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INHIBITION EFFECTS OF INTRALIST REPETITION IN FREE RECALL[1]

ENDEL TULVING[2] AND REID HASTIE

Yale University

When some to-be-remembered words occur twice in a list, recall of words occurring only once in the same list is impaired in relation to recall of words in comparable lists in which all words occur only once. This intralist inhibition of one class of items, accompanying facilitated recall of another class, was demonstrated in two single-trial free recall experiments, using the A + 2B paradigm. While the explanation of the effect is not clear, the findings have implications for interpretation of data from experiments in which some items are "strengthened," in relation to other items, as a consequence of their repeated occurrence in input lists, their recall by *S*s, or their presentation by *E* as part-list retrieval cues.

Availability and accessibility of mnemonic information about an event, such as the occurrence of a word in a particular list, depend upon two broad classes of variables. One has to do with properties of the event as such, for instance, its meaningfulness, the amount of study time devoted to it, or the mode of its presentation. The other is specified in terms of other events in the same to-be-remembered collection or category, for instance, the number of other items in the list, semantic or logical relations among items within a list or between lists, or presence of experimentally manipulated retrieval cues. Mnemonic processing of an event may, therefore, occur independently of other events, but it may also be affected because of interdependence among events. Identification and clarification of conditions determining the extent to which events are stored and retrieved independently or in an interdependent manner remain among important experimental objectives in research on human memory, and the search for a coherent pattern of these conditions represents a major theoretical challenge.

This paper describes two experiments demonstrating interdependence of items in a single-trial free recall task involving unrelated words. The experiments show that facilitation of recall of repeated items in a list is accompanied by inhibition of recall of nonrepeated items.

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[2] Requests for reprints should be sent to Endel Tulving, Department of Psychology, 333 Cedar Street, Yale University, New Haven, Connecticut 06510.

The A + 2B Paradigm

The basic plan of the experiments—we refer to it as the A + 2B paradigm—was simple. Some of the words in the to-be-

TABLE 1

SCHEMATIC OUTLINE OF THE A + 2B PARADIGM

List or cond.	Subsets of items	Scored recall
Type control	A + B	A
Token control	A + B + C	A
A + 2B	A + B + B	A

remembered list occurred twice, others only once. The *S*s were instructed to recall the occurrences of all words in the list. The level of recall of once-presented (1x) words in the list containing twice-presented (2x) words was compared with the level of recall of 1x words in comparable lists in which all words had occurred only once. A schematic description of the experimental plan, consisting of two control conditions (lists) and the A + 2B condition, is shown in Table 1.

In Table 1, each of three lists is defined by a different combination of mutually exclusive subsets of items (A, B, and C). Subset A is common to all three conditions, but it occurs in a different intralist context in different conditions. In the Type Control condition Subset A items occur together with Subset B items, in the Token Control condition Subset A items are mixed with items from Subsets B and C, and in the A + 2B list each of Subset A items occurs once in the list while each of Subset B items occurs twice. The size of Subset C equals the size of Subset B, but otherwise the three subsets can assume any size.

Consider, as an illustration, a case where Subset A consists of Items *i* and *j*, Subset B of Items *k*, *l*, and *m*, and Subset C of Items *n*, *o*, and *p*. Then, with items ordered unsystematically in each list, the Type Control list consists of Items *k*, *i*, *m*, *j*, *l*; the Token Control list of Items *p*, *k*, *j*, *o*, *l*, *n*, *i*, and *m*; and the A + 2B list of Items *l*, *m*, *i*, *k*, *l*, *j*, *k*, *m*. Since each Subset B item occurs twice in the A + 2B list, this list contains the same number of item *types* as the Type Control list, although more *tokens*, and since the size of Subset C is equal to that of Subset B, the A + 2B list contains the same number of tokens as the Token Control list, although fewer types. In our A + 2B experiments where each *S* was tested under all conditions, the identity of subsets corresponding to one another in different lists was controlled statistically, rather than physically, but the logic of the design remains the same.

The major interest in this type of experiment lies in recall of items from Subset A. Items in this subset are identical in all three conditions—or their individual properties are held constant statistically—and hence any difference in their recall must be attributed to occurrence of other items in the study list and in recall. Since probability of recall of any given item is known to vary inversely with list length (e.g., Murdock, 1962), recall of Subset A items will be higher in the Type Control list than in the Token Control list. The question that the first experiment reported in this paper sought to answer had to do with the level of recall of Subset A items in the A + 2B list in relation to the recall of equivalent items in the two control lists. Such information is not yet available in the literature. However, several experiments rather similar in conception to the A + 2B paradigm have been described by Brown (1968). Brown's interesting results supported the hypothesis that "strong associations block weak ones [p. 42]."

EXPERIMENT I

Method

Design.—Experiment I followed the basic plan shown in Table 1. There were three conditions, represented by three types of lists: Type Control, Token Control, and A + 2B. Every subset contained 5 words. Thus, list length in the Type Control condition was 10 words, in the Token Control condition 15 words, and in the A + 2B condition 15 words of which 5 occurred once and the other 5 twice. Each list also contained four buffer items described below.

There were 32 *S*s, divided into eight groups of 4. Each group constituted an independent replication of the experiment and was tested with a different set of lists. All *S*s were given a single study and test trial on four lists under each of the three conditions, for a total of 12 lists. Thus, the recall data in each of the three experimental conditions were based on 32 separate and different lists. The order of lists was randomly determined for each of the eight groups.[3]

[3] In this experiment, each of 12 list trials was followed by a second trial on which the list com-

Materials.—Each of the 12 lists seen by a subgroup of four *S*s was composed by random selection, without replacement, and random ordering of words from a pool of 150 two-syllable nouns of relatively low imagery ratings, with mean *I* of 4.06 in the Paivio, Yuille, and Madigan (1968) norms. The serial input positions of 2x words in the A + 2B condition were also determined randomly with the restriction that the two tokens of a repeated word had to be separated from each other by at least one other word.

In addition to the 10 or 15 nouns, each list also contained a one-item primacy buffer and a three-item recency buffer: the first one and the last three items in each list were two-syllable common male and female first names. Thus each list contained either 14 or 19 tokens, including both buffers and experimental items. The buffers were included to minimize primacy and recency effects in the recall of items of primary interest.

Subjects.—The *S*s were 23 male and 9 female undergraduates at Yale University. Twelve of them were paid for their time and services; the remainder received participation credit toward psychology course requirements.

Procedure.—The *S*s were tested in small groups of up to four people. They were given instructions to pay close attention to all the words presented, and at the end of the presentation to recall as many words from the list as possible, including the buffer items (names), in any convenient order. They were also told that when a word occurred in any given list twice, they had to record it twice in recall. (Separate presentations of a word in a list were thus to be treated by *S*s as distinct events.) The *S*s did not know before the presentation of any list how long it was going to be and whether or not it was going to contain any repeated words.

Computer-generated word lists were presented visually on a closed-circuit television monitor, one word at a time, at the rate of 2 sec/word. At the end of the presentation of each list, *S*s wrote their responses, without abbreviations, on recall sheets. They were given 40 sec. and 55 sec. for the recall of 14- and 19-item lists, respectively.

Results

The mean numbers of buffer items recalled were 3.40, 3.30, and 3.26 in Type Control, Token Control, and A + 2B conditions, respectively. Examination of serial position curves in Type Control and Token Control conditions showed that, as expected, the buffer items had absorbed most of the primacy and recency effects, leaving the recall of the critical list items relatively invariant with their input position.

In the two control conditions there was no possibility, and no need, to separate Subset A items from other items, since all other items in these lists were 1x items. Probability of recall of Subset A items, therefore, was calculated on the basis of frequencies of recall of all items in these lists. These recall probabilities, with the data combined over all *S*s and all lists, were .41, and .37, for the Type Control and Token Control conditions, respectively. These two figures are based on 1,280 and 1,920 observations, respectively (32 *S*s × 4 lists × 10, or 15, words).

Probability of recall of Subset A, that is, 1x items, excluding the buffer items, in Cond. A + 2B, based on 640 observations, was .29. This figure was reliably lower than the corresponding proportion of .37 in the Token Control condition, $F(1, 62) = 17.75$, $p < .001$. The proportion of 2x items recalled in the A + 2B condition was .54 when token-scoring criteria were used (giving *S*s 2 credits for recalling a 2x word twice and 1 credit for recalling such a word only once, with a maximum possible score of 10 in each A + 2B list) and .61 when type-scoring criteria were used (giving *S* 1 credit for recall of a 2x word, regardless of whether the word was recalled once or twice, with a maximum score of 5 in each list).

The mean output position of 2x items in A + 2B lists was 6.73, while that of 1x words was 8.13. (The mean output position of buffer items was 2.84.) A sign test was done on scores represented by each *S*'s mean output positions for 1x and 2x items in all four A + 2B lists seen by the *S*. It was highly significant, $p < .001$.

Thus, the results of this study showed that (*a*) presentation of an item twice in a list greatly increases the probability of recall of its two tokens, (*b*) this facilitation of recall of repeated items is accompanied by inhibition of recall of nonrepeated items, in comparison with equivalent items in lists in which no items are repeated, and (*c*) nonrepeated items tend to be recalled later on the recall trial than repeated items.

position either remained the same or was changed according to a systematic design. The data from these second trials can be euphemistically labeled as "complex." No reference will be made to them in this or, probably, any other paper.

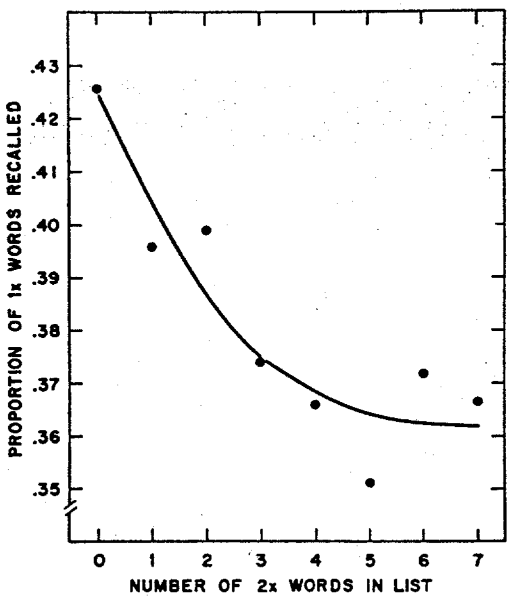

FIG. 1. Proportion of once-presented words recalled as a function of density of twice-presented words in the list.

We will discuss these results after we have examined the findings from the second experiment.

EXPERIMENT II

In Exp. I, the effect of five 2x words on the recall of five 1x words was investigated in A + 2B lists of 15 tokens. In Exp. II, the density of 2x words was systematically varied, and the effect of such variations on recall of 1x words observed.

Method

Design.—The overall list length was held constant at 15 tokens, but the number of 2x words assumed values of 0, 1, 2, 3, 4, 5, 6, or 7 in different types of list. Lists in which the number of 2x items was 0 are equivalent to the Token Control lists in Exp. I, while others are A + 2B lists in which sizes of Subsets A and B vary in a systematically confounded manner.

Each of 64 *S*s was tested twice with each of the eight types of lists. The *S*s were assigned to 16 groups of 4 in order of their appearance in the laboratory, each group constituting an independent replication of the experiment and being tested with a different set of lists. The order of lists in each replication group was as follows: two practice lists of 15 words, eight experimental lists as specified above, a 2-min rest, two more practice lists of 15 words, and a second set of eight experimental lists. The order of experimental lists in both the first and second set was systematically counterbalanced among the 16 groups, according to the Latin square design. All lists for the second half of *S*s, 8 groups of 4 *S*s tested last, were those used with the first 8 groups, except that the sequence of words in each list was exactly reversed.

Materials.—The 20 lists (4 practice and 16 experimental) were separately computer generated for each of 16 replications from a basic pool of 244 words. These were mostly nouns, but also contained some verbs and adjectives, with Thorndike-Lorge frequencies of 5 to 25 per million. List items were drawn from the pool without replacement, the 20 lists exhausting the pool. Words in all lists were ordered randomly, with the restriction that the two tokens of a repeated word type could not occur in immediately adjacent input positions. Unlike in Exp. I, no primacy and recency buffers were used in Exp. II. Thus, all lists contained exactly 15 tokens.

Subjects.—The *S*s were 64 university students, 40 men and 24 women, between the ages of 16 and 30, who were paid for their services. The first set of 32 *S*s were students at the University of Toronto; the remaining *S*s were students at Yale University.

Procedure.—The *S*s were tested in small groups of up to four individuals. Instructions called for careful attention to list words during presentation, and recall of as many words as possible, in any convenient order, immediately at the end of presentation. As in Exp. I, *S*s were instructed to write down each word twice that had occurred twice in the list. They did not know before the presentation of any list what its structure was going to be.

Words were presented auditorily, being read by *E* at the rate of 40 words/min. The *S*s wrote their recall on prepared recording sheets. The *E* introduced the next list when no *S* had written anything on the recall sheets in a period of 15 sec. At that point, *S*s were instructed to place their current recall sheet face down and to be ready for the next list.

Results

Probability of recall of 1x words as a function of the density of 2x words in the list is depicted in Fig. 1. The smooth line was fitted to the data points by eye and represents our educated guess as to the form of the function relating the two variables in these lists. An analysis of variance was carried out on proportions of 1x words recalled per *S* per list. A partition of the treatments sum of squares yielded a significant *F* ratio for the linear trend component, $F(1, 63) = 6.80$, $p < .02$. But additional analyses somewhat weakened the conclusion that recall of 1x words, under the present experimental conditions, tended to decrease with increasing numbers of 2x words in the lists. While a comparison of the Token Control condition with the seven conditions in which lists contained 2x words yielded a highly significant F (1, 63) = 13.21, $p < .01$, a test for linear trend across these seven remaining conditions did not reach conventional levels of significance, F (1, 63) = 3.62, $p < .10$. Nevertheless, it should be noted that these tests are quite conservative. Our confidence in the fitted curve in Fig. 1 is based on the fact that both the Toronto and Yale *S*s provided the same general pattern of data. We conclude, therefore, that inhibition of recall of 1x items is, within as yet to be determined limits, an increasing function of the density of 2x items in the same list.

Twice-presented words were, of course, recalled at higher levels than 1x words. Figure 2 illustrates the overall repetition effect. It shows mean number of words recalled as a function of number of words presented, separately for 1x and 2x words. Data points plotted in Fig. 2 were derived from all eight conditions. The variable scaled on the abscissa, number of words presented, must be considered separately for 1x and 2x words and not identified with the same ordering of lists in both cases. Thus, for instance, *S*s recalled, on the average 1.1 1x words, 4.3 2x types, and 7.5 2x tokens from lists containing three 1x words and six 2x words, the 3 + 2(6) list. Thus, on the 1x curve, the value of 1.1 is plotted above the scale value of 3 on the abscissa, 4.3 is plotted above 6—there were six types of 2x words in the 3 + 2(6) list—and 7.5 is plotted above the scale value of 12—there were 12 tokens of 2x words in the 3 + 2(6) list.

We have fitted straight lines to these values to illustrate the general effect of repetition in as simple a manner as possible, although there may be some doubt about the linearity of the two 2x functions, and although, as we have already seen in Fig. 1, the 1x function may not be linear. All the functions have intercept values of 0, as they should, since recall must be 0 when no words are presented. The slopes of the

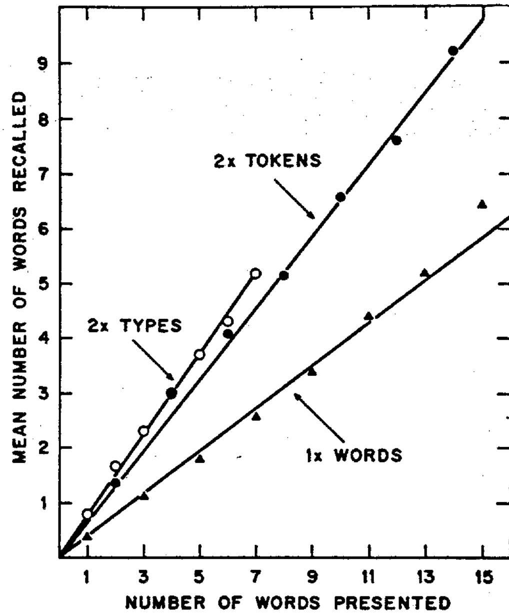

FIG. 2. Number of word tokens and word types recalled as a function of number of word tokens and word types in the list. (Token and type scores are identical for once-presented words.)

functions were .75 for the 2x types, .65 for the 2x tokens, and .39 for the 1x words. The approximate 2:1 ratio of the slopes of the 2x-type and 1x-word functions replicates the same ratio of recall probabilities of 2x types and 1x words in Exp. I and confirms similar data previously reported by Waugh (1963, 1967). The right-most data point for 1x words represents recall from the Token Control list. The fact that it lies above the curve fitted through other data points from A + 2B lists represents an alternative way of depicting the inhibition effect under scrutiny in this study.

Figure 3 shows serial position curves for the 1x words from (*a*) control lists, that is, the two lists learned by each *S* containing 1x items only and (*b*) those A + 2B lists that showed more sizable inhibition effects, as shown in Fig. 1, namely, Lists 1 + 2(7), 3 + 2(6), 5 + 2(5), 7 + 2(4), and 9 + 2(3). The curves were smoothed by plotting above the *n*th serial position the mean recall probabilities for positions $n - 1$, n, and $n + 1$, with the exception of Serial Positions 1 and 15, which show their actual recall values.

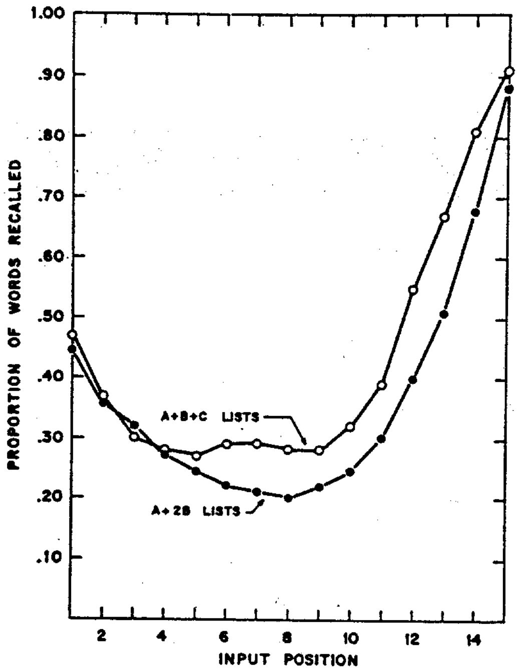

FIG. 3. Smoothed serial position curves for once-presented words in Token Control (A + B + C) and A + 2B lists.

The data in Fig. 3 show that recall of 1x words occurring in the first few positions in A + 2B lists was not impaired, while recall of all subsequent 1x words, with the possible exception of the last word, was considerably lower than that of words in the corresponding control list. (Similar serial position curves in Exp. I turned out to be quite "noisy," perhaps because of the smaller number of observations in that experiment, and thus it was impossible to confirm the same pattern of data in that experiment. But in Exp. II, the same pattern was obtained separately with the first and second sets of eight replication groups of *S*s.) We report these data here for the sake of completeness of the record, although we feel that their surprising and unreplicated appearance renders any interpretative comments premature.

Finally, as in Exp. I, *S*s in Exp. II, too, tended to recall 1x words in A + 2B lists later than 2x words, thus conforming to the "spew" principle (Underwood & Schulz, 1960, p. 86) in this type of situation. The mean output position of 2x items in 5 + 2(5) lists, for instance, was 4.87, while the mean output position of 1x words in the same list was 6.14. The sign test on individual *S*s' mean scores for the two types of items yielded a highly significant $p < .001$.

DISCUSSION

The central finding of the two experiments was lowered probability of recall of once-presented items in lists containing twice-presented items, in comparison with recall of equivalent items in lists containing only once-presented items. This intralist inhibition of "weak" items by the "strong" agrees well with Brown's (1968) findings in a somewhat different semantic memory[4] experiment. The data from Exp. II also suggested that, at least within limits, the extent of inhibition of once-presented items by twice-presented items is an increasing function of the density of twice-presented items in the list. This finding, however, is at variance with data reported by Waugh (1963, Fig. 2) in a similar experiment. The reasons for the discrepancy are unknown.

The intralist inhibition effect observed in these experiments appears to violate both common sense and current theoretical notions (e.g., Shiffrin, 1970) since both would lead us to expect less intralist interference from repetition of list items than from additional new items introduced into the list. We can describe the effect as a manifestation of the mechanism of response competition, or as yet another instance of limited capacity retrieval in free recall (cf., Tulving, 1967), but such labels do not explain it. The search for the explanation of the inhibition effect might be easier if we knew more about it. Why were once-presented buffer items, members of a different conceptual category, impervious to the inhibiting effects of twice-presented items in Exp. I? Does the observed inhibition effect in any way depend on the requirement that *S*s remember and recall frequencies of occurrence of items in addition to their list membership? Does lowered recall of once-presented items in A + 2B lists reflect loss of appropriate information from the memory store or only impaired access to it? Would the effect occur under conditions where more powerful retrieval cues are provided to *S*s than those present in a typical free recall test? Is the inhibition a consequence of repeated presentation of other

[4] The distinction between episodic and semantic memory is discussed by Tulving (1972).

items, higher recall of these repeated items, earlier recall of repeated items, or a combination of these factors? Is the inhibition only transient and reversible, or is it more permanent? A part of the suppression or inhibition of recall of items from an earlier list by the "stronger" items from a more recent list in multilist experiments (e.g., Postman, Stark, & Fraser, 1968) is clearly only temporary, and even the more permanent component of inhibition largely vanishes in presence of more effective cues present at retrieval (Tulving & Psotka, 1971). Is the apparent similarity between intralist and interlist inhibition effects only accidental, or are we justified in seeking a common explanation?

These and other possibly relevant questions must necessarily await further research. In pursuing these problems, it may be important to remember two things. First, our inference about inhibiting effects of twice-presented items is based on a comparison of recall probabilities of once-presented items in two types of list. It is therefore equally meaningful at this stage, and it may turn out to be more productive, to ask why the presence of other once-presented items in the list *facilitates* recall of once-presented items, in comparison with a list containing twice-presented items. The question about facilitation is logically equivalent to the question about inhibition, but one of them may be easier to answer than the other. The second thing we must remember is that the inhibition of recall of one class of items in our study occurred in conjunction with facilitation of recall of items of another class. Thus, with reference to the number of tokens recalled from A + 2B lists, the overall effect was not inhibition of recall but facilitation.

Despite our inability to make much theoretical sense out of the empirical results obtained in these experiments, it may be worth while to briefly discuss three implications of our data. The first lies in the possibility that intralist inhibition of weak items by the strong represents a ubiquitous process that occurs in all free recall tasks, and perhaps also in other situations, even when no deliberate attempt is made to manipulate item strength differentially. There exist at least three possible sources of differential item strength in any task: (*a*) selective attention and rehearsal of items by *S*s on idiosyncratic bases, (*b*) systematically changing recency of items in the course of the presentation of the list, and (*c*) the act of successive recall of items. The last one of these is particularly interesting. It is well known that recall of an item renders it stronger, that is, more readily recallable, on a subsequent occasion (e.g., Darley & Murdock, 1971). It is not impossible, therefore, that whenever an item is recalled in the output phase of a trial it becomes stronger in relation to other, as yet not recalled, items. As recall proceeds, the density of such stronger items increases, with increasingly greater detrimental consequences for recallability of remaining list members. Thus, limited recall after limited amounts of study of the material may be, at least partly, a consequence of the cumulative inhibiting effects of the act of recall (Brown, 1968; Waugh, 1967).

The second implication of our findings concerns interpretation of results from experiments in which some list items (call them members of Subset B) have been presented to *S*s, after the study of the whole list, as cues to aid the recall of the remaining items in the list (call them members of Subset A). These experiments have generally failed to demonstrate any facilitating effect of such part-list retrieval cues, despite the fact that on certain theoretical grounds such facilitation might be expected (Allen, 1969; Freund & Underwood, 1968; Slamecka, 1968, 1969).

Part-list cueing experiments are formally similar to both the A + 2B studies described here and to Brown's (1968) experiments. It is not impossible, therefore, that their outcomes have been influenced by intralist inhibition of weak items by the strong ones. In part-list cueing experiments, *S*s (*a*) study Subset A and B items in the input phase, (*b*) in some experiments then recall as many items as they can, (*c*) study Subset B items presented to them by *E* as "retrieval cues," and (*d*) attempt to recall as many remaining items from the list as they can. If studying cue items strengthens them, and if these stronger items have an inhibiting effect on the recall of weaker items, then recall of noncue items should be less in "cued" conditions than in noncued conditions. Available data suggest that it is, provided that *S* is given cue items before he starts his recall (Slamecka, 1968, 1969). Indeed, Slamecka's (1968, Exp. II and IV) findings of systematically increasing inhibition effects (differences between proportions of noncue items recalled by cued and noncued *S*s) with increasing density of cue items are not incompatible with data depicted in Fig. 1 of this paper. In experiments in which *S* is first permitted to recall list items under noncued conditions and is then presented with cues, inhibition effects have not been observed (Allen, 1968; Freund & Underwood, 1968; Slamecka, 1968, Exp. V; Wood, 1969) possibly because intralist inhibition created by the initial recall reaches an asymptotic level beyond which no further effects are possible. In the light of the data we have described in this paper, it seems advisable to keep in mind the possibility that outcomes of cueing operations may reflect joint effects of both facilitative and inhibitory processes, with the net result depending upon their relative contributions.

The third implication of our findings follows from the second: caution should be exercised in interpreting data from free recall experiments in which experimental procedure used may, either deliberately or inadvertently, produce items of widely varying strength in the same list. For instance, recall of once-presented items from lists containing repeated items (e.g., Madigan, 1969; Melton, 1967, 1970; Underwood, 1969; Waugh, 1963, 1967) may be reduced by virtue of items presented more frequently in the same list. The absence of appropriate comparison conditions in these experiments—lists containing items only at one level of experimentally manipulated frequency—makes it impossible to detect any intralist inhibition of once-presented items by the items presented more frequently. If such inhibition occurs, its identification and measurement may contribute to the understanding of intralist repetition and distribution effects.

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