EXPERIMENTAL STUDY OF FATIGUE DURING WORK WITH A LARGE SENSORY AND SMALL MUSCULAR COMPONENT

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In the work of the driver of an electric locomotive, consisting of driving the train and making observations on objects of relevance to the safety of movement, the sensory component is much greater than the motor. Time and motion study shows that during 10 h of work in the locomotive the driver receives and assesses more than 1300 discrete and relevant stimuli (signals, crossings, and so on). In addition, he keeps a continuous watch on the state of the track and the power lines, the readings of the indicators on the control panel, the character of the noise from the engines, and he also obtained information about its work periodically from his assistant. Hence, the total number of stimuli received by the driver and related to his work is very great.

The motor component is of relatively little importance in the activity of the locomotive driver. During 10 h of work on the footplate, the driver makes about 1100 movements with the levers and buttons of the control panel, accounting for only about 12% of the working time; the movements are short in duration, require little muscular effort, and are kinematically simple. However, the constant change of speed determined by the frequent changes in the signals, and the large number of stops (as many as 80 during a shift) call for speed and accuracy of the motor reactions.

The nervous stress is increased by the risk of possible "incidents," which is particularly high in the case of the driver of an electric locomotive, for his work is carried out in the suburban zone with intensive movement of traffic and many crossing points for vehicles and pedestrians. The large number of objects threatening the safety of movements of the train is shown by the number of warning whistles given by the driver (as many as 250 per shift, i.e., one every 2-3 min).

The special features of his job demand from the driver the ability to maintain constant attention and constant preparedness for action. The work of the driver is greatly complicated by its arrhythmic character, interfering with the formation of an occupational stereotype, an important factor in increasing working capacity, and also by the presence of intensive noise and vibration stimuli.

The work of an electric train driver is thus characterized by considerable neuropsychic stress, absence of rhythm, a considerable volume of information to be received and analyzed, and a small but responsible motor activity.

EXPERIMENTAL METHOD

Observations were made on drivers aged 33-35 years, in normal health, engaged in this occupation for not less than 3 years.

The physiological investigations were made before and during the working day (6-7 times). Each driver was investigated during 15-20 shifts. The critical frequency of fusion of flashes of light was measured by means of a relaxation oscillator, consisting of a neon lamp connected to the output of an audiofrequency generator. By rotating a disc, the frequency could be varied from 0 to 200 cps, with the possibility of distinguishing a difference of 0.5 cps. The orthostatic reaction was investigated on a special revolving table. The reaction of demographism was

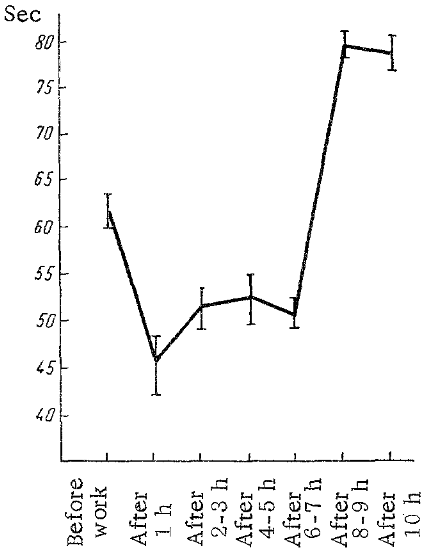

Fig. 1. Time of switching attention.

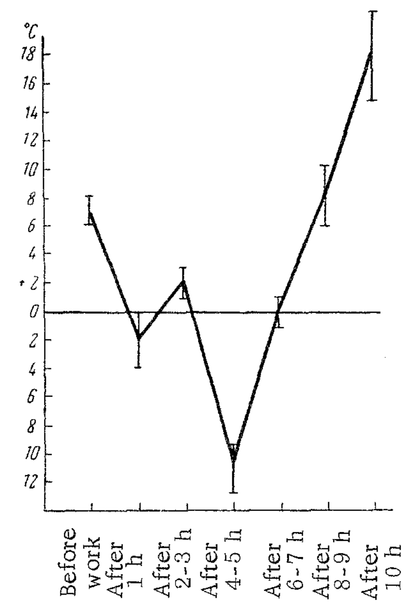

Fig. 2. Mean deviation from given level during reaction to moving object.

determined in the recumbent position by graded (300 g) stimulation of the skin of the chest. The time of development of the reaction, and the width and character of the band were recorded. The visuo-motor reaction was studied by K. K. Platonov's apparatus: the driver had to extinguish as quickly as possible red, yellow, and green lights shining before him in a random manner by pressing on the appropriate knobs. The total time of the reaction and the length of the latent period were measured by means of a millisecond counter. The switching of attention was investigated by means of Platonov's numerical table. The driver had to count the black numbers in increasing order as quickly as possible, followed by the red numbers in diminishing order, and then to count the black numbers in direct order and the red numbers in the opposite order, and to alternate them. The difference between the time of counting the mixed numbers and the total of the red and black numbers counted separately was an index of the time of switching attention. The reaction to a moving object was also investigated: by pressing on a knob the driver had to stop an arrow, moving in a circle at a uniform rate, at a particular mark. Deviations to one side or the other in degrees were recorded.

EXPERIMENTAL RESULTS

At the end of the first h of work, the time of switching attention was shortened by 28% (Fig. 1), the deviation from the given level in the reaction to the moving object was reduced to $-2(\pm 2)^\circ$ compared with $+7(\pm 1)^\circ$ before work (Fig. 2), the latent period was reduced by 12%, and the motor reaction by 28% in the visuo-motor reaction. The latent period of dermographism was increased (Fig. 3), the excitability of the optic analyzer was slightly increased (Fig. 4), the arterial pressure was raised, and the pulse rate was slowed.

During the next 5-6 h of work, the state of the investigated functions remained relatively stable at a level slightly higher than initially. After 6-7 h of work, a further decrease in the time of switching attention by comparison with the initial level was observed (Fig. 1), and the mean deviation in the reaction to the moving object was also reduced (Fig. 2). The latent period of dermographism was appreciably lengthened (by 54.7%, Fig. 3), the excitability of the optic analyzer was increased (Fig. 4), the total number of cases of normal reactions in the orthostatic test was increased, and so on. After work for more than 7 h, the reaction of switching attention was slowed by 26% (Fig. 1), the deviation in the reaction to the moving object rose to $+18(\pm 3)^\circ$ (Fig. 2), the latent period of dermographism fell by 11% (Fig. 3), while the time of the motor components of the visuo-motor reaction and the number of cases of strongly positive and inverted reactions during the orthostatic test increased. The excitability of the optic analyzer rose slightly (Fig. 4).

The changes in the state of the recorded functions after working for 1 h demonstrated an increase in the lability of the cortical centers during the period of formation of the working dominant. Meanwhile, the tone of the sympathetic nervous system was increased, allowing the fullest development of the functions of the somatic apparatus. During the next 5-6 h of work, the working capacity and functional state were stabilized, indicating the coordinated tuning of the dominant centers of the working function, and the equilibrium between the fundamental nervous processes in the cerebral cortex. The fresh increase in the functional state after 6-7 h of work must evidently be attributed to mobilization of restorative and compensatory mechanisms, aimed at maintaining working capacity at its previous level. This phase evidently heralds a fall in working capacity and functional powers, for if the work activity is prolonged, several indices of the functional state fall, despite considerable voluntary effort. This period may be called the period of gradual development of limiting inhibition.

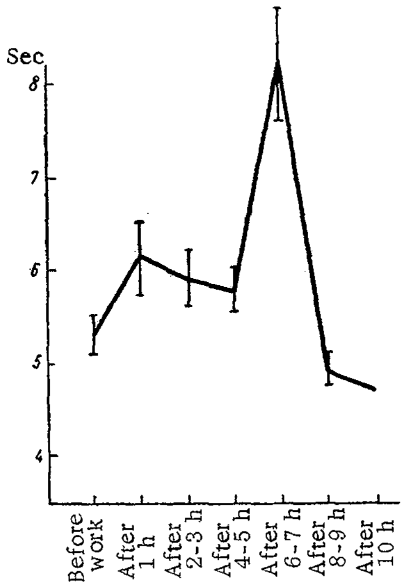

Fig. 3. Latent period of dermographism.

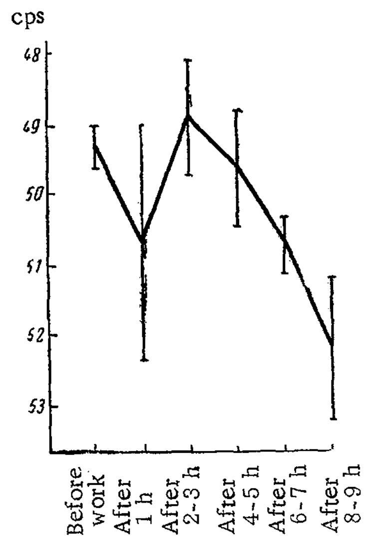

Fig. 4. Critical frequency of fusion of flashes of light.

Analysis of these results shows that the changes in the functional state during a working shift in drivers in whose work the sensory component is predominant obey the same rules as those established for work with a large muscular component; phases of preparation for work, of a stabilized working state, and of a falling off of functional capacity are observed. In the present investigations, this last phase was preceded by a phase of a temporary increase in functional capacity, heralding its subsequent fall.