DOCUMENT RESUME

ED 043 223 EM 008 362

AUTHOR	Bruce, Darryl; Papay, James P.
TITLE	The Primacy Effect of Single-Trial Free Recall.
INSTITUTION	Florida State Univ., Tallahassee. Computer-Assisted Instruction Center.
SPONS AGENCY	Office of Naval Research, Washington, D.C. Personnel and Training Branch.
REPORT NO	TM-19
PUB DATE	30 Jul 70
NOTE	53p.
EDRS PRICE	EDRS Price MF-$0.25 HC-$2.75
DESCRIPTORS	Cues, Extinction (Psychology), Inhibition, *Memory, *Primacy Effect, *Recall (Psychological), Serial Learning

ABSTRACT

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CAI CENTER

TECH MEMO

THE PRIMACY EFFECT OF SINGLE-TRIAL FREE RECALL

Darryl Bruce and James F Papay

Tech Memo No 19
30 1970

Project NR 154-280
Sponsored by
Personnel & Training Research Programs
Psychological Sciences Division
Office of Naval Research
Washington, D C
Contract No N00014-68-A-0494

FLORIDA STATE UNIVERSITY

Security Classification

DOCUMENT CONTROL DATA - R & D
(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author)
Florida State University
Computer-Assisted Instruction Center
Tallahassee, Florida 32306

2a. REPORT SECURITY CLASSIFICATION
Unclassified

2b. GROUP

3. REPORT TITLE
The Primacy Effect of Single-Trial Free Recall

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Tech Memo No. 19, July 30 1970

5. AUTHOR(S) (First name, middle initial, last name)
Darryl Bruce and James P. Papay

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
July 30, 1970	48	23

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
N00014-68-A-0494	
b. PROJECT NO. NR 154-280	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
c.	
d.	

10. DISTRIBUTION STATEMENT
This document has been approved for public release and sale; its distribution is unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Personnel & Training Research & Programs Office of Naval Research Arlington, Va. 22217

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DD FORM 1 NOV 65 1473 (PAGE 1)
S/N 0101-807-6811

Security Classification
A-31408

Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT

FORM 1473 (BACK)
DD 1 NOV 65
S/N 0101-807-6821

Security Classification
A-31409

THE PRIMACY EFFECT OF SINGLE-TRIAL FREE RECALL

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Tech Memo No. 19
July 30, 1970

Project NR 154-280
Sponsored by
Personnel & Training Research Programs
Psychological Sciences Division
Office of Naval Research
Washington, D. C.
Contract No. N00014-68-A-0494

Abstract

In three experiments using a single-trial free-recall procedure, Ss were sometimes presented a forget cue during a list, meaning that they were not responsible for recalling any of the words which preceded it, only those which followed it. Since the primacy effect over the functional beginning of such lists was not diminished, the PI hypothesis was rejected. The primacy effect may be due to initial list members being relatively free of proactive inhibition (PI), spending longer time in a limited-capacity rehearsal buffer, or being associated with stronger retrieval cues. Tests of memory showed consistently depressed retention of items immediately preceding a forget cue. This result was considered to be more in harmony with a rehearsal-buffer notion than a stronger-retrieval-cues position.

THE PRIMACY EFFECT OF SINGLE-TRIAL FREE RECALL[1]

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In single-trial free recall of a list of unrelated but familiar words, recollection of the initial few items is typically higher than recall of those from intermediate serial positions. This is called the primacy effect, and Tulving's (1968) comment that it "...has so far eluded explanation" (p. 11) is probably still accurate, recent investigations not withstanding (Borfein, Bennett, Arbak, & Graves, 1969; Leicht, 1968). The purpose of these experiments was to secure information bearing on this problem.

Three hypotheses of the primacy effect were examined. One of them says simply that first-presented items are rehearsed more than items from the middle of the list (cf. Rundus & Atkinson, 1970). The particular variant of this idea which was tested derives from a model of free verbal recall purposed by Atkinson and Shiffrin (1968, 1970). Among other things, their model posits a limited-capacity

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[1]This research was supported by the Office of Naval Research, Contract N000 14-68-A-0494, Project NR 154-280 and by grants from the Florida State University of the senior author.

[2]We thank the following persons for their assistance in this project: Marcus Marshall and Richard Tomsic (Experiment I); Dennis Howland (Experiments II and III); DiAnne Bradford and Elizabeth Vereen (Experiment III).

rehearsal buffer and a long-term memory store. During list presentation each incoming item is held to enter the rehearsal buffer and to remain there until displaced by a succeeding item. Which word an incoming word displaces is randomly determined. The longer a verbal unit remains in the buffer, the more information about it is transferred to the long-term store. Retrieval of an item from this store is directly proportional to the amount of information which is copied into it about the item. Given that the initial words of a list enter a rehearsal buffer whose capacity has not been reached (for the data which they considered, Atkinson and Shiffrin estimated capacity to be four words), then these items will spend, on the average, more time in the buffer before they are displaced than will subsequently presented list members. Thus, more information about them will be transferred to the long-term store and they will be more likely to be recalled. In short, a primacy effect will be obtained. These ideas will be referred to as the rehearsal-buffer hypothesis.

The second hypothesis proceeds from a conception of memory storage being unitary with serial position differences in the recall of list members reflecting differences in their accessibility. Or as Tulving and Patterson (1968) have stated, "The explanation of differential accessibility...

of words from different parts of the input list...must be sought if differential effectiveness of different kinds of retrieval cues" (p. 247). Retrieval cues are effective when the information about them is stored with each to-be-remembered word at input time (Tulving and Osler, 1968). Hence, the primacy effect is attributable to the fact that retrieval information, whatever its nature, stored with each of the various input items is in general more effective in the case of words from the beginning of the list as compared with words from intermediate serial positions. This notion will be termed the stronger-retrieval-cues hypothesis.

The third hypothesis incorporates the concept of proactive inhibition (PI). On this view, the initial words of a list, inasmuch as they are preceded by very few other words at most, are subject to smaller amounts of intraserial PI than are the occupants of later serial positions, which have many more words preceding them. Minimal PI in the case of the first few list members leads to greater recall of these words. This explanation of the primacy effect will be called the intraserial-PI hypothesis.

Experiment I

These three hypotheses were tested in the first experiment. For expository purposes the investigation may be divided into two parts. The first part consisted of the auditory presentation of six lists of words, each of which

was followed by a free-recall test. The critical independent variable was the occurrence or nonoccurrence of a tone during the recitation of a list. No-tone conditions involved the presentation and immediate free recall of a list of 25 words. The interpolation of a tone during a list signified that only those words which succeeded it would have to be recalled, not those which preceded it. Thus a tone may be termed a forget cue, and when it occurred it followed the 10th or the 20th word in a list. Thereafter, 25 more words were presented. Thus in each case (tone or no tone), Ss were responsible for remembering 25 words.

Each of the three hypotheses predicts a primacy effect for recall of the tone-absent lists. The more critical question, however, is whether a primacy effect is to be expected over what is effectively the beginning of the tone-present lists, namely, the first few positions following the forget signal.

The rehearsal-buffer hypothesis predicts such an effect. Atkinson and Shiffrin (1968) hold that the S can change the occupants of the rehearsal buffer at any point in the presentation of a list. Thus in the current experiment, the contents of this store should be deleted following the 10th or 20th words of forget-cue lists. In each case, the next few items will enter a buffer which has not been filled to capacity, and these words will remain there longer, on the

average, than later inputs. Consequently, recall probabilities for words immediately subsequent to the tone can be expected to be increased in a fashion similiar to the primacy effect obtained with no-tone lists.

This outcome is also predicted by the stronger-retrieval-cues hypothesis. Whatever their nature, the same kind of more potent retrieval cues which are stored at the time of input of the initial items should also be stored with respect to words immediately following the tone, since functionally, these items now represent the beginning of the list. Their recall should be increased accordingly, regardless of what position in the list a tone occurs.

By contrast, the intraserial-PI hypothesis holds that words following a forget signal and preceded by 10 or 20 other words should be subject to a considerable amount of intraserial PI. Thus there should be no substantial primacy effect for tone lists. In addition, this prediction would seem to apply regardless of whether a tone is sounded after 10 or 20 words, inasmuch as Murdock (1961, Exp. II & III) found that PI reached a maximum after three or four prior words. But in the event that intraserial PI in the present task is ineffectual until more than 10 words have been presented, then the absence of a primacy effect may hold only for lists in which a cue occurs after the 20th word.

The second part of the experiment consisted of a study-

test trial on a 35-word list. For half of the Ss (control group) the list did not contain a tone. For the other half (tone group) a tone was presented after the 10th word. At the end of the list, however, the latter group was instructed to recall all of the words which had been presented, that is, those which preceded as well as those which succeeded the tone.

Again, the rehearsal-buffer and stronger-retrieval-cues hypotheses predict what is essentially a primacy effect for the first few words following the tone, whereas the intra-serial-PI hypothesis does not. However, the former two notions would seem to make different predictions with respect to the recall of words immediately preceding the tone. On a rehearsal-buffer view, the S should delete the contents of the buffer upon the presentation of a forget signal. At this time the most likely residents of the rehearsal store are those words which occurred immediately prior to the tone. Hence, the duration of their rehearsal will be truncated, with the truncation being more abrupt in the case of the more recent entries into the buffer. Thus recollection of these words ought to suffer, with the decrement in recall being greater the closer the word is to the tone. Of course this should not be characteristic of the control group's performance over the same serial positions.

The prediction of the stronger-retrieval-cues hypothesis rests in part on the conclusion of Tulving and Osler (1968)

that an item and its retrieval cues are stored at the same time. This would seem to imply that beyond the presentation period of any item, no additional retrieval information about it is stored. This portion says nothing about the subsequent loss of retrieval cues. Thus, sounding a tone in this experiment should be of no particular consequence to the recall of words immediately preceding it. Since there is no reason to believe that the retrieval cues stored with these words are any more or less effective than those encoded with respect to comparable inputs in the control condition, it follows from the stronger-retrieval-cues hypothesis that there should be no substantial difference between the recall of these items by the two groups. The intraserial-PI hypothesis would also appear to make this prediction.

Method

Materials and equipment. All instructions and lists were played to Ss over a tape recorder. The members of each list were chosen from the AA words of the Thorndike-Lorge count excluding contractions, archaic words, proper names, and homophones, although some homophones were inadvertently included. Responses to each free-recall test were written on a separate page in a test booklet. Between any two successive test sheets was a page of arithmetic or number-series problems.

Procedure and experimental design. A S first heard a practical list, which consisted of 21 items presented at a

There were two sets of lists used for the first six experimental conditions. A 6 X 6 Latin square specified the sequences in which the conditions were to be administered. The same Latin square was used for both sets of words with seven Ss tested under each combination of sequence and set.

The final list consisted of 35 words recited at a 2.5-sec rate. For a control group of 42 Ss, no tone occurred during this list. A tone group, also consisting of 42 Ss, heard the same 35 words but with a tone after the 10th word. Contrary to the initial instructions, however, members of this group were asked after the terminal input to "...recall all of the words that you heard, ...those which preceded the tone as well as those which followed the tone." Thus, both groups had to try to recollect 35 words. After the recall test, 40 control and 32 tone Ss were given an unpaced, 35-item, four-alternative, forced-choice recognition test. In each case, distractors were randomly chosen from all members of the previous six lists that a S had heard. There were two samples of the final list and each was used equally often within the two groups. In addition, prior to the last list, the two groups had been exposed equally often to the Latin-square sequences governing the presentation of the six previous lists and to the two item samples of which these lists were constituted.

Subjects. The Ss were 84 male and female students at

1-sec rate, and then seven experimental lists. In each case, a 1-min free-recall test was administered. Except where otherwise indicated, the end of a set of words was signaled by the instruction "Please recall." In an effort to minimize the influence of any interlist PI on the primacy effect (Wing and Thomson, 1965), a 2-min interval during which Ss worked on arithmetic or number-series problems was interpolated between the end of each recall period and the beginning of the next list.

Two within-S variables were combined factorially to yield the first six experimental lists. One factor was presentation rate. Words were presented once every sec or once every 2.5 sec. Each list was prefaced by a verbal description (fast or slow) of the presentation rate to be used. The other independent variable was whether or not a list contained a forget signal, specifically, a .5-sec, 2000-Hz tone. No forewarning was given concerning the presentation of this cue. Lists in which a tone was absent are designated 0. In such cases, Ss listened to a series of 25 words. If a tone was sounded, however, it occurred on the tape, depending on the presentation rate, 1 or 2.5 sec after the onset of the 10th (10) or 20th (20) word. Thereafter and beginning 1 or 2.5 sec, respectively, from the onset of the tone, a sequence of 25 more words was presented. During the practice list, a tone was interpolated between the sixth and seventh words.

Florida State University who served in fulfillment of a course requirement or as volunteers. Up to five Ss were tested at a time. The particular Latin-square sequence, sample of lists, and type of final list administered within an experimental session was dictated by a schedule drawn up from a table of random numbers.

Results and Discussion

Table 1

Mean and Standard Deviation of the Number of Words Recalled from each of the First Six Lists

List	Mean	SD
1-0	6.3	2.0
1-10	5.8	1.9
1-20	6.2	2.1
2.5-0	8.1	3.0
2.5-10	9.0	2.6
2.5-20	8.8	2.7

Performance on the first six lists. The number of words correctly recalled under each of the first six treatments is described in Table 1. The first number of the label for each list refers to the presentation rate; the second number to the

tone or forget-cue variable. For the forget-cue lists, statistics represent the recall of items presented subsequent to the tone. In scoring responses, homophones, misspellings, and additions of the plural suffix -s or -es were not counted as errors. Analysis of variance disclosed that differences among means for the 1-sec lists were not statistically significant, F (2, 360) = 1.54, $p > .05$, but that they were for the 2.5-sec lists, F (2, 360) = 5.35, $p < .01$. Therefore, comparisons between 2.5-sec means were made. (The Newman-Keuls method was used in all analyses of this kind which are reported.) The 2.5-10 and 2.5-20 treatments did not differ significantly, but both were superior to the 2.5-0 condition, $p < .01$ and .05, respectively. In summary, overall recall scores were not adversely affected by the study of 10 or 20 words immediately preceding the words to be recalled.

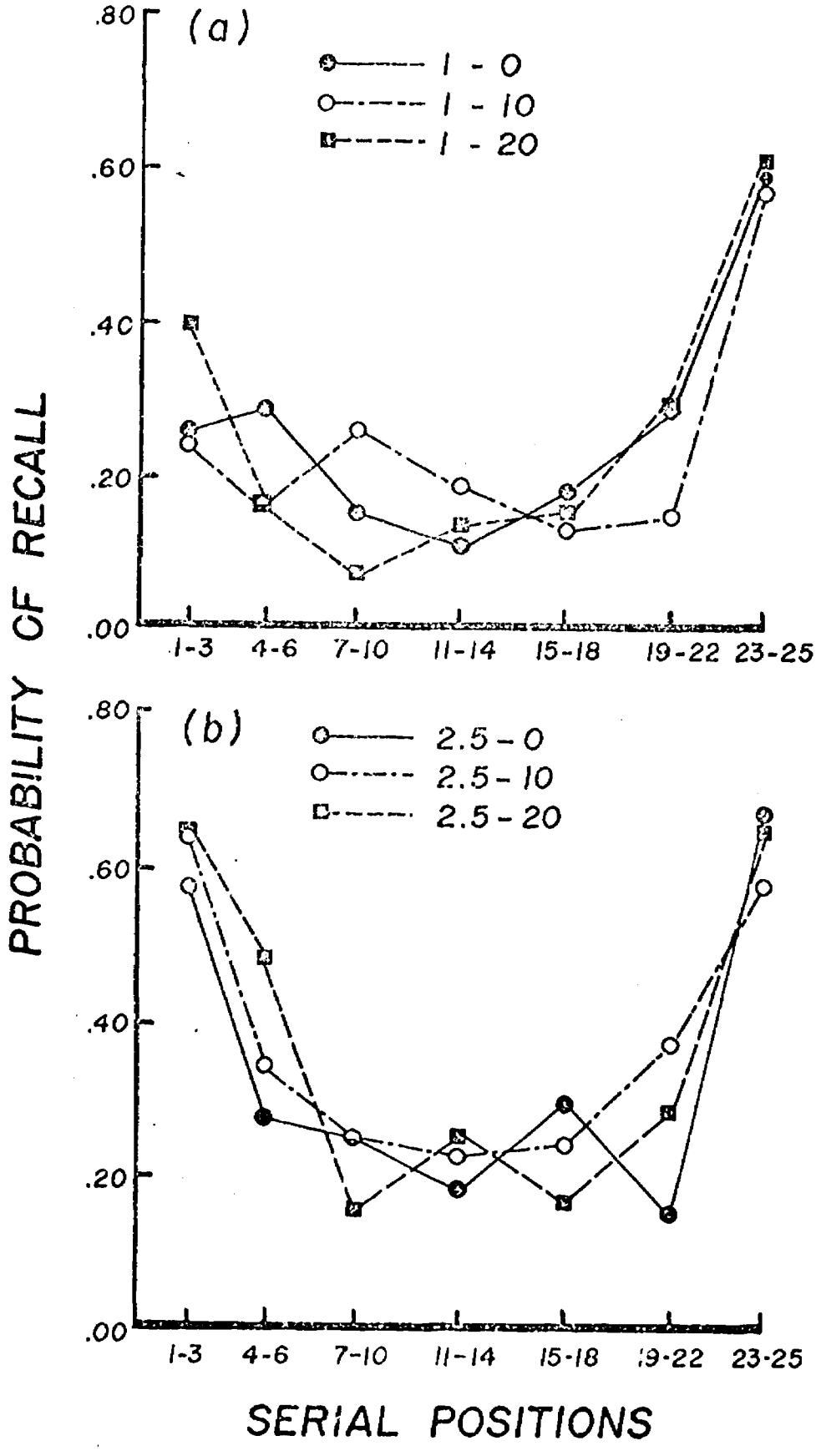
In a study of the short-term retention of paired associates that used a procedure analogous to that of the current experiment, Bjork (1967; cited by Bjork, LaBerge, & Legrand, 1968) also failed to obtain evidence of any intraserial-PI effects. And in the sense that the present results reflect a release from PI, they are also in accord with data obtained by Bjork et al. (1968), Elmes (1969), and Turvey and Wittlinger (1969). On the other hand, Bjork et al. also found that curing a S to forget an initially presented CCCC unit just prior to the occurrence of a second one produced slightly poorer recall

of the latter unit than a condition involving the presentation of the second unit by itself. Perhaps no serious inconsistency is involved here since the method was considerably different from that of the present experiment.

For the forget-cue lists, words prior to the tone intruded into the recall of words which followed the tone. Medians for the four lists were as follows: .25 (1-10); .64 (1-20); .45 (2.5-10); .66 (2.5-20). Intrusions of this kind as a function of ordinal position prior to the tone showed no pattern which was characteristic of all lists. (See Figure 1)

Figures 1(a) and 1(b) set forth serial position curves for the 1- and 2.5-sec lists. The description of performance on tone-present lists pertains to recall of words following the tone. For clarity of presentation, recall proportions have been calculated over either three or four adjacent serial positions.

Figure 1(a) indicates that primacy effects for the 1-sec lists were not extensive. In general, they spanned the first three input positions. However, recall of items from positions 4-6 in the 1-0 condition was also better than recall from input positions. Accordingly, analyses of variance were performed on both number correct for the first three serial positions and number correct for the first six serial positions. In each case, the overall difference among treatments was statistically significant; F (2, 166) = 8.76 and 4.79, $p < .001$


(a)
1 - 0
1 - 10
1 - 20
.80
.60
.40
.20
.00
1-3
4-6
7-10
11-14
15-18
19-22
23-25
(b)
2.5 - 0
2.5 - 10
2.5 - 20
.80
.60
.40
.20
.00
1-3
4-6
7-10
11-14
15-18
19-22
23-25
PROBABILITY OF RECALL
SERIAL POSITIONS

and .01, respectively. With respect to number correct over serial positions 1-3, individual comparisons between lists disclosed that 1-20 was superior to both 1-0 and 1-10, $p < .01$, but that the latter two did not differ significantly. For number correct over the first six serial positions, 1-20 and 1-0 were not reliably different, but both showed substantially better performance than 1-10, $p < .05$.

Figure 1(b) indicates marked primacy effects for the 2.5-sec lists which extended, for the most part, over the first six serial positions. Analysis of variance of the number of items recalled from these positions revealed a significant overall treatment effect, $F(2, 166) = 8.81$, $p < .001$. The results of individual comparisons between lists were as follows: 2.5-20 > 2.5-0, $p < .01$; 2.5-20 > 2.5-10 and 2.5-10 > 2.5-0, $p < .05$.

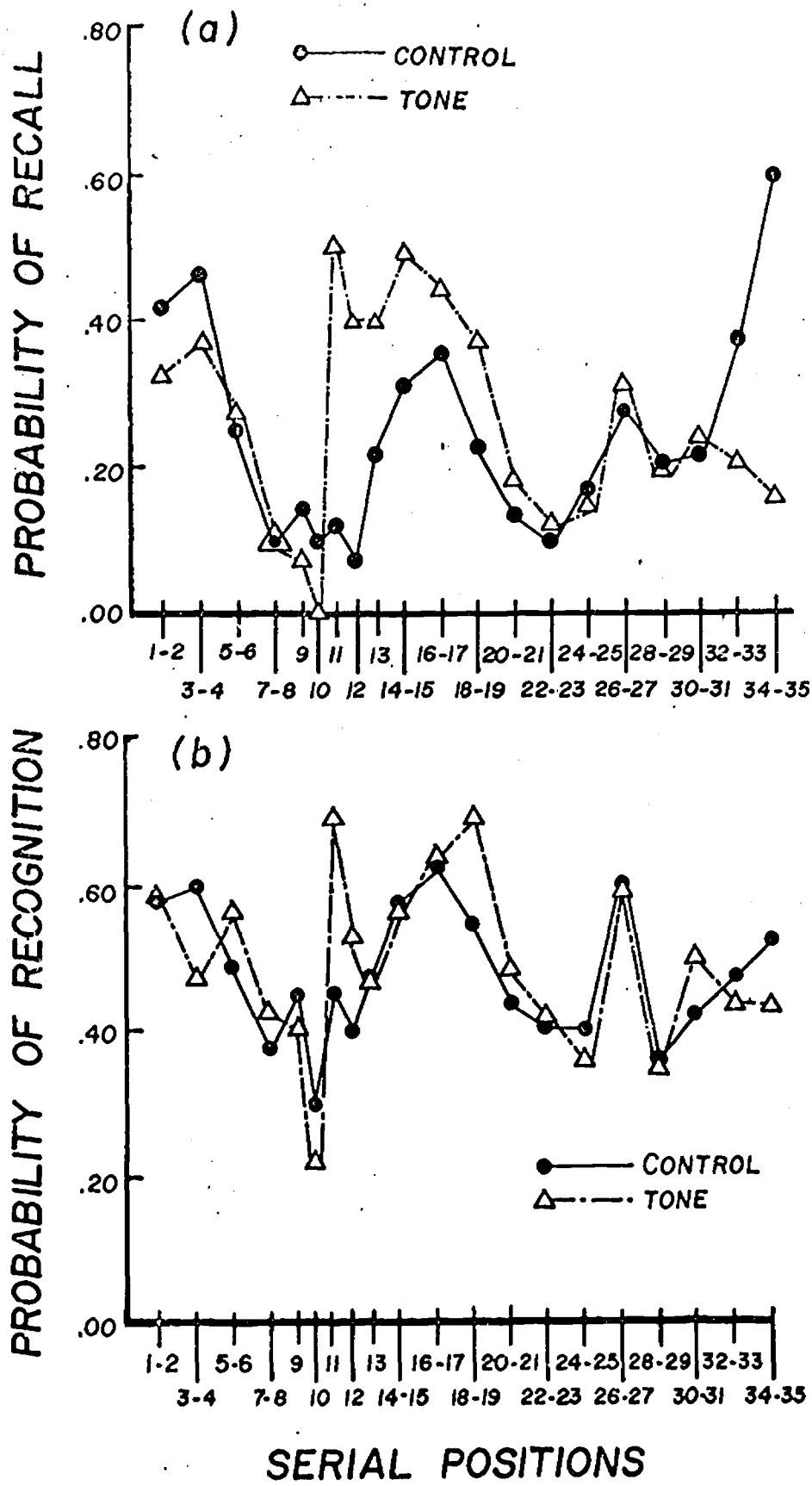
In short, whether words were presented at a 1- or a 2.5-sec rate, the primacy effects obtained under standard free-recall conditions were not consistently higher than the primacy effects observed with forget-cue lists. In view of this evidence, the explanation of the primacy effect offered by the intraserial-PI hypothesis does not seem tenable. These results are more in keeping with the rehearsal-buffer and stronger-retrieval-cues hypotheses.

Performance on the final list. The mean number of items correctly recalled from the final list was 9.0 (SD = 3.0) for

the control group and 9.2 (SD = 3.9) for the tone group. The corresponding recognition means were 16.9 (SD = 4.7) and 17.3 (SD = 4.9). In neither instance was the difference statistically significant; F (1, 80) < 1 and F (1, 70) < 1, respectively. (See Figure 2)

Serial position curves for the two groups under recall and recognition testing appear in Figures 2(a) and 2(b), respectively. Some smoothing of the functions has been attempted by averaging proportions over sets of two adjacent serial positions, except in the immediate vicinity of the tone. There are a number of salient features of these curves. One is the superior retention by the tone group particularly under recall testing, of words which immediately followed the forget cue. This effect is consistent with the rehearsal-buffer and stronger-retrieval-cues hypotheses but not with the intraserial-PI notion.

A second important feature of Figure 2 concerns the retention of items 9 and 10. Figure 2(a) indicates that recall of these two words was depressed under the tone condition, and particularly so in the case of item 10. This decrement, as indicated previously, is in keeping with the rehearsal-buffer position. On the other hand, recollection by the control group from serial positions 9 and 10 was rather low as well. To test the significance of the difference between the two curves over these points, six macro-subjects were formed


(a)
CONTROL
TONE
PROBABILITY OF RECALL
.80
.60
.40
.20
.00
1-2
3-4
5-6
7-8
9
10
11
12
13
14-15
16-17
18-19
20-21
22-23
24-25
26-27
28-29
30-31
32-33
34-35
(b)
CONTROL
TONE
PROBABILITY OF RECOGNITION
SERIAL POSITIONS

per condition. Each macro-subject comprised seven Ss who had received the same prior sequence of materials and treatments. Analysis of variance indicated that recall of the control group significantly exceeded that of the tone group, F (1, 8) = 6.72, $p < .05$. Furthermore, differences at serial positions 9 and 10 were not entirely eliminated with recognition testing. These results would appear to favor the rehearsal-buffer interpretation of the primacy effect rather than the stronger-retrieval-cues position.

A final point about Figure 2 concerns the recall of terminal inputs. Figure 2(a) illustrates that their recollection was poorer under the tone condition. This can probably be ascribed to the fact that at the end of the final list, members of the tone group received additional instructions stressing that they should also recall words which had occurred prior to the forget signal, whereas control Ss were told only to "Please recall." These extra instructions undoubtedly erased much of the rehearsal buffer in the tone condition, thus eliminating the recency effect (cf. Atkinson and Shiffrin, 1970).

In summary, Experiment I demonstrated that the primacy effect was not seriously diminished by the presentation of 10 or 20 words prior to a forget cue. Rejection of the intraserial-PI hypothesis is clearly in order. On the other hand, even though the depressed retention of words immediately

preceding the tone in the final list favors, in our opinion, a rehearsal-buffer interpretation; rejection of the stronger-retrieval-cues hypothesis at this time may be premature. Perhaps the more prudent course is to suspend judgment until more data are collected and examined. Experiment II was conducted for this reason and also to probe further into the absence of any overall PI effect in this experiment due to the processing of words prior to a forget cue.

Experiment II

In this study, by contrast with Experiment I, the number of items to be recalled was varied rather than presentation rate, and visual rather than auditory presentation was used. The major reason for the former change was to give more opportunity for PI effects to operate. That is, given a constant presentation rate, then the longer the list, the longer is the retention interval for each list member likely to be. And since it appears that in short-term memory, PI is more potent at longer retention intervals (Keppel & Underwood, 1962), it may be that in free-recall tasks, detrimental effects of items preceding a forget cue are obtained only with longer lists. The change from auditory to visual presentation represented a modest attempt to assess the generality of the phenomena observed in Experiment I. Both of these purposes, however, were ancillary to the objective of securing additional evidence bearing on the rehearsal-buffer

and stronger-retrieval-cues explanations of the primacy effect.

Method

Materials and equipment. The materials were similar to those of Experiment I. That is, the number-series problems were reused and lists were constructed by sampling without replacement from the same population of words. Unlike Experiment I, however, an IBM 1500 instructional system was used. It controlled and individualized the presentation of instructions and materials via the cathode ray tubes of IBM 1510 instructional display units. A S typed in his responses at the keyboard of one of these units.

Procedure and experimental design. To familiarize Ss with the procedure, and in particular, with the nature of the forget cue and the typing of responses, initial instructions included two practice lists of 8 and 10 items. The second of them contained a forget cue after the fifth word. Following this, Ss were also shown two illustrative number-series problems. Otherwise, the instructions were comparable to those of Experiment I.

The first four lists administered represented the factorial combination of two within-S variables. One was the occurrence or nonoccurrence of a visual signal during a list. The signal, which meant the same thing as the tone used in Experiment I, was a row of five squares for half the Ss and a row of three asterisks for the other half. If a forget

cue occurred, it was preceded by 15 words. The second variable was the number of items to be recalled. No-forget-cue (NFC) lists contained either 20 or 35 words, and forget-cue (FC) lists had either 20 or 35 words which followed the cue.

A 4 X 4 Latin square provided four sequences of conditions. A fourth of the Ss was tested under each sequence. Within each of these subgroups, two 20-word lists and two 35-word lists were used equally often with each forget cue (squares or asterisks) under each appropriate treatment combination.

As a final list, a forget-cue group of 80 Ss was shown 35 items with a forget signal following the 15th item. This group was subsequently asked to recall all of the words it saw, that is, words both prior and subsequent to the forget cue. A control group of 80 Ss also viewed and then attempted to recall 35 words, but no forget signal occurred during the list. After the recall test; both groups were given an unpaced, paper-and-pencil, 35-item; four-alternative, forced-choice recognition test. The distractors were randomly selected from the to-be-remembered items of previously presented lists. There were four different lists for the final treatment; and each was used equally often in both groups and equally often under the two variations of forget cue. In addition, the forget-cue and control conditions followed each of the four different sequences of the first four lists

equally often.

The main temporal features of the procedure were as follows: ready signals (a row of three asterisks if the forget signal which might be administered was five squares or five squares if the forget signal was three asterisks), forget cues, and words presented at a 2.5-sec rate; a recall period of 2 min, except that if the S failed to respond within any span of 30 sec, the test was terminated; a 2-min interval between the end of the recall period and the ready signal for the next list during which the S solved number-series problems. All recall periods, save that for the final list, were cued by the appearance of a row of five question marks. Following the final list, the forget-cue group was delayed for 10 sec by the instruction to recall all of the words. Therefore, members of the control group were delayed by a message of equivalent length and duration which simply indicated that no forget signal had occurred and that they should try to recall all of the words which had been presented.

Subjects. The Ss were 160 male and female students in introductory psychology at Florida State University. Participation in experiments is a course requirement. The particular sequence of treatments, materials, and final condition to which a S was assigned was governed by a schedule drawn up from a table of random numbers. Up to 16 Ss were tested at a time.

Results and Discussion

Table 2

Mean and Standard Deviation of the Number of Words Recalled from each of the First Four Lists

List	Mean	SD
20-NFC	6.4	2.4
20-FC	5.7	2.4
35-NFC	8.0	3.6
35-FC	7.2	3.5

Performance on the first four lists. The number of words correctly recalled on each of the first four lists is described in Table 2. The first part of a list label indicates the number of words Ss were responsible for recalling, and the second part whether or not a forget cue occurred. Statistics for the FC conditions refer to recall of items presented after the forget cue. Unlike Experiment I, a response was counted correct only if the word was reproduced exactly as it had been presented. Analysis of variance revealed that mean recall from lists which did not contain a forget signal substantially exceeded that from lists in which a forget signal did occur, F (1, 456) = 11.41, $p < .001$ and F (1, 456) = 13.36, $p < .001$ for the 20- and 35-word lists,

respectively. By contrast with Experiment I, then, an overall PI effect was obtained.

Whether this result should be given an interference-theory interpretation however, is debatable. For one thing, the PI effect was not substantially greater with the 35-word lists than it was with the 20-word lists. This might have been expected on the basis of interference theory, however, since it apparently holds that PI effects increase with time (Postman, 1969). A second point is that the median number of pre-forget-cue intrusions was .48 for the 20-FC list and .36 for the 35-FC list. This difference, while slight, would nevertheless seem to be in a direction opposite to what might have been predicted by interference theory. (The functions relating intrusions to serial position prior to the forget cue were irregular and dissimilar.) But while an interpretation of the obtained PI effect which stresses interference of pre- and post-cue memory traces may not be particularly compelling, we confess that we are unable to offer a convincing alternative explanation. (See Figure 3)

Figure 3(a) sets forth serial position curves for the 20-NFC and 20-FC lists. Corresponding functions for the 35-word lists are shown in Figure 3(b), except that each recall proportion beyond the span of the primacy effect represents an average over two adjacent input positions. For FC lists, the functions depict the recall of items which followed the

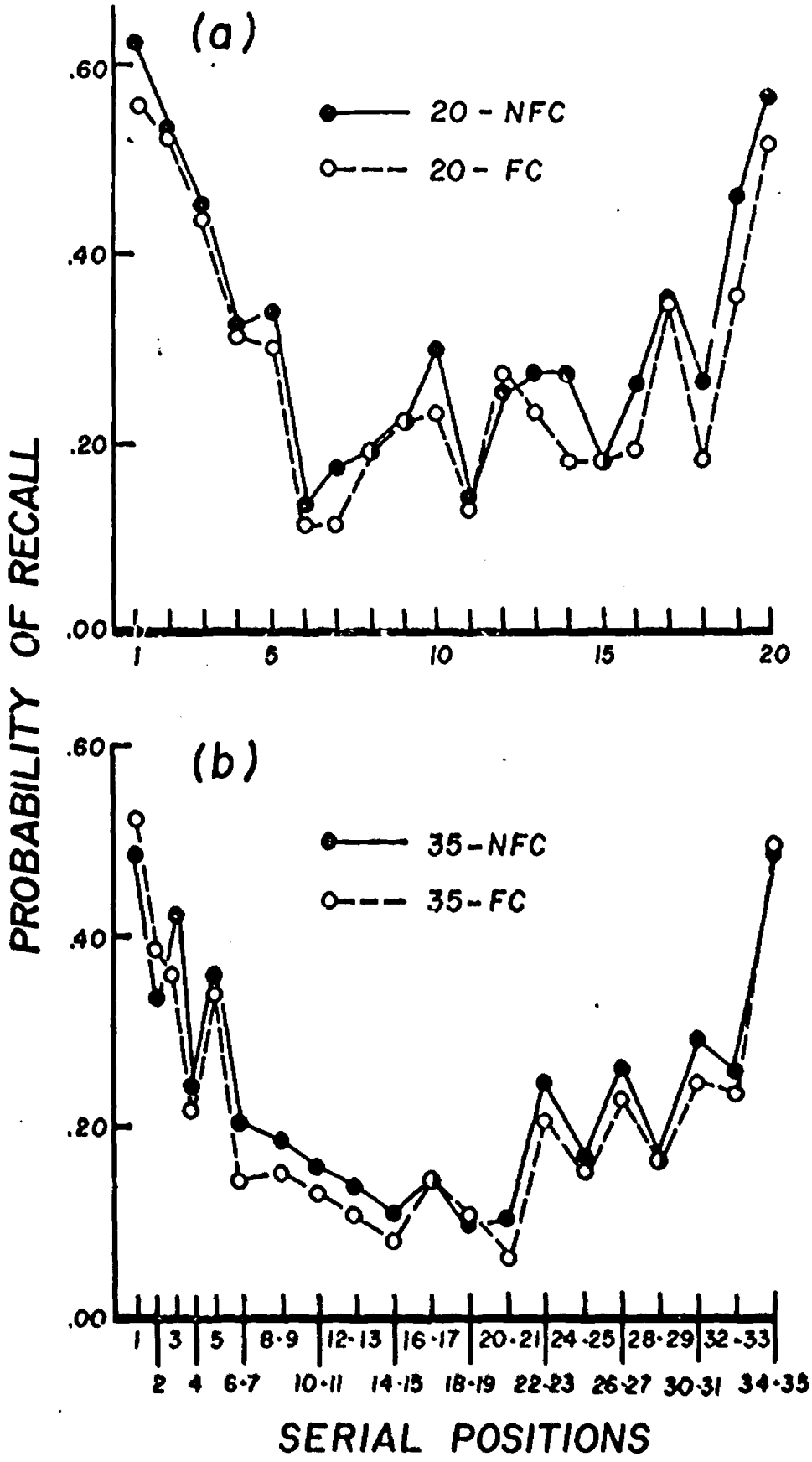

(a)
20 - NFC
20 - FC
.60
.40
.20
.00
1
5
10
15
20
(b)
35-NFC
35-FC
.60
.40
.20
.00
1
3
5
8-9
12-13
16-17
20-21
24-25
28-29
32-33
2
4
6-7
10-11
14-15
18-19
22-23
26-27
30-31
34-35
PROBABILITY OF RECALL
SERIAL POSITIONS

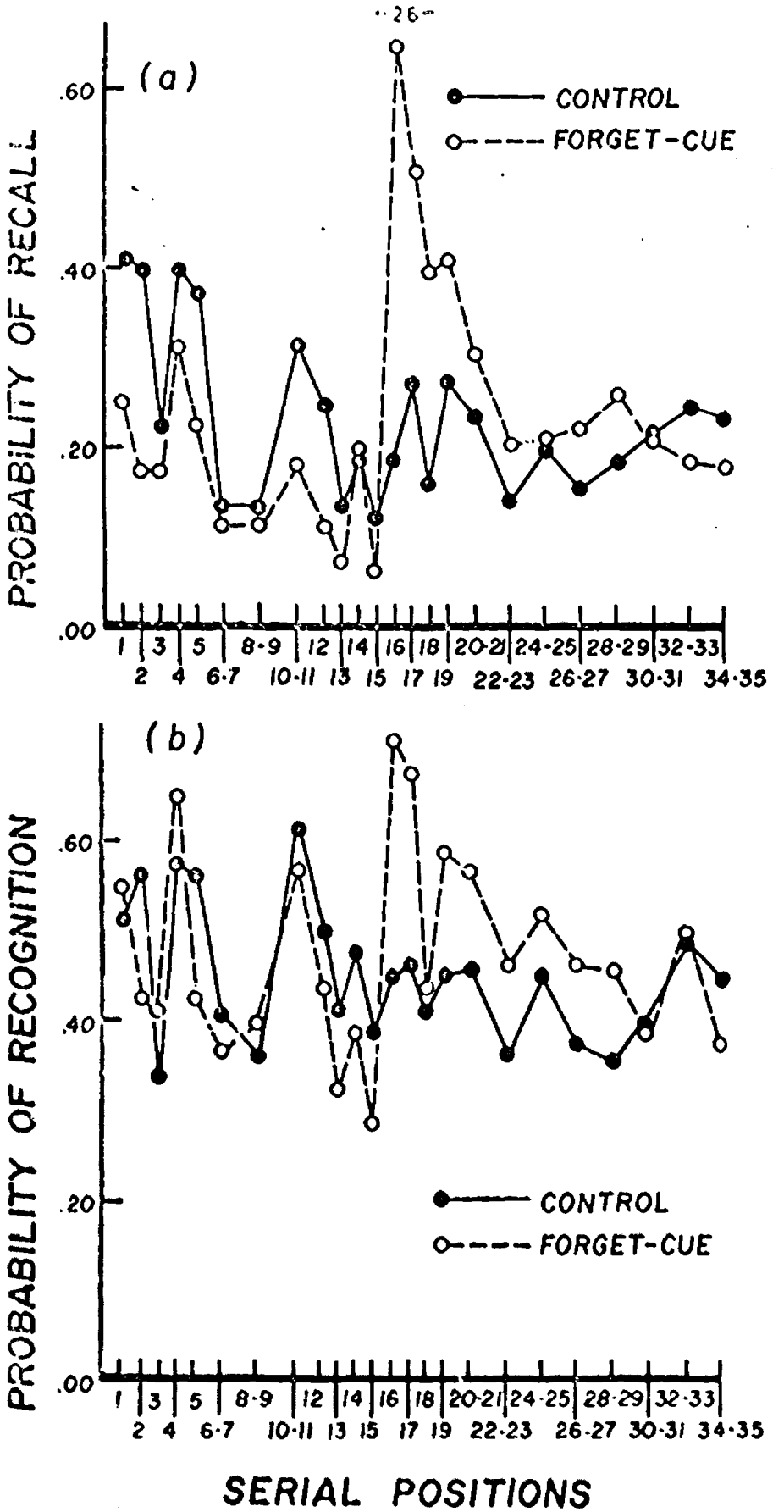
Figure 3

forget cue. Under all conditions, primacy effects appeared to range over the first five items. Analysis of variance of the number of items recalled from the first five serial positions disclosed that there was no significant difference between the NFC and FC treatments for either the 20- or 35-word lists, F (1, 456) < 1 in each case. These results reinforce the earlier refutation of the intraserial-PI hypothesis.

Performance on the final list. From the final list of 35 words, the forget-cue group recalled an average of 8.0 items (SD = 4.3) and the control group, an average of 7.8 (SD = 3.4). The corresponding recognition means were 15.5 (SD = 5.4) and 16.4 (SD = 6.1). As in Experiment I, neither difference was statistically reliable, F (1, 144) < 1 in each case. (See Figure 4)

Serial position curves for recall and recognition testing appear in Figures 4(a) and 4(b), respectively. Proportions are averages over two consecutive serial positions save for those in the vicinity of the forget signal (positions 12-19) and those representing the initial part of the list (positions 1-5).

Two features of these curves are of primary interest. One concerns the retention of words preceding but proximal to the forget signal. As in Experiment I, the minimum of both the forget-cue recall and recognition functions occurred at the serial position immediately prior to the forget


(a)
CONTROL
FORGET-CUE
PROBABILITY OF RECALL
.60
.40
.20
.00
1 2 3 4 5 6-7 8-9 10-11 12 13 14 15 16 17 18 19 20-21 22-23 24-25 26-27 28-29 30-31 32-33 34-35
(b)
CONTROL
FORGET-CUE
PROBABILITY OF RECOGNITION
.60
.40
.20
.00
1 2 3 4 5 6-7 8-9 10-11 12 13 14 15 16 17 18 19 20-21 22-23 24-25 26-27 28-29 30-31 32-33 34-35
SERIAL POSITIONS

signal. The recall proportions offered little guidance as to what serial positions to examine by a posteriori statistical tests for purposes of evaluating differences between the forget-cue and control conditions. However, the recognition data suggested that the dependent variable should be the number correct from the four input positions 12 through 15, a range consistent with Atkinson and Shiffrin's (1968, 1970) estimate of the rehearsal-buffer size for free verbal recall. Analysis of variance of these values for both recall and recognition tests revealed that in each case, retention in the control group significantly exceeded that in the forget-cue group, F (1, 144) = 4.35, $p < .05$ and F (1, 144) = 4.06, $p < .05$, respectively. For reasons outlined earlier, these findings would seem to point to a rehearsal-buffer rather than a stronger-retrieval-cues explanation of the primacy effect.

The second point concerns primacy. Figure 4(a) indicates that for free recall, primacy effects extended over the initial five items. Analysis of variance of the number correct from the first five input positions disclosed that the effect was greater under the control condition as compared with the forget-cue condition, F (1, 144) = 11.24, $p < .001$. While this might appear to provide additional evidence for the general notion that initial list members are accorded more rehearsal time thus accounting for the

primacy effect, this result can also be handled by the stronger-retrieval-cues hypothesis. It need only be assumed that in the forget-cue group, the same retrieval cues are stored for both initial list items and items which closely follow the forget cue. This would lead, in effect, to an A-B, A-D retroactive paradigm which, under instructions to recall all responses, is known to produce retention effects analogous to those in Figure 4(a) (e.g., Barnes & Underwood, 1959). The fact that the recognition functions of Figure 4(b) show no differential primacy effects, F (1, 144) < 1, is not necessarily in conflict with either hypothesis. In the case of the rehearsal-buffer position, one could posit that multiple partial copies of items are transferred to long-term storage (Atkinson & Shiffrin, 1970); and further, that differences in effects noted with recall and recognition simply reflect the availability of such partial information (cf. McNulty, 1965). On the other hand, the stronger-retrieval-cues position could hold that recognition tests largely bypass the differential retrieval problems occasioned by the two final-list conditions (cf. Murdock, 1968), thus resulting in the absence of the substantial difference in primacy effects which was obtained with a recall test.

To summarize, Experiment II buttresses the previous decision to reject the intraserial-PI hypothesis. But by contrast with Experiment I, an overall PI effect attributable

to the processing of items prior to a forget cue was observed. However, it is moot whether to interpret this according to interference theory. The depressed recall and recognition of items just prior to a forget cue corroborates the same tendency noted in Experiment I and disposes us toward a rehearsal-buffer interpretation of the primacy effect. Nevertheless, this influence of a forget cue on the retention of items immediately preceding it, while consistent, has not been dramatic in these studies, and Experiment III was conducted to provide a third demonstration of its occurrence. In addition, Experiment III inquired into the functional similarity of an isolating stimulus and a forget signal as it was under the final-list conditions of Experiments I and II.

Experiment III

Although the von Restorff effect--the heightened retention of an item which is noticeably distinguished from a context of other items--has been most often studied in serial and paired-associates learning tasks (Wallace, 1965), its occurrence in free recall has also been examined (e.g., Waugh, 1969). Certain parallels between some of Waugh's methods and results and those of the final lists administered in Experiments I and II raised the question of whether there is a fundamental similarity between the operation of forget cues and isolation stimuli in single-trial free recall. To this end, Experiment III added a third variation to the kinds

of final lists presented in Experiments I and II. That is, in addition to forget-cue and control conditions, some Ss were presented a list containing a forget signal but without ever having received any instructions about its occurrence or meaning. Moreover, the final list shown to these Ss was the only one in which such a signal occurred. Under such circumstances, it can be expected that the cue would be considered as simply a perceptually novel stimulus. A comparison with the forget-cue condition, it was felt, would yield some idea of the functional similarity of forget cues and isolation stimuli. Of course, the administration of forget-cue and control final-list treatments was intended to permit another assessment of the retention of items preceding a forget signal.

Method

Materials and equipment. Lists were drawn from the pool of words described earlier and were presented via a slide projector controlled by a timer. All instructions were played over a tape recorder. Free recalls were written in test booklets, alternate pages of which consisted of number-series problems.

Procedure and experimental design. Each S received standard free-recall instructions, a practice list of 10 words, and three experimental lists. All lists were presented at a 2.8-sec rate and were terminated by the appear-

ance of a row of three question marks. The ready signal was either an unfilled circle or an unfilled rectangle. Each was used approximately equally often in each major condition. Subjects were accorded 1 min for free recall and 2 min to work on the number-series problems between successive lists.

... were three main conditions of the experiment. These are termed control, forget, and isolation conditions in accordance with the type of final list administered. The control and forget groups, which were not treated differently until the final list, were alerted to the possible occurrence of a forget cue. In this experiment, the forget marker was a word with a circle or a rectangle around it; a circle for those Ss who had a rectangle as a ready signal, and a rectangle for those who had a circle as a ready signal. Instructions indicated that if such a marked item occurred, only it and the items which followed it would have to be remembered, not those which preceded it. The occurrence of a signaled word was antedated by 15 other words.

One of the first two lists shown to the control and forget groups contained a forget-cue word (an FC list) and one did not (an NFC list). In each instance, 20 words had to be remembered. For half the Ss, an FC list occurred first, and for the other half, it occurred second. There were four lists available for this part of the experiment. Each was presented as the first list and as the second list approximate-

ly equally often, and each occurred in combination with the FC and NFC treatments approximately the same number of times. The Isolation group was told nothing about forget cues. The first two lists which it received did not contain forget signals, that is, they were NFC lists.

The three variations of the final list were as follows: The forget group was shown a list of 35 words, the 16th of which had either a circle or a rectangle around it. At the end of the list, however, the members of this group were told to recall all of the words which had been presented. The control and Isolation groups also saw a list of 35 words, but only in the Isolation condition was the 16th word marked by a circle or a rectangle. Both groups were delayed following the terminal input by redundant free-recall instructions which were approximately equal in length and duration to the instructions issued to the forget group. There were eight samples of the final list and they were used approximately equally often within each of the three treatments.

Subjects. The Ss, 213 male and female students at Florida State University, were either selected from the same source as those in Experiment II or were volunteers. The final-list condition and the particular sequence of lists and forget-cue treatments to which a S was assigned was dictated by a schedule drawn up on the basis of a table of random numbers. Up to three Ss were tested at a time. To

begin with. 57 Ss were allocated to each of the three main groups in the experiment. It was subsequently discovered, however, that 42 control Ss had been incorrectly tested on the final list, although data which they contributed regarding the first two lists were usable. Hence, 42 more Ss were selected for this condition. This meant that for the comparison of the FC and NFC treatments applied to the control and forget groups, observations from 156 Ss were available (57 + 42 + 57).

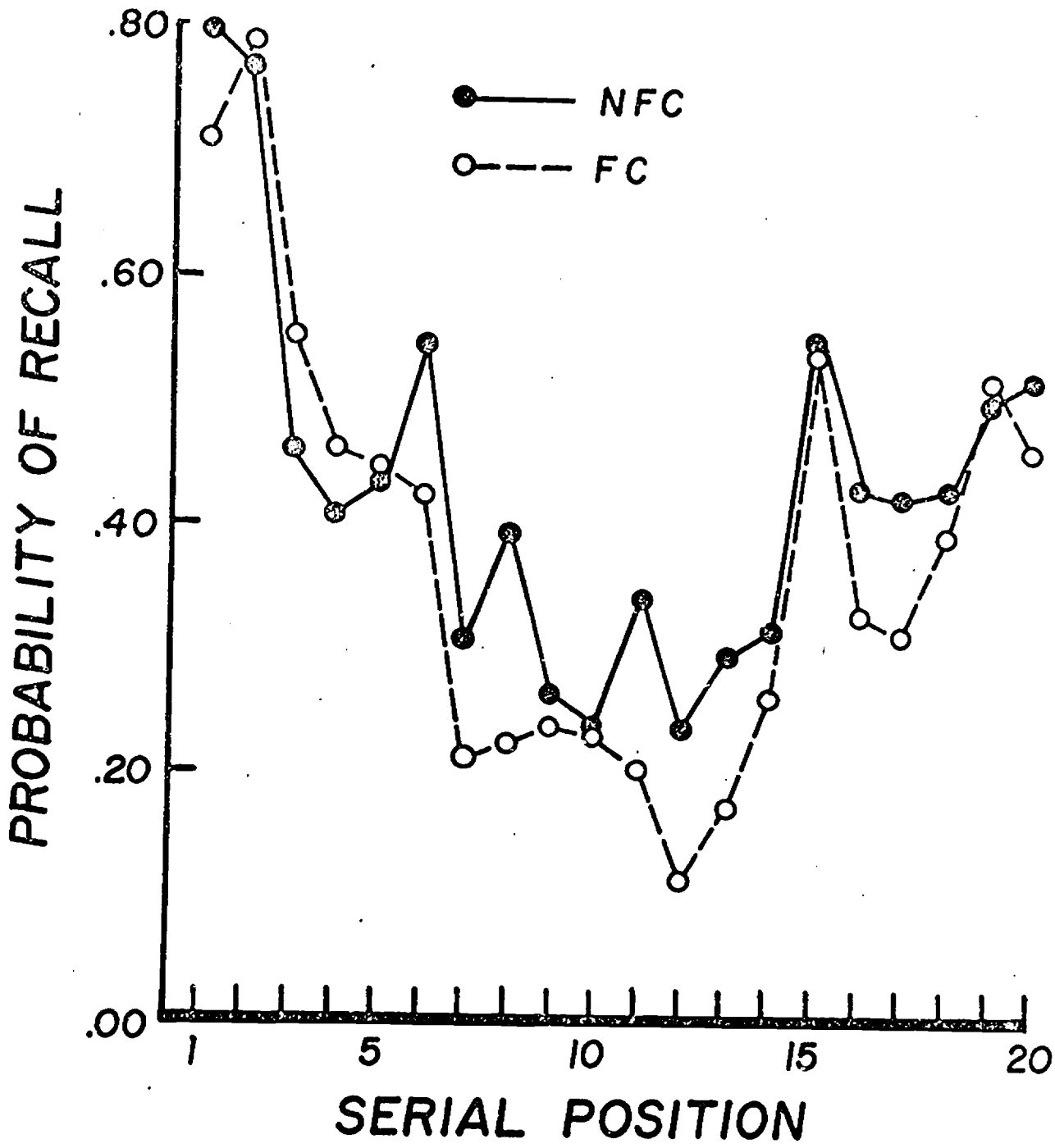
Results and Discussion

Performance on the first two lists. In scoring protocols, a word was also counted as correct if it differed from a list member because of an obvious misspelling, because the plural suffix -s or -es had been added, or both. The comparison of interest regarding the first two lists is between the NFC and FC treatments. The data from the isolation group are irrelevant for this purpose, and so only the performance of the control and forget Ss will be described. The mean number of items remembered from the NFC list was 8.7 (SD = 2.8) and from the FC list, 7.6 (SD = 2.3). This overall PI effect was statistically significant, F (1, 154) = 15.96, $p < .001$. As in Experiment II then, studying a set of words prior to a forget signal proved detrimental to recollection of the to-be-remembered items. The median number of pre-forget-cue words intruding into the recall of

correct words was 1.24. The frequency of these intrusions, however, bore little systematic relationship to pre-cue serial position. (See Figure 5.)

Figure 5 shows serial position curves for the NFC and FC lists. Probabilities for the FC treatment refer to the recall of the forget-cue word and the 19 words which followed it. Primacy effects spanned the first six serial positions. An analysis of variance performed on the number correct from this part of the list disclosed that the difference between the curves was not statistically significant, F (1, 154) $<< 1$, thus again disconfirming the intraserial-PI interpretation of the primacy effect.

Performance on the final list. The mean number of words recalled by the control group from the final list was 10.0 (SD = 3.7), by the forget group, 10.1 (SD = 3.3), and by the isolation group, 9.8 (SD = 2.7). The difference among these means was not statistically reliable, F (2, 168) < 1. However, Figure 6 discloses that the serial position curves for the three groups differed substantially. (See Figure 6) In depicting these functions, probabilities from two adjacent input positions have been averaged except in the range of the primacy effect (positions 1-4) and in the vicinity of the forget-cue word (positions 13-19). Heightened recall of the 16th word, the one which was enclosed by a circle or a rectangle, is evident in both the forget and isolation


.80
.60
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NFC
FC
PROBABILITY OF RECALL
1
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10
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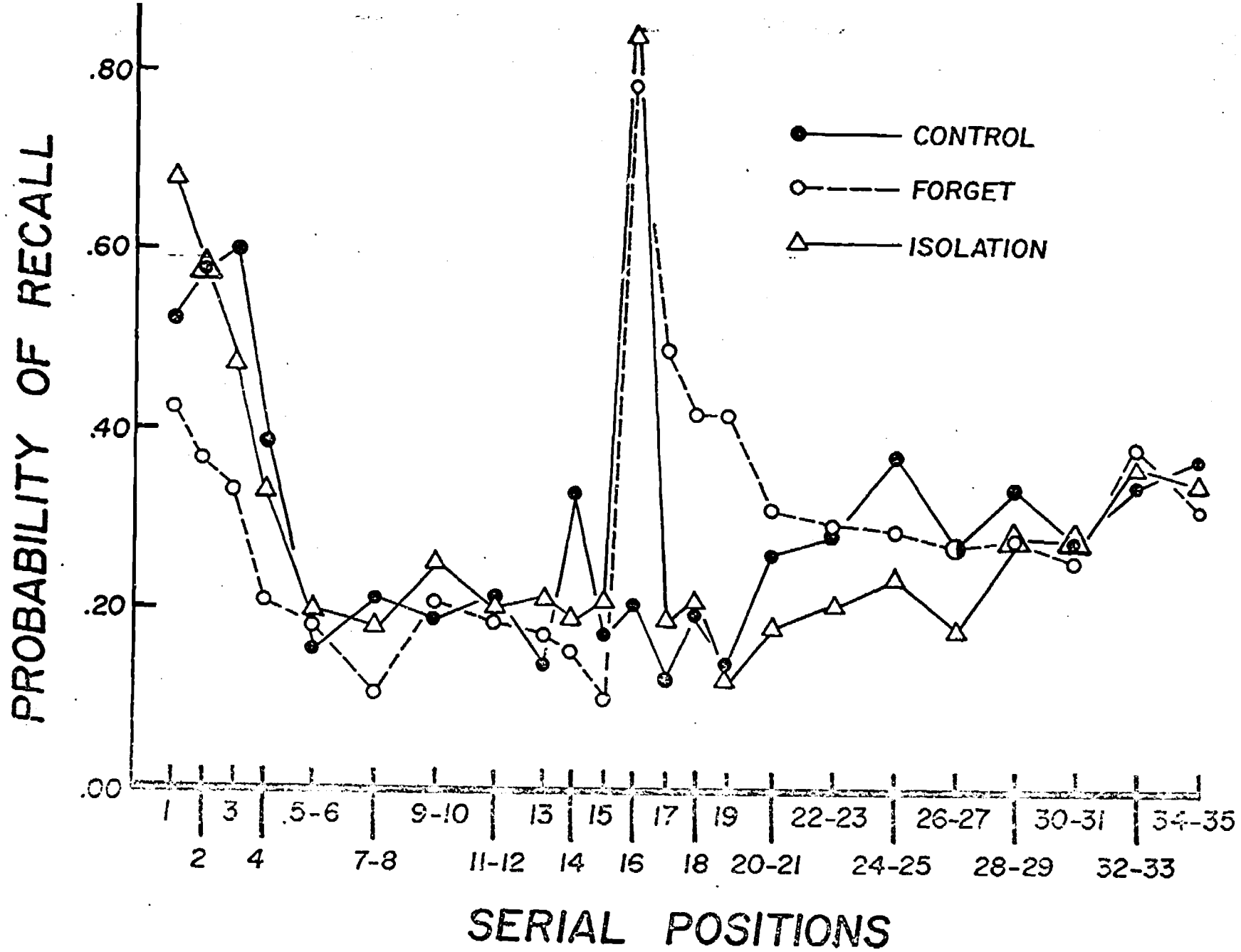
20
SERIAL POSITION


PROBABILITY OF RECALL
.80
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.00
CONTROL
FORGET
ISOLATION
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22-23
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26-27
28-29
30-31
32-33
34-35
SERIAL POSITIONS

Figure 6

conditions. However, it is abundantly clear from other portions of the curves that the effects of a forget signal were quite different from those of an isolating stimulus. In particular, the function for the forget group as compared with that for the isolation group featured a diminished primacy effect, a dip prior to the forget-cue word, and substantially higher recall of words immediately subsequent to the forget cue. The conclusion seems clear: in a single-trial free-recall task administered under conditions similar to those of the present experiment, there is probably little parallel between the processing of a perceptually novel stimulus and a forget cue.

The differences between the control and forget cue functions were generally in accord with the observations of Experiments I and II. Particularly pertinent to a decision between the rehearsal-buffer and stronger-retrieval-cues hypotheses is the fact that again, words immediately prior to the forget signal were not recalled as often as they were when no forget signal occurred, that is, under control conditions. Positions 14 and 15 seemed to demonstrate the point, and so an analysis of variance was carried out on the number correct from these serial positions. To increase the number of values which this variable could assume, however, the 57 Ss in each condition were randomly blocked into 19 sets of 3 Ss each. The analysis revealed that the superior-

ity of the control group with respect to positions 14 and 15 was statistically significant, $F(1, 36) = 5.17$, $p < .05$. This represents, to our way of thinking, further support for the rehearsal-buffer hypothesis.

Conclusions

The main conclusion of these experiments concerns the primacy effect. Any explanation stressing intraserial PI seems quite untenable. Thus, all three studies were unequivocal in demonstrating that the primacy effect was not at all diminished by the presentation and study of a sequence of words immediately prior to the functional beginning of a free-recall list. This is not to say that intraserial PI does not operate in free recall (cf. Experiments II and III), but only that its absence probably does not account for the primacy effect.

What can account for this phenomenon is a rehearsal-buffer process. We are persuaded to this point of view by recall and recognition tests of to-be-forgotten items. Both consistently showed depressed retention of words immediately prior to a forget signal. In our opinion, this result is more in keeping with the rehearsal-buffer hypothesis than the stronger-retrieval-cues explanation of the primacy effect. This particular finding, it may be noted, appears akin to Tulving's (1969) observations of experimental retrograde amnesia.

A final conclusion is that an isolation stimulus is probably not processed in the same manner as a forget cue. We do not wish to imply by this that a rehearsal-buffer notion cannot accommodate isolation effects (cf. Waugh, 1969). The point is simply that there is probably only minimal functional similarity between isolation stimuli and forget cues.

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Figure Captions

Fig. 1. Serial position curves for three different types of list presented under (a) 1-sec and (b) 2.5-sec rates. Points represent the average of probabilities from three or four adjacent serial positions.

Fig. 2. Serial position curves under (a) recall and (b) recognition testing for control and tone conditions. Some points represent the average of probabilities from two adjacent serial positions.

Fig. 3. Serial position curves for NFC and FC lists of (a) 20 and (b) 35 words. Some points for the 35-word lists represent the average of probabilities from two adjacent serial positions.

Fig. 4. Serial position curves under (a) recall and (b) recognition testing for control and forget-cue conditions. Some points represent the average of probabilities from two adjacent serial positions.

Fig. 5. Serial position curves for NFC and FC lists.

Fig. 6. Serial position curves for control, forget, and isolation conditions. Some points represent the average of probabilities from two adjacent serial positions.

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