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Effects of Spacing on Memory for Homogeneous Lists

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The *spacing effect* refers to the advantage in memory for information repeated at separate points of time over information repeated in massed fashion. Three experiments showed that no spacing effect was found in free recall of lists containing items of high interstimulus semantic similarity. However, spacing effects were found when recognition or frequency-discrimination tests were given on these materials. The results support the hypothesis that several distinct processes underlie the spacing effect.

Repeated information is generally remembered better when it is presented at widely spaced times than when presented in massed fashion. This *spacing effect* is one of the most widespread of memory phenomena, occurring on many different kinds of tests (e.g., free recall, recognition, word completion, perceptual identification), with many different kinds of materials (e.g., words, pictures, prose), and using many different subject populations (e.g., preschool children, young adults, older people). Numerous theories have been developed to explain the spacing effect (for reviews, see Crowder, 1976; Greene, 1989; Hintzman, 1974, 1976). Several authors (e.g., Glenberg, 1979; Glenberg & Smith, 1981; Greene, 1989) have concluded that only complex theories postulating the operation of several processes could offer satisfactory accounts of this phenomenon.

There is at least one finding here that remains unexplained (and generally unaddressed) by all theories of the spacing effect. Elmes, Dye, and Herdelin (1983) studied the role of affect in this phenomenon. In one of their experiments, they presented subjects with a list that either contained words with only a positive connotation or words with only a negative connotation. There was no significant difference in free recall between the positive and negative words. Elmes et al. presented some words once and others twice. For both positive and negative words, repeated words were recalled more than once-presented words. However, the most striking finding was that there was no difference in recall between words repeated in massed fashion and those repeated at larger spacings. In other words, Elmes et al. found that there was no spacing effect in recall of an affectively homogeneous list (i.e., either all good items or all bad items). Elmes, Chapman, and Selig (1984) replicated this null result. On the other hand, when subjects were put in a depressed mood through a mood-induction procedure, substantial spacing effects were found in free recall of these materials.

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The findings of Elmes et al. (1983, 1984) are not necessarily inconsistent with current theories of the spacing effect. That is, no aspect of these findings directly contradicts the fundamental assumptions of any account with which we are aware. However, these findings truly are unaddressed by current theories. Although theories of the spacing effect may make many assumptions regarding the encoding and retrieval processes used by subjects, they do not address why the affective quality of the materials should be crucial.

The experiments reported here were intended to shed more light on the findings of Elmes et al. (1983, 1984). In the first experiment, we followed Hintzman's (1974) recommendation of caution regarding null effects of spacing and attempted a replication of the Elmes et al. (1983, 1984) studies. In subsequent experiments, we investigated whether the null effect of spacing on recall of affectively homogeneous material could be viewed as part of a larger empirical generalization, namely, that spacing effects are not found in retention of materials of high interstimulus similarity.

Experiment 1

Method

Subjects. Twenty students from Case Western Reserve University participated to fulfill a course requirement.

Materials. The lists used were modeled after the lists of connotatively good words used by Elmes et al. (1983, Experiment 3). (Connotatively good words were used because the null effect of spacing was clearer there than with the set of connotatively bad words; see Figure 3 in Elmes et al., 1983.) The stimuli were 36 one- and two-syllable words with mean evaluative ratings falling between 1.8 and 2.4 on Jenkins's (1960) norms. The stimuli were randomly partitioned into 20 target words, 8 primacy buffers, and 8 recency buffers. Of the 20 target words, 10 were presented once on the list, 5 occurred twice in massed fashion (no intervening items), and 5 occurred twice in spaced fashion (7 or 8 intervening items). Thus, each list had a total of 46 presentations. Two lists were created to allow counterbalancing of words in the spaced and massed conditions. The lists were made so that the mean serial positions were similar for massed (25.1) and spaced (24.8) items.

Procedure. Subjects were tested in groups of 10, with each group hearing one of the two lists. They were told that they would hear a list of words, some of which would be repeated, and that they would receive an unspecified memory test on the list. The list was presented at a rate of one item every 3 s in a male voice recorded on a cassette tape. Immediately after list presentation, subjects were instructed to write down as many words as they could remember without taking wild guesses. There was no time limit on recall.

Results

Subjects recalled .54 of the spaced words, .60 of the massed words, and .19 of the once-presented words. The difference between number of spaced words and number of massed words recalled was not significant ($F < 1.0$). This replicates the findings of Elmes et al. (1983, 1984). For completeness, it should be noted that fewer once-presented words were recalled than twice-presented words, $F(1, 19) = 122.14$, $MS_e = 1.15$.

Experiment 2

Elmes et al. (1983, 1984) attributed their finding of null spacing effects to their use of connotatively homogeneous words. We wondered whether a broader empirical generalization was possible. Is it possible that spacing effects are not found in free recall when the list items are highly similar to each other or share a single prominent semantic feature? We tested this possibility in Experiment 2 by using lists composed of words from a single semantic category (i.e., four-legged animals).

Method

Subjects. Forty-eight students from Case Western Reserve University and Cleveland State University participated to fulfill course requirements.

Materials. The 36 most commonly named one- and two-syllable exemplars of the category "a four-footed animal" in Battig and Montague's (1969) norms were used as stimuli. They were inserted into the same list structures as were used in Experiment 1 (8 primacy buffers, 10 once-presented items, 5 massed items, 5 spaced items, and 8 recency buffers). As in Experiment 1, two lists were created to allow counterbalancing of massed and spaced items. Equal numbers of subjects heard each list.

Procedure. Subjects were again tested in groups, with each group receiving one list. The details of instructions, list presentation, and recall were identical to those of Experiment 1.

Results

The subjects recalled .59 of the spaced words, .60 of the massed words, and .47 of the once-presented words. The difference between spaced and massed words was not significant ($F < 1.0$). The difference between recall of once-presented and twice-presented words was again significant, $F(1, 47) = 20.08$, $MS_e = 1.93$. The major finding, the lack of a spacing effect, was the same in the first two experiments. This suggests that the Elmes et al. (1983, 1984) finding of no spacing effects in recall of connotatively similar words might have resulted from a broader empirical pattern, namely, that spacing effects are not found in recall of a list of items that are highly similar to each other.

Experiment 3

To determine the generality of the results of Experiment 2, we performed a replication using names of occupations as list items.

Method

Subjects. Twenty-four students from Cleveland State University participated to fulfill a course requirement.

Materials and procedure. The 36 most frequently given exemplars of the category "occupation" from the Battig and Montague (1969) norms were used as stimuli and were placed in the same list structures used in the first two experiments. The procedure was in other respects identical to that used in the first two experiments.

Results

The subjects recalled .60 of the spaced words, .57 of the massed words, and .39 of the once-presented words. As in the previous experiments, there was a significant difference between the number of once-presented words and twice-presented words recalled, $F(1, 23) = 31.62$, $MS_e = 1.46$, but the difference between spaced words and massed words was not significant ($F < 1.0$). When we combined all of the data from Experiments 1–3, we found that .58 of the spaced words and .59 of the massed words were recalled; clearly, spacing had no effect here. Curiously, although the level of recall of repeated words was similar in the three experiments, recall of once-presented words was much higher in Experiments 2 and 3 than in Experiment 1. Insofar as both the stimuli used and (to some extent) the nature of the subject populations differed across the experiments, this finding should be interpreted with caution.

Because the results of Experiments 1–3 required acceptance of the null hypothesis, we considered whether some peculiarity of the list structures used was responsible for the failure to find spacing effects. To rule out this possibility, we tested 32 additional subjects. They received a list composed of unrelated two-syllable nouns selected from the Toronto Word Pool. The list structure and the details of presentation were identical to those used in Experiments 1–3. When free recall was tested, subjects recalled .42 of the massed words, .56 of the spaced words, and .22 of the once-presented words. Both the advantage of twice-presented words over once-presented words, $F(1, 31) = 110.46$, $MS_e = 1.12$, and the advantage of spaced words over massed words, $F(1, 31) = 4.69$, $MS_e = 1.47$, were significant. Thus, when nonhomogeneous words were used in these list structures, significant spacing effects were found. It should also be noted that the magnitude of the spacing effect with these materials made it unlikely that a lack of power was responsible for the null effects obtained in Experiments 1–3. Assume that the effect found with nonhomogeneous materials can be taken as an estimate of the magnitude of the spacing effect that could be expected on homogeneous materials if the null hypothesis is false. One then finds that each of the first three experiments had a power greater than .90 of rejecting the null hypothesis.

Experiment 4

Several authors (e.g., Glenberg & Smith, 1981; Greene, 1989, 1990; Hintzman, 1974) have argued that the spacing effect in free recall may reflect different processes from those operating in different memory tests. Thus, even though spacing effects appear to be absent in free recall of these materials, it may nevertheless be found when a different test is given. In Experiment 4 we examined this possibility by testing recognition of the positive-connotation items used in Experiment 1.

Method

Subjects. Twenty-eight students from Case Western Reserve University participated to fulfill a course requirement.

Materials and procedure. The 36 positive-connotation words employed in Experiment 1 were used as list items. An additional 20 words with mean evaluative ratings between 1.8 and 2.4 in the Jenkins (1960) norms were used as distractors on the recognition test. List presentation followed the procedure of Experiment 1. Subjects were then given a yes–no recognition test. Subjects were handed a sheet on which each of the spaced, massed, and once-presented items were randomly intermixed with 20 distractor words. Subjects were asked to circle the words that had been presented.

Results

Subjects correctly recognized .89 of the spaced words, .79 of the massed words, and .62 of the once-presented words. The false-alarm rate was .03. There was a significant difference between the number of massed items and spaced items recognized, $F(1, 43) = 6.04$, $MS_e = 0.50$, as well as between the number of once-presented items and twice-presented items recognized, $F(1, 43) = 58.66$, $MS_e = 1.21$. Thus, unlike the free-recall test used in Experiment 1, a recognition test on the list of positive-connotation words revealed a spacing effect. We tested the generality of this finding in Experiment 5 by using a list of animal names.

Experiment 5

Method

Subjects. Forty-four students from psychology classes at Case Western Reserve University participated to fulfill a course requirement.

Materials and procedure. The animal names used in Experiment 2 were employed here, along with an additional 20 animal names from the Battig and Montague (1969) norms that served as distractors in the recognition test. The procedure otherwise followed that used in Experiment 4.

Results

The subjects recognized .94 of the spaced words, .87 of the massed words, and .74 of the once-presented words. The false-alarm rate was .04. There was a significant difference both between the number of spaced words and massed words recognized, $F(1, 43) = 5.69$, $MS_e = 0.29$, and between the number of once-presented and twice-presented words recognized, $F(1, 43) = 40.15$, $MS_e = 1.47$.

Experiment 6

Greene (1989, 1990) argued that spacing effects in free recall reflect different processes from those that underlie spacing effects on tests using experimenter-supplied cues (e.g., recognition, frequency judgment, cued recall, word completion). On the basis of Experiment 5, this argument would suggest that spacing effects should be found on cued memory tests other than recognition. We tested this prediction in Experiment 6 by using a frequency-discrimination task.

Method

Subjects. Twenty students from Case Western Reserve University participated to fulfill a course requirement.

Materials and procedure. The animal name stimuli employed in Experiments 2 and 4 were used here. The method of list presentation was identical to that used in the earlier experiments. After the list was played, subjects were handed a piece of paper, on which each of the twice-presented words was paired with one of the once-presented words. Subjects were told to circle the word in each pair that had been presented twice. The test sheet was the same for all subjects. Because massed and spaced words were counterbalanced across subjects, all once-presented words were paired equally often with massed and spaced words.

Results

Subjects correctly chose the repeated word in .82 of the pairs containing a spaced word and .67 of the pairs containing a massed word. This difference was significant, $F(1, 19) = 7.18$, $MS_e = 0.78$.

General Discussion

There are two general themes underlying the results reported here. The first is that the null spacing effect in free recall of affectively homogeneous lists (Elmes et al., 1983) is replicable and is part of a more general pattern. Spacing effects appear to be absent in free recall of lists containing homogeneous items (where homogeneity was defined in terms of emotional connotation in Experiment 1 and category membership in Experiments 2 and 3). This suggests that the explanation for the Elmes et al. findings should not deal with affect per se but with the similarities among the list items. The second general theme is the dissociation between spacing effects in free recall and spacing effects on cued memory tests. This is demonstrated by the finding that these homogeneous lists led to significant spacing effects in recognition and frequency discrimination but not in free recall. Other variables that may dissociate spacing effects in free recall from those in cued memory tests include retention interval (Shaughnessy, 1977), stimulus generation (Glenberg & Smith, 1981), and intentionality of learning

(Greene, 1989). This bolsters the argument that a multiprocess account is needed to explain the overall effects of spacing in memory.

Greene (1989) proposed such a multiprocess account. According to this account, spacing effects on cued memory tests reflect a rehearsal strategy that allots fewer rehearsals to massed items than to spaced items. A separate process is largely responsible for spacing effects in free recall. This second process is the storage of a greater variety of contextual elements with spaced items than with massed items. Because subjects may use aspects of the experimental context to retrieve items in free recall, this could lead to an advantage for spaced items. A post hoc interpretation of the present data in light of this two-process account can be constructed. This interpretation makes two general assumptions. The first is that subjects will use the most effective retrieval cue available to them at the time of testing. The second assumption is that the major effect of using homogeneous lists here is that it gives subjects another retrieval cue, namely, the feature shared by all of the list items.

According to this interpretation, subjects in free recall of a homogeneous list do not have to rely on contextual cues to retrieve items. Rather, they use the feature shared by all the list items. That is, they try to generate positive words (Experiment 1), animal names (Experiment 2), or occupations (Experiment 3) to use as possible responses in free recall. Because the subjects are no longer relying on contextual cues in retrieval, the fact that traces of spaced items contain more contextual elements than do traces of massed items becomes irrelevant, and no spacing effects are found. In recognition or frequency discrimination, the best retrieval cue available is the item itself supplied at testing. Thus, all subjects essentially use the same retrieval processes on homogeneous lists as they do on lists of random heterogeneous items, resulting in spacing effects in both situations.

Elmes et al. (1984) found that depressed subjects showed a spacing effect in free recall of lists composed entirely of positive-connotation or negative-connotation words. We have no answer as to why depressed subjects showed a different pattern from control subjects. However, it would certainly not be surprising to find that depressed individuals encode words with strong affective connotations differently than do nondepressed individuals. One very speculative suggestion is that perhaps depressed subjects are less likely to notice that these connotatively homogeneous items have anything in common. Individuals in a depressed mood may be so influenced by their own mood that the affective quality of list words is effectively ignored. It would be interesting to see whether depressed subjects fail to exhibit spacing effects in free recall of other kinds of homogeneous lists (e.g., animal names or occupations).

Obviously, our account of the present data is entirely post hoc and must therefore be viewed cautiously. However, our results provide further evidence that it is unlikely that any single process will be able to account for the effects of spacing on all memory tests.

References

Battig, W. F., & Montague, W. E. (1969). Category norms for verbal items in 56 categories: A replication and extension of the Connecticut category norms. *Journal of Experimental Psychology Monographs 80* (3, Pt. 2).

Crowder, R. G. (1976). *Principles of learning and memory.* Hillsdale, NJ: Erlbaum.

Elmes, D. G., Chapman, P. F., & Selig, C. W. (1984). Role of mood and connotation in the spacing effect. *Bulletin of the Psychonomic Society, 22,* 186–188.

Elmes, D. G., Dye, C. G., & Herdelin, N. J. (1983). What is the role of affect in the spacing effect? *Memory & Cognition, 11,* 144–151.

Glenberg, A. M. (1979). Component-levels theory of the effects of spacing of repetitions on recall and recognition. *Memory & Cognition, 7,* 95–112.

Glenberg, A. M., & Smith, S. M. (1981). Spacing repetitions and solving problems are not the same. *Journal of Verbal Learning and Verbal Behavior, 20,* 110–119.

Greene, R. L. (1989). Spacing effects in memory: Evidence for a two-process account. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 15,* 371–377.

Greene, R. L. (1990). Spacing effects on implicit memory tests. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 16,* 1004–1011.

Hintzman, D. L. (1974). Theoretical implications of the spacing effect. In R. L. Solso (Ed.), *Theories in cognitive psychology: The Loyola Symposium* (pp. 77–99). Hillsdale, NJ: Erlbaum.

Hintzman, D. L. (1976). Repetition and memory. In G. H. Bower (Ed.), *The psychology of learning and motivation* (Vol. 11, pp. 47–91). San Diego, CA: Academic Press.

Jenkins, J. J. (1960). Degree of polarization and scores on the principal factors for concepts in the Semantic Atlas Study. *American Journal of Psychology, 73,* 274–279.

Shaughnessy, J. J. (1977). Long-term retention and the spacing effect in free recall and frequency judgments. *American Journal of Psychology, 90,* 587–598.

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