EFFECT OF SINGLE PHYSICAL EXERTION ON FORMATION, FIXATION, AND REPRODUCTION OF TEMPORARY CONNECTIONS IN RATS

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One way of studying the nature of consolidation of temporary connections in the CNS is to investigate and compare the influence of various procedures modifying the functional state of the body as a whole, and of the higher levels of the CNS in particular, on this process. Among the many different factors influencing this process, physical exertion has been studied less than others although, according to some data, physical exertion can have a marked influence on higher nervous activity [1, 3, 6]. The object of this investigation was to study the effect of single submaximal and maximal physical exertion on the formation and consolidation of temporary connections.

EXPERIMENTAL METHOD

Experiments were carried out on noninbred male albino rats weighing 150-180 g, in which conditioned passive and active two-way avoidance reflexes (CPAR and CAAR respectively) had been formed. The CPAR was formed in an apparatus consisting of a lit "safe" and a dark "dangerous" compartment, connected by a window. To form the CPAR a rat was placed in the lit compartment, from which a change into the dark compartment was accompanied by an electric shock (ES). The ES continued until the animal returned into the "safe" compartment, after which the rat was removed from the apparatus and returned to the animal house. Preservation of CPAR was tested 1 h and 1 and 7 days after its formation by placing the animal in the lit compartment and recording the time of its stay therein. The maximal time of observation per animal was 300 sec. The CAAR was formed in a shuttle box, using light as the conditioned stimulus, reinforced at the 6th second of action of ES. In the initial and repeated experiments (the last was done 7 days after the initial) the animal was presented with 50 combinations of light and ES and the number of conditioned avoidance reactions was recorded. The number of conditioned avoidance reactions served as the indicator of reflex formation in the initial experiment and of its preservation in the repeated experiment.

Two series of experiments were carried out, each of them on two groups of animals. In series I the effect of submaximal and maximal physical exertion on formation and preservation of the CAAR and CPAR was investigated. The submaximal load consisted of running in a circular treadmill rotating at a speed of 16 m/min for 10 min, whereas maximal exertion consisted of running in the treadmill up to the limit of endurance. The mean duration of running in this case was 66 min. In the experiments of series II the animals were subjected to submaximal and maximal physical exertion immediately after formation of the CPAR or CAAR. By comparing the results of these two series it was possible to assess the influence of physical exertion on the formation, fixation, and subsequent preservation of temporary connections. The Wilcoxon–Mann–Whitney method was used for statistical analysis. Altogether more than 200 animals were used in the experiments.

EXPERIMENTAL RESULTS

The results of the experiments of series I are given in Table 1. Analysis of the data showed that under the influence of submaximal and maximal physical exertion CPAR formation

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TABLE 1. Effect of Physical Exertion before Training on Formation, Fixation, and Reproduction of Temporary Connections

Character of reflexes formed	Experimental conditions	Conditioned reflex formation 10 min after physical exertion	Preservation of conditioned reflexes		
			after 1 h	after 1 day	after 7 days
Conditioned passive avoidance reflexes	Control	8,78	272,57 (n=14)	269,71 (n=19)	256,00 (n=18)
	Submaximal exertion	16,31*	289,00 (n=15)	245,60 (n=14)	227,05 (n=20)
	Maximal exertion	48,24*	281,54 (n=13)	223,33* (n=15)	183,94* (n=18)
Conditioned active avoidance reflexes	Control	5,20	—	—	20,81 (n=15)
	Submaximal exertion	6,88	—	—	23,25 (n=10)
	Maximal exertion	0,99*	—	—	7,10* (n=15)

Legend. Here and in Table 2, asterisk indicates P < 0.05 compared with control; number of animals shown in parentheses.

TABLE 2. Effect of Single Physical Exertion after Training on Preservation and Reproduction of Conditioned Reflexes

Character of reflexes formed	Experimental conditions	Conditioned reflex formation 10 min after physical exertion	Preservation of conditioned reflexes		
			after 1 h	after 1 day	after 7 days
Conditioned passive avoidance reflexes	Control	8,78	272,57 (n=14)	269,71 (n=19)	256,00 (n=18)
	Submaximal exertion	7,95	232,60 (n=12)	258,89 (n=18)	190,32* (n=14)
	Maximal exertion	8,45	223,72* (n=17)	212,41* (n=27)	111,58* (n=15)
Conditioned active avoidance reflexes	Control	5,20	—	—	20,81 (n=15)
	Submaximal exertion	6,00	—	—	11,60* (n=15)
	Maximal exertion	5,40	—	—	9,60* (n=15)

was disturbed, as shown by a marked increase in the length of stay of the animals in the lit compartment of the apparatus, especially in the case of maximal exertion. As regards the CAAR, preliminary submaximal exertion did not affect their formation, whereas maximal physical exertion sharply reduced (fivefold) the formation of this reflex. Subsequent preservation of CPAR and CAAR was disturbed only in animals exposed to maximal physical exertion before training. Different results were obtained in experiments in which the animals were exposed to physical exertion immediately after conditioning. As Table 2 shows, preservation of CPAR was disturbed as early as 1 h after conditioning, whereas in animals exposed to physical exertion before training, this parameter was unchanged at this same time point. After 7 days disturbances of preservation of CPAR and CAAR were found in animals exposed to both maximal and submaximal physical exertion immediately after training. It can be concluded from a comparison of the results of the two series of experiments that physical exertion immediately after training disturbs subsequent preservation of temporary connections more severely than the same exertion before training. These differences are evidently attributable to the fact that physical exertion immediately after training occurred during the process of consolidation of the corresponding temporary connections, and prevented its full completion. As a result, disturbances of preservation of CPAR were found as early as 1 h after conditioning and they were still present 1 and 7 days later. When submaximal physical exertion was used, impairment of preservation of CPAR developed slowly and was not found until 7 days after conditioning. Disturbances of preservation of the reflexes in the case of physical exertion before training are evidently secondary in character and are due to disturbances of their formation, although in experiments under these conditions the effect of physical exertion on the consolidation process also cannot be ruled out.

When the effects described above are assessed it must be recalled that a definite place in the complex series of physiological and metabolic shifts taking place in the body as a result of physical exertion is occupied by changes in metabolism of biogenic monoamines [2, 5, 7-10]. The noradrenalin concentration in the brain as a rule falls under these circumstances [4, 9] whereas the serotonin level, on the contrary, rises [2, 5, 8]. It has been shown that under these conditions the formation and fixation of temporary connections are disturbed [4], and this probably played an essential role also in the development of the disturbances described in this paper.

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MICROIONTOPHORETIC ANALYSIS OF RETICULAR FORMATION NEURONS IN FOOD-MOTIVATED ANIMALS

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The concept of the pacemaker role of hypothalamic centers in the formation of the principal biological motivations was formulated by Anokhin [2]. Further investigation of this problem showed that food motivated excitation, arising in the hypothalamic structures, spreads to several regions of the cortex and basal ganglia [5, 6]. The presence of two-way morphological and functional connections between the mesencephalic reticular formation and the lateral region of the hypothalamus, and also the fact that a duplicate pacemaker of food motivated excitation can be produced in the reticular formation indicate that this structure is directly implicated in the functional system of the food-getting act [1, 4].

Several investigations have shown [4, 10-12] that food-motivated excitation involves neurons of cortical and deep brain structures in the performance of a behavioral act with the aid of neurotransmitters of both adrenergic and cholinergic nature. For instance, the formation of food motivation at the level of hypothalamic structures takes place on account of adrenergic mechanisms [4, 10]. However, no investigation has yet been undertaken of the neurochemical reactions of single neurons of the reticular formation in the presence of food motivation.

It was accordingly decided to study the neurochemical properties of the neurons of this structure in food-motivated rabbits.

EXPERIMENTAL METHOD

Experiments were carried out on 12 hungry rabbits (deprivation for 48 h) weighing from

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