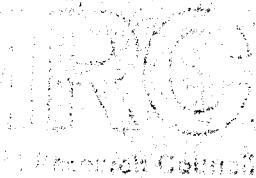


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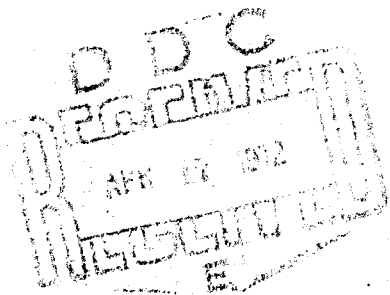
PERFORMANCE AFTER AWAKENING AT DIFFERENT
TIMES OF NIGHT

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SUMMARY

Naval ratings were roused during the night and presented themselves, dressed, for testing in a nearby room within 4 minutes. During the next 11 minutes they were given tests of reaction time, calculation and muscular co-ordination and steadiness. In all three tests performance was well below the normal level achieved during the day.

On different occasions the men were aroused at different times of night and this factor influenced which task was affected most.

Reaction time, with its intermittent call for rapid response, was impaired most in the early part of the night; the adding and co-ordination, which demanded more continuous performance, were more affected later in the night.

It is suggested that the early effects may be due to the depth of the preceding sleep, while the later ones may be influenced more by the trough in the circadian cycle of physiological activity.

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INTRODUCTION

1. Over the last ten years there have been at least seven studies carried out with the aim of assessing performance soon after sudden awakening. In a series of experiments dating from 1961 (Hartmann and Langdon, 1961; 1965; Hartmann, Langdon and McKenzie, 1965) subjects were tested for 10 minutes commencing some 2 minutes after awakening either at the usual time in the morning, at midnight, or at 0300 hours. Performance was worse than when the same tasks were carried out just before retiring at 2230 hours. There were, however, no significant differences between the three times of awakening. Two tests were given: response time to the onset or offset of displays in Complex Behaviour Simulator, and a Multidimensional Pursuit Test. In general the effect of sudden awakening was the same for both tasks. Jeannaret and Webb (1963) who carried out the next study in this field, restricted their examination to performance following waking at the usual time in the morning, at which time they asked their subjects to stand up and squeeze a dynamometer three times. Grip strength was 13% less than when tested during normal wakefulness in the early afternoon. In a further experiment from the same laboratory two modifications in the technique were introduced: subjects were tested in bed, to make the performance follow "immediately upon awakening" (Agnew, Webb and Williams, 1964) and, second, the arousal from sleep was carried out in the afternoon, the control comparisons being with the same routine of tests carried out before and after the midday meal and 5 minutes after arousal. The test was one of pressing four numbered switches in order of four numbers presented on a display panel. Time was taken to the first response, and for the whole sequence. Five trials were run in the 60 seconds following awakening. Performance in all five trials was well below normal, and that of the first trial particularly so.
2. Although the EEG was recorded in the study of Webb and Agnew (1964) (to achieve arousal from the Stage 4 EEG record where possible) no attempt was made to analyse results as a function of the stage of sleep from which subjects were aroused. There exists, however, a brief report of such an attempt by Scott (1969) using reaction time, arithmetic and two-flash discrimination as the tests of performance. The authors state, "Preliminary results ... indicate ... progressively greater impairment in relation to Stages 1-REM, 2 and 3+4 respectively". Performance in the later half of the night was also regarded as more like that of waking.
3. The final item of this brief review is a recent article by Seminara and Shavelson (1969) which differs from the others in that the setting for the tests was an altitude chamber configured to represent an early lunar shelter. The subjects were confined in this for five days and had to make typical emergency responses to auditory warning signals presented when they were alert or asleep. Performance on sudden awakening was inferior in all three tests: a) immediate response to the warning sound and then monitoring the status of five meters, b) setting a system of rotary switches, potentiometers and valves, c) donning a pressure suit. Performance was worst within 3 minutes of awakening, but 9 minutes after awakening it was still below normal.
4. From this review it seems clear that within 10 minutes of arousal from the normal sleep at night the performance of a number of tasks is less efficient than under usual conditions of alertness. Given agreement on this point two unresolved questions remain for immediate consideration. The first concerns how much of the above difference may be due to the effect of time of day (or night) upon performance independent of the influence of

sudden arousal. Only the study of Agnew and Webb (1964) avoids this problem by arousing men from sleep in the afternoon. Perhaps it is significant that they found the effects of the sudden awakening were confined to the 60 seconds following waking. Five minutes later the men were performing normally, whereas in other studies involving night awakenings a residue of inefficiency remained for up to 10 minutes at least. This could be due solely to physiological levels being set for sleep rather than wakefulness and might not be present following sleep during the day.

5. The second question concerns the time of night at which people are awakened. If the depth of sleep varies through the night we ought to expect time of awakening to have a bearing upon the subsequent level of performance. The present experiment was designed specifically to study this question.

METHOD

6. The subjects were enlisted men of average intelligence, volunteers, and under 30 years of age. The tests were carried out at the service unit in which the men lived. They were aroused once only during the nights of the Tuesday, Wednesday and Thursday of five successive weeks. On each occasion they dressed informally and walked as quickly as possible from the dormitory to the testing room, a distance of about 50 ft. This took about 4 minutes. On arrival at the testing room they carried out three tasks which occupied about 11 minutes, following which they returned to bed. As a control they carried out the same routine of tasks at 1430 on the Wednesday of each week having been awake since the normal rising time of 0630 hours.

7. The subjects came in two groups, one of 5 and one of 6 for 5 weeks each. They were aroused at one of four times: 0030, 0130, 0330 and 0530 hours on any given night. The first week served as a practice and the scores were not included in the results.

8. The three tests used were: Adding, reaction time, and a test of steadiness and co-ordination of motor control. Adding required the subjects to add columns of five 2-digit numbers and write the answer at the foot of the columns. The score was the number of these sums completed correctly in 3 minutes. Reaction Time required a simple key pressing response to a tone presented with warning. About 24 tones were presented at random intervals. For the third task, Co-ordination, a 10" x 10" square tray was mounted at right angles on a short stick. The surface of the tray was of glass, surrounded by a raised wooden ledge. A metal ball $\frac{3}{4}$ " dia. was placed on the glass as the subject held the tray horizontally on the handle. The task was to keep the ball at a point at the centre of the tray. A count was made in arbitrary units of the time that the ball was maintained in this position. To do so the tray had to be maintained absolutely level, a deviation causing the ball to roll away from the centre point. Thus, while subjects had to compensate for any such deviation according to an acceleration law, the test was essentially one of the steadiness with which the tray was held in the horizontal plane.

9. The order of presentation of these tests in a session was randomised with the constraint that over all sessions each test occurred with equal frequency in first, second and third positions. During control sessions on the Wednesday afternoons, the order of

the tests was similarly balanced. Competition was encouraged by giving knowledge of results. The whole group of subjects was tested together, two doing adding, two co-ordination, and two reaction time at any one time. In this way the duration of the whole session was reduced to about 11 minutes, so that there was minimum delay between arousal and performance of the three tests.

RESULTS

10. The fig. shows scores in the three tests at the four times of wakening during the night. The scores are expressed in terms of percentage impaired performance in relation to the control level during the day. At every point and for all three tests performance following sudden awakening was inferior to that under normal conditions in the afternoon, most of the differences being significant at better than the 5% level of probability using Wilcoxon's nonparametric test (Siegel, 1966). Combining the scores from the four times of testing the effect of sudden awakening was examined as a function of the time since waking, which varied from 4 minutes, to 8 minutes to 12 minutes according to whether the tests occurred first, second, or third in the 11-minute programme which followed rising and getting to the testing room. No significant differences emerged with respect to any of the tests, implying that no pronounced recovery of function took place during the period 4 ~ 15 minutes following waking.

11. The fig. also shows the influence of time of waking upon the level of performance within 15 minutes of arousal. The trends vary with the nature of the task: reaction time was at its worst early in the night, adding and co-ordination later at the 0130 and 0330 points. When all possible pairs of testing times were compared, a number of the differences approached significance but only those between 0030 and 0330 hours in reaction time and 0030 and 0130 hours in co-ordination were significant at better than the 5% level of probability. Nevertheless, the curve for reaction time appears almost the mirror image of that for adding, while that for co-ordination has features common to both.

DISCUSSION

12. The present experiment, since it incorporated tests involving a reasonably wide range of skills, suggests strongly that men's performance will be below normal for at least 15 minutes after being suddenly called to action from their normal night's sleep. This conclusion supports, in general, previous results in rather different settings, which suggests that the finding may have fairly general application.

13. Little has been added concerning the time course of the recovery of performance after wakening, except perhaps that in the present setting no evidence of swift recovery over a few minutes was seen.

14. The data on the influence of the time of sudden awakening are more interesting, although in some cases they fall tantalisingly short of conventional significance levels.

Two factors might be expected to influence these results: one is the depth of sleep, which if it be related to presence of EEG Stage 4 sleep, or to sensory threshold during sleep (Rechtshaffen, Hauri, and Zeitlin, 1966; Zung and Wilson, 1961) might be expected to produce poor performance early in the night with a progressive improvement later on as sleep becomes shallower. The second factor is the circadian rhythm of physiological and behavioural activity which usually reaches its lowest point rather later in the night between the hours of 0300 and 0500. Conceivably these two influences could have interacted in the present experiments to produce an impression of no change in performance during the course of the night. In fact, what appears to have happened is that one test, the reaction time, responded as if to depth of sleep, while the other two, particularly adding, responded as if to the circadian cycle. It is interesting to note that reaction time is a situation requiring relatively few quick discrete decisions. The other two tests affected later in the night required continuous application and concentration, albeit for only three minutes. This dichotomy between intermittent and continuous work may prove useful in any further attempts to distinguish tonic circadian factors from phasic arousal ones in situations where men are suddenly called to action from sleep.

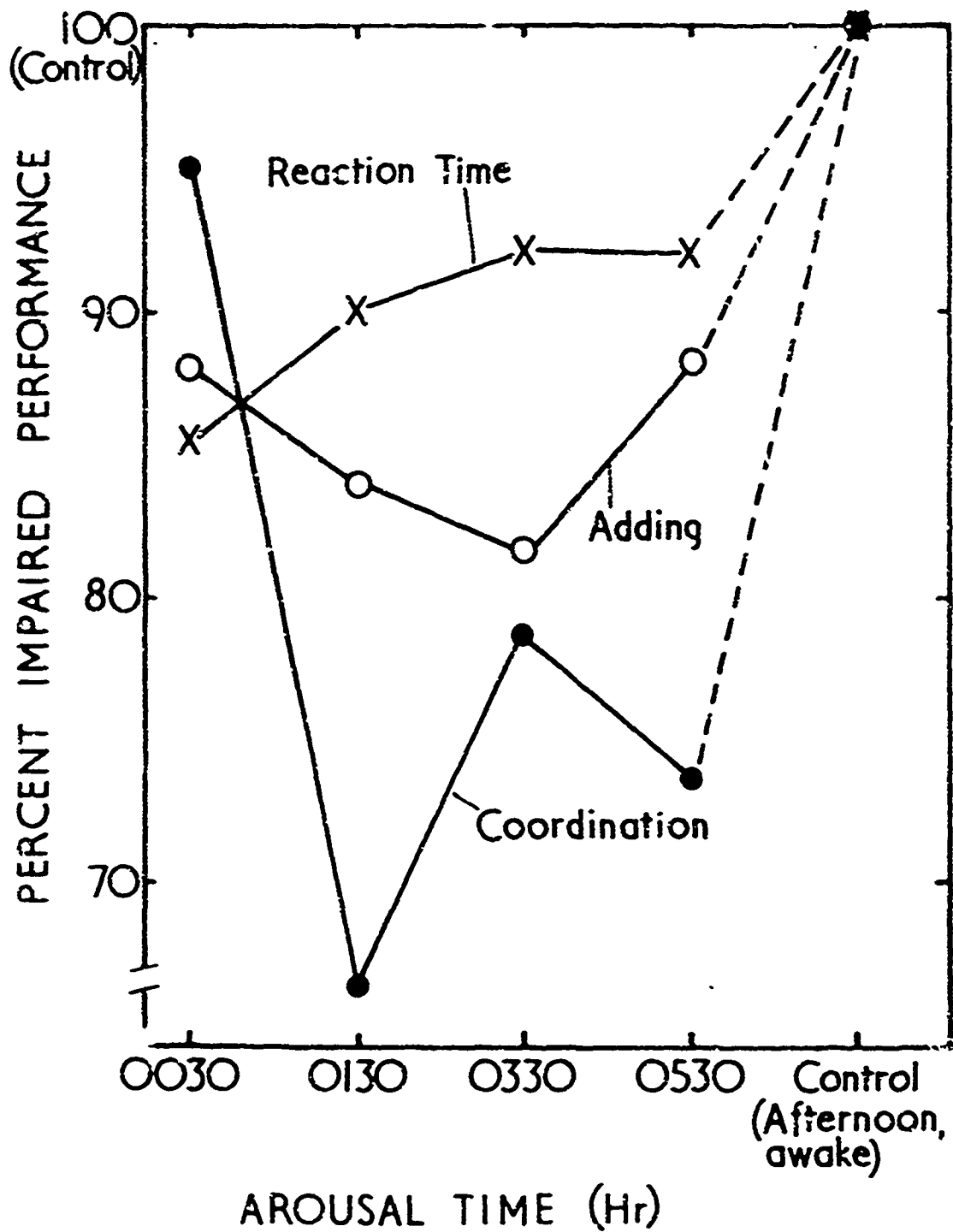
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The degree to which performance is impaired following sudden awakening at different times of the night. For all three tests, reaction time, adding, and co-ordination impairment is expressed as a percentage of normal alerted performance during the day.