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AN INVESTIGATION OF SELECTIVE REMEMBERING
IN AUDITORY SHORT-TERM MEMORY

by

Elizabeth S. Sechler

A THESIS SUBMITTED
IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE DEGREE

DOCTOR OF PHILOSOPHY

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AN INVESTIGATION OF SELECTIVE REMEMBERING
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Elizabeth S. Sechler

ABSTRACT

The research constitutes an investigation of selecting material for
remembering, and specifically of the ability to pick out wanted from
unwanted items intermixed in the same spoken message. In Experiments 1–4,
subjects tried to remember a list of words heard under (a) a no-distraction
condition, in which no other words were presented; (b) a precuing condition,
in which the to-be-remembered words were intermixed with unwanted words
and the to-be-remembered words were specified before list presentation;
and (c) a postcuing condition, which differed from the precuing condition in
that the to-be-remembered words were not specified until after list
presentation. Wanted and unwanted words were distinguished on the basis of
semantic category (e.g., colors versus trees). In Experiments 1–3, there were
12 wanted and 12 unwanted words, and the wanted words could be recalled in
any order. Recall in the precuing condition was considerably higher than in
the postcuing condition and only slightly lower than in the no-distraction
condition, indicating a high degree of selective remembering. Interestingly,
the degree of selective remembering depended little if any on within-list
positions (Experiment 1), rate of word presentation (Experiment 2), or
predictability of wanted and unwanted items (Experiment 3).

Such results contrast sharply with the suffix effect, in which recall of a list of items is substantially depressed by a single, nominally irrelevant item at the end of a list. Experiment 4 was similar to the first three but incorporated features of the suffix paradigm, namely a short (8-item) list and the requirement that items be recalled in their presentation order. The efficiency of selection, although reduced, was still appreciable. Experiments 5 and 6 sought to reduce the suffix effect by interpolating the suffix item after each to-be-remembered item rather than just the last one, and by presenting the list and suffix items in different voices. The suffix effect was reduced, but only modestly. It is concluded that the last item to be presented is not easily ignored, and that the suffix effect, therefore, represents a special difficulty in selective remembering.
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In addition, I would like to extend special thanks to Mike Watkins for giving me the opportunity to pursue basic research, and for sharing his great wealth of technical expertise and scientific vision. I would also like to thank Bill Howell for providing me with excellent training during my first years at Rice and with much wise counsel and encouragement throughout my graduate school experience.

Finally, I would like to dedicate this dissertation to my mother, Virginia S. Sechler, and my brother, Joseph S. Sechler, whose love and faith in me made it possible to finish.
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AN INVESTIGATION OF SELECTIVE REMEMBERING IN
AUDITORY SHORT-TERM MEMORY

The scientific study of human memory is for the most part carried out under antiseptic conditions. During the study phase of most experimental procedures every effort is made to prevent the occurrence of extraneous information. This practice simplifies the research and, for most purposes, does so without undermining its validity. It does, however, neglect an important aspect of the overall remembering process, namely the selecting of information. When listening to a national weather forecaster or sports correspondent, to a lecturer, or indeed to just about anyone, usually we are not uniformly interested in every word that is spoken; we find some of what is said to be important and worth remembering, and some to be of no interest. The concern of this dissertation is with the efficiency with which information is selected for remembering.

Perhaps the chief reason for the neglect of this topic is the popular movement towards an analysis of cognitive functioning in terms of its constituent stages. In contemporary research on human cognition the selecting-for-remembering phase of memory is typically distinguished from remembering as such, and is examined under the heading of selective attention (Kahneman & Treisman, 1984; Moray, 1970; Schneider, Dumais, & Shiffrin, 1984). The practice is not altogether undesirable. To some extent
it is reasonable to draw inferences about the nature of selecting for remembering from studies of selective attention (such as those by Cherry, 1953, Moray, 1959, and Treisman, 1964, on auditory shadowing and those by Schneider & Schiffrin, 1977, and Schiffrin & Schneider, 1977, on speeded visual search). On the other hand, since the exact connection between the putative attention stage and the subsequent stages of the remembering process is by no means fully understood, the direct study of remembering defined broadly enough to encompass selection of the wanted information would seem to be not only a legitimate pursuit, but essential for a comprehensive understanding of the nature of memory.

To say that selecting for remembering has been comparatively neglected is not, of course, to say that it has been completely ignored. In fact, the study of certain aspects of this topic has flourished from time to time. Two such aspects warrant brief mention. The first is that of "directed forgetting," a topic pursued in a flurry of studies in the late 1960's and early 1970's. In a typical directed forgetting study, subjects are presented with a sequence of randomly selected verbal items, such as words or pairs of words, and after each individual item or set of items they are given either a remember or a forget signal. Subsequently, the subjects are given a memory test in which, to their surprise, they are required to recall the
to-be-forgotten as well as the to-be-remembered items. Typically, probability of recall is found to be higher for the items that had been designated as to-be-remembered than for those that had been designated as to-be-forgotten (see Bjork, 1972, or Epstein, 1972, for a review of such studies). At face value, such a result would appear to indicate some ability to select for remembering. On the other hand, as Epstein (1972) has argued, it is conceivable that this result is an artifact of the subjects' adopting at the time of test a strategy of complying with what they assume to be the experimenter's hypothesis. Another and probably more serious limitation of the directed forgetting paradigm is that the distinction between wanted and unwanted information is not made until after the information has been presented, so that opportunity for selecting for remembering is truncated, as it were, at the front end.

The second aspect of selective remembering that has generated a fair amount of research concerns the ability to select one of two or more sets of items presented at the same time. The procedures used in this research can be divided into two broad types, one in which all of the information, wanted and unwanted, is presented in a single brief burst, and another in which the wanted and unwanted material is presented over time in two simultaneous streams. Examples of the former procedure can be found in several studies
of memory for visual material with the to-be-recalled information signaled either before or after presentation (Broadbent, 1970; Brown, 1960; Keren, 1976, Experiment 1; von Wright, 1968). This procedure is neatly illustrated in an experiment reported by Brown (1960). Subjects were shown displays of simple verbal items (e.g., matrices of letters and digits) for a brief period (e.g., 500 msec), and immediately after presentation of the display were tested on recall of a subset of the items. A major finding evolving from research of this sort, although curiously not from Brown’s study, is that the advantage of knowing which set of items is to-be-recalled before rather than after presentation is affected by how the sets are defined. In particular, the advantage is usually greater when the to-be-recalled set is distinguished from the unwanted set by a physical rather than a semantic criterion.

A procedure calling for the remembering of one of two simultaneous streams of material has been used in studies by Broadbent (1952a, 1952b, 1954b). In each of these studies, subjects listened to two voices that occurred simultaneously but delivered different messages, typically questions about the content of a visual display. Each voice identified itself by a call name at the beginning of its message, and after presentation of the two messages, the subjects attempted to respond to the voice that the
experiment had designated as relevant before presentation. Broadbent found that subjects were able to perform this kind of selective remembering more efficiently when the voices were spatially separated by means of different loudspeakers or different headphone ears.

A form of selecting for remembering that has been explored surprisingly little is that in which (unlike the simultaneous paradigm) wanted and unwanted information occur sequentially in a single stream and (unlike the directed forgetting paradigm) are defined prior to presentation. These characteristics capture the essence of the ordinary way in which we selectively remember auditory material, as in the example of listening to a lecturer, noted above.

To model this sequential, single-stream situation, a "precuing" procedure is needed in which subjects first are told what kind of information they should remember, and then are presented in some sort of sequence with information of this kind and information of another, unwanted kind. To evaluate the subjects' success in selecting for remembering, level of recall obtained in a test given after this procedure needs to be compared with that obtained in a test given after control procedures. At least three control conditions might be used. The first of these would involve testing the subjects' memory for the information they were not asked to remember.
As noted in the discussion of the directed-forgetting paradigm, this procedure is questionable in that it leaves open the possibility of biased responding as a consequence of the subjects' trying to confirm (or disconfirm) what they believe to be the experimenter's hypothesis. This difficulty is avoided with two other controls. The first of these, which may be referred to as the "no-distraction" control, consists simply of restricting the presentation, as well as the recall, to the to-be-remembered set. To the extent that recall in this condition exceeds recall in the precuing condition, the unwanted items in the latter condition are distracting and the ability to select for remembering is imperfect. To appreciate this point, assume that selection of the to-be-recalled items in the no-distraction condition is perfect. This is not to assume that all of the subjects' mental resources are tied up with the to-be-remembered items; the subjects may monitor other aspects of the environment or think of other things. Rather, it is to assume that there is no chance that subjects will think of and remember the particular unwanted words that would have been presented if the subjects were serving in the precuing condition. To the extent that this assumption is valid, a perfect ability to select for remembering would be shown by a level of recall in the precuing condition equal to that in the no-distraction control condition. Such a finding would mean that the presentation of the unwanted
items would have been entirely nondistracting. Conversely, to the extent that recall is lower in the precuing than in the no-distraction condition, the unwanted items are distracting and ability to select for remembering is less than perfect.

The other control condition, which may be called the “postcuing” condition, is exactly like the precuing condition except that the subjects are not informed which set of items they will have to recall until after presentation. Of course, subjects may adopt the strategy of guessing which set will be cued for recall, but so long as they are given no information on this point prior to the test, they will over the long run select the cued items for remembering no more frequently than the uncued items. Thus, the benefit of selecting must, over the long run, tend to zero in this condition. It follows that to the extent that the level of recall is higher in the precuing than in the postcuing condition, selective remembering was achieved.

Ideally, then, an experimental study of selective remembering would involve the conditions of no-distraction, precuing, and postcuing. The comparison of recall in the precuing condition with that in the postcuing condition would show whether subjects are able to benefit from the precue, and the comparison of recall in the precuing condition with that in the no-distraction condition would show whether the benefit is maximal.
This logic may be extended to yield what might be called a relative benefit index simply by expressing the absolute benefit (given by level of recall in the precuing condition minus that in the postcuing condition) as a proportion of the maximum achievable benefit (given by level of recall in the no-distraction condition minus that in the postcuing condition).

Of the few studies identified which have used a sequential, single-stream presentation of wanted and unwanted material, none has included all three of the conditions. Some, however, have included a precuing condition and one or the other of the two control conditions. These studies will now be considered.

A search of the literature uncovered two studies in which both precuing and postcuing conditions were included, one by Broadbent (1970) and one by Hamilton and Hockey (1974). In Broadbent’s study subjects heard lists of 6 items and after each list were tested for immediate recall of 3 of them. For one group of subjects, half the items were digits and half were letters; for a second group, all the items were digits but half were spoken in a male voice and half in a female voice. In each case, half of the lists were presented in a precuing condition (with subjects being told in advance of list presentation which set of items they would be required to recall) and the other half were presented in a postcuing condition (with subjects not being told until after
list presentation). Statistical analyses showed an advantage of precuing condition that was reliably greater for those subjects for whom wanted and unwanted items were differentiated on the basis of presentation voice than for subjects for whom wanted and unwanted items were defined in terms of the letter-digit distinction.

A similar procedure was used in two experiments described by Hamilton and Hockey (1974). In one of these (Experiment 5), subjects were presented with lists of 4 digits and 4 letters and tested for immediate serial recall of either the digits or letters. For any given subject, half the lists were presented under precuing instructions and half under postcuing instructions. In addition, half of the lists within each of the cuing conditions were presented at a fast rate and half at a slow rate. Their interest being focused elsewhere, Hamilton and Hockey reported no statistical comparison between levels of recall for the two cuing conditions. Nonetheless, a graphic display of the data (their Figure 5) shows that recall was higher under precuing instructions than under postcuing conditions, regardless of presentation rate. In the other experiment (Experiment 6), similar conditions were used, except that in addition to the locus of cuing and rate manipulations, the temporal organization of list items was also varied. Once again, no direct analysis of the benefit of precuing over postcuing was reported, but the
summary data (see their Figure 6) shows that recall was higher in the precuing condition than in the postcuing condition.

A comparison between recall with precuing and recall with no-distraction has been made in an experiment reported by Morton (1968). Subjects were tested on serial recall of sets of 6 letters. For a given set, the letters were either presented alone (e.g., B, F, T, H, M, R) or alternated with digits (B, 3, F, 8, T, 6, H, 2, M, 9, R, 1). In the latter condition, subjects knew in advance of list presentation that only the letters were to be recalled. Of relevance for present purposes is the finding that level of recall was lower in this condition than when the letters were presented alone, indicating that the wanted digits were distracting in some degree.

Other evidence that the benefit of precuing is limited is implicit in the suffix effect. This effect refers to the sharp reduction in the serial recall of the last few of a short list of items that occurs when the list is followed by a single, nominally irrelevant "suffix" item (e.g., Crowder & Morton, 1968; Morton, Crowder & Prussin, 1971). Since subjects are aware before list presentation that only the list items and not the suffix item have to be recalled, this procedure is tantamount to a precuing procedure. That performance is impaired in this condition relative to that in a no-distraction control condition indicates that subjects are not able to ignore the suffix
It would appear, then, that although the data are extraordinarily sparse, such studies as there are comparing recall in the precuing and postcuing conditions are consistent in suggesting that information can be selected for remembering, and those comparing recall in the precuing and no-distraction conditions are consistent in suggesting that selection is less than perfect. The purpose of the research to be described here was to explore further the nature of selective remembering using a precuing procedure and both the no-distraction and postcuing control procedures.
EXPERIMENT 1

For an initial look at the remembering of selected information, a free recall test of 12 to-be-remembered items was given under conditions of precuing as well as under conditions of both postcuing and no distraction. The use of all three conditions should provide a more complete picture of selective remembering than that given by any previous study. To the extent that performance in the precuing condition exceeds that in the postcuing condition, remembering is selective; to the extent that performance in the precuing condition is lower than that in the no-distraction condition, the benefit of being able to select is less than perfect.

In addition to taking an overall look at how well subjects select for remembering, it should be of considerable interest to compare their ability to select for items that occurred in the first half of the list with that for items that occurred in the second half. Past research on immediate free recall has shown that if probability of recalling an item is plotted against its position within the list, the resulting function is bow-shaped with level of recall dropping across the first two or three items to a low plateau and then increasing progressively across the last six or seven positions (see, e.g., Murdock, 1962). Moreover, there is much evidence for a functional dissociation between recall of the last six or seven, or "recency" items and
recall of the earlier, or "prerecency" items. That is to say, variables that control overall level of recall typically have different effects on recency and prerecency items. In particular, even though one or two variables, such as presentation modality (Murdock & Walker, 1969; Watkins, 1972), have their effect localized at the recency positions, the majority have a greater effect at the prerecency positions. This is the case with, for example, list length (Murdock, 1962; Tulving & Colotila, 1970), item presentation rate (Glanzer & Cunitz, 1966; Murdock, 1962), frequency of the items' everyday occurrence (Raymond, 1969; Sumby, 1963), semantic similarity of the items (Craik & Levy, 1970), phonological similarity of the items (Watkins, Watkins, & Crowder, 1974), age of the subjects (Arenberg, 1976; Craik, 1968), and intelligence (Belmont & Butterfield, 1971).

In the light of such findings, it would not be at all surprising if the effects of presentation condition in the present experiment differed for recency and prerecency items. The most likely possibility is that the benefit of selection would be more apparent for prerecency items, insofar as precuing presumably affects strategy, and many variables that would seem to influence strategy (notably, presentation rate, semantic similarity of items, item frequency and intelligence) conform to the standard pattern of affecting prerecency items more than recency items. The notion that
precuing will be more beneficial for prerecency than for recency items also
gains support from the finding that interpolating a brief distractor task
between list presentation and recall eliminates, or at least sharply
attenuates, the recency effect (e.g., Glanzer & Cunitz, 1966). Presumably,
the distractor information replaces the recency items as being the most
recallable, and assuming that subjects would be unlikely to remember the
distractor information by choice, this finding would seem to indicate that
knowing whether a recency item is to be remembered or not would have little
effect on whether it is actually remembered.

At a more theoretical level, the functional dissociation between the
recall of recent and prerecent items has been interpreted in terms of
hypothetical stores, a limited-capacity short-term store underlying recency
recall and a long-term store of essentially unlimited capacity underlying the
prerecency recall (see, e.g., Atkinson & Shiffrin, 1968; Glanzer, 1972; Waugh
& Norman, 1965). There have been many different versions of this model, and
while they may differ in whether they would allow for selection among the
most recent few items presented, they would virtually all allow for
selection as one determinant of what gets transmitted from the short-term
store to the long-term store. Thus, on the basis of the two-store model of
immediate free recall, we would again predict that the benefits of being able
to select for remembering would be greater at, if not confined to, prerecency serial positions.

**Method**

**Overview.** Each subject studied and recalled four word lists under each of three conditions, namely the precuing, no-distraction, and postcuing conditions. All lists included 12 to-be-remembered words drawn from the same conceptual category, and were presented on a tape recorder at a rate of one word every 2 seconds. In the no-distraction condition, these were the only words presented. In the precuing and postcuing conditions these words alternated with 12 words of another category; the only difference between these latter conditions was that the to-be-remembered category was identified before presentation in the precuing condition and not until after presentation in the postcuing condition. The free recall test, given immediately after list presentation, was the same for all conditions.

**Stimulus lists and design.** Twelve instances from each of 24 categories were selected from the Toronto Categorized Word Pool (Murdock, 1976). For half of the categories, the selected instances were the first 12 odd-numbered instances listed in the word pool (i.e., 1st, 3rd, ...23rd), and for the other half of the categories they were the even-numbered instances (i.e., 2nd, 4th, ...24th). The order of listing in the word pool appears to
correspond to the frequency with which the words are generated in response to the category name (according to the Battig and Montague (1969) norms from which the word pool was constructed), with the first instance in a list being the instance most frequently generated. The category instances were presented in an order that, across categories, precluded any confounding between position and frequency rank. To this end, the categories were arbitrarily divided into two sets of 12, and within each set each presentation position included one instance of each of the 12 within-category frequency rankings. Next, each category of one set was arbitrarily merged with a category of another set to form a 24-word master list. This merging of the lists involved assigning the successive instances of the first-set category to successive odd-numbered positions and successive instances of the second-set category to successive even-numbered positions.

The master list was recorded with an AKAI Model 1722 II, reel-to-reel stereo tape recorder in a female voice at a rate of one word every second. A warning signal and an end-of-list signal were added 6 seconds before the first word and one second after the onset of the last word; these signals were nonverbal, made simply by rapping the table with the knuckles. For the precuing and postcuing conditions, these master lists served directly as the
presentation lists. For the no-distraction condition, two forms of presentation lists were made from the master list, one with the instances of one category erased and the other with the instances of the other category erased. Note that for all presentation lists, the instances of the to-be-recalled category occurred at a rate of one every 2 seconds and that for each of the three conditions the end-of-list signal occurred 1 second after the last of these items for half of the lists and 2 seconds after for the other half of the lists.

The ordering of the 12 master lists was the same for all subjects, but their "selection condition" was counterbalanced between groups of subjects. For this purpose, the 12 lists were partitioned into 4 blocks of 3 lists. Within each block one list occurred in each condition, with list condition being varied among three equal-sized groups of subjects (Groups I, II, and III) according to a Latin square. Thus, across subjects, each list occurred equally often in each condition. The same Latin square was used for each block of lists, so that the order of conditions rotated in a regular fashion. The choice of which of the two categories of a master list was to be recalled was varied between two equal-sized subgroups of subjects within each of the three major groups. For any given subgroup, a randomly chosen half of the cued categories within each of the precuing and postcuing conditions
occupied the odd-numbered positions of the presentation sequence, and the other half of the cued categories occupied the even-numbered positions.

In sum, the structure of the experiment conformed to a single-factor, within-subjects design. Six independent groups of subjects were used to counterbalance the assignment of categories to selection conditions, so that across all subjects, each category occurred equally often in the precuing, postcuing, and no-distraction conditions. The details of the presentation and timing were identical for the three conditions.

Procedure. Subjects were tested in groups of six or fewer. After the procedure had been explained in detail, the subjects were given response sheets showing 12 columns, one for each of the study lists. Each column was headed by the name of the category or categories that would be represented in that list. Before the presentation of each list, subjects were told the selection condition under which presentation would occur; in the case of the precuing and no-distraction conditions the subjects were told which category they would have to recall, and they were told to circle the name of this category at the top of the appropriate column of the response sheet. In the case of the postcuing condition, the experimenter simply told the subjects to circle the names of both categories at the top of the column. It was explained that the circling of both names meant that presentation would
be under the postcuing condition.

Immediately following the end-of-list signal, the experimenter announced the name of the target category regardless of the selection condition, thereby equating across conditions both delay between list presentation and recall and any inhibitory effects of saying the category name. Subjects were allowed 40 seconds to recall in any order they chose as many words from the cued category as they could.

Prior to the experiment proper, subjects were given one practice list in each of the three selection conditions. The ordering of these conditions was the same as in the actual experiment.

Subjects. The subjects were 36 Rice University undergraduates who participated for credit in a psychology course.

Results and Discussion

Of interest, of course, are the relative levels of recall for the three selection conditions. These are considered first with the data collapsed across within-list position, and then for each list half taken separately.

The overall mean proportion of critical items recalled was .622 in the no-distraction condition, .573 in the precuing condition, and .423 in the postcuing condition. The ordering of these means was just as expected. Thus, recall was highest when conditions were set up for what can be
thought of as maximum efficiency in selection (i.e., in the no-distraction condition) and lowest when conditions precluded effective selection (i.e., in the postcuing condition). The advantage of recall in the no-distraction condition over that in the postcuing condition was reliable, $t(35) = 14.44, p < .001$. Of more interest is the statistical comparison of the precuing condition and each of these two conditions. Performance in the precuing condition was in fact reliably greater than that in the postcuing condition, $t(35) = 10.08, p < .001$, indicating that there was indeed some benefit from the opportunity to select for remembering. On the other hand, performance in the precuing condition turned out to be reliably lower than that in the no-distraction condition, $t(35) = 3.224, p < .001$, indicating that the benefit was not all it might have been. Beyond saying that level of recall in the precuing condition is reliably greater than in the postcuing condition and reliably less than in the no-distraction condition, it is possible to express numerically the extent of the selection advantage. As noted earlier, one way to do this is by means of what is called the relative benefit index, which is given by: $(B-A)/(C-A)$, where $A$, $B$, and $C$ refer to the level of recall in the postcuing condition (A, for “after”), in the precuing condition (B, for “before”), and in the no-distraction condition (C, for “control”). Note that the numerator of this index expresses the absolute benefit of selecting (as given
by the advantage of the precuing condition over the postcuing condition) and
the denominator expresses the range in recall performance in moving from
maximum benefit (as measured in the no-distraction condition) to zero
benefit (as measured in the postcuing condition). Thus, just as relative
humidity expresses the amount of water vapor in the air as a proportion of
the maximum amount that can be held at that temperature, so the relative
benefit index expresses the benefit of precuing as a proportion of the
maximum amount that could be achieved. The logic of this index is, of
necessity, firmly tied to the assumptions that performance in the
no-distraction condition represents what amounts to perfect selection and
hence maximum benefit, and that in the postcuing condition it represents
zero selection. In any event, for the present data, this proportion turned out
to be .75.

Consider now how efficiency in selection varies with within-list
position. Figure 1 shows the mean level of recall for each of the three
selection conditions as a function of serial position. Consistent with the
moderately high level of the relative benefit index for the data overall, level
of recall in the precuing condition is generally closer to that in the
no-distraction condition than to that in the postcuing condition. This
tendency, however, is greater for recency items than for prerecency items:
Separate analyses of the data for each list half (see Table 1) yielded relative benefit indices of .59 for the first half of the list and .93 for the second half.

Inferential comparisons of the relative benefit index are problematic insofar as the index becomes highly unstable as the denominator tends to zero, and yet small, zero, or even negative denominators are almost certain to occur in the data for individual subjects. The relative benefit index for these subjects would therefore be very high or indeterminate. However, no such problems occur in comparing relative levels of recall in the individual selection conditions. The results of such comparisons indicated that list half interacted with the precuing/no-distraction conditions (t(35) = 1.779, p < .05), but just failed to do so at conventional levels of significance with the precuing/postcuing conditions (t(35) = 1.534, .05 < p < .10). In descriptive terms, the difficulty of selection (or degree of distraction) was greater with items in the first half of the list, and yet at the same time the absolute benefit of precuing showed at least a suggestion of being greater in the second half.

This pattern of results lends no support to the predictions made on the basis of the modal two-store model. As argued above, items known to be irrelevant (i.e., the to-be-ignored category in the precuing condition) would be expected to be more detrimental to recency recall than to prerercency.
Figure 1. Mean Proportion of Items Recalled Under Free Recall Instructions by Selection Condition and Serial Position (Experiment 1)
Table 1

Mean Proportion of Items Recalled Under Free Recall Instructions by Selection Condition and List Half (Experiment 1)

<table>
<thead>
<tr>
<th>Selection Condition</th>
<th>List Half</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>First</td>
<td>Second</td>
<td></td>
</tr>
<tr>
<td>No Distraction</td>
<td>.580</td>
<td>.664</td>
<td></td>
</tr>
<tr>
<td>Precuing</td>
<td>.496</td>
<td>.650</td>
<td></td>
</tr>
<tr>
<td>Postcuing</td>
<td>.373</td>
<td>.474</td>
<td></td>
</tr>
</tbody>
</table>
recall. That the data tended to show, if anything, the opposite pattern undermines the assumption that recency items are recalled on the basis of a separate short-term store.
EXPERIMENT 2

The objective of the second experiment was to bring the benefit of precuing under experimental control. The essential idea was based on the intuition that precuing would be more beneficial if the items were presented at a leisurely rather than a brisk pace. It is well documented that level of free recall increases with the per-item presentation time (e.g., Bernbach, 1975; Glanzer & Cunitz, 1966; Murdock, 1960). It is generally assumed that during the intervals between presentations of successive items, subjects engage in rehearsal or other mental activity in an effort to enhance the likelihood of the items being recalled in a subsequent test. Since such mental activity is generally considered to be under a substantial degree of conscious control, it should make for better remembering of wanted items. If it is further assumed that such control is more effective in the blank intervals between the occurrence of successive items than during the actual item presentation, then the slower the rate of presentation (and hence the longer the blank interval between the presentation of successive items), the greater should be the benefit of precuing.

As was noted in introducing the first experiment, the effect of presentation rate on free recall performance is substantially confined to the prerereency part of the serial position function (e.g., Glanzer & Cunitz, 1966;
Murdock, 1962; Murdock & Walker, 1969; Roberts, 1972). For this reason, list presentation was followed by a brief distractor task designed to eliminate the recency effect and thereby give what in effect would be a prerenency status to all list items (cf. Glanzer & Cunitz, 1966).

**Method**

**Overview.** The methodology is similar to that of Experiment 1 with two major exceptions. First, the presentation of each list was followed by a 15-second distractor task. Second, the three selection conditions were crossed factorially with two levels of presentation rate to give six presentation conditions. Each subject received two lists under each of these six conditions.

**Stimulus lists and design.** As in Experiment 1, 12 master lists were constructed by combining 12 instances from each of two semantic categories taken from the Toronto Categorized Word Pool. This time, category instances of more than 3 syllables were avoided. The purpose of this constraint was to ensure that the items would be clearly audible in the fast-rate condition. The procedure for counterbalancing the assignment of items to list positions (i.e., with respect to an item's relative rank within its category) was the same as that used in Experiment 1.
The master lists were recorded at a rate of one word every 0.5 seconds for the fast condition and one word every 2.0 seconds for the slow condition. The to-be-remembered words therefore occurred at a rate of one every second and one every 4 seconds, respectively.

As in the first experiment, the 12 lists were presented in the same order to all subjects, but the assignment of lists to selection condition was counterbalanced according to a Latin square. The choice between the two categories comprising each master list as the category to be remembered was counterbalanced between subgroups within each of the three main subject groups in precisely the manner described for Experiment 1. In addition, presentation rate alternated from one list to the next. Specifically, for half the subjects in each of the six subgroups, the odd-numbered lists were presented at the fast rate and the even-numbered lists at the slow rate, and for the other half of the subjects the odd-numbered lists were presented at the slow rate and the even-numbered lists at the fast rate. In short, across all subjects each category occurred equally often in each of the 12 combinations of rate, list selection conditions, and wanted/unwanted status, and for any one subject two categories were assigned to each of these combinations.
Procedure. The main departure of the procedure from that of Experiment 1 was in the addition of a distractor task. Immediately after presentation of each list, the experimenter read aloud a string of 15 2-digit numbers at a rate of one every second. As the experimenter did so, the subject wrote down the numbers in their response booklets but with the digits comprising each number reversed (e.g., "32, 15, 86..." was written as "23, 51, 68..."). Directly following the reading of the distractor numbers, the experimenter announced the name of the to-be-recalled category.

Prior to the experiment proper, subjects were given practice on 2 miniature lists in each of the 6 conditions (3 selection conditions by 2 rate conditions), with each list comprising just 4 items per category and being followed by 6 seconds on the distractor activity. The ordering of conditions for these lists was the same as that in the actual experiment.

Subjects. The subjects were 48 Rice University undergraduates. They were given course credit for their participation.

Results and Discussion

Consider first the relative levels of recall for the three selection conditions with data combined over the fast and slow presentation rates. As in Experiment 1, the proportion of items recalled was highest in the no-distraction condition (.584), next highest in the precuing condition (.552),
and lowest in the postcuing condition (.407). The relative benefit index was
.82. Analysis of the advantage of the precuing over the postcuing condition
indicated that the opportunity to select during presentation enhanced
memory to a reliable degree \( t(47) = 9.860, p < .001 \). On the other hand, a
reliable advantage of the no-distraction condition over the precuing
condition \( t(47) = 2.342, p < .02 \) indicated that the enhancement, while
considerable, was not all that it might have been. The advantage of the
no-distraction condition over the postcuing condition was, of course, also
reliable \( t(47) = 11.979, p < .001 \).

Table 2 shows the levels of recall for the three selection conditions
separately for the slow and fast presentation rates. As was expected, the
overall mean level of recall was generally higher with the slow rate (.602)
than with the fast rate (.426), \( t(47) = 5.873, p < .001 \). More important,
however, were the findings relating to the relation between the precuing
advantage and presentation rate: In particular, statistical analyses showed
no evidence for a reliable interaction between rate and the precuing versus
postcuing manipulation \( t(47) = .333 \). Thus contrary to expectations,
selective remembering—as reflected in the extent to which precuing
benefits recall—as was no better under slow presentation rates than under
fast. Similarly, there was no evidence of an interaction between
Table 2
Mean Proportion of Items Recalled Under Free Recall Instructions By Selection Condition and Item Presentation Rate (Experiment 2)

<table>
<thead>
<tr>
<th>Selection Condition</th>
<th>Presentation Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Distraction</td>
<td>.491</td>
</tr>
<tr>
<td>Precuing</td>
<td>.469</td>
</tr>
<tr>
<td>Postcuing</td>
<td>.319</td>
</tr>
<tr>
<td></td>
<td>.495</td>
</tr>
<tr>
<td></td>
<td>.677</td>
</tr>
</tbody>
</table>
presentation rate and the advantage of the no-distraction condition over
the precuing condition ($t(47) = .774$), indicating that rate had no effect on
the extent to which the level of selection was less than perfect. When
analyses were performed separately for each rate condition, the advantage
of precuing over postcuing was found to be reliable for the fast rate ($t(47) =
9.025, p < .001$) as well as for the slow rate ($t(47) = 6.332, p < .001$). Also
the advantage of no-distraction over precuing was found to be reliable in
the slow rate condition ($t(47) = 9.025, p < .001$) but not in the fast rate
condition ($t(47) = 1.224, p > .10$). The failure of these results to confirm
expectations was reflected in the relative benefit indices: the index for the
slow rate (.77) was no greater than that for the fast rate (.87).

Clearly, the results of this experiment have given no support to the
hypothesis that the benefit of precuing can be enhanced by slowing down the
rate at which information is presented.
EXPERIMENT 3

This experiment represents another attempt to bring the precuing advantage under experimental control. In the precuing condition of the first two experiments, the wanted and unwanted items occurred in strict alternation so that subjects knew whether an item was to be remembered or not even before it was presented. It seems at least possible that this knowledge made the selection of the wanted items more efficient. If an upcoming item is known to be unwanted, then it might be possible to ignore it more completely, and perhaps, as a result, to devote more mental capacity to the to-be-remembered items. If, on the other hand, if the two categories of items were combined in an irregular way, so that the relevance of any upcoming item to the subjects' task was unpredictable, selection may be less effective.

Empirical evidence pertaining to this hypothesis is sparse. There is, of course, evidence showing that the temporal predictability of stimuli enhances the speed with which the stimuli can be responded to. Thus, with a simple reaction time procedure, varying the foreperiod (i.e., interval between the warning signal and the stimulus itself) unpredictably from one trial to the next gives rise to a longer mean reaction time than if the trials are blocked by length of foreperiod (see Naatanen & Merisalo, 1973, for a review
of such findings). But a search of the literature turned up only one experiment in which the task was one of selective remembering rather than of reaction to stimuli. This was reported in the study by Hamilton and Hockey (1974) already mentioned. In their Experiment 5, subjects were presented with lists comprising four digits and four letters and their task was to recall either just the digits or just the letters in their order of presentation. For half of the lists digits and letters were positioned alternately, and for the other half they were positioned randomly. In addition, for half of each type of list subjects were told before presentation whether they would have to recall the letters or the digits, and for the other half of the lists they were not told until after presentation. Other variables were built into the experiment, but the finding of relevance here is the apparent relation between the organization of the list items and the time at which subjects were informed of which items were to be recalled. Specifically, the precuing advantage was less with the random than with the alternating arrangement. Unfortunately, this finding was not of direct interest to the authors and was not evaluated statistically. The purpose of this experiment was to provide further evidence on the hypothesis that benefit of precuing varies with the predictability of the wanted and unwanted items.
Method

Overview. The methodology was essentially the same as in Experiment 2 except that (a) item presentation rate was the same for all lists, and (b) the three selection conditions were crossed factorially with the manner in which the wanted and unwanted items were organized. Each subject was presented with two lists in each of these six experimental conditions.

Stimulus lists and design. Twelve master lists were constructed in the way described for Experiment 1. Two versions of the master lists were recorded, one in which the instances of the two categories of items occurred in alternating order, and one in which they were mixed up at random. Randomization was separately determined for each list by the order of a shuffled deck of 12 red and 12 black playing cards. Within a given category, the items were ordered for presentation by the procedure described in Experiment 1. As before, the presentation lists for the no-distraction condition were obtained by, in effect, deleting the items of the unwanted category from the list. This was done separately for each category and also separately for the alternating and random conditions.

Items were recorded at a rate of one every second in the precuing and postcuing conditions, and hence at a regular rate of one every 2 seconds in the alternating/no-distraction condition and an irregular rate that averaged
one every 2 seconds in the random/no-distraction condition.

As in the first two experiments, the order of the 12 master lists was the same for all subjects. Their assignment to selection condition and the assignment of categories to wanted and unwanted (or in the case of the no-distraction condition, nonpresented) roles was counterbalanced between subjects, just as in Experiment 1. Further, within each of the six subject groups required for this counterbalancing, the assignment of item-organization condition was varied between two subgroups such that for one subgroup the first 6 lists were presented in the alternating condition and the second 6 in the random condition, and for the other subgroup this arrangement was reversed. Thus, within the overall framework of a two-factor within-subjects design, 12 subgroups of subjects were used to assign each category equally often to each combination of selection condition, wanted or unwanted status, and predictability condition.

Procedure. Subjects were tested individually or in small groups. The procedure followed closely that of Experiment 1. In advance of the actual experiment subjects were given practice on 2 short lists (3 items per category) in each of the six experimental conditions. They were informed of the selection and predictability conditions of each list prior to its presentation.
Subjects. Forty-eight Rice University undergraduates participated for course credit.

Results and Discussion

Perhaps the most striking feature of the results is that the precuing advantage was even higher than in the first two experiments. With the data collapsed across predictability conditions, level of recall in the precuing condition (.482) was virtually as high as in the no-distraction condition (.483). Both of these means were reliably higher than that for the postcuing condition (.336): for the precuing condition, t(47) = 11.890, p < .001; for the no-distraction condition, t(47) = 10.635, p < .001. Obviously level of recall in the precuing condition did not differ reliably from that in the no-distraction condition, t(47) = .081. The relative benefit index was .99.

The main question addressed by this experiment was whether the predictability of the wanted and unwanted items would affect how well subjects could select the wanted ones for remembering. Table 3 presents the mean proportions of items recalled in each selection condition for the alternating (predictable) and random (unpredictable) conditions. Given the very strong precuing advantage found at the overall level of analysis, it is not surprising that the advantage was substantial for both predictability conditions. It turned out that the benefit of precuing, while reliable in both
Table 3
Mean Proportion of Items Recalled Under Free Recall Instructions by Selection Condition and Within-List Organization of Category Instances (Experiment 3)

<table>
<thead>
<tr>
<th>Selection Condition</th>
<th>Organization Condition</th>
<th>Alternating</th>
<th>Random</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Distraction</td>
<td>.479</td>
<td>.489</td>
<td></td>
</tr>
<tr>
<td>Precuing</td>
<td>.489</td>
<td>.476</td>
<td></td>
</tr>
<tr>
<td>Postcuing</td>
<td>.319</td>
<td>.353</td>
<td></td>
</tr>
</tbody>
</table>
the alternating condition ($t(47) = 8.472, p < .001$) and the random condition
($t(47) = 6.390, p < .001$), was lower in the latter case, just as predicted.
This result should not be taken too seriously, however. Not only was the
smaller benefit of precuing shown in the random condition of only borderline
reliability ($t(47) = 1.537, .05 < p < .10$), it was due in substantial degree to
what was in all likelihood a chance advantage in the post-cuing condition,
and to a lesser degree to a level of recall in the alternating/precuing
condition that probably also owed something to chance insofar as it was
slightly higher than for the alternating/no-distraction condition. This
latter fact caused the relative benefit index in the alternating condition to
be slightly in excess of unity, specifically, 1.06; the index for the random
condition was .90.

In conclusion, this experiment provided no strong support for the
prediction that selection for remembering is less effective when wanted
and unwanted items occur in unpredictable order. It does, on the other hand,
show that remembering can be quite selective even when the order of the
wanted and unwanted is unpredictable.
EXPERIMENT 4

In the three experiments described thus far the benefit of being able to select for remembering has been remarkably high. Mixing unwanted items in with items that were to be remembered had rather little effect on recall of the latter provided that it was known prior to their presentation which set of items was to be remembered. Although previous studies have not included all three conditions necessary for deriving the relative benefit index, their findings suggest that the benefit of precuing is not always as marked as has been found in the present experiments. This suggestion is particularly apparent in the studies of the stimulus suffix effect. A single, irrelevant item appended to the end of a list of to-be-remembered items has quite a damaging effect on recall performance even though the subject knows the item is coming and knows it is irrelevant (e.g., Crowder & Morton, 1968; Morton, Crowder &, Prussin, 1971). In fact, a careful analysis of data presented by Crowder (1971) indicates that the unwanted "suffix" item is just about as detrimental to recall as is an additional to-be-remembered item, implying a total lack of benefit from precuing.

What is the reason for this discrepancy? Why should a suffix item be so disruptive when the interspersed unwanted items of the present procedure have so little effect on remembering the wanted items? One potentially
critical factor is list length. In the case of the suffix procedure the number of to-be-recalled items presented rarely exceeds nine, whereas in the experiments that have been described here 12 items were presented.

Another factor that may be important is the type of recall test given: With the suffix procedure the list items typically have to be recalled in their order of presentation (serial recall) whereas in the present experiments items could be recalled in any order the subjects pleased (free recall).

Support for these conjectures comes from an experiment by Engle (1974, Experiment 1), in which a suffix item was interpolated before the free recall of 12-item lists. The effect of the suffix under these conditions was much milder than under the standard short-list, serial recall conditions.

Certain more tentative strands of support for the role of list length and/or type of recall test can be gleaned from procedures closer to those used in the first three experiments. In particular, the study by Broadbent (1970) mentioned earlier, in which just three to-be-remembered items were mixed in with three other items suggested that, when wanted and unwanted items are distinguished by a conceptual criterion as in the present experiments, the benefit from precuing is far from perfect. Also, Hamilton and Hockey's (1974) evidence that presentation rate affected the benefit of precuing, which Experiment 2 of this present series failed to replicate, was
also obtained with a list of just four to-be-remembered items and a serial recall test.

The present experiment combines the selection conditions of the first three experiments with the list length and recall requirements of the standard suffix procedure. Specifically, lists of eight instances of a given conceptual category were presented alone or alternating with eight instances of another category, with the to-be-recalled category identified either before or after list presentation. The to-be-recalled category was named immediately following list presentation, and the subjects responded by writing down as many of the instances of that category as they could in the order in which they had been presented.

Method

Stimulus lists and design. Twelve stimulus lists were prepared exactly as in Experiment 1 with the single exception that the number of instances included in each category was reduced from 12 to 8; the mean rank of the category instances at each serial position was therefore 4.5 rather than 6.5. The design was also identical to that of Experiment 1 with the single and very minor exception that the order in which the three selection conditions occurred varied between successive 3-list blocks.
**Procedure.** The procedure was identical to that for Experiment 1 in all details except for the manner in which the subjects recalled the words. The columns of the response sheet were ruled with eight horizontal lines, and the first to-be-recalled word that had been presented was first written on the top line, then the second word was written on the second line, and so on; each recall failure was indicated by a dash. The subjects were monitored during recall to ensure that they worked from top to bottom with no backtracking.

**Subjects.** Thirty-six Rice University undergraduates participated for course credit.

**Results and Discussion**

In scoring the data, credit was given only for words written in the proper place. Level of recall was, as expected, highest in the no-distraction condition (.472) and lowest in the postcuing condition (.204). Of more interest is how level of recall for the precuing condition fitted into the picture. This level (.362) turned out to be more intermediate in position than in the first three experiments. Thus, the relative benefit index was .590, which, while still substantial, was somewhat lower than in the earlier experiments. The findings of this experiment therefore lend some support to the conjecture that there is less of a benefit from being able to select for
remembering during presentation with a traditional serial recall procedure than with a free recall procedure.

The data were also analyzed as a function of serial position. Figure 2 shows the serial position function for each of the selection conditions. The figure shows the functions to be well separated throughout most of the list but to converge towards the end. It is perhaps worth noting that this pattern of results is not consistent with the view that serial recall is a product of a unitary process (e.g., Morton, 1970), but is consistent with the view that as with free recall, serial recall of the last few items of a list is functionally distinct from recall of the earlier items (Watkins & Watkins, 1977). Statistical analyses confirmed that the precuing advantage was reliably greater for items presented in the first half of the list than for items presented in the second half, $t(35) = 4.998, p < .001$. The relative benefit index turned out to be no lower for the second half of the list (.60) than for the first (.59), but the index for the second half should be treated with considerable caution, for the index becomes unstable as the difference between the no-distraction and postcuing conditions becomes small.
Figure 2. Mean Proportion of Items Recalled Under Serial Recall Instructions by Selection Condition and Serial Position (Experiment 2)
EXPERIMENT 5

The results of Experiment 4 are certainly consistent with the notion that selecting for remembering is more difficult with a short-list serial recall procedure than with a free recall procedure. On the other hand, the precuing advantage was still appreciable, much more so than would be expected from the standard suffix effect demonstration.

One plausible reason for this discrepancy is that unwanted items can be more effectively ignored if they occur repeatedly rather than just once within a list. If so, the suffix effect would be appreciably attenuated if other unwanted items occurred throughout the list. The purpose of Experiment 5 was to test this hypothesis. The dice were loaded in favor of obtaining such a result by repeatedly presenting the suffix item itself throughout the list rather than using a series of different unwanted items.

The assumption behind the hypothesis of a reduction in the suffix effect when the suffix item is repeatedly presented throughout the list was that subjects adapt to, or learn to ignore, the suffix item by the time of its final presentation in the role of a suffix. This assumption is not without intuitive appeal—the ticking of a newly acquired clock soon loses its hold on our attention. Moreover, the assumption is generally in line with the results of research showing that the focussing of attention in a visual search task
improves with practice, provided that the wanted and unwanted categories remain fixed (e.g., Shiffrin & Schneider, 1977).

It turns out that the variation of the suffix procedure used in the present experiment has been included in an experiment reported by Hitch (1974, Experiment 2). That is, the effect of following an 8-digit list by a suffix item was compared for standard presentation conditions and for conditions in which the suffix item was interspersed throughout list presentation. A reliable suffix effect was found in both conditions. More critical is the relative magnitude of the suffix effect for these two conditions. A graphic display of the summary data (see Hitch's Figure 2) shows that interpolating the suffix item throughout list presentation did indeed diminish the detrimental effect of the suffix item when it occurred in its usual post-list position. Unfortunately, however, Hitch reported no statistical analyses for this comparison. The present experiment is essentially a replication of Hitch's experiment though with an eye to seeking direct evidence on the comparative effects of the suffix on performance in the standard and what will be referred to here as the "iterant" condition.

Method

Overview. Each subject was presented with 60 lists of digits. Half of these lists were presented in the suffix condition, in which the
to-be-remembered digits was followed by the suffix item "zero" (which was never used as a to-be-remembered item), and half were presented in the no-suffix condition. Half the suffix lists and half the no-suffix lists were presented in the iterant condition, in which the suffix item, zero, was interpolated between successive items. The other half of the lists were presented in the standard condition, in which no zero's were interpolated. Thus for a given subject the lists for the four conditions may be illustrated as follows using only 4 to-be-remembered digits in each condition:

No-Suffix Standard: 5, 3, 2, 9
No-Suffix Iterant: 5, 0, 3, 0, 2, 0, 9
Suffix Standard: 5, 3, 2, 9, 0
Suffix Iterant: 5, 0, 3, 0, 2, 0, 9, 0

For all four conditions, list presentation was followed by an immediate serial recall test.

Stimulus lists and design. Both pilot research and Hitch's (1974, see Figure 2) experiment have shown that overall level of recall for 8-item lists was higher in the standard condition than in the iterant condition. Because the shape of the serial position function in serial recall has been found to vary with overall level of performance (Murdock, 1968), the effect that a suffix item has on the serial position function for the to-be-remembered items could differ between the standard and iterant
conditions for reasons not directly related to the reiteration of the suffix item throughout list presentation. For this reason, an attempt was made to make overall level of performance in the iterant condition roughly comparable to that in the standard condition by using a shorter list length. Specifically, lists comprised 9 digits in the standard condition and 8 in the iterant condition.

Each list in the iterant condition was prepared by randomly ordering the digits 1 through 8 within the constraints that neither numerically consecutive items (e.g., 6, 7) nor sequences of odd and even numbers (e.g., 3, 5) occupied successive list positions. Lists for the standard condition were prepared by adding the digit 9 after one of the first five positions of each of the iterant lists. In this way the two sets of lists were identical with respect to the critical recency positions.

A set of 60 8-digit lists was prepared for the iterant condition and a yoked set of 60 9-digit lists was prepared for the standard condition. Half of the subjects were presented first with Iterant Lists 1-30 and then with Standard Lists 31-60; the other half were presented first with Standard Lists 1-30 and then with Iterant Lists 31-60. These two groups of subjects were each split into two subgroups, one of which received Lists 1-15 and 31-45 in the no-suffix condition and Lists 16-30 and 46-60 in the suffix
condition, and the other received Lists 1-15 and 31-45 in the suffix condition and Lists 16-30 and 46-60 in the no-suffix condition. Thus, across the four subgroups, each list or modified version thereof appeared equally often in each of the four possible combinations of iterant/standard and no-suffix/suffix conditions.

The lists were prepared for presentation in synthetic speech (specifically, in the male, bass voice of "Smoohtalker," Version 2, distributed by First Byte, Inc.) on a Macintosh 512K microcomputer. The to-be-remembered digits were presented at a rate of one every second, and the suffix items were presented a half second after the onset of the last digit in the list. A separate sequence of lists was prepared for each of the four subgroups, the sequences differing in regard to which lists included zero's between successive to-be-recalled digits and to which lists were followed by a suffix.

Procedure. Subjects were given an oral description of each of the four types of lists that would be presented. It was stressed that they should do their best to concentrate on the to-be-recalled digits and to ignore any zeros. They were then given four response sheets, one for each condition. Each sheet had been ruled with 15 rows of 8 or 9 blank lines as appropriate. The subjects were monitored during recall to ensure that their responses
were written strictly from left to right in the order in which they occurred and that a dash was entered in the place of any item that could not be recalled. Fifteen seconds were allowed for the recall of each list. Prior to each block of 15 lists, subjects were given one practice list in the condition of that block.

Subjects. The subjects were 48 Rice University undergraduates. Some participated for course credit, others for money.

Results and Discussion

In the scoring of subjects' responses, credit was given for each item recalled in its correct list position. Figure 3 presents the serial position functions: the left-hand panel shows the functions for the suffix and no-suffix lists in the standard presentation condition, and the right-hand panel shows the functions for the suffix and no-suffix lists in the iterant presentation condition. It is clear that a (post-list) suffix item impaired recall in both the standard and the iterant conditions, and statistical analyses indicated that, with data collapsed across serial positions, both of these suffix effects were reliable. Thus, in the standard condition, mean overall proportion of items recalled in the suffix condition (.543) was reliably lower than in the no-suffix condition (.674), t(47) = 8.325, p < .001; and in the iterant condition, the proportion recalled in the suffix condition
Figure 3. Mean Proportion of Items Recalled by Experimental Condition and Serial Position (Experiment 5)
(.520) was likewise lower than that in the no-suffix condition (.580), t(47) = 3.559, p < .001.

Evidently, presenting the suffix item after each list item rather than after just the last item failed to eliminate the suffix effect. Nevertheless, as a comparison across the panels of Figure 3 shows, the suffix effect was appreciably smaller in the iterant condition. Moreover, this reduction in the magnitude of the effect was statistically reliable, t(47) = 2.188, p < .025.
EXPERIMENT 6

The purpose of this experiment was to try to reduce the suffix effect even more than it was reduced in the last experiment. Several previous experiments have shown that the suffix effect is reduced when the suffix item is presented in a different voice from that of the to-be-remembered items (e.g., Balota & Engle, 1986; Morton, et al., 1971, Experiments 14 & 15; Watkins & Watkins, 1980, Experiment 3). It is possible, therefore, that the degree to which the wanted items can be selected for remembering and the suffix item ignored might be maximized if a change in voice procedure were combined with the iterant procedure used in Experiment 5. Thus, the procedure of the present experiment was the same as that of Experiment 5 except that, instead of presenting all items in the same voice, the to-be-remembered items were presented in one voice and the suffix item in another.

Method

Materials and design. The stimulus lists were the same as those of Experiment 5, except that they were presented in natural speech rather than synthetic speech. The to-be-remembered items occurred in a female voice, and the suffix item occurred in a male voice.
The recording of the stimulus lists was carried out using a Morantz Model PMD 350 cassette recorder, and a Tascam Mini-Studio, which allows for independent recording on each of four tracks of a cassette tape. For each of the four conditions the to-be-remembered items were recorded in a female voice at a rate of one item every second. Within both the standard and the iterant conditions, two recordings were made of each of the 60 lists, one for the no-suffix condition and one for the suffix condition. The standard/no-suffix lists comprised 9 to-be-remembered items, and a "zero" was appended to each of these lists one second after the onset of the last to-be-remembered item to form the standard/suffix lists. For the iterant condition, a single male-voiced utterance of "zero" was recorded, and copied over and over, with a 1 second interval after the onset of successive copies, until a string of seven zeros had been built up. This string was then merged with each list of the 60 8-item lists such that a zero occurred midway between each successive pair of to-be-remembered items. In the iterant/suffix condition, the suffix item (another copy of the same "zero" utterance) occurred 1 second after the onset of the last to-be-remembered item, exactly as in the standard/suffix condition.

Procedure. The stimulus lists were played from the Morantz cassette tape recorder. In all other respects the procedure was the same as that used
in Experiment 5.

**Subjects.** The subjects were 24 Rice University undergraduates. They participated either for pay or for course credit.

**Results and Discussion**

The data for the four conditions of this experiment are shown in Figure 4. Those for the standard conditions, summarized in the left-hand panel, are considered first. Statistical analysis indicated that level of recall, averaged across list positions, was reliably lower in the suffix condition (.747) than in the no-suffix condition (.692), \( t(23) = 2.344, p < .025 \). Yet consistent with previous research on the effects of voice change, the magnitude of the suffix effect is smaller than is typical when the same presentation voice is used for all items. This claim is supported by a comparison of the suffix effect in the standard condition of this experiment with that found in the previous experiment (Figure 3, left-hand panel). A between-subjects statistical analysis confirmed that the effect was smaller in the present experiment, \( t(70) = 2.781, p < .005 \).

Consider now the data for the iterant condition. Level of recall was again lower in the suffix condition (.769) than in the no-suffix condition (.819), \( t(23) = 2.880, p < .005 \), indicating that, as in the previous experiment, the suffix effect survived the reiteration of the suffix item throughout list
Figure 4. Mean Proportion of Items Recalled by Experimental Condition and Serial Position With To-Be-Remembered Items in a Female Voice and Suffix Item in a Male Voice (Experiment 6)
presentation. This time, however, the suffix effect was not lessened by the iterant procedure, \( t(23) = .171, p > .10 \). Thus, the combination of reiterating the suffix item during list presentation and presenting it in a different voice from that used in presenting the to-be-remembered items did not reduce the distracting effect of the suffix any more than did voice change alone. Similarly, a between-subjects statistical analysis showed that the suffix effect in the iterant condition of this experiment was not reliably smaller than that in the previous experiment, \( t(70) = .374, p > .10 \).

It appears from the results of both this experiment and the previous one that the discrepancy between the modest level of distraction from unwanted items found in the first three experiments and the very high level that characterizes a suffix item is partly due to a difference in opportunity to adapt to the presence of unwanted material, but this is not the whole story. Other factors would seem to be involved in making a suffix difficult to ignore. Indeed, the present findings no more demonstrate that the suffix effect can be controlled than they attest to the robustness of the effect.
GENERAL DISCUSSION

The research reported here has been concerned with the problem of remembering a set of verbal items that is heard, not in isolation as is standard practice in studies of short-term memory, but along with other, unwanted items. In other words, the focus of this work was on the ability to engage in selective remembering.

In the first four experiments selective remembering was assessed using three experimental conditions: a precuing condition in which two conceptually distinct categories of words were presented within the same list, and subjects were informed before list presentation of the category that would have to be recalled; a postcuing condition which was like the precuing condition, except that subjects were not informed until after list presentation of the category to be recalled; and a no-distraction condition in which only the to-be-recalled items were presented. Selective remembering was defined in terms of the benefit that results from being able to identify relevant material during its presentation, or in operational terms as the extent to which recall performance in the precuing condition exceeded that in the postcuing condition. Moreover the concept of selective remembering was treated within a purely functionalist framework, with no appeal being made to the particular mental processes that may underly the beneficial
effects of precuing.

The degree of selective remembering can be assumed to be, in some sense, maximal in the no-distraction condition. If, therefore, recall in the no-distraction condition were found to be superior to that in the precuing condition, it would indicate that selective remembering in the critical precuing condition was not as successful as it might have been. For the purpose of measuring the efficiency of selective remembering, a "relative benefit index" was derived by taking the absolute level of benefit from precuing (i.e., the level of recall in the precuing condition minus that in the postcuing condition) as a proportion of the maximum benefit that could be achieved (i.e., the level of recall in the no-distraction condition minus that in the postcuing condition).

The distinction should be kept in mind between selective remembering, which was the focus of this research, and what might be called selectivity in remembering. Whereas selective remembering refers to the performance benefit that arises from being able to identify to-be-remembered material, selectivity in remembering refers to the tendency for remembering to be confined to the wanted, as opposed to the unwanted items. Evidence for selectivity can be obtained only by measuring recall of both the wanted and the unwanted items. Although certainly an interesting issue, selectivity is,
as discussed earlier, not quite as straightforward to study as it might at first appear. For example, requiring subjects to recall items they have been told not to remember creates the potential for subjects’ withholding these items in an attempt to comply with what is perceived as the experimenter’s hypothesis.

The major conclusions from the first three experiments were that (a) subjects were able to select information for remembering, as revealed by the consistent finding that recall was higher with precuing than with postcuing; (b) the efficiency of selective remembering achieved was considerable, as reflected by the rather high relative benefit indices (with averages of .75, .82, and .99 for Experiments 1, 2, and 3, respectively); and (c) the efficiency of selective remembering tended to be insensitive to item presentation rate and the temporal predictability of wanted and unwanted items. The latter result is not only counterintuitive, but is inconsistent with previous research.

The considerable facility in selective remembering observed in the present research contrasts sharply with the stimulus suffix effect, in which recall of a list of items is drastically reduced by the presentation of a single nominally irrelevant item at the end of the list. Two features distinguishing the present research from that on the suffix effect are list length and order
of recall. In suffix procedures the lists tend to be shorter (viz., 8-9 items) than those used here and the items must usually be recalled in their order of presentation. The results of Experiment 4 provided some limited support for the argument that such variables affect how well people can remember selectively: With a short-list and serial recall procedure, the relative benefit index (.59) was lower than that obtained in the preceding experiments.

The last two experiments were conducted to explore further the basis of the low level of selective remembering that occurs in the standard suffix paradigm. A suffix procedure was used, but as in the first four experiments the opportunity was provided for subjects to become adapted to the presence of unwanted material during presentation of the to-be-remembered items. In other words, a deliberate attempt was made to weaken the suffix effect (or alternatively enhance selection) by presenting the suffix item after each to-be-remembered item of the study list. In Experiment 5, the same voice was used for presenting both the to-be-remembered and suffix items, and in Experiment 6 different voices were used to maximize perceptual discriminability of the two types of items. The results indicated that the suffix effect was diminished, although not nearly eliminated, by reiterating the suffix item and that the effect of the reiteration was not appreciably
larger with the voice change. Thus, even when subjects have the opportunity to adapt in some sense to the presence of the suffix item, the presence of the item at the end of the list is sufficient to impair recall of the to-be-remembered items.

Recent theorizing regarding the suffix effect (see Baddeley & Hull 1979; Balota and Engle, 1981; Crowder, 1976; and especially Penney, 1985) involves the proposal that the damaging effect of the suffix item arises in part from the perceptual distinctiveness that would be afforded any stimulus that is the last in a series to be presented. If this view is correct, it follows that selective remembering may be higher if the suffix item is followed by another stimulus. In fact such a diminished suffix effect may underly the high level of selective remembering in the first four experiments in this research. To elaborate, in the precuing condition, when items in the wanted category occupied the odd-number list positions and items in the unwanted category occupied the even numbered positions, the last item of the unwanted category functioned as a suffix item for items in the wanted category. In other words, half the lists presented in the precuing condition involved the same list structure as that used in the iterant suffix condition of Experiments 5 and 6. Yet the potentially detrimental effect of the suffix item may have undermined by the spoken recall cue (i.e., the name of the
relevant category) that occurred immediately after list presentation. A particularly interesting question that follows from this speculation is whether the suffix effect would persist if the suffix item were reiterated not only after each of the to-be-remembered items, but continuously from the start of the list to the end of the recall period. Perhaps such a continuous presentation would produce the adaptation or habituation necessary to undercut the distinctiveness of the suffix item.

Considering the results of the first four experiments, it would seem essential to bring the level of selective remembering within a range that is more susceptible to experimental control. A step in this direction might involve the use of shorter lists and serial recall, as suggested earlier. Furthermore, it would be instructive to examine under these conditions the effects of presentation rate and item predictability in addition to certain other variables. An obvious example is the way in which wanted and unwanted stimuli are distinguished—a variable that has been found to play a major role in performance on selective attention and perception tasks (see Broadbent, 1971; Keren, 1976). As discussed in Experiment 3, one of the striking findings of this research was that selective remembering was highly efficient even when subjects were forced to use semantic categories to select wanted items. Perhaps efficiency would not be so high if the two
categories were semantically related. For example selective remembering may be less successful when subjects have to select between fruits and vegetables, or between citrus fruits and noncitrus fruits, rather than fruits and professions. It may also be interesting to examine selective remembering when subjects must perform various orienting tasks differing in depth of processing, and specifically to see whether selective remembering is increasingly jeopardized as depth of analysis increases.

Finally, it remains an open question whether the reduction in the efficiency of selection that appeared to occur in Experiment 4 was the result of shorter lists or a change in recall requirements. If list length is the relevant factor then a paradox seems to arise. It is generally assumed that primary memory functioning plays a larger role in the recall of shorter lists than does secondary memory, and it has been shown that recency recall (i.e., primary memory recall) tends to be more susceptible to distraction than prerence recall (i.e., secondary memory recall), (Glanzer & Cunitz, 1966). On this basis it would be expected that efficiency in selective remembering would be lower with shorter lists than with longer lists. The results of the serial position analyses conducted in Experiment 1 suggested just the opposite, of course, namely that selection was more efficient for items presented in the second half of the lists (i.e., primary memory items) than
for items presented in the first half (i.e., secondary memory items).

Obviously a much needed extension of the present research is an investigation of the effect of list length under conditions in which list length is not confounded with recall procedure as was the case in Experiment 4.
REFERENCES


