Bulletin of the Psychonomic Society
1979, Vol. 14 (4), 288-290

Item similarity and proactive interference in short-term memory

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The present paper addresses the question of the nature of interitem similarity effects in short-term retention. An interference theory prediction is pitted against an opposing expectation based on a cognitive strategy subjects could use in the "release-from-PI" paradigm. The experiment consisted of three conditions that differed in the extent of overlap among items in the short-term retention task. Results supported interference theory, in that increasing the interitem similarity of the to-be-recalled items resulted in a substantial decrease in correct recall.

In a seminal paper, Wickens, Born, and Allen (1963) introduced what has come to be known as the "release-from-PI" paradigm (cf. Wickens, 1972). Wickens et al. (1963) demonstrated that marked interference in short-term memory was obtained with as few as three proactive items when the test item on the fourth trial and the proactive items were from the same class of materials, namely, consonant trigrams or three-digit numbers. However, no proactive interference (PI) was found when the proactive and test items represented different classes of materials, namely, consonant trigrams and three-digit numbers. Thus, the authors concluded, with Keppel and Underwood (1962), that interference theory provided a viable account of short-term memory performance, as well as of long-term memory performance.

However, this conclusion was made despite the fact that their data failed to support the prediction of interference theory in one respect, as Wickens et al. (1963, p. 444) themselves note. Specifically, within a class of materials, interference theory predicted that greater interference should be observed with test items having greater similarity to the proactive items. This was tested by Wickens et al. in their "consonant control groups" by manipulating, between subjects, whether or not the test items were composed of consonants that had occurred at least once in the proactive items. The performance of these two groups was "essentially identical and very low." A mean of less than 13% correct recall of test items was observed in both groups, implying the modal performance in both groups was zero items correctly recalled. Thus, it seems plausible that this lack of a difference between the groups was due to a floor effect.

However, without the floor effect, an alternative account, based on certain plausible cognitive strategies, might have expected that the repetition group would have performed even better than the control group having nonoverlapping items. Approaching the task analysis from this perspective, one might posit that subjects initially adopt the suboptimal strategy of trying to retain in memory not only the current set of elements, but also all previous elements, in an attempt to avoid intrusion errors. [This account has certain similarities to the "restricted guessing strategy" discussed by Hinrichs, Mewaldt, and Redding (1973) as a model of performance in digit-span tasks.] An item containing some elements from the preceding items would, in such an account, serve to signal the subject that such a strategy is not necessary. That is, an item with repetitions might "jar" the subject into the strategy of concentrating on the current item and no longer expending effort to retain earlier items as well. Similarly, presentation of items from a different class of materials should thus be expected to bring about an apparent release from PI by cuing subjects that they need not concentrate on retaining previous items, since items may also be selected from additional classes of material.

Thus an experiment was designed to provide a test of the interference theory and cognitive strategy predictions for item-similarity effects in short-term memory. In order to avoid a floor effect, visual presentation of the entire item for 2 sec was employed (Keppel & Underwood, 1962). (Wickens et al., 1963, had the experimenter read the letters at a .5-sec rate, which resulted in recall on the first trial of only 70%.) The two principal groups in the study were a standard control group with nonoverlapping items and an experimental group that on the final trial was shifted from nonoverlapping items to an item composed entirely of letters from previous items. Since the cognitive strategy prediction of superior performance for the latter group was independent of the serial position of the items, each of the letters repeated for the experimental group appeared in a different serial position than it had originally, in order to maximize the interference of the previous items with the retention of the test item. A third group, involving partial item-to-item overlap,

The authors wish to thank Robert Stanley, Mila Allen, and Kimberlee Gray for their assistance in collecting the data for the present experiment.

0090-5054/79/100288-03$00.55/0

was also included. According to the cognitive strategy account, this group, for reasons outlined above, would also be expected to exhibit performance superior to that of the control group. Interference theory, on the other hand, would predict this group's recall performance in trials after the first trial would be worse than that of groups having nonoverlapping items, but that final trial performance would not be as poor as that in the principal experimental group.

METHOD

Subjects

Sixty undergraduate students in lower division courses at the University of New Mexico volunteered for the study and received credit toward their course grades for participating. Subjects were individually assigned at random, in order of appearance at the laboratory, to one of three conditions, subject to the constraint that one of each successive group of three subjects be assigned to a different one of the three treatments.

Materials

All the to-be-remembered stimuli were consonant trigrams selected from the Witmer list (Underwood & Schulz, 1960, Appendix B) so as to have association values of 33%. The stimuli were arranged as in a transfer experiment (Ellis, 1969; Wickens, 1972), in that all groups on the critical final trial received the same test item. The first three items for both the principal experimental group and the control group did not share any consonants in common. However, for the principal experimental group, the list was such that the final trigram had one letter in common with each of the three previous items, with each of the three letters appearing in a different serial position within the final item than in an earlier item. For the control group, as is typically the case in release-from-PI studies, the final trigram consisted entirely of elements that had not previously appeared in that group's list. For the third group, items were selected so that each item after the first had exactly one letter in common with the immediately preceding item.

Procedure

Subjects in all groups were read the same task instructions. Stimuli were presented on a Lafayette memory drum, Model 2303A. A trigram appeared for 2 sec in a window of the memory drum, with subjects being asked to read the letters out loud as soon as they appeared. A three-digit number appeared immediately after the trigram, and subjects were required to count backward by threes from this number throughout the retention interval. A total of 18 sec after the trigram was removed from view, subjects attempted to recall the letters in order, with their instructions being to state the letters they thought made up the trigram, even if they were uncertain of their order. Subjects were given 8 sec for recall; this interval was signaled by a series of red lines on the memory drum tape. This recall interval appeared, in both pilot work and the actual experiment, to be sufficiently long for subjects to make their oral responses without difficulty. Immediately following the recall interval, the appearance of a blue line in the window of the memory drum for 2 sec served as a "ready" signal, warning subjects the next frame would contain another trigram. This procedure was repeated on each trial, with each trial taking 30 sec.

RESULTS

Scoring of responses was in terms of number of letters correctly recalled, and results will be presented using both a criterion of an item's being considered correct only if it is in the correct position and a free recall criterion. The basic results using these scoring procedures are shown in the two panels of Figure 1. Before considering the final trial performance, note that the typical build-up of PI was observed on the first three trials. The linear decline of performance from Trial 1 to Trial 3 for the nonoverlapping groups was significant both when scoring was according to position [$F(1,38) = 10.63$, $p < .01$] and when free recall scoring was used [$F(1,38) = 9.68$, $p < .01$].

The result of primary interest was the relative performance of the three groups on the final test trial. The mean number of letters correctly recalled, either in order or without regard for order, was drastically lower for the principal experimental group than for either of the other groups. For the principal experimental group, where the last item was the first item to overlap in its composition with previous items, the mean number of letters recalled in order was .30; the comparable figures for the control group and the group having partial item-to-item overlap were 1.80 and 1.75, respectively. Thus, a highly significant overall test of group differences [$F(2,57) = 14.98$, $p < .001$] was due almost exclusively to the difference between the last-item overlap group and the other groups [$F(1,57) = 29.98$, $p < .001$], with the other two groups performing equivalently ($F < 1$). In terms of individual subject performance, the last item was recalled entirely correctly by 40% of the subjects in the control group and by 35% of the subjects in the item-to-item overlap group, but by no one in the last-item overlap group.

The pattern of results was essentially the same when the scoring of responses was done without regard to order. The groups were significantly different from each other on this measure as well [$F(2,57) = 8.48$, $p < .001$], with the last-item overlap group's recall of .90 letters being significantly lower than that of the other two groups [$F(1,57) = 16.71$, $p < .001$]. The mean free recall scores of the control and item-to-item overlap groups of 2.05 and 1.90 letters recalled,

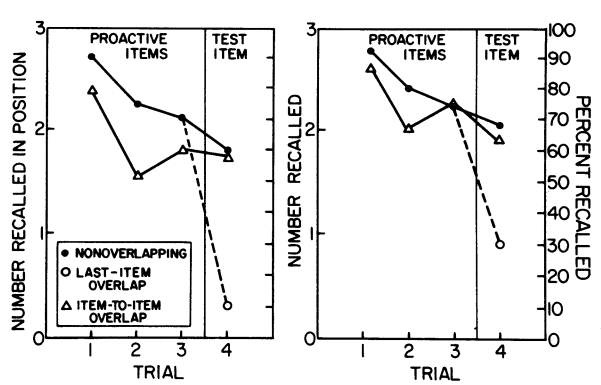

Figure 1. Mean correct recall of letters in the appropriate position (left panel) and without regard to position (right panel) as a function of item overlap.

respectively, were not significantly different ($F < 1$).

Performance on trials other than the final, test trial was of interest primarily in order to examine the effects of presenting items that partially overlapped preceding items. In comparison to the mean ordered recall of the other groups, both of which involved nonoverlapping items for the first three trials, the item-to-item overlap group performed significantly worse only on Trial 2 [$F(1,57) = 4.54$, $p = .037$]. Interestingly, this difference was not significant when scoring was without regard to order [$F(1,57) = 1.99$, $p > .15$]. An examination of the recall of individual letters indicated that this pattern of results was primarily due to the repeated letter being recalled in the wrong position by subjects in the item-to-item overlap group. When a free recall criterion rather than a correct-position criterion was used on Trial 2 for this group, recall of the repeated letter increased from 60% correct to 95% correct, whereas the recall of the other letters only changed from 48% to 58% correct.

DISCUSSION

The two principal findings of the study were (1) the presentation of an item containing all old letters resulted in a dramatic increase in PI in short-term retention, and (2) presentation of an item containing a letter repeated from the preceding item but in a different serial position led initially to a more rapid build-up of PI. The former result obtained not only for correct recall of letters in their appropriate positions, but also for free recall of the letters without regard to position; the latter was observed only when a correct-position criterion was employed. These results are basically in agreement with expectations based on an interference interpretation of PI in short-term retention.

In contrast to the results of Wickens et al. (1963), when the short-term memory PI paradigm was arranged so that there was no floor effect for all groups on any trial, a significant difference between groups was observed as a function of degree of similarity, within a single class of materials, of the to-be-recalled items. As predicted by interference theory, recall was significantly lower when the test item was comprised entirely of letters used in different serial positions on previous trials than when the composition of the test item did not overlap with that of previous items. In fact, recall of items in the correct serial position was approximately six times higher in the latter condition. The magnitude of this difference (10% recall vs. 59% recall) is substantially greater than the decrement in retention that has been reported as a result of variation in intralist similarity in long-term memory (Underwood & Richardson, 1956). As in long-term memory (e.g., Melton & Irwin, 1940), however, the tendency to give a previously learned, related response, which in this case meant responding with the right letter in the wrong position, could by no means account for all of the decrement in the performance of the experimental group relative to the control. This is seen here in the highly significant difference between groups that remained even when free recall scoring was used.

Further evidence in support of interference theory was obtained in the data from the earlier trials as well. Duplication of only a single letter in a different serial position resulted in significantly worse performance the first time this duplication occurred. That the difference was due to problems in arranging of letters in the correct serial position in the item-to-item overlap condition was supported by the fact that the difference disappeared when scoring was without regard to order. In turn, the fact that it was the repeated letter that made the difference was indicated by the finding that this letter was more frequently recalled in an incorrect position than other letters.

The only bit of evidence consistent with the cognitive strategy account outlined in the introduction is that the impairment of the item-to-item group relative to controls did not persist beyond Trial 2. This suggests that subjects may not be as taken aback by repetition of letters after such repetition has occurred once. However, it must also be acknowledged that the lack of persistence of a decrement is quite different from the facilitation of performance actually predicted for this condition by the cognitive strategy hypothesis.

In summary, the basic contribution of the current research is a unique demonstration of strong support for the predictions of interference theory regarding the effects on short-term retention of similarity manipulations within a single class of materials. Conversely, an alternative cognitive strategy explanation received almost no support.

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(Received for publication July 10, 1979.)