REMINISCENCE: A TEST OF EYSENCK'S
THREE-FACTOR THEORY

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ABSTRACT

A test was made of a consolidation theory of reminiscence for the pursuit rotor and inverted alphabet printing (IAP). This theory suggests that reminiscence for these tasks is a result of consolidation of learning. A similar task interpolated early in rest should decrease reminiscence for the pursuit rotor. A similar effect is expected for IAP, but less pronounced. Subjects were 150 female undergraduates. All subjects did each task for 5 minutes, took a 20 minute rest, then did the task again for 2 minutes. Order of the tasks was counterbalanced. Subjects were randomly assigned to orders and to experimental groups, which differed in the nature of the rest period. The five levels of treatment were: rest only, immediate reverse-cue (mirror image) pursuit rotor practice, delayed reverse-cue practice, immediate mirror tracing practice, or delayed mirror tracing. The immediate interpolated tasks began at the start of the rest period, and the delayed tasks after 6 minutes of the rest period.

Three replications of the experiment, with 50 subjects each, were performed. Analysis of the data for the pursuit rotor showed that the experimental treatments did not alter the amount of reminiscence. Reminiscence was lower for subjects who had done the IAP first. A significant difference between replications indicates possible instrument error, which appears to be equal across the treatment groups. Analysis of the IAP data showed no significant differences in reminiscence for replications, treatments, of order of tasks.

The data fail to support the consolidation theory. The possibility of sex differences in the effect of interpolated tasks is discussed. It is concluded that no adequate theory of reminiscence has yet been advanced.

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Reminiscence, usually defined as an improvement in performance following a period of rest without practice, has been repeatedly demonstrated for a number of motor and perceptual tasks, including the pursuit rotor (Ammons, 1947), inverted alphabet printing (Kimble, 1949), tapping (Eysenck, 1964), and the visual kinesthetic aftereffect (Holland, 1963). Despite considerable variation in the amount of reminiscence shown by different individuals, the occurrence of the phenomenon is quite reliable (Huang & Payne, 1975). The main attempt to account for the phenomena of reminiscence (superiority of spaced over massed practice and the typical post-rest upswing) has been that of Hull (1943), who postulated reactive and conditioned inhibition as the explanatory factors.

With only a few exceptions, experiments on reminiscence and related phenomena have been used to test Hull's theory. Snoddy's (1935) explanation of reminiscence in terms of his proposed "opposed processes of mental growth" produced little research. Eason and White (1960) and Kling and Schlosberg (1961) assembled some evidence concerning physiological correlates of reminiscence, which suggests that an approach considering reminiscence to reflect levels of arousal or activation might be fruitful, but I am unaware of any systematic treatment of such an approach.

The accumulation of experimental results seemingly inexplicable in terms of Hullian theory led Eysenck (1965) to formulate a three-factor theory of reminiscence, which accounts for it as a result of consolidation of learning for some tasks, and as a result of the dissipation of reactive inhibition for others. Rachman and Grassi (1965) testing a prediction from Eysenck's theory, produced experimental confirmation of Eysenck's explanation of pursuit rotor reminiscence as reflecting the consolidation across time of the learning that has taken place during the initial practice. Griffith (1968) has reported similar findings.

A recent attempt by the author to reproduce these findings under conditions similar to those used by Rachman and Grassi (1965) led to results which appear to contradict Eysenck's three-factor theory. These results seem equally inexplicable by Hullian theory. Replication of this procedure is necessary to attempt to determine the source of the difference in results.

THE PROBLEM

A period of rest introduced after several minutes of massed practice of a motor task such as the pursuit rotor or inverted alphabet printing will lead to an improvement in performance when the task is resumed (reminiscence). The level of performance reached after resumption of practice will not, however, be as high as the level of subjects who have followed a schedule of spaced practice, with short trials and frequent rest pauses. Hull (1943) attempted to account for these phenomena as a result of a "negative drive" (reactive inhibition) and a habit (conditioned inhibition) which together inhibit performance under conditions of massed practice.

Reactive inhibition accumulates as a function of the amount of work done. When sufficient reactive inhibition accumulates, work will temporarily cease--a so-called involuntary rest pause. This brief cessation of work interferes with performance. Reactive inhibition is dissipated during these brief rest pauses and, since release of drive tension is reinforcing, non-responding becomes a habit. This habit is referred to as conditioned inhibition. Reactive and conditioned inhibition summate to oppose the drives expressed in performance, leading to a decrement in performance. Reactive inhibition is dissipated during rest, as a function of time, leading to an improvement in performance when practice is resumed. This improvement in performance is reminiscence. Conditioned inhibition is not significantly affected by rest, however, and the permanent work decrement (Ammons, 1947) associated with conditioned inhibition leads to a lower level of performance for subjects whose initial acquisition of the skill was under conditions of massed practice, as opposed to subjects whose acquisition of the skill was under conditions of spaced practice. For these subjects the frequent programmed rest pauses allow the dissipation of reactive inhibition before it accumulates to a level where involuntary rest pauses can occur, thus preventing the occurrence of conditioned inhibition.

Despite the attention received by Hull's theory, it does not appear to offer any great advance over a conceptualization of the problem in terms of "simple fatigue," with an open admission that the exact nature of that fatigue is unknown as yet. Adams (1964) has suggested that "we undoubtedly would be ahead in motor learning to abandon Hull's work-inhibition postulates and marshal our findings for work and rest ... for a fatigue theory of our own" (p. 194). William of Occam's warning against the needless multiplication of explanatory entities is perhaps appropriately applied to Hull's explanation of reminiscence.

Empirical evidence suggesting that reactive and conditioned inhibition fail as a model of pursuit rotor reminiscence has been reviewed by Eysenck (1965). Studies by Eysenck and Willett (1961), Willet and Eysenck (1962), and Feldman (1964) have shown that high- and low-drive groups did not differ in pre-rest performance. The differences in reminiscence were due to the superior performance of the high-drive groups post-rest. Inhibition theory would predict that the high-drive group would perform better during pre-rest practice, and would show more reminiscence as a result of accumulating more reactive inhibition during pre-rest practice. Reminiscence would be greater owing to the larger amount of inhibition that could be dissipated during rest. Rachman (1962) tested Pavlov's (1927) theory concerning the "disinhibiting" effects of an alien stimulus. It was predicted that the introduction of a stimulus (a buzzer) late in pre-rest practice on the pursuit rotor should lead to dissipation of the accumulated inhibition, with an improvement in pre-rest performance after the buzzer, and thus a lowering of reminiscence. Reminiscence was indeed decreased for the group receiving the stimulus, but this was due to a lowering of post-rest performance, rather than an improvement in pre-rest performance following the stimulus.

In the light of these findings, Eysenck (1965) suggests that a more adequate explanation of reminiscence in pursuit rotor learning can be offered by a consolidation theory. Eysenck's three-factor theory explains reminiscence in terms of reactive and conditioned inhibition and consolidation of learning. Different motor tasks require different explanations, or different combinations of these factors. Tapping and vigilance tasks, in which performance is best at the beginning of pre-rest practice, deteriorates during pre-rest practice, and then recovers during rest, are examples of relatively pure reactive inhibition tasks. Since no learning is taking place (and thus no consolidation of learning), inhibition alone accounts for the reminiscence that occurs.

Pursuit rotor performance, on the other hand, offers an example of reminiscence accounted for almost exclusively by consolidation of learning, with inhibition playing a negligible role. Because learning of the task must take place, consolidation of learning is assumed to occur. Consolidation of learning continues after practice ceases, but much of the learning during the massed practice is not consolidated during practice, owing to the interference of continued practice. Thus the learning that takes place during massed practice is not wholly available for performance. The learning that takes place during spaced practice is consolidated during the frequent rest pauses, and thus is available for performance.

A test of this theory was undertaken by Rachman and Grassi (1965). They suggest that reminiscence will be prevented, or at least decreased, by interpolation during the rest period of a task designed to interfere with consolidation. They tested four groups of subjects on the pursuit rotor. Each group had five minutes of continuous practice, followed by four hours and ten minutes of rest, followed by two minutes of post-rest practice. During the first ten minutes following pre-rest practice the subjects remained in the laboratory and were subjected to one of four conditions. The first was rest, with no interpolated task. The second group practiced for three minutes on the pursuit rotor while looking at the rotor in a mirror (reverse-cue practice). The three minutes of reverse-cue practice began immediately after the pre-rest practice ended. The third and fourth groups also had three minutes of reverse-cue practice, beginning after three and six minutes of rest, respectively. All subjects then left the laboratory, returning four hours later for the post-rest practice.

The four hours of rest were assumed to be sufficient for the dissipation in all groups. Thus, any differences in reminiscence would be accounted for by the introduction of the interpolated tasks. On the assumption that consolidation would be interfered with by the practice of a similar learning task, and that most consolidation occurs within the first few minutes after learning, it was expected that the rest-only group would show typical reminiscence, and that the immediate reverse-cue group would show little or none, with the two delayed reverse-cue groups intermediate. That was indeed the case, with the immediate reverse-cue group showing a slight negative reminiscence (a drop in performance from pre-rest levels).

Griffith (1968) has repeated this experiment, with a shorter rest period, and obtained similar results. Since that time, little work has been done on this theory. This author has conducted a similar experiment testing this theory, but with different results, which are summarized below.

Eysenck (1965) suggests that reminiscence in pursuit rotor learning is largely a result of consolidation, that reminiscence in tapping and vigilance is largely a result of the accumulation and dissipation of inhibition, and that such tasks as inverted alphabet printing (IAP) are intermediate on this continuum. These suggestions assume that they require less learning than the pursuit rotor, but are not pure performance tasks, essentially devoid of learning, such as tapping. For that reason, in the present study, the experimental design of Rachman and Grassi (1965) was extended to include the IAP task. Reminiscence has been convincingly demonstrated for IAP (Kientzle, 1946; Kimble, 1949; Huang & Payne, 1975).

Mirror tracing suggests itself as a task likely to interfere with consolidation in IAP in somewhat the same manner as the reverse-cue practice is said to for the pursuit rotor. For this reason, five conditions were employed in the present study: rest only, immediate reverse-cue practice, delayed reverse-cue practice, immediate mirror tracing, and delayed mirror tracing. Each subject was tested under the same condition for each task (pursuit rotor and IAP), with order counterbalanced. A twenty minute rest was used, which is expected to be sufficient for dissipation of any accumulated reactive inhibition (Ammons, 1947).

According to Eysenck's consolidation theory, reminiscence should occur for the pursuit task under all conditions except immediate reverse-cue, and should be diminished for the delayed reverse-cue group. Reminiscence should be unaffected by mirror tracing, since the task is dissimilar to pursuit rotor. For the IAP task, reminiscence should occur for the rest only and reverse-cue conditions, but be blocked by the immediate mirror tracing, and diminished by the delayed mirror tracing.

In contrast to Rachman and Grassi's findings, there was no significant difference between the groups, using the measure of reminiscence for the pursuit rotor as the difference between the time-on-target score for the first 10 seconds post-rest and the last 10 seconds pre-rest. No significant differences in reminiscence occurred between the groups with respect to the IAP. For the measure of reminiscence for the pursuit rotor based on the difference between time-on-target scores for the first 30 seconds post-rest and the last 30 seconds pre-rest, it was found that the delayed mirror tracing group showed less reminiscence than the other groups. There was no difference between the rest only and immediate reverse-cue groups in level of reminiscence with either measure. No significant order effects occurred for either task.

Owing to the disagreement between these results and those obtained by Griffith (1968) and Rachman and Grassi (1965) it is proposed that a replication of the study outlined above be undertaken. The number of subjects will be increased from the 50 used previously to 100. The study will be designed as two seperate but identical experiments with 50 subjects each. Should the results warrant it, data from the three studies will be combined for further analysis. The method described below for this experiment is exactly the same as that used previously except that the pursuit rotor will be connected to a set of counters, to determine the number of hits during each 10 seconds of practice, in addition to the usual time-on-target score.

A REVIEW OF THE LITERATURE ON REMINISCENCE

Reminiscence, first reported by Ballard (1913), has been found to occur in a wide variety of tasks--verbal, perceptual, and motor. An early definition of reminiscence held that it is an improvement in retention as measured sometime after a partial mastery of the material, without formal review between learning and recall (McGeoch, 1935). That definition was based on studies of verbal learning, and will hardly serve for other types of studies. Buxton (1943) suggested an improved definition of reminiscence as "an improvement in performance, as shown by some measure of recall at some point after the original practice, without (any) intervening practice" (p. 314). Buxton attempted to avoid, in this definition, some of the difficulties encountered in other studies, eliminating from consideration the effects of practice and rehearsal and the test-retest effect. Except that "performance" might be substituted for "recall" in order to make this definition more exactly applicable to perceptual and motor tasks, the definition given by Buxton can be considered most nearly applicable to the wide range of experiments reported here.

In his original studies, Ballard (1913) found that, when school children were put to the task of memorizing poetry, their ability to recall the material learned was better after a few days than it was immediately after the learning period. This contradicts the Ebbinghaus curve of forgetting, which predicts a gradual decline in the amount recalled over time (Erdelyi & Kleinbard, 1978). Experiments confirmed these results, using a number of different popular ballad poems, nonsense verse, and geometrical shapes. Ballard's procedure was to test the children immediately after the learning period and then to retest them after various intervals. He found that a period of at least a day was necessary for the occurrence of reminiscence. He also found that reminiscence was greatest at about age six, and absent by age 20.

After Ballard's initial studies, little was done in this area until Williams (1926) repeated his work. Using essentially the same procedures, he found reminiscence for partially learned, meaningful material. Like Ballard, he found that the amount of reminiscence was greatest in younger children. He also found more reminiscence in girls than in boys.

Certain possible sources of error are apparent in Ballard's and Williams' work, most notably the lack of control of review or rehearsal during the rest period, and a possible test-retest effect. In an effort to control these variables, Ward (1937) and Hovland (1938a, 1938b) conducted more rigorous studies.

Both used short time intervals, rather than the several days between test and retest used by Ballard and Williams, in order to allow them some control over possible rehearsal. Ward used intervals of from 30 seconds to 20 minutes. Hovland used a two minute interval throughout. Both experimenters had their subjects engage in color-naming during the rest period, in an effort to prevent rehearsal. Ward also compared this intervening task to the use of light reading during the rest period, and found reliably more reminiscence for the color-naming group, where rehearsal was presumably more completely controlled than by light reading.

Hovland found a clear superiority of distributed (spaced) practice over massed practice, with subjects able to learn to criterion in fewer trials under distributed practice. He also found considerable reminiscence under the condition of massed trials, both for recall and for number of trials to relearn from the original criterion of 7 out of 12 items correct or to complete mastery. Distribution of trials during the acquisition phase led to less reminiscence. Perhaps most interestingly, Hovland found a significant increase in recall following a rest period when there had been only one presentation of the list prior to rest, as compared to controls tested for recall immediately after one presentation.

Ward's general procedure was to have the subjects learn lists of nonsense syllables by the method of serial anticipation to either complete mastery of the material or to a criterion of 7 out of 12 correct. After an interval of from 30 seconds to 20 minutes, subjects were tested for recall as well as for rate of relearning. Reminiscence was most noticeable after two minutes of rest. Reminiscence was scored by comparing the level of retention after each interval to a control group which was tested for recall immediately after learning to criterion. In clear contradiction of the results of Ballard and Williams, reminiscence occurred for completely learned lists as well as for those partially learned. Ballard and Williams had each compared retention scores after a rest interval to the criterion scores, which had ruled out the possibility of reminiscence for complete learning. Ward concluded that the criterion score is not a valid measure of mastery, since the score on an immediate recall test is usually slightly lower.

Hovland (1938a) concerned himself with various amounts of distribution of practice, as well as with massed practice interrupted by a single rest period. He also used nonsense syllables learned by serial anticipation, to either 7 out of 12 items correct or mastery. In order to control rehearsal, he had subjects name colors presented on the memory drum during the rest intervals.

Two major objections to the Ballard-Williams type of experiments were made by Ward and Hovland. These were the lack of control of rehearsal during rest, and the possibility of test-retest error influencing the results.

Besides the color-naming and light reading used by Ward, other investigators report using arithmetic problems (McGeoch, McKinney, & Peters, 1937), motor activities (Hovland, 1939), and rapid color-naming (Melton & Stone, 1942). Following their theoretical view that reminiscence is a result of an accumulation of some sort of inhibition during practice and the dissipation of that inhibition during rest, Ward (1937) and later Holland (1963) have suggested that using another activity during the rest period leads to disinhibition. This view is based on Pavlov's concept of disinhibition (1927).

Despite the attempts to control for rehearsal, Buxton concluded that there was the "haunting possibility" of review in even the best controlled experiments. Animal studies with rats (Bunch, 1933; Anderson, 1940) and pigeons (Boneau & Axelrod, 1962) have shown apparent reminiscence. Given the unlikelihood that the rats or pigeons could engage in symbolic rehearsal, these studies seem to indicate that reminiscence can occur in the absence of rehearsal.

The most serious question concerning the studies of Ballard (1913) and Williams (1926) is that of a possible test-retest effect. Ward and Hovland had found far less reminiscence than either Ballard or Williams, after using proper controls for rehearsal and switching to a reminiscence score based on differences between a control group tested immediately and an experimental group tested after a rest interval. Other methodological differences could have accounted for the results, however. Ballard used a number of age groups, finding the most reminiscence in young children, whereas Ward (1937) and Hovland (1938a, 1938b) both used college students, who could not be expected, on the basis of Ballard's results, to show much reminiscence. Ballard and Williams also both found more reminiscence as the meaningfulness of the material increased. Ward and Hovland used nonsense syllables throughout, which Ballard would have predicted to yield lower reminiscence scores.

Other tests of the possibility of a test-retest effect confounding Ballard's and Williams' results seem more conclusive. Bunch (1938) demonstrated that in fact an immediate recall test did improve the score on post-rest performance. Gray (1940) compared delayed recall without pre-test with delayed recall following a pre-test and found higher reminiscence scores with the pre-test. In addition, Gray used meaningful material learned by the whole method, as Ballard and Williams had. Both Bunch and Gray concluded that the procedure used by Ward and Hovland was the best--to bring experimental and control groups to the same level of mastery, test the control group immediately after the criterion is attained, and test the experimental group after the rest interval. The difference between the experimental group scores and the control group scores would then be a measure of reminiscence.

The most thorough test of the possible test-retest effect in Ballard's study was done by H. Ammons and Irion (1954), who repeated Ballard's experiment using the same recall materials, but with both a test-retest group and a seperate test of a post-test only group compared to a control. The comparison of the two reminiscence scores indicated that the extremely high reminiscence scores obtained by Ballard were mainly an artifact. The increase in retention on the retest was seriously confounded by the additional learning that took place during the first test.

Before turning to the theories put forth to explain reminiscence in verbal learning, a brief review of other pertinent studies will be given, showing the range of variables manipulated in the verbal learning studies.

Buxton (1943), in his review of the literature, found no reliable evidence for differences in reminiscence based on age, sex, or intelligence, despite the early indications of such differences by Ballard (1913). McGeoch (1935), in a test of age differences, found no differences between children and college students.

The nature of the practice before rest, whether massed or distributed, was shown by Hovland (1938a) to be related to the amount of reminiscence. More reminiscence is expected, according to an inhibition hypothesis, if practice is massed, and such an effect is found. Melton and Stone (1942) found no reminiscence, even with very rapid rates of learning. This was in contradiction to Hovland's results, but it is likely that the material used by them (adjectives in serial anticipation method) influenced the results.

The nature of the material to be learned has a great effect. Hovland (1938a) found reminiscence using nonsense syllables, though Melton and Stone (1942) found no reminiscence with adjectives. Buxton (1949) repeated Ward's (1937) design with a comparison of nonsense syllables with unrelated adjectives under the same conditions of rate of presentation and length of rest. Like Melton and Stone, he found no reminiscence with adjectives, though it did occur with syllables. Noble (1950) also failed to find reminiscence in serial learning of adjectives.

Another attempt to measure reminiscence with different types of material is that of Edwards and English (1939) and English and Edwards (1939), using a prose passage to be learned, and testing recall by a true-false test. The test was designed to include two types of items--S-items, which test the content or summary of a sentence or several sentences, and V-items, which test verbatim recall of statements from the learned passage. The authors contend that reminiscence occurs with S-items, but that V-items are more quickly forgotten and show no reminiscence.

Their study used test-retest methods and had no control for review, which makes the results suspect. There was also a lack of clear equality in difficulty of the S-items and the V-items.

Rate of exposure of the items in serial anticipation studies influences results. Hovland (1938b) found that a four-second rate, as opposed to a two-second rate, lowered the reminiscence score. McClellend (1942) found the same effect. Hovland speculated that the slow rate made the task much easier, thus leading to less accumulation of inhibition. Only if a large amount of inhibition has accumulated during practice can reminiscence occur.

Length of the rest interval itself is an obvious source of differences in reminiscence, but no definite conclusions can be reached. There is apparently an interaction of length of the lists to be learned, rate of presentation, and other variables with the duration of rest.

Kleinsmith and Kaplan (1963) tested a consolidation theory of reminiscence in paired-associate learning, using high and low levels of arousal. The hypothesis that material learned under high arousal would show stronger permanent memory and weaker immediate memory was confirmed.

Theories of Reminiscence

McGeoch and Irion (1952) reviewed the various theories of reminiscence, dividing them into work theories, perseveration theories, and theories of differential forgetting. Their general outline is followed here, except that Hull's reactive inhibition theory is only briefly discussed. A more complete discussion of it is presented below, in relation to motor learning.

Work Theories

Fatigue. A simple accumulation of fatigue during practice, with recovery from fatigue during rest, has some appeal as an explanation. A number of results make it untenable, however. In Hovland's (1938a) finding of reminiscence following a single presentation of a list of nonsense syllables there was hardly enough mental work to have caused fatigue. In relation to motor learning and memorization, the concept of fatigue is too vague to prove useful in explaining reminiscence.

Reactive inhibition. This theory assumes that an inhibition of the response in a task accumulates as a result of performing the task, and that this inhibition disappears with rest. Hull (1943) formulated this theory most explicitly, but the idea that some form of inhibition might affect reminiscence was mentioned by Ballard (1913). This theory has great predictive value, and can account for some interesting findings, such as that of Rohrer (1949) that intentional rehearsal does not lead to more reminiscence. An inhibition theory would account for this by the continued accumulation of inhibition during rehearsal.

Inhibition theories are, of course, forms of fatigue theory. Hull's theory attempts to improve on a theory of simple fatigue by making the nature of the inhibiting process more explicit.

Motivation. The idea that continuous work leads to a loss of motivation has been suggested. The same objections that occur in relation to a simple fatigue theory also apply here. Loss of motivation could scarcely explain the reminiscence found by Hovland (1938a) following a single presentation of a list, or in similar cases where short work intervals are concerned.

Perseveration Theories

Classical perseveration theory. The idea that neural activity in learning persists for some time after formal learning stops is termed classical perseveration theory by McGeoch and Irion, who dismiss this area of speculation as "unpromising." This theory was the one thought most adequate by Ballard (1913), who expressed it in terms of neural growth or actual physiological change which continues after learning. "Reminiscence may be said to be due to the inertia of the nervous system, which does not yield to an influence at once. Nor does the inertia stop yielding at once" (Ballard, 1913, p. 82).

Rehearsal. This is mentioned by McGeoch and Irion as another rehearsal theory. It has been shown to be inadequate to explain reminiscence, though it may have a confounding effect on some experiments.

Snoddy's theory of primary and secondary growth. Snoddy (1935) postulated two opposed processes of mental growth. Primary growth appears early in learning and increases during the rest period. Secondary growth begins late in practice and is at its maximum when practice is continuous. Ammons' (1947) review of the theory makes it clear that the variables are not sufficiently well defined to be of predictive value. Almost no work has been based on this theory, except that of Dore and Hilgard (1938), who failed to support it.

Differential forgetting

Theories of differential forgetting hypothesize that during practice a subject learns both correct responses and incorrect and conflicting ones which retard fixation of correct responses and interfere with performance. The conflicting responses may be expected to be forgotten at a faster rate, due to extinction. Hull's concept of reactive inhibition is treated as an operationally defined construct, and this inhibition presumably could take the form of learning of ineffective approaches to the task.

Reminiscence in Motor Learning

Since the early 1950's, most of the work done on reminiscence has been done with motor tasks, most often the pursuit rotor. These tasks have the advantage of allowing control over practice (with the possible exception of internal, symbolic practice), and of avoiding many of the other problems that plague verbal learning and memorization studies. Eysenck (1965), in formulating the theory of reminiscence on which the study proposed here is based, excluded verbal learning studies from consideration in his theoretical reformulation "because of the great difficulties that attend the very demonstration of reminiscence in their field" (p. 164). Thus, the area where reminiscence was first found is now viewed as the most suspect and least reliable area of experimentation, though there has been some recent work on reminiscence in recall (Erdelyi & Kleinbard, 1978). Pursuit rotor learning, on the other hand, allows a clear demonstration of reminiscence, and since a score is generated for each trial, learning curves and other presentations of the data can more easily be made, without the problem of repeated testing. In most of the motor and perceptual tasks used in recent work on reminiscence, each trial provides its own score of performance.

In addition to pursuit rotor performance, other tasks have been used to investigate reminiscence. These include inverted alphabet printing (Kientzle, 1946), visual kinetic after-effects (Holland, 1961), vigilance tasks such as signal detection (Buckner & McGrath, 1963), symbol substitution (Eysenck & Willet, 1962), and writing of Chinese-like nonsense characters (Furakawa, 1970).

In the pursuit rotor task, the subject attempts to keep the tip of a hand-held stylus on the target area of a disk rotating at a fixed speed (typically 60 revolutions per minute). The length of each trial is from 10 to 60 seconds in most studies, with only enough time between trials for re-setting the timer and recording the score, if this is being done manually. A buzzer sounds whenever the subject is on target. Scoring of the amount of time on target is automatic.

After a few minutes of massed practice, a rest pause is introduced. After rest, massed practice is continued for a short time. Reminiscence is usually scored by subtracting the score on the last pre-rest trial from the score on the first post-rest trial.

Besides length of individual trials, the length of pre-rest practice has been manipulated, along with the length of the rest period prior to retesting. Irion (1949) found that as the amount of pre-rest practice increases, the amount of reminiscence first increases and then decreases. Ammons (1947) found that the amount of reminiscence appears to be a negatively accelerated, increasing function of the length of the rest period, with a very rapid rise in reminiscence during the first five minutes of rest. These results were also obtained by Kimble and Horenstein (1948). Koonce, Chambliss, and Irion (1964) have found that reminiscence occurs for pursuit rotor learning after periods as long as 730 days.

Length of the intertrial rest period has been systematically studied by Adams (1954), who found that performance improves as the length of the intertrial interval increases. This amounts to a greater distribution of practice, which has been shown to affect performance on verbal learning and recall (Hovland, 1937), presumably as a result of the dissipation of inhibition during the interval. Adams had subjects practice for 150 30-second trials, with distribution varied from completely massed trials (no intertrial interval) to 30-second intertrial intervals. All groups reached an asymptote at about 60 trials, and remained at this level through the remaining trials. Level of performance at the asymptote increased with the increase in intertrial intervals.

Size of the target has been experimentally manipulated. Larger target size shows a larger amount of reminiscence (Humphries, 1961), as well as showing typical post-rest upswing and downswing. A smaller target size was found to show little reminiscence and neither post-rest upswing nor post-rest downswing. Post-rest upswing and downswing refer to an increase in time on target score between the first and second post-rest trials, and a decrease in score between the second and thrid post-rest trials, respectively (Eysenck & Gray, 1971). These phenomena are most usually observed with 10-second trials. Ammons (1947) first described post-rest upswing, which he called the warm-up decrement, suggesting that the second post-rest trial was higher than the first owing to a "warm-up" or regaining of set. Eysenck (1969) has suggested that this is due to a physiological "warming up" of the muscles, rather than to a psychological resumption of set.

A large amount of work has been done to test the possibility of personality factors in pursuit rotor learning. One variable tested is drive. Eysenck and Maxwell (1961) and Willet and Eysenck (1962) found that a high-drive group showed more reminiscence than a low-drive group, but that overall performance was not significantly different. Eysenck and Willet found that performance level was similar for the two groups but, contrary to prediction, found more reminiscence in the low-drive group (Eysenck and Willet, 1962). A severe limitation of these studies was the assignment of subjects to high- and low-drive groups. High drive groups were engineering apprentices at the Ford Motor Company in Great Britain. Low-drive subjects were apprentices in trades where they were guaranteed advancement through union agreement. Wasserman (1951), using inverted alphabet printing as his task, did find better performance and more reminiscence for a high-drive group. In his study, high drive was produced by telling the subjects that they were being given a new type of intelligence test, while low-drive groups were told that they were helping with a preliminary experiment in a learning study.

Hicks (1975) has compared cognitive styles, as determined by the Stroop test, and also high and low anxiety and the interaction between anxiety and cognitive style. The cognitive styles are designated Cognitive and Perceptual-Motor. Perceptual-Motor subjects were superior overall in performance on the pursuit rotor. For the Cognitive group, reminiscence was greatest under low anxiety, while for the Perceptual-Motor group reminiscence was greatest under high anxiety.

Meier (1964) has shown that level of electroencephalogram (EEG) abnormality in subjects with siezure disorders is related to amount of reminiscence. He found significant differences between persons with normal EEG patterns and those with highly abnormal patterns, with more reminiscence on the pursuit rotor occurring in the normal group. Meier (1961) has also found relations between degrees of reminiscence and various psychiatric diagnostic categories. Broadhurst and Eysenck (1973) on the other hand, failed to find differences between normals and schizophrenics on pursuit rotor reminiscence.

The largest body of work relating reminiscence to personality variables has been that of Eysenck and his associates correlating reminiscence with the dimension of extraversion-introversion. Eysenck developed the theory that extraverts should show more reminiscence than introverts. An individual in whom reactive inhibition is easily generated, and in whom it is only slowly dissipated, will be predisposed to extraverted patterns of behavior. On the other hand, persons in whom only low levels of reactive inhibition accumulate, and who dissipate it quickly, will be predisposed to introverted patterns of behavior (Eysenck, 1955). Eysenck has developed a test of extraversion-introversion and neuroticism, the Maudsley Personality Inventory, which is generally the instrument used to determine extraversion or introversion in his studies. Some twenty tests of this hypothesis have been made (Eysenck, 1965), most of which show the expected direction of correlation, though in almost all the tests the correlation is a weak one. The importance of these findings, and of the findings of Eysenck and his associates on drive and reminiscence, will become apparent below in relation to certain difficulties with the Hullian theory of reminiscence. These and other findings have led Eysenck (1965) to propose his three-factor theory of reminiscence.

Two- and Three-Factor Theories of Reminiscence

C. L. Hull's (1943) theory of reminiscence has been the most widely accepted and certainly the most widely used by experimenters as a theoretical framework for reminiscence research. This two-factor theory of reminiscence holds that an effortful response produces a tendency to avoid repeating that response. This hypothetical tendency is called reactive inhibition ($\underline{I}_{\underline{R}}$). Hull considered this to be a negative drive state, which accumulates due to the effort involved in the task or a rapid rate of responding. The appropriate goal situation for reactive inhibition is rest, which dissipates the inhibition.

If responding is rapid, as under conditions of massed practice, $\underline{I}_{\underline{R}}$ can accumulate to the point that its strength is equal to the positive drive under which the subject is performing the task. When this occurs, there is a brief pause in the task, called an involuntary rest pause (IRP). Dissipation of $\underline{I}_{\underline{R}}$ during the IRP allows a return to the performance. Because they reduce a drive state, IRP's are reinforcing. This reinforcement occurs as a result of not performing, thus conditioning the subject not to perform. This habit of not performing is called conditioned inhibition ($_{\underline{S}}\underline{I}_{\underline{R}}$).

In pursuit rotor investigations, it is hypothesized that the subject's score (time on target) improves up to the point where enough reactive inhibition accumulates to cause IRP's, at which time the score will reach an asymptote, reflecting the balance between drive to perform and reactive inhibition. During the massed trials conditioned inhibition also accumulates, and plays a part in keeping the scores low. During rest, however, it is not dissipated, since it is a habit rather than a drive. The amount of resistance to continued practice due to reactive inhibition is referred to as temporary work decrement (Ammons, 1947). The resistance due to conditioned inhibition, which does not substantially diminish over time, is referred to as permanent work decrement.

Eysenck (1965) points out, however, that there are facts concerning reminiscence that are not adequately explained by the theory. Interestingly, the findings that most clearly call into question the validity of the reactive inhibition theory are all a result of tests of that theory in which the results were as predicted. Closer examiniation of the results, however, shows that the verification of the theory was only apparent.

Studies on the effects of drive states on reminiscence, discussed above, have tended overall to confirm the prediction that high-drive groups would exhibit more reminiscence. Kimble (1950) contended that high motivation leads the subject to tolerate greater amounts or reactive inhibition, leading to its accumulation, since involuntary rest pauses are less frequent. For this reason, there will be better performance prior to rest by the high-drive group (since there is less interference from IRP's) and greater reminiscence (since there is more reactive inhibition that can dissipate during rest).

Eysenck and Maxwell (1961), Eysenck and Willet (1962) and Willet and Eysenck (1962) found that reminiscence was indeed greater for the high-drive groups. But there was no difference found between the high- and low-drive groups on pre-rest performance.

Eysenck's prediction that the amount of reminiscence would correlate positively with extraversion assumed that extraverts accumulate reactive inhibition more rapidly, producing a greater work decrement prior to rest and greater reminiscence. Simple correlations of reminiscence with extraversion seemed to verify this hypothesis, but when Eysenck (1964b) investigated the possibility that the greater reminiscence scores were produced by improved post-rest performance, rather than by poorer pre-rest performance, he found no difference between extraverts and introverts on pre-rest performance.

Eysenck (1964a) attempted to test the hypothesis, based on inhibition theory, that reminiscence occurs at least in large measure due to poor pre-rest performance, which is lowered by the accumulation of inhibition. He matched 300 subjects for their initial ability on the pursuit rotor and then divided them into groups on the basis of whether or not their performance during the last 90 seconds of pre-rest practice showed a decline. On the basis of inhibition theory it would be predicted that the subjects showing the decline in performance prior to rest would show the greatest amount of reminiscence. No difference was found between the groups.

Another contradiction of inhibition theory comes from Rachman (1962), who tested the hypothesis first put forward by Pavlov (1927) that the introduction of an alien stimulus will lead to a very rapid removal of inhibition. Rachman tested the effects of a very loud buzzer, introduced after the 28th of 30 10-second trials prior to rest. There was then a 10 minute rest, followed by six more trials. As predicted, there was a lowering of reminiscence scores for subjects exposed to the buzzer.

But the lowering of reminiscence scores did not come about from a sudden rise in pre-rest performance following the disinhibiting stimulus, as predicted. Rather, the lowered reminiscence resulted from lower post-rest performance. Feldman (1964) and Mohan (1968) have demonstrated the same effect.

Results such as these led Adams (1964), in a review of work on motor skills, to conclude that "we undoubtedly would be ahead in motor learning to abandon Hull's work-inhibition postulates and marshal our findings for work and rest (which are considerable) for a fatigue theory of our own" (p. 194).

In an effort to provide a theory of reminiscence in pursuit rotor tasks, and a framework for dealing with reminiscence in other tasks, Eysenck (1965) has proposed a three-factor theory of reminiscence, based on reactive and conditioned inhibition along with a third factor--consolidation. Eysenck suggests that Hullian theory deals with decrements in performance, while consolidation deals with decrements in learning. These two approaches are seen by Eysenck to be complementary rather than antithetical. That is, both are required to explain reminiscence phenomena. A further assumption that Eysenck makes is that the causes of reminiscence are task-specific. Thus some tasks, such as the pursuit rotor, are explicable almost completely in terms of consolidation, while other tasks, such as vigilance and spiral after-effect, are affected by inhibition. The basic assumptions of the consolidation theory are that some sort of (unspecified) neural fixation of learning takes place, that this neural fixation requires time to reach its optimum, and that this fixation process is interfered with by work (continuation of the task) or by irrelevant sensory stimuli (Eysenck, 1964a).

The main phenomena of reminiscence in pursuit rotor learning are adequately explicable in terms of consolidation theory. In general, reminiscence occurs as a result of the consolidation which has taken place during rest. During pre-rest practice, a point is reached (asymptote) where continued work interferes with consolidation of the learning already accomplished. But consolidation theory cannot explain some of the phenomena of reminiscence such as the permanent work decrement and post-rest upswing. Consolidation theory can explain the findings of Rachman (1962) that an alien stimulus introduced late in massed practice leads to a decrement in the post-rest performance. According to consolidation theory, the alien stimulus (a buzzer or, in Mohan's (1968) study, a bright light) interferes with consolidation, somehow disrupting the neural trace.

There have been few tests of Eysenck's theory. Rachman and Grassi (1965), in the experiment discussed above, confirmed a prediction from the theory that a competing learning task would interfere with consolidation in pursuit rotor learning, thus lowering reminiscence. Griffith (1968) produced the same results. Stelmach (1968) had subjects read aloud during rest in an effort to interfere with reminiscence in free-standing ladder climbing, but found no reduction in reminiscence from the interpolated task.

Earlier work testing aspects of Hullian theory bears on consolidation theory. Duncan (1957) had subjects being tested on the pursuit rotor either continue visual tracking during rest, continue rotary arm movement at the same speed with the subjects blindfolded and the stylus guided by a track, or rest. Rotary arm movement depressed post-rest performance (i.e., reduced reminiscence), while visual tracking did not. Humphries and McIntyre (1963), in a similar experiment, found no interference with reminiscence from either visual tracking or rotary arm movement.

There has been little work in recent years on reminiscence, due probably to changing areas of interest for researchers. The improvements in ready availability of more advanced data analysis techniques and improved knowledge of the physiology of the motor and visual systems suggest that research might now be able to offer insights into reminiscence not previously available.

METHOD

Subjects

Subjects were 150 female undergraduates at Texas Woman's University, ages 18 to 26. Preferred hand was not taken into account. Subjects were volunteers, recruited by personal appeal to classes in various departments. The first group of 50 subjects was tested during the Spring semester, 1979. The remaining 100 subjects were tested during the Fall semester, 1979.

Apparatus

Inverted Alphabet Printing

The apparatus for this test consisted of commercially available graph paper, ruled in .25 inch squares. One inch divisions were heavily ruled. The ruled area was 7 by 10 inches.

A Lafayette mirror tracing apparatus, model 31010, was used as the interpolated task predicted to lower reminiscence for the IAP task. Mimeographed circles with an inside diamter of 5.75 inches (14.6 cm) and an outside diameter of 6.25 inches (15.9 cm) were used as targets. Subjects traced around each target once with a pencil.

Pursuit Rotor

A Lafayette polar pursuit apparatus was used, model 30013. Lafayette .01 second stop clocks were used to record time on target (TOT). Two Hunter decade interval timers cycled timing between the two stop clocks every 10 seconds, so that TOT scores were recorded by the experimenter and each stop clock reset while the other was recording.

For the reverse-cue pursuit rotor, the interpolated task predicted to reduce reminiscence for the pursuit rotor, a frame of copper tubing was attached over the pursuit rotor, which permitted attachment of a sheet of cardboard that blocked the subjects' view of the rotor without interfering with movement of the stylus. A mirror mounted on the wall behind the pursuit rotor allowed the subjects to see the target indirectly during reverse-cue practice.

The pursuit rotor target was provided by flourescent lights inside the rotor. A turntable mounted above the lights is opaque except for a strip .75 inches (1.9 cm) wide. A sheet of glass with a paper backing is mounted above this. The circular route of the target is then determined by cutting out the appropriate pattern on the paper. The circle pattern used an inside diameter of

5.62 inches (14.29 cm) and an outside diamter of 6.25 inches (15.89 cm). The target of light was thus approximately square.

The surface of the pursuit rotor was 37.5 inches (95.25 cm) above the floor. The IAP and mirror tracing tasks were done with the subject seated at a table 28.5 inches (72.39 cm) high. Timing of all IAP trials and interpolated tasks and rest period was done with an Arista stopwatch, with graduations of .1 seconds.

Procedure

Each subject was tested on both IAP and pursuit rotor, with order of the tasks counterbalanced across all groups. Five levels of treatment and two orders resulted in 10 groups of subjects for each replicate. Subjects were randomly assigned to groups within each replicate.

All subjects performed on the pursuit rotor for 5 minutes of massed practice, followed by 20 minutes of rest, followed by 2 more minutes of practice. For the IAP task, subjects completed 10 trials of 30 seconds each, followed by a 20 minute rest, followed by 4 more trials. The interval between trials on the IAP task was approximately 3 seconds. During the rest period for each task, subjects were exposed to one of five conditions:

1. Rest only (no interpolated task).

2. Immediate reverse-cue (reverse-cue pursuit rotor practice for 3 minutes at the beginning of the rest period).

3. Delayed reverse-cue (reverse-cue practice for 3 minutes, beginning 6 minutes after the start of rest).

4. Immediate mirror tracing (mirror tracing for 3 minutes, beginning at the start of the rest period).

5. Delayed mirror tracing (mirror tracing for 3 minutes, beginning 6 minutes after the start of rest).

The interval between the end of pre-rest practice and the start of the immediate interpolated tasks was approximately 20 seconds.

For the IAP task, subjects were instructed to begin in the lower right corner of the paper and print across to the left, printing each letter upside down and backwards. A demonstration of the first few letters was given. At the end of 30 seconds, subjects were told "Stop. Ready. Begin." At that time they started again at the next numbered section on the right. Subjects were instructed to continue on the next line if they finished a line (29 letters per line), and to continue through the alphabet again if they reached the end of the alphabet during a trial. Subjects were instructed to begin each trial with the next letter of the alphabet from where they finished the last trial, rather than starting each trial with the letter A.

During the rest period, when not engaged in interpolated tasks, subjects either read or conversed with the experimenter. Subjects were not allowed to smoke during the rest period, and were not allowed to read textbooks or study during that time.

The interval between the IAP and pursuit rotor tasks was approximately 2 minutes, when the IAP was done first. When the pursuit rotor was done first, the interval was about 5 minutes, since the IAP instructions took longer than instructions for the pursuit rotor.

For the mirror tracing, subjects were instructed to trace around the circle clockwise, staying within the lines. A supply of circle targets was beside the mirror tracing apparatus, and subjects were told to complete as many as possible, tracing around each target once.

For the pursuit rotor, subjects were shown how to perform the task, then asked to do the task for a few seconds, to be certain that instructions were understood. Subjects were told to try to keep the tip of the stylus on top of the moving target. The target moved in a circle at 60 rpm.

For the reverse-cue practice, the experimenter attached a sheet of cardboard to the frame over the pursuit rotor, blocking the subjects' direct view of the target. Subjects were instructed to track the target while looking in the mirror mounted behind the apparatus.

Data Analysis

For purposes of this discussion, the term "performance measure" will be used to refer to the three different sets of scores generated by each subject. These are the number of letters printed during each 30-second trial of IAP, the number of seconds time on target during each 10-second trial on the pursuit rotor, and the number of seconds TOT for the pursuit rotor averaged across three consecutive trials of 10 seconds each. The performance measures will be referred to as IAP, 10-second pursuit rotor, and 30-second pursuit rotor, respectively. The IAP thus had 10 trials pre-rest and 4 trials post-rest. The 10-second pursuit rotor had 30 trials pre-rest and 12 trials post-rest. The 30-second pursuit rotor had 10 trials pre-rest and 4 trials post-rest. The 30-second pursuit rotor measure is expressed in TOT in seconds out of 10 seconds. That is, the same unit of measurement is used for both the 10-second and 30-second pursuit rotor measures, except that the 30-second measure represents a mean across three 10-second trials.

The trials of interest for the analyses are the last pre-rest trial and the first post-rest trial for each measure. Since these are the only scores used, "pre-rest scores" will refer to the scores on the last trial pre-rest, and "post-rest scores" will refer to the scores on the first post-rest trial.

For each performance measure, the assumptions of normality and homogeneity of variance and regression were tested, and an analysis of covariance performed as the principal analysis. The normality assumption was tested on the three main effects, which are defined below. The Kolmogorov-Smirnov test for the similarity of distributions was performed by the NPAR program of the SPSS computer package (Matzek, 1978), which generates the normal distribution with the mean and standard deviation supplied by the user. The means and standard deviations for the groups within each main effect were input as the parameters of the normal distribution that the obtained distribution was compared to. According to the

SPSS manual (Matzek, 1978), this results in a more conservative test than if known parameters are used.

The assumption of homogeneity of variances was tested seperately for each main effect, using Levene's test, which was computed by the BMDP7D program (Dixon & Brown, 1979). The assumption of homogeneity of regression was tested for each performance measure using the BMDP1V program (Dixon & Brown, 1978). This program computes the regression slopes for the dependent variable (post-rest scores) against the covariate (pre-rest scores). These 30 slopes are then compared for equality. For each of these analyses, the degrees of freedom are p - 1 and n_t - 2p, where p is the number of slopes to be compared and n_t is the total number of sub ects in all groups (Dayton, 1970).

The analyses of covariance on the three performance measures used the post-rest scores as dependent variables, with the pre-rest scores as covariates. The main effects for each ANCOVA were Replicates, Levels of Treatment, and Order of Treatment.

There were three levels of the Replicates effect, representing the replications of the experiment with 50 subjects in each replicate. The five Levels of Treatment represent the five conditions outlined in the Procedures, above. The Order effect compares subjects who did the pursuit rotor first to those who did the IAP first. Order was counterbalanced, since each subject did both the pursuit rotor and IAP tasks. Each ANCOVA was thus a 3 x 5 x 2 analysis with five subjects per cell of the design, totalling 150 subjects. The Tukey (a) procedure for multiple comparisons, with the adjusted error mean square corrected according to Winer (1962), was used for post hoc comparisons between means for significant effects in the ANCOVAs with pre-rest scores as the single covariate.

The first set of analyses for each performance measure used the ANCOVA with post-rest scores as the dependent variables and pre-rest scores as the covariates. A second set of analyses used the age of the subjects and the pre-rest scores as covariates, with post-rest scores as dependent variables. These analyses are thus the same as the initial ANCOVAs, except for the addition of age as a second covariate. A third set of analyses used pre- and post-rest scores as two levels of a Repeated Measures factor, along with the Replicates, Level, and Order factors.

The occurrence in the repeated measures design of a significant Repeated Measures effect indicates that reminiscence occurred, ignoring the other main effects. Significant interactions of the Repeated Measures factor with the other factors indicate the the degree of reminiscence differed across different levels of the other factor in the interaction. A significant Repeated Measures by Levels interaction would thus indicate the reminiscence differed for different levels of treatment. Significant main effects in the ANCOVAs should thus be matched by significant first-order interactions between the Repeated Measures factor and the other main effects.

Finally, an analysis of variance was performed for each performance measure using the pre-rest scores as the dependent variables, testing the equality of groups on the performance measures prior to introduction of the treatment. This tested equality of pre-rest performance.

The BMDP2V program (Dixon & Brown, 1978) was used for all of the analyses of variance and covariance discussed above.

Correlations were computed between pre- and post-rest scores and between pre-rest scores and reminiscence scores (where reminiscence scores are obtained by subtracting the pre-rest score from the post-rest score for each subject) for each performance measure. Correlations between reminiscence scores for the three performance measures were also computed. Correlation coefficients for each of these relationships were computed for each treatment group seperately and for the subjects as a whole. Pearson product-moment correlations were used throughout. These were computed using the SPSS regression program (Nie, Hull, Jenkins, Steinbrenner, & Bent, 1975).

For all analyses except the correlations, exact values of p, as provided by the various computer programs, are reported, rather than reporting which values of the statistics reached significance at a preset level of alpha. The level of significance, alpha, was set at .05 prior to testing, but in reporting results it is felt that exact probabilities give the reader a more adequate understanding of the data than merely a listing of "significant" or "not significant." When, in the text, an effect is referred to as "significant," this is to be interpreted as meaning that the statistic is significant at any conventional level of alpha, i.e., .05 or less.

The values of p, the probability that the sample came from a population (or populations) of some specific type (usually one in which the population means are equal), offer a possibly misleading exactness, implying that the probability is known with a high level of precision. The degree of variance of the data from the assumed forms (equal variances, normality, and equal regressions) alters the precision of the reported levels of p by some unknown amount. Nevertheless, if this inexactness is kept in mind, reporting of "exact" probabilities should enable the reader to decide whether the interpretations placed on the outcomes of the analyses are warranted, and to decide for themselves what interpretation to place on borderline effects.

The ready availability of "exact" probabilities, from the output of the various computer programs, seems to offer an aid to interpretation, beyond comparison of obtained values to table values at the specified level of alpha. Some considerable caution should be exercised, however, and the trap of treating the values of p as precisely known values must be avoided.

RESULTS

Inverted Alphabet Printing

For the inverted alphabet printing task, performance was measured by the number of letters printed during each 30-second trial. The last pre-rest trial and first post-rest trial provided the scores of interest. Means and standard deviations for each of the 30 cells of the design are reported in Tables 1 and 3 for pre-rest and post-rest scores, respectively. Marginal means and standard deviations for these measures are reported in Tables 2 and 4. Post-rest means, adjusted for equality of pre-rest scores, along with reminiscence scores, defined as post-rest score minus pre-rest score, are reported in Table 5. The adjusted post-rest means are the means compared in the analysis of covariance using pre-rest scores as the single covariate. Marginal means for the adjusted post-rest scores and for the reminiscence scores are reported in Table 6.

The Kolmogorov-Smirnov tests of normality are reported in Table 7. These test the null hypothesis that the scores at each level of each main effect do not differ from a normal distribution. In each case the null hypothesis is retained.

Table 1

Pre-rest Means and (Standard Deviations) for Inverted Alphabet Printing

Replicate	Order	Level of Treatment				
		RO	IRC	DRC	IMT	DMT
1	1	22.8 (6.38)	25.8 (8.01)	28.2 (5.07)	25.2 (4.76)	19.6 (2.61)
	2	25.2 (5.45)	25.4 (3.85)	22.2 (6.10)	25.2 (1.92)	26.4 (4.16)
2	1	25.4 (4.10)	23.8 (5.93)	23.4 (5.68)	20.2 (5.21)	24.6 (8.08)
	2	21.6 (6.50)	27.2 (3.96)	23.2 (2.59)	26.2 (3.11)	20.2 (5.89)
3	1	25.6 (5.32)	23.8 (2.59)	23.0 (4.47)	25.0 (3.08)	20.2 (2.39)
	2	26.8 (3.70)	22.2 (3.96)	22.2 (4.20)	26.8 (3.27)	21.2 (5.22)

Note: RO = rest only; IRC = immediate reverse-cue pursuit rotor; DRC = delayed reverse-cue pursuit rotor; IMT = immediate mirror tracing; DMT = delayed mirror tracing.

Table 2

Marginal Means and (Standard Deviations) for Pre-rest Inverted Alphabet Printing

Factor	Levels of Factors				
	1	2	3		
Replicates	24.6 (5.19)	23.6 (5.35)	23.7 (4.19)		
	RO	IRC	DRC	IMT	DMT
Levels of Treatment[a]	24.6 (5.19)	24.7 (4.88)	23.7 (4.86)	24.8 (4.03)	22.0 (5.32)
	1	2			
Order	23.8 (5.23)	24.1 (4.63)			

[a]See Note, Table 1, for definitions of treatments.

Table 3

Post-rest Means and (Standard Deviations) for Inverted Alphabet Printing

Replicate	Order	Levels of Treatment[a]				
		RO	IRC	DRC	IMT	DMT
1	1	23.6 (6.50)	27.4 (9.42)	28.2 (3.77)	28.4 (5.27)	21.0 (3.39)
	2	27.8 (6.83)	27.6 (4.50)	24.4 (6.80)	24.4 (7.50)	26.8 (3.27)
2	1	27.8 (4.09)	27.2 (5.76)	25.6 (7.23)	23.0 (5.24)	25.0 (7.48)
	2	24.0 (4.53)	29.6 (4.93)	27.2 (4.81)	29.0 (2.12)	22.6 (3.13)
3	1	26.4 (3.65)	28.2 (6.42)	28.0 (3.24)	24.4 (3.78)	25.4 (2.70)
	2	30.0 (4.58)	26.0 (2.92)	26.8 (3.27)	27.4 (3.58)	22.0 (6.20)

[a]See Note, Table 1, for definitions of treatments.

Table 4

Marginal Means and (Standard Deviations) for Post-rest Inverted Alphabet Printing

Factor	Levels of Factors				
	1	2	3		
Replicates	26.0 (5.95)	26.1 (5.23)	26.5 (4.37)		
	RO	IRC	DRC	IMT	DMT
Levels of Treatment[a]	26.6 (5.23)	27.7 (5.57)	26.7 (4.85)	26.0 (5.00)	23.8 (4.78)
	1	2			
Order	26.0 (5.42)	26.4 (4.97)			

[a]See Note, Table 1, for definitions of treatments.

Table 5

Adjusted Post-rest Means and (Reminiscence Scores) for Inverted Alphabet Printing

Replicate	Order	Level of Treatment[a]				
		RO	IRC	DRC	IMT	DMT
1	1	24.5 (0.8)	26.0 (1.6)	24.9 (0.0)	27.4 (3.2)	24.4 (1.4)
	2	26.8 (2.6)	26.5 (2.2)	25.8 (2.2)	23.4 (-0.8)	24.9 (0.4)
2	1	26.7 (2.4)	27.3 (3.4)	26.0 (2.2)	25.9 (2.8)	24.5 (0.4)
	2	25.8 (2.4)	27.1 (2.4)	27.8 (4.0)	27.3 (2.8)	25.5 (2.4)
3	1	25.1 (0.8)	28.3 (4.4)	28.7 (5.0)	23.6 (-0.6)	28.3 (5.2)
	2	27.8 (3.2)	27.4 (3.8)	28.1 (4.6)	25.2 (0.6)	24.1 (0.8)

[a]See Note, Table 1, for definitions of treatments.

Table 6

Marginal Means for Adjusted Post-rest Scores
and (Reminiscence Scores)
for Inverted Alphabet Printing

Factor	Levels of Factors				
	1	2	3		
Replicates	25.5 (1.36)	26.4 (2.52)	26.7 (2.78)		
	RO	IRC	DRC	IMT	DMT
Level of Treatment[a]	26.1 (2.03)	27.1 (2.97)	26.8 (3.00)	25.5 (1.33)	25.2 (1.77)
	1	2			
Order	26.1 (2.20)	26.2 (2.24)			

[a]See Note, Table 1, for definitions of treatments.

Table 7

Tests of Normality for Inverted Alphabet Printing[a]

Factor	Levels of Factors	n	Maximum D	Kolmogorov-Smirnov Z	p
Replicate	1	50	.1227	.867	.439
	2	50	.0840	.594	.872
	3	50	.1309	.926	.358
Levels of Treatment[b]	RO	30	.1157	.634	.816
	IRC	30	.0886	.485	.973
	DRC	30	.1556	.852	.462
	IMT	30	.1464	.802	.541
	DMT	30	.1090	.597	.868
Order	1	75	.0780	.676	.751
	2	75	.0979	.848	.468

[a]Means and standard deviations used for each test are those reported in Tables 2 and 4.

[b]See Note, Table 1, for definitions of treatments.

The assumption of homogeneity of variance was tested with Levene's test for each of the main effects. These tests are reported in Table 8. None of the tests leads to a rejection of the hypothesis of equal variances. The test of the assumption of homogeneity of regression slopes is reported in Table 9. The test fails to reject the hypothesis of equal regression slopes for the 30 cells of the design. The regression slopes tested are the regression of post-rest scores on pre-rest scores.

The assumptions of the analysis of covariance do not appear to be violated, at least for the tests of the main effects. The assumptions of normality and homogeneity of variance were not tested for all 30 cells of the design (representing samples from 30 populations). The number of subjects for each cell of the design is equal, however, so that the analysis is expected to be robust to violations of the assumptions.

The analysis of covariance using the scores on the first post-rest trial as the dependent variable and the scores on the last pre-rest trial as the covariate is reported in Table 10. No significant $\underline{F}$-ratios occurred. The correlation between the covariate and the dependent

Table 8

Tests of Homogeneity of Variance
for Inverted Alphabet Printing

Factor	df_{num}	df_{denom}	F	p
Replicate	2	147	1.21	.300
Levels of Treatment	4	145	0.22	.925
Order	1	148	0.86	.356

Table 9

Test of Homogeneity of Regression
for Inverted Alphabet Printing

Source	SS	df	MS	F	p
Equality of Slopes	371.17	29	12.80	0.98	.508
Error	1176.89	90	13.08		

Table 10

Analysis of Covariance on Inverted Alphabet Printing
Pre-rest Scores are Covariate

Source	SS	df	MS	F	p
Replicate (R)	39.95	2	19.97	1.54	.220
Level of Treatment (L)	78.35	4	19.59	1.51	.205
Order (O)	0.54	1	0.54	0.04	.838
R x L	61.19	8	7.65	0.59	.786
R x O	5.09	2	2.55	0.20	.823
L x O	24.11	4	6.03	0.46	.762
R x L x O	113.26	8	14.16	1.09	.376
Error	1548.06	119	13.01		

variable was .73, which is significant, $p < .001$. Correlations between the covariate and dependent variable for each level of the treatment factor are reported in Table 40.

A second analysis of covariance, using post-rest scores as the dependent variable, with pre-rest scores and age of the subjects as covariates, is reported in Table 11. The introduction of age as a second covariate had little effect on the analysis. It should be noted that the age of six of the subjects was unknown. The total number of subjects was thus 144 for this analysis. The correlation between age and the post-rest scores was .09, $p = .268$. Age was entered as a second covariate in the analysis of each performance measure due to significant Replicate effects in the 10-second and 30-second pursuit rotor measures, as discussed below.

The analysis of variance using the pre-rest and post-rest scores as levels of a Trials factor in a repeated measures design is reported in Table 12. The repeated measures factor is significant at beyond the .001 level, supporting the hypothesis that reminiscence did occur. In agreement with the analysis of covariance reported in Table 10, there were no significant interactions of the repeated measures, or Trials factor with any of the

Table 11

Analysis of Covariance on Inverted Alphabet Printing
Pre-rest Scores and Age are Covariates

Source	SS	df	MS	F	p
Replicate (R)	27.11	2	13.55	1.08	.343
Level of Treatment (L)	101.04	4	25.26	2.02	.097
Order (O)	0.61	1	0.61	0.05	.826
R x L	55.83	8	6.98	0.56	.811
R x O	8.39	2	4.19	0.33	.716
L x O	35.07	4	8.77	0.70	.594
R x L x O	110.56	8	13.82	1.10	.367
Error	1403.59	112	12.53		

Table 12

Analysis of Variance with Repeated Measures for Inverted Alphabet Printing

Source	SS	df	MS	F	p
Among Subjects:					
Replicate (R)	9.69	2	4.84	0.11	.895
Level of Treatment (L)	377.31	4	94.32	2.17	.076
Order (O)	10.83	1	10.83	0.25	.619
R x L	155.95	8	19.49	0.45	.889
R x O	2.18	2	1.09	0.03	.975
L x O	114.68	4	28.67	0.66	.621
R x L x O	707.65	8	88.46	2.04	.048
Error	5215.00	120	43.46		
Within Subjects:					
Trials (T)	369.63	1	369.63	52.52	<.001
T x R	28.58	2	14.29	2.03	.136
T x L	32.89	4	8.22	1.17	.328
T x O	0.03	1	0.03	0.01	.948
T x R x L	50.85	8	6.36	0.90	.516
T x R x O	2.78	2	1.39	0.20	.821
T x L x O	21.72	4	5.31	0.75	.557
T x R x L x O	51.92	8	6.49	0.92	.501
Error	844.60	120	7.04		

other effects. The Replicates by Levels by Order interaction reached significance at the .05 level. The mean of the subjects' pre-rest and post-rest scores provides the measure being used in the among subjects effects, and no straight-forward interpretation of the interaction seems possible.

The analysis of variance on the pre-rest scores indicates that performance was approximately equal across groups prior to the experimental treatments. This suggests that random assignment of subjects to the Levels and Order groups was succesful in equating initial performance, and that subjects in the three replications of the experiment did not differ on initial performance on the IAP task. See Table 13.

The analyses of the IAP data indicate that reminiscence occured for subjects, ignoring grouping. It is clear, however, that the experimental manipulations produced no significant differences in either performance or degree of reminiscence, nor were there effects due to Replicates or Order of the tasks. Neither the mirror-tracing, which was predicted to interfere with reminiscence in IAP, nor the reverse-cue pursuit rotor practice, reduced the degree of reminiscence for the IAP task.

Table 13

Analysis of Variance on Pre-rest Scores for Inverted Alphabet Printing

Source	SS	df	MS	F	p
Replicate (R)	31.61	2	15.81	0.67	.512
Level of Treatment (L)	160.37	4	40.09	1.71	.152
Order	4.86	1	4.86	0.21	.650
R x L	156.99	8	19.62	0.84	.572
R x O	0.84	2	0.42	0.02	.982
L x O	97.97	4	24.49	1.04	.388
R x L x O	342.43	8	42.80	1.82	.079
Error	2815.60	120	23.46		

Ten-second Pursuit Rotor

For the 10-second pursuit rotor measure, performance was measured by the number of seconds time on target during each 10-second trial. The last pre-rest trial and first post-rest trial provided the scores of interest. Means and standard deviations of pre-rest and post-rest scores for the 30 cells of the design are reported in Tables 14 and 16. Marginal means and standard deviations for these measures are reported in Tables 15 and 17. Post-rest means, adjusted for equality of pre-rest scores, are reported in Table 18, along with reminiscence scores, which reflect the difference between pre-rest and post-rest performance. The adjusted post-rest means are the means compared in the analysis of covariance using pre-rest scores as the single covariate. Marginal means for adjusted post-rest scores and reminiscence scores are reported in Table 19.

The Kolmogorov-Smirnov tests of the normality of scores at each level of the main effects are reported in Table 20. The null hypotheses that the scores are from populations that do not differ from a normal distribution are all retained.

The assumption of homogeneity of variance was tested for each of the main effects, using Levene's test. These

Table 14

Pre-rest Means and (Standard Deviations) for 10-second Pursuit Rotor Measure

Replicate	Order	Level of Treatment[a]				
		RO	IRC	DRC	IMT	DMT
1	1	3.03 (1.13)	3.24 (2.33)	4.57 (0.43)	3.75 (1.73)	3.13 (2.12)
	2	3.30 (1.21)	3.88 (1.74)	2.80 (1.70)	4.14 (0.80)	4.20 (1.17)
2	1	2.26 (1.62)	3.10 (1.85)	2.06 (1.58)	2.77 (1.46)	2.51 (1.97)
	2	2.56 (1.00)	2.38 (0.74)	3.15 (1.55)	2.17 (0.52)	2.06 (1.53)
3	1	2.28 (1.84)	1.10 (0.98)	1.82 (1.07)	2.25 (0.92)	1.72 (1.31)
	2	2.34 (1.37)	2.63 (0.61)	2.61 (1.48)	1.94 (1.08)	1.09 (0.76)

[a]See Note, Table 1, for definitions of treatments.

Table 15

Marginal Means and (Standard Deviations)
for Pre-rest 10-second Pursuit Rotor Scores

Factor	Levels of Factors				
	1	2	3		
Replicates	3.60 (1.50)	2.50 (1.37)	1.98 (1.20)		
	RO	IRC	DRC	IMT	DMT
Levels of Treatment[a]	2.67 (1.33)	2.72 (1.68)	2.84 (1.55)	2.84 (1.35)	2.45 (1.74)
	1	2			
Order	2.64 (1.65)	2.75 (1.38)			

[a]See Note, Table 1, for definitions of treatments.

Table 16

Post-rest Means and (Standard Deviations) for 10-second Pursuit Rotor Measure

Replicate	Order	Level of Treatment[a]				
		RO	IRC	DRC	IMT	DMT
1	1	5.13 (1.57)	5.35 (1.95)	5.49 (0.81)	5.16 (1.32)	4.00 (2.13)
	2	4.56 (0.77)	5.77 (1.53)	4.16 (1.52)	4.91 (1.31)	5.44 (1.01)
2	1	3.68 (1.62)	3.86 (1.63)	3.62 (1.40)	2.79 (1.00)	2.58 (1.29)
	2	2.61 (1.59)	2.16 (1.49)	3.24 (1.29)	3.04 (0.91)	2.01 (1.40)
3	1	3.44 (2.53)	2.44 (1.26)	2.33 (0.60)	1.89 (0.90)	2.60 (0.97)
	2	2.10 (1.14)	2.40 (1.00)	3.23 (1.55)	2.24 (1.33)	1.73 (1.14)

[a]See Note, Table 1, for definitions of treatments.

Table 17

Marginal Means and (Standard Deviations) for Post-rest 10-second Pursuit Rotor Scores

Factor	Levels of Factors				
	1	2	3		
Replicates	4.99 (1.43)	2.96 (1.33)	2.44 (1.31)		
	RO	IRC	DRC	IMT	DMT
Levels of Treatment[a]	3.59 (1.82)	3.66 (2.02)	3.68 (1.51)	3.34 (1.65)	3.06 (1.81)
	1	2			
Order	3.62 (1.78)	3.31 (1.74)			

[a]See Note, Table 1, for definitions of treatments.

Table 18

Adjusted Post-rest Means and (Reminiscence Scores) for 10-second Pursuit Rotor Measure

Replicate	Order	Level of Treatment[a]				
		RO	IRC	DRC	IMT	DMT
1	1	4.93 (2.10)	5.03 (2.11)	4.40 (0.92)	4.55 (1.41)	3.75 (0.87)
	2	4.20 (1.26)	5.08 (1.87)	4.10 (1.36)	4.07 (0.77)	4.56 (1.24)
2	1	3.93 (1.42)	3.62 (0.76)	3.99 (1.56)	2.75 (0.03)	2.68 (0.06)
	2	2.68 (0.05)	2.34 (-0.22)	2.97 (0.08)	3.34 (0.86)	2.39 (-0.04)
3	1	3.68 (1.16)	3.36 (1.33)	2.83 (0.51)	2.15 (-0.36)	3.17 (0.88)
	2	2.30 (-0.24)	2.44 (-0.23)	3.28 (0.62)	2.68 (0.30)	2.66 (0.64)

[a]See Note, Table 1, for definitions of treatments.

Table 19

Marginal Means for Adjusted Post-rest Scores
and (Reminiscence Scores)
for 10-second Pursuit Rotor Scores

Factor	Levels of Factors				
	1	2	3		
Replicates	4.47 (1.39)	3.07 (0.46)	2.86 (0.46)		
	RO	IRC	DRC	IMT	DMT
Levels of Treatment[a]	3.62 (0.96)	3.65 (0.94)	3.60 (0.84)	3.26 (0.50)	3.20 (0.61)
	1	2			
Order	3.65 (0.98)	3.27 (0.56)			

[a]See Note, Table 1, for definitions of treatments.

Table 20

Tests of Normality for 10-second Pursuit Rotor Scores[a]

Factor	Levels of Factors	n	Maximum D	Kolmogorov-Smirnov Z	p
Replicates	1	50	.0831	.587	.881
	2	50	.0969	.685	.736
	3	50	.0778	.550	.923
Levels of Treatment[b]	RO	30	.0830	.455	.986
	IRC	30	.0992	.543	.929
	DRC	30	.0715	.392	.998
	IMT	30	.0862	.472	.979
	DMT	30	.0733	.402	.997
Order	1	75	.0679	.588	.880
	2	75	.0513	.445	.989

[a]Means and standard deviations used for each test are those reported in Table 17.

[b]See Note, Table 1, for definitions of treatments.

tests are reported in Table 21. The hypothesis of equal population variances was supported in each case. The test of the assumption of homogeneity of regression slopes is reported in Table 22. The test fails to reject the hypothesis of equal population regression slopes.

The analysis of variance using the scores on the first post-rest trial as the dependent variable and the scores on the last pre-rest trial as the covariate is reported in Table 23. The Replicate effect is highly significant, and the Order effect is also significant. The significant Replicate effect indicates the performance across the three replications changed, ignoring the experimental manipulations and order of the tasks.

Pairwise comparisons of marginal means for the Replicate effect indicate that the first replication differed significantly from the second and third, but that the second and third replications did not differ significantly. A difference between means of 0.54 was required for significance at the .05 level. For the first and third replications, the difference between means was 1.61. For the first and second, the difference was 1.40. For the second and third replications, the difference between means was 0.21.

Table 21

Tests of Homogeneity of Variance for 10-second Pursuit Rotor Scores

Factor	df_{num}	df_{denom}	F	p
Replicate	2	147	0.37	.689
Levels of Treatment	4	145	0.68	.604
Order	1	148	0.02	.876

Table 22

Test of Homogeneity of Regression for 10-second Pursuit Rotor Scores

Source	SS	df	MS	F	p
Equality of Slopes	24.85	29	0.86	0.60	.937
Error	127.56	90	1.42		

Table 23

Analysis of Covariance on 10-second Pursuit Rotor Scores
Pre-rest Scores are Covariate

Source	SS	df	MS	F	p
Replicate (R)	59.88	2	29.94	23.38	<.001
Level of Treatment (L)	5.65	4	1.41	1.10	.359
Order (O)	5.45	1	5.45	4.26	.041
R x L	7.37	8	0.92	0.72	.674
R x O	1.72	2	0.86	0.67	.512
L x O	8.74	4	2.19	1.71	.153
R x L x O	8.23	8	1.03	0.80	.601
Error	152.40	119	1.28		

Examination of the marginal means for the Order effect indicates that post-rest performance, adjusted for equality of pre-rest scores, was higher for the subjects who performed the pursuit rotor first, followed by the IAP task. This indicates that reminiscence was reduced for subjects whose post-rest practice on the pursuit rotor came at the end of an hour-long experimental session.

In order to clarify the significant Replicate effect, the only available organismic variable, age, was examined. An analysis of variance was performed on the subjects' ages, comparing the mean ages for the three replications. For the first replication, the mean age was 20.93; for the second, 19.80; and for the third, 19.16. The standard deviations were 2.06, 1.89, and 1.61 for the first, second, and third replications, respectively. The analysis of variance showed a significant difference in ages, $F(2,141) = 10.87$, $p < .001$. Data on ages was available for 144 subjects.

A second analysis of covariance was performed, using pre-rest scores and age as covariates. This analysis is reported in Table 24. The introduction of age as a second covariate had little effect on the analysis, and did not reduce the Replicate effect. The correlation

Table 24

Analysis of Covariance on 10-second Pursuit Rotor Scores
Pre-rest Scores and Age are Covariates

Source	SS	df	MS	F	p
Replicate (R)	55.20	2	27.60	21.19	<.001
Level of Treatment (L)	5.92	4	1.48	1.14	.344
Order (O)	3.55	1	3.55	2.73	.101
R x L	5.05	8	0.63	0.49	.865
R x O	2.32	2	1.16	0.89	.413
L x O	10.45	4	2.61	2.01	.099
R x L x O	9.29	8	1.16	0.89	.526
Error	145.87	112	1.30		

between age and post-rest performance was significant, $r = .217$, $p = .009$. Age also correlated with pre-rest performance, $r = .279$, $p = .001$. Thus, the correlation between pre-rest performance and post-rest performance ($r = .67$, $p < .001$) accounted for most of the variability in scores, and age, as a second covariate, did little to reduce that variability further. It seems likely, therefore, that the significant difference in ages across replications was unrelated to the Replicate effect in the analysis of covariance.

The analysis of variance using the pre-rest and post-rest scores as levels of a Trials factor in a repeated measures design is reported in Table 25. The significant Trials factor indicates that post-rest scores were higher than pre-rest scores; that is, that reminiscence occurred. Significant Trials by Replicate and Trials by Order effects are in agreement with the analysis of covariance using pre-rest scores as the covariate. The significant Replicate effect appears to indicate that the level of performance changed across replications, as well as reminiscence. This interpretation is supported by the analysis of variance on pre-rest scores.

The analysis of variance on pre-rest scores shows that the difference between replications existed prior

Table 25

Analysis of Variance with Repeated Measures for 10-second Pursuit Rotor Scores

Source	SS	df	MS	F	p
Among Subjects:					
Replicate (R)	237.04	2	118.52	38.13	<.001
Level of Treatment (L)	9.01	4	2.25	0.72	.577
Order (O)	0.78	1	0.78	0.25	.617
R x L	9.02	8	1.13	0.36	.938
R x O	3.00	2	1.50	0.48	.618
L x O	1.70	4	0.43	0.14	.968
R x L x O	37.27	8	4.66	1.50	.165
Error	373.04	120	3.11		
Within Subjects:					
Trials (T)	44.52	1	44.52	55.14	<.001
T x R	14.50	2	7.25	8.98	<.001
T x L	2.50	4	0.63	0.78	.543
T x O	3.45	1	3.45	4.27	.041
T x R x L	5.02	8	0.63	0.78	.623
T x R x O	0.64	2	0.32	0.40	.672
T x L x O	5.88	4	1.47	1.82	.129
T x R x L x O	5.27	8	0.66	0.82	.590
Error	96.90	120	0.81		

to the application of the treatment manipulations. On the other hand, the Order effect observed in the other analyses does not appear, indicating that the effect of the different orders of the tasks was to alter reminiscence, rather than to simply alter the overall level of performance.

The analyses of the 10-second pursuit rotor data indicate that reminiscence did occur for subjects, ignoring grouping. The experimental manipulation designed to alter reminiscence did not do so. Reminiscence was reduced for subjects who did the IAP task first. Both the level of performance and the degree of reminiscence changed across replications, becoming lower for each repetition of the design. See Table 26.

Thirty-second Pursuit Rotor

For the 30-second pursuit rotor measure, performance was measured by the mean number of seconds time on target during three consecutive 10-second trials. The mean of the last three trials pre-rest and of the first three trials post-rest provided the scores of interest. Means and standard deviations of pre-rest and post-rest scores for the 30 cells of the design are reported in Tables 27 and 29. Marginal means and standard deviations for these scores are reported in

Table 26

Analysis of Variance on Pre-rest Scores for 10-second Pursuit Rotor

Source	SS	df	MS	F	p
Replicate (R)	68.89	2	34.44	17.43	.001
Level of Treatment (L)	3.14	4	0.78	0.40	.811
Order (O)	0.47	1	0.47	0.24	.626
R x L	6.56	8	0.82	0.41	.910
R x O	0.83	2	0.42	0.21	.811
L x O	1.86	4	0.46	0.23	.918
R x L x O	23.69	8	2.96	1.50	.165
Error	237.15	120	1.98		

Tables 28 and 30. Post-rest means, adjusted for equality of pre-rest scores, are reported in Table 31, along with mean of reminiscence scores, reflecting the difference between pre-rest and post-rest performance. The adjusted post-rest means are the means compared in the analysis of variance using pre-rest scores as the single covariate. Marginal means for adjusted post-rest scores and reminiscence scores are reported in Table 32.

The Kolmogorov-Smirnov tests of normality are reported in Table 33 for each level of each of the main effects. The hypotheses that the scores are samples from normally distributed populations are all retained.

The assumption of homogeneity of variance was tested for each of the main effects, using Levene's test. These tests are reported in Table 34. The hypothesis of equal population variances was retained in each case. The test of the assumption of homogeneity of regression slopes is reported in Table 35. The test fails to reject the hypothesis of equal population regression slopes, $\underline{p} > .05$.

The analysis of covariance using the post-rest scores as the dependent variable and the pre-rest scores as the covariate is reported in Table 36. As with the similar analysis of the 10-second pursuit rotor scores, the Replicate and Order effects are significant. The

Table 27

Pre-rest Means and (Standard Deviations) for 30-second Pursuit Rotor Measure

Replicate	Order	Level of Treatment[a]				
		RO	IRC	DRC	IMT	DMT
1	1	3.09 (1.39)	3.29 (2.15)	4.26 (0.68)	4.04 (1.22)	3.23 (1.76)
	2	3.52 (0.16)	3.78 (2.17)	2.85 (1.35)	4.32 (0.59)	4.14 (0.87)
2	1	2.02 (0.93)	3.01 (2.00)	2.13 (1.04)	2.50 (0.77)	2.38 (1.67)
	2	2.33 (1.06)	2.40 (0.27)	2.96 (1.42)	2.13 (0.52)	1.86 (1.73)
3	1	2.78 (2.08)	1.08 (0.82)	1.56 (0.66)	2.07 (0.81)	1.83 (1.22)
	2	1.85 (1.07)	2.36 (0.77)	2.58 (1.12)	2.24 (1.27)	1.45 (1.01)

[a]See Note, Table 1, for definitions of treatments.

Table 28

Marginal Means and (Standard Deviations) for Pre-rest 30-second Pursuit Rotor Scores

Factor	Levels of Factors				
	1	2	3		
Replicates	3.65 (1.35)	2.37 (1.19)	1.98 (1.16)		
	RO	IRC	DRC	IMT	DMT
Levels of Treatment[a]	2.60 (1.29)	2.66 (1.67)	2.72 (1.30)	2.88 (1.25)	2.48 (1.60)
	1	2			
Order	2.62 (1.51)	2.72 (1.33)			

[a]See Note, Table 1, for definitions of treatments.

Table 29

Post-rest Means and (Standard Deviations) for 30-second Pursuit Rotor Measure

Replicate	Order	Level of Treatment[a]				
		RO	IRC	DRC	IMT	DMT
1	1	5.74 (1.22)	5.66 (1.81)	6.47 (0.59)	5.68 (1.39)	4.32 (1.67)
	2	5.43 (0.97)	5.82 (1.43)	4.51 (1.88)	5.47 (1.11)	5.07 (1.12)
2	1	3.75 (1.18)	4.72 (2.22)	3.48 (0.91)	3.42 (0.75)	3.54 (1.43)
	2	3.01 (1.54)	3.11 (1.24)	4.00 (0.95)	3.54 (0.45)	2.32 (1.63)
3	1	3.71 (2.63)	2.42 (1.50)	2.88 (0.48)	2.69 (1.00)	2.70 (1.11)
	2	2.14 (1.23)	2.66 (1.30)	3.78 (1.65)	2.92 (1.33)	2.21 (1.27)

[a]See Note, Table 1, for definitions of treatment.

Table 30

Marginal Means and (Standard Deviations) for Post-rest 30-second Pursuit Rotor Scores

Factor	Levels of Factors				
	1	2	3		
Replicates	5.42 (1.38)	3.49 (1.34)	2.81 (1.41)		
	RO	IRC	DRC	IMT	DMT
Levels of Treatment[a]	3.96 (1.92)	4.07 (2.04)	4.19 (1.59)	3.95 (1.54)	3.36 (1.66)
	1	2			
Order	4.08 (1.80)	3.74 (1.70)			

[a]See Note, Table 1, for definitions of treatments.

Table 31

Adjusted Post-rest Means and (Reminiscence Scores) for 30-second Pursuit Rotor Measure

Replicate	Order	Level of Treatment[a]				
		RO	IRC	DRC	IMT	DMT
1	1	5.50 (2.65)	5.15 (2.36)	5.18 (2.21)	4.57 (1.64)	3.87 (1.09)
	2	4.73 (1.90)	4.92 (2.03)	4.36 (1.66)	4.13 (1.15)	3.88 (0.93)
2	1	4.28 (1.73)	4.44 (1.71)	3.92 (1.35)	3.56 (0.92)	3.78 (1.16)
	2	3.30 (0.69)	3.33 (0.71)	3.77 (1.05)	3.98 (1.41)	2.98 (0.46)
3	1	3.61 (0.92)	3.71 (1.34)	3.78 (1.32)	3.18 (0.62)	3.38 (0.87)
	2	2.80 (0.29)	2.91 (0.30)	3.85 (1.19)	3.27 (0.68)	3.20 (0.77)

[a]See Note, Table 1, for definitions of treatments.

Table 32

Marginal Means for Adjusted Post-rest Scores and (Reminiscence Scores) for 30-second Pursuit Rotor Scores

Factor	Levels of Factors				
	1	2	3		
Replicates	4.51 (1.76)	3.73 (1.12)	3.37 (0.83)		
	RO	IRC	DRC	IMT	DMT
Levels of Treatment[a]	4.02 (1.37)	4.07 (1.41)	4.14 (1.46)	3.78 (1.07)	3.51 (0.88)
	1	2			
Order	4.12 (1.46)	3.69 (1.02)			

[a]See Note, Table 1, for definitions of treatments.

Table 33

Tests of Normality for 30-second Pursuit Rotor Scores[a]

Factor	Levels of Factors	$\underline{n}$	Maximum $\underline{D}$	Kolmogorov-Smirnov $\underline{Z}$	$\underline{p}$
Replicates	1	50	.0838	.593	.874
	2	50	.1017	.719	.680
	3	50	.0709	.502	.963
Levels of Treatment[b]	RO	30	.0748	.410	.996
	IRC	30	.1051	.576	.895
	DRC	30	.1006	.551	.922
	IMT	30	.1102	.604	.859
	DMT	30	.0885	.485	.973
Order	1	75	.0958	.830	.496
	2	75	.0588	.509	.958

[a]Means and standard deviations used for each test are those reported in Table 30.

[b]See Note, Table 1, for definitions of treatments.

Table 34

Tests of Homogeneity of Variance for 30-second Pursuit Rotor Scores

Factor	df_{num}	df_{denom}	F	p
Replicate	2	147	0.14	.870
Levels of Treatment	4	145	1.31	.270
Order	1	148	0.59	.444

Table 35

Test of Homogeneity of Regression for 30-second Pursuit Rotor Scores

Source	SS	df	MS	F	p
Equality of Slopes	23.29	29	0.80	0.92	.581
Error	78.16	90	0.87		

Table 36

Analysis of Covariance on 30-second Pursuit Rotor Scores
Pre-rest Scores are Covariate

Source	SS	df	MS	F	p
Replicate (R)	29.61	2	14.81	17.37	<.001
Level of Treatment (L)	8.04	4	2.01	2.36	.057
Order (O)	6.79	1	6.79	7.93	.006
R x L	6.36	8	0.79	0.93	.493
R x O	0.24	2	0.12	0.15	.865
L x O	3.52	4	0.88	1.03	.394
R x L x O	3.66	8	0.46	0.54	.827
Error	101.45	119	0.85		

Level of Treatment effect approaches significance at the .05 level.

Pairwise comparisons of marginal means for the Replicate effect indicate that the first replication differed significantly from both the second and third, but that the second and third did not differ significantly. A difference between means of .54 was required for significance at the .05 level. For the first and second replications, the difference between means was 0.79. The difference was 1.15 between the means of the first and third replications. For the second and third replications, the difference was 0.36.

Examination of the marginal means for the Order effect indicates that adjusted post-rest scores were higher for the subjects who performed the pursuit rotor first. Reminiscence was reduced for subjects who had performed the IAP task before beginning the pursuit rotor.

As noted above, the mean age of subjects differed significantly across replications of the design. A second analysis of covariance was therefore performed, using post-rest scores as the dependent variable, with pre-rest scores and age as covariates. This analysis is reported in Table 37. The introduction of age as a

Table 37

Analysis of Covariance on 30-second Pursuit Rotor Scores
Pre-rest Scores and Age are Covariates

Source	SS	df	MS	F	p
Replicate (R)	29.72	2	14.86	18.09	$<.001$
Level of Treatment (L)	7.80	4	1.95	2.37	.056
Order (O)	4.74	1	4.74	5.77	.018
R x L	5.32	8	0.66	0.81	.596
R x O	0.24	2	0.12	0.14	.866
L x O	4.98	4	1.24	1.52	.202
R x L x O	4.12	8	0.52	0.63	.753
Error	91.99	112	0.82		

second covariate had little effect on the analysis, and did not materially reduce the Replicate effect. The correlation between age and post-rest performance was significant, $\underline{r} = .244$, $\underline{p} = .003$. Age also correlated highly with pre-rest performance, $\underline{r} = .281$, $\underline{p} = .001$. The correlation between pre-rest and post-rest performance ($\underline{r} = .73$, $\underline{p} < .001$) accounted for most of the variability in scores. Age, as a second covariate, did little to reduce that variability further. The significant difference in age across replications appears to be unrelated to the Replicate effect in the analysis of covariance.

The analysis of variance using pre-rest and post-rest scores as levels of a Trials factor in a repeated measures design is reported in Table 38. The significant Trials factor indicates that post-rest scores were higher than pre-rest scores. The occurrence of reminiscence is thus confirmed. Significant Trials by Replicate and Trials by Order effects agree with the analysis of covariance using pre-rest scores as the covariate. The significant Replicate effect appears to indicate that the level of performance changed across replications, along with changes in reminiscence.

The analysis of variance on pre-rest scores, which

Table 38

Analysis of Variance with Repeated Measures for 30-second Pursuit Rotor Scores

Source	SS	df	MS	F	p
Among Subjects:					
Replicate (R)	247.91	2	123.96	40.42	<.001
Level of Treatment (L)	11.08	4	2.77	0.90	.465
Order (O)	1.14	1	1.14	0.37	.543
R x L	8.46	8	1.06	0.34	.947
R x O	1.82	2	0.91	0.30	.743
L x O	2.56	4	0.64	0.21	.933
R x L x O	41.61	8	5.20	1.70	.106
Error	368.00	120	3.07		
Within Subjects:					
Trials (T)	115.00	1	115.00	254.94	<.001
T x R	11.45	2	5.72	12.70	<.001
T x L	3.80	4	0.95	2.10	.084
T x O	3.71	1	3.71	8.22	.005
T x R x L	4.07	8	0.51	1.13	.350
T x R x O	0.06	2	0.03	0.07	.932
T x L x O	1.85	4	0.46	1.03	.397
T x R x L x O	1.42	8	0.18	0.39	.922
Error	54.13	120	0.45		

is reported in Table 39, supports the idea that the level of performance changed across replications, along with a change in degree of reminiscence. The difference in level of performance existed prior to the occurrence of reminiscence, and prior to the application of the treatment manipulations. The lack of an Order effect indicates that the effect of the different orders of the tasks was to alter reminiscence, rather than level of performance by itself.

As for the 10-second pursuit rotor scores, the analyses of the 30-second scores indicate that reminiscence did occur, ignoring grouping. The experimental manipulations designed to reduce reminiscence did not do so. Reminiscence was reduced for subjects who did the IAP task first. Both the level of performance and the degree of reminiscence changed across replications, becoming lower with each repitition of the design.

Correlation Analyses

Correlations between a number of variables are reported in Table 40. For each of the three performance measures, the correlations of pre-rest scores with post-rest scores are reported, as are the correlations between pre-rest scores and reminiscence scores. In addition, correlations between reminiscence scores for the

Table 39

Analysis of Variance on Pre-rest Scores
for 30-second Pursuit Rotor

Source	SS	df	MS	F	p
Replicate (R)	76.50	2	38.25	23.76	.001
Level of Treatment (L)	2.68	4	0.67	0.42	.797
Order	0.37	1	0.37	0.23	.633
R x L	7.44	8	0.93	0.58	.795
R x O	0.62	2	0.31	0.19	.825
L x O	0.93	4	0.23	0.15	.965
R x L x O	19.54	8	2.44	1.52	.158
Error	193.21	120	1.61		

Table 40

Correlations Among Pre-rest, Post-rest, and Reminiscence Scores For All Performance Measures

Relationship[b]	Levels of Trestment[a]					
	RO	IRC	DRC	IMT	DMT	Total
PrePR10-PostPR10	.65***	.67***	.58***	.66***	.79***	.67***
PrePR30-PostPR30	.78***	.74***	.83***	.84***	.91***	.81***
PreIAP-PostIAP	.86***	.74***	.68***	.60***	.72***	.73***
PrePR10-RemPR10	-.10	-.19	-.48**	-.20	-.26	-.24*
PrePR30-RemPR30	.17	-.11	-.02	.05	-.07	-.01
PreIAP-RemIAP	-.25	-.19	-.40*	-.25	-.49**	-.30*
RemPR10-RemPR30	.80***	.83***	.68***	.80***	.58***	.75***
RemPR10-RemIAP	.10	.13	-.37*	-.07	.06	-.02
RemPR30-RemIAP	-.10	.24	-.40*	-.06	-.12	-.02

[a]See Note, Table 1, for definitions of treatments.

[b]Pre = Pre-rest; Post = Post-rest; Rem = Reminiscence; PR10 = 10-second Pursuit Rotor; PR30 = 30-second Pursuit Rotor.

* $p < .05$; ** $p < .01$; *** $p < .001$

three performance measures are reported. All correlations are reported for the total of 150 subjects, and for the five levels of treatment seperately, with n = 30 for each of these correlations.

Pre-rest and post-rest scores are highly correlated. As noted above, the strength of these correlations supports the use of the analysis of covariance to adjust post-rest scores for pre-rest level of performance. The correlations between pre-rest scores and reminiscence are uniformly low and negative, reaching significance for subjects as a whole for the 10-second pursuit rotor and inverted alphabet printing measures. These two correlations indicate that reminiscence was lower for subjects with higher performance levels.

Not surprisingly, the two pursuit rotor measures of reminiscence were highly correlated. Neither of these measures, however, correlated with reminiscence for the IAP task, except for the subjects in the delayed reverse-cue condition, for whom high amounts of reminiscence on the pursuit rotor were associated with low amounts of reminiscence on the IAP task.

DISCUSSION

The chief object of the research reported here has been to test Eysenck's (1965) three-factor theory of reminiscence, using a design similar to that of Rachman and Grassi (1965), but extending it to include IAP. The present results fail to support the theory. The treatment effects predicted by the theory, and demonstrated by Rachman and Grassi (1965) and Griffith (1968) did not occur, nor was there a trend in the predicted direction.

Given the clear-cut and highly significant results reported by others, it is difficult to know how to interpret the failure of the present research to achieve similar results. Several differences between the experiment reported here and the experiments conducted by others exist. These are differences in the length of rest, the sex of the subjects, and possibly in motivation.

Rachman and Grassi (1965) used a 4 hour and 10 minute rest period. The first 10 minutes were spent in the lab, during which time the treatment (reverse-cue pursuit rotor) was applied. Subjects returned 4 hours later for the post-rest practice. Griffith used a rest period of 13 minutes. The length of rest used here (20 minutes) seems unlikely, therefore, to be responsible for the failure to find the interference effect.

The subjects used by Rachman and Grassi were soldiers. The voluntary or involuntary status of the subjects is not reported. Griffith used perhaps the opposite extreme, paid volunteers who were undergraduate students. Assuming that the status of the subjects (whether voluntary of not and whether paid or not) affects their motivation, the interference effect would seem to have been demonstrated over a wide range of motivational levels. The present use of unpaid volunteer undergraduate students seems unable to account for the failure to find the predicted interference effect.

Rachman and Grassi used all male subjects, while Griffith used equal numbers of each sex. Griffith did not, however, compare males and females in her analyses, nor are group means reported seperately for males and females. Thus, there remains the possibility that the interference effect occurred only for the male subjects, but was strong enough to remain significant even when the scores for both sexes were combined. This sex-related difference could account for the non-appearance of the interference effect in the current study, which used females only.

Obviously, a direct comparison of males and females is in order to determine whether the interference effect is sex-specific. Eysenck's (1965) theory does not predict such a sex effect, which, if it occurs, seems to offer evidence against the consolidation theory of pursuit rotor reminiscence, since the course of consolidation of learning seems unlikely to differ for males and females. A study testing for a sex-specific effect in interference with pursuit rotor reminiscence is currently under way (St. James, Note 2), and preliminary results indicate that the interference effect may, in fact, be sex-specific. As yet, however, the amount of data does not permit statistical comparison.

The appearance of a highly significant Replicates effect is of concern. The level of performance decreased from the first set of subjects to the last. Assuming that the effect is not simply due to sampling error (and the level of significance strongly suggests that it is not), there must be some systematic difference across replications in the procedures, subjects, or equipment.

The age difference across replications suggests the possibility that the slightly older subjects in the first replication performed differently because of age-related differences in attitude or some other variable. Older students might, for example, be more at ease in the laboratory as a result of greater prior exposure to similar situations. Since age, when entered into the analysis as a covariate, does not reduce the Replicate effect, it seems likely that the age difference is merely coincidental. No other organismic variables were collected on the subjects, so further investigation of possible subject differences is not possible.

The instructions given to the subjects were the same in each replication, and other procedures were kept as uniform as possible. Although it is not possible to rule out some systematic differences in the treatment of the subjects by the experimenter, I am unaware of any such differences.

The possibility of instrumentation changes also presents itself. The same equipment was used throughout, but there is a possibility of changes in the speed or sensitivity of the pursuit rotor. Dial settings remained constant, but calibration may have changed. Since the pursuit rotor activates the clocks when the photo-sensitive tip of the stylus produces switch closure, a change in the sensitivity of the equipment would have the effect of altering target size.

The lack of a Replicate effect for the IAP task adds support to the suggestion of instrument error, as does the lack of any significant interaction between the Replicates effect and either Order or Levels for the two pursuit rotor measures. If this is the case, the error can probably be assumed to be constant across groups, and to have no very damaging effect on the test of the research hypotheses. Since the means for the five levels of treatment are not ordered as predicted by Eysenck's three-factor theory, it seems unlikely that any inaccuracy caused by instrument error that affects all groups equally could be responsible for the failure to find a treatment effect, or even a trend toward an effect.

The significant Order effect for both pursuit rotor measures shows that reminiscence was lowered for those subjects who performed the IAP first. For these subjects, the post-rest practice on the pursuit rotor came at the end of an hour-long experimental session. The lack of such an effect on the IAP task, when it was preceeded by the pursuit rotor, suggests that a lowering of motivation and interest in the experiment may have differentially affected pursuit rotor performance, but not IAP performance.

Examination of the cell means for the pursuit rotor measures shows that reminiscence was greatest in general for the 30-second scores. This effect is expected, due to post-rest upswing (PRU). Rachman and Grassi (1965), in their Figure 2, graph the mean TOT scores for the experimental groups across all trials. The immediate reverse-cue group showed a slight decrease in performance after rest (negative reminiscence), based on the 10-second scores. From this figure it appears that this group may well have shown reminiscence if the 30-second scores had been used. Reminiscence scores and data analyses based on the 10-second scores suffer from two possible confounding effects. The TOT scores for 10-second trials fluctuate more from trial to trial, indicating that they have greater variability. The other difficulty is that the 10-second scores overlook the possibility that the experimental treatment affected the PRU, or warm-up decrement, rather than affecting reminiscence. In this case, reminiscence is delayed briefly, but does occur. The negative reminiscence reported by Rachman and Grassi for the immediate reverse-cue group appears from their figure to possibly reflect an increase in PRU, rather than a decrease in reminiscence.

The highly significant correlations between pre-rest and post-rest scores for each performance measure indicate that post-rest performance level is highly dependent upon pre-rest performance level. Despite this, however, the amount of reminiscence was generally negatively correllated with pre-rest scores, and the degree of the relationship was small. Reminiscence thus bore only a slight relationship with level of performance. The correlations between the reminiscence measures were non-significant, except for the relation between the two pursuit rotor measures, which, as expected, were quite high. Neither of the pursuit rotor measures was shown to correlate with reminiscence in the IAP task. This is in agreement with the findings of Huang and Payne (1975) of low correlations between reminiscence scores on different motor tasks.

In addition to the fairly restricted conclusions offered above, it is possible to make some more general statements about the state of knowledge concerning reminiscence, the factors that suggest themselves as possibly being involved in reminiscence, and the requirements for any general theory of reminiscence. The remainder of this section will be devoted to dealing with these issues.

Adams (1963) has discussed flaws in the logic of the Hullian reactive inhibition theory, and he and

Eysenck (1965) have shown that various empirical predictions that seem to follow clearly from that theory are not borne out in experimental results. Eysenck's tests, failing to support reactive inhibition theory, were contemporaneous with Adam's (1963) objection to the "London group's" continuing use of reactive inhibition as an explanatory principle. Despite this, and the availability of alternative models for reminiscence, such as consolidation and arousal, the reactive inhibition theory remains the principal approach to reminiscence (Evans, 1976; Huang & Payne, 1977; McBride & Payne, 1979).

Eysenck's suggestion of a consolidation theory of pursuit rotor reminiscence is the most fully enunciated attempt to account for the phenomenon in non-Hullian terms. Arousal, or activation, has been suggested by several authors (Eason & White, 1960; Kling & Schlosberg, 1961) to be a variable closely involved with reminiscence, though none of these authors has developed this idea into a more specific theoretical form.

Assuming that the results of the experiment reported here bear up to repitition, they seem to make consolidation theory less attractive as an alternative to reactive inhibition. Even without this experiment, the literature reporting tests of the consolidation theory is quite limited, and the theory can hardly be said to have much evidential backing.

The evidence supporting the consolidation theory is sparse, as noted, and not without some problems. The pursuit rotor experiment by Rachman and Grassi (1965) is strongly supportive, as is the pursuit rotor portion of Griffith's work. Griffith, however, failed to find the interference effect in verbal learning and Stelmach (1968) could not produce it in the Bachman ladder task, though this may have been a less than adequate test of the theory, as noted previously. The present attempt to produce the phenomenon in the IAP task was unsuccesful, though the effect was expected to be weaker for this task than for the pursuit rotor.

Huang and Payne (1975) have suggested, on the basis of low correlations between reminiscence for various tasks (a finding supported by the present research), that it might be necessary to explain reminiscence in different tasks in terms of different causal factors. Thus, reminiscence for different tasks would be treated as different phenomena. Another approach suggests itself as possibly fruitful. That approach is to assume that reminiscence is the result of a number of factors, and that the lack of correlation between reminiscence for different tasks is a result of different degrees of involvement of the factors in different tasks. Rather than assuming that reminiscence for different tasks represents different fundamental processes, it is suggested here that perhaps reminiscence is the result of a number of processes which are more or less active in each task.

A number of factors suggest themselves as possible candidates for inclusion. These are arousal, attention, motivation, peripheral muscle fatigue, consolidation, and more rapid forgetting of incorrect responses. Other factors may certainly be involved, and the factors suggested here may not all be required for a satisfactory explanation of reminiscence for various tasks.

An example of how these variables might interact can be given by comparing rote memory, pursuit rotor, and tapping for speed. For rote memory, consolidation might be a major factor, attention certainly is, fatigue is at most a minor factor (since there is little involvement of the peripheral musculature), and forgetting of competing responses would not be greatly involved, since the subject likely has no false recall of items that must be "unlearned" for succesful performance.

For the pursuit rotor, fatigue is more involved, consolidation may still be involved, forgetting of incorrect or competing responses is likely to be involved, but attention may be only a minor factor, since this is a task on which there would be a shift to automatic performance without verbal direction as performance improves (Adams, 1973). For the tapping task, peripheral fatigue seems to be a potent force in lowering performance across massed practice, with recovery from fatigue acting to improve post-rest performance. Subjects report that they pay little attention while tapping (St. James, Note 1), in line with Adams' (1973) theory, which is treated in more detail below. Extinction or forgetting of incorrect responses should have little effect, since virtually no incorrect responses occur for this task. Consolidation should be a minimal factor, since little learning takes place.

Following this scheme, it should be possible to list, for each task, the factors expected to be included in determining reminiscence for that task, and the factors thought not to be included. Inclusion or exclusion in the examples just given is on the basis of either a common-sense approach (such as expecting peripheral muscle fatigue to play a role in reminiscence for tapping, but not for rote memory), or is based on theoretical considerations. An example of the latter is determining whether shifts in attention are involved in reminiscence on the basis of whether verbal-cognitive direction of the activity is required for skilled performance. This is based on Adams' (1971) closed-loop theory of motor learning, in which he postulates that most motor learning moves from verbal-cognitive control, in the early stages of acquisition, to automatic, non-verbal control when skilled performance is obtained. In Adams' terms, the subject goes from the Verbal-Motor Stage to the Motor Stage.

For tapping, control quickly reaches the Motor Stage. Subjects usually report that they pay little attention while tapping, but rather let their thoughts wander (St. James, Note 1). Shifts in attention across time thus seem unlikely to be major causes of the decline in performance during pre-rest practice, or its recovery after rest (reminiscence). For rote memory, on the other hand, conscious attention is necessary in order to perform at all. It does not seem unreasonable to suppose that the lower performance curves in rote memorization for massed practice as compared to distributed practice are a result of shifts in attention that reduce performance level. Rest periods during distributed practice, or a single rest during massed practice (the reminiscence paradigm), lead to a recovery of the capacity for conscious attention, and improved performance.

Eysenck (1965) divides various tasks on which reminiscence occurs into "performance" tasks such as tapping, in which little learning takes place, and "learning" tasks such as the pursuit rotor, in which it does. It seems to me that the main contribution of Eysenck's theory may be in shifting from theories explaining reminiscence as recovery from a decrement to theories considering reminiscence in terms of improvement in performance (rather than recovery from decrement). Even if reactive inhibition and consolidation fail as explanatory principles, it may be useful to preserve this distinction between what might be termed performance decrement theories and performance increment theories.

The various factors suggested above as possibly involved in reminiscence can generally be classified in one of those theoretical categories, based on whether their effect on performance is to improve it or lower it. Examples of performance decrement theories are reactive inhibition, peripheral muscle fatigue, attention, and motivation. The expected action of each of these (an increase in reactive inhibition or fatigue or a decrease in attention or motivation) is to lower pre-rest performance. Recovery from this decrement could contribute to reminiscence in various tasks.

Examples of performance increment theories are consolidation, more rapid forgetting of incorrect responses, and increased arousal as a result of practice or as a result of anticipation of a return to practice (Kling & Schlosberg, 1961). All of these factors are expected to lead to an improvement in performance, either during practice or during rest.

The model outlined above does no more than suggest a possible approach that falls between the extremes of a single factor being invoked as the cause of reminiscence for all tasks and reminiscence being viewed as a different phenomenon for each task. Some other approach may be needed, or a modification of an existing approach. Some consideration will now be given to outlining the necessary conditions for a succesful theory of reminiscence.

One point that seems often to be ignored in the literature is the need to account for the performance curve for various tasks, and not just for the reminiscence scores. The shape of the performance curve under different degrees of distribution of practice, including massed practice before and after a single rest, must be examined by any comprehensive theory, since the phenomena of massed versus distributed practice seem inseperable from reminiscence. The improvement in performance following rest (reminiscence) should be viewed as one of the details of the performance curve that must be accounted for.

Sex differences in reminiscence, and in performance (Huang & Payne, 1975), must also be accounted for by a theory of reminiscence. For motor tasks in which peripheral muscle fatigue occurs, males may show higher performance levels as a result of generally greater strength. The greater degree of reminiscence for females could then reflect the degree of fatigue from which recovery is possible. If differences in performance and reminiscence exist between males and females on a task, then the factors suggested as accounting for either performance level or reminiscence must be shown to also be related to sex differences, at least indirectly.

Another necessary part of any succesful theory must be the prediction of tasks for which reminiscence occurs, as well as the tasks for which it does not. No general examination of the latter issue seems to have been offered, and it could help clarify some points. There must be some basis for deciding that a factor is at work in a task other than simply whether or not reminiscence occurs. To argue that reminiscence is a result of accumulation and dissipation of reactive inhibition says nothing unless there is evidence for reactive inhibition other than that performance decrements occur under massed practice. If a priori grounds could be given for whether reactive inhibition accumulates in a task, and the task could be shown to produce reminiscence or not, in accordance with the supposed occurrence of reactive inhibition, this would provide more meaningful support for reactive inhibition as an explanatory principle. This same argument applies to any other proposed explanatory factor.

Tied up with this argument is the problem of specifying the necessary conditions for reminiscence and specifying the variables or conditions that block reminiscence. Rachman and Grassi's (1965) attempt to alter the course of consolidation and thus alter reminiscence, Rachman's (1962) attempt to alter the course of reactive inhibition by introducing an alien stimulus, and Catalano's (1967) attempt to alter muscle tension (and thus arousal) during rest, thereby enhancing reminiscence, are the few studies that I am aware of where an attempt was made to alter the level of a possible explanatory factor in an effort to reduce or enhance reminiscence.

The problems of specifying the tasks for which reminiscence should and should not occur, and of specifying the necessary conditions for reminiscence appear to be bound up with the same issue--that of specifying more than one operation for measuring the explanatory factor. Bridgman (1959) has argued that the whole problem of verification involves basically the ability to reach the same terminus by two different methods. This implies that the value of an explanatory principle lies in large measure in our ability to specify more than one operation by which it can be measured. As long as reactive inhibition can only be measured by the degree of difference between massed and distributed practice, the concept cannot be verified. A seperate operation that yields an equal measure of reactive inhibition is necessary for verification. The same holds true of any factor introduced to explain reminiscence.

In this context, it might be argued that one moves from a model of reminiscence to a theory precisely when one has specified some independent measurement of the explanatory principles. As an example, if peripheral muscle fatigue were suggested as the cause of reminiscence in tapping, then the performance decrement associated with massed practice, and the recovery from this decrement associated with rest would offer one measure of fatigue. That is, the performance curve would yield one such measure. If a measure of muscle tension, such as the electromyogram, which is presumed to also measure muscle fatigue, were found to correlate highly with the performance measure, this would offer some verification of fatigue as an explanatory concept.

Since I have suggested that a set of factors might be required to account for reminiscence, and have also proposed that any theory must account for the performance curve as a whole, rather than just for the reminiscence score, it follows that the single factor example just given is likely unrealistically simplified. But ideally the performance curve should be shown to be reproducible by some summation of the curves of independent measures of the explanatory factors. This amounts to predicting the level of performance at each trial of the task by some combination (such as multiple regression) of the independent variables (independent measures of the explanatory factors).

It is obvious that no entirely satisfactory means yet exists for specifying methods of measuring the variables suggested as contributing to reminiscence. Measures such as the electromyogram and electrodermal activity appear to be themselves determined by a complex interaction of variables. Eason and White (1961) have suggested that both fatigue and motivation have the effect of increasing the amplitude of the electromyographic signal. Electrodermal activity, such as skin conductance level, appears to be influenced by arousal and by shifts in attention.

It is, of course, entirely possible that various of the explanatory constructs do not exist independently of one another (such as perhaps arousal and attention), and that attempts to provide wholly independent measures of them fail to recognize that the constructs have no seperate "reality." In this case, measures such as electrodermal activity may, temporarily at least, provide a reasonable way of approaching the problem.

For the present, reminiscence is probably best considered an unsolved problem, despite the efforts made in the last 50 years or so to produce an explanation.

APPENDIX

SOME STATISTICAL CONSIDERATIONS IN REMINISCENCE STUDIES

Reminiscence studies offer a straightforward case of measuring change. The amount of change across a rest period is the variable of interest, and the researcher is usually concerned with whether groups exposed to different conditions differ in the amount of change following rest. Various approaches can be taken to the analysis of this type of data, and this Appendix will review these approaches, and the strengths and limitations of each. Consideration is then given to the techniques that have been most frequently used. In general, the analyses of reminiscence studies have used techniques known to be less precise than other available techniques. No wholly satisfactory solution seems available.

Three methods of analyzing pre-test-post-test settings have been most often used: the analysis of gain scores, the randomized blocks design, and the analysis of covariance using pre-test scores as the covariate, with post-test scores as the dependent variable. Two other methods will be discussed as well. These are the analysis of covariance using gain scores as the dependent variable, with pre-rest scores as the covariate, and the use of repeated measures on the pre-rest and post-rest scores.

The analysis of gain scores (post-rest minus pre-rest) offers the most straight-forward analysis of change. A distinct advantage of this method for the analysis of reminiscence studies is that the means being compared are in the measure of interest--gain in performance. Feldt (1958) has examined the precision of the gain score, blocking, and covariance methods, and found the use of gain scores wanting. For settings in which the analysis of covariance assumptions are met, the analysis of variance on gain scores has the lowest precision (that is, it has the largest error variance). In general, the reason for this is that the error of measurement for gain scores is higher than for either the pre-rest or post-rest scores. The increased error variance makes this test relatively insensitive to differences among group means.

The randomized blocks design involves the assignment of subjects to levels of a blocking factor (pre-rest performance), in an analysis of variance on the post-rest measures. Feldt (1958) states that blocking is the most precise design of the correlation between pre-test and post-test (or, in terms of reminiscence studies, pre-rest and post-rest) is .4 or less. This design has the very large advantage of not having the restrictive assumptions of the analysis of covariance, concerning the equality of regression slopes. A distinct disadvantage to this analysis is the need to assign subjects to treatment groups based on their pre-rest scores. This is no problem if the experimental manipulation is applied some time after these scores are acquired. But in reminiscence studies such as that reported here, this would be an overly restrictive requirement, since the treatment is applied in most cases quite soon after the pre-rest practice.

Another problem with the use of the rendomized blocks design is that the blocking factor, if it exists at the optimum number of levels, reduces the number of subjects per cell of the design to perhaps an intoler-able degree. This problem can only be overcome with the use of larger numbers of subjects.

The analysis of covarainoe, using the pre-rest scores as the covariate, and the post-rest scores as the dependent variable, is recommended by Feldt (1958) when a correlation of .6 or greater exists between the scores. Keppel, (1973) notes that this level of correlation is rare in the social sciences. For the reminiscence study reported here, however, this level of correlation is easily met (see Table 40). The assumptions of the analysis of covariance were also met by this data. This analysis adjusts the post-rest scores for equality of pre-rest scores, then compares the adjusted post-rest scores for equality of means. The analysis of variance on gain scores does much the same thing, but the use of a covariance approach helps avoid the increase in error variance resulting from subtracting post-rest scores from pre-rest scores.

A disadvantage to the analysis of covariance with pre-rest scores as the covariate and post-rest scores as the dependent variable is that the means compared are means of performance scores, not gain scores. Since the variable of direct interest in reminiscence studies is improvement in performance, the adjusted means for this analysis do not permit an entirely satisfactory grasp of what is going on with the data. Adjusted post-rest means have little intuitive appeal as measures of reminiscence. A possible way out of this dilemma is discussed by Hendrix, Carter, and Hintze (1979). This involves using the gain scores as the dependent variable, with pre-rest scores as the covariate. In effect, this adjusts the scores twice--once by subtracting pre-rest performance from post-rest scores, and then by equaiting the groups on pre-rest scores by regression. The interesting aspect of this procedure is that it results in precisely the same $\underline{F}$-ratios and probabilities as the analysis of covariance using the post-rest scores as the dependent variable. A numerical example showing the equivalence of the two methods is given in Li (1957), but I have discovered no discussion of the procedure offering an explanatáon of the equivalence or presenting information about the assumptions or dangers of such an approach. As noted by Hendrix, et a., this procedure has the advantage of comparing adjusted mean gain scores--the actual measure of interest for reminiscence studies.

A final method to be discussed is the use of repeated measures, with pre-rest and post-rest scores forming the two levels of the repeated measures, or Trials, factor. The within subjects effects of this analysis test the significance of the Trials factor and the interactions of this factor with the other factors in the design. A significant Trials factor is equivalent to a significant test of the grand mean in the analysis of variance on gain scores, and tests whether scores did, in fact, change from pre-rest to post-rest. This amounts to a test of whether reminiscence occurred.

The values of F and the associated probabilities from this analysis are the same as those from the analysis of variance on gain scores, where the tests of the main effects in the analysis of gains are the same as the tests of the interaction between the Trials factor and the other main effects in the repeated measures design. This analysis has been used by Pubols (1960), and is illustrated for this study in Tables 12, 25, and 38 for the three performance measures. The among subjects effects in this analysis do not seem to permit easy interpretation, since the collapsing of scores across the repeated measures factor (Trials) makes the marginal means being compared for equality a combination of pre-rest and post-rest scores. Thus, they are influenced by both pre-rest level of performance and amount of reminiscence.

Purely practical objections make the use of the randomized blocks design difficult in reminiscence studies such as that reported here. The other four analyses appear to offer essentially the same results. Until some clearly superior method of analyzing data in reminiscence settings is offered, the method of choice seems to me to be to beat the data with as many statistical sticks as one can. If the methods yield similar results, as they did in the current case, and reach significance on the same effects, then one can have some confidence that at least one of the methods is right. Clearly, the problem of assessing gains in performance is not yet satisfactorily solved.

A brief catalogue of studies using the different methods of analysis might be of some value, if only to show that most researcher have used the analysis of variance on gain scores rather than the more precise analysis of covariance. Out of 18 studies reviewed, all of which are concerned with whether the amount of reminiscence is the same in groups given different conditions, 11 used the analysis of variance on gain scores or the *t*-test on gain scores for comparing two treatment groups. These are Broadhurst and Eysenck (1973), Grassi (1973), Humphries and McIntyre (1963), Kimble and Horenstein (1948), Mohan (1968), Mohan and Mohan (1973), Payne and Huang (1977), Rachman (1962), Rachman and Grassi (1965), Stelmach (1968), and Willet and Eysenck (1962). It is interesting to note that Grassi (1973) used multiple *t*-tests as a post hoc procedure for pairwise comparisons.

The repeated measures analysis discussed above was used by Pubols (1960) and by Williams and Herbert (1976). The analysis of covariance using post-rest scores as the dependent variable, with pre-rest scores as the covariate, was used by Eysenck and Maxwell (1961) and by Adams (1955).

Other techniques that have been used are the one-sample t-test on gain scores, used to determine whether reminiscence occurred (Catalano, 1978; Kimble, 1949), and the use of an analysis of variance on gain scores, with blocking on pre-rest level of ability (Eysenck & Gray, 1971). No attempt will be made here to discuss techniques that have been used to investigate the effects of various treatments on the performance curve itself. The studies mentioned above have all dealt with reminiscence only.

The heavy reliance on the analysis of variance on gain scores, in the literature on reminiscence, is understandable for older studies, when the analysis of covariance would have required hand calculation. The availability, to most researchers, of computer programs for computing the analysis of covarariance makes the loss of precision in that analysis less acceptable than it may once have been.

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