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The Spacing of Lists in Free Recall

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Spaced presentations of 12- and 15-word lists were better recalled when no task or an easy task, rather than a demanding task, intervened between the presentations, contrary to the results of Bjork and Allen (1970). When no task intervened between spaced presentations, recall was better than when presentations were massed (Experiment I). These results are important because (a) they indicate a lack of generality of Bjork and Allen's findings, often considered crucial to general understanding of spacing effects; (b) they indicate a need for (at least) a two-factor theory of the spacing effect; and (c) they are the first evidence for a spacing effect when lists are considered as the unit of repetition.

In a fairly wide variety of memory situations it has been found that when two presentations of to-be-remembered information are separated in time, recall of this information is generally better than when the two presentations occur in close temporal proximity (see Hintzman, 1974; Crowder, 1976, chap. 9, for reviews). This advantage of spaced over massed presentation has created great theorectical and empirical interest since it seems somewhat paradoxical: Memory for the first presentation is better immediately after the presentation than at some later time, yet the eventual recall, from both presentations together, is better if the second presentation occurs when the "strength" of the trace from the original presentation has decreased. Apparently the benefit owing to a repetition is inversely related to the memory for the first presentation, at least up to some limit.

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Three primary reasons that have been advanced to explain this state of affairs will be considered here. First, the consolidation–rehearsal theory maintains that superior performance occurs with spaced presentation because spacing allows consolidation (or rehearsal) of information during the interval between presentations and thus leads to more effective utilization of the second presentation than in the case when the presentations are massed (Peterson, 1966; Landauer, 1969; Atkinson & Shiffrin, 1968). The spacing effect is, then, no longer paradoxical for, although recall may be declining after a first presentation (perhaps due to loss from a short term buffer), the "strength" of a long-term trace is growing at the same time due to rehearsal or consolidation. A distinction is often made between consolidation and rehearsal theories on the grounds of whether or not processes are under voluntary control (Hintzman, 1974), but for present purposes these two theories can be lumped together. A second explanation for spacing effects is the encoding variability theory, which takes several different forms (e.g., Estes, 1955; Melton, 1967; Madigan, 1969; Martin, 1968; Bower, 1972), but which generally maintains that subjects extract more different types of information about the target item from two presentations when they are widely distributed in time than when they occur close together, and that later memory performance is better supported when numerous types of information can be relied on for later recall. With spaced presentation, encoding of information is more variable than with massed presentation since the context of the second presentation is more likely to be changed in the former than in the latter case. A third interpretation of the spacing effect is the habituation hypothesis offered by Hintzman (1974) based on the analogy to benefits accruing to spacing in other situations. The general idea here is that on presentation of to-be-remembered information, the mechanism that allows for the representation of the trace of this experience becomes refractory immediately after being fired and thus will not "fire" again until this refractoriness wears off. The advantage of spaced to massed repetitions, then, is due to this gradual decrease in refractoriness.

An experiment that has deservedly received a great amount of attention as helping decide among these theoretical alternatives was reported by Bjork and Allen (1970). This experiment used a modified Brown–Peterson technique in which a short list of three words was presented and then repeated either 4.5 or 18 sec later. After the second presentation, recall was required after either 12 or 30 sec. Besides varying the spacing of the presentations, Bjork and Allen also varied the difficulty of a shadowing task performed between the presentations. In single presentation control conditions, it was shown that the more difficult shadowing task produced greater forgetting than the easier shadowing task. Bjork and Allen reasoned that consolidation–rehearsal theories predict that recall should be better in conditions where an easy interpolated task separated the two presentations, since greater opportunity for consolidation or rehearsal between the two presentations presumably existed in this case than when a difficult interpolated task intervened. On the other hand, encoding variability theory would presumably predict memory for two repetitions to be no worse, and probably better, when a difficult task is interpolated between the two presentations than when an easy task is interpolated, since with a difficult task the context determining the original encoding would more likely be changed at the time of the second presentation and thus the second encoding would be more likely to vary from the first. Results from the Bjork and Allen experiment showed that, whatever the spacing interval between presentations (4.5 or 18 sec), and whatever the retention interval following the second presentation (12 or 30 sec), performance was better when the processing task between the two presentations was difficult than when it was easy. The benefit in recall accruing to presentations separated by a difficult as opposed to an easy task was small, but consistent, and has been confirmed in two similar experiments (Robbins & Wise, 1972; Tzeng, 1973).

The finding that performance is better when two presentations are spaced by difficult, rather than easy, tasks argues strongly against the consolidation–rehearsal theory of the spacing effect. The difficult task allows less opportunity for consolidation or rehearsal immediately subsequent to the first presentation, yet performance is better in this case than when the easy task follows the first presentation. Arguing that consolidation is an automatic process unaffected by interpolated task difficulty appears to offer no solution to the problem; at best this would argue that there should be no difference in recall when interpolated task difficulty is varied, when in fact there is a benefit in recall with the difficult relative to the easy task. Bjork and Allen (1970) argued that the results favored the differential encoding hypothesis, while Hintzman (1974), who faults encoding variability on other grounds, finds the Bjork and Allen results consistent with the habituation hypothesis. Both the habituation theory and the encoding variability theory appear to demand the finding that recall be better when two presentations are separated by a difficult interpolated task than by an easy one. Whatever the specific theoretic interpretation, the empirical finding is important. Bjork and Allen (1970, p. 571) comment on the basis of their results that

> one general conceptualization of the learning-memory process, explicit in many theories a few years ago and often still implicit in our thinking now, is remarkably wrong. The general tenets of this conceptualization are (a) memory traces can be thought to vary in strength alone some continuum, (b) the strength of the memory trace determines the probability of recall in a direct way, (c) during interference the strength of a trace decreases in an orderly fashion, and (d) a repetition increments the strength of a memory trace according to some inverse function of the current strength of a trace such that the stronger of two traces before repetition is still stronger after repetition.

The two experiments reported here reveal evidence from a slightly different paradigm that is quite inconsistent with the results reported by Bjork and Allen (1970), Robbons and Wise (1971), and Tzeng (1973). Subjects studied 12- or 15-word lists presented either once or twice under free recall conditions. In some double presentation conditions, subjects spent the interval between the two presentations of the list engaged in either a difficult or easy interpolated task (Experiment II), or in either a fairly demanding task or no task (Experiment I). Recall following the second presentation was consistently better when the interval between presentations was filled in such a way as to allow better retention of the first presentation, that is, in the "no task" or "easy task" conditions.

Experiment I

Method

Subjects. The subjects were 18 paid participants from the pool of summer subjects at Yale University, and 27 Purdue undergraduates who participated for course credit.

Design. There were nine conditions, each realized twice in a within-subjects design. Thus all subjects heard and later recalled 18 different lists, two in each of the nine conditions. Three of the nine conditions involved a single presentation of a list and its recall: (a) immediately after the list had been presented, (b) after a 30-sec interval during which subjects rested, or (c) after a 30-sec interval during which subjects performed mental arithmetic. The other six conditions involved presentation of the list twice, with the second presentation occurring, for two of these conditions, where the recall period was inserted on single presentation trials. So for three additional conditions a list was presented and then (d) presented again immediately, or (e) after a 30-sec rest interval, or (f) after a 30-sec interval filled with mental arithmetic. Recall in these conditions occurred immediately after the second presentation. The other three conditions involving two presentations of the list (g, h, i) were identical to the three just discussed, with the exception that after the second presentation, subjects were engaged in a copying task for 30 sec before recall was requested. Thus in the double presentation conditions, the variables of interest were massed versus spaced repetition, the nature of the activity between presentations in spaced presentation conditions, and whether or not recall was requested immediately after the second presentation or was delayed 30 sec. Reference to Table 1 should make the design of the experiment clearer. The lettering of the conditions there is consistent with the lettering in the description above.

All 45 subjects heard and recalled the 18 lists in the same order, but the lists were assigned to "serve" in the nine different conditions by a balanced Latin square so that subjects heard and recalled each list in each condition equally often, and all conditions preceded and followed one another equally often. The nine conditions each appeared once in the first nine and last nine lists.

Procedure. All subjects were tested individually in a session lasting 1.5 hr. The words were read by the experimenter at a 1 sec rate of presentation, and subjects recorded responses as well as mental arithmetic (in some conditions) in booklets of 18 sheets. At the beginning of the experiment, subjects were given lengthy instructions describing the various conditions of the experiment and what was expected of them. They were told that their primary task was always to remember the current list as well as possible, and that it would be presented once or twice. After a list had been presented they knew they would either have to recall it immediately, hear the list again, or be instructed to "rest" or "subtract" for a 30-sec period. When told to rest, subjects were encouraged to rehearse the list, and when told to subtract they were told that the experimenter would read three digit numbers at a 3-sec rate and that they should copy each number and subtract by sevens as fast as possible (writing the remainders on their sheets) until the next number was read. They were also told that a second presentation of the list might occur after these tasks, and that they would then either be asked to recall the list immediately after the second presentation or after a 30-sec interval during which the experimenter would read numbers at a 3-sec rate while the subject simply copied them. This task was prefaced by the instruction "copy."

The subjects were further told: "All this sounds rather complicated and it is. However, at each stage of the experiment you will be instructed as to what you are to do next—either listen to a list as it is presented, perform mental arithmetic, rest and rehearse the list, or recall the list you have most recently heard." All 45 subjects understood the basic tasks required in the experiment and had no trouble following directions.

Each of the 18 list–trials began by the experimenter saying "Ready, list number . . ." and then reading the 15 word list at a 1-sec rate in time to a metronome. This presentation was followed by a command appropriate to the condition at hand (recall, rest, subtract, list number . . . again). Depending on the condition, various instructions continued until the subject was instructed to recall the list. When a list was repeated, the words were presented in the same order as on the first presentation.

A short break of about 15 to 30 sec was allowed between recall of one list and presentation of the next, and following the ninth list, subjects were allowed a break of several minutes in hopes of reducing fatigue. After all 18 trials were completed, subjects were engaged in conversation for 3–4 min and then surprised by a final instruction to recall as many items as possible from all 18 lists in any order. Ten minutes were allowed for this final free recall.

Materials. The 270 words used in the experiment were taken from the norms of Paivio, Yuille and Madigan (1969) and provided a wide variety of imagery, meaningfulness, and frequency values. They were randomly assigned to the 18 lists with the restriction that semantically similar words were not placed in the same list insofar as this was possible.

Results and Discussion

The mean number of words recalled in both initial and final free recall presented for each of the nine conditions is shown in Table 1. Each mean is based on 90 observations (45 subjects, two lists).

Single presentation conditions. When subjects recalled lists immediately after a single presentation, a mean of 6.47 words was recalled. When a 30-sec rest interval was interpolated between presentation and recall, performance dropped off to 5.91, a small though statistically reliable difference, $t(44) = 2.07$, $p = .05$. Examination of the serial position curves in Fig. 1 indicates that this slight loss came from the recency portion of

TABLE 1

MEAN NUMBER OF WORDS RECALLED IN EACH CONDITION IN IMMEDIATE AND FINAL FREE RECALL

	Condition	Immediate recall	Final free recall
Single presentation	(a) P1—Recall	6.47	2.22
	(b) P1—Rest-Recall	5.91	2.47
	(c) P1—Subtract-Recall	3.70	2.06
Double presentation	(d) P1-P2—Recall	8.72	3.58
	(e) P1—Rest-P2—Recall	9.94	4.12
	(f) P1—Subtract-P2—Recall	8.61	3.63
	(g) P1-P2—Copy-Recall	7.02	3.46
	(h) P1—Rest-P2—Copy-Recall	8.41	4.19
	(i) P1—Subtract-P2—Copy-Recall	7.19	3.49

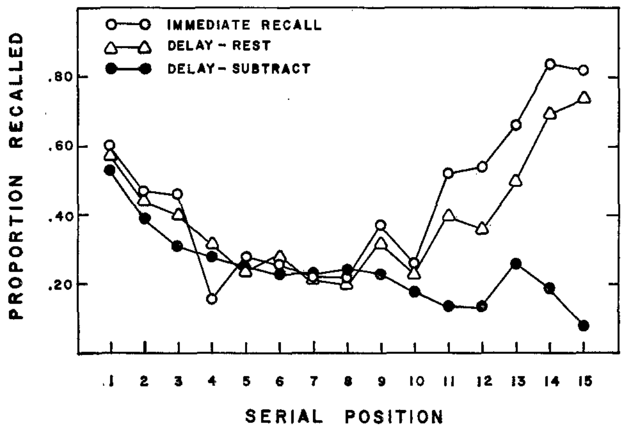

FIG. 1. Recall following single presentations of lists in Experiment I.

the serial position curve. Performing the difficult subtraction task between presentation and recall reduced performance to a mean of 3.70 words which was reliably different from recall in both the other two single presentation conditions ($p < .001$ by a t-test in each case). The loss is primarily attributable to performance on the last seven serial positions with negative recency appearing at least on the last position. Apparently a difficult interpolated task does not simply remove the recency effect, but can produce negative recency, contrary to the conclusion of Glanzer, Gianutsos, and Dubin (1969). At any rate, the subtraction task obviously produced greater forgetting than simply allowing subjects to rest for an equivalent amount of time.

Double presentation conditions. Results from the double presentation conditions are remarkably consistent: Spaced presentations of a list resulted in better performance than when the list was presented twice in immediate succession, but only when there was no task occupying the interval between presentations. When initial recall followed the second presentation immediately, subjects under the spaced presentation conditions with a rest interval recalled 9.94 items, while subjects in the massed presentation condition recalled

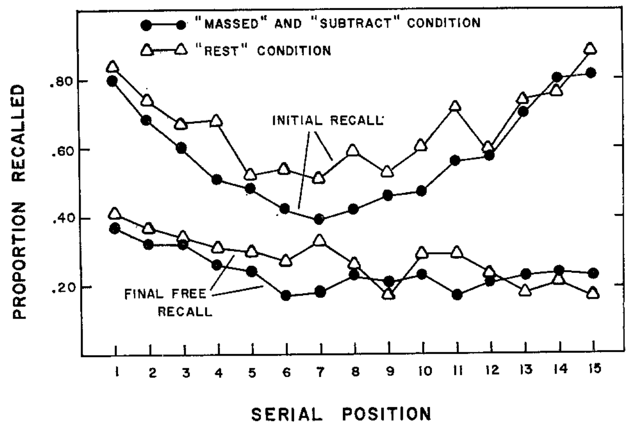

FIG. 2. Initial and final free recall following two list presentations in Experiment I when recall occurred immediately after the second.

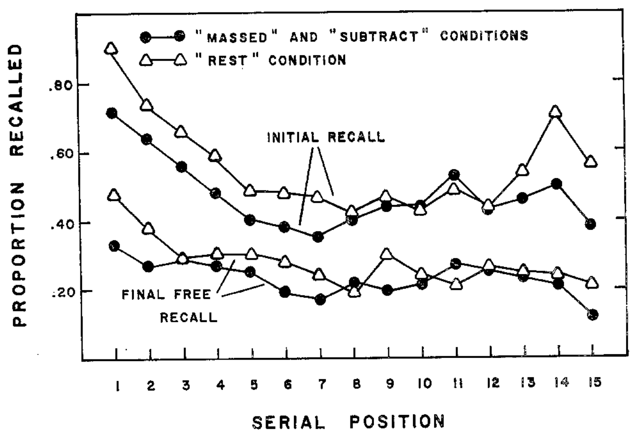

FIG. 3. Initial and final free recall following two list presentations in Experiment I when recall was delayed 30 sec after the second.

8.72, and subjects in the spaced presentation condition with the intervening subtraction task recalled 8.61. Performance under the spaced presentation-rest condition was reliably better than under massed presentation conditions, $t(44) = 5.52$, $p < .001$, as well as better than recall under the spaced presentation–subtraction condition, $t(44) = 5.18$.

There was no difference between the massed presentation condition and spaced presentation filled with the subtraction task. The same general pattern for these conditions appears in final free recall. Serial position curves for these conditions are presented in Fig. 2 for both initial and final free recall, with the massed repetition and spaced repetition conditions filled with subtraction pooled since there was no apparent difference between them. The advantage of spacing when there is a rest interval between presentations is apparent on all but the last four serial positions.

When recall is delayed for 30 sec after the second presentation by a copying task, the same pattern of results emerges in both initial and final free recall. In initial recall there is an advantage of spaced presentations to massed, so long as the interval between presentations is left free, 8.41 versus 7.02, $t(44) = 4.66$, $p < .001$. Recall in the spaced conditions is reliably greater in the condition when subjects were allowed to rest than when they were required to subtract, 8.41 versus 7.19, $t(44) = 4.43$. The slight advantage of the spaced condition with an intervening subtraction task to massed repetition, 7.19 versus 7.02, was not reliable. It is evident from Fig. 3 that the advantage of spaced presentations with the rest interval occurs primarily on the early serial positions, though there is also an advantage in initial recall on the last three positions. Once again, the primary conclusion is that spaced presentations of lists only aids later recall, when compared to massed presentations, if subjects are left free (presumably to "rehearse" or whatever) during the interval between presentations.

Experiment II

The methodological details of the first experiment differed from those of the Bjork and Allen (1970) experiment in a number of ways. Perhaps the two most crucial were the amount of material to be remembered and the variation in the difficulty of the interpolated task. In the first experiment the lists were 15 words long and the comparison was between either no interpresentation task or a subtraction task, whereas in the Bjork and Allen experiment the lists had only three words and two levels of difficulty of a number-copying task were used between presentations. It might be complained that the condition we used, with no interpolated task between the two presentations, is in some way unique and that if two actual tasks with different levels of difficulty were used between the two presentations perhaps the same pattern as found by Bjork and Allen would be obtained: That is, later recall would be better after two spaced presentations with a difficult than with an easy interpolated task. The second experiment was a classroom demonstration experiment (actually performed prior to the one reported first) which allows generalization of the finding that spaced presentation of a list is more beneficial with an easy than with a difficult intervening task. In this experiment the lists were 12 words long, and the intervening task in the spaced presentation conditions was either number copying or number copying and mental arithmetic.

Method

Design and procedure. The 25 subjects were Yale undergraduates enrolled in a course on human learning and memory who were tested in one session. The experiment was part of a course project. All subjects heard and recalled the 12 lists in one order. There were six conditions, three involving a single presentation of the list, and three involving two presentations. In the single presentation conditions, subjects heard the list presented once and then either recalled the list immediately, recalled the list after performing a 30-sec number copying task, or recalled the list after performing the copying task and a concomitant subtraction task for 30 sec. In the three double-presentation conditions, subjects heard the list repeated either immediately after the first presentation or after a 30 sec interval filled with the copying or copying and arithmetic task. All 25 subjects served in the single list presentation and immediate recall condition (Lists 1 and 12) and in the double presentation condition with massed presentation (Lists 4 and 9). In the other conditions, all of which involved a subsidiary task, 12 subjects performed the copying task both after single presentations of the list and between the spaced presentations, while the other 13 subjects performed the copying and arithmetic task during these intervals. Thus task difficulty was a between-subjects factor. Lists 3, 6, 7, and 10 were presented once and followed by 30 sec of arithmetic or copying before being recalled, while Lists 2, 5, 8, and 11 involved two presentations of the list separated by copying or arithmetic. This arrangement allows uncontaminated comparison of subjects in the conditions of primary interest, namely conditions differing only in task difficulty. Subjects in these conditions recalled the same lists at the same stage of practice with the only difference being whether or not the interpolated task was merely copying down numbers, or copying and, in addition, performing mental arithmetic on the numbers. However, comparison of recall under these conditions involving an interpolated task with conditions where no such task was used (immediate free recall and massed repetition) is hazardous since the particular to-be-remembered lists differed in these comparisons, as did stage of practice.

The procedure was quite similar to that of the first experiment. Subjects heard a list presented, and then were given different instructions depending on the condition to which the list was assigned. Twelve subjects were told that when numbers were read after the list they were simply to record these numbers and wait for the next instruction (to listen to the list again or to recall it) Thirteen subjects received an instruction to copy each number as it was read and then count backwards by sevens (recording the successive remainders in the appropriate space on their answer sheets) between sucessive presentations on the numbers. Subjects were allowed 45 sec for the recall of each list.

Lists were presented at the rate of 1.5 sec per word and on trials involving an interpolated task, numbers were presented at the rate of one every 3 sec during the 30-sec interpolated period. Subjects were allowed 45 sec for the recall of each list.

Results

Single presentation trials. Recall of lists presented only once was analyzed in order to see whether or not the variation in interpolated task affected memory performance. Lists 3, 6, 7, and 10 were presented once and then recalled after a 30-sec interval filled either with simply recording numbers or with recording and mental arithmetic. When the interval was filled with mental arithmetic, recall was somewhat poorer than when the interval was filled with only copying; the mean recall in the former case was 5.27 and in the latter was 6.42, $t(23) = 1.63$, $p = .06$. Immediate free recall, though not strictly comparable since it was measured on only the first and last lists, was 7.50.

The serial position curves for these conditions are presented in Fig. 4. Immediate free recall results display the usual advantages of primacy and recency, but, more interestingly, there appears to be a striking negative recency effect in immediate recall when the difficult mental arithmetic task is interpolated between presentation and recall. This effect appears greater than in the first experiment, perhaps because of the more difficult interpolated task.

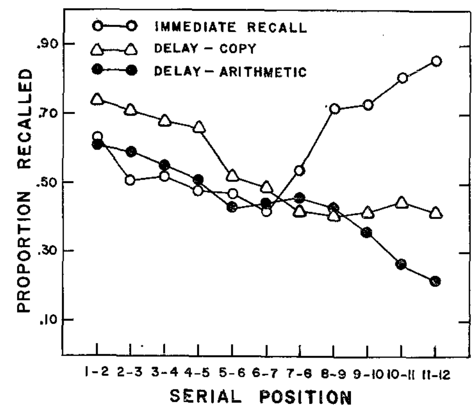

FIG. 4. Recall following single presentations of lists in Experiment II.

Double presentation trials. The primary interest of the present experiment is recall of twice-presented lists when the presentations were separated by a 30-sec interval filled with either the easy (copying) or difficult (subtraction) task. Lists 2, 5, 8, and 11 were recalled under these conditions by the two groups of subjects. Recall after the second presentation was better when subjects had spent the 30-sec interval between presentations simply copying the numbers as the experimenter read them, rather than copying and subtracting. Mean recall of the four lists was 9.75 in the former case and 8.70 in the latter, $t(23) = 1.95$, $p = .04$. Mean recall in the condition where the lists were read twice with no interval between presentations (Lists 4 and 9) was 9.34, but again no comparisons between this and the other double presentation conditions can be justified.

Serial position curves for the distributed presentation lists are presented in Fig. 5. The top curves represent initial free recall, and it is apparent that the advantage enjoyed by the group receiving an easy task between the two presentations accrues from recall of the first 10 items. Generally, the same pattern holds up in final free recall (represented at the bottom of Fig. 5) where subjects with the copying task between the two presentations recalled a mean of 3.82 items, while those with the subtraction task recalled 2.83.

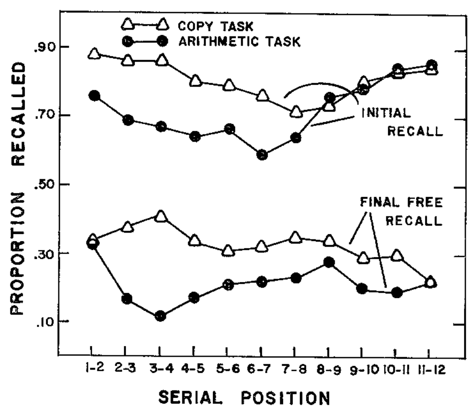

FIG. 5. Initial and final free recall following two spaced presentations of lists in Experiment II.

In this experiment, as in the first, recall of a list was better following spaced presentations of the list when the interval between the two presentations was occupied by an easier task (copying) than by a more difficult task (copying and mental arithmetic). Thus the discrepancy between the results of the first experiment and those of Bjork and Allen (1970) is not attributable to there having been no interpolated task in the "easy" condition of the first experiment. The second experiment lends generality to the conclusion that under conditions of single (recall) trial free recall that the easier the task employed between two spaced presentations of a list, the better is recall. Since the lists employed in the massed practice condition of the present experiment differed in nature and stage of practice of presentation from those in the spaced conditions, there is no way to decide if a spacing effect were found under the conditions of the second experiment.

General Discussion

In the two experiments reported here recall was consistently superior under conditions of spaced repetition when the interval between the presentations of the list was either unfilled or filled with an easy interpolated task, relative to conditions where the two presentations were separated by a more challenging mental arithmetic task. In addition, in the first experiment there was a spacing effect since spaced presentation of a list produced better recall than presentation of the list twice in immediate succession. This is the first reported case we know of where a spacing effect has been found when rather long lists have been repeated at various intervals, rather than individual items. Apparently the failure of some investigators (Underwood, 1961) to obtain an advantage of spaced over massed practice in learning lists of paired associates is not due to the long intervals which separated the repetition of individual items when they are placed into lists, as has sometimes been maintained (Hintzman, 1974, p. 79).

Whatever theoretical interpretation is placed on the present results, they do limit the generality of a principle of memory (similar to Jost's law) that has grown out of studies (Bjork & Allen, 1970) of the spacing effect: The effectiveness of a repetition on memory for an event or series of events is directly proportional to the decrease in recall probability of the first presentation at the time of repetition. In our experiments a repetition was consistently more effective the *less* forgetting there was of the first presentation in the conditions with distributed list presentations. But the present results cannot be discounted as being somehow outside the boundary conditions under which the spacing effect operates since a spacing effect was indeed found in the first experiment.

Other results agree more with the generalization from the present experiment, that a repeated item is better remembered when little rather than much forgetting is likely to have occurred between two presentations, than with the opposite conclusion of Bjork and Allen (1970). Melton (1963) required serial recall of nine-digit numbers and presented a particular series one, two, three, or four times with varying numbers of other series intervening between two presentations of the same series. The general finding from his experiment was that recall following a repetition was better with fewer additional series intervening between presentations of the same series. The effectiveness of repetition did not increase with the forgetting of the first presentation. This is true also in the A-B, A-D paired associate transfer paradigm when the A-B list is relearned. If a repetition were more effective to the extent that a first presentation was forgotten, then one would expect that relearning of an original A-B list would be superior when the interpolated list was A-D rather than C-D, since more forgetting of the original list is produced in the former case. There are probably well over 100 experiments now that show that this is not the case. Apparently no simple generalization can be made concerning the effectiveness of a repetition as a function of the amount of forgetting of the first presentation.

The simplest interpretation of the present results is to argue that they provide straightforward confirmation of the rehearsal or consolidation theories of the spacing effect (Peterson, 1966; Landauer, 1969; Atkinson & Shiffrin, 1968). Spaced presentations in the first experiment produced benefits relative to massed presentations only when the interval between the two presentations was not occupied by mental arithmetic and was thus left free for rehearsal or conslidation. Similarly, in the second experiment, recall was better when an easy task rather than a hard task was interpolated between two spaced presentations. There seem at least two objections to this theoretical approach. First, it is unclear why these results would favor rehearsal or consolidation accounts of memory any more than accounts invoking imagery, subjective organization, levels of processing, or any other hypothetical mnemonic activity. All of these hypothesized processes require mental capacity, and to the extent that this capacity is engaged in other activities, such as mental arithmetic, it will be unavailable for mnemonic activities and recall will consequently suffer. So these results provide no special comfort for theories of consolidation or rehearsal. More importantly, an account of the present results in terms of consolidation or rehearsal fails to accommodate the discrepancy between the results of the present experiment and those of others (Bjork & Allen, 1970; Robbins & Wise, 1972; Tzeng, 1973) employing similar designs which have shown that recall following spaced presentations is better when a difficult, not an easy, task intervenes between the two presentations. One low-level implication we draw from the present results and from others (Elmes & Bjork, 1975) is that single-factor accounts of the spacing effect, such as consolidation, differential encoding, or habituation, are no longer capable, if they ever were, of providing a satisfactory account of the complex literature on the spacing effect.

The problem created by the present experiment in conjunction with that of Bjork and Allen (1970) is that under some circumstances recall is better following spaced presentations when the intervening task is difficult rather than easy while under other conditions, such as those of the present experiments, these results are reversed. In order to account for this state of affairs at least two factors are needed. We shall sketch one such two factor theory, derived mainly from Anderson and Bower's (1972, 1974) theory of recall. Like others before them (Deese, 1959; Kintsch, 1970) these authors endorse the basic notion of two processes being involved in recall, retrieval or generation of information from memory and then a postretrieval check, similar to a recognition test, to determine whether or not the generated information occurred in the relevant context. The generation and recognition processes are not only separate, but to some extent reciprocal: To put it quite crudely, the subject has his choice whether to concentrate on associations among list items, which will greatly aid the generation phase of recall, or, on the other hand, to concentrate on associating list items to the experimental context, which will greatly aid in making recognition decisions. Thus we may expect that experimental manipulations, such as the difficulty of an interpresentation task, to have perhaps a beneficial effect on one stage of the generation–recognition process, but a harmful effect on the other.

The main point is that if the task in our experiment placed a different degree of stress on the generation–recognition balance than the Bjork and Allen (1970) task, then it should not be surprising that different results were obtained in these two situations. We suggest that the Brown–Peterson task used by Bjork and Allen put an inherent premium on the formation of distinctive associations to the experimental context, whereas our (relatively) long-list free recall task puts a premium on interitem relationships. Gardiner, Craik, and Birtwistle (1972) have assigned the phenomenon of proactive inhibition—the single major cause of forgetting in the Brown–Peterson situation—to discriminability of information against an experimental context; they imply, and we concur, that the main problem facing a subject trying to recall short sets of items as in the Brown–Peterson situation is one of deciding which, from among numerous available memory traces, were the most recently presented items (see also Loftus & Patterson, 1975). It follows that if two occurrences of a repeated Brown–Peterson item have maximally distinctive contextual settings, as they would tend to have when a difficult task is performed during the spacing interval, they will lead to better performance than if the two occurrences have similar contextual associations.

On the other hand, with relatively long free recall lists, the major problem is probably to overcome the numerical limitations of memory through the use of subjective organization and other complex mnemonic techniques. This activity, carried out at the expense of paying attention to the ongoing context, would be best served by a non-demanding assignment for the subject during the interpresentation interval. Thus the spacing effect in Experiment I is probably due to the generation component of recall and not to the recognition component. In a nutshell, we are accepting what has traditionally been called a rehearsal–consolidation account of the spacing effect for our experiment, while reserving some other hypothesis for spacing effects observed in other paradigms.

This formulation obviously was devised after the fact, but probably serves as well as any other at the present level of knowledge and theoretical sophistication about the spacing effect. It may also help account for the interesting results recently reported by Elmes and Bjork (1975). They presented subjects with short lists of words in a Brown–Peterson type situation, and then repeated the list either immediately or at various intervals up to 18 sec later. The other primary variable of interest was an instruction used to induce different levels of encoding. Subjects were instructed to use a rote code (like remembering a phone number) or an elaborate code (making up a sentence, using images) in order to remember words. Subjects used rote or elaborative codes on both presentations, or one form of encoding on one and a different form on the other. The results of three experiments showed that a spacing effect occurred only on trials when both presentations were coded in a rote manner. Since other results have shown that such rote coding affects recognition performance but not recall (Woodward, Bjork & Jongeward, 1973), this agrees with the notion that the spacing effect in the Brown–Peterson paradigm is the result of operations which enhance discriminability of information. It is unclear as to why there was no spacing effect with elaborative encoding, since such processing would seemingly be expected to enhance the discriminability as well as retrieval component of recall.

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