PHYSIOLOGY

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Age-Specific Features of Rat Performance Abilities with Positive Emotional Reinforcement by Hypothalamic Self-Stimulation

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Physical performance abilities decline with age, as has been shown in studies on humans and experimental animals [7, 10]. Experimental data were obtained in motor activity model experiments on animals examined under negative emotional stress. Prolonged emotional stress is conducive to exhaustion of the reserve potential of the body, this sometimes leading to the development of diseases [2], particularly in old age [6].

The present research was aimed at experimental study of physical performance abilities of adult and old rats with positive emotional reinforcement.

MATERIAL AND METHODS

Nichrome monopolar electrodes with a tip diameter of 0.15 mm were implanted in the lateral hypothalamic area, in accordance with the stereotactic atlas, of 4 adult (aged 7 month) and 5 old (aged 31 month) male Wistar rats [9]. Fifteen days later the animals were trained to run up a declined belt of a device for studies of performance abilities [4]. Running up, the rats aimed at pressing the vertical shutter, resulting in getting a reinforcing stimulation of the lateral hypothalamus (a series of rectangular pulses 0.3 sec long, pulse frequency 40 Hz, pulse duration 1 ms, strength of current 210-270 A). On the training day and the two subsequent days the animals were allowed to perform self-stimulation on the moving belt for 5 min; after a day they were transferred to a more sophisticated experiment with an initial intensity of self-stimulation of at least 50 min^{-1}. The rats' performance ability was assessed from the mean power, that was estimated on the basis of the parameters of the animals' work (moving against the pull of gravity) in consecutive 5 min periods [4]; the volume of the work performed was taken into consideration as well. The results were assessed making use of Fisher'test one-factor analysis.

RESULTS

The initial frequencies of the approaches of adult and old animals to the shutter were 97 ± 14 and 81 ± 7 min^{-1}, respectively. As fatigue developed, the length of pauses grew, thus reducing the overall power, as seen from Fig. 1. The initial power values were significantly lower in old rats as against adult ones, this indicating a more rapid reduction of the performance abilities of old rats with self-stimulation.

The majority of the experiments were carried out before "refusal", that is before self-stimulation was stopped for more than 5 min. Two types of refusal were distinguished. One, characteristic of the adult animals, consisted in cessation of self-stimulation in the presence of an evident ability to go on moving. this could easily be seen if the self-stimulation site was stimulated via the same electrode immediately after the cessation of self-stimulation: motor activity was resumed and was even more intensive. Three adult rats out of the four stopped self-stimulation on the 46th, 79th, and 168th minutes of the experiment, having performed work of 312, 433, and 820 J, respectively.

Such a type of refusal was not observed in the old animals. Three old rats out of the five ceased moving, being evidently fatigued (lying on the belly, breathing rapidly and deeply, attempting to reach the shutter, but failing), on the 35th, 41st and 50th minutes of the experiment,the work performed by them by this time

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being, respectively, 213, 278, and 265 J. Two of these rats died within the next 24 hours.

Refusal of the same type was observed in one adult rat, which stopped self-stimulation after 29 min of the experiment, having performed 179 J of work.

The capacity of some old animals for prolonged work, as is seen in Fig. 2, was quite unexpected. Two old rats performed self-stimulation for 540 and 600 min, their work making up 1463 and 1261 J, respectively. Manifest symptoms of fatigue were seen by the end of the experiment: significant reduction of the mean power and an altered pattern of approaching the shutter (crawling or swaying). The scientist stopped the experiment, though the rats retained the ability of self-stimulation. Despite their prolonged motor activity, these animals regained their former ability of self-stimulation

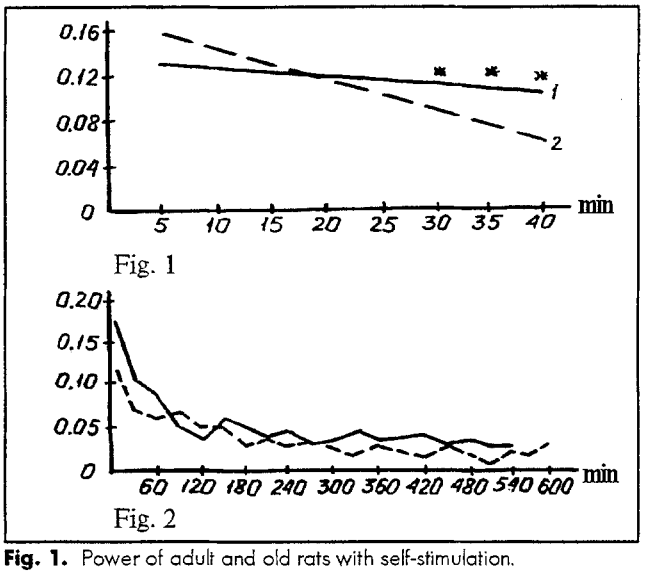

Fig. 1

Fig. 2

Fig. 1. Power of adult and old rats with self-stimulation. 1) adult rats; 2) old rats. The asterisk shows the values with $p<0.05$.
Fig. 2. Power of two old rats with self-stimulation.

and showed even a higher power in comparison with the first experiment.

These data evidence a rather high initial performance ability of old rats under conditions of positive emotional reinforcement. With fatigue the performance abilities of the old animals decreased sooner than those of the adult rats. This may be explained by a changed energy metabolism in the myocardium and skeletal muscles of old rats [1, 5], age-specific functional shifts in various components of muscle activity regulation [7], and the development with age of inadequate hemodynamic center [8]. A conflict between the low adaptation potential of the organism and a high motivational level might have caused the death of two old animals after intensive work. This fact seems to be significant, since it attests to the possibility of disorders, incompatible with life, resulting from physical activity under conditions of positive emotional reinforcement. The unfortunate end of the experiments with the old rats gives grounds for suggesting that an important mechanism preventing exhaustion becomes disrupted with age, namely the protective inhibition first proposed by I.P.Pavlov [3]. It may be assumed that this mechanism efficacy in adult animals implies that in fatigue they stop self-stimulation, despite the presence of sufficient functional resources. This inhibition process appears to be weakened in the old animals, that is why they continue self-stimulation under the effect of the emotional excitation focus, formed in the brain, until their resources are completely exhausted. Still, possibly due precisely to the degradation of the inhibition process, some old rats manage to perform more work during one experiment than adult rats.

Thus, physical performance of old rats with positive emotional reinforcement is characterized by the same initial power values as that of adult rats, but by a higher rate of power reduction in the course of fatigue. Intensive motor activity caused by positive emotional reinforcement may in some cases result in the death of old animals. Some old rats are capable of prolonged motor activity and performance of large volumes of work under conditions of positive emotional reinforcement. Our findings may be interesting in discussion of the results of studies on the high performance abilities of elderly people, whose working rhythm is voluntary, on the large volumes of work that they are able to perform when the rhythm of their activity is not high, and on the optimal approaches to mobilization of the organism's functional reserves.

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