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PI AND RELEASE FROM PI ON A BROWN-PETERSON TEST, 
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OF VARIOUS LENGTHS

DISSERTATION

Presented in Partial Fulfillment of the Requirements for 
the Degree Doctor of Philosophy in the Graduate 
School of The Ohio State University

By 

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***

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The effects of time and activity on the dissipation of proactive inhibition in short-term memory.

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# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Acknowledgments</th>
<th>11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vita</td>
<td>111</td>
</tr>
<tr>
<td>List of Tables</td>
<td>vi</td>
</tr>
<tr>
<td>List of Figures</td>
<td>vii</td>
</tr>
</tbody>
</table>

## CHAPTER

**I. INTRODUCTION**

| 1 |

**II. EXPERIMENT I**

<table>
<thead>
<tr>
<th>Method</th>
<th>11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Results</td>
<td>17</td>
</tr>
<tr>
<td>Discussion</td>
<td>21</td>
</tr>
</tbody>
</table>

**III. EXPERIMENTS 2 AND 3**

<table>
<thead>
<tr>
<th>Method</th>
<th>28</th>
</tr>
</thead>
<tbody>
<tr>
<td>Results</td>
<td>32</td>
</tr>
<tr>
<td>Discussion</td>
<td>40</td>
</tr>
</tbody>
</table>

**IV. GENERAL DISCUSSION**

| 47 |

**BIBLIOGRAPHY**

| 52 |

## APPENDICES

**A**

| 56 |

**B**

| 57 |

**C**

| 58 |
# LIST OF TABLES

Table 1. Pre-Test and Test Conditions for the Groups of Experiment 1

Table 2. Mean Recall Scores for the Brown-Peterson Test Trials in Experiment 2, as a Function of Pre-Test Instructions and Class Tested

Table 3. Mean Recall Scores for the Brown-Peterson Test Trials in Experiment 3, as a Function of Pre-Test Instructions and Class Tested

Table 4. Mean Recall in Experiment 2 of Both Target and Non-Target Words, Following the Brown-Peterson Test, as a Function of Pre-Test Instructions and Class Tested

Table 5. Mean Recall in Experiment 3 of Both Target and Non-Target Words, Following the Brown-Peterson Test, as a Function of Pre-Test Instructions and Class Tested

Table 6. Mean Number of Target and Non-Target Words Recognized in Experiment 2, as a Function of Pre-Test Instructions and Class Tested

Table 7. Mean Number of Target and Non-Target Words Recognized in Experiment 3, as a Function of Pre-Test Instructions and Class Tested
LIST OF FIGURES

Figure 1. PI and Release Scores on the Brown-Peterson Test Trial Following a Standard PI Build-Up Procedure, or the Reading of a List.................. 18

Figure 2. PI as a Function of the Number of Trials with the Same Item Prior to a Test Trial to a New Item................. 62
INTRODUCTION

In a classic paper published in 1932, McGeoch repudiated earlier memory trace and disuse theories of forgetting and postulated reproductive interference as the cause of memory loss. He pointed out that time per se can rarely be invoked as a causative agent and marshaled evidence that forgetting is an active process brought about by the learning of new material. Since McGeoch's paper, American psychologists have subscribed to interference theory as the predominant theoretical framework guiding research in learning and memory.

Sources of interference can be defined in terms of their temporal relationship to the learning and recall of the to-be-remembered material. Retroactive Inhibition (RI) was coined by Muller and Pilzecher to refer to interference stemming from events interposed between learning and recall. Proactive Inhibition (PI) is interference which comes from experiences which occur prior to the learning of the critical material. For many years RI was considered to be the most important factor in forgetting, seemingly accounting for the forgetting of up to 75% of learned material over a 24 hour period. Intuitively this was
extremely reasonable, since clearly the most likely events to interfere with the recall of what has been learned would seem to be those which occur between learning and recall.

In 1957 Underwood published a critical review paper in which he pointed out that PI was in fact a major, if not the major, cause of forgetting in the research on memory which had been published prior to that time. The studies he analysed had shown varying amounts of forgetting which had been attributed to retroactive effects. He found, however, that a more powerful determinant of forgetting was the number of lists which had been learned prior to the learning of the critical list. It was obvious that the common experimental method of giving the subjects practice trials and of counterbalancing lists had obscured the effect of PI.

Most of the research on memory and forgetting, and hence on PI and RI effects, was research on what is normally defined as long-term memory. In this kind of experiment the subjects repeat and rehearse the critical material and some time later, a matter of minutes or hours, they are asked to recall it. By far the bulk of the research was concerned with Paired Associate tasks in which subjects learned a series of responses, each associated with a particular stimulus, and were later required to recall the appropriate response when presented with the stimulus with which it had previously been paired. It
was not until the 1960's that research on PI spread over into the area of short-term memory. Obviously the shortest of short-term memory is what has often been referred to as "primary memory" (James, 1890; Craik & Jacoby, 1975). This refers to intervals over which the items to be recalled are still basically available in conscious awareness. There are also memory processes which are short term in nature, say less than 20 seconds, but which still have to be retrieved and brought back into consciousness before they can be operated on or verbalized. This is the time span of memory with which this dissertation will be concerned.

Short-term memory research has, for the last seventeen years, made considerable use of a research methodology now generally referred to as the Brown-Peterson paradigm. Although this method was introduced by Brown (1958), the experiment which triggered the widespread use of this design in the study of interference and encoding in short-term memory, was an experiment by Peterson and Peterson (1959). In this experiment subjects heard a consonant trigram (GHJ, for example) which was followed by a three digit number. They were told to count backwards by threes or fours from that number for 3, 6, 9, 12, 15 or 18 seconds. The purpose of this counting task was to inhibit the rehearsal of the consonants. At the end of the appropriate retention interval, the onset of a light signalled the subjects to reproduce the three consonants that they had
heard at the beginning of the trial. Recall of the consonants was a decreasing monotonic function of the retention interval, reaching a very low level of performance (about 10% correct) after 12 seconds. This was a rather dramatic demonstration of the forgetting of items well within the memory span of the subjects, over a remarkably short interval.

Peterson (1963) analysed the data from this and other of his studies to see if he could find evidence for PI effects. Since the subjects in his experiments had been tested under all of the conditions in counterbalanced order, they had experienced a large number of trigrams. In his analysis he ignored two practice trials and blocked the data from trials 3-8, 9-14, and 45-50. He found no apparent decrement in performance over these blocks of trials and concluded that there was no evidence of Proactive Inhibition in this type of task. The problem with this reasoning became apparent with the publication of a study by Keppel and Underwood (1962). They measured the retention of six nonsense syllables over either three or eighteen seconds. On the first trial both groups performed extremely well and there was no difference between them. By trial six, however, the performance of the three-second group had dropped only slightly, while that of the eighteen-second group had decreased to a minimum of about 40% correct. It appeared that in ignoring the two practice trials, and in blocking the data from the other trials in
five trial blocks, Peterson had missed any Proactive Inhibition effects because they had already occurred by early in the first block of trials.

Since the Keppel and Underwood study the occurrence of PI in short-term memory has become a well established phenomenon. Much research using the Brown-Peterson paradigm has shown that when rehearsal is inhibited during retention intervals of up to 20 seconds, PI increases with increasing interval (Loess, 1964), and reaches a maximum by the third or fourth trial. It was discovered quite early that this PI does not generalize to items belonging to a different class of material. Wickens, Born, and Allen (1963), using consonant trigrams (CCCs) and digit trigrams (NNNs), demonstrated that when a series of trials using a particular class of material was followed by a test trial to the same class, CCC to CCC or NNN to NNN, performance on the test trial was poor. When, however, the test trial required that the subjects recall a different class of material to that of the previous trials, CCC to NNN or NNN to CCC, performance was dramatically improved. This improvement in performance due to the shift in the type of material to be recalled was labeled "release from PI".

The build-up and release from PI has been replicated often, and has been utilized in an attempt to gain some insight into the characteristics which are important in the differential encoding of words (Wickens, 1970, 1972). Wickens reports many studies which have demonstrated
release as a function of shifts in both method of presentation and semantic category.

The research of this dissertation involves three experiments. The first experiment was designed to test the effectiveness of an alternative method of building PI to semantically encoded materials, and to compare this method to the established procedure which uses a series of three Brown-Peterson trials. This alternative method consisted of having the subjects merely read a single list of from three to eighteen items, homogeneous as to semantic category. They were then tested for PI and "release from PI" using a single standard Brown-Peterson test trial to the same class or to a different class from the words in the list. The second and third experiments used lists containing words from two taxonomic categories to investigate PI and "release" phenomena produced under various instructions for list processing.
EXPERIMENT 1

Given a sufficiently long recall interval, a Brown-Peterson trial appears to be a very sensitive test of "resident" PI. PI, however, seems to dissipate over time at a rate that would reduce it to zero by about 120 seconds (Kincaid & Wickens, 1970; Nield, 1968; Peterson & Gentile, 1965). A series of Brown-Peterson trials may, therefore, be a very inefficient method of producing interference. Since each trial usually takes 16-30 seconds to present, by the fourth or fifth trial most of the interference from trial one, and much from trial two, should have dissipated.

In an unpublished experiment, this author built up PI to consonant trigrams over five Brown-Peterson trials. The subjects then either rested, or read but did not learn a matrix of consonants, during an 80 second interval prior to trial six. Those subjects reading the consonants performed at the same low levels as subjects who continued with trigrams, and significantly more poorly than the control subjects who had rested. Recently in an experiment on dichotic listening, Wickens, Moody and Shearer (in press) made a similar observation. Under the guise of testing volume levels, nine items were read to some subjects before the first Brown-Peterson test trial was presented. These
subjects performed more poorly on this first trial than those who had not had the "volume test". There is, therefore, evidence to suggest that PI can be built up using a single presentation of a list or matrix of items and tested using a Brown-Peterson test trial. The obvious question is, how do the two methods of building PI compare in effectiveness.

A series of Brown-Peterson trials might be expected to be superior to a list of items if the sub-span nature of these trials were relevant. This, presumably, could increase the availability of items, or of trigram units, to interfere with newly presented material. A review of data gathered for this author's Masters thesis (Nield, 1968) does show that on trials two, three, and four practically all intrusions are consonants from prior trigrams. However, the number of intrusions does not increase beyond trial two. What does increase is the number of omissions.

<table>
<thead>
<tr>
<th>TRIAL</th>
<th>INTRUSIONS</th>
<th>OMISSIONS</th>
<th>INVERSIONS</th>
<th>TOTAL</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>13</td>
<td>25</td>
<td>10</td>
<td>48</td>
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<td>5</td>
<td>75</td>
<td>53</td>
<td>2</td>
<td>130</td>
</tr>
</tbody>
</table>

It can be seen that the maximum errors occurred on trial three and that the omissions account for all but six of the 36 additional total errors. Interestingly, although the 13 intrusions on trial one are all, obviously, external,
on trial two only two of the 72 intrusions came from external sources. (These external sources stem entirely from letter sequence habits, rhyming of consonants, and strong prior associations i.e., GMC for GCM). The implication seems to be that, for consonant trigrams, the availability of interfering items may remain constant beyond trial two while the availability of the item to be recalled decreases.

Additional analyses showed the following:

(1) Errors on trial four were independent of performance on trial three.

\[
\begin{array}{c|c|c}
\text{Trial 3} & \text{Correct} & \text{Incorrect} \\
\hline
\text{Correct} & .384 & .616 \\
\text{Incorrect} & .395 & .605 \\
\end{array}
\]

(2) Intrusions from trial three on trial four occurred on 16% of the occasions when trial three was incorrect, and 13% of the occasions when trial three was correct.

(3) Of the errors on trial four, 52% came from previously correct, and 48% from previously incorrect trigrams.

(4) At termination of testing, each subject was asked to recall as many as he could of the trigrams which had been used in the experiment. An analysis of the free recall data for trials on which the subject had made a recordable
incorrect response (e.g., RJM for XPJ), showed that half the subjects recalled the correct trigram, and half recalled their incorrect response.

In summary, it appears that individual elements in a trigram will interfere whether or not the trigram itself is available; and so, to some extent, the degree to which a trigram is learned will not necessarily determine the amount of interference it generates. This conclusion is substantiated further by a study (Wickens & Gittis, 1974) which showed no decrement in performance when the interfering material was three repeated trigrams as opposed to six trigrams each presented once.¹

It seems, therefore, that since a list of consonants can maintain PI built up to consonant trigrams, then a list of semantically homogeneous words might be expected to produce PI to that semantic class. If this is true, a Brown-Peterson test trial utilizing a triad of words of the same class should be a sensitive measure of the amount of PI thus generated.

This first experiment compares the PI generated by word lists of various lengths with that developed over the standard three-trial Brown-Peterson design, and also investigates the degree to which it is possible to build PI to two semantic classes simultaneously.

¹ The same kind of result can be seen in the experiment described in Appendix 3.
METHOD

Subjects

The subjects were 672 students, enrolled in elementary psychology classes, who participated in the experiment to fulfill a course requirement. They were assigned randomly to one of the 2 control or 10 experimental groups when they arrived for the experiment. There were 48 subjects in each group.

Materials and Apparatus

The items to be learned were words drawn from three different semantic categories: men's first names, animal names, and occupations; all drawn from the Battig and Montague category norms (Battig & Montague, 1969). On the practice trials, number trigrams were used with the numbers spelled out. The items on the Brown-Peterson practice and test trials were presented three to a slide, in a column, with each item indented one character from the item above it. The word lists were presented 3, 6, 9 or 18 words to a slide. On the 3, 6 and 9-word slide they were in a single column with the left margin aligned. The 18-word slides consisted of two columns of 9 words each. Distractor slides used during the retention interval on the Brown-Peterson trials contained 36 colored dots arranged in a 6 x 6 matrix.
All the materials were projected using a Kodak Carousel projector controlled by a 35 mm timer.

**Procedure**

On all trials for the Brown-Peterson control groups and on the practice and test trials for the experimental groups, a standard Brown-Peterson procedure was employed. An asterisk was presented for one second, as a ready signal, followed by a 1.5 second presentation of a trigram, which the subject read aloud once. The subject then spent 12 seconds naming the colors of the dots on a distractor slide. Finally, a question mark was presented for five seconds as the cue to attempt recall of the trigram just presented. Each trial therefore lasted for 19.5 seconds.

In each group of 48 subjects 16 were tested to each of the three classes of material. Those tested for PI received the same class throughout. For those subjects in the "release" conditions, eight had prior experience with each of the other two classes of material. The order of presentation of the word trigrams and the trigram units within the lists was counterbalanced throughout the experiment.

All subjects began by receiving four Brown-Peterson practice trials, using number trigrams. This was to give those subjects in the experimental groups experience with the Brown-Peterson procedure before they encountered it on the test trial. There were seven pre-test conditions. The control subjects received three Brown-Peterson trials,
with the word trigrams on all three trials drawn from the same semantic class, a typical PI build-up situation. The two groups in this condition will be referred to as B-P groups. The experimental subjects read aloud either a single class list containing 3, 6, 9 or 18 words of the same semantic class (referred to as groups 3, 6, 9 and 18), or a double class list of 18 words, nine of which were drawn from one semantic class and nine from a different class. The groups which will be referred to as 9-99 had the words in their 18-word lists blocked as to class (9 of one class followed by 9 of the other), whereas the groups 9+9 received 9 words of each class randomly mixed.

The test trial was a standard Brown-Peterson trial. Half the subjects in each condition were tested with words of the same class as those used in the pre-test condition (PI test) and half with a new class of words (release test). The groups tested for release are denoted by an (R) after the pre-test designation. Hence a subject reading a nine-word list and tested to the same class of material was in group 9; whereas if he or she were tested with a different class of material, the group designation would be 9(R). The fourteen groups of the experiment are presented in Table 1.

After being seated in the experimental room, the subjects received the following instructions:

"This is a short-term memory experiment. I am interested in the way in which your memory for words is
<table>
<thead>
<tr>
<th>Group</th>
<th>Pre-Test Condition</th>
<th>Class Tested (B-P Test Trial)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-P</td>
<td>3 B-P trials; 1 trigram/trial</td>
<td>same class</td>
</tr>
<tr>
<td>B-P(R)</td>
<td>3 B-P trials; 1 trigram/trial</td>
<td>different class</td>
</tr>
<tr>
<td>3</td>
<td>Read 3-word list</td>
<td>same class</td>
</tr>
<tr>
<td>3(R)</td>
<td>Read 3-word list</td>
<td>different class</td>
</tr>
<tr>
<td>6</td>
<td>Read 6-word list</td>
<td>same class</td>
</tr>
<tr>
<td>6(R)</td>
<td>Read 6-word list</td>
<td>different class</td>
</tr>
<tr>
<td>9</td>
<td>Read 9-word list</td>
<td>same class</td>
</tr>
<tr>
<td>9(R)</td>
<td>Read 9-word list</td>
<td>different class</td>
</tr>
<tr>
<td>18</td>
<td>Read 18-word list</td>
<td>same class</td>
</tr>
<tr>
<td>18(R)</td>
<td>Read 18-word list</td>
<td>different class</td>
</tr>
<tr>
<td>9→9</td>
<td>Read 9 class 1 words then 9 class 2 words</td>
<td>class 1 or class 2</td>
</tr>
<tr>
<td>9→9(R)</td>
<td>Read 9 class 1 words then 9 class 2 words</td>
<td>class 3</td>
</tr>
<tr>
<td>9+9</td>
<td>Read 9 class 1 words and 9 class 2 words, randomly mixed</td>
<td>class 1 or class 2</td>
</tr>
<tr>
<td>9+9(R)</td>
<td>Read 9 class 1 words and 9 class 2 words, randomly mixed</td>
<td>class 3</td>
</tr>
</tbody>
</table>
affected by how they are presented to you. I am going to present a series of trials, each consisting of four slides. The first slide will be on very briefly and will have an asterisk on it. This slide is merely a warning that a new trial is about to begin. The second slide will have three words on it and I want you to read the words aloud once. This slide will be followed by one with some colored dots on it. There will be six rows of six dots, 36 in all, and I want you to name the color of each dot as quickly and accurately as you can. The simplest way is to name the color of each dot on the first row, then on the second row, and keep on going until the slide goes off. Then there will be a question mark. At the question mark, I want you to recall the three words you saw on the second slide. So, there will be an asterisk as a warning, three words to read aloud, colors to name, and a question mark for you to recall the words. Do you have any questions?"

When the subjects indicated they had understood what they had been told, the instructions continued:

"For the first few trials there will be three numbers on the second slide rather than three words. This will allow you to get used to the procedure."

After the subjects had completed the four practice trials, the control subjects were told that there would now be words rather than numbers on the second slide. The
Experimental subjects were told that they would now be seeing a slide containing a list of words that they were to read aloud, and that following this slide there would be an asterisk signalling the beginning of a trial just like the practice trials with the numbers. They were also told that they would be asked about the words in the word list at the end of the experiment. This last instruction was intentionally, and apparently satisfactorily, vague. The reason for this was that a few subjects early in the experiment were told they would be expected to recall the words in the 18-word list. Their response to this was, in effect, (although in a couple of cases rather more colorfully expressed) that the experimenter was expecting rather a lot. At the end of the experiment they were in fact asked what kind of words had been in the list.
Results

Recall of the three words on the Brown-Peterson test trial was scored by assigning one point for each correct word, and an additional point if the words were recalled in the correct order.

The results for all the groups are shown in Figure 1. The left portion of the figure shows the performance of groups B-P and B-P(R) on their three pre-test trials and on the test trial (trial 4). The bars which make up the rest of the figure represent the performance, on the test trials, of the groups who read lists in the pre-test condition. The cross hatched bars show the performance of those groups tested to the same class of material they had read in the pre-test list. The open bars show performance of the release groups who were tested to a different class.

An overall analysis of variance of test trial performance showed release to be the only significant variable: F (1,658) = 60.71, p < .001. There were no significant effects of prior experience, F (6,658) = 1.16, nor was there any interaction between prior experience and test condition F (6,658) = 1.23 (release or non-release).

Performance of the Brown-Peterson Controls

The build-up of PI over the first three trials in the Brown-Peterson control groups (B-P and B-P(R)), followed the familiar pattern. The largest decrement in performance occurred between trial 1 and trial 2, with little change on trial 3. As expected, the B-P group showed continued poor
Figure 1. PI and release scores on the Brown-Peterson test trial following a standard PI build-up procedure, or the reading of a list.
The amount of release due to shift in word class on the test trial for group B-P(R) was considerable. A measure of release commonly used (Wickens, 1970) is to subtract the score attained by group B-P on trial 4 from the score for group B-P(R) on that trial, and divide this difference by the decrement in performance from trial 1 to trial 4 for group B-P. Multiplying this number by 100 gives the percent release for that trial. This calculation reveals that a respectable 65% release can be assigned to group B-P(R).

Performance of the Single Class List Groups

Groups tested for PI all showed some evidence of interference. Group 3 showed the poorest recall at testing and group 9 the best, with groups 6 and 18 falling between the two extremes. None of these differences were significant. However, the Newman-Keuls test showed the difference between the performance of group 9 and group B-P approaching significance.

Those groups tested for release showed slightly but not significantly poorer recall than the appropriate control group B-P(R).

A Newman-Keuls test of the difference between the release and PI conditions in these groups, showed groups 3(R) and 18(R) to be significantly different (p<.05) from groups 3 and 18 respectively. The groups 6(R) and 9(R) were not different from their appropriate PI groups.
Performance of the Double Class List Groups

The groups which were tested for PI showed less interference than the B-P controls, but again not significantly so. The 9+9 group performed very like groups 6 and 18 and the 9→9 group like group 9. A Newman-Keuls test showed the difference between group 9→9 and group B-P to be approaching significance.

Similarly, among the groups tested for release, group 9+9(R) performed like group 6(R) and 18(R) and group 9→9(R) like group 9(R). None of these groups showed significantly poorer recall than group B-P(R).

The Newman-Keuls comparison of the release conditions with the PI conditions showed group 9+9(R) to be different from 9+9 (p < .05). Groups 9→9(R) and 9→9 did not differ significantly.
Discussion

PI Build-Up. Semantically homogeneous lists of words were in no case more effective in building PI than the traditional Brown-Peterson procedure. A three-word list produced about as much interference as three Brown-Peterson trials. Longer lists were somewhat, but not significantly, less effective.

The optimal nature of the Brown-Peterson PI build-up procedure in producing interference on a Brown-Peterson test trial can be considered in terms of the nature of the retrieval cues available to the subject. Retrieval cues are any feature of the learned material, or of the situation in which it is learned, which the subject can utilize to discriminate between items in memory (Tulving, 1968; Tulving & Watkins, 1975).

Distinguishable retrieval cues which can be used by a subject on a Brown-Peterson test trial are minimized by the Brown-Peterson build-up procedure. In this traditional procedure each trial resembles the others in every way, with the only differentiating characteristic being the actual words which make up the to-be-recalled trigram. When a trial is presented in which subjects are given an opportunity to attach new and distinguishable cues to a trigram, then they can utilize these cues and show considerable improvement in performance. This is in fact what happens on a release trial.
Apparently, presenting words in lists did not provide sufficiently discriminable retrieval cues to enable the subjects to perform well on the test trigram.

One unexpected phenomenon which occurred with subjects in group 3 and 3(R), was what seemed to be a masking of the Brown-Peterson trigram by the 3 words in the list. Four subjects in each of the 3-item list groups showed a rather dramatic inhibition of the words in the test trial trigram. When the question mark appeared at the end of their Brown-Peterson test trial, they responded with the words from the list. When asked, they denied having seen any other words. Even after being cued with the type of words, or even with the words themselves, they continued to deny any recognition of having seen, let alone read aloud, the Brown-Peterson trigram. It may be that these subjects were concentrating on the 3-word list to the exclusion of the Brown-Peterson trigram, and that reading the trigram aloud was not sufficient to cause it to be stored. It could also be argued that because of close temporal proximity of the two sets of words, temporal cues were rendered ineffective. The confusion brought about in this way would be expected, however, to be at least symmetrical, with an equal number of subjects being unable to recall the 3 words from the list. Unfortunately, no subjects who correctly recalled the trigram were specifically required to recall the items in the preceding list, although all of them were
able to identify the class from which those items came, and many volunteered the actual items.

**PI Release.** The subjects in all of the release conditions demonstrated very creditable performance, with the list groups showing the same overall trends, but with smaller between-group differences, as those shown by the PI build-up groups.

Although none of the list groups achieved as good a performance on the test trial as group B-P(R) -- the Brown-Peterson control for release -- in no case was the difference in performance significant. The lack of significance when comparing the 6(R), 9(R), and 9+9(R) groups with the 6, 9 and 9+9 groups, is due to superior recall scores of the PI groups rather than poor scores for the release groups. Nonetheless, taken as a whole, the list groups do appear inferior.

In a relevant study, Bennett and Bennett (1974) found that although performance in a PI release condition was excellent after four trials, performance after only one trial depended on the semantic dimensions involved. Subjects who were shifted from consonant trigrams to words demonstrated excellent recall when there was only one prerelease trial. When the relevant shift was from one sense impression (round) to another (white), there was negligible release on trial 2, with the amount of release gradually increasing to a maximum after four prerelease
trials. The experimenter assumed that for a coding dimension as obscure as sense impression, it took the subjects several trials before they could recognize a change along this dimension as a usable retrieval cue. If the number of trials, rather than the number of words experienced, is the critical variable, this analysis can be applied to the data that are under consideration here. If the subjects are using self-generated retrieval cues, it may require an attempt to recall the material to bring about the utilization of the appropriate cues. Subjects who have never previously recalled a particular type of information may conceivably be deficient in the utilization of the appropriate retrieval cues relating to semantic class. This deficiency could exist for some subjects even for such obvious semantic dimensions as those used in this experiment, and could produce the small performance decrement observed.

The double class lists with randomly mixed classes demonstrated significant PI to both classes of words in the list. This made it possible in the following two experiments to have subjects differentially process two classes of words within a single list and test for PI effects.
Craik and Lockhart (1972), examining data from a variety of experiments, concluded that the recall of verbal materials is primarily a function of the kinds of processing that the subject applies to them. The most impressive evidence for this comes from incidental learning studies. In such studies, the way in which subjects process words is defined by the task which directs their attention to those words.

Semantic orienting tasks produce better recall (Tresselt & Mayzner, 1960; Hyde & Jenkins, 1969; Gardiner, 1974) and recognition (Schulman, 1971) for words than do nonsemantic tasks. Subjects processing words semantically also appear to show equivalent recall performance to subjects who knew they would be tested for recall (Mandler, 1967; Craik, 1973; Hyde & Jenkins, 1973). It seems reasonable that this should be the case since the semantic characteristics of a word are generally more distinctive than the phonemic or structural characteristics.

Orienting instructions in scanning tasks emphasize retrieval information of varying degrees of usefulness for learning or recall. Instructions for semantic searches presumably require that the subject attend to those features
of words which aid recall, whereas searches for structural characteristics should divert the subject's attention from these useful semantic attributes.

When indulging in search procedures, subjects must process both target and non-target words in order to perform their task successfully. Using highly practiced subjects, Neisser (1964) found no recognition for non-target words following the semantic scanning of lists, and argued that for even semantically sorted items, words rejected as targets may not even be "registered" in memory. Schulman (1971), however, found that although recognition of non-target items was inferior to that of target items, there was still some recognition of non-target items under both semantic and letter search conditions. The letter search conditions seemingly involved at least minimal awareness of all the words searched. Further evidence for this comes from research demonstrating shorter letter search times through words than through nonwords (Krueger, 1970), whether or not the subject was searching for the presence or for the absence of the letter (Krueger & Weiss, 1976).

It would seem that the kinds of processing required of a subject in a search task would have consequences for performance on a following PI test. In Experiment 1, performance on a Brown-Peterson test trial was clearly affected by having the subjects read a list. Different types of list search prior to a PI test trial should have
similar effects in varying degrees, depending on the type of search involved. Performance on such a test trial would presumably be a function of the type of processing required, and of the relationship of the semantic class of words making up the test trigram, to the words in the list.

In these next experiments, subjects were instructed to scan a list and to either verbalize, or count, words of a particular semantic class, or containing a particular letter. Upon completion of this task, they were tested with a Brown-Peterson test trial to the same semantic class as the target words or the non-target words, or to a class of words not represented in the list.

In Experiment 2, the subjects conducted a positive search. That is, they read aloud words which were members of a particular semantic class or which contained a certain letter. Subjects in Experiment 3, on the other hand, read aloud words which were defined as not members of a particular class or not containing a letter. In Experiment 3, therefore, the words that the subjects were told to look for were in fact, when found, rejected.
METHOD

Subjects

The subjects for Experiment 2 were 381 — and for Experiment 3, 192 — students drawn from the same pool as those used in Experiment 1. They were randomly assigned to one of the 12 groups of Experiment 2 or six groups of Experiment 3. There were 32 subjects per group.

Materials and Apparatus

The number trigram practice slides, the list slides, and the Brown-Peterson test slides and distractor slides were the same as those used for groups 9+9 and 9+9(R) (two classes randomly mixed) in Experiment 1. The recognition test slides were those used for groups 16 and 16(R) in the first experiment. The apparatus was also the same.

Procedure

As in Experiment 1, the subjects practiced with four Brown-Peterson trials using number trigrams prior to seeing the list of words they were to process. The words used in the first experiment were selected such that all animal names contained the letter L at least once, but not the letter R; and all men's names contained the letter R, but not the letter L. Subjects scanning for the letter L in a list containing nine animal names and nine men's names would be searching, in fact, for animal names. The occupations
were not so coded. However, the release scores in the first experiment were evenly divided with total number correct being 42 for men's names and animal names, and 43 for occupations. This similarity was fortuitous in that it made it possible to use occupations as a release control class in this second experiment.

The only difference from the procedure used in the first experiment was in the instructions for processing the list. The instructions given to the subjects in each search condition of Experiment 2 were as follows:

Condition SV - (Semantic-Verbalize): "I want you as quickly as you can to find and read out loud all of the words which are (men's names/types of animals)."

Condition SC - (Semantic-Count): "I want you as quickly as you can to count out loud the number of words which are (men's names/types of animals). By 'count out loud' I mean for you to say 'one' when you come to the first word, 'two' when you come to the second, etc."

Condition LV - (Letter-Verbalize): "I want you as quickly as you can to find and read out loud all of the words which contain the letter (R/L)."

Condition LC - (Letter-Count): "I want you as quickly as you can to count out loud the number of words containing the letter (R/L). By 'count out
loud' I mean for you to say 'one' when you come to the first word, 'two' when you come to the second, etc."

For Experiment 3 the instructions were either of the following:

Condition SVN - (Semantic-Verbalize Non-Target Words): "I want you to quickly find and read out loud all of the words which are not (men's names/types of animals)."

Condition LVN - (Letter-Verbalize Non-Target Words): "I want you to quickly find and read out loud all of the words which do not contain the letter (R/L)."

In both experiments a third of the subjects were tested for PI build-up to the semantic class to which the target words belonged, a third to the class of the non-target words, and the remaining third to a class not represented in the list. The group designation included the test condition as the last letter in the sequence: subjects tested to target words were designated (T), those tested to non-target words were designated (NT), and subjects tested to a new class of material were designated (R) for release. The group which searched semantically, verbalized the words and were then tested to the same class as the target words, were group SV(T). Those tested to the class of the non-target words were group SV(NT).
The subjects were not told that they would be required to recall the words they had seen. At the end of the session they were, however, asked to do so. After attempting recall, they were given a recognition test with slides which contained the nine items from the list they had scanned and nine other items of the same semantic class.
Results

Proactive Inhibition. The scoring method used for recall of the Brown-Peterson test trigrams was the same as in Experiment 1: one point for each item correct, and one point for correct order of recall. The resulting recall scores for Experiment 2 are shown in Table 2. It might be useful here to point out that the scores for the relevant groups in Experiment 1, groups 9+9 and 9+9(R), were 1.94 in the PI condition and 2.65 for the release condition.

An overall analysis of variance on the data in Table 2 shows test class to be the only significant main effect, $F(2,372) = 4.83$, $p < .01$. A Newman-Keuls post hoc analysis shows only that group SV(T) was different ($p < .05$) from groups SV(R), SC(R) and LV(R), all of which were release groups.

This research was designed to investigate the differences in the amount of PI produced by the target words as opposed to the non-target words, and to also ask if any PI at all would be produced to the non-target words. It is therefore legitimate to apply Planned Comparisons statistics (Hays, 1963) to performance on tests to the target class versus the non-target class, and to the non-target class versus the release class.

The target versus non-target comparison showed that only the SV instructions produced a significant difference
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The target versus non-target comparison showed that only the SV instructions produced a significant difference.
**TABLE 2**

Mean Recall Scores for the Brown-Peterson Test Trials in Experiment 2, as a Function of Pre-Test Instructions and Class Tested

<table>
<thead>
<tr>
<th>PI Test Class</th>
<th>S Semantic Search</th>
<th>L Letter Search</th>
</tr>
</thead>
<tbody>
<tr>
<td>V Verbalize Target Words</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T</td>
<td>2.06</td>
<td>2.38</td>
</tr>
<tr>
<td>NT</td>
<td>2.69</td>
<td>2.34</td>
</tr>
<tr>
<td>R</td>
<td>3.03</td>
<td>3.03</td>
</tr>
<tr>
<td>Total</td>
<td>7.78</td>
<td>7.75</td>
</tr>
</tbody>
</table>

| G Count Target Words |
| T | 2.72 | 2.72 |
| NT | 2.88 | 2.78 |
| R | 3.09 | 2.69 |
| Total | 8.69 | 8.19 |

**TABLE 3**

Mean Recall Scores for the Brown-Peterson Test Trials in Experiment 3, as a Function of Pre-Test Instructions and Class Tested

<table>
<thead>
<tr>
<th>PI Test Class</th>
<th>S Semantic Search</th>
<th>L Letter Search</th>
</tr>
</thead>
<tbody>
<tr>
<td>VN Verbalize Non-Target Words</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T</td>
<td>2.38</td>
<td>2.41</td>
</tr>
<tr>
<td>NT</td>
<td>2.13</td>
<td>2.37</td>
</tr>
<tr>
<td>R</td>
<td>2.98</td>
<td>3.01</td>
</tr>
<tr>
<td>Total</td>
<td>7.49</td>
<td>7.79</td>
</tr>
</tbody>
</table>
in performance. Group SV(T) differed significantly from
group SV(NT), t (372) = 1.96, p < .05. The comparison of the
non-target words with the release words (words new to the
subject), showed significant differences for only one pair:
group LV(NT) differed from group LV(R), t (372) = 2.16,
p < .025. For those subjects who verbalized the target words,
the average amount of PI from words in the list (target and
non-target) was the same (2.38 versus 2.36), regardless of
the type of list search involved.

The data for Experiment 3 are shown in Table 3. As in
Experiment 2, an analysis of variance shows that test class
is the only significant main effect, F (2, 186) = 10.18,
p < .001. The Newman-Keuls analysis shows group SVN(NT)
performed differently from group LVN(R), p < .05. Planned
Comparison tests showed group SVN(NT) differing from group
SVN(R), t (186) = 2.46, p < .025; and group LVN(NT) differing
from group LVN(R), t (186) = 1.84, p < .05.

Recall. After the Brown-Peterson test trial, the
subjects were asked to recall as many of the words as they
could from the list they had seen. The mean number of
target and non-target words correctly recalled in Experiment
2 are shown in Table 4. Those numbers which are underlined
in the table represent recall of words of the same class as
the Brown-Peterson test trigram. These scores might be
expected to be lower than the others in the same instruction
condition, since the Brown-Peterson trigram should have
### TABLE 4

Mean Recall in Experiment 2 of Both Target and Non-Target Words, Following the Brown-Peterson Test, as a Function of Pre-Test Instructions and Class Tested

<table>
<thead>
<tr>
<th>PI Test Class</th>
<th>Target Words</th>
<th>Non-Target Words</th>
</tr>
</thead>
<tbody>
<tr>
<td>V Verbalize</td>
<td>S Search</td>
<td>L Search</td>
</tr>
<tr>
<td>Target Words</td>
<td>3.09</td>
<td>2.28</td>
</tr>
<tr>
<td>NT</td>
<td>3.69</td>
<td>3.38</td>
</tr>
<tr>
<td>R</td>
<td>3.56</td>
<td>2.93</td>
</tr>
<tr>
<td>Total</td>
<td>10.34</td>
<td>8.59</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>C Count</th>
<th>Target Words</th>
<th>Non-Target Words</th>
</tr>
</thead>
<tbody>
<tr>
<td>T</td>
<td>2.75</td>
<td>1.81</td>
</tr>
<tr>
<td>NT</td>
<td>3.44</td>
<td>2.03</td>
</tr>
<tr>
<td>R</td>
<td>3.72</td>
<td>1.91</td>
</tr>
<tr>
<td>Total</td>
<td>9.91</td>
<td>5.75</td>
</tr>
</tbody>
</table>

### TABLE 5

Mean Recall in Experiment 3 of Both Target and Non-Target Words, Following the Brown-Peterson Test, as a Function of Pre-Test Instructions and Class Tested

<table>
<thead>
<tr>
<th>PI Test Class</th>
<th>Target Words</th>
<th>Non-Target Words</th>
</tr>
</thead>
<tbody>
<tr>
<td>VN Verbalize</td>
<td>S Search</td>
<td>L Search</td>
</tr>
<tr>
<td>T</td>
<td>1.65</td>
<td>1.04</td>
</tr>
<tr>
<td>NT</td>
<td>2.54</td>
<td>1.34</td>
</tr>
<tr>
<td>R</td>
<td>2.66</td>
<td>1.13</td>
</tr>
<tr>
<td>Total</td>
<td>6.85</td>
<td>3.51</td>
</tr>
</tbody>
</table>
retroactively interfered with the recall of the words from the list.

Since the target words and the non-target words so clearly differed in a mean recall, the analyses of both sets of words were undertaken separately.

An overall analysis of variance on the mean recall of the target words shows all the main effects, and the interaction of search instructions with verbalization instructions, are significant. The results break down as follows: Search instructions, $F(1,372) = 46.51, p < .001$; verbalization instructions, $F(1,372) = 14.28, p < .001$; class tested, $F(2,372) = 7.74, p < .001$; and the interaction of search instructions with verbalization instructions, $F(1,372) = 7.45, p < .01$.

A Newman-Keuls analysis shows the three groups in the LC instruction condition to be different from all the other groups ($p < .05$) except group LV(T) (a group suffering the effects of RI from the test trial). In the other three instructional conditions the three RI groups, LV(T), SV(T) and SC(T), do not differ from one another or from group LV(R). All four of these groups differ from all other groups. There were no other significant differences. Retroactive inhibition seems to account for most of the class tested effect, since the mean number of words recalled in the groups subject to this interference (the (T) groups) was 2.48, as opposed to 3.14 and 3.04 for the (NT) and (R) groups.
An analysis of variance on the mean recall of the non-target words indicated search instructions ($F(1,372) = 9.39, p < .005$) and class tested ($F(2,372) = 5.72, p < .005$) to be significant. No other effects were significant. The Newman-Keuls analysis proved only that group SV(T) scored significantly higher than group LC(NT), a not very interesting result.

Retroactive interference from the test words seems to have been present on the non-target words. The mean number of correct words which would show RI effects was .89, as opposed to 1.36 and 1.20 for the non-RI conditions. This was presumably the cause of the overall class effect.

The data from Experiment 3 are shown in Table 5. The target words were defined here as the words rejected in the search, since they were the words which were specifically semantically defined. As before, the underlined numbers represent those scores which are subject to RI; and also as before, the analyses were performed on the target and non-target words separately.

The analysis of variance on the recall of the target words shows significant effects of both search instructions, $F(1,186) = 9.31, p < .005$, and class tested, $F(2,186) = 4.53, p < .01$. The Newman-Keuls test showed no significant effects. The analysis of the non-target words showed an effect only of class tested, $F(2,186) = 4.32, p < .05$. Again, this appears to be primarily due to RI effects from the Brown-Peterson test.
Recognition. Following the recall test the subjects were shown two slides, with half of the 18 words on each slide being the 9 words from one of the classes in the list. The mean number of target and non-target words recognized in Experiment 2 are shown in Table 6.

The analysis of variance on target word recognition shows no effect of search instructions, but there is an effect of verbalization instructions, $F(1, 372) = 14.84$, $p < .001$, and of class, $F(2, 372) = 3.92$, $p < .05$. However, the Newman-Keuls analysis of the data shows only the two extreme means to be different ($p < .05$). Those means are for groups LV(R) and LC(R).

The groups which might have been influenced by RI from the test trial show no consistent pattern. They are highest, but not by much, in one instruction condition, about equal to the second highest scores in two of the conditions, and lowest in the fourth condition.

The analysis of variance on the non-target words shows class tested to be the only significant effect, $F(2, 372) = 8.02$, $p < .001$. If anything, the (T) groups seem to show poorer recall; however, it is certainly not a dramatic effect.

The results for Experiment 3 are shown in Table 7. An analysis of variance produces no significant effects of anything; for either the target or the non-target words, $F(< 1)$ for all effects. However, the difference between
### TABLE 6

Mean Number of Target and Non-Target Words Recognized in Experiment 2, as a Function of Pre-Test Instructions and Class Tested

<table>
<thead>
<tr>
<th>PI Test Class</th>
<th>S Semantic Search</th>
<th>L Letter Search</th>
<th>S Semantic Search</th>
<th>L Letter Search</th>
</tr>
</thead>
<tbody>
<tr>
<td>V Verbalize</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Target Words</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T</td>
<td>7.03</td>
<td>6.47</td>
<td>4.55</td>
<td>3.83</td>
</tr>
<tr>
<td>NT</td>
<td>6.39</td>
<td>7.00</td>
<td>4.77</td>
<td>5.20</td>
</tr>
<tr>
<td>R</td>
<td>6.97</td>
<td>7.53</td>
<td>4.13</td>
<td>5.34</td>
</tr>
<tr>
<td>Total</td>
<td>20.39</td>
<td>21.00</td>
<td>13.45</td>
<td>14.37</td>
</tr>
<tr>
<td>C Count</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Target Words</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T</td>
<td>6.63</td>
<td>6.09</td>
<td>4.25</td>
<td>3.89</td>
</tr>
<tr>
<td>NT</td>
<td>5.83</td>
<td>5.83</td>
<td>4.77</td>
<td>4.42</td>
</tr>
<tr>
<td>R</td>
<td>6.59</td>
<td>5.81</td>
<td>5.47</td>
<td>4.72</td>
</tr>
<tr>
<td>Total</td>
<td>19.05</td>
<td>17.73</td>
<td>14.49</td>
<td>13.03</td>
</tr>
</tbody>
</table>

### TABLE 7

Mean Number of Target and Non-Target Words Recognized in Experiment 3, as a Function of Pre-Test Instructions and Class Tested

<table>
<thead>
<tr>
<th>PI Test Class</th>
<th>S Semantic Search</th>
<th>L Letter Search</th>
<th>S Semantic Search</th>
<th>L Letter Search</th>
</tr>
</thead>
<tbody>
<tr>
<td>VN Verbalize</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-Target Words</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T</td>
<td>5.34</td>
<td>6.17</td>
<td>6.27</td>
<td>7.02</td>
</tr>
<tr>
<td>NT</td>
<td>5.34</td>
<td>5.41</td>
<td>7.38</td>
<td>6.81</td>
</tr>
<tr>
<td>R</td>
<td>5.90</td>
<td>5.09</td>
<td>7.38</td>
<td>7.13</td>
</tr>
<tr>
<td>Total</td>
<td>16.58</td>
<td>16.67</td>
<td>21.03</td>
<td>20.96</td>
</tr>
</tbody>
</table>
target and non-target words is maintained; and as with recall in Experiment 3, fewer target words were recognized than non-target words.

Discussion

Proactive Inhibition and Release. It is probably appropriate to begin this discussion by noting the relevant comparison scores from Experiment 1. The Brown-Peterson controls clearly produced the greatest amount of PI and the best performance on the release trials. The scores for these groups were 1.56 for the PI group, and 2.96 for the release group. The appropriate comparison groups for "intentional" learning of a double class list would be groups 9+9 and 9+9(R), which produced scores of 1.94 (PI) and 2.65 (release) respectively.

No groups in Experiments 2 and 3 matched the low level of performance of the Brown-Peterson PI controls from Experiment 1, but five out of the six release groups achieved a performance equivalent to the Brown-Peterson release controls from that experiment.

Only two groups (groups SV(T) and SVN(NT)) in these last two experiments approached the low level of performance of group 9+9 (the PI group of Experiment 1). There are several groups, six in all, which fall near the release performance of group 9+9(R). Five groups, with scores of about 2.4, fall almost exactly between the PI and release scores of the 9+9 condition. Since these scores prove to
be, in at least one case, significantly different from the release scores (group LV(NT) vs. group LV(R)), perhaps all of them represent some intermediate amount of PI.

The result which appears most easily interpreted is the performance of the release groups in these last two experiments.

In Experiment 1, the list group showing the best performance under release conditions was group 9→9(R). The subjects in this group had seen the words in the list as, in fact, two separate lists categorized as to class. Perhaps this improved definition of, or emphasis on, the categories involved was of value. In Experiments 2 and 3, both semantic search and verbalization instructions seem to produce, in the subjects, an awareness of the retrieval cues which prove to be most useful at the time of the PI release test.

It is easy to see, and it was in fact predicted, that semantic searches can define retrieval information that will be useful to the subjects on a release trial. It is not quite as clear why a letter search under verbalization instructions should define the information as clearly. Of necessity, the words in the lists could be easily, and possibly automatically, coded for meaning. The good performance on the part of group LV(R) implies an awareness of both classes in the list. There is some evidence that this is the case, since subjects verbalizing letter search
results (LV(T) and LV(NT)) showed moderate levels of interference to both the classes in the list.

The results of the PI tests to the classes of the items in the list are not quite so easily interpretable. Although statistically there was no significant interaction of class with instructions, there is clearly a different pattern of results under each instructional condition.

It is apparent that counting words in a list produced little PI. The only difference attributable to search instructions was the already discussed effect in the release groups.

The interaction of verbalization and search instructions is interesting and somewhat puzzling. Intuitively it appears as though verbalization instructions make available a certain amount of interference which the search instructions cause to be distributed differently. The conclusion that words found in a semantic search, and then verbalized, produce as much PI as does intentional learning of the words, is not surprising. The difficulty comes in explaining why, if verbalization instructions are important, the non-verbalized words produce as much interference as the verbalized words in the letter search condition. There is evidence in the literature that word processing occurs during letter searches and indeed that recognition of the word may precede recognition of letters contained in it (Krueger & Weiss, 1976; Johnson, 1975).
Perhaps part of this processing includes an implicit verbalization of the words. If this were always true, the LC groups should show the same amount of PI as the LV groups. So verbalization of non-target words would have to occur only when the subjects are operating under verbalization instructions. In this latter case, groups LV(T) and LV(NT) would benefit from both verbalization and semantic awareness. This, however, comes back to the question of why the verbalized class shows more interference in the SV condition and not in the LV condition. It is possible that, while verbalization can be a part of the letter search procedure, semantic searches may be performed without even implicit verbalization of the words which are rejected. The semantic-verbalization group of Experiment 3 does show PI effects to both the semantically defined target words and the verbalized non-target words, which is not true of group SV in Experiment 2. Although the assumptions underlying these arguments are tentative, they do provide at least a minimally satisfactory explanation of the data.

It is also possible that counting per se interferes with the potentially interfering items or terminates the processing of those items. The difficulty here lies in the lack of interference produced by counting on recall and recognition scores.

Recall and Recognition. The recall and recognition data are consistent with that described by Craik and
Lockhart (1972) in their overview of the incidental learning literature.

The recall and recognition scores were higher for target words than for non-target words, and the search and verbalization instructions showed effects in the predictable direction. On the whole, verbalization produced better recall and recognition, but semantic search improved only the recall scores. This conflicts with Schulman (1971), who found better recognition for semantic than for letter search. Schulman's subjects, however, scanned a list of 192 words, as opposed to 18 in this study. Presumably the small number of items would make recognition easier, and obscure differences as a function of search procedure.

Again, this ease of recognition could probably be assumed to be responsible for the lack of retroactive interference, from the PI test trial, on the recognition task. The recall scores, however, showed considerable effects of RI from the test trial.

**PI and List Recall.** In Experiment 2, the recall performance of the (NT) and (R) groups demonstrates the degree of recall of the target words with which the test trial has not retroactively interfered. The (T) and (R) groups show the degree of recall of the non-target words. To the extent that these recall scores represent the degree of availability of the words at the time of the Brown-Peterson test trial, it should be possible to
analyse the relationship between these scores and PI. Unfortunately, this relationship is extremely untidy. The SV instructions, which produce excellent recall of the target words, do produce considerable PI to those words, and poor recall of, and little PI to, the non-target words. The LC instructions show poor recall for, and little PI to, either the target or non-target words. These two conditions would have been predicted to produce exactly these results. However, this orderly relationship does not continue. Condition LV produced more interference from the non-target words than would have been predicted from the poor recall scores; and similarly, condition SC produced less interference than expected from their good recall of the target words.

In effect, a group receiving verbalization instructions was unexpectedly successful with the words they did not verbalize and the group showing excellent recall, due to semantic search instructions, who merely counted the target words, showed little interference. Perhaps acoustic (Conrad, 1964) or reproductive (Peterson & Johnson, 1971) cues, long known to be effective cues in short-term memory, are predominant in the Brown-Peterson test while semantic codes are more important in the free recall of the list. Alternatively, the operation of counting words affects the interference produced by those words but not their recall. It appears, in summary, that strategies which aid in the
free recall of a list do not in themselves predictably affect the Proactive Inhibition produced by the items in the list, on a Brown-Peterson test trial.
GENERAL DISCUSSION

Taken as a whole, the results of these experiments fit nicely into the levels of processing framework of Craik and Lockhart (1972), and the encoding specificity hypothesis of Tulving and his associates (Tulving & Osler, 1968; Thomson & Tulving, 1970). Craik and Lockhart suggest that memory is determined by the analyses, ranging from sensory to semantic, which are performed on the to-be-remembered items. Tulving proposes that the cues which are to be used in recall must be stored along with the item to be recalled. Both of these approaches imply that recall is subject to the strategies and intent of the person attempting the recall, and it would be reasonable to believe that different strategies are appropriate in different circumstances.

The results of Experiment 1 indicate that there is no better way of interfering with performance on a Brown-Peterson trial than by preceding it with one or more Brown-Peterson trials with the same class of material. One of the most common types of error in Brown-Peterson experiments is the position intrusion. Presumably in this circumstance the triad provides interfering retrieval cues. This is borne out by the fact that, in the list groups, those subjects reading a three-word list showed as much
interference as the Brown-Peterson subjects. The three-word list group, however, showed poorer performance in the release condition. It was assumed (following Bennett and Bennett, 1974) that a single reading of the three-word list, resembling only one Brown-Peterson trial, may not have provided the subjects with sufficient evidence to apply the appropriate semantic retrieval cues to the release trigram.

In Experiments 2 and 3, release performance was slightly, but not significantly, improved by both semantic search and verbalization. It was assumed that the verbalization of the results of a letter search produced some semantic awareness. Since semantic processing is likely to draw attention to the very characteristic that the experimenter is manipulating, this result would be anticipated.

Experiments 2 and 3 also show that processing words in a way designed to produce good free recall of those words, does not necessarily imply that they will produce interference on a Brown-Peterson trial. Similarly, poorly recalled words may produce considerable interference. In these experiments, the critical variable affecting PI was verbalization instructions. However, overt verbalization of the words was not necessary to produce PI. Verbalization instructions produced effective PI when recall was poor, as well as when recall was good. Lack of verbalization pro-
duced no PI, even in subjects demonstrating good recall of the list.

It appears that within the Brown-Peterson paradigm, PI can be maintained by merely reading items with no intent to recall them (Nield, 1968). PI can be built up by listening to a volume test (Wickens, Moody, & Shearer, in press), reading a list with intent to recall it (Experiment 1) and verbalizing the results of a semantic or letter search (Experiments 2 and 3). The first two of these instances, and the letter search condition of Experiments 2 and 3, involve incidental tasks which are unlikely to produce good free recall. This could indicate that a Brown-Peterson test trial is sensitive to lower levels of processing than required for recall. However, the subjects who counted the results of a semantic search showed little PI and excellent recall. It seems likely that the Brown-Peterson task is merely a very different kind of task which places different demands on the subjects.

The Brown-Peterson PI release paradigm, as suggested before, is designed to reduce distinguishable retrieval cues to a minimum on trials prior to the release trial. It is important that the semantic attributes and the method of presentation of the potentially interfering information remain constant. In free recall situations, homogeneity of semantic class is not only useful, but is in fact sought by the subjects in the organizational
grouping that they apply to the material they are attempting to recall (Tulving, 1968).

The most effective strategy in a Brown-Peterson task is to use whatever physical characteristics are available in order to distinguish one set of semantically similar words from another. When the trigrams are verbalized, since they are easily recitable, acoustic or reproductive cues are presumably most useful in maintaining the items over the relatively short retention intervals used. When any noticeable change occurs in the semantic class of the words to be recalled, or in the physical characteristics of the situation at the time of storage, this change can be utilized by the subjects to improve their performance on that trial.

The one identifying feature of the experimental situations not producing PI in Experiments 2 and 3, was that subjects who had not previously verbalized words were verbalizing them on the Brown-Peterson trial. Apparently, this was a distinguishable cue.

From the Wickens and Gittis (1974) study and the experiments of this dissertation, it appears that operations which aid recall of interfering items do not distinguish them from other items of the same class used on a test trial. Apparently, degree of availability is not a retrieval cue, although presumably there must be some minimal availability for interference to occur.
The dissipation of PI over time, shown in the Nield (1968) and Kincaid and Wickens (1970) studies, has been postulated to be due to a temporal retrieval cue (Goggin & Riley, 1974). There is some evidence against this (Cermak, 1970; Gorfein, 1974). It seems possible that acoustic or reproductive information might indeed be subject to some fading with time, and certainly subject to interference from other verbal activities.
BIBLIOGRAPHY


APPENDIX A

The Words from Three Categories Used for Brown-Peterson Trigrams and Lists and Their Battig and Montague Frequency Values

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APPENDIX B

Number Trigrams Used for the Brown-Peterson Practice Trials

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APPENDIX C

The Effect of Multiple Trials with the Same Trigram on PI in the Brown-Peterson Paradigm

Introduction

In the experiments of this dissertation it was necessary to provide the subjects with an opportunity to practice the Brown-Peterson task. Several different manipulations, with potentially interesting results, were introduced in the early stages of Experiment 1. Most of these manipulations involved the relationship of the order and the serial position of the numbers in the test trigram, as related to their occurrence on the previous trials. None of the above mini-experiments showed enough of an effect to make further investigation worthwhile. One manipulation involving the three PI build-up trials produced a result which appeared to be worth pursuing.

The initial paradigm involved presenting the same trigram on all of the first three trials, and then testing for PI on the fourth by presenting a new trigram. The experimenter had assumed that the frequent repetition, which led to excellent recall on trial 3, would make this repeated item readily distinguishable and thus less interfering. This proved not to be the case. Performance on trial 4 for these pilot subjects was the same as for
subjects receiving different trigrams on each of the first three trials. It was therefore decided to investigate this effect more fully.

There are two possible arguments which can be applied to predict the interference effects produced by well-learned items. If the dissipation of PI with time (Nield, 1968; Kincaid & Wickens, 1970; Peterson & Gentile, 1965) can be attributed to the forgetting of the potentially interfering item, then better learning of these items might be expected to cause more interference on the test trial. Alternatively, due to increased discriminability of the well-learned items, they may produce less interference. This argument assumes that such an item would be easily differentiated from the test item at the time of recall, and that it could, in fact, almost be considered a different class of item per se due to frequency of presentation.

Wickens and Gittis (1974) investigated the effects of repetition on the rate of dissipation of PI to CCCs over an interval filled with Brown-Peterson trials using NNNs. They found that PI after such an interval was not affected by whether the six trials in the PI build-up sequence utilized six different trigrams, or used the trigrams from trials 1, 2 and 3 on trials 4, 5 and 6. This was in spite of the fact that the subjects who repeated trigrams were performing at a level of about 70% correct on the last pre-test trial, as opposed to 40% for the control subjects.
It was also clear that the increased availability of the interfering trigrams did not cause poorer performance on the test trial. Neither did it cause better performance, however. Since at least some of the potentially interfering material was well learned, it seems as though the possibility that well-learned items produce more interference can be ruled out.

It is, however, conceivable that, in the Wickens and Gittis study, the first of the repeated items was sufficiently undifferentiable at testing to produce interference. It may not be possible therefore to conclude with certainty that well-learned items will not cause less interference than half-forgotten items.

The study described below was designed to test the interference effects of various degrees of learning prior to the critical test trial, and was conducted concurrently with the other experiments of this dissertation.

Method

Subjects. The subjects were 224 of the students who participated in Experiments 1, 2 and 3 reported in the main body of the dissertation. There were 56 subjects in each of three experimental groups and one control group.

Procedure. The materials, apparatus and Brown-Peterson procedures were described in Experiment 1. After receiving the instructions for the practice trials, the control subjects received four trials with a new trigram on each
trials. The three experimental groups received different numbers of repetitions of the trigram used on trial 1. Group E2 received the same trigram on three consecutive trials (two repetitions), then a new trigram on the fourth. Group E1 received the same trigram on two consecutive trials (one repetition), a new trigram on trial 3, and then repeated the first trigram on trial 4. Group E0 received a different trigram on each of the first two trials (zero repetition) and returned to the trigram of the first trial on trial 3.

Results

The subjects were scored as either correct or incorrect on each trial, and the results are presented graphically in Figure 2. The solid line with the closed squares represents the performance of the control group on each of the four trials. The open dots show the level of performance of each of the experimental groups, prior to the test trial with the new trigram, and the open squares represent their performance on the test trial. Performance to the repetition of the trigram of the first trial on the trial following the test trial is signified by closed dots. The dashed lines show the progress of the experimental groups from the trial before (the last repetition) to the trial after the test trial. Since the graphical representation of the data is so clear, no statistical analyses were performed.
Figure 2. PI as a function of the number of trials with the same item prior to a test trial to a new item.
The control group dropped from about 70% correct on trial 1, to 36% on trial 2, and remained at around 40% for trials 3 and 4. The test trial performance of the experimental groups proved to be within 5% of that for the control group for groups E1 and E2. Although group E0 was about 7% better on trial 2 than the controls, they were also 7% better on trial 1. The experimental groups showed performance to the repeated trigram improving from about 69% with zero repetitions to 94% after two.

When the first trigram was repeated following an intervening new trigram (group E0), performance was about 10% lower than for the group which had repeated the trial 1 trigram on trial 2 (group E1).

Discussion

The control group in this experiment shows more or less typical Brown-Peterson performance, reaching an asymptote at about 40% correct. The experimental groups, as would be expected, demonstrate a progressive improvement in performance as a function of number of repetitions, achieving a level of 94% correct after only two repetitions. This high level of performance, however, does not affect their ability to recall the new trigram on the following trial. It seems clear that after two repetitions the item is fairly firmly established, since after only one repetition (group E1) there is no sign of the retroactive effects of the new item which occurs in group E0. Well learned and highly
available number trigrams apparently neither help nor hinder the subjects in their recall of the test trigram.

Since the numbers used did not include zero, the control group experienced repeats of numbers from prior trigrams on at least one trial. This would be expected to cause additional difficulties for the control subjects to the extent that associations with other numbers or with serial position would have to be unlearned. This was not the case for the experimental groups.

The subjects were certainly aware of the repetitions, and those in group E2 frequently remarked on the test trial that they were glad to see a new trigram. It appears, in this case, that novelty is not among the cues which enable subjects to perform well on the test trial.

Strangely, the intrusions, which would be the one class of error which would be expected to be reduced by this procedure, made up the same proportion of total errors on the test trial for experimental group E2 as they did on trial 4 for the controls.

This experimenter is at somewhat of a loss to explain why such interference should occur. Since number trigrams show this result, it might be interesting to repeat this experiment using items such as words with more informational content.