TYPE OF BEHAVIOR AND ACTIVITY OF SUPEROXIDE DISMUTASE IN THE RAT BRAIN (COMPARISON OF TWO TRYON STRAINS)

N. M. Khonicheva, N. V. Gulyaeva,
I. V. Zhdanova, A. B. Obidin,
I. L. Dmitrieva, and N. L. Krushinskaya

UDC 612.821-08:[612.822.1.015.1]:612.605

KEY WORDS: superoxide dismutase; rat brain; type of behavior; Tryon genetic strain.

The principle of comparing genetic strains of animals in order to discover common mechanisms of regulation of functions is well known in experimental physiology. Analysis of the characteristics of antioxidant and antiradical protection of the brain in connection with the type of behavior was undertaken in this investigation by comparing maze-bright and maze-dull strains of Tryon rats [14]. These strains were initially compared only as "bright" and "dull" with respect to learning in a complex maze (food-seeking behavior). Later, however, several "secondary" differences were noted in the general organization of behavior and in metabolism [15]. For instance, very recently significant differences have been shown between these strains with respect to the change in the blood glucose level in response to injection of adrenalin, evidence that the mobilization capacity in stress is better in the "dull" than in the "bright" line [3]; this parameter, moreover, correlates highly significantly with the dominant status of the "dulls" in the group [2].

With these facts in mind it was decided to compare the responses of animals of these strains under conditions of Simonov's emotional resonance method [8]. The conditions involve the action of stimuli adequate for rats: a closed and an open space, and also signals of nociceptive stimulation of another individual. By means of this method several typical variants of behavior, reflecting fundamentally different methods of adaptation to a biologically conflicting situation, were distinguished previously in noninbred albino rats, i.e., methods of protection at the behavioral level, which correlate with some parameters of resistance to stress [1, 4, 5, 9]. However, in the chain of correlations studied the problem of relationship between type of behavior and state of antiradical protection of the brain was not considered. It has been generally accepted that one of the most important factors in antiradical protection is the enzyme superoxide dismutase (SOD), which blocks the development of free-radical processes mediated by the superoxide anion [10]. Intensification of these processes is a universal pathological reaction in stress, one of the results of which is enhanced peroxidation of membrane phospholipids (LPO) [6, 7]. However, no convincing data on the role of SOD in resistance of the organism to stress have yet been adduced.

The aim of this investigation was to study the type of behavior in rats of the Tryon strain, irritated by an individual rat, and to compare these data with SOD activity, and also with parameters of the potential intensity of LPO processes in the brain, based on the malonic dialdehyde (MDA) level.

EXPERIMENTAL METHOD

Rats of bright and dull strains (12 and 14 individuals, respectively), aged about 3 months, not previously taking part in the experiment, were used. During the experiment the animals were kept in individual cages with free access to food and water. The investigation of behavior with a pain-irritated partner by the emotional resonance method [8] included observations on the rat in a chamber with a large, brightly lit (150 lx) part and with a small dark

---

Institute of Higher Nervous Activity and Neurophysiology, Academy of Sciences of the USSR, Moscow. Institute of Experimental Medicine, Academy of Medical Sciences of the USSR, Leningrad. Institute of Developmental Biology, Academy of Sciences of the USSR, Moscow. (Presented by Academician of the Academy of Medical Sciences of the USSR, V. S. Rusinov.) Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 102, No. 12, pp. 643-645, December, 1986. Original article submitted January 3, 1986.

0007-4888/86/0012-1619$12.50

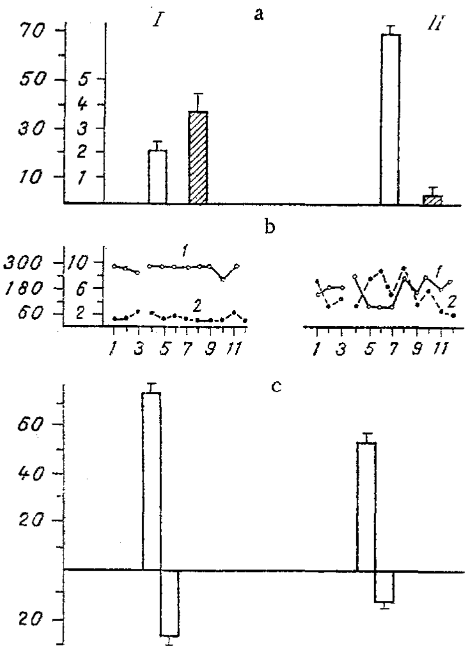

Fig. 1. Types of behavioral responses and state of antiradical protection of brain in Tryon rats: I) bright rats; II) dull rats. a) Parameters of behavior in open field: number of horizontal responses, i.e., number of squares crossed (unshaded columns) and number of defecations (shaded columns). Ordinate, number of squares crossed (left scale) and number of defecations (right scale); b) parameters of behavior in situation with pain-irritated partner, in the emotional resonance test: time spent in "house" (1) and number of visits to it (2). Abscissa, No. of experiment (first three are controls); ordinate, time (in sec, left scale) and number of visits (right scale). Typical variants shown for rats of bright and dull strains; c) SOD activity and MDA concentration in animals' brain. Ordinate: above — SOD activity (in conventional units/g wet weight of brain); below — MDA concentration (in mmoles/g wet weight of brain).

(50 lx) compartment — a "house," in which the rat was subjected (after the first three control experiments) to nociceptive stimulation of another rat. When the animal came out into the open part of the chamber, the nociceptive stimulation ceased. During 10 or 11 daily experiments the total time spent in the "house" and the number of visits in 5 min were recorded. After the end of all the experiments, a single 3-minute test was carried out in an open field (a circular ring 1 m in diameter, with walls 30 cm high), with recording of standard parameters: horizontal and vertical activity, visits to the center, number of defecations. For the biochemical investigation the rats were decapitated by means of a guillotine and the brain was cooled in ice-cold isotonic NaCl solution, homogenized in 3 volumes of this same solution, and centrifuged for 5 min at 1500g; SOD activity in the supernatant was determined by inhibition of the reaction of adrenalin auto-oxidation [11], and in a system containing phenazine methosulfate, NADH, and nitro-blue tetrazolium [12]; the MDA concentration also was determined in the reaction with thiobarbituric acid [13].

EXPERIMENTAL RESULTS

The predominant type of behavior (66% of cases) for rats of the bright strain was a strategy of avoiding nociceptive stimulation of the other individual, i.e., absence of emotional resonance according to Simonov [8]. This type of behavior assumes stable preference for the small, closed state — a marked strategy of protective, passive-defensive character. In 25% of cases the dynamics of behavior observed was very close to this, and only in one case of 12 (8%) was there a tendency to avoid the "house" during cries of the other individual (emotional resonance). The most common feature of behavior of the bright rats in this situation was a low frequency of movements into the other compartment (Fig. 1b, I). Thus more than 90% of these animals are characterized by a similar type of behavioral responses: marked preference for the closed space.

By contrast to this, in the group of dull rats this kind of strategy was found extremely rarely (8%). The most frequency variant (63%) corresponded to the type of behavior with "a high degree of strain of emotional conflict" [8], in which the greater frequency of visits to the "house" and back creates the impression of unease and absence of purposive behavior (Fig. 1b, II). In 29% of cases a distinct time course of avoidance was observed, when the number of visits was reduced from 5.7 ± 1.3 in 4-6 experiments to 1.0 ± 0.2 in 9-11 experiments.

The differences between animals of the two strains thus consisted of predominance of a certain type of behavior. The averaged characteristics of the dominant variant for each group were (for the last three experiments): time in the "house" 270 ± 6 sec, number of visits 1.3 ± 0.1 for rats of the bright strain, and 190 ± 13 sec and 4 ± 0.7 visits for the dull rats ($P < 0.001$).

These differences in the situation with a pain-irritated partner corresponded to totally different behavior in the open field test (Fig. 1a). All parameters of motor activity were significantly lower ($P < 0.001$) but the defecation level was higher ($P < 0.001$) in rats of the bright strain compared with the dull rats. The open field test is the classical test for discovering relations between the motivations of "fear" and "curiosity." The behavior of the bright rats was thus determined by a marked motivation of "fear," that of the dull rats by an "investigative" response.

The differences thus discovered were undoubtedly linked with a different method of adaptation to a stress situation, with (bright) or without (dull) a passive-defensive reaction. Comparison with the biochemical data shows that in the first case SOD activity in the brain tissues was significantly higher (by 1.4 times, $P < 0.001$). Values of these parameters for dull rats were within the normal limits characteristic of noninbred albino rats. However, the LPO level, determined as the MDA concentration, was not lower in the bright rats, as might be supposed [10], but was twice as high ($P < 0.001$) as that in rats of the dull strain.

The increase in the potential ability of brain lipids of the bright animals to undergo peroxidation, evidence of the lower stability of the phospholipids, may be associated with a higher proportion of readily oxidized lipids or with a decrease in the content of endogenous antioxidants. Since the main mechanism of the harmful action of stress at the membrane level is activation of LPO [6], the suggestion arises that at this level rats of the bright strain have lower resistance to stress. In this connection activation of SOD in the brain of these animals can be regarded as a compensatory process, directed toward strengthening antiradical protection. However, this process is insufficient to ensure the normal level of antiradical oxidation.

During the discussion of the results the question arises of relations between protective mechanisms at different levels of organization. Predominance of inborn passive-defensive responses with a distinctly protective character, in the behavior of the bright rats is coupled with activation of antiradical protection of the brain. The properties listed above are combined with lower mobilization capacity in stress as shown by parameters of carbohydrate metabolism during adrenalin loading [3]. The absence of passive-defensive behavior in rats of the dull strain correlates with the less strained state of biochemical protection under "normal" conditions, and this corresponds with the more favorable levels of these parameters in stress [3]. It is an interesting fact that these properties, characteristic of the dull strain, are combined with high aggressiveness during establishment of hierarchic relations in the group [2], and at the same time, with lower effectiveness of learning during individual maze testing [14, 15].

LITRATURE CITED

1. M. G. Airapetyants and A. M. Vein, Neuroses in Experimental and Clinical Medicine [in Russian], Moscow (1982).
2. I. L. Dmitrieva, N. L. Krushinskaya, and E. I. Semiokhina, Rodents [in Russian], Leningrad (1984), p. 257.
3. N. N. Zolotareva, I. L. Dmitrieva, and N. L. Krushinskaya, Proceedings of the 4th All-Union Congress of the Theriologic Society [in Russian], Moscow (1985).
4. A. V. Zukhar', "Types of higher nervous activity, resistance to stress, and reproductive function," Author's Abstract of Candidate's Dissertation for the Degree of Biological Sciences, Moscow (1985).
5. I. V. Zhdanova, Zh. Vyssh. Nerv. Deyat., No. 1, 770 (1985).

6. F. Z. Meerson, Adaptation, Stress and Prophylaxis [in Russian], Moscow (1981).
7. M. M. Melkonyan, A. G. Arakelyan, and V. G. Mkhitaryan, Biol. Zh. Armenii, No. 10, 818 (1983).
8. P. V. Simonov, A Neurophysiological Approach to the Analysis of Intraspecific Behavior [in Russian], Moscow (1976), p. 6.
9. N. M. Khonicheva, I. L. Dmitrieva, N. L. Krushinskaya, and T. A. Voronina, Zh. Vyssh. Nerv. Deyat., No. 3, 537 (1984).
10. J. Fridovich, in: Oxygen Living Processes. An Interdisciplinary Approach, ed. by D. L. Gilbert, Springer (1981), pp. 250-275.
11. H. P. Misra and J. Fridovich, J. Biochem., 247, 3170 (1972).
12. N. Nishikimi and N. A. Rao, Biochem. Biophys. Res. Commun., 46, 849 (1972).
13. H. Ohkava, N. Ohishi, and J. Kunio, Anal. Biochem., 95, 351 (1979).
14. R. C. Tryon, J. Comp. Psychol., 32, 407 (1941).
15. D. Wahlstein, Crit. Rev. Biol., 7, 143 (1972).

EFFECT OF ABLATION OF THE SOMATOSENSORY CORTEX ON PAIN SENSITIVITY IN CATS

V. K. Reshetnyak and M. L. Kukushkin

UDC 616.831.2-089.87-07:616.8-009.7-092.9

KEY WORDS: first and second somatosensory cortical areas; nociception.

An important role in the formation of the complex of pain-related sensations is ascribed to the cerebral cortex and, in particular, to its orbitofrontal and somatosensory divisions [1, 4, 6]. The most convincing data on the role of the orbitofrontal cortex in the formation of the emotional-affective component of pain consists of clinical observations which show that patients undergoing frontal lobotomy, with division of connections between the frontal cortex and thalamus, no longer complain of severe, distressing pain, no longer ask for pain-relieving drugs, and do not exhibit unease, although they continue to feel pain [1, 11]. The role of the somatosensory cortex in the formation of the sensory-discriminative component of pain has been demonstrated by numerous clinical and experimental studies [1, 4, 6, 12]. The existence of a double organization of the somatosensory projection zone raises the question of the importance of the first (SI) and second (SII) somatosensory areas in the mechanisms of integrative evaluation of pain sensitivity.

The aim of this investigation was to study changes in pain sensitivity of animals after ablation of area SI and area SII in unrestrained animals.

EXPERIMENTAL METHOD

Experiments were carried out on 15 adult cats unrestrained in the experimental chamber. Nociceptive electrical stimulation was applied through bipolar electrodes inserted into the dorsal part of the forearm of both forelimbs by bursts of pulses (frequency of pulses in the burst 5/sec, duration of pulse 1 msec, of burst 1 sec). The intensity of stimulation was gradually increased from 100 mV to 30 V. The results were expressed on a conventional scale, as used with rats and rabbits [1, 2], and adopted by the writers for recording the nociceptive response in freely behaving cats (Table 1). The significance of the results was estimated by Student's test. Unilateral ablation of the cortical areas was done by electrical coagulation under hexobarbital anesthesia (30 mg/kg, intraperitoneally). To remove area SI the posterior sigmoid and coronal gyri were coagulated (6 animals), and to remove area SII, the anterior ectosylvian gyrus was destroyed [6]. Part of the lateal and suprasylvian gyri of the parietal association cortex were destroyed in animals of the control group. Before extirpation of the cortical areas all cats were tested to determine their nociceptive response profile, and tests after cortical ablation began on the 8th day. At the end of the investigation the dimensions of the coagulated cortical areas were studied.

Central Research Institute of Reflex Therapy, Ministry of Health of the USSR, Moscow.
(Presented by Academician of the Academy of Medical Sciences of the USSR A. V. Val'dman.) Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 102, No. 12, pp. 645-647, December, 1986. Original article submitted November 10, 1985.

 0007-4888/86/0012-1622$12.50