PHYSIOLOGY

Effect of Stimulation of Subthalamic Nucleus on Grooming Movements and Their Rhythmicity in Pups and Mature Rats

L. M. Lepekhina and V. O. Voskresenskii

Translated from *Byulleten' Eksperimental'noi Biologii i Meditsiny*, Vol. 138, No. 9, pp. 244-246, September, 2004
Original article submitted July 31, 2003

The effect of rhythmic stimulation of subthalamic nucleus on grooming movements and their rhythmicity was studied on mature rats and on 13- and 14-day rat pups. Unilateral monopolar stimulation of subthalamic nucleus was performed on unrestrained animals via implanted electrodes. This stimulation activated virtually all grooming movements (scratching, hair-plucking, licking, and body-shaking); the effect was most pronounced in pups. Acceleration of the rhythm of grooming movements was observed only in rat pups for hair-plucking and scratching on the contralateral side relatively to the stimulated nucleus. In mature rats stimulation of the subthalamic nucleus prolonged grooming movements in most cases, but did not increase their number and rhythm.

Key Words: *subthalamic nucleus; electrical stimulation; grooming movements; rhythms*

Subthalamic region (STR) is a part of the striatal system [7] and hypothalamic locomotor area [1]. STR is an adaptive system, which promotes reflex activity. Stimulation of the fields of Forel in STR modulates the locomotion rhythm and determines the order of movements of the extremities [5]. Stimulation of subthalamic nucleus (STN) neurons decelerates locomotion [6].

Grooming movements such as face washing, licking, scratching, body-shaking, and hair-plucking are rhythmic. It is established that destruction of STN (especially within the period of ontogenetic development of the rhythm of grooming movements) retards the development of the rhythmic phase of these reflexes [2,4]. For evaluation of the role of STN in supraspinal control of grooming movements and their rhythms we examined the effect of STN stimulation on these reflexes.

I. M. Sechenov Institute of Evolution Physiology and Biochemistry, Russian Academy of Sciences, St. Petersburg

MATERIALS AND METHODS

Nichrome electrodes were implanted into STN of 12-day-old rat pups (n=4) and 3-month-old mature rats (n=3) under ether narcosis. Indifferent electrode was placed on the occipital bone. One day after implantation of electrodes, unrestricted animals were stimulated with unipolar rectangular voltage pulses (0.1 msec duration, 40-60 Hz repetition rate). Pulse amplitude varied from 50.0 to 500 mV depending animal age. At the end of the experiments, histological control of electrode was performed via anodal electrolytic destruction with a constant current pulse of 3 mA delivered during 2 sec (Fig. 1).

Motor activity was recorded on an ink-pen electroencephalograph. The effect of STN stimulation on the rhythm of various grooming movements was studied using high-sensitive actograph [3]. The duration of individual grooming movements and their number over 30 min were recorded.

0007-4888/04/1383-0213

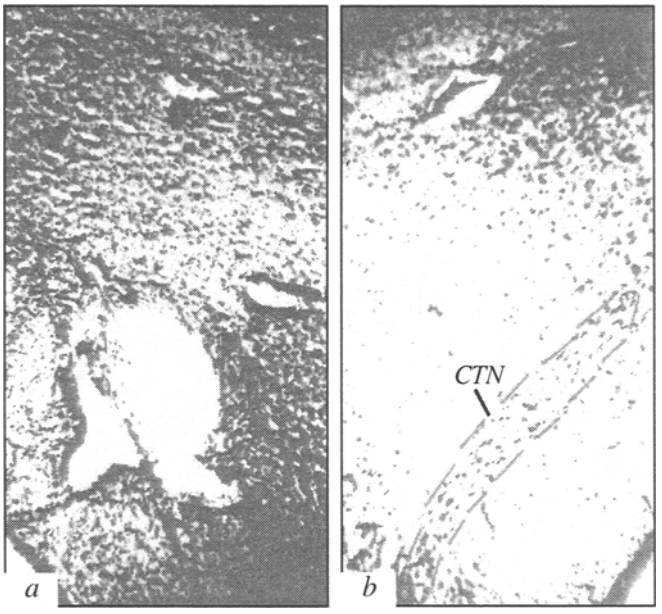

Fig. 1. Histological control of stereotactic electrode insertion into subthalamic nucleus. *a*) destructed region, *b*) intact side of the brain. Subthalamic nucleus (STN) is marked by dashed line.

RESULTS

The stimulating electrode was correctly implanted in STN (Fig. 1). Initially, stimulation of STN in rat pups induced the orientation response manifested in sniffing and alertness. Then grooming movements were activated. This activation lasted for a long time after the end of stimulation. The frequency of some grooming movements varied in 13- and 14-day-old rat pups. The frequency of hindpaw scratching movements before stimulation was 9±2 per sec; after stimulation of STN this parameter increased 2-fold (to 18±5 per sec, $p<0.001$). Acceleration of scratching movements was observed predominantly on the contralateral side (Fig. 2). Evidently, this feature results from the fact that the ascending output of STN (Meyert ligament) projects to the contralateral globus pallidus. Stimulation of STN in rat pups accelerated the rhythm of hair-plucking from 11±1 to 15±1 per sec ($p<0.02$; Fig. 3). In addition, it increased the amplitude of grooming movements, the most pronounced changes were observed for hair-plucking (152%, $p<0.001$; Figs. 2, 3). By contrast, stimulation of STN in rat pups had no effect on the frequency of face washing and licking movements, which remained within the range of 3.7-4.0 per sec. Destruction of STN in rat pups, especially during ontogenetic consolidation of the frequency parameters of grooming movements, delayed the increment in the frequency of scratching and hair-plucking movements, but did not affect the rhythm of face washing and licking movements [4]. Therefore, STN modulates the rhythm of grooming movements, which normally has enhanced frequency of 9-11 per sec corresponding to tremor frequency range. It is noteworthy that destruction of STN prevents tremor [8]. Stimulation of STN produced no effect on the rhythm of grooming movements in mature rats.

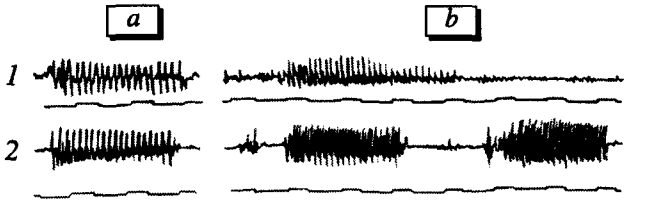

Fig. 2. Effect of stimulation of subthalamic nucleus on the frequency of scratching. *a*) before stimulation, *b*) after stimulation. *1*) scratching movements of the left leg (ipsilateral to the stimulation side); *2*) scratching movements of the right leg (contralateral to the stimulation side). Time mark corresponds to 1 sec.

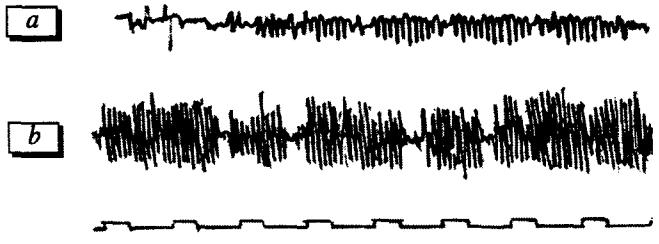

Fig. 3. Effect of subthalamic nucleus stimulation on the frequency of hair-plucking. *a*) before stimulation, *b*) after stimulation. Time mark corresponds to 1 sec.

The increase in total duration of grooming movements induced by STN stimulation was more pronounced in rat pups than in mature animals. It resulted from prolongation of individual movements and from the increase in the number of these movements. By contrast, in mature rats similar increase resulted mainly from prolongation of individual grooming movements. Stimulation of STN decelerated face washing. This effect was more pronounced in mature rats (by 91 and 49% in mature rat and rat pups, respectively). Locomotion was completely inhibited. STN stimulation produced the greatest effect on the total duration of hair-plucking, which increased 37- and 2.4-fold in the pups and mature rats, respectively. By the frequency parameter and graphic pattern, the hair-plucking movements were similar to tremor oscillations.

These findings suggest that STN stimulates almost all grooming movements, and its effect was most pronounced in young animals. Stimulation of this brain structure in mature rats had no effect on the rhythm of grooming movements.

REFERENCES

1. K. V. Baev, *Neurobiology of Locomotion* [in Russian], Moscow (1984).

2. L. M. Lepekhina, *Adaptive and Trophic Effects of Cervical Sympathetic Ganglia in Ontogeny* [in Russian], Leningrad (1984).
3. L. M. Lepekhina and V. O. Voskresenskii, *Byull. Eksp. Biol. Med.*, **112**, No. 10, 340-341 (1991).
4. L. M. Lepekhina and E. A. Tsitsurina, *Ibid.*, **128**, No. 7, 106-108 (1999).
5. G. N. Orlovskii, *Biofizika*, **14**, No. 6, 1095-1102 (1969).
6. A. L. Benabid, A. Koudsie A., and P. Pollak, *Neurol. Res.*, **22**, No. 3, 237-246 (2000).
7. P. Svenningsson and C. Le Moine, *Eur. J. Neuroscience*, **15**, No. 1, 133-142 (2002).
8. F. Velasco, M. Velasco, and S. P. *Machado, Appl. Neurophysiol.*, **38**, No. 1, 38-46 (1975).