THE EFFECT OF WARM-UP ON FIRST AND SECOND LIST RETENTION AT IMMEDIATE AND TWENTY-FOUR HOUR RECALL

A Thesis

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by

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ABSTRACT OF THESIS

It is usually found in verbal studies of retention that, when two lists are learned, the second list is stronger at immediate recall, but the two lists are of equal strength at more extended retention intervals. The purpose of the present investigation was to determine whether this equating of the strengths of the lists over time could be due to equating of the sets for the two lists, where set is defined as a dominant tendency to give a response from a particular list. While the set for the second list would be stronger at immediate recall, producing greater facility in recalling this list, this dominant set might be weakened during longer rest intervals, to the point where it would be no stronger than the set for the first list.

All groups learned two paired-adjective lists, conforming to the A-B,A-C paradigm. The two lists were learned on different machines. Then the Ss were required to recall both the first and second responses when they were shown the common stimulus word. Half the Ss had immediate recall, while half had recall after twenty-four hours. At each interval the set for one list or the other was reintroduced just before recall by having the S indulge in a simple " warm-up" guessing experiment on the machine on which one of the lists had been learned. In this way the set for the list learned on the warm-up machine should be restored. Recall was also given on a machine relevant to either the first or second list. Control groups had warm-up relevant to neither list, but still had recall relevant to a specific list.

It was suggested that, if the set explanation was tenable, equating of recall for the two lists should appear at immediate retention when set activities were relevant to the first list, i.e. when the set for the second list had been destroyed and the set for the first list restored. At twenty-four hours, retention should be greater for the list related to the set activities given before recall.

The results showed that warm-up activities did not enhance recall for the relevant list at either immediate or twenty-four hour recall. However the recall machine did enhance recall for the relevant

list, and the effect appeared to be greater at immediate recall.

As an incidental finding, it was discovered that an excess of learning apparatus manipulation, i.e. switching the presentation machine more often during learning and recall, depressed recall for both lists, and at both retention intervals. It was suggested that this finding might be due to an increased complexity of the memory task, since a continual shifting of the background factors might bring these factors more into prominance, to the point where they become an important part of what is to be remembered.

It was concluded that some evidence in favour of the set explanation of the time effect was obtained, but that the equating of the two lists at immediate recall had not been conclusively demonstrated. It appeared that pre-recall warm-up activities were not effective in manipulating the sets for the two lists. However it was suggested that the recall machine might conceivably be producing the desired differential sets.

CHAPTER I

HISTORICAL SURVEY

UNLEARNING AND SPONTANEOUS RECOVERY

This study is concerned with the retention and forgetting of similar verbal habits which are in competition. Retention of such habits is known to depend upon which habit is aquired first in an experimental session. Further, it is now well established that the relative strength of first and second learned verbal habits changes radically over retention intervals of a day or two. With immediate retention, the second learned habit is stronger than the first, but with longer retention intervals the two habits are found to be of equal strength. This paper reports an attempt to manipulate this time change in relative habit strength by restoring the original experimental context for one habit or the other.

The forgetting of learned verbal material is usually thought to be due, not to a simple decay process, but rather to the interfering effects of other learning. When the retention loss is attributed to the interference of material interpolated between original learning and recall it is known as Retroactive Inhibition (RI). When it is attributed to material learned prior to original learning it is known as Proactive Inhibition (PI).

Such interference effects have often been studied by use of the A-B,A-C paradigm. In this design, subjects are presented with a list composed of a series of stimulus words (A), each paired with a response word (B), and are told to learn to associate each pair. However interference groups also learn another such list with identical stimuli (A), but different responses (C). Control groups do not learn the A-C list. A simple table may clarify the treatments for the various conditions.

CONDITION	PRIOR LEARNING (PL)	ORIGINAL LEARNING (OL)	INTERPOLATED LEARNING (IL)	RECALL
PI	A-C	A-B	rest	A-B
RI	rest	A-B	A-C	A-B
CONTROL	rest	A-B	rest	A-B

Any decrement in recall of the A-B list for the RI and PI groups as compared with the control groups is thus attributed to the interfering effect of the A-C learning.

Historically, theoretical explanations of interference effects have undergone several modifications in the light of increasing experimental evidence. McGeogh (1932) proposed a competition of response explanation of interference. If two incompatible responses are attached to the same, or identical stimuli, the two responses compete at recall, and the stronger response occurs; equal response strength results in response blockage. Implicit to this idea is an " independence hypothesis" i.e. the absolute strength of one response is not altered by the learning of a competing response.

Melton and Irwin (1940) rejected the independence hypothesis and simple competition theory, as a result of experiments varying the degree of IL. Contrary to what McGeogh's theory would predict, they found no linear relationship between the amount of RI and the number of overt interlist intrusions (responses from the interfering list which are given at recall instead of the correct responses from the to-be-recalled list). The number of overt intrusions, which were considered to be a direct measure of response competition, dropped off at high levels of IL much more rapidly than did the total amount of RI. To account for this finding, Melton and Irwin postulated a second factor of forgetting, which increased in a negatively accelerated manner with the number of interpolated trials. Further, since RI was found to be most persistent at intermediate levels of IL, but to dissipate rapidly when IL was high, the second factor was assumed to dissipate rapidly during relearning. Melton and Irwin suggested that this second factor might be the unlearning of the first list responses during second list learning. Contrary to the independence hypothesis, they claimed that the absolute strength of responses from the first list <u>decreases</u> with the learning of the second list. These unlearned responses can however be relearned with considerable savings.

Presumably, the first list is unlearned during second list learning, but the second list is not unlearned. Therefore, a direct prediction from the concept of unlearning is that RI will be greater than PI, since in RI the list to be recalled is the first, or unlearned list, while in PI conditions, the list to be recalled is the second learned list, which is not unlearned. As support for the unlearning hypothesis, Melton and von Lackum (1941) showed that RI was in fact greater than PI.

In its current form then, the two-factor theory of interference states that all interference effects are either due to competition-of-response, which has its effect at the attempted recall of one of the competing responses, or to unlearning, which has its effect during second list learning, and consequently affects only the first-learned list. Until recently however, unlearning had not been demonstrated where competition factors were not also present.

To fill this gap in two-factor theory, Barnes and Underwood (1959) used a Modified-Modified Free Recall (MMFR) technique. In this technique subjects, having learned the two competing lists, are presented with the common stimulus A, required to name <u>both</u> responses that go with it, and if possible identify the list membership of each response. This procedure differs further from ordinary recall in that the subject is allowed a great deal more time to respond in MMFR. Since both responses are to be recalled, and at a leisurely rate, then supposedly MMFR should eliminate response competition as a factor. Barnes and Underwood showed that with increasing IL, fewer OL responses are available at recall. Thus it appears very probable that there is actually unlearning of the first list during second list learning.

The simple two-factor explanation of interference effects has been complicated however, by the finding that the relative strength of the two lists changes as the retention interval is lengthened. Underwood (1948a) found that, while the expected difference between RI and PI existed after five hours, there was no difference after forty-eight hours. To explain this finding, Underwood proposed a modified form of unlearning theory, in which unlearning was thought to be analagous to classical experimental extinction. During second list learning the first list responses are extinguished, but, as in classical extinction, they spontaneously recover over time. This first list recovery results in increasing PI over time.

The spontaneous recovery explanation gained further weight from Underwood's (1948b) use of a Modified Free Recall (MFR) technique. In MFR the subject is given the common stimulus A at recall, and told to give the first response that comes to mind. As Postman (1961) has pointed out, MFR measures response dominance; whichever response is stronger at recall will occur. Thus MFR measures the <u>relative</u> strengths of the competing responses; it does not give an <u>absolute</u> measure of the individual response strengths, as MMFR is thought to do. Underwood found no change in the number of OL responses given with increasing retention interval, but he did find a consistent drop in IL responses. He presents these results as evidence for spontaneous recovery, since, he maintains, OL ordinarily would also be expected to lose strength over time. Thus the spontaneous recovery and the " usual forgetting" of List I balance each other out. The result is that List I retention stays constant despite the increasing retention interval.

Briggs (1954) has duplicated and extended Underwood's findings, in a similar MFR study, by showing an increase in occurrence of List I responses with increasing retention interval. Thus his results suggest that the rather unparsimonious " balancing out" explanation advanced by Underwood is not necessary to support the idea of recovery. However the fact still remains that MFR does not eliminate the competition factor, and therefore only supplies a relative measure of response strength. Consequently, the increase in List I responses over time found by Briggs could be due to decreasing List II strength rather than to recovery of List I.

Two recent attempts have been made to assess absolute changes in List I strength over time. Adams (1961), using nonsense syllables in place of the meaningful words previously used in studies of time changes, examined MMFR over different retention intervals. MMFR, as pointed out previously, should eliminate competition and reveal any time changes in absolute response strengths. Adams' results showed an absolute increase in the availability of OL responses with time, in line with spontaneous recovery, but only when the first list was overlearned. In opposition, Koppenaal (in press), using meaningful adjectives in a similar MMFR study, but without overlearning of List I, found no evidence for absolute recovery. Therefore, while the experimental evidence seems to support List I recovery as the cause of list equating over time, this evidence does not seem to be conclusive.

Support for a different interpretation of these time changes in retention comes from Koppenaal and O'Hara's (1962) demonstration that List I and List II strength could be equated over short retention intervals, equivalent to the more gradual " spontaneous recovery", by the learning of a third list. They argue that the equating of the two lists over time may not be due to any gain in List I strength, but rather to a simple loss of List II strength. This process of list equating would have been accelerated in Koppenaal and O'Hara's experiment by the learning of the third list. They maintain that the first list was already much unlearned and therefore would not lose as much as the second list during third list learning.

Koppenaal and O'Hara, transfering these notions to the time change, suggest that contrary to Underwood's expectation, little further loss of OL strength would necessarily be predicted with increasing time. Unlearning during experimental IL may cause most of the loss of List I strength which would ordinarily occur more slowly over time. Since IL is not unlearned, it is more succeptible to the interfering effects of extraexperimental learning during the retention interval, and shows more net loss over time, just as it was more affected by the learning of a third list. The result is an eventual equating of the two list strengths.

It appears then that the observed equating of List I and List II over extended retention intervals may be attributed to either a gain in List I strength, (spontaneous recovery) or to a more rapid loss of List II strength (negatively accelerated unlearning).

A third explanation is suggested by recent evidence that at least a part of RI is not due to the unlearning or competition of specific responses attached to the same stimulus, but rather to a loss of " set" for the critical list as a whole. Set may be defined as a tendency to give responses of a certain class, where this tendency is somewhat independent of the immediate environmental stimulation.

Changes in this set over time may be related to the temporal change in the relative strengths of List I and List II.

GENERALIZED RESPONSE COMPETITION

Experiments conducted by Newton and Wickens (1956) concerned with the effect of the temporal point of interpolation of IL during the OL-RL interval have led to a theoretical statement of the importance of set at recall. When a common stimulus, different response (A-B,A-C) design was used, the temporal point of interpolation of IL was found to have no effect on OL recall. However when an A-B,D-C (unrelated stimulus) paradigm was used, the results indicated significantly less retention when IL came just before recall.

The authors maintain that unlearning and specific response competition would be minimal in the second paradigm. Stimulus generalization between stimuli A and D may have caused some specific unlearning and competition, but the fact that no overt intrusions occurred during recall suggests that no such generalization was taking place.

Newton and Wickens propose that the greater inhibition of OL when IL occurs just prior to recall may be due to a generalized tendency, or set, to give responses from the list just learned. The interfering effects of this disruptive set factor they term Generalized Response Competition (GRC). When IL occurs long before recall, GRC is less, since the set for IL has been lost; that no effect appeared with the A-B,A-C design was attributed to the fact that specific interference would be maximal and might serve to obscure the forgetting due to generalized interference.

Runquist (1957) has presented additional evidence for a generalized competition interpretation. He found that while the effect of RI on any item of the OL list was related to the OL item's strength, it was not related to the absolute strength of the corresponding interfering or interpolated item. Thus the increasing interference effects usually found with increasing amounts of interpolated learning (McGeogh, 1932, 1936; Briggs, 1954, 1957) may be due to increasing generalized interference from the interpolated list, rather than to increasing specific competition from IL responses attached to identical stimuli.

More support for GRC comes from some evidence in serial list learning. With serial lists, it is usually found that at recall, the words at the beginning and end of the list are better recalled, resulting in a bow-shaped serial position recall curve. Postman and Riley (1959), using serial lists and varying both OL and IL, found that RI led to increased forgetting of the initial items, resulting in a flattening of the first part of the expected bow-shaped curve. PI and rest conditions both presented the expected bow-shaped curve at recall.

In both PI and rest, the list learned last is being recalled; consequently the set for the to-be-recalled list is not disturbed. In RI, the set for the list that is to be recalled has been depressed during IL and must be restored during the first recall trial. As a result, more responses at the beginning of the recalled list are lost, and the initial segment of the recall curve is depressed. Further support for this interpretation comes from the fact that the RI condition showed the bow-shaped curve on Trial II of recall. Presumably the set for List I has been largely restored in one trial.

Postman (1962) and Ceraso (in an unpublished study), have both resorted to a split-list design to present evidence regarding the importance of GRC in RI. In this technique, the IL list is constructed so that half the items have the same stimulus as the corresponding items of the OL list, i.e. A-B,A-C. The remaining items have a different stimulus to the corresponding OL items, i.e. A-B,D-C. In this design a specific unlearning theory would predict more loss for the A-B,A-C items, while GRC predicts no difference in retention between the identical stimulus and different stimulus items, since the interfering set is the same for each item in the list.

Ceraso found that the percent retention loss was equal for the repeated stimulus and new stimulus items. Further the equal loss for the new stimulus items was apparently not due to specific unlearning resulting from stimulus generalization. In a subsequent experiment with homogenous IL lists (either all A-C or all D-C items), the

A-B,A-C list produced significantly more forgetting than did the A-B,D-C list. However Postman was not able to show the expected GRC results using the split list technique. Consequently the evidence for GRC in this respect must be regarded as inconclusive.

The current theoretical interest in GRC has refocused attention on some earlier experimental work related to the effect of learning the first and second lists under different experimental conditions. Bilodeau and Schlosberg (1951) have shown that presenting IL under conditions of exposure, illumination and posture different from those for OL significantly lessens the interfering effect of IL, and increases OL recall. The authors suggest that the physical isolation of IL from OL may lead to a changed set during IL learning. Consequently IL is more easily discriminated from OL at recall, resulting in less interference.

Greenspoon and Ranyard (1957), elaborating upon this idea, used two different combinations of rooms, postures and exposure devices, labelling the two conditions as A and B. OL, IL, and recall could then take place under either condition A, or condition B. The groups in order of decreasing recall were ABA, (AAA, ABB), AAB, where for each group the first letter represents the experimental condition for OL, the second for IL, and the third for recall (differences between conditions in parentheses are not significant). Thus OL recall seems to depend on the degree to which recall conditions are related to the OL list, rather than to the interfering list; this <u>may</u> in turn result in a beneficial set at recall. It should be noted that this evidence is not incompatible with specific competition. Changing the conditions for IL would be expected to lessen the interfering effect of the individual IL items, since the similarity of IL to OL items would be lessened. Therefore the availability of the corresponding OL items would be greater at recall. But the explanation in terms of changed set is in line with GRC theory.

Also related to considerations of set factors is a methodological phenomenon that has been known to exist for some years, but has never been tied in with the mainstream of interference theory. Irion (1948) has demonstrated that a few trials of color recitation on the memory drum just prior to recall improves recall significantly. Irion explains this enhancement in terms of a restoration of set for the experimental situation. This enhancement of recall has been called Warm Up (WU). WU is not believed to have an effect on the strength of S-R connections, since it is not related in time to a specific stimulus situation, but is thought to restore secondary factors related to goal performance, such as postural and visual cues associated with the correct responses, and perhaps set. When WU is given, these factors which ordinarily must be restored on the first recall trial, are restored during the preliminary activity, and enhanced recall is the result.

Hartley (1948) has presented strong evidence against the argument that WU leads to learning how to learn, or to subliminal rehearsing of goal responses. He showed that recall was only enhanced when WU was presented just before recall, but was not improved if WU was presented just after OL, some time before recall.

It would appear that if WU is having its effect on set factors as Irion has suggested, WU may be a convenient method of manipulating GRC effects. An experiment by Thune (1958) suggests how WU may be used in this way, although his study was not done with that purpose in mind. Following Bilodeau and Schlosberg, Thune presented OL and IL on two different machines, a memory drum and a film projector. Then just prior to recall of OL twenty-four hours later he gave WU on either the machine relevant to OL or the machine relevant to IL. A control group had WU immediately after IL.

Thune found enhanced recall of OL for the group having WU appropriate to OL. Presumably the WU relevant to OL reintroduced the set for that list, whereas the WU relevant to IL introduced the set for the interfering list, and depressed recall. The latter group in turn showed better recall than the control group, suggesting that any WU, relevant or irrelevant, is helpful after an extended rest interval in reintroducing the subject to the experimental situation in general.

The fact that Thune found WU relevant to List I beneficial after twenty-four hours has implications for a set interpretation of the time effect. It might be expected that the effect of presenting WU relevant to List I would be even more pronounced at immediate recall. At twenty-four hour recall there should probably be no dominant set for either list, since according to Newton and Wickens' results, the extended rest interval should destroy any such sets. Therefore the major effect of giving WU relevant to a particular list should be to restore the set for that list. The WU would probably have little disruptive effect on the irrelevant list, since little set should exist for that list. In fact Thune's results suggest that there might even be some beneficial effect on the irrelevant list. But at immediate recall, there would probably be a strong set for List II; consequently the set for List I might be depressed. Therefore the effect of WU relevant to List I might be even more extreme at short retention intervals. Further, reintroducing the set for List I might serve to disrupt the strong set for List II, producing some decrement in List II recall. The rise in List I and the drop in List II recall would be in the direction of equal recall for the two lists, which is the effect usually found only over longer retention intervals. If this time effect can be reproduced at short intervals by lessening the difference between the two list sets, it would then be reasonable to argue that the time effect might in fact be due to similar changes in the relative strength of such sets over time.

STATEMENT OF THE PROBLEM

The set interpretation of the time effect suggests that the equating of first and second list retention over time is due to an equating of the sets for the two lists, which is produced both by a gradual lessening of the initially dominant set for the second list, and a corresponding rise in the initially depressed set for the first list. This interpretation would be much strengthened if the time effect could be reproduced at immediate recall by reproducing this supposed time change in set strength. Thune's experiment suggests how WU may be used for this purpose

The purpose of the present investigation is to attempt first of all to replicate Thune's results using MMFR, and secondly to extend his experiment to an immediate recall situation, in order to determine whether the absolute strengths of two learned lists may be equated at short retention intervals, the usual time effect, by lessening the difference between the sets for the two lists.

CHAPTER II

EXPERIMENTAL METHOD

MATERIALS

Original learning materials- Two lists composed of ten pairs of meaningful two-syllable adjectives were used. The two lists, in accordance with the A-B,A-C paradigm, had common stimulus words, but different response words. Both meaningful and structural similarities between all words in the two lists were kept as low as possible. The two lists are given in Table I.

TABLE I

The two lists used in the experiment

Stimulus A	List E1 Response B or C	List E2 Response C or B
Nimble	Surplus	Overt
Pious	Obscure	Rising
Human	Yonder	Arctic
Oldish	Chilly	Fancy
Lovely	Placid	Sudden
Jellied	Filmy	Defunct
Drastic	Curved	Zesty
Uphill	Silent	Joyful
Adrift	Inward	Limpid
Rancid	Humble	Equal

To minimize serial learning, a list was presented in three different orders on successive trials. Half the Ss in each condition learned list E1 first, and half learned E2 first, to control for differences in list difficulty.

In keeping with Thune's (1958) procedure, the two lists were presented on two different machines. One machine was a Gerbrand Memory Drum, with a 3 second anticipation period, during which the stimulus A appeared alone, and a 3 second learning period, when the stimulus and response appeared together. A 9 second rest interval was given between successive trials. The lists for the memory drum were typed in upper case type on rolls of plain white paper $2\frac{1}{4}$ inches in width; list E1 was typed in brown, and list E2 in green for purposes of identification.

The second machine used was a Hunter Card Master #340, similar to one described by Norcross and Spiker (1958). It consisted of a grey metal box with a 6 inch x 3 inch apperture through which the words could be seen. The apperture was covered by two independently operated grey shutters, which could be lifted at intervals controlled by electric timers. The left shutter opened alone during the anticipation period. Then the right shutter opened to reveal the response word next to the stimulus word.

The Card Master lists were typed in lower case type on strips of sticky white paper $\frac{1}{2}$ inch in width. Each pair of words was then mounted on plastic cards $3\frac{1}{2}$ inches x $6\frac{1}{2}$ inches in size. List E1 had a thin brown line across the top of the strip of paper, while list E2 had a yellow line, again for purposes of identification.

A 3 second anticipation interval was also used on the Card Master. However the nature of the apparatus was such that both shutters had to remain closed for two seconds while the cards bearing the words were changed. Consequently only a 2 second period was allowed with both the stimulus and response in view, so that the seven seconds from the appearance of one stimulus to the appearance of the next stimulus was as close as possible to the 6 seconds required for the memory drum. There was a 14 second interval between trials.

Any possible differential effects of the two machines were counterbalanced by having half the Ss in each condition learn the first list on the memory drum, and half on the card master.

Warm up materials- The warm-up lists were similar to those used by Thune (1958). The stimulus which appeared alone during the anticipation (guessing) period was a straight horizontal line, 1 inch in length. The " response" which was to be guessed was one of five geometric figures- a circle, square, diamond, cross, or triangle.

The warm-up list for the memory drum was drawn in dark blue ink on a roll of white paper similar to that which the original learning lists were on. The warm-up lists for the card master were drawn on the same type of sticky paper mounted on similar plastic cards to the ones used for the original lists. The Ss who had learned list E1 on the card master again had a brown line across the top of the paper strip during WU, while the Ss who had learned list E2 on the card master again had a yellow strip.

Whether warm-up was administered on the card master, or on the memory drum, an attempt was made to duplicate original learning procedure for that machine as closely as possible. To this end, anticipation intervals, learning intervals, intertrial intervals, and number of pairs in each trial of guessing were the same as for original learning on that machine.

Ss in the groups having warm-up relevant to neither list (control groups) were taken to a different room for guessing. The warm-up materials for this condition were drawn in blue ink on green cards 6 inches x 2 inches with the straight horizontal line on one side of the card, and one of the five geometric figures on the other side. No machine was used for presentation. The experimenter merely covered each geometric figure with his hand until a guess was made. No attempt was made to control either anticipation or exposure time, and the cards were presented continuously, with no division into trials.

Recall materials- For MMFR, the Ss were presented with each common stimulus in turn on either the memory drum or the card master. The memory drum recall lists appeared on a similar roll of white paper, the words were typed in the same color, and were the same size and case as were the words in the original memory drum list. For the card master lists, a similar attempt was made to reproduce the appearance of the original stimuli as to size, case of type, and mounting. The color of the thin line across the top of the mounting paper was the same as that of the original list learned on the card master.

Design- The design was a 2 x 3 x 2 x 2 (Retention Interval x Warm-Up Machine x Recall Machine x List) factorial. The first three variables were between Ss effects. The two retention intervals were zero and twenty-four hours. The three warm-up conditions were warm-up relevant to List I (WU I), warm-up relevant to List II (WU II), and neutral warm-up (WU III). The two recall machine conditions were recall machine relevant to List I, and recall machine relevant to List II. The list effect was a within Ss effect since in MMFR the Ss are asked to recall the responses from both lists when the common stimulus is presented. Thus the two list conditions are List I recall and List II recall.

Subjects- The Ss were 144 male and female students at the University of Manitoba who were enrolled in Introductory Psychology, and were taking part in the experiment as part of a course requirement. 12 Ss were assigned randomly to each of the 12 experimental groups. None of the Ss had previously taken part in a verbal learning experiment, and all were naive concerning the purpose of the investigation.

An S was arbitrarily dropped from the experiment if he failed to give at least one correct anticipation during the first 5 trials of List I learning, or if learning of List I was not completed by the twenty-fifth trial. As a result of these restrictions 4 Ss were dropped and replaced by the next Ss tested. Three Ss failed to return for recall after 24 hours, and were also replaced.

Procedure- The S was seated in front of a table with a large white cardboard screen mounted on it, through which one of the two machines projected. The experimenter sitting behind the screen was hidden from S's view during testing with the memory drum. During testing with the card master, the experimenter sat at a desk behind S.

The S was first instructed in this way:

> " What I want you to do is to learn to associate pairs of words. Two words will appear together in the window of this machine, and you have to learn to associate this pair so that when the first word appears alone, you can name the second word. For example, " glossy" might appear alone, and then " glossy-tiresome". The next time you see " glossy", you would have to call out " tiresome". The first word will

always appear alone before the second word, and you have to name the second word before it actually appears. I'll give you some practise with pairs of numbers just to be sure you know what you're doing. On the first time through the list you won't be able to name any of the second numbers before they appear, because you haven't seen the pairs before. On the second time through the list, when you see the first number of a pair, try and remember the second number of a pair and call it out."

S was then given practise on a list of seven paired numbers, with two digit numbers as stimuli, and single digit numbers as responses. Practise was always given on the machine on which List I was to be learned. As soon as S had given a correct anticipation to demonstrate understanding of the procedure, practise was discontinued. No S required more than three trials to accomplish this objective.

Following usual paired-associate instructions, (see Appendix A), the first list was learned to a criterion of one errorless trial. Then after additional instruction (see Appendix A), the other machine with the second list to be learned was placed in front of S. The second list was also learned to a criterion of one errorless trial. The Ss in the 24 hour condition were then instructed to return the next day about the same time, and were asked to try to avoid thinking about the experiment during the interim.

The experimental Ss in immediate retention conditions were given immediate warm-up either on the machine relevant to List I, or to List II. The control Ss were taken into another room and given a neutral guessing experiment as previously described. The procedure was the same for Ss in the 24 hour condition, when they returned for warm-up and recall. An attempt was made to make the warm-up experiment as meaningful to S as possible. With this object in mind, the following instructions were given:

" Now we are going to do something a little different. In every case, a straight horizontal line will be shown to you alone, and then it will be shown to you paired with one of these five geometric figures on this paper (S is given a paper). The task is to guess which of these five figures you think will come up paired with the straight line, every time you see it alone. There is no learning or memory involved, since the figures come up in completely random order. This is being done to determine if there is such a thing as individual differences in luck. By chance you should guess 2 out of 10 correctly. However some people consistently get a lot more correct, and we are trying to find out how general this ability is. So let's see how lucky you are."

After S had been given five trials of warm-up, the machine for recall was placed in front of him, and he was told:

" Now I am going to show you a list composed of just the first words from the lists you learned earlier (yesterday), the words that were common to both lists. When you see each of these words, I want you to try and tell me both of the words that went with it if you can. I'll give you as much time as you need to remember both words. You don't have to give them in the order you learned them; rather give them in the order they occur to you. You'll have as much time as you need, but give them as quickly as you can.

Each stimulus word was presented to S, and remained in his sight until he had either given two responses, or professed ignorance of any more responses. If he had given no responses by the end of fifteen seconds, he was asked whether he remembered any words for that word showing. S saw each stimulus only once, but was allowed to change his mind about a response given earlier, if he so desired. S was then dismissed from the experiment, after a request was made not to discuss the experiment with any friends that might be subjects.

CHAPTER III

RESULTS

ORIGINAL LEARNING

The number of trials required by each group to reach criterion in learning each list is shown in Table II.

TABLE II

Mean trials to criterion for each experimental group

Ret. Interval	0						24					
WU Machine	I		II		III		I		II		III	
Recall Machine	1	2	1	2	1	2	1	2	1	2	1	2
List I	11.0	10.8	9.1	11.9	11.0	10.3	10.2	10.8	10.3	10.7	10.4	11.2
List II	9.4	9.3	9.5	10.3	9.1	9.1	9.8	10.0	9.3	10.2	10.8	8.5

An analysis of variance of these learning scores is shown in Table Ia of Appendix B. The only significant F-value is the list main effect, resulting from faster learning of the second list. As can be seen in Table II, only two groups do not show this positive transfer.

The extremely small F's for the Between S conditions are due to precautions taken to insure equal learning speed across groups. Toward the end of the experiment Ss were assigned to groups on the basis of their original learning scores, to insure that original learning speed would not vary significantly across groups.

RECALL

Table III shows the mean recall scores for each group.

TABLE III

Mean scores on MMFR

Ret. Interval	0						24					
WU Machine	I		II		III		I		II		III	
Recall Machine	1	2	1	2	1	2	1	2	1	2	1	2
List I	8.58	6.80	7.58	7.50	8.00	7.75	7.75	7.16	7.58	7.50	7.50	8.00
List II	9.00	8.91	9.33	9.58	8.50	9.33	8.08	6.91	7.16	7.91	7.50	8.16

The analysis of variance for these data is shown in Table IIa of Appendix B. Unfortunately the adjustments made to insure equal original learning speed across groups were later found to produce an inflated estimate of the Between Ss error term for recall, since speed of original learning is positively correlated with amount recalled (Cochran and Cox, 1950, Pp. 305-6). This accounts for the inordinately small F-scores for some of Between Ss comparisons. An analysis of covariance, to adjust for the effect of original learning was carried out, but the change in the Between-Subjects error term was only slight (Table IIIa, Appendix B), and there was no noticeable rise in the low F-values. Since the Between-Subjects error term is still inflated in the analysis of covariance, it cannot be ascertained whether any of the non-significant F's might rise to a significant level if an unbiased error estimate was obtained. However, significant Between Subjects F's would still be significant.

A graphical representation of the List x Retention Interval interaction is shown in Figure I. As the Figure shows, the interaction is due to the falling off of List II retention with time, while List I retention remains relatively constant. Thus the usual time effect, the superiority of List II at immediate recall, and the gradual equating of the two list strengths over time, is demonstrated. However it should be noted that there is no evidence for absolute recovery of

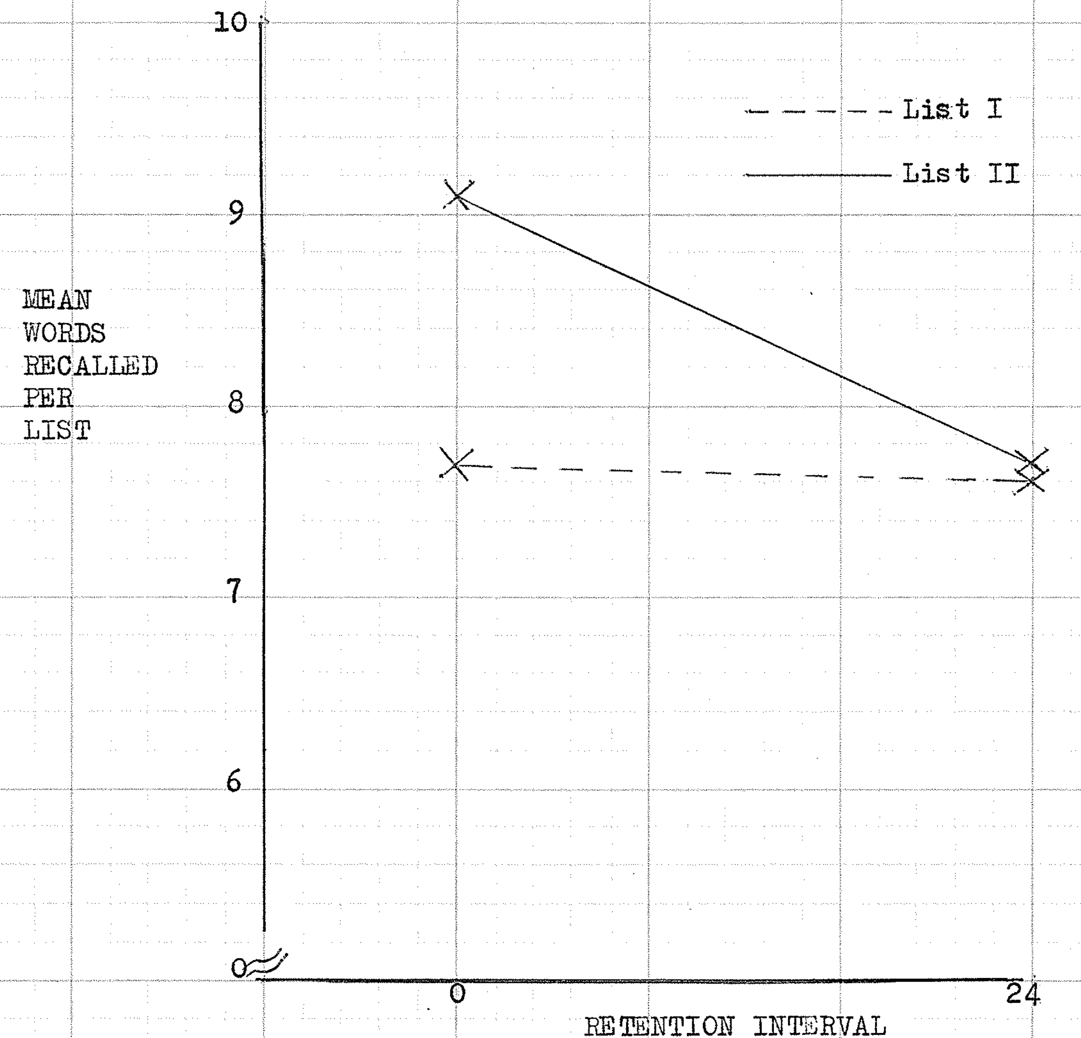

Figure I: Change in List I and List II retention as a function of time.

List I at the longer retention interval. This finding supports an MMFR study by Koppenaal (in press), which also shows no evidence of absolute recovery when the two lists are learned to the same criterion.

The graphical representation of the Warm-Up x Recall interaction is shown in Figure II. The interaction is produced largely by the sharp drop in retention for groups given warm-up relevant to List I, when the recall machine is changed from List I-relevant to List II-relevant. Both the group having warm-up relevant to List II, and the group having warm-up relevant to neither list, show a <u>rise</u> in overall retention with the same change in recall machine relevancy.

Figure III shows the List x Recall Machine interaction graphically. This interaction is produced by a rise in List II retention, and a corresponding drop in List I retention, when the recall machine is changed from List I-relevant to List II-relevant.

As an addition to the availability results presented above, Table IV shows for each group, the percentage of times second list responses were given first when <u>both</u> responses were given correctly.

TABLE IV

The percentage of times a second list response was given first, when both responses were given correctly

Retention Interval	0						24					
WU Machine	I		II		III		I		II		III	
Recall Machine	1	2	1	2	1	2	1	2	1	2	1	2
Percentage	43	58	50	59	39	53	38	47	29	40	26	37

As the table shows, changing the list relevancy of WU does not seem to change the tendency to give a response first from one list or the other. On the other hand, there is a pronounced recall machine effect. The percentage of second list responses given first rises notably when the recall machine relevancy is shifted from List I to List II, regardless of other conditions.

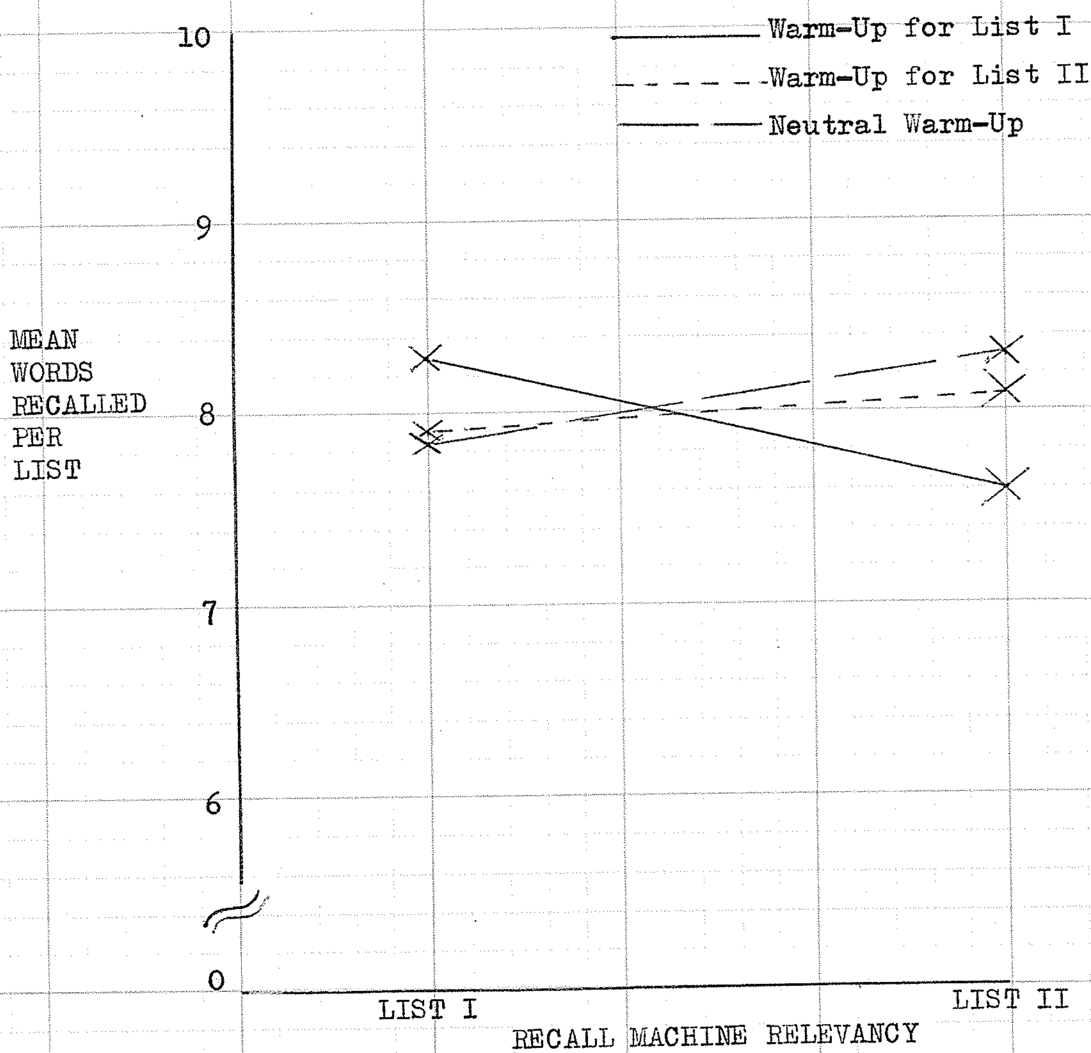

Figure II: Overall retention as a function of warm-up relevancy and recall relevancy, ignoring list and retention interval.

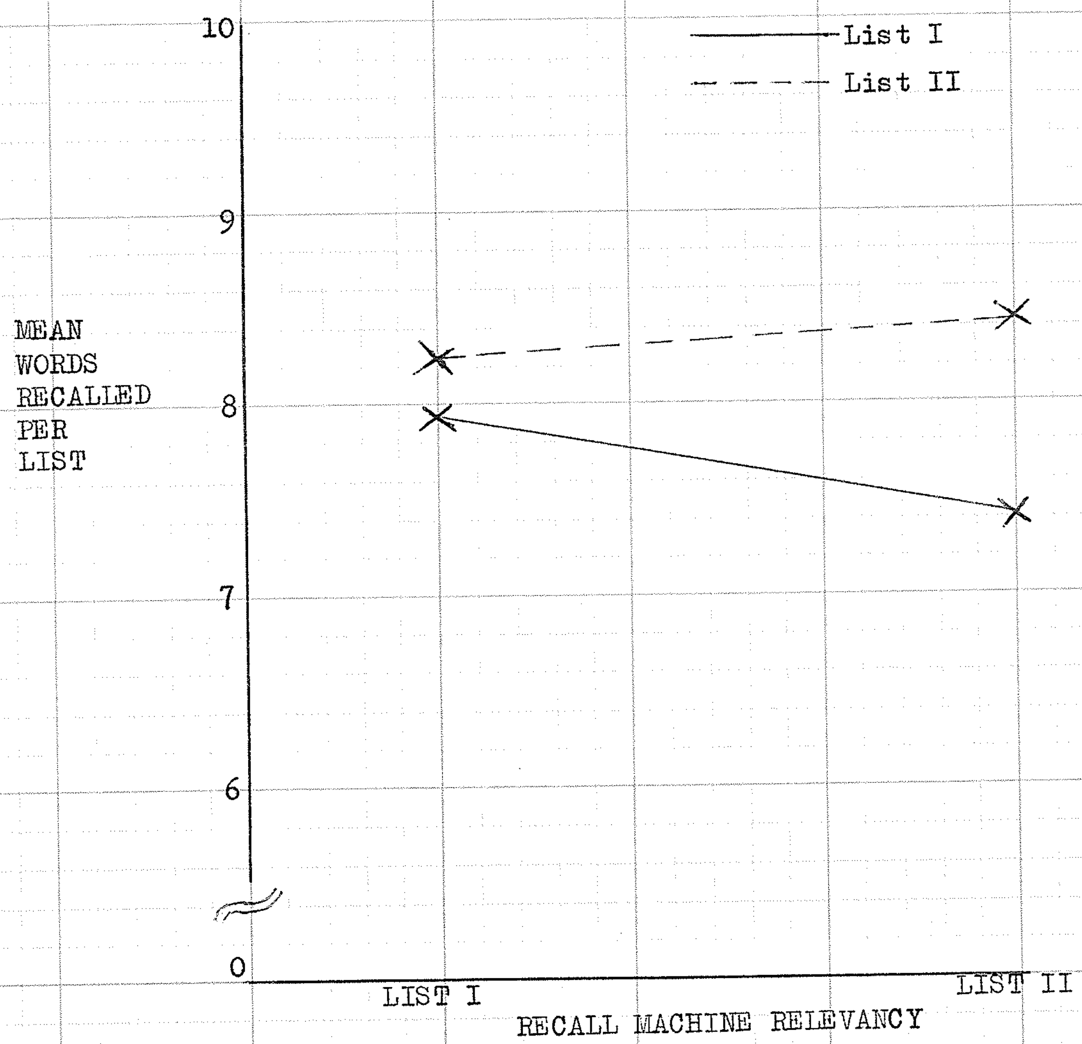

Figure III: Change in List I and List II retention with changing relevancy of recall machine.

CHAPTER IV

DISCUSSION OF RESULTS

The original hypothesis was that the usual time effect, the equating of first and second list retention over time, might be demonstrated at shorter intervals by the restoration of the set to give first list responses. Confirmation of this hypothesis would lend support to the notion that the time effect is at least partially due to the gradual equating over time of the sets for the two lists.

In general, the set explanation leads to the expectation that List I retention should be enhanced when set activities are relevant to List I, and List II enhanced when these conditions are relevant to List II. Furthermore, it might be expected that set activities relevant to List I would have a more pronounced effect on the relative strengths of Lists I and II at immediate recall. At this interval the set for List II should be very strong, and the set for List I depressed. Therefore WU relevant to List I might be expected to have a greater beneficial effect on restoring List I set, and might also interfere with the dominant set for List II. At twenty-four hours the sets for the two lists are presumably equal; neither list is either dominant or depressed. Consequently List I recall should still be enhanced by relevant WU, but probably to a more moderate degree. However List II recall should now be relatively unaffected, and might even, as Thune's (1958) evidence suggests, be improved slightly.

On the other hand, set activities relevant to List II might be expected to have a more pronounced effect at twenty-four hours. At immediate recall List II has just been learned, and consequently the set for it should be strong. Set activities could probably not appreciably enhance this dominant set. However, GRC explanations predict that this initially dominant set should be somewhat weakened over the retention interval. Thus this list should probably be more amenable to beneficial set activities after an extended rest interval.

First of all, it will be noted that in this experiment WU has not noticeably enhanced recall for the relevant list at either immediate or twenty-four hour recall. The lack of any significant WU effects at the latter interval is in conflict with Thune's findings. The explanation of this result that seems most feasible is that the use of MMFR has lessened the importance of set factors. In MMFR, it will be remembered, the subject has an extended anticipation period. Possibly differential set factors are only effective when the subject must respond quickly, as is the case in ordinary recall. With more leisurely recall, the set for a certain list may become less important, as the S becomes aware of the particular stimulus environment independent of past stimulation.

It might be expected however, that if leisurely recall was the reason for the absence of WU effects on response availability, WU would still produce a tendency to give the relevant response first. Table IV shows that changing the relevancy of WU does not change the tendency to give a response first from a given list. Therefore it seems doubtful that the use of MMFR is responsible for the abscence of WU phenomena at recall.

It would appear then, that contrary to Thune's results, WU has not served to manipulate list sets since there is no evidence either that WU has enhanced recall for the relevant list or depressed recall for the irrelevant list. It is conceivable however that the recall machine might produce a set for the relevant list. Thus any meaningful recall machine effects could be interpreted in set terms. As pointed out previously, however, such effects are not incompatible with specific response competition theory, and can by no means be regarded as conclusive support for set interpretations.

The significant List x Recall Machine interaction demonstrates the same phenomenon that Bilodeau and Schlosberg (1951) discovered, i.e. when recall factors are relevant to one list and irrelevant to the other, then recall for the relevant list is enhanced. Figure II shows that in the present experiment, when the recall machine relevancy is changed from List I-relevant to List II-relevant, then List II recall rises and List I falls. Although the List x Retention Interval x Recall Machine interaction is not significant, this recall machine effect on list dominance does seem to be more pronounced at immediate recall (Table III). More specifically, groups 24, III, 1 and 24, III, 2 (where the first number refers to retention interval, the second to warm-up relevancy, and the third to recall machine relevancy) do not show any shift in individual list dominance. On the other hand, groups 0, III, 1 and 0, III, 2 do show quite a pronounced shift in list dominance. The former group shows almost no difference in recall between the first and second lists, while the latter group shows much better retention for the second list. Since WU is not a factor in the above four groups, it appears that these groups represent a close approximation to the Bilodeau and Schlosberg experiment, with the addition of the twenty-four hour retention groups. This being the case, the above results suggest that their effect is applicable to short retention intervals, but is perhaps entirely absent at twenty-four hour recall. As pointed out in Chapter I, their results are compatible with either specific response competition or set interpretations. The fact that it may be limited to short retention intervals fits in with a set interpretation of their finding, since for reasons outlined above, variables which are manipulating set would be expected to have a more pronounced effect at immediate recall.

The recall machine appears to be having other effects as well. At immediate recall the two groups showing equal first and second list recall are groups 0, I, 1 and 0, III, 1. Were it not for the fact that group 0, II, 1 does show the usual immediate recall result, the unlearning of List I, we could state that the time effect has been reproduced at immediate recall by use of the recall machine relevant to List I. However since this group does show a good deal of unlearning, and since we cannot attribute this unlearning to the WU relevant to List II (WU being apparently so ineffective in producing any meaningful effects elsewhere), we must allow that the list equating shown by the two previously mentioned groups may be due to chance.

In brief then, the present experiment has presented some evidence in favour of a set interpretation of the time effect, but has by and large found little to support such an interpretation. First of all, WU has had no meaningful effect at either immediate or, (in conflict with Thune's results) twenty-four hour recall. This suggests that either WU does not serve to manipulate set at recall or set is not as important at recall as has previously been thought. The recall machine has had some effect, particularly at immediate recall. If the recall machine has its effect on set factors, then it would appear that set is having an important effect, and is likely involved in producing the time effect. But the recall machine could be having its effect through specific S-R connections, if machine cues form part of the actual stimulus situation to which each response is attached. Therefore recall machine effects cannot be presented as conclusive evidence for either a set or specific response competition explanation of the time effect. We now pass on to consider an incidental finding of the study, which perhaps has more constructive implications.

The significant Recall Machine x Warm-Up Machine interaction shown in Figure II, is due almost entirely to lower retention by the Warm-Up I, Recall 2 groups, at both retention intervals and for both lists (see Table IV). That this particular condition should result in lower recall is difficult to explain within the framework of existing theories. The hypothesis that seems most suitable is what we have chosen to call a " Confusion Effect." Referring to the experimental procedure, it will be noted that a Warm-Up I, Recall 2 subject is having more shifting of machines take place in front of him than is any other subject. He sees machine 1, then 2, then machine 1 again for warm-up, and then machine 2 again for recall. Possibly he becomes confused with all the experimental manipulation, and overall retention is depressed.

As support for this interpretation, Table V shows the average recall of all Warm-Up x Recall groups, and the number of machine shifts each group experienced. A removal from the experimental situation (i.e. WU III) is not considered a shift in terms of machines used in list learning.

TABLE V

Average recall and number of machine shifts for each Warm-Up x Recall group

Warm-Up Machine	Recall Machine	Mean Recall	No. of Shifts
I	1	8.3	2
I	2	7.6	3
II	1	7.9	2
II	2	8.1	1
III	1	7.9	2
III	2	8.3	1

The Pearson Product-Moment Correlation Coefficient between mean recall and number of machine shifts is $-.76$ ($\underline{p} < .05$). Thus recall seems to have varied inversely with the " confusion" of the particular condition, although it should be noted that the differences are small.

As a tentative theoretical interpretation of these findings, it may be helpful to regard the typical verbal learning situation as a figure-ground complex. The actual words compose the figure that is to be learned and recalled. The environmental context, especially the machine used for presentation forms the ground, which is irrelevant to the actual experimental task. Continual shifting may emphasise the ground factors, thus lessening the figure-ground dichotomy. In a sense, the background becomes part of the to-be-recalled figure; now a more complex figure must be recalled. The result is overall diminished recall.

It must be allowed that this interpretation of the confusion phenomenon is based on very little experimental evidence, and a large amount of conjecture. Its verification or rejection will have to await more investigation.

CHAPTER V

SUMMARY AND CONCLUSIONS

It is commonly found in verbal studies of retention that, when two lists are learned, the second is stronger at immediate recall, but the lists are of equal strength at longer intervals. This time change in relative list strength has previously been attributed to either recovery of the first list, or to greater relative loss of second list strength over the extended rest interval. The present investigation was designed to see whether this time change could be due instead to changes over time in the relative strengths of the sets for the two lists. While the set for the second list should be stronger at immediate recall, there might be no dominant set for either list after an extended rest interval, resulting in equal list strengths. It was hypothesized that this time effect might be reproducable at immediate recall by the use of Warm-Up (WU) related to the first list. This warm-up would supposedly restore the set for the first list to the point where there would be no dominant set for List II. If this equating of list sets at immediate recall resulted in equal list recall, then the set explanation of the time effect would be much strengthened.

All subjects learned two lists of ten paired-adjectives, conforming to the A-B,A-C paradigm; however the two lists were learned on different machines. Recall, given to half the Ss immediately and half after twenty-four hours, consisted of presenting each of the common stimulus words and instructing S to give both the first and second list responses that went with it. Further, S was allowed up to one minute to give these responses. This procedure has been called Modified-Modified Free Recall (MMFR). Just prior to recall experimental Ss were given a warm-up guessing experiment on either the machine used for the first or the second list, in order to restore the set for the list learned on that machine. Recall was also given on a machine relevant to either the first or second list. Control groups at both retention intervals had warm-up relevant to neither list, but still had recall relevant to a specific list.

If the set explanation was tenable, it was hypothesized that equating of absolute recall for the two lists should appear at immediate retention when the sets for the two lists were equal. WU relevant to List I might restore the depressed set for List I and might also disturb the dominant set for List II, possibly to the point where the two list sets would be equal. At twenty-four hours there should not be a stronger set for either list. Therefore WU might enhance recall for the relevant list, but probably would not have marked destructive effects on recall for the irrelevant list.

The results showed that WU did not improve retention for the relevant list at either immediate or twenty-four hour recall. The recall machine did however improve recall for the relevant list. This machine effect was also more pronounced at immediate recall, although interaction with retention interval was not statistically significant.

It was also found that groups having more manipulation of learning apparatus during learning and recall showed depressed recall of both lists and at both retention intervals. This result was attributed to a lessening of the figure-ground dichotomy inherent in the usual verbal learning situation, where the actual words that are to be associated would be the figure, and the experimental context, including the learning machine, would be the ground. It was suggested that continual manipulation of these background factors might make them more prominent, thus increasing the complexity of the figure that is to be remembered.

It was concluded that some limited support for a set interpretation of the time effect had been obtained, but that on the whole the experimental findings did not warrant such an interpretation. The lack of any WU effect suggested that either WU did not serve to manipulate list sets, or that differential set was not as important a factor at recall as had been suggested. The recall machine effect gave some limited support to the set interpretation, but it was pointed out that recall machine could conceivably be a part of the stimulus complex for each S-R connection. Therefore improved recall with relevant machine would also be predicted by specific response competition explanations of the time effect, and could not be presented as conclusive evidence for the set explanation.

APPENDIX A

INSTRUCTIONS FOR FIRST LIST LEARNING

" Now I will show you the word pairs you have to learn. As in the practise list there is no rhyme or reason to the way these words are paired. This is straight memory. You just have to learn to associate the correct second word with each first word. Most of these words should be familiar to you. If a word isn't familiar, just pronounce it as well as you can. There are ten pairs of words in the list, and we keep going through the list until you anticipate all the second words correctly on one trial. But don't wait until you know all the words before you start naming any, and continue giving a correct response even though you gave it correctly on a previous trial."

INSTRUCTIONS FOR SECOND LIST LEARNING

" Now you have to learn another list. This list has the same first words as the list you just learned, but it has different second words, so you have to learn to put new second words with the same first words."

APPENDIX B

TABLE Ia

ANALYSIS OF VARIANCE FOR ORIGINAL LEARNING

Source	df	ss	ms	F
Between Ss	143	4072		
Retention Interval (I)	1	1.13	1.1	
Recall Machine (R)	1	4.50	4.6	
Warm-Up Machine (W)	2	.97	0.5	
I x R	1	1.39	1.3	
I x W	2	1.51	0.8	
R x W	2	40.69	20.4	
I x R x W	2	10.63	5.3	
Error (b)	132	4011.17	30.4	
Within Ss	144	905		
List (L)	1	76.06	76.0	11.0***
L x I	1	2.20	2.2	
L x W	2	8.79	4.4	
L x R	1	10.12	10.1	
L x R x W	2	3.78	1.8	
L x R x I	1	1.69	1.7	
L x I x W	2	5.04	2.5	
L x R x I x W	2	32.81	17.2	2.5*
Error (w)	132	763.33	6.9	
Total	287	4977		

***$p < .001$

*$p > .05$

TABLE IIa

ANALYSIS OF VARIANCE FOR RECALL (MMFR)

Source	df	ss	ms	F
Between Ss	143	425		
Retention Interval (I)	1	46.72	46.72	18.0***
Warm-Up Machine (W)	2	2.14	1.07	0.4
Recall Machine (R)	1	0.50	1.50	0.2
I x W	2	1.60	0.80	0.3
I x R	1	0.89	0.89	0.3
R x W	2	24.40	12.20	4.7**
I x R x W	2	0.08	0.04	0.02
Error (b)	132	348.67	2.60	
Within Ss	144	375		
List (L)	1	39.01	39.01	18.31***
L x I	1	33.35	33.35	15.65***
L x W	2	1.98	0.96	.45
L x R	1	6.13	6.13	2.86
L x R x W	2	0.01	0.01	.00
L x R x I	1	4.01	4.01	1.87
L x W x I	2	2.95	1.47	.69
L x R x I x W	2	6.40	3.20	1.50
Error (w)	132	281.16	2.13	
Total	287	800		

***$p < .001$
**$p < .025$

TABLE IIIa

ANALYSIS OF COVARIANCE OF ORIGINAL LEARNING AND RECALL

Source	df	ss Recall	ss xy	ss OL	ss	ms	F
Between Ss	143	425.00	-317.50	4071.99			
Ret. Interval (I)	1	46.72	-7.25	1.13	45.62	45.62	18.40***
Recall Machine (R)	1	.50	-1.50	4.50	.30	.30	.12
WU Machine (W)	2	2.14	-0.88	.97	2.01	1.01	.40
I x R	1	.89	-1.11	1.39	.73	.73	.29
I x W	2	1.60	+1.55	1.51	1.85	.93	.37
R x W	2	24.40	+0.50	40.69	24.72	12.36	4.98**
I x R x W	2	.08	-0.77	10.63	.03	.02	.00
Error (b)	132	348.67	-308.04	4011.17	325.01	2.48	
Within Ss	144	375.00		905.00			
List ($\overline{L}$)	1	39.01	-54.47	76.06	62.70	62.70	34.45***
L x I	1	33.35	-8.17	1.99	37.22	37.22	20.45***
L x W	2	1.98	+4.12	8.79	.53	.26	.14
L x R	1	6.13	-7.88	10.12	10.28	10.28	5.65*
L x I x W	2	2.95	+2.89	5.04	1.87	.94	.51
L x I x R	1	4.01	+2.60	1.69	2.88	2.88	1.58
L x W x R	2	.01	-0.27	3.78	.35	.18	.10
L x W x R x I	2	6.40	+7.64	32.81	4.63	2.32	1.27
Error (w)	132	281.16	+180.04	763.33	238.69	1.82	
Total	287	800.00	-191.00	4976.99			

***$p < .001$

**$p < .01$

*$p < .025$

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