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THE EFFECTS OF DISTRACTION ON PURSUIT ROTOR LEARNING, PERFORMANCE AND REMINISCENCE

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Five groups of thirty subjects were equated for performance on the pursuit rotor, and were then given massed practice under conditions of no distraction, a little, medium or considerable distraction, as well as a control distracting condition. It was found that performance declined proportionally to the amount of distraction given and that the effect of distraction was on performance only, and not on learning. During a subsequent rest pause half the subjects were given a distracting task, the other half were simply rested; performance after this rest period failed to show any effect of the distracting task on consolidation processes theoretically taking place during the rest period.

The measurement of distraction effects, i.e. the investigation of the effects of a distracting task (P_d) on performance on another task (P_a), was introduced into psychology in the 1880's, and reviews are available by Geissler (1909), Pauli (1930), and Kreezer, Hill & Manning (1954). Most of this work arose from an interest in certain problems of attention. As this concept began to be disregarded by psychological writers in the last thirty years or so, work on distraction began to decline, although many of the original findings, in spite of being based on small samples, inadequate experimental data and poor statistical treatment, are nevertheless capable of verification (Sterky & Eysenck, 1965).

The experiment described in this paper makes use of distraction in order to attack certain theoretical problems in learning theory which are rather far removed from those which motivated the earlier experimenters, and is in line rather with more recent work, such as that of Briggs, Fitts & Bahrick (1957). In particular we were concerned with two questions which have not received an adequate answer in modern learning theory. The first of these relates to the well-documented fact that performance on P_a declines when P_d is simultaneously performed, in rough proportion to the amount of attention required for the execution of P_d (Sterky & Eysenck, 1965); is it only performance which is interfered with, or is there also an interference with learning? Hullian theory, and indeed any form of reinforcement theory as applied to the learning of skills, would suggest the latter. Let us assume that over a period of 5 min two groups performed on the pursuit rotor, one without P_d, the other with P_d, and let us assume further that performance of the P_d group is roughly at a level one third that of the group without P_d. This means that the P_d group will only receive one third of the total reinforcement given to the other group, reinforcement being here taken as meaning 'knowledge of successful performance'. If learning is dependent in any sense on reinforcement, then the P_d group should learn less well than the other group. Equally, if learning is mediated in whole or in part by the successful performance of a given task, then again the no-P_d group should show considerably more learning than the P_d group. Even using a rather old-fashioned type of nomenclature one might think that the more attention an individual can devote to a task which he

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is attempting to learn, the more successful would be his attempt, so that the no-P_d group, able to concentrate completely on pursuit rotor learning, should learn much better than the P_d group whose concentration is demonstrably affected by P_d.

The second problem to be dealt with relates to the events which take place during a rest pause following a period of massed practice. Eysenck (1965) has argued that in pursuit rotor learning a process of consolidation takes place during this rest pause which enables performance to reach a higher level after the rest pause; this hypothesis is an alternative to the Hull–Kimble theory of dissipation of reactive inhibition. Several writers have shown that whatever processes may go on during the rest pause are relatively immune from various types of activities, ranging from talking to the experimenter to rating jokes and pictures, or looking at magazines. It has also been shown, however, that other types of activity, such as carrying out pursuit rotor practice in a mirror has the effect of interfering with consolidation if the activity is carried out during the first few minutes after massed practice (Eysenck, 1965). It is not known whether these different effects are due to the more or less attention-demanding qualities of P_d, or whether the differences are due to the considerable degree of similarity existing between pursuit rotor performance and pursuit rotor performance in a mirror (the term 'distracting task' in this connexion refers to its possible distracting character as far as the process of consolidation is concerned). It seemed likely that an experiment of this kind using a P_d making considerable demands upon attention but nevertheless quite different in nature to pursuit rotor learning would throw light on this problem.

METHOD

Plan

One hundred and fifty male subjects (industrial apprentices), ranging in age from 16 to 18 yr, were divided into five groups of thirty each. Subjects were not naïve with respect to pursuit rotor learning but had taken part in an experiment 12 months previously. Subjects were assigned to groups on the basis of their average level of performance on the pursuit rotor task during an initial practice period extending over 2 min.

Tasks

The experiment involved two tasks, the primary task (P_a) and the distracting task (P_d). The primary task was pursuit rotor learning, in which each subject attempted to keep the tip of a stylus in contact with a 'target' on a rotating turntable. For each of the five groups of subjects, the primary task itself was invariant. Differences between groups involved variations of the distracting task performed simultaneously with the primary task. Pursuit rotor performance was always massed and integrated over 10 sec periods. Details of apparatus, instructions and scoring have been given elsewhere (Eysenck, 1964).

The distracting task consisted of pressing either the right or the left foot pedal in response to one of two distinctive signals, a high- or low-pitched tone. During the experiment, the subject was seated in a chair with each of his feet resting on a pedal. Tones were transmitted to the subject through earphones, and he was instructed to respond to the high-pitched tone by pressing the right foot pedal and to the low-pitched tone by pressing the left foot pedal.

Three levels of difficulty of the distracting task were used, these levels depending upon the frequency with which tones were transmitted to the subject for his response. In the *easy distraction* condition the subject responded to 20 tones/min; the *medium distraction* condition required a response to 47 tones/min; and subjects in the *difficult distraction* condition responded to 72 tones/min. High-pitched tones and low-pitched tones were presented in random order. Further details of this experimental set up, and data regarding its effectiveness, have been given by Sterky & Eysenck (1965).

Practice periods

Initially all five groups were given experience with the primary task and the distracting task. For 2 min, each subject was allowed to practise the primary task. Since the groups were to be equated in terms of the initial ability of the subjects on the pursuit rotor, scores on this initial practice period determined the assignment of the subject to a group, Following this initial practice period, each subject performed the difficult condition of the distracting task for 2 min. After these two practice sessions, subjects were given a 10 min rest period during which they performed an irrelevant task, i.e. ranking a set of polygons according to aesthetic preference.

Experimental period I

During this 5 min period each of the five groups was treated as follows. Group *A* performed the primary task only. Group *B* performed the primary task and the distracting task in the easy condition. Group *C* performed the primary task and the distracting task in the medium condition. Group *D* performed the primary task and the distracting task in the difficult condition. Group *E* (a control group) performed the primary task, but in addition subjects were instructed simply to press either of the foot-pedals once each second; although these subjects heard the tones through the earphones (medium condition), they were instructed to ignore them.

During the last 30 sec of this period, all distracting stimuli were withdrawn, for reasons explained below. After experimental period I, all subjects had a 10 min rest period, during which they again performed the irrelevant task of ranking a different set of polygons.

Experimental period II

The second experimental period consisted of the performance of the primary task only for all five groups for 5 min. After this period each of the groups was divided into two subgroups of fifteen subjects each. One of the subgroups of each pair performed the difficult condition of the distracting task for 5 min; the other subgroup had a 5 min rest period.

Experimental period III

The last experimental period consisted of the performance of the primary task for 2 min by all subjects in each of the five groups.

Instructions

Immediately prior to experimental period I, all subjects were told that during the period the experimenter would say the word, 'Now', which indicated that there were 30 sec remaining in the period. For subjects in group *A*, this signal meant that they were simply to continue the primary task. For subjects in groups *B*, *C* and *D*, this signal meant that they were to discontinue performance of the distracting task and merely perform the primary task. Subjects in group *E* stopped pressing the foot-pedals at the signal and continued the primary task. The use of these instructions enabled the experimenter to obtain a pre-rest measure of a subject's performance in a non-distracted condition.

Scoring

For the primary task, time spent on target was electronically measured during the initial practice period and the three experimental periods; the experimenter recorded these scores for each 10 sec period, each period being termed a trial. In addition, for subjects performing the distracting task, a record of correct, incorrect and omitted responses was kept.

Results

Pursuit rotor performance scores during the initial practice period and experimental periods I and II have been plotted in Fig. 1. It will be seen that all groups perform in almost identical fashion during the 2 min practice period preceding the experiment proper, and analysis of variance confirms a complete absence of significant difference between groups. There is a significant learning effect at the 1 % level, but no significant interaction.

The differential effects of P_d are shown in the first twenty-seven trials of experimental period I, where the groups were graded in precise accordance with the amount of distraction presented. Fig. 2 gives a plot of the performance of groups *A*, *B*, *C* and *D*, showing a linear relation between time on target and mean signal number, which

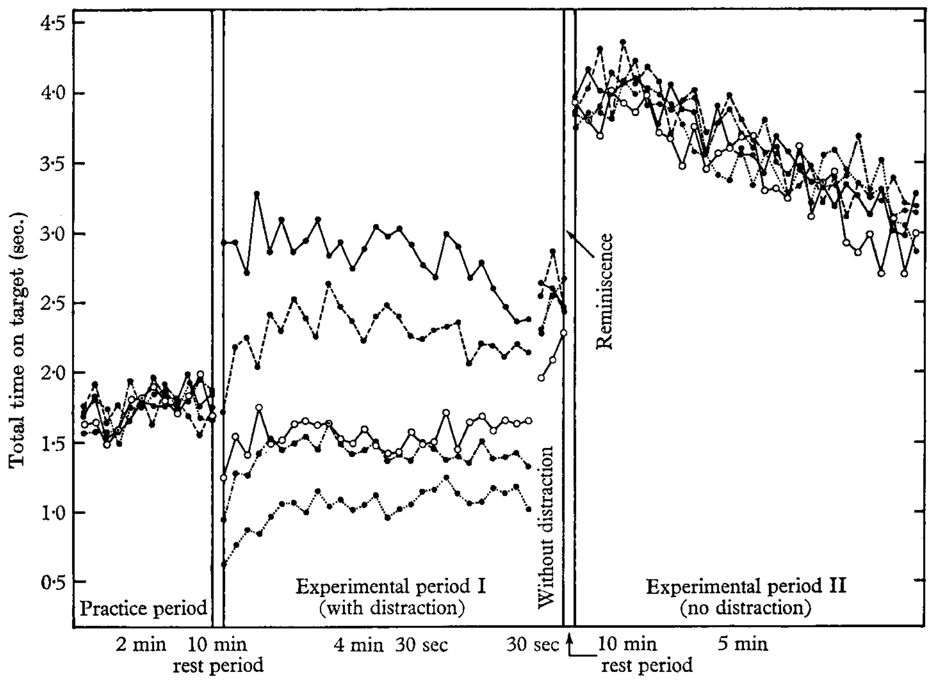

Fig. 1. Pursuit rotor scores for practice period, experimental period I (with distraction), and experimental period II (without distraction). ●——● , Group A (no distraction) ●– – –● , group B (easy distraction) ●– · – ●, group C (medium distraction) ●- - - ●, group D (difficult distraction) ○——○, group E (control group with distracting task).

Table 1. *Analysis of variance of pursuit rotor scores for the twenty-seven trials of experimental period I*

Sources	D.F.	S.S.	M.C.	*F*
Between groups	4	1689·42	422·36	16·714*
Between trials	26	38·61	1·49	3·548*
$G \times I$	104	68·52	0·66	1·571*
People within groups	145	3663·63	25·27	—
Residual	3770	1592·11	0·42	—
Total	4049	7052·29	—	—

$* P < 0{\cdot}01$.

may be taken as an index of distraction. Group *E* performed slightly better than group *C*, although the number of responses on the distracting task produced is much higher; this suggests that a certain amount of distraction is caused by the need to link the auditory signal to the appropriate foot movement. Analysis of variance (cf. Table 1) gave a highly significant difference between groups, and rather less significant values of F (although still beyond the 1 % level) for differences between trials and for the groups by trials interaction. The interaction effect, as can be seen, is due to the fact that group *A* declined in performance throughout the practice period while the other groups (particularly group *D*) improved. The decline of group *A* shows the usually

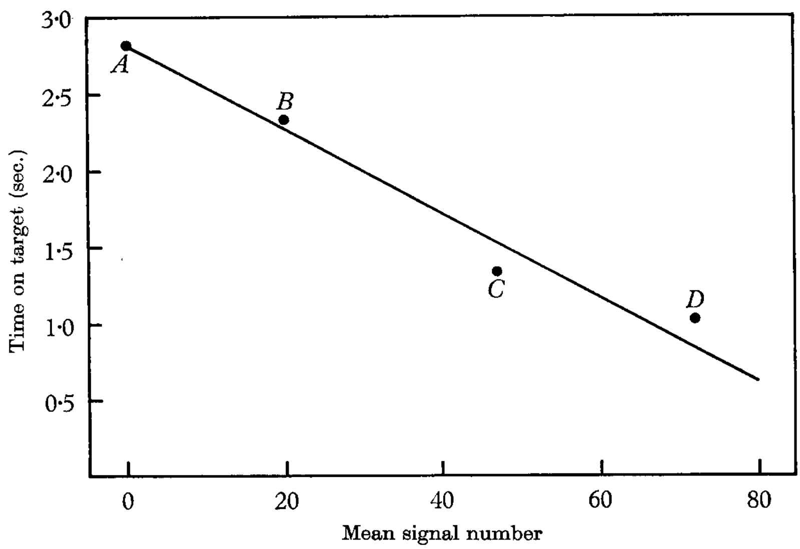

Fig. 2. Differential effect of the severity of distraction (mean signal number per minute) on time on target on pursuit rotor task.

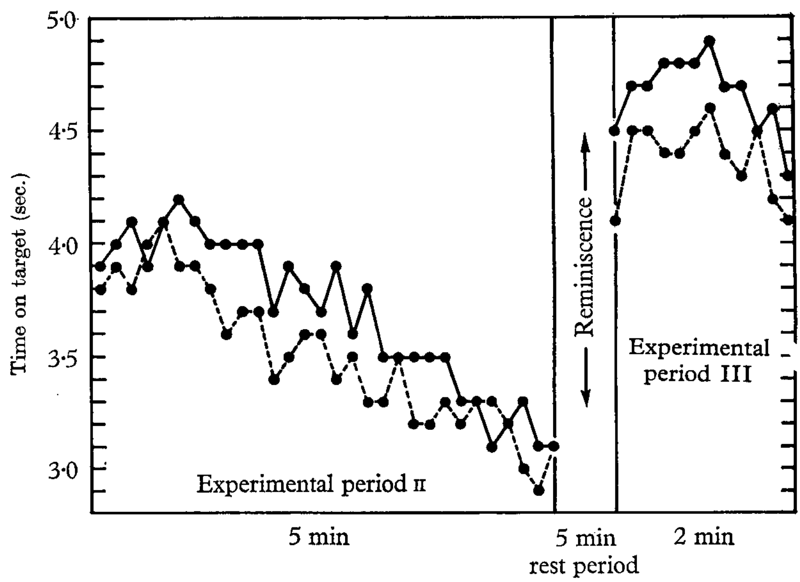

Fig. 3. Performance on pursuit rotor during experimental periods II and III of groups given either distracting task or rest during the 5 min period intervening between experimental periods: – – –, distracting task prior to experimental period III; ——, rest prior to experimental period III.

found phenomenon of post-rest decrement; the unusual increase in scores of the other groups is possibly due to some such effect as learning to disregard the distracting stimulus by making responses more automatic. In order to establish the significance of differences between pairs of groups, Tukey's (1949) test for differences between means was used, and it was found that each mean was significantly different from every other mean at the 1 % level, except that the difference between the means of groups *E* and *C* was significant only at the 5 % level.

All groups worked without P_d for the last three trials of experimental period I. In spite of the difference in pursuit rotor performance during the preceding trials, the five groups are indistinguishable from each other during these 30 sec without P_d ($P > 0{\cdot}05$). Thus it would appear that there has been no interference with learning but that P_d has simply held down performance to a lower level in strict accordance with the amount of P_d imposed.

This finding was brought out equally clearly in experimental period II. All five groups show identical reminiscence and identical performance; none of the differences is statistically significant. The only source of variance giving rise to a significant *F* ratio is that arising from trials; there is a highly significant decline in performance for all groups. Interaction effects are negligible. All data summarized in Fig. 1 agree therefore in demonstrating a failure of P_d to affect learning and the conclusion is suggested that distraction affects performance only.

Fig. 3 shows pursuit rotor performance scores during experimental periods II and III: subjects have been classified into two groups, i.e. the seventy-five subjects (fifteen from each of the five original groups) who were given 5 min rest between experimental periods II and III, and the other seventy-five subjects who performed the medium condition of the distracting task during this 5 min period. Analysis of variance of the pursuit rotor scores for the two groups during the last period failed to show any evidence of significance. In addition, reminiscence scores from the last trial of experimental period II to the first trial of experimental period III were computed and no significant difference was found between the two groups of subjects. It is obvious from the data that the two types of intervening activity, rest and P_d did not produce significant differences in subsequent pursuit rotor performance.

A word must be said about the significant differences found between trials during the initial practice period and experimental periods I, II and III, as well as the significant groups by trials interaction during experimental period I. Since scores on successive trials during these periods were not actually independent of each other, it is somewhat fallacious to ascribe the large numbers of degrees of freedom to the sources of variance. Therefore, a 'conservative test' has been devised (Greenhouse & Geisser, 1959) which reduces the degrees of freedom and thereby provides a more rigorous test of significance. When the 'conservative test' is employed, it is found that the differences between trials during the initial practice period, the between-trials differences during experimental period I, and the groups by trials differences during experimental period I are no longer significant. However, the differences between trials during experimental period II remain significant ($P < 0{\cdot}01$), while the differences between trials during experimental period III is significant ($P < 0{\cdot}05$), using the 'conservative test'. Our main conclusions, therefore, are not affected by the use of the conservative test.

Discussion

The results of this experiment are unusually clear-cut. They are: (1) distraction depresses performance on the pursuit rotor; (2) the interference caused by distraction is a linear function of the amount of distraction provided; (3) distraction does not affect learning, but only performance; (4) distraction does not affect consolidation.

It may be useful briefly to discuss these results in the framework of consolidation theory. We may conceive of what happens during massed practice on the pursuit rotor, followed by a rest period, along the lines of the following diagram:

$$L \quad C_1 \quad M_1 \quad C_2 \quad M_2$$

In this diagram L stands for the original learning process which is set into motion during massed practice, and which may be conceived in some such way as the setting up of certain types of 'cell assemblies', for instance. These cell assemblies, however, are not immediately available for improved performance; they require a period of consolidation (C_1, or primary consolidation). Primary consolidation can only take place during a rest period and if no rest period is programmed within a given time after the original learning, the cell assemblies cease to function and are no longer available for consolidation. The period during which they are available is probably of the nature of 12–15 min or thereabouts. The length of time taken by primary consolidation to be complete depends of course on the amount of learning that has to be consolidated but apparently it does not exceed, in normal persons, 8 or 10 min (in schizophrenics there is evidence that it might take 24 hr or even more). If primary consolidation takes place it places the learning into short-term memory storage and thus makes it available for the improvement of performance. If the rest pause is continued there is now a transfer from short-term memory storage to long-term memory storage; this transfer is designated C_2 in the diagram and may be referred to as secondary consolidation. Its function essentially is to protect the memory from being disrupted by electric shock and other cerebral disturbances.

The distinction between primary and secondary consolidation is perhaps unusual; it is necessary because in the usual type of consolidation experiment reference is only made to secondary consolidation. This is due to the fact that practically all the work that has been done in this field has been done on tasks involving essentially spaced practice; primary consolidation occurs naturally under those conditions during the rest periods following each increment of learning. There are important differences, as well as important similarities, between primary and secondary consolidation; primary consolidation in the normal person is accomplished in a relatively short period of time, whereas secondary consolidation apparently takes considerably longer, possibly extending from 30 sec to several days. Unfortunately, no direct evidence is available on interference with secondary consolidation in skilled tasks performed under massed practice conditions, so that part at least of the theory outlined above must remain speculative.

It would appear that the cortical processes underlying primary consolidation, as well as those underlying secondary consolidation, are not easily disrupted by distraction, however severe, unless this distraction is very closely similar indeed to the activity itself which has been learned in the first place. The converse presumably also follows, i.e. the process of primary consolidation interferes with the practice of the original learning activity, if this is resumed before primary consolidation is completed, but does not for other types of activity (for one explanation of this interference see Eysenck, 1965).

We are left with the problem of learning. The theory outlined above accounts for the fact that there is very little improvement during massed practice; what little there is may be due to a certain amount of primary consolidation taking place during blocks, involuntary rest pauses, etc. Our results seem to clarify to some extent the nature of the conditions requisite for learning to take place. It does not appear that reinforcement, successful practice, or attention are closely concerned with the acquisition of skill during massed practice, as our groups showed significant differences in all these conditions during the practice period but failed to show any effects on learning. The only remaining condition which appears to be significantly related to learning is the actual exercise of the perceptual-motor actions required, and the drive conditions under which the individual is working (Eysenck, 1965). Clearly one experiment is not sufficient to settle so important a controversy (cf. also Briggs *et al.* 1957) but it is suggested that the use of distracting tasks may enable us to investigate the various theories mentioned at the beginning of this article in greater detail.

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