phenomena. Perhaps the self-imposed slow rate used by these subjects gave them more adequate opportunity to take advantage of multiple encodings than does the typical experimenter-paced situation.

A final note on a finding reported in Experiment I is in order. It will be remembered that first-occurrence biasing words were better recalled than second-occurrence biasing words in the DC condition of that study. The outcomes of Experiments II and III strongly suggest that this finding may be best explained by the fact that subjects study first-occurrence events longer than second-occurrence events.

CONCLUSION

Theoretical Issues

There has been a prevalent tendency in psychology, beginning with the early Greeks, to parse man's behavior and experience into neat categories such as knowing, willing, and feeling. These categories have come to be implicitly viewed as mutually exclusive.

This behavior on the part of psychologists is no where more pronounced than in the field of memory and information processing, where the "cognitive" has been extolled and the "motivational" played down and/or ignored. This dominant, pretheoretic stance is very pointedly exemplified by recent reaffirmations of the importance of aiming memory research at coding strategies in subjects rather than at hypotheses based on motivational or attentional factors (e.g., Melton, 1970; Walsh & Jenkins, 1973). Thus, currently popular theories of memory stress differences in the kind or quality of memory codes and de-emphasize differences in the amount of coding (e.g., Craik & Lockhart, 1972). The results of experiments reported herein suggest that both amount and kind of processing are important for retention of information, and that both aspects of learning should be considered in the investigation of the effect of distributed practice.

In general, the present findings are consistent with a cognitive-motivational position, such as that couched by Walker (1964). The fact that subjects in these investigations exhibited an unambiguous tendency to avoid the reprocessing of recently processed information indicates that college students are indeed biased against the immediate repetition of psychological events, as Walker's theory would lead us to expect. The reasons for the tendency to attenuate processing of massed items are not apparent at this time but may be related to concepts such as "fatigue," boredom _versus_ interest, or the degree of confidence the subject has in his ability to retain the item at the time of its repetition. In any case, the importance of a motivational element seems clear.

It must be pointed out, however, that the present data are relevant to the lag phenomenon in free-recall only to the extent that this subject-paced paradigm is analogous to the more typical experimenter-paced paradigm. This discussion assumes, then, that even with experimenter-paced presentation, subjects can be quite versatile in selectively distributing their rehearsal activities. In short, the present position holds that subjects' "control processes" (cf. Atkinson & Shiffrin, 1968) are as pertinent to varying the amount of processing afforded an item as they are to varying the kind of processing imposed upon an item. There is evidence that this is a tenable assumption (Rundus, 1971).

Melton (1970) has said that it is unclear to him how the notion of attenuated processing of massed items can account for the regular increase in free-recall performance with increasing interpresentation intervals. He reasoned that because eight intervening items is typically viewed as sufficient to displace an "old" item from primary memory, full processing should be restored to repetitions occurring beyond a lag of eight items. Thus, he continues, an attenuation-of-processing notion would not be able to explain the fact that lag-20 words are consistently recalled better than lag-8 items.

The data reported in this paper expose the fallacy in Melton's logic. It has been shown that subjects do not allocate full processing to repetitions even after a lag of 20 intervening events, if the mean amount of study time given first presentations can be considered the standard of "full processing." These data, as well as those reported by Maki (1974), indicate that subjects are capable of accurately monitoring differences in the age of items beyond the assumed limits of primary memory, and that they adjust their processing activities accordingly. Further, a continuous function rather than a STM-LTM dichotomy is suggested in connection with this control process.

Practical Implications

To the extent that the present investigatory circumstances are generalizable to more common situations, the implications for practice deriving from these studies are relatively straightforward. The fact that the incidental and intentional learning groups of Experiment I did not differ in overall recall suggests that the key to "painless" learning may be the implementation of activities that effect an "extraction of meaning" on the part of the learner.

Experiment II suggests that the classroom learning experience is not appreciably enhanced when teachers repeat information soon after its initial presentation. The idea that knowledge must be "drilled" into students by repeating information in immediate succession is definitely not supported. Indications are that students probably will not adequately process such repetitions.

The current findings suggest that a teacher who wishes to use lecture time efficiently should not attempt an immediate repetition of information. Rather, important points should be delivered in an interesting fashion initially (to ensure initial processing) and, then, repeated after a reasonable amount of time has elapsed.

The results of Experiment III imply that students may profit substantially from immediate repetition of information if that information is set forth in two different ways or from two or more perspectives. Should this approach be taken, however, it would probably be wise for the person who is imparting the material to present the repetition at a rate and in a manner that will permit the student to discern the relation between the respective presentations and to take full advantage of the separate encodings.

Suggested Research

This research has created more questions than it has dealt with. Of the many investigations suggested by the outcomes, the following seem to lie in the most fruitful directions.

The question of a lag effect in incidental learning was not efficaciously addressed by Experiment I, and due to methodological problems already noted, the results of that investigation can only be considered suggestive. The aim of future research along these lines will be to simplify the task and list structure so as to avert the difficulties associated with that study. First, single words, rather than pairs, will be presented. Second, the incidental-learning subjects' task will be to classify each word as "active" or "passive", which should induce a semantic analysis. This design will look at the effect of lag *per se*, uncomplicated by the element of same *versus* different encoding. This arrangement will not only simplify list structure and stimuli, but also provide more observations per cell per subject--thereby yielding data that are likely to be more stable and more normally distributed than those found in Experiment I. Finally, a larger range of lag will be employed to add power to the design. As in Experiment I, there will be an intentional learning (control) group.

Subjects in Experiments II and III were permitted as much time as they wished to progress through a list of unknown length. It will be interesting to see, in still another investigation, how subjects distribute their study time when they have a fixed amount of time in which to cover a list of words prior to a free-recall test. In this study the independent variable will be lag, and the dependent variables will be free recall and viewing time. Each subject will be given 4 min. to pace himself through each list, and each list will be 40 events long. The subject will receive 10 lists, the first five of which will be for purposes of practice. A 4-min. clock will be provided to assist subjects in budgeting their time. The purposes of such an experiment will be to (*a*) assess the generality of the present findings; (*b*) provide a "transitional" study that will bridge the paradigmatic gap between subject-paced and experimenter-paced presentation.

A third investigation suggests itself in connection with the effect of modifier type evinced in Experiment III. Because free recall of DM items was superior to that of SM items in that study, but not in earlier investigations of a similar nature, it was suggested that an enhancing effect of differential encoding may be operative only at very slow rates of presentation. A parametric study in which rate of presentation is systematically varied from a very fast rate (1 sec./word) to a tediously slow rate (8 sec./word) will support or contraindicate this explanation. A positive result in this study would have implications for a constructive modification of differential encoding theory.

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ACKNOWLEDGEMENTS

I am beholden to many persons who have contributed in some very significant way to the completion of this project. For their continued support and encouragement, I would like to express deepest appreciation to my committee members: Dr. Don C. Charles, Dr. David C. Edwards, Dr. James R. Redmond, and Dr. Leroy Wolins. A special debt is owed Dr. Edwards, whose equipment savvy spared the mechanical side of these studies from the brink of disaster on more than one occasion. Special thanks also go to Dr. Lloyd Avant who kindly substituted for one member of my committee who was not able to attend the final oral examination.

It has been a truly rewarding experience to work with my major professor, Dr. Wayne H. Bartz. In many instances, he has gone beyond his formal duties by continually expressing confidence in my capabilities and by making himself almost constantly available for consultation. It was his infectious enthusiasm that inspired me to pursue experimental psychology.

Many heart-felt thanks go to my wife, Lois, for tolerating the role of "Old Botany widow" for so long, for mounting countless stimulus slides, and for the general support she afforded me during the execution of this project. Finally, I would like to thank my little daughter, Laura, for making graduate school an unusual challenge.

APPENDIX A

Table 16. Stimulus pairs used in Experiment I[a]

Repetition type			
Same cue	Different cue	Match-nonmatch	Once-presented
floor	rod	mumps	duct
wall	staff (acre)	flu (window)	pipe
church	club	private	dot
temple	gun (group)	captain (method)	speck
coffee	file	noun	glass
milk	drawer (chisel)	verb (length)	crystal
perch	cardinal	cart	plug
tuna	pope (bluejay)	wagon (member)	wire
dollars	tap	yoyo	drive
pounds	spigot (waltz)	doll (sea)	road
hail	gold	jar	butler
rain	copper (green)	bottle (profit)	maid
paper	rock	onion	knife
parchment	jazz (stone)	garlic (canal)	spoon
pine	track	rattler	coat
elm	tennis (footprint)	cobra (seal)	shirt
rose	second	mayor	jungle
daisy	hour (first)	senator (trap)	forest
novel	foot	brother	candle
play	toe (inch)	niece (powder)	lamp
----	----	----	row
----	----	----	height
----	----	----	brush
----	----	----	name
----	----	----	neck
----	----	----	morning
----	----	----	student
----	----	----	firm
----	----	----	gift
----	----	----	pocket

[a]Words in parentheses are alternative biasing words.

APPENDIX B

Table 17. Stimulus items used in Experiments II and III[a]

Buffer	Item type: Twice-presented	Item type: Once-presented
half	ceiling	news
BACK	BEAM	FLASH
kick	light	lightning
costume	spelling	hired
BALL	BEE	HAND
basket	honey	minute
rubber	jail	strawberry
BAND	BIRD	JAM
marching	blue	traffic
blasting	court	fishing
CAP	CASE	LINE
skull	packing	bus
trash	padded	northern
FIRE	CELL	PIKE
rifle	blood	turn
shoe	hot	army
HORN	DOG	POST
party	bull	hitching
cotton	first	light
MOUTH	DOWN	SWITCH
big	goose	hickory
mountain	truck	front
PASS	DRIVER	YARD
weekend	screw	lumber
industrial	sports	----
PLANT	FAN	----
tomato	window	----
human	pole	----
RACE	VAULT	----
horse	bank	----
work	bell	----
SHIFT	HOP	----
stick	bunny	----

[a]Items in uppercase letters are target words, and items in lowercase letters are modifiers.

Table 17. (Continued)

Buffer	Item type Twice-presented	Once-presented
wrist	garden	----
WATCH	HOSE	----
night	panty	----
sun	grid	----
BURN	IRON	----
side	steam	----
sugar	table	----
CANE	LEAF	----
walking	maple	----
night	hazel	----
CLUB	NUT	----
golf	wing	----
wheat	pig	----
FIELD	PEN	----
medical	fountain	----
house	gas	----
FLY	PIPE	----
bar	bag	----
winter	knockout	----
JACKET	PUNCH	----
yellow	party	----
beer	boxing	----
JOINT	RING	----
elbow	diamond	----
license	sea	----
PLATE	SHELL	----
dinner	shotgun	----
circus	blue	----
SEAL	SHIELD	----
official	wind	----
steel	loud	----
MOLD	SPEAKER	----
bread	guest	----
car	movie	----
HORN	STAR	----
bull	distant	----

Table 17. (Continued)

Buffer	Item type Twice-presented	Once-presented
rose	spinning	----
BOWL	TOP	----
cereal	counter	----