of litter over the forest floor. When heavy thinning and pruning take place the annual deposition of litter may increase to 15,000 kgm. of dry matter per hectare and branch material forms a much greater proportion of the litter. In all, the total oven-dry weight of litter falling from the crop of *Pinus sylvestris* during fifty-five years of afforestation is approximately 300,000 kgm. per hectare, about half of this being leaf material.

The contribution of the ground flora to litter formation varies considerably, depending upon the density and nature of the tree crop. In old plantations the ground flora may be heavier than the weight of leaf carried on the trees, so that the death of the shoots of the associated herbs results in a significant annual contribution to litter formation.

Considerable amounts of plant nutrients are contained in the organic matter falling each year in woodlands. Since the accumulation of litter after forty-seven years of afforestation with *Pinus sylvestris* only equals the litter fall for two average years, it is evident that a large proportion of the plant nutrients has been released into the ecosystem by the decomposition of the litter. The release and circulation of plant nutrients may be much greater in an actively growing woodland with a mor humus layer than in a slower growing woodland having a mull humus. A more dynamic approach to litter formation in woodlands by studying the diverse aspects of nutrient turn-over is needed and should be closely linked with the biological activity of the micro-flora and fauna.

J. G. BOSWELL

VIGILANCE

A SYMPOSIUM on "Vigilance—the Nature of Alertness and the Problem of its Maintenance during Long Spells of Work" was held by Section J (Psychology) of the British Association during the recent meeting there. Dr. N. H. Mackworth (Medical Research Council Applied Psychology Research Unit), the opening speaker, defined vigilance as a state of readiness to detect and respond to certain specified small changes, occurring at random time-intervals, in the external environment. In real life, the problem was to discover why people failed to notice and act on a signal which they were normally quite able to detect. Although they knew what they were looking for, they did not know when to expect this signal. Experimentally it had become customary to measure inspection performance by considering (1) the average number of signals neglected over a given period, or (2) the intensity to which a given signal had to be raised before it was reported.

The main factors in vigilance were either environmental or motivational. The environmental factors included the work situation as well as the general surroundings.

The environmental variables in the work situation were mostly concerned with the dimension of time. For example, Deese[1] had demonstrated how the probability of detection depended on the frequency of signals per hour. Baker[2] had shown that the uneven spacing of signals along the time scale was of even greater importance. This unpredictability in time was thought to carry more weight than any other single environmental factor in causing a loss of alertness during prolonged work. Long working spells were known to be a further factor, Wyatt[3] had demonstrated this in industry, as had Mackworth[4], Broadbent[5], Baker[2], Whittenburg and others[6], and Adams[7] in the laboratory. According to circumstances, alertness began to deteriorate anywhere between a few minutes to one hour from the start of the spell, but usually about half an hour from the beginning. The duration of the signals was also of importance in some cases[7]; but Saldanha[8] had demonstrated that there could be a marked decline in accuracy of response even when the signal remained available until response was made. Aspects of the working situation not yet studied in any detail were the possible effects on alertness of having to neglect many unwanted signals. Regularity in the temporal spacing of wanted signals helped performance; but perhaps regularity in the unwanted signals might hinder it. Little was also known about the effects of systematically increasing the frequency of unwanted events.

The environmental factors in the general surroundings that reduced watchfulness were continuous noise[9], high atmospheric temperatures[10] and isolation[11].

The motivational variables were less clear although of equal importance; the increased motivation of immediate knowledge of results could keep vigilance at its initial level for two hours[4]. Reducing motivation by lack of sleep gave a marked increase in the number of unreported signals during a 45-min. test[12].

Mr. E. Elliott (Admiralty Research Laboratory) discussed the change of the effective threshold during the day. The classical threshold for detecting a stimulus was the level at which the stimulus was detected on half the presentations, but this assumed the optimal conditions of expectancy and perception. In real life, such optimal conditions were not present and men did not detect the stimulus at the classical level but at some higher level which could be called the effective threshold. This was measured by giving the subject at random intervals an auditory signal the strength of which was equal to the classical threshold for that subject. The effective threshold was regarded as zero decibels if the subject gave a response at that level. If he did not detect this signal it was repeated about 30 seconds later one decibel louder than the classical level. If still undetected, the signal was repeated after about the same time-interval two decibels above the classical level, and so on until the signal was detected and reported by a key being pressed. The effective threshold was the amount the signal had to be increased above the classical threshold for detection.

This ascending series was given at intervals about ten times during the two-hour test. This technique was used for examining effective auditory thresholds in six subjects tested daily for three weeks. In the morning they were given ten measurements of effective thresholds in two hours, and in the afternoon they were given ten signals per minute each 1 decibel above threshold. The average effective threshold was found to be about 4 db. above the classical threshold; 10 per cent of the time it was less than 1 db.; but 10 per cent of the time it would exceed 8 db. It was found that there was a large improvement in the effective thresholds for each subject (as measured in the morning) as time went on, but the improvement did not affect the 5–10 per cent period during which effective thresholds were 8 db. or worse.

Other subjects were first tested only by the morning procedure and then the faster presentation of the afternoon was added later. This improvement in the morning results seemed to depend on the presence of the afternoon tests, suggesting a transfer effect. However, the commissive error rate was roughly doubled by the introduction of the afternoon sessions. In fact, the subjects were trained by the frequent but weak signals of the afternoon to listen down to the noise itself.

Thus when a high probability of detection of a signal in noise was required, a high commissive error rate should be encouraged. But the really serious problems of vigilance were related to the larger peaks in effective threshold curves, when the signal strength had to be 8 db. or more above the classical threshold to be detected. These peaks could lead to very expensive mistakes and dangerous accidents.

When a man was asked to do a vigilance task, he had to stop his normal behaviour of scanning rapidly from one set of stimuli to another and concentrate on one set only. It was desirable that his effective threshold for these stimuli should be very low, although his natural living threshold might be very high. It was therefore necessary to study normal vigilant behaviour outside formal test periods.

Mr. D. E. Broadbent (Medical Research Council Applied Psychology Research Unit) discussed the relation between the failures of the vigilant man who was only watching for an occasional signal to which he had to react, and those of the active man who was keeping up a steady stream of activity which had to be related to random changes in his environment. There was considerable evidence that failures in perception could occur with the active job just as with the passive one, and lead to poor performance or accidents. For example, the studies by Saldanha[8] had demonstrated that in accurately setting a Vernier gauge by means of a small handwheel, less accurate settings were being accepted after only 15 min. The accuracy with which a man could keep a pointer on a mark by turning a handle at a constant speed had been investigated by Siddall and Anderson[13]. Again, the errors became greater as time went on. In both these active tasks there was deterioration in performance, just as there was in the passive vigilance tasks.

Other workers had also shown that continuous activity did not maintain alertness in a passive vigilance task. Moreover, Adams[14] had reported that a rest pause was not so helpful to performance at an active task when the rest was spent watching someone else do the work, as when it was taken right away from the work.

It was therefore clear that failure of observation was an important element in active as well as in passive tasks. This suggested that active tasks could be usefully employed to study perceptual failure. In self-paced tasks the speed of response to a signal depended on the probability of that signal. Although the average rate of work might remain the same, there might be an increased unevenness in response shown by pauses and spurts in the activity. It seemed likely that these irregularities in performance represented fluctuations in perception and that similar fluctuations might occur in a pure vigilance task. A brief signal might occur during a brief failure of attention and therefore be missed. If, however, the signal were prolonged or repeated it would exceed the moment of failure and so be detected.

In addition to its considerable theoretical interest, vigilance was also of great practical importance, particularly as regards accident prevention.

Dr. D. H. Irvine (Army Operational Research Group) discussed vigilance in industry in relation to machine-minding and to inspection tasks, and also touched on the reliability of clinical judgments. He pointed out that the signal to be identified might be very brief, or machine paced, or it might persist until attention was paid to it. In the latter case, the signal might become more urgent as time went on, as with the warning light indicating to a motorist that his oil was low, or it might remain static, as with many inspection tasks, where the operator could take his own time to decide whether each item was faulty or not.

Inspection tasks might involve a yes/no decision, where the faulty item had to be identified and rejected, or they might involve grading into classes, or finally, they might involve accurate determinations of measurements along an apparently continuous scale. This visual inspection was affected by factors of vigilance, subjective judgments and decision taking.

Several experiments had been carried out on the variations of subjective judgments between one person and another, even when these people were experts in their own field. Moreover, they varied widely in their judgments on the same materials repeated on two successive occasions. Many of these experiments concerned clinical judgments of disease, since this was a field where the single opinion of an expert could be vitally important. This variability in diagnosis had been extensively surveyed in the examination of X-rays by experts[15–17]; the experimenters found that the use of standards reduced the variability, and that reduction of the number of possible categories also improved consistency. They recommended that for anything as important as a medical opinion at least two examinations of the material should be employed.

One of the major difficulties in investigation of inspection work in industry was the difficulty of finding out how many potential rejects were missed by the operator. Dr. Irvine had carried out an experiment in which subjects were asked to grade pharmaceutical ampoules, first for impurities, and secondly by the nature of the impurities, and each subject graded the ampoules four times, while the batch of 200 ampoules was graded by 24 different subjects, and also 32 times by the author. There was considerable variability in the grading, but it appeared that accuracy of grading improved as the results for many inspections were pooled. As with the clinical material, where high accuracy was essential, it appeared that the same material should be examined several times, if possible by several people.

This experiment also showed that the rejection-rate depended on the batch size; that is, a higher rejection-rate was obtained when the material was examined in two sessions of approximately half an hour each, than when it was all examined in one session. There was no correlation between the time each person took to complete the examination and the reject rate.

Mr. D. Wallis (Admiralty) emphasized some of the more important aspects of the papers. He pointed out that when signal frequency was increased, performance was improved in terms of probability of detection; indeed, the percentage success rose from about 40 to 90 per cent. But the absolute number of signals missed remained about the same, that is, 4 per hour, in the experiment under discussion[1]. Thus, if missing a signal was due to a fluctuation of attention, then these brief but serious lapses might be thought to occur at the same rate whatever the speed of signal presentation.

Mr. Wallis also saw a wide application of the technique described by Mr. Elliott, as this enabled an investigator to sample the precise level of vigilance throughout lengthy periods.

Among the various methods of improving performance in vigilance or inspection tasks the most effective in practice was the use of two operators at the same time, since the lapses suffered by two individuals were uncorrelated in time. In a recent study, Mr. Wallis had found that detection probabilities could be doubled by this approach. There was also the possibility of transfer from tasks specially designed to maintain vigilance to the actual task. Finally, there was the possibility that some people who liked to be quiet and alone might be better at vigilance tasks that require this than would more extroverted people.

Dr. P. Bakan (U.S. National Science Foundation) discussed his experiments on vigilance[18]. The occurrence of performance decrement over time was a result of an increase in the effective threshold for the discrimination required for the task. Repeated effective threshold measurements for the detection of occasional brighter flashes had shown that the required increase in intensity had to be raised after 15 min. Variables related to sleep were also related to a loss of vigilance in performance tasks. Monotonous environments might produce either of these states, while amphetamine sulphate could counteract them. Moreover, physiological changes such as electroencephalogram changes and reduction of muscle potentials were common to both states. However, the subject in a vigilance task would usually make efforts to keep awake by self-generated stimuli, for example, the characteristic increase in restlessness, singing or day-dreaming. It was important also for the experimenter to try to raise vigilance by introducing external stimuli in order to avoid a state of sensory deprivation[19]. Such external stimulation could be irrelevant to the particular vigilance task, yet had to be compatible with it.

Mr. D. C. Fraser (Institute of Aviation Medicine) said that three conditions were needed in a vigilance task: (1) the presence of neutral signals which had to be disregarded but throughout which the significant signals were randomly interspersed; (2) stress conditions were also required in terms of speed, load, duration, etc.; (3) knowledge of results had to be minimal. Tests of effective threshold were therefore of a different nature from the classical vigilance test. Two kinds of vigilance had been found, the alertness needed throughout a long test to detect the occasional significant signals among many other slowly presented signals, and that needed in a short test for detecting the occasional signal among many rapid neutral signals.

Actual sampling during the work itself was even more promising than effective threshold techniques. Recent experiments at Farnborough had shown that vigilance fell off after 40 min.—which was very close to the earlier findings[4].

A full study was now needed of the relationships between vigilant behaviour and neurophysiological measures. The chairman of the meeting (Prof. J. Drever) had developed electroencephalogram techniques which Mr. Fraser suggested should be used to detect changes in the neurophysiological pattern during vigilance tasks. N. H. MACKWORTH

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OBITUARIES

Dr. H. R. Kraybill

HENRY REIST KRAYBILL, who died in Chicago on September 30 at the age of sixty-five after several months illness, was particularly well known for his research studies on meat and meat products over the past fifteen years.

After graduating in agricultural chemistry at Pennsylvania State College in 1913, Dr. Kraybill took his doctorate at the University of Chicago in 1917. He organized and developed the Departments of Agricultural Chemistry first in the University of New Hampshire from 1919 until 1924 and then in the Purdue University from 1926 until 1941. During this period, he also served as State chemist for New Hampshire and Indiana and held appointments at the Boyce Thompson Institute and the United States Department of Agriculture.

He returned to Chicago in 1941 as director of the Department of Scientific Research of the American Meat Institute and as professorial lecturer in the