SHORT-TERM REDUCTIONS IN RETROACTIVE INHIBITION AS A FUNCTION OF UNREINFORCED RECALL

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By

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ABSTRACT

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It has been proposed that two factors contribute to retroactive inhibition: competition and unlearning. Competition refers to the competition between one or more responses at the time of recall. Unlearning is considered to be measured on unpaced tests of recall such as modified-modified free recall (MMFR) where competition effects such as confusion between lists and temporary dominance of incorrect responses are minimized.

At present, the most prevalent view of unlearning holds that it is an extinction-like phenomenon resulting from the nonreinforcement of incorrect overt and covert first-list intrusions during second-list learning. The present experiment was aimed at determining the effect of further nonreinforcement following second-list learning on unlearned associations.

All learning material consisted of eight-item nonsense syllable-adjective paired-associate lists. Lists were learned by the anticipation method at a

2:2 second rate of presentation with a four-second intertrial interval. First-list learning criterion was 7/8 correct responses in a single trial. A second list was presented to interpolated learning (IL) work groups for 14 anticipation trials. Conventional single-list control subjects spent a period of time equivalent to that required for IL on an irrelevant digit cancellation task.

The basic design was a 3 x 4 factorial ($\underline{n}$=24 per cell) with three paradigms (Control, AB-AC, and AB-DC) and four post-IL treatments. Two transfer paradigms that yield unlearning were used: AB-AC (identical stimuli, different responses and AB-DC (different stimuli, different responses). All subjects received a written unpaced MMFR test after one of four types of post-IL treatments. Two post-IL conditions consisted of unreinforced recall of the first list. Two other conditions did not require recall of the first list prior to MMFR. Specifically, 12 unreinforced paced recall trials were administered prior to MMFR in the Paced condition. A second unreinforced recall condition, Self-Paced, was identical to the Paced except that recall (exposure of stimulus terms) was subject paced. Self-paced recall continued for the amount of time taken up by the 12 paced recall trials (7.13 minutes). In order to determine the effect of time per se on later MMFR, a

third group spent 7.13 minutes on an irrelevant task prior to recall (Time condition). A fourth condition was used to determine the amount of unlearning produced by the materials and procedure of the experiment under standard immediate MMFR conditions (Immediate).

The main results from self-paced and paced recall were that the two forms of unreinforced recall yielded equivalent amounts of retention when they were each considered as a single test for a given subject and that all paradigms showed improvements in recall over the 12 paced recall trials, work conditions improving more than controls. These results were viewed as reflecting (a) the accumulation of recall time in paced recall which reduced pacing decrements in all paradigms and (b) decreased competition in work groups over paced recall.

The results from MMFR for first-list recall indicated that (a) the simple effects of time taken up by unreinforced recall had no effect on recall (b) self-paced and paced recall did not substantially differ in their effects and (c) unreinforced recall improved recall in both work paradigms but not in the control condition.

Several interpretations were offered for the reduced unlearning that was attributable to unreinforced recall.

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INTRODUCTION

The present study was concerned with the "fate" of first list associations during second list practice in two transfer paradigms. The problem of the effect of second list practice on first list associations is illustrated most clearly in the context of the interference theory of forgetting (Postman, 1961). We will first discuss laboratory procedures and terminology employed in the study of the above problem. Then the general tenets of interference theory will be stated and, finally, more specific background of the present investigation will be discussed.

Retroactive Inhibition, Proactive Inhibition, and Transfer Paradigms

A common method used in laboratory investigations of forgetting involves having subjects (*S*s) learn two lists of verbal material after which, retention of one or both lists is measured. Decrements in retention of the first list that are attributable to interpolation of the second list are called retroactive inhibition (RI); decrements in retention of the second list attributable to learning of the prior first list are called proactive inhibition (PI). Estimates of RI and PI require reference to a control group that gets an appropriate interval of irrelevant activity instead of the second list or first

list, respectively (Slamecka & Ceraso, 1960).

The most prevalent learning task in the area of RI and PI research is that of paired-associate learning. If the stimulus (A) and response (B) of first-list pairs are designated AB, various transfer paradigms can be indicated be depicting the relationship of second list stimulus-response pairs to the first list pairs. For example, AB-AC indicates identical stimuli but different responses in the two lists; AB-DB, identical responses but different stimuli; and AB-DC, different stimuli and different responses in both lists. AB-ABr indicates identical stimuli and responses in both lists, but different pairings (re-paired).

<u>The Interference Theory of Forgetting</u>

Interference theory today is an elaboration and extension of the competition-of-response-at-recall (or reproductive inhibition) theory advocated by McGeoch (McGeoch, 1932; McGeoch, 1942). According to McGeoch's formulation, original learning (OL) response tendencies retain their strength during interpolated learning (IL). In the case of the AB-AC paradigm, AB is not weakened in any absolute sense as a result of AC interpolation. Barnes and Underwood (1959) have called this the independence hypothesis. Since OL is not weakened, RI is a function of the degree of response competition at the time of recall; the stimulus at recall elicits competing responses (e.g., B and C), the stronger of which is given.

If B is stronger, it is given and scored as a correct recall. On the other hand, if C is stronger than B, C is given ("winning out" in the competition) and a retention loss is manifested. If no response is given, this is viewed (a) as the result of a mutual blocking out of responses that are of nearly equal strength or (b) because of an implicit intrusion whereby an incorrect response occurs to S but is recognized as incorrect, hence inhibited. Thus all decrement resulting from IL is thought of as the result of response competition occurring at the time of recall (reproductive inhibition) with no weakening of OL response tendencies implied. Similarity of the conditions of learning (context, learning method) and of the materials in OL and IL tends to result in competition.

One explicit prediction that can be made from McGeoch's competing response theory is that amount of RI should be positively related to the number of overt inter-list intrusions at recall. To test this, Melton and Irwin (1940) varied the number of IL repetitions (trials) in the anticipation learning of serial lists. As McGeoch (1932) had found earlier, RI increased initially with the number of IL trials then leveled off and showed a tendency to drop slightly at the highest IL level (40 trials). However, the number of IL intrusions at recall failed to correspond to the degree of RI across levels of IL, first increasing then greatly decreasing. In view of

the lack of correlation between amount of RI and overt interlist intrusions, Melton and Irwin postulated that another factor or process, in addition to competition, was involved in RI. They called this factor "Factor X" and tentatively suggested it was the weakening or unlearning of OL response tendencies during IL and that it might be analogous to experimental extinction in classical conditioning. Their basis for suggesting that Factor X was perhaps analogous to extinction of OL responses was the observation that first list responses were sometimes given during IL. These interlist intrusions in IL are incorrect; hence are not reinforced and may even be implicitly punished. Thus with Melton and Irwin's postulation of unlearning, RI is viewed as a result of competition occurring at two points in time (two-factor theory): (a) during IL (unlearning) and (b) at the time of recall (McGeoch's competition-at-recall).

While two-factor theory states that RI is a combination of the operation of two factors, it is readily seen that PI can be attributed only to competition. Melton and von Lackum (1941) tested the prediction that RI should be greater than PI when practice on the interfering lists is equal. After giving an equal number of trials on two lists, half of the <u>S</u>s underwent testing on the first list (estimating RI), the other half being tested on the second list (PI). On the first relearning trial, twenty minutes after second list learning, RI was

greater than PI, confirming the prediction from two-factor theory.

Melton and Irwin's Factor X was an empirically derived curve that resulted when RI attributable to partial and complete interlist intrusions was taken out of total RI. Thune and Underwood (1943) soon showed that it was not advisable to attribute all of Factor X to unlearning. These investigators studied RI of paired-associates (AB-AC) as a function of degree IL. Retention was measured by relearning trials following IL. Consistent with the results of Melton and Irwin (1940), RI increased as number of IL trials increased. However, if Factor X ("the other-than-competition factor," Melton, 1961) is viewed solely as unlearning, Thune and Underwood's obtained curve forces rather "incongruous psychological properties" on unlearning. Specifically, X decreased from two to ten IL trials, then increased drastically at twenty IL trials. With the introduction of the concept of differentiation (ability to discriminate list membership) to handle the decline in overt intrusions at recall with high levels of IL, unlearning needed to account for only the portion of RI not attributable to intrusions (Thune & Underwood, 1943; Melton, 1961). That is, list differentiation should increase with degree of practice on either list (Underwood, 1945) and decrease with increases in the learning-recall interval (Underwood, 1949). What this means is that at high levels of IL, intrusions are

easily discriminated as incorrect and are simply not given.

Underwood (1945, 1950a, 1950b) actually considered the possibility that all RI is a result of competition at recall. If the lack of relationship between total RI and number of overt intrusions obtained at high degrees of list differentiation (e.g., high levels of IL) is caused by implicit intrusions at recall, extending the recall anticipation interval (usually two seconds) might allow S both to reject the erroneous response and verbalize the correct response, resulting in a decrease in RI at high levels of IL. However, extension of the anticipation interval to eight seconds did not produce the above effect, supporting the unlearning hypothesis (Underwood, 1950a; Underwood, 1950b).

Thus far, we have discussed three factors hypothesized as influencing retention in retroactive and proactive designs: competition at recall, unlearning, and differentiation. Now, the unlearning assumption will be considered with regards to measurement techniques, implications, and available data.

The first retention method employed to rest the unlearning hypothesis with the effects of differentiation removed was the modified free recall (MFR) technique (Underwood, 1948; Briggs, 1954). Prior to the introduction of MFR, recall was estimated from relearning trials (including the first trial) administered after IL.

However, with the conventional relearning technique the consequences on recall of differentiation and unlearning (associative strength) are confounded. The stimulus may elicit two responses in competition and degree of competition is a function of differentiation. Since response dominance is viewed as the index of associative strength and response dominance is a function of the relative strength of the competing responses, response occurrence will be influenced by the degree of differentiation influencing competition. MFR permits an estimate of response dominance when S does not attempt to discriminate list membership. The common stimulus term (A) is presented and S is asked to give a response from either the first (B) or second (C) list.

Several experimenters found systematic changes in response dominance of AB-AC lists as a function of degree OL, degree IL, and retention interval that supported the general notion of unlearning. Underwood (1948) showed a convergence of first-and second-list responses over a 24 hour retention interval that was interpreted as possibly indicative of spontaneous recovery of unlearned or extinguished responses. Also, an increase in extralist intrusions was found, suggesting these responses were extinguished during OL and IL. Brigg's (1954) subsequent results lent support to Underwood's conclusions. While the results of MFR were interpretable in terms of two-factor theory, unlearning was not clearly demonstrated since Ss were asked to give either response so that an OL response that failed to occur at retention might, in fact, be available but interfered with by the stronger IL response.

Barnes and Underwood (1959) are generally regarded as being the first to provide conclusive evidence for unlearning. Following AB-AC learning with nonsense syllable stimuli and unrelated adjectives as responses, Ss were presented the eight stimuli and were given four minutes to write both the responses from the first list and from the second list (Modified-Modified Free Recall, MMFR). It is assumed that the effects of competition and differentiation are eliminated by this technique, thus providing a "pure" estimate of response availability. Following one perfect trial on OL, Ss began IL; different groups were stopped after one, five, ten, or twenty anticipation trials and given MMFR. Their results indicated a progressive decrease in the number of correct OL responses as trials on IL increased that could not be attributed merely to time spent in learning IL. This decrement in retention was viewed as substantial support for the unlearning of OL responses as a result of second list practice. Since 1960, considerable amounts of research have been directed to the problem of unlearning in the framework of two-factor theory. It is to these matters we now turn.

Three types of unlearning and other paradigms (McGovern). The most extensive investigation of unlearning was carried out by Barnes (1960) in her doctoral dissertation which was later published in Psychological Monographs (McGovern, 1964). McGovern postulated three types of associations in paired-associate learning which could be subject to unlearning: specific forward (S-R), specific backward (R-S), and contextual-response (X-R). These three associations can be related to the two-stage view of paired-associate learning (Underwood & Schulz, 1960; Underwood, Runquist, & Schulz, 1959) in which X-R associations determine response learning or availability and S-R and R-S associations determine the hook-up or associative stage. McGovern further hypothesized that unlearning would occur when any association in successive lists conformed to that of an AB-AC relationship. The above implies that specific associative unlearning can occur independently of decrements in response availability (response unlearning) and vice versa. Response availability was assumed measured by the total number of responses recalled, regardless of pairing, on MMFR. Specific S-R associative strength was considered to be measured on an S-R matching test where S was required to match first-list stimuli and responses. Since all stimuli and responses were made available to S on the matching test, any effects of response unlearning should have been eliminated. Keeping in mind that for backward associations, paired-associate responses can be viewed as functional stimuli and that for response learning the context is considered the functional stimulus, the following predictions regarding unlearning (the type and source of unlearning are indicated in parentheses, respectively) can be made for common transfer paradigms: AB-AC (S-R associative, AB-AC, and response, XB-XC); AB-DB (R-S associative, BA-BD); AB-ABr (S-R and R-S associative, AB-ABr and BA-BAr); AB-DC (response, XB-XC). McGovern used these four transfer paradigms and the MMFR and S-R matching retention tests in independent groups. Fifteen anticipation trials on IL were given following a perfect recitation of OL. Except for a few inconsistencies, her results largely supported the above predictions.

McGovern, in fact, did not require second-list recall on either MMFR (as Barnes and Underwood, 1959) or the S-R matching test. However, Houston, Garskof, Noyd, and Erskine (1965) found no differences in recall of either list of an AB-AC paradigm when conventional MMFR (both responses required) was compared to McGovern's MMFR (single-list response required).

Two experiments requiring first-list stimulus recall have further supported McGovern's analysis in addition to showing that first-list stimulus unlearning occurs in the AB-DC and AB-DB paradigms, presumably because of the XA-XD relationship between stimuli in successive lists (Keppel & Underwood, 1962; Houston, 1966b). Also, Ellington and Kausler (1965) demonstrated increasing unavailability of first-list stimuli as IL practice increased in the AB-DB paradigm and progressive decrements in AB matching as a function of degree IL appeared in an experiment by Garskof (1968). These latter two experiments extend the Barnes-Underwood effect to XA-XD and specific AB-AC associations, respectively.

The conditioning analogy. The most prevalent explanation for the unlearning phenomenon is that whenever stimuli and responses in successive lists conform to an AB-AC relationship, OL responses are overtly or covertly elicited during IL. These elicited responses are not reinforced, and are even "punished," resulting in extinction (Friedman & Reynolds, 1967; Goggin, 1967; Postman, Keppel, & Stark, 1965). Three basic types of experiments have been conducted to determine the validity of this analogy from studies of conditioning: (a) tests of the importance of elicitation in IL, (b) attempts to show spontaneous recovery, and (c) the manipulation of variables known to influence extinction in instrumental and classical conditioning situations.

Critical to the extinction analogy is the notion of elicitation of to-be-extinguished associations or responses in IL (the elicitation-extinction hypothesis). That is, any manipulations which increase the probability that elicitation will occur, should facilitate unlearning. Postman, Keppel, and Stark (1965) reasoned that if the response class was changed in AB-AC learning (e.g. adjectives-letters versus the usual adjectives-adjectives), elicitation of OL responses should decrease and less unlearning should be evident. Their results showed that while substantial amounts of response unlearning were found when the response class was the same, unlearning was significantly reduced when the response class was different in the two lists. Friedman and Reynolds (1967) have extended the finding of Postman et al. by demonstrating a gradient of unlearning in AB-AC as a function of response class similarity in that degree of unlearning declined across four decreasing levels of OL-IL response class similarity.

Also consistent with the elicitation-extinction hypothesis is Postman's (1965) study in which the number of IL lists was either none (control), 1, 2, or 4. The AB-AC paradigm was used and a total of 16 anticipation trials on IL was given. Some Ss learned a single list for the 16 trials (AC), others learned two lists (AC then AD), and others learned four lists with four successive trials on each. Postman found that as the number of interpolated lists increased, unlearning as measured by MMFR and S-R matching increased. These results were viewed as due to the lower dominance of IL as more were interpolated, allowing for increasing amounts of elicitation, hence unlearning. Goggin (1968) has recently varied IL dominance by alternating two IL (AC) lists 1, 3, 7, or 15 times. However, unlearning decreased as the number of alternations increased (IL dominance decreased). Also in conflict with the elicitation hypothesis, degree of unlearning was not related to the number of interlist intrusions during IL in Goggin's study. That is, interlist intrusions are viewed as overt representations of elicitation, hence unlearning should increase as the number of these intrusions increase.

Three other experiments are available which show failure of interlist intrusions (elicitation) to reflect amount of obtained unlearning in AB-AC situations. Keppel and Rauch (1966) and Houston and Johnson (1967) manipulated intrusions in IL by varying instructions regarding guessing. While guessing instructions increased the number of interlist intrusions in both experiments, degree of unlearning was virtually the same in guessing groups as in non-guessing groups (very few intrusions). In another experiment, number of interlist intrusions in IL (AC) was manipulated by either retaining some AB pairs in IL or by using the typical AC list where all pairs are AC ones (Paul & Silverstein, 1968). While significantly more specific interlist intrusions were given to AC pairs in lists with retained AB pairs as compared to lists with all AC pairs, significantly more unlearning was found with the list that produced fewer interlist intrusions in IL.

If the extinction analogy is valid, spontaneous recovery of extinguished associations should occur. Two types of recovery are possible, both requiring comparison of control and experimental groups that are tested following various retention intervals (Keppel, 1968). Relative recovery indicates less decrement with time in experimental groups than in controls. For relative recovery the experimental groups may show a decrease in retention over time but the controls show less of a decrement, i.e., control-experimental by retention interval interaction. Absolute recovery, also requiring an interaction, is an actual increase in retention by experimental groups over time. Absolute recovery on MMFR in AB-AC learning has been demonstrated by Adams (1962), Ceraso and Henderson (1965), Kammann and Melton (1967), Silverstein (1967), and, following sleep but not normal activity, Ekstrand (1967) over intervals ranging, in different experiments, from 16 minutes to 48 hours. Relative recovery, in the absence of absolute recovery, has appeared in the experiments of Birnbaum (1965) and Howe (1967). Abra (1967), Houston (1966a), Koppenaal (1963), Slamecka (1966), and Ceraso and Henderson (1966) all failed to find clear evidence for even relative recovery in the AB-AC paradigm on MMFR. Since MMFR is viewed as reflecting first-list response availability, it must be concluded that the data on the recovery of OL responses following AC interpolation and rest are somewhat conflicting. It is impossible to begin to explain the varied outcomes of the above experiments especially since the extinction analogy offers no reason why spontaneous recovery should be found other than stating that recovery is a phenomenon of conditioning.

Houston (1967c) was unable to find recovery of OL responses on MMFR in the AB-DC paradigm after a one-week retention interval. Employing both the AB-DC and AB-A'C (stimuli highly similar in both lists) paradigms and testing for retention 1 minute, 1, 5, or 24 hours after IL, Saltz and Hamilton (1967) found recovery in AB-A'C but not in AB-DC. However, Saltz and Hamilton used no control group, allowing no estimate of relative recovery. In addition, their retention test probably did not measure total response availability at recall since only the first list stimuli were presented, one at a time, for 10 seconds on the single recall trial. Their only AB-A'C group showing a decrement, in comparison to the rest of the groups, was the one minute condition. Whether this relative decrement was due to loss of response availability, associative loss, or both, is indeterminable. Finally, in stimulus recall in the AB-DB paradigm, Abra (1967) reports relative recovery with a 24 hour retention interval but no absolute recovery.

Thus, while experiments on the recovery of unlearned associations are by no means in agreement, it appears that something akin to spontaneous recovery may occur under circumstances yet to be specifically delineated. But even if recovery were a highly reliable phenomenon, it would not follow that extinction is the basis of the unlearning effect.

The two experiments manipulating other variables known to influence rate of extinction in conditioning have varied per cent of reinforcement or per cent occurrence of response member (% ORM). According to the extinction analogy, % ORM should have differential effects on unlearning depending whether it is varied in OL or IL. If varied in OL, the partial reinforcement effect (Lewis, 1960) predicts that reduced % ORM will reduce degree of unlearning. Silverstein's (1967) results supported this prediction in that Ss learning OL (AB) under 50% ORM showed significantly less unlearning than Ss learning OL under 100% ORM; IL (AC) was 100% ORM for both groups. If punishment is operating in IL, the presentation of AC after "A" overtly or covertly elicits "B" in the anticipation procedure, should be punishing and should follow results on frequency of punishment in punishment-extinction of instrumental responses. As such, higher degrees of unlearning should occur with larger % ORMs in IL. While Keppel, Zavortink, and Schiff (1967) found slight evidence for the partial reinforcement effect when OL was learned under 50% or 100% ORM, there was no indication that a partial punishment effect was operative (50% versus 100% ORM in IL).

Extinction and unlearning. At this point it is worthwhile to differentiate the terms "unlearning" and "extinction" with regard to conventional studies of PI and RI. While several writers have used the terms interchangeably, there is some value in distinguishing what each implies.[1] In this paper, we will take unlearning to mean one of the two hypothesized factors in Melton and Irwin's (1940) two-factor theory of forgetting, the other factor being competition. Experiments testing two-factor theory have either attempted to demonstrate properties of unlearning by using retention tests that supposedly minimize competition (and differentiation) effects (e.g., Barnes & Underwood, 1959), or have directly compared conventional anticipation recall with MMFR in order to test hypothesized properties of both competition and unlearning (e.g., Houston, 1966a; Howe, 1967). Unlearning, then, is that hypothesized factor underlying the decrement in retention on unpaced recall tests such as MMFR not attributable to "usual forgetting" or to response competition. This use of unlearning is "neutral" with respect to its underlying mechanism.

"Extinction," on the other hand, is more appropriately used in terms of the conditioning analogy whereby unlearning is hypothesized to result from the unreinforced evocation of associations during IL. That is, the

[1] McGovern (1964), for example, entitled her paper "Extinction of associations...."

elicitation-extinction hypothesis suggests that the mechanism for unlearning is elicitation of associations and their subsequent nonreinforcement or punishment.

The major points discussed thus far concerning the fate of first-list associations during interpolated practice are summarized below:

1. The independence hypothesis was rejected in the light of data which showed decrements in response availability on MMFR tests. Two-factor theory proposes that RI is a function of competition both during IL (producing unlearning) and at recall.
2. Unlearning is theoretically measured on retention tests that eliminate response competition and list differentiation effects.
3. An AB-AC relationship between successive S-R, R-S, X-S, and X-R associations is effective in producing retention decrements of particular paired-associate components that do not seem attributable to response competition.
4. The conditioning analogy assumes an elicitation-extinction mechanism for unlearning.
5. Specific conditions underlying "spontaneous recovery" of unlearned associations have not been specified.
6. Specific interlist intrusions in IL do not appear to predict degree of unlearning to any

great degree, if at all.

Now consideration will be given to matters pertinent to the present investigation.

The Present Experiment

In studying the nature of the retention decrement in RI the experimenter has three obvious points available at which he can make experimental manipulations so as to observe the effect of these manipulations on RI (OL; IL, including time of IL onset; and recall, including time of recall onset). Except for variations in the type of retention test and duration of the retention interval, the influence of other post-IL factors has been little investigated in experiments involving the unlearning hypothesis. However, it is in this post-IL period that the further "behavior" of unlearned associations can be observed. This can be achieved in one way by comparing the typical immediate or short interval retention test (e.g., MMFR) with a later retention test, this second test being preceded by various types of activity (e.g., by various rest intervals in tests of recovery). Further, if groups are used to estimate "usual" recovery, the effects of other types of post-IL conditions can be evaluated with recovery effects taken out. The present experiment used this basic procedure just outlined in order to gain further information regarding the unlearning effect. We will now discuss the post-IL activity that was of interest.

<u>Recall in the absence of informative feedback (re-inforcement): single-list</u>. There has been in verbal learning, some interest in the effect of successive recall trials on which <u>S</u> is given no information regarding the correctness of his responses (Richardson & Gropper, 1964). While this procedure can be viewed as analogous to the operation of extinction since the stimuli are repeatedly presented in the absence of reinforcement (the original elicitor of the response), several studies have shown improvement over such nonreinforced recall trials. Early experiments with repeated recalls were concerned with the influence of rehearsal on the reminiscence phenomenon (e.g., Brown, 1923; Raffel, 1934). However, reminiscence research will not be considered here, since the definition of reminiscence implies that "...if retention is measured by two or more tests over the same material with the same <u>S</u>s, an improvement in retention can not be called reminiscence because the first test serves as an additional practice period (Buxton, 1943, p. 337)." In other words, successive recalls are to be avoided in studies of reminiscence.

Brown (1923) gave a class of students five minutes in which to write the names of the 48 United States. After 30 minutes of unrelated activity, another similar recall period was given. Comparison of the number of states correctly recalled on the two tests showed an absolute gain of approximately three states on the second recall even though feedback was given at no time. Raffel (1934) showed Ss 100 words five times, then administered free recall to all Ss on Day 2 to obtain a base (100%) with which to compare subsequent performance. One group was then retested on Day 8; a second on Days 6, 7, and 8; and a third on every intervening day. Recall on Day 8 was positively correlated with number of interpolated tests, which could merely indicate that recall served to allow for rehearsal. However, the fact that groups receiving repeated tests tended to improve performance on subsequent tests, after an initial drop off, suggests that interpolated unreinforced recalls did more than just retard forgetting via rehearsal of available items. Words not recalled earlier became available during later recalls.

More recently, several experimenters have shown increments in recall of single paired-associate lists on trials in which only the stimulus terms were presented. Richardson (1958) gave five paced recall trials 48 hours after learning and found significant increases in number correct over trials. Similar increases were found after a seven day retention interval in a subsequent study (Richardson, 1960). Lazar and van Laer (1966) administered unreinforced paced recall following learning with the study-test procedure. Their results suggested that forgetting occurring over a 24 hour interval was almost entirely eliminated over 10 recall trials, although no improvement was found when the 10 recalls were given immediately after learning.

Goss and his associates removed the response terms (0% ORM) of paired-associate lists immediately after attainment of different acquisition criteria in three different experiments. Under such conditions, significant increments in number correct with many types of lists were found in two studies (Goss, Morgan, & Golin, 1959; Goss, Nodine, Gregory, Taub, & Kennedy, 1962). In a third experiment (Goss, 1965), improvements under post-acquisition 0% ORM were more evident with lists of low intralist similarity than those of high intralist similarity. A fourth experiment yielded results similar to Goss _et al_. (1962) when recall under 0% ORM was instituted 24 hours after acquisition (Goss & Nodine, 1965, Exp. 1).

Butler and Peterson (1965) removed the response terms of a paired-associate list after 10, 20, or 30 regular anticipation trials. The _S_ was told he should still keep trying to anticipate the original response. Their results showed systematic increases in both correct responses and incorrect responses over 30 non-feedback trials.

Estes' Miniature Experiments, designed to test implications of all-or-none and incremental theories of learning, include _S_s who receive two or more recalls in the absence of feedback (Reinforcement-Test-Test, $R_1T_1T_2$). While systematic increases in the number of correct responses over recall trials are not generally found in these experiments, increases in the probability of a correct response given a previous correct response are found (Estes, Hopkins, & Crothers, 1960). Extending the Miniature Experiment to four test trials after an initial presentation ($R_1T_1T_2T_3T_4$), Jones (1962) found the proportion incorrect (N_1) on T_1 to be .45 (Exp. 2). On T_2 the conditional probability of correct (C_2) given N_1 was .29. Thereafter, the value of N_1-C_2-C_3 was .61 and of N_1-C_2-C_3-C_4, .77. Eimas and Zeaman (1963) report that the response latency of items correctly recalled decreased but that the latency of incorrect recalls did not change.

While the studies referred to above have all indicated some type of performance increment as a result of the unreinforced recall of single lists, there are some reports of negligible effects over successive recall trials, all in experiments using the study-test method with paired-associate lists (Berry & Battig, 1966; Cofer, Diamond, Olsen, Stein, & Walker, 1967, Exp. 7; Lazar and van Laer, 1966, sup.; Montaque & Kiess, 1966). There is, however, only a single study of which the writer is aware that showed anything like extinction with repeated presentation of paired-associate stimuli in the absence of the responses. After one perfect anticipation trial, three stimuli from an eight-item list were presented 50 times without being followed by their responses terms (Peak & Deese, 1937). Three other pairs (control pairs) were not represented in this "extinction" period and two other pairs continued to be treated as during acquisition (experimenter read the stimulus which was followed by the response on a drum tape). The Ss were informed they were only to pronounce the responses that appeared on the drum. (Another group was given no further information prior to omission of the responses, was "perplexed", and will be ignored here.) On a retention test immediately following the 50 trials, more responses of control pairs than extinction pairs were retained and latency of response to extinction pairs, but not to control pairs, showed a sharp increase. The authors suggested that perhaps their procedure was analogous to the acquisition and extinction phases of classical conditioning. It should be noted that this is the only experiment cited in which Ss were specifically instructed not to respond in the presence of stimulus terms. The critical test for retention took place after a long series of exposures to only the stimulus terms, not during the series as in the other experiments above. Therefore, Peak and Deese did not have a series of recall trials, per se.

Several suggestions as to why improvement should occur during nonreinforced recall trials have been offered. Brown (1923) invoked a notion similar to what Hull later called "behavioral oscillation" (Hull, 1943). Previously failed items could appear because of oscillatory inhibition at earlier recall, be rehearsed, and summate with items previously given, resulting in increments for total retention. Raffel (1934) pointed out that recall may serve to bring associations that are close to recall threshold into a "state of readiness" whereby accessibility to stored items is facilitated.

Jones (1962) and Eimas and Zeaman (1963) propose a factor which may be called "subjective reinforcement" or response-produced feedback whereby S is able to distinguish correct from incorrect responses, thus strengthening correct associations by the recognition of correct responses. These weak responses may first be given as a "guess," but once given can be recognized as correct. As a result of differential improvements found with easy and difficult lists, Goss (1965) suggests that, in paired-associate lists, response integration and specific S-R associations may not be sufficiently strong to result in complete and consistent correct responding over short anticipation intervals. But as response availability and S-R associative strength increase, the occurrence of response terms are not as critical for maintenance of correct responding and even for the further strengthening of the two processes.

Other authors (Lazar & van Laer, 1966; Richardson, 1958) have recognized that successive recalls, especially after relatively long retention intervals (24 hours), are similar to warm-up before recall as in the research of

Irion and his collaborators (Irion, 1949; Irion & Wham, 1951). However, due to the difficulty of showing pre-recall warm-up effects when the warm-up material is unrelated to the learned material (Underwood, 1953; Lazar, 1967), improvements found over successive recalls must be heavily influenced by factors other than nonspecific warm-up. Also, improvements have been found when unreinforced recalls were instituted immediately after the usual short acquisition intertrial interval (Butler & Peterson, 1965; Goss, Morgan, & Golin, 1959).

Recall in the absence of reinforcement: RI paradigms. Three investigators have been directed to unreinforced recall of OL following IL in RI designs. Two of these (Greenbloom & Kimble, 1966; Richardson & Gropper, 1964) showed increments over trials in the paced recall of AB responses after AC interpolation. Both studies employed nonsense syllable-adjective pairs that were presented at a 2:2 second rate of presentation throughout learning. Richardson and Gropper (1964) gave eight IL trials following a 75% acquisition criterion on OL. Immediately after completion of IL, five OL recall trials were given with the stimuli presented at a four second rate. A small but statistically reliable increase was found from the first to the fifth recall trial. Greenbloom and Kimble (1966) took Ss to a criterion of one perfect trial on OL, then presented IL for 14 anticipation trials. On eight recall trials, administered at the end of IL, the stimuli were presented at a six second rate. Two groups which differed in the color and printing of the stimuli at recall (same versus changed from OL) showed significant increments in number correct responses over the recall trials. Changing the nature of the stimulus terms had only a minimal effect on recall.

A parsiminious explanation of these two studies, as well as the single-list experiments mentioned above that used paced recall, is that the improved recall over successive trials represents the effect of cumulative recall time. For example, it has been shown that single-list recall obtained from conventional anticipation (E-paced) is inferior to that estimated from S-paced MMFR (Houston, 1966a; Houston, 1967b; Howe, 1967; Postman, 1962). In control groups (single list), differences in recall between conventional anticipation recall and MMFR are assumed to reflect usual ("simple") pacing losses or decrements due to reduced recall time. Hence, for single-list groups, this interpretation (analogous to the total time hypothesis of acquisition, Cooper & Pantle, 1967) requires comparison between paced groups and nonpaced groups that are equated for total recall time. When total recall time is equated, recall performance should be equivalent. Available experiments do not permit a conclusion to be drawn regarding, what can be called, a total recall time notion.

It is possible that something such as the cumulation of recall time can also account for results of Richardson and Gropper (1964) and Greenbloom and Kimble (1966) on paced OL recall following IL, but the rationale of MMFR suggests another factor, in addition to simple pacing losses, is operating when experimental groups are compared on paced recall and MMFR. As stated in a previous section, MMFR, theoretically, removes the effects of competition at recall. Therefore, for experimental groups, differences between paced recall and MMFR should reflect effects of usual pacing losses as well as those of competition. In terms of RI in the AB-AC paradigm, control-experimental differences on conventional paced recall (competition and unlearning) should be greater than on MMFR (unlearning). If competition is reduced with increased recall time, it is possible that the improved recall of the experimental groups over the unreinforced paced recall trials in the two experiments under consideration was due to (a) reduction of simple pacing losses and (b) reduced competition.

The results of a third study in which unreinforced recall trials were administered after IL suggest that another factor, in addition to the two just mentioned, may operate over such repeated recalls. Greenbloom and Kimble (1965), employing the AB-DC and AB-DB paradigms with noun pairs, gave eight recall trials after IL. At recall, one group in each of the paradigms was given the A terms and was asked to recall the B terms (S-R recall);

another group in each paradigm was given the B terms and was asked to recall the A terms (R-S recall). The stimuli were presented at a four second rate at recall. Of main interest here is the AB-DC, S-R recall group. According to the McGovern (1964) analysis, response unlearning should be obtained in the AB-DC paradigm because of the XB-XC relationship between successive responses. The results of McGovern (1964) and Houston (1967c) support this prediction. Greenbloom and Kimble found a significant improvement in recall over the unreinforced paced recall trials in the AB-DC, S-R recall group (and in all others) and, of particular relevance to the unlearning hypothesis, what looked like a total recovery of response availability by the last recall trial. Unfortunately, interpretations regarding this apparent recovery remain inconclusive because no control groups were run, making it impossible to determine (a) if response unlearning was, in fact, initially obtained in their procedure and (b) the extent of the recovery in terms of what a paced recall control group would have shown. However, a control group would probably not have recalled much more than the D-C, S-R recall group since recall reached a level slightly above that reached on the criterion acquisition trial. As such, the main problem is whether or not Greenbloom and Kimble's procedure would have actually shown response unlearning on an immediate MMFR test. Assuming the latter, it may be concluded that unlearning was reduced. We now have the third factor, in addition to reduction of both simple pacing losses and competition, which may operate on unreinforced recall trials in RI paradigms, viz., increased response availability or a reduction in unlearning.

This possible third phenomen has important implications for two-factor theory and the unlearning hypothesis. In terms of the elicitation-extinction notion, it is difficult to see how extinguished responses would recover in the face of further nonreinforcement. Such "induced recovery," if not attributable to usual recovery (as after rest), would suggest that not all available responses are brought forth by the typical MMFR test.

In view of the significance of nonreinforced recall for analyses of two-factor theory and unlearning, the present experiment was designed to investigate the effect, on subsequent MMFR, of unreinforced recalls in two RI paradigms and in a conventional RI control condition. The two RI or work paradigms were AB-AC, hereafter referred to as AC, and AB-DC, hereafter referred to as DC.

Four types of post-IL conditions were used. In the Immediate condition, MMFR was administered upon completion of IL enabling determination of the amount of RI produced by the particular materials and procedures of the experiment. As such, the Immediate condition

provided a base for evaluation of the effects of the other post-IL conditions. A second post-IL condition required unreinforced paced recall of OL following IL, after which MMFR was given. The Ss in this Paced condition received a total of 12 trials. The third post-IL condition (Self-Paced) was identical to the Paced condition except that OL recall was S paced rather than E paced. Self-paced recall continued for a period of time identical to that taken up by the 12 paced recall trials of paced recall. A fourth condition permitted evaluation of the usual effects of time-since-IL on MMFR. The Ss in this Time condition worked on an irrelevant digit cancellation task for the period of time taken up by self-paced and paced recall. The MMFR test of the Time condition had the same retention interval as that of the Paced and Self-Paced conditions.

METHOD

Design

Three paradigms (Control, DC, and AC, the latter two being IL-work conditions) and four post-IL, pre-MMFR recall conditions (Immediate, Time, Self-Paced recall, and Paced recall) were variables in a 3 x 4 factorial design. Work groups learned either a DC or an AC second list after AB learning and controls, after first-list learning, performed an irrelevant digit cancellation task for a period of time equivalent to that required in the work conditions. All Ss received an MMFR recall test either immediately after IL (Immediate), after self-paced recall of AB (Self-Paced), after paced recall of AB (Paced), or after a period of time on an irrelevant digit cancellation task that was equivalent to the time spent by Self-Paced and Paced groups (Time). In analyzing the data, orthogonal comparisons were used which enabled comparisons of control with combined work groups and of combined Immediate and Time conditions with combined Self-Paced and Paced conditions.

Subjects

A total of 288 Ss, 24 in each of the 12 groups, served in the experiment. Approximately equal numbers of males and females were represented in the 12 treatments. All

Ss were naive with regard to verbal learning experiments. The 12 treatment combinations were randomized for order of running 24 times such that each treatment occurred once in each successive block of 12. The Ss were assigned to this arrangement in the order of their appearance at the laboratory. Assignments to particular lists, list combinations, and starting positions were also randomized with the restrictions imposed by having equivalent numbers of Ss undergo the particular conditions within treatments.

Materials

Three eight-item, paired-associate lists (AB, AC, and DC), with two pairings of stimulus and response terms in each were used. These lists are presented in Appendix A. All Ss received one of the two pairings of the AB list as their first list. All lists and list combinations within a particular treatment were used equally often. The stimulus terms consisted of consonant-vowel-consonant trigrams with 40%-60% Archer (1960) association values. Intralist similarity of stimuli was kept minimal by using a given consonant only once and by using three of the five vowels twice. Interlist stimulus similarity in the AB and DC lists was kept at a minimum by having no trigram in the DC list start with a consonant used as the initial letter of any stimulus in the AB list and by using only one of the three vowels used twice in the AB list twice in the DC list. Two sets of eight response

terms were formed from a pool of 16 semantically unrelated two-syllable adjectives with Thorndike-Lorge (1944) G-count values ranging from 1 to 12 per million. All 16 words had different initial letters. One set was used in the AB list and the other set of response terms was used in both the AC and DC second list.

Procedure

First-and second-list learning. The procedure for OL and IL was similar to many previous experiments in order that RI would be maximized in the Immediate condition. The Ss were individually run. Both lists were learned by the anticipation method at a 2:2 second rate with a 4-second intertrial interval on a Stowe memory drum (Model 459B). After reaching a learning criterion of 7/8 correct responses in a single trial, OL terminated. Forty-five seconds later work Ss began IL which was administered for a total of 14 anticipation trials. Control Ss spent a period of time equivalent to that required for IL (9 minutes) on an irrelevant digit cancellation task. Instructions (see Appendix B) were read prior to OL and between OL and IL.

Post-IL activity. For an estimate of RI at the end of IL. Immediate groups were administered a written MMFR test immediately after the termination of IL. Upon completion of IL, Paced recall groups had the first list presented exactly as during OL, except that all response

terms were omitted on the tape. Instructions emphasized that recall of first-list responses was required. The first paced recall trial for a particular S began with the list order following the OL criterion order. After 12 paced recall trials, written MMFR was administered. Self-Paced recall groups were treated identical to Paced recall ones except that OL recall was S paced. The self-paced recall continued for 7.13 minutes, the amount of time required for the 12 paced recall trials. All Self-Paced Ss completed at least one list order in the assigned time. Informational feedback was given at no time during paced and self-paced recall. Finally, Time groups, after IL, spent 7.13 minutes on a slightly different version of the IL control irrelevant digit cancellation task prior to written MMFR. Instructions read to Paced, Self-Paced, and Time groups are presented in Appendix C.

MMFR. The unpaced written MMFR test was presented on a sheet of paper which contained either eight (Control and AC paradigms) or 16 (DC paradigm) stimulus terms with the appropriate number of blanks beside the trigrams. Spaces were also provided at the bottom of the sheet for any recalled response that S was unwilling to pair with a stimulus. Two random orderings of the stimulus terms were prepared for each paradigm and each order was used approximately equally often. Instructions for MMFR as well as examples of the sheets used for each paradigm can be seen in Appendix D.

RESULTS

First-List (OL) Learning

The mean number of trials to the OL criterion of 7/8 correct responses in a single trial is presented in Table 1 for each of the 12 groups. A summary of the analysis of these data can be seen in Table 2. As would be expected due to randomization, none of the 11 orthogonal components in the analysis of variance reached an acceptable level of significance (all *p*s $> .10$).

Second-List (IL) Learning

The mean number of correct responses throughout IL for the AC paradigm was 65.46, 58.54, 61.25, and 59.29 for the Immediate, Time, Self-Paced, and Paced subgroups, respectively. The means for the DC paradigm were 71.25, 76.67, 73.71, and 76.75 for the Immediate, Time, Self-Paced, and Paced subgroups, respectively. The analysis of variance, summarized in Table 3, indicates only a significant paradigm effect, $F\ (1, 184)=25.87$, $p < .001$, with none of the other comparisons approaching significance. This latter finding is understandable since the various subgroups at each paradigm were not differentially treated throughout OL and IL. In view of the extreme overlap among post-IL conditions at each paradigm, they were combined prior to plotting IL performance across the

Table 1. Mean Number of Trials to First-List Criterion and SDs for the 12 Groups

Paradigm		Post-IL condition			
		Immediate	Time	Self-Paced	Paced
Control	M	12.21	10.50	12.79	10.88
	SD	3.54	4.88	7.30	6.48
DC	M	14.00	10.67	13.63	14.00
	SD	6.92	5.41	7.44	6.53
AC	M	12.38	12.38	12.13	12.50
	SD	5.51	5.98	6.51	6.79

Table 2. Summary of the Analysis of Variance of Trials to OL Criterion

Source	df	MS	F	p
Control (C) vs. Comb. work	1	79.50	2.07	>.10
AC vs. DC	1	25.52	< 1	
Immediate (Im.) vs. Time	1	101.68	2.65	>.10
Self-Paced vs. Paced	1	5.45	< 1	
Comb. Im. & Time vs. Comb. Self-Paced & Paced	1	28.75	< 1	
C vs. Comb. work X Im. vs. Time	1	.01	< 1	
C vs. Comb. work X Self-Paced vs. Paced	1	42.01	1.09	>.20
C vs. Comb. work X Comb. Im. & Time vs. Comb. Self-Paced & Paced	1	.85	< 1	
AC vs. DC X Im. vs. Time	1	66.67	1.73	>.10
AC vs. DC X Self-Paced vs. Paced	1	0.00	< 1	
AC vs. DC X Comb. Im. & Time vs. Comb. Self-Paced & Paced	1	28.52	< 1	
Within cell (error)	276	38.43		

Table 3. Summary of Analysis of Variance of Total Number of Correct Responses in Second-List Learning

Source	df	MS	F	p
AC vs. DC	1	8694.08	25.87	< .001
Immediate (Im.) vs. Time	1	13.50	< 1	
Self-Paced vs. Paced	1	7.04	< 1	
Comb. Im. & Time vs. Comb. Self-Paced & Paced	1	2.52	< 1	
AC vs. DC X Im. vs. Time	1	912.67	2.72	> .10
AC vs. DC X Self-Paced vs. Paced	1	150.00	< 1	
AC vs. DC X Comb. Im. & Time vs. Comb. Self-Paced & Paced	1	108.01	< 1	
Within cell (error)	184	336.12		

14 anticipation trials for each work paradigm (Figure 1). While it should be noted that the AC and DC lists were not equated for difficulty, the significantly poorer AC learning is consistent with previous findings (e.g., McGovern, 1964) showing negative transfer in the AC paradigm when compared to the DC condition.

Two types of interlist intrusions during IL were possible, specific and generalized. The former type, possible only in the AC condition, refers to a response to a second-list stimulus with a word that was paired with this stimulus in the first list. The latter type, which may be found in both AC and DC conditions, refers to a response to a second-list stimulus with a first-list word, this word not being paired with the eliciting second-list stimulus in the first list. Thus, all interlist intrusions in DC are generalized intrusions. Table 4 presents the total number of both types of interlist intrusions during IL (as well as the number of Ss contributing) for the eight work conditions. As is typically found (Postman, Keppel, & Stark, 1965), the absolute frequencies of interlist intrusions were very small.

Self-Paced and Paced Recall

Comparison of self-paced and paced recall with stringent and lenient scoring. Both Self-Paced and Paced groups spent 7.13 minutes in recall of first-list re-

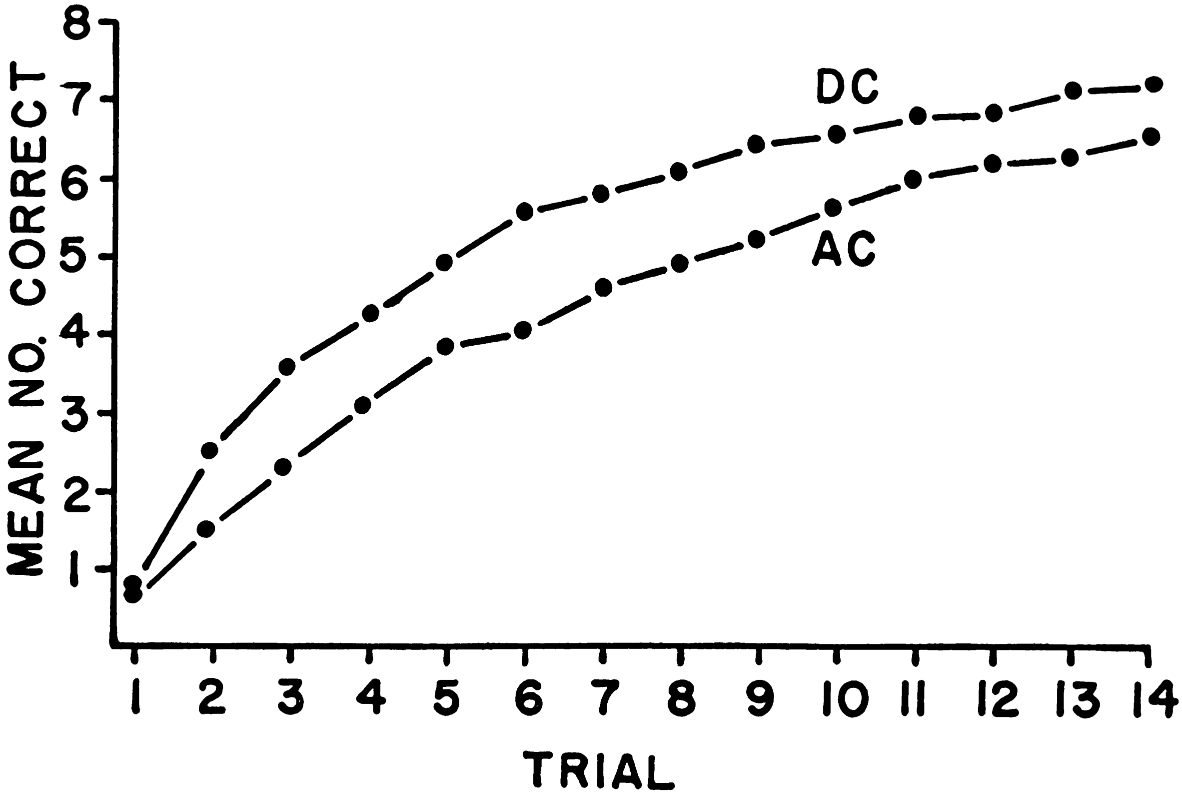

Figure 1. Mean number of correct responses in second-list learning over the 14 anticipation trials as a function of work paradigm. (Immediate, Time, Self-Paced, and Paced subgroups of each paradigm have been combined).

Table 4. Total Number of Specific and Generalized Interlist Intrusions and Number of Ss Contributing at Least One in the Eight Work Groups During IL

		Specific interlist intrusions		Generalized interlist intrusions	
Paradigm	Post-IL condition	Total No.	No. Ss con-tributing	Total No.	No. Ss con-tributing
DC	Immediate	--	--	0	0
	Time	--	--	3	1
	Self-Paced	--	--	2	2
	Paced	--	--	1	1
AC	Immediate	7	5	4	1
	Time	3	2	4	2
	Self-Paced	4	2	2	2
	Paced	2	2	0	0

sponses. Retention in these two conditions was compared by scoring the eight items for each S such that credit was given for a particular item if S gave a correct response at any time throughout recall. As such, a particular item contributed only once to each S's score and individual scores could range from 0-8. In effect, the repeated nature of the two types of recall was ignored.

Recall was scored by two methods typically used with MMFR. In stringent scoring S receives credit for a particular item only if the response term is recalled and correctly paired with the stimulus term. Lenient scoring gives S credit for all responses recalled, regardless of pairing. The mean number of responses recalled under both scoring methods during self-paced and paced recall for control and work paradigms is presented in Table 5. Tables 6 (stringent scoring) and 7 (lenient scoring) summarize the analyses of variance of these data.

For stringent scores, control recall was better than recall in combined work groups, F (1, 138)=104.72, $p < .001$. Recall following AC interpolation was poorer than recall following DC interpolation, F (1, 138)=66.26, $p < .001$. Thus RI was obtained and it was greater in AC groups than in DC groups. The Self-Paced vs. Paced comparison, over all paradigms, did not approach significance ($F < 1$). Also, self-paced and paced recall were

Table 5. Number of OL Responses Recalled During Self-Paced and Paced Recall as Scored Stringently and Leniently

		Stringent scoring		Lenient scoring	
Paradigm		Self-Paced	Paced	Self-Paced	Paced
Control	M	7.50	7.58	7.75	7.67
	SD	.66	.66	.45	.57
DC	M	6.00	6.46	6.38	6.50
	SD	1.62	1.10	1.53	1.06
AC	M	4.46	3.54	5.00	4.25
	SD	1.69	1.81	1.59	1.82

Table 6. Summary of the Analysis of Variance of the Number of OL Responses Recalled During Self-Paced and Paced Recall
(Stringent scoring)

Source	df	MS	F	p
Control (C) vs. Comb. work	1	188.50	104.72	$<.001$
AC vs. DC	1	119.26	66.26	$<.001$
Self-Paced vs. Paced	1	.56	<1	
C vs. Comb. Work X Self-Paced vs. Paced	1	.79	<1	
AC vs. DC X Self-Paced vs. Paced	1	11.34	6.30	$<.025$
Within cell (error)	138	1.80		

Table 7. Summary of the Analysis of Variance of the Number of OL Responses Recalled During Self-Paced and Paced Recall
(Lenient scoring)

Source	df	MS	F	p
Control (C) vs. Comb. work	1	151.66	92.48	$< .001$
AC vs. DC	1	78.85	48.08	$< .001$
Self-Paced vs. Paced	1	2.00	1.22	$> .20$
C vs. Comb. work X Self-Paced vs. Paced	1	.44	< 1	
AC vs. DC X Self-Paced vs. Paced	1	4.59	2.80	$> .05$
Within cell (error)	138	1.64		

not differentially affected by control and combined work conditions, $F < 1$. However, the AC vs. DC X Self-Paced vs. Paced interaction was significant, F (1, 138)=6.30, $p < .025$, indicating that the AC vs. DC difference was greater on paced recall than on self-paced recall. While DC groups were somewhat better on paced recall than on self-paced recall, the reverse was found for AC groups.

Lenient scores lead to the same conclusions as those obtained from stringent scores for the following comparisons: Control vs. Combined work, F (1, 138)=92.48, $p < .001$; AC vs. DC, F (1, 138)=48.08, $p < .001$; Self-paced vs. Paced, F (1, 138)=1.22, $p > .20$; Control vs. Combined work X Self-Paced vs. Paced, $F < 1$). With lenient scoring, the AC vs. DC X Self-Paced vs. Paced interaction fell short of significance, F (1, 138)=2.80, $.05 < p < .10$.

Recall across the 12 paced recall trials. Immediately above, the 12 paced recall trials were essentially considered as a single test of OL retention. We will now consider recall over the paced recall trials for each of the three paradigms. The S was given credit for a correct response when the first-list word originally paired with a stimulus was given during the four seconds the stimulus was exposed. Such scoring is analogous to stringent scoring as described above. Figure 2 shows the mean number of correct responses throughout paced recall

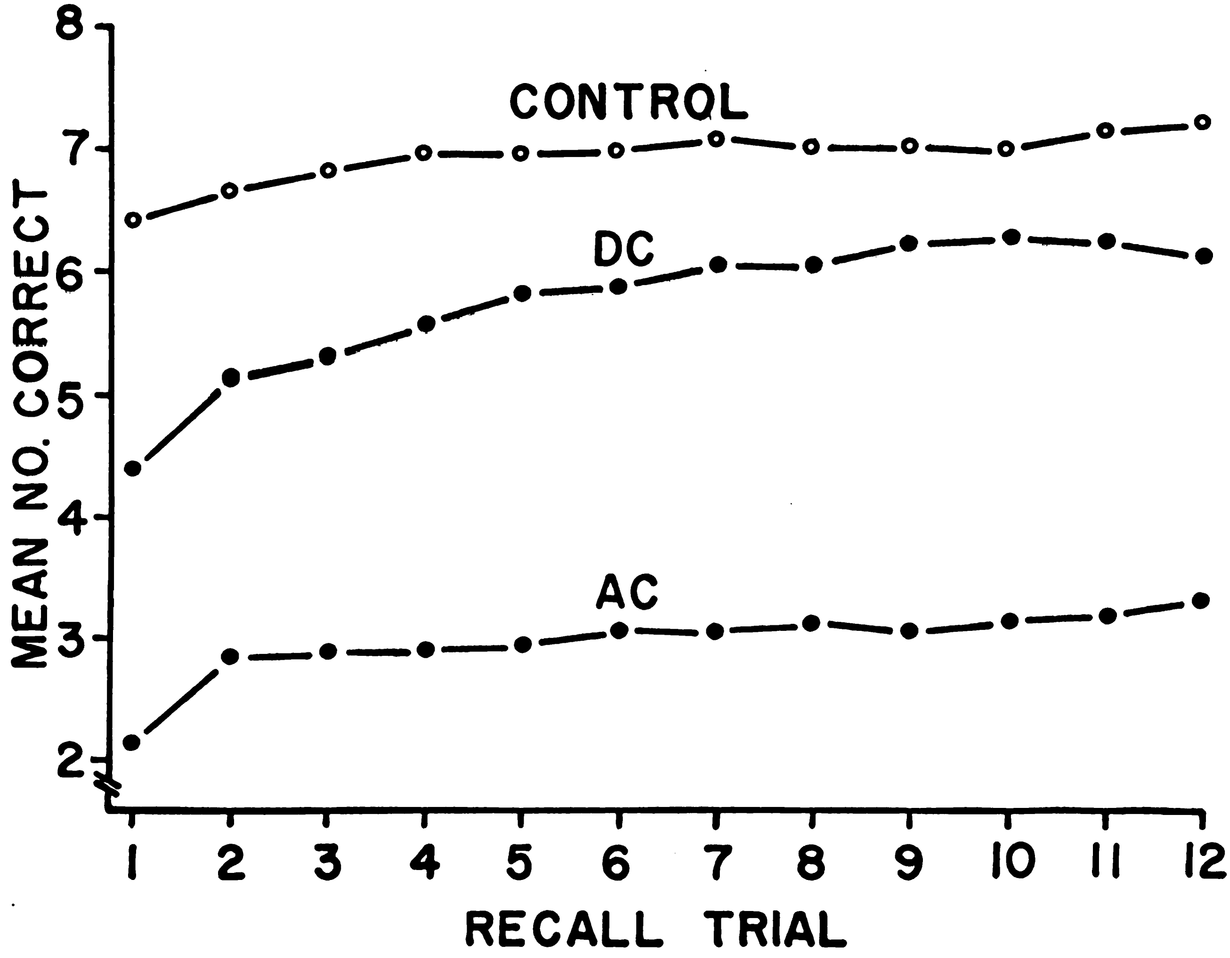

Figure 2. Mean number of correct responses over the 12 unreinforced paced recall trials as a function of paradigm.

as a function of paradigm and Table 8 summarizes the repeated measures analysis of variance of these data. RI was in evidence (Control vs. Combined work, $\underline{F}$=74.33, $\underline{p} < .001$) and more RI was found with AC than DC (AC vs. DC, $\underline{F}$=65.01, $\underline{p} < .001$). The main effect of trials was significant, $\underline{F}$ (11, 759)=16.43, $\underline{p} < .001$. Combined work groups showed a greater increment over trials than controls, $\underline{F}$ (11, 759)=7.93, $\underline{p} < .001$, this increment in work groups being greater in the DC group than in the AC group, $\underline{F}$ (11, 759)=2.69, $\underline{p} < .01$. An analysis of the simple effects of trials, summarized in Table 9, indicated that all three paradigms improved significantly over trials (Control, $\underline{F}$=2.95, $\underline{p} < .05$; DC, $\underline{F}$=18.60, $\underline{p} < .001$; AC, $\underline{F}$=5.52, $\underline{p} < .001$).

The nature of the incorrect responses throughout self-paced and paced recall was such that omissions (failure to respond) were predominant. For the DC condition, of 656 incorrect responses during the 12 paced recall trials (stringently scored) 86.3% were omissions, 12.3% were misplaced responses from within the list, 1.4% were second-list responses, and no extra-experimental items (words not in either list) were given. Of the 1452 incorrect responses during paced recall for the AC condition 81.1% were omissions, 11.6% were misplaced responses from within the list, 6.4% were second-list responses, and .9% were extra-experimental items. A total of 309

Table 8. Summary of the Analysis of Variance of the Number Correct Responses Over the 12 Paced Recall Trials for the Control, DC, and AC Paradigms

Source	df	MS	F	p
Control (C) vs. Comb. work	1	1257.68	74.33	< .001
AC vs. DC	1	1100.03	65.01	< .001
Ss within groups (error)	69	16.92		
Trials (Tr.)	11	6.90	16.43	< .001
C vs. Comb. work X Tr.	11	3.33	7.93	< .001
AC vs. DC X Tr.	11	1.13	2.69	< .01
Tr. X Ss within groups (error)	759	.42		

Table 9. Summary of Analysis of Simple Effects of Paced Recall Trials for Each Paradigm

Source	df	MS	F	p
Trials (Tr.) for Control	11	1.24	2.95	$< .005$
Tr. for DC	11	7.81	18.60	$< .001$
Tr. for AC	11	2.32	5.52	$< .001$
Tr. X Ss within groups (error)	759	.42		

incorrect responses was obtained in paced recall for the controls; 60% of these incorrect responses were omissions, and 40% were misplaced responses from within the list.

MMFR, First-List Recall

Stringent scoring. Table 10 presents first-list recall data for the 12 groups on stringently-scored MMFR. The analysis of variance of these data is summarized in Table 11. As expected, the Control vs. Combined work comparison was significant, indicating that RI was obtained, F (1, 276)=181.33, $p < .001$. The AC treatment yielded more RI than the DC condition, F (1, 276)=44.78, $p < .001$.

Comparison of the Immediate and Time conditions enables a determination of the "usual" effects of time on MMFR. Since evaluation of any increments (or decrements) of self-paced and paced recall, relative to immediate MMFR, should take into consideration the simple effects of time involved in the two former conditions, it is important to determine what, in terms of retention, took place during the approximately seven minutes of irrelevant activity after IL. The results of all relevant comparisons (Immediate vs. Time, $F < 1$; Control vs. Combined work X Immediate vs. Time, $F < 1$; AC vs. DC X Immediate vs. Time, F=2.02, $p > .10$) indicate that the hypothesis of no difference between immediate and delayed (Time) MMFR

Table 10. Number of Correct OL Responses on Written MMFR Stringently Scored

Paradigm		Post-IL condition			
		Immediate	Time	Self-Paced	Paced
Control	M	7.04	6.88	7.25	7.17
	SD	1.20	1.11	1.07	1.05
DC	M	4.79	4.46	5.58	6.25
	SD	1.98	1.91	1.72	1.19
AC	M	3.21	3.75	4.46	3.83
	SD	1.59	1.51	1.62	1.76

Table 11. Summary of the Analysis of Variance of Stringently-Scored OL Recall on MMFR

Source	df	MS	F	p
Control (C) vs. Comb. work	1	413.44	181.33	$<.001$
AC vs. DC	1	102.09	44.78	$<.001$
Immediate (Im.) vs. Time	1	.01	< 1	
Self-Paced vs. Paced	1	0.00	< 1	
Comb. Im. & Time vs. Comb. Self-Paced & Paced	1	39.01	17.11	$<.001$
C vs. Comb. work X Im. vs. Time	1	.59	< 1	
C vs. Comb. work X Self-Paced vs. Paced	1	.10	< 1	
C vs. Comb. work X Comb. Im. & Time vs. Comb. Self-Paced & Paced	1	8.51	3.73	$<.06$
AC vs. DC X Im. vs. Time	1	4.60	2.02	$>.10$
AC vs. DC X Self-Paced vs. Paced	1	10.02	4.39	$<.05$
AC vs. DC X Comb. Im. & Time vs. Comb. Self-Paced & Paced	1	4.69	2.06	$>.10$
Within cell (error)	276	2.28		

cannot be rejected. That is, controls showed no reliable losses over time, no evidence for relative or absolute recovery was found, and the two work conditions were not differentially affected by the two recall conditions (Immediate and Time).

The present analysis also enabled comparison of the effects of self-paced and paced recall on the common MMFR test. When considered over all paradigms, the Self-Paced vs. Paced comparison fell far short of significance, $\underline{F} < 1$. Also, the Control vs. Combined work X Self-Paced vs. Paced interaction was negligible, $\underline{F} < 1$. Paced recall contributed more to the AC vs. DC difference than self-paced recall, $\underline{F}$ (1, 276)=4.39, $\underline{p} < .05$. These latter three findings are consistent with those previously reported for the analysis of recall (also stringently scored) _during_ self-paced and paced recall.

If the repeated nonreinforced recalls of the Self-Paced and Paced conditions serve as extinction trials, these unreinforced recall groups should be inferior to the single recall groups (Immediate and Time) on MMFR. Inspection of Table 10 shows that the exact opposite was found. Within all three paradigms, with no exceptions, Self-Paced and Paced conditions were superior to Immediate and Time conditions. The results of the analysis of variance showed that the superiority in OL recall of Self-Paced and Paced treatments to Immediate and Time

conditions was reliable, F (1, 276)=17.11, $p < .001$. In addition, the increment in work paradigms tended to be greater than that in the control paradigm, Control vs. Combined work X Combined Immediate and Time vs. Combined Self-Paced and Paced interaction, F (1, 276)=3.73, $p < .06$. The basis for this latter interaction can be seen in Combined Immediate and Time vs. Combined Self-Paced and Paced comparisons for each of the three paradigms. These comparisons (Winer, 1962, p. 238) showed that Combined Self-Paced and Paced scores were significantly greater than Combined Immediate and Time scores for the two work paradigms, F (1, 276)=17.56, $p < .001$ for DC and F (1, 276)=4.68, $p < .05$ for AC, but not for the controls, $F < 1$. That is, facilitation of OL recall on MMFR, apparently not attributable merely to usual time effects, was found in both work conditions with unreinforced recall. The reduction in unlearning was approximately equal in both work paradigms (AC vs. DC X Combined Immediate and Time vs. Combined Self-Paced and Paced interaction, F=2.06, $p > .10$.

RI measured in terms of percentages, or relative RI (Houston, 1966a; Postman, 1962), yielded identical conclusions regarding less RI in Combined Self-Paced and Paced conditions than in Combined Immediate and Time conditions. These values, where percentage RI= Control-Work/Control, for the DC paradigms were 33.5

and 17.9 for Combined Immediate and Time and Combined Self-Paced and Paced conditions, respectively. The percentage RI values for the AC Combined Immediate and Time and Combined Self-Paced and Paced conditions were 50.0 and 42.5, respectively.

Lenient scoring. The results of leniently-scored MMFR can be seen in Table 12. Table 13 summarizes the analysis of variance. While lenient scores are greater than stringent scores in all groups, the former yield the same conclusions as the latter with a single exception. Therefore, presentation of the results of leniently-scored MMFR need emphasize only a few matters.

First, the minor discrepancy between stringent and lenient MMFR has already been noted in the stringent and lenient analyses of recall during self-paced and paced recall. That is, while the AC vs. DC X Self-Paced vs. Paced interaction was significant for stringent scores, it fell short of significance for lenient scores in the latter analyses. Similarly, this interaction fell short of significance for the lenient MMFR scores under present consideration, F (1, 276)=1.57, $p > .20$.

With lenient scores, Combined Self-Paced and Paced conditions were again superior to Combined Immediate and Time conditions, F (1, 276)=19.19, $p < .001$. Work groups tended to show a greater increment from immediate and time recall to self-paced and paced recall than controls,

Table 12. Number of Correct OL Responses on Written MMFR Leniently Scored

Paradigm		Post-IL condition			
		Immediate	Time	Self-Paced	Paced
Control	M	7.46	7.21	7.67	7.58
	SD	.72	.83	.48	.66
DC	M	5.25	4.92	6.08	6.46
	SD	1.85	1.79	1.44	1.10
AC	M	3.96	4.54	5.08	4.75
	SD	1.66	1.77	1.41	1.85

Table 13. Summary of the Analysis of Variance of Leniently-Scored OL Recall on MMFR

Source	df	MS	F	p
Control (C) vs. Comb. work	1	353.13	183.92	< .001
AC vs. DC	1	57.42	29.91	< .001
Immediate (Im.) vs. Time	1	0.00	< 1	
Self-Paced vs. Paced	1	.01	< 1	
Comb. Im. & Time vs. Comb. Self-Paced & Paced	1	36.84	19.19	<.001
C vs. Comb. work X Im. vs. Time	1	1.12	< 1	
C vs. Comb. work X Self-Paced vs. Paced	1	.08	< 1	
C vs. Comb. work X Comb. Im. & Time vs. Comb. Self-Paced & Paced	1	6.45	3.36	<.07
AC vs. DC X Im. vs. Time	1	5.05	2.63	>.10
AC vs. DC X Self-Paced vs. Paced	1	3.02	1.57	>.20
AC vs. DC X Comb. Im. & Time vs. Comb. Self-Paced & Paced	1	3.26	1.70	>.10
Within cell (error)	276	1.92		

F (1, 276)=3.36, $p < .07$. Individual comparisons between Combined Immediate and Time conditions vs. Combined Self-Paced and Paced conditions yielded Fs (all dfs = 1, 276) of 1.06 ($p > .20$), 17.63 ($p < .001$), and 5.56 ($p < .025$) for the Control, DC, and AC paradigms, respectively.

Percentage RI measures yielded similar patterns. Percentage RI values for the DC Combined Immediate and Time and Combined Self-Paced and Paced conditions were 30.7 and 17.8, respectively. RI percentages for AC Combined Immediate and Time and Combined Self-Paced and Paced conditions were 42.0 and 35.5.

MMFR, Second-List Recall

Recall of IL on MMFR is presented in Table 14 for both stringent and lenient scoring. Summaries of the analyses of variance of stringent and lenient scores are presented in Tables 15 and 16, respectively.

As found with OL recall, the hypothesis of no difference between Immediate and Time conditions could not be rejected for either stringent or lenient scoring (Immediate vs. Time, $F < 1$, for stringent MMFR and F=1.00, for lenient MMFR; AC vs. DC X Immediate vs. Time interaction, F=3.14, $p > .05$, for stringent scoring and F=1.00, for lenient scoring).

Neither the Self-Paced vs. Paced comparison ($F < 1$ for stringent scores and F=1.62, $p > .20$, for lenient

Table 14. Number of Correct IL Responses on Written MMFR, Scored Stringently (St.) and Leniently (Len.), for Both Work Paradigms

Paradigm	Scoring		Post-IL condition			
			Immediate	Time	Self-Paced	Paced
DC	St.	M	6.92	7.29	7.04	7.38
		SD	1.61	1.27	1.30	.88
	Len.	M	7.42	7.42	7.46	7.54
		SD	1.06	1.17	.72	.72
AC	St.	M	7.46	6.71	6.00	5.88
		SD	1.02	1.66	2.17	2.05
	Len.	M	7.54	7.08	7.00	6.33
		SD	.83	1.21	1.06	1.81

Table 15. Summary of the Analysis of Variance of Stringently-Scored IL Recall on MMFR

Source	df	MS	F	p
AC vs. DC	1	20.02	8.27	$< .005$
Immediate (Im.) vs. Time	1	.85	< 1	
Self-Paced vs. Paced	1	.26	< 1	
Comb. Im. & Time vs. Comb. Self-Paced & Paced	1	13.02	5.38	$< .025$
AC vs. DC X Im. vs. Time	1	7.59	3.14	$> .05$
AC vs. DC X Self-Paced vs. Paced	1	1.26	< 1	
AC vs. DC X Comb. Im. & Time vs. Comb. Self-Paced & Paced	1	18.75	7.75	$< .01$
Within cell (error)	184	2.42		

Table 16. Summary of the Analysis of Variance of Leniently-Scored IL Recall on MMFR

Source	df	MS	F	p
AC vs. DC	1	10.55	8.37	$<.005$
Immediate (Im.) vs. Time	1	1.26	1.00	
Self-Paced vs. Paced	1	2.04	1.62	$>.20$
Comb. Im. & Time vs. Comb. Self-Paced & Paced	1	3.80	3.02	$>.05$
AC vs. DC X Im. vs. Time	1	1.26	1.00	
AC vs. DC X Self-Paced vs. Paced	1	3.38	2.68	$>.10$
AC vs. DC X Comb. Im. & Time vs. Comb. Self-Paced & Paced	1	6.37	5.06	$<.05$
Within cell (error)	184	1.26		

scores) nor the AC vs. DC X Self-Paced vs. Paced interaction ($F < 1$ for stringent MMFR and $F=2.68$, $p > .10$, for lenient MMFR) was reliable, indicating that Self-Paced and Paced conditions yielded equivalent estimates of IL recall regardless of scoring method.

The overall AC vs. DC comparison was significant for both stringent, $F\ (1, 184)=8.27$, $p < .005$, and lenient, $F\ (1, 184)=8.37$, $p < .005$, scoring. However, the AC-DC difference was more in evidence in Combined Self-Paced and Paced conditions than in Combined Immediate and Time conditions (AC vs. DC X Combined Immediate and Time vs. Combined Self-Paced and Paced interaction, $F=7.75$, $p < .01$, for stringent scores and $F=5.06$, $p < .05$ for lenient scores). Individual comparisons showed that DC groups did not differ significantly between Combined Immediate and Time and Combined Self-Paced and Paced conditions, $F < 1$ for both stringent and lenient scores. On the other hand, AC Combined Self-Paced and Paced groups were significantly inferior to Combined Immediate and Time groups ($F=13.02$, $p < .001$, for stringent scores and $F=7.94$, $p < .01$, for lenient scores).

Since the Time condition can be considered an irrelevent task control condition for IL recall (Learn IL, rest, recall IL), it would appear that interpolated AB recall (after IL) in Self-Paced and Paced conditions

(Learn IL, recall AB, recall IL) resulted in RI for second-list responses in the AC paradigm but not in the DC paradigm.

DISCUSSION

The results of the study will be discussed in terms of three major points of consideration, performance during self-paced and paced recall, MMFR first-list recall, and second-list recall on MMFR.

Self-Paced and Paced Recall

The main findings from the paced recall trials themselves were that increments in OL recall were seen in control and both work paradigms, that work paradigms showed greater increments across trials than controls, and that, of the work paradigms, DC improved more than AC. It was suggested above that simple pacing losses, response competition, and perhaps unlearning are reduced in paced recall. The results of the paced recall trials provide support for reduced pacing losses and competition but cannot, by themselves, permit evaluation of effects on unlearning since, by definition, the MMFR test is required at two points in time, immediately after IL and after paced recall, in order for statements to be made regarding unlearning effects. It is possible that recall performance would improve over unreinforced paced recall trials due to increased recall time but that an MMFR test given after paced recall would indicate

increased unlearning. For this reason, discussion of the effects of unreinforced recall on unlearning will be deferred until later.

Recall during self-paced and paced recall provides evidence that pacing decrements were reduced on paced recall due to the accumulation of recall time. When work groups were combined, small nonsignificant differences between self-paced and paced recall were obtained in control and work paradigms. Since total recall time was equivalent in self-paced and paced recall, it seems reasonable to assume that the similar recall obtained in the two conditions reflects that nothing particularly unique occurred in one method to the exclusion of the other. In other words, self-paced recall yielded a certain amount of retention over a given period of time, as did paced recall. Of course, an experiment in which total recall time is systematically varied should be designed to further test the suggestions that self-paced and paced recall do not yield different degrees of retention with recall time equated and that improvements over paced recall trials are in large part due to increases in total recall time (reduction of simple pacing losses).

While reduction of simple pacing decrements should be the only source of improvement in controls, the finding that work paradigms improved more than controls

over paced recall provides evidence for the reduction of competition in work groups. The first paced recall trial was identical to conventional anticipation measures of RI except that response terms were not presented. Competition should have been maximized on this first paced recall trial (Postman, 1962). But as the number of trials increased paced recall actually approached S-paced MMFR in terms of total recall time. That is, the paced recall trials may be viewed as reflecting a continuum from conventional anticipation (maximal competition) to a limited recall-time MMFR test (minimal competition), even though recall of a given item was paced throughout. Since competition would only be present in work paradigms, the differential improvements of control and work groups are interpreted as due to the reduction of competition effects in DC and AC conditions as conventional anticipation approached MMFR.

One apparent point of difficulty with the above interpretation is the finding that DC resulted in greater improvements than AC over paced recall. If, as according to currently accepted analyses of the DC and AC paradigms (Keppel, 1968), DC results only in generalized response competition (the tendency at recall to continue responding with items from the most recent list) and AC results in generalized competition plus specific competition (competition between two or

more responses associated with the same stimulus), it might be expected that AC (reduction of two sources of competition) should show larger improvements over paced recall than DC (reduction of a single source of competition). What appears to have happened is that specific associative unlearning, present in AC but not in DC (McGovern, 1964), limited the final level of recall in AC. As competition effects were lessened across paced recall trials, more available responses would be correctly paired to stimuli in the DC conditions than in the AC condition because of specific associative unlearning effects in AC, thereby allowing reduced competition to manifest itself to a greater extent in DC than in AC.

MMFR, First-List Recall

Written MMFR unequivocally showed that unreinforced recall did not weaken OL response strength in any paradigm. Rather, unreinforced recall maintained response strength in controls and induced recovery in work conditions. These findings pose a rather formidable degree of opposition to the conditioning analogy's elicitation-extinction hypothesis of unlearning which maintains that associations are weakened by nonreinforcement and that increases in the length of the IL-recall interval lead to spontaneous recovery. However, no weakening of response strength was indicated and the recovery of the present study cannot simply be attributed

to time taken up by unreinforced recall. Rather, unreinforced recall itself was apparently responsible, in some manner, for reducing unlearning. Several interpretations of the unreinforced recall effect are considered below.

One interpretation, in which the elicitation-extinction hypothesis is maintained, is that reinforcement, though not externally provided, was present throughout unreinforced recall by way of S-provided "subjective reinforcement." Given that subjective reinforcement occurred, increments in the recall of work groups are seen as akin to relearning after extinction. The main difficulty with this interpretation lies in specifying a mechanism for subjective reinforcement.

Eimas and Zeaman (1963) and Jones (1962) have suggested that S may give a response as a guess to a stimulus and, assuming that recognition is easier than recall, recognize that the guess was actually correct. However, a "recognition of correct guesses" mechanism appears more plausible in paired-associate recall situations where responses, hence guesses, are already highly available and relatively restricted in extent (e.g., single digit numbers), thus rendering recall largely a matter of specific S-R associative strength, than in the present study where the pool of response guesses consisted of two-syllable adjectives. At any rate, the possibility that unreinforced recall led to subjective reinforcement and relearning cannot be ruled out and seems worthy of further investigation.

A second alternative is that competition is present on MMFR (Houston, 1966a; Houston, 1967a; Keppel, 1968) and that unreinforced recall merely reduced this source of interference at recall. According to this position the distinction between unlearning and competition effects is minimized, thereby deemphasizing the theoretical importance of nonreinforcement both in IL and in unreinforced recall.

Postman and Stark (1965) have suggested that generalized response competition in the form of a tendency or set to restrict responses to those last practiced may influence MMFR performance. Unreinforced recall, by focusing on first-list recall, could have served to overcome such a set to restrict responses to those from IL. The faster rate of improvement of the DC condition over that of the control condition across paced recall trials was considered as evidence for the weakening of generalized response competition. However, generalized response competition must be independently demonstrated on MMFR before it can be concluded that all recovery in the present investigation is attributable to reduction of competition on MMFR.

A third interpretation of the unreinforced recall effect is that unlearning is the result of the suppression of OL responses by dominant IL responses at

recall (Keppel, 1968). If nonreinforced recall of OL tends to bring OL and IL dominance closer together (as by weakening IL), some of the suppressive effects of IL would be overcome.

One prediction from a suppression hypothesis is that OL recall should be negatively related to IL rate of learning. However, amount of OL retention has been found to be positively related to IL rate (Postman & Stark, 1965; Postman, in Keppel, 1968). In the Postman and Stark study, for an AC condition most comparable to the present AC-Immediate condition the partial correlation between IL rate and stringently-scored MMFR performance was .55, with the correlation between OL rate and recall controlled. In the present study, the relationship between number correct in IL and amount recalled on MMFR (stringently scored) was determined by combining the Immediate and Time conditions of each work paradigm. Partial correlations were used to control for the correlation between OL rate and recall. Contrary to the suppression hypothesis, neither work paradigm showed a negative correlation between IL rate and recall. The partial correlations were .15 (AC) and .53 (DC), with only the latter reaching an acceptable level of significance ($p < .005$). Since it does not appear that strong IL responses suppressed OL responses in the usual MMFR Immediate and Time conditions, there is no basis for suggesting that unreinforced recall overcame suppression effects.

A fourth interpretation of the recovery with unreinforced recall focuses on new learning (IL) and postulates disruption of retrieval induced by IL. This view holds that unlearning, or a substantial amount of it, is a manifestation of difficulties with memory search. Unreinforced recall would, then, be considered as facilitating retrieval of, not extinguished, but intact associations.

Feigenbaum (1961) and Hintzman (1968) have proposed information processing models of verbal learning and memory in which retrieval from storage is based upon the sorting of information through associative networks. In these models, forgetting occurs "...because learned material gets lost and inaccessible in a large and growing association network (Feigenbaum, 1961, p. 128)." No absolute weakening of associations (or destruction of information in storage) is implied; instead, inaccessibility of intact traces is considered to underlie forgetting.

Assuming that IL disrupted retrieval processes, the question remains as to how unreinforced recall aided retrieval. One possible answer can be found in Greenbloom and Kimble's (1965) hypothesis that context cues, lost in IL, are reinstated. These authors suggest that the critical context cues are in some way related to the actual presentation of the list itself (less response terms, of course) coupled with response-produced feedback from attempted recall and correct responses.

Critical tests of the notion that unlearning is a matter of retrieval rather than of weakened associations, would involve the manipulation of variables at recall that should facilitate retrieval. Repeated unreinforced recall trials, if nonreinforcement does not in fact act as the elicitation-extinction hypothesis states, might be one such method. Another possibility is the use of cued and noncued recall (Tulving & Pearlstone, 1966). Cued recall refers to the presentation at recall of some stimulus which was either associated with the response in the laboratory (as in paired-associate learning) or associated with the response prior to the experiment (as a category name used as a stimulus cue for recall of an instance of the category). Noncued recall refers to standard unaided free recall.

In the recall of single lists Tulving and Pearlstone (1966) and Wood (1967a; 1967b) have shown that many items in memory are not retrieved unless cued recall is used. In terms of unlearned material, items recalled in the presence of cues but not recalled in the absence of cues would appear to have been inaccessible, not extinguished, at noncued recall. Recent unpublished work of the present writer, using materials and procedures similar to those of the present study, has indicated reliably higher estimates of OL availability in the DC paradigm when cued (stimulus terms provided) as opposed to noncued (standard free recall) recall was used. Further work should be directed to determination of the effects of various retrieval cues on unlearned material in order to test the validity of this fourth interpretation of the unreinforced recall effect.

To summarize the analysis of first-list recall, four interpretations of the reduction in unlearning induced by unreinforced recall was considered. One, involving the suppression hypothesis of unlearning, was rejected. Three alternatives were viewed as viable: one involving subjective reinforcement and relearning on unreinforced recall, a second which postulated generalized response competition on MMFR and its reduction with unreinforced recall, and a third which maintained that unreinforced recall aided retrieval of responses which were inaccessible not extinguished.

MMFR, Second-List Recall

The main finding from IL recall on MMFR was that unreinforced recall resulted in a recall decrement in the AC paradigm but not in the DC condition. This decrement can be considered analogous to unlearning since it cannot be attributed to the usual or "simple" effects of time.

Unfortunately, interpretations of this effect of unreinforced recall on IL recall are precluded due to the fact that degree of IL learning was not equated in AC and DC groups. Any analysis leading to conclusions different from those already discussed for OL recall would have to take into consideration the differential effect of unreinforced recall on the two work paradigms. Whether this differential effect was simply due to the over-learning of DC preventing unlearning (Garskof & Bryan, 1966) or to some unique effect of unreinforced recall is indeterminable.

In view of this difficulty in determining "what to make" of the failure to find an unlearning-type effect in DC with unreinforced recall of OL, all that can be concluded is that unreinforced recall, while improving recall of OL in both work paradigms, adversely affected IL recall only in AC. Any of the three nonrejected interpretations placed on the unreinforced recall effect for OL recall would be applicable to the IL recall data.

In Conclusion

The operation of repeated presentations of stimuli in the absence of reinforcement contains two interrelated points of interest for the two-factor theory of RI. One refers to what has become the most often suggested mechanism for unlearning--the nonreinforcement of intrusions in IL. The other point of interest regards the conceptualization of unlearning (Factor X) itself.

First, even though nonreinforcement, in terms of the withholding of explicit presentation of response terms, resulted in recall increments rather than decrements, the elicitation-extinction mechanism can be retained if the subjective reinforcement and relearning interpretation is given additional support. However, should unreinforced recall be shown to reduce competition on MMFR or to facilitate retrieval in some manner, the elicitation-extinction notion would not be required as an explanation of the unlearning effect. Future work along these lines should contribute to our understanding of the underlying mechanism of unlearning.

Secondly, unlearning has been typically conceptualized as analogous to experimental extinction in classical conditioning; hence the emphasis on nonreinforcement of responses in IL. However, as the present study has shown, two-factor theory can remain just as valuable in handling RI if unlearning is viewed as something other than an extinction effect.

APPENDIX A

Lists Used in the Experiment

The Two Pairings of the AB (OL) List

Stimulus	Response	
	Pairing 1	Pairing 2
BEM	JOYOUS	TRANQUIL
CEK	INSANE	MOTLEY
HIG	BASHFUL	JOYOUS
JOX	TRANQUIL	SCENIC
PAF	CONVEX	INSANE
TUS	MOTLEY	REGAL
VUL	SCENIC	CONVEX
ZON	REGAL	BASHFUL

The Two Pairings of the AC List

Stimulus	Response	
	Pairing 1	Pairing 2
BEM	VINTAGE	FRAGILE
CEK	OPAQUE	ZEALOUS
HIG	ACUTE	UNFIT
JOX	UNFIT	ACUTE
PAF	ZEALOUS	VINTAGE
TUS	FRAGILE	LATENT
VUL	GIFTED	OPAQUE
ZON	LATENT	GIFTED

The Two Pairings of the DC List

Stimulus	Response	
	Pairing 1	Pairing 2
DEV	UNFIT	OPAQUE
FAH	VINTAGE	GIFTED
GOK	ACUTE	VINTAGE
LUT	ZEALOUS	FRAGILE
MIP	OPAQUE	ZEALOUS
NUZ	FRAGILE	LATENT
RAQ	GIFTED	UNFIT
WIY	LATENT	ACUTE

APPENDIX B

Instructions for First-List Learning, Second-List Learning, and Irrelevant Task of Controls

First-List Learning (all Ss):

"This is an experiment in verbal learning. We are studying the way people learn lists of pairs of items. In front of you is what is called a memory drum. The lists to be learned will appear in the opening that you see in the drum. It will work like this. First, a syllable will appear on the left side of the opening. After 2 seconds, a word will appear next to it. Two seconds after you see both the syllable and word, they will disappear and another syllable will be seen, followed again in 2 seconds by a word. This process of seeing first a syllable and then a word paired with it will continue until 8 pairs of syllables and words have been seen. Then there will be a 4 second pause in which you will see a row of asterisks in the opening of the drum. Then the same 8 pairs of syllables and words will begin to appear again, but they will appear in different order. Your job is to say the correct word, that is the one which goes with the syllable, during the 2 second time period when only the syllable can be seen. As I said, you have 2 seconds to make your decision and tell it to me before the answer is revealed. If you cannot think of the answer, read it aloud when it appears. Naturally, the first time through

the list you will not know any answers, but say them anyway when they can be seen. It is not necessary to say the syllable aloud."

"After this list is learned, you will rest and then a second task will be presented. Remember your job is to anticipate the correct word which goes with each syllable you see, and you must do this before the answer is revealed. Are there any questions?"

Second-List Learning (DC and AC Paradigm)

"Now you may rest for a moment, after which I want you to learn another list in exactly the same manner in which you learned the first. This time, I may arbitrarily stop you before you have learned all the pairs or ask you to continue for a number of times after you have already learned all the pairs. Be sure and pronounce all of the words the first time through the list."

Digit Cancellation Task (Controls)

"Now I have a second task for you to perform. Your job will be to circle all of the odd numbers and draw a slash through each even number on this sheet. Treat each 2 digit number as 2 single digits, ignoring zeros. That is, you must deal with the digits 1 through 9. Accuracy and speed are stressed in this task. Since most people complete about the same amount of material, accuracy carries more weight. I will inform you when to stop. Again, circle odd numbers, draw a slash through even numbers, and ignore zero. Ready. Begin."

APPENDIX C

Instructions for Post-IL, Pre-MMFR Tasks

(Instructions below were for work groups; for Controls they were modified to avoid reference to first-list, etc.)

<u>Instructions for Post-IL Digit Cancellation (Time Groups)</u>

"Your task now will be to circle all of the odd numbers and draw a slash through each even number on this sheet. Treat each block of two digits as a number from 0 to 99. Ignore double zero. Accuracy and speed are stressed in this task, but since most people complete about the same amount of material, accuracy carries more weight. I will inform you when to stop. Work across each row, starting on the first one. Again, circle odd numbers, draw a slash through even numbers, and ignore double zero. Any questions? Ready. Begin."

<u>Instructions for Self-Paced Recall</u>

"Now, in the first list a word was paired with each syllable. I will now expose each of the first-list syllables one at a time. Your job will be to try and say the word from the first list that was paired with each syllable. I won't move the drum until you say a word or unless you tell me to move it. We will continue going through the list for a period of time, so if you are unable to think of the word that goes with a particular syllable we will probably come back to that syllable later. When you want me to move the drum, say "move." <u>You</u> will determine how

many times you go through all the syllables. So remember, you are to try and recall first-list words and to give these to the syllables they were paired with in the first list. Any questions? Ready."

Instructions for Paced Recall

"Now, in the first list a word was paired with each syllable. I will now start the drum, exposing each of the syllables one at a time as before, except this time, no words will be shown next to the syllables. Your job will be to try and say the word from the first list that was paired with each syllable, when the syllable appears. That is, it will be the same as when you originally saw the first list except that now the words won't appear. You may say the word that goes with the syllable anytime the syllable is exposed, even after the bar goes up. So remember, you are to try and recall first-list words and to give these to the syllables they were paired with in the first list. Any questions. Ready."

APPENDIX D

Instructions and Examples of Recall Sheets Used for the Written MMFR Test

(Instructions below were for the AC paradigm; the wording for Controls and DC Ss was modified where necessary)

Instructions for MMFR

"In the two lists you have seen, two words were connected with each of the syllables on this sheet. In the spaces provided, write as many of the words as you can next to the appropriate syllables. Write the words in any column, just so they are next to the appropriate syllables. Write down each word as soon as you think of it. Use the lines at the bottom if you are not sure of the syllable it was paired with. You may work at your own pace. There is no penalty for guessing. Tell me when you are finished." (After S indicates he is finished) "Did you write down all the words you remember?"

<u>Example of MMFR Recall Sheet for Control Ss</u>

JOX ____________

HIG ____________

BEM ____________

TUS ____________

ZON ____________

VUL ____________

PAF ____________

CEK ____________

____

____

____

<u>**Example of MMFR Recall Sheet for AC Ss**</u>

CEK	________	________
VUL	________	________
PAF	________	________
ZON	________	________
BEM	________	________
HIG	________	________
TUS	________	________
JOX	________	________
	________	________
	________	________
	________	________

<u>Example of MMFR Recall Sheet for DC Ss</u>

(On the sheets actually used a number of spaces were provided at the bottom of the page)

HIG __________

WIY __________

FAH __________

PAF __________

JOX __________

RAQ __________

TUS __________

GOK __________

LUT __________

VUL __________

BEM __________

ZON __________

NUZ __________

CEK __________

MIP __________

DEV __________

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