FATIGUE

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Two comprehensive reviews, that of Robinson (**49**) in 1934 and that of Viteles (**53**) in 1932, adequately summarize findings in the study of fatigue up to their time. The former gives consideration for the most part to laboratory experiments, while the latter includes more readily applicable data from actual industrial situations. It may well happen that some of the typical laboratory studies treated by Robinson, involving work decrement and fluctuation in short periods of rapid output ranging from a few seconds to a matter of minutes, may assume a new practicality in view of the developing tendency in modern combat toward short bursts of intensive activity, as in aircraft machine gun battery firing.

In more recent treatment of fatigue problems there continues a regrettable unwillingness to consider work decrement empirically and from the standpoint of the organism as a whole. Dill, Bock, Edwards, and Kennedy (**17**), for instance, contend that the breakdown of the finger in ergographic performance is a problem that concerns the physiologist, while output in the usual industrial job is a problem for the psychologist, psychiatrist, and sociologist. Dill (**15**), furthermore, sees the very real contributions of the Industrial Health Research Board of Great Britain in the investigation of output decrement and variability accompanying the experience of boredom merely as a pseudosolution to the fatigue problem—a solution consisting of renaming. Wyatt and Langdon (**58**) have since demonstrated decrement in the same subjects accompanying monotony at a slow speed of machine operation and associated with strain and tiredness at a higher speed in the same task.

Trends of output in fast light manual work are reported by Philip (**43**) from a laboratory experiment involving work spells of far greater duration than is customary for this type of activity. Tapping was maintained with surprisingly little decrement (even conceding an opposing practice effect) for from six to seven hours, with less than three rest periods on an average per subject. Periodicity characterized the output curves of 7 of 12 subjects. In another study (**44**) in which a like work period was broken into

10-minute trials, Philip found that the short period work curves formed a series of short hyperbolas in conformity with results previously reported by others.

Whitehead (**56**) similarly finds little decrement in performance of a light manual industrial operation. Average hourly production curves calculated for periods of some months for each of five workers rarely showed deviations of more than 5% from their average except for the early part of the morning spell. As a matter of fact, these output curves often showed a rise during the afternoon period, continuing to its end, though output was generally lower in the afternoon than in the morning. Graf (**22**), reporting on the output of conveyor operators working at their own pace, also notes a tendency to speed up work in the afternoon, but in this case it occurred when morning output had been low. Graf (**23**) recommends use of an indicator informing the worker when he is working too slow or too fast, rather than an imposed rate of operation.

Dill (**15**) concludes that the moderate activity of modern industry causes little fatigue effect as indicated by the physiologist's measurements of pulse rate, lactic acid, respiration, oxygen consumption, etc., and offers a classification of moderate, hard, and maximal work on the basis of the ratio of metabolic rate in work to the basal metabolic rate. He includes a review (1936) of metabolic findings in studies involving work thus classified. Dill, Bock, Edwards, and Kennedy (**17**) contribute a noteworthy discussion of industrial fatigue with simple treatment of the questions of fatigue substances, exhaustion of energy reserves, inadequacy of oxygen supply, and alteration of the physicochemical state. Lahy (**30**), employing a portable laboratory carried on 18-hour truck routes, finds that reaction time and dynamometer performances suffer with prolonged driving. Other investigators have observed energy exchanges involved in the work of carpenters, masons, mechanics (**41**), and metallurgy workers (**40**). Much of recent experimental work in muscular exercise and its accompanying bodily changes is treated in a review by Dill (**16**).

Among numerous studies in mental fatigue by Bills is one pertaining to the extent of transfer of fatigue from one task to another in relation to the proportion of elements common to both. Output curves here resulted which resemble in general form those which have been found in repetitive work situations in monotony studies of the Industrial Health Research Board. Problems in mental fatigue including its practical differentiation from physical fatigue, its indices, and its principles are well treated on the basis

of experimental findings in a survey by Bills (7), who in the same year summarizes the literature on facilitation and inhibition in mental work (6).

The contention of Haggard and Greenberg (24) that industrial output is favorably influenced by an increase in meals from three to five per day has not met with general acceptance because of the lack of adequate controls in their supporting study. Laird (31) and Weston and Adams (55) describe the adverse influence of noise upon a motor task performance and the work of weavers, respectively. Effects of the loss of sleep upon behavior are comprehensively reviewed by Kleitman (28), and Edwards (18) subsequently adds an experiment in which loss of sleep has been extended to 100 hours with results in accord with those of earlier studies.

The search for additional criteria of fatigue continues with Hollingworth (26) offering perceptual fluctuation, Wickwire and Burge (57) the threshold stimulus for the patellar tendon reflex, and Feree and Rand (20) speed of accommodation in near and far vision as measured by a tachistoscopic instrument. Evidence for a relationship between ordinary fatigue and alteration in behavior resulting from the low oxygen tension of high altitudes is cited by Bills (5). Whether or not such a relationship is ever definitely established, studies in low oxygen tension such as those reported by Barach, McFarland, and Seitz (2), Seitz (51), and McFarland (35, 36) and reviewed by McFarland (37) represent invaluable contributions toward a more complete understanding of variation in man's behavior.

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