# CHANGES IN THE BRAIN SEROTONIN AND NORADRENALIN LEVEL IN ALBINO RATS DURING TRAINING WITH EMOTIONALLY DIFFERENT REINFORCEMENT

N. L. Vekshina and T. P. Semenova

UDC 612.822.1:577.175]-06:612.821.1/.3

Changes in the brain serotonin (5-HT) and noradrenalin (NA) concentration in the brain of rats during training with emotionally positive (food) and negative (pain) reinforcement were compared. Training of the animals in both cases was accompanied by elevation of the biogenic amine level, but during emotionally positive reinforcement the increase was greater than with emotionally negative reinforcement. Training the animals with food reinforcement was accompanied by an increase in 5-HT predominantly in the cerebral cortex, evidently reflecting the active functioning of the serotoninergic system. After training in a defensive situation, increased activity of the noradrenergic system was observed. The character of the change in the brain biogenic amine level during training thus depends on the emotional quality of the reinforcement used.

KEY WORDS: *Memory; emotions; biogenic amines.*

Much information has now been obtained on the role of the biogenic amines of the brain in learning and memory processes [2, 3, 6, 7]. However, data on the mechanism of this participation are highly contradictory, for in most investigations no account was taken of the emotional background against which the training took place, and biogenic amines have a direct relation to the formation of emotional responses [1, 5]. It has also been shown that the level of emotional tension determines the character of mnemic activity [4].

The object of this investigation was to compare changes in the serotonin (5-HT) and noradrenalin (NA) concentrations in the brain of rats during training with emotionally positive (food) and negative (pain) reinforcement.

## EXPERIMENTAL METHOD

Experiments were carried out on 68 male Wistar rats weighing 180-200 g. The formation of a conditioned reflex of running alternately to the right and left from the starting compartment to the place where food was obtained [8] was used as the model of training with emotionally positive reinforcement. As the model of training with emotionally negative reinforcement a conditioned reflex of active avoidance (CAAR) of painful punishment was formed. The conditioned stimulus in the latter case was switching on a light for 5 sec, whereas the unconditioned stimulus was nociceptive stimulation by an electric current (50 Hz, 35-40 V) passed through the mesh floor of the cage. At the end of the experiment the animals were decapitated, the brain was quickly extracted, the cortex, diencephalic region, and caudal portion of the brain stem were removed, and the material was frozen in liquid nitrogen. The 5-HT and NA concentrations were determined [9] on a Hitachi spectrofluorometer. Untrained animals served as the control.

Laboratory of Pathophysiology of Neurohumoral Regulation, Institute of General Pathology and Pathophysiology, Academy of Medical Sciences of the USSR, Moscow. Laboratory of Emotional Memory, Department for Problems of Memory, Institute of Biological Physics, Academy of Sciences of the USSR, Pushchino-on-Oka. (Presented by Academician of the Academy of Medical Sciences of the USSR A. M. Chernukh.) Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 82, No. 11, pp. 1285-1286, November, 1976. Original article submitted April 16, 1976.

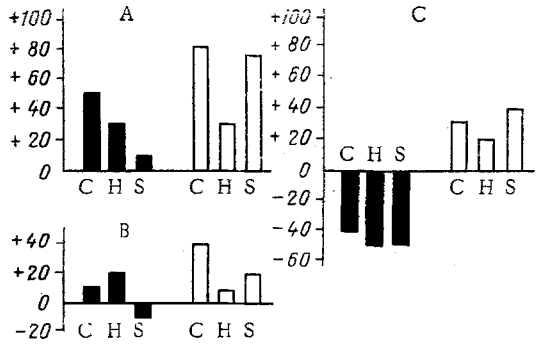


Fig. 1. Changes (in %) in 5-HT (black columns) and NA (white columns) levels in cortex (C), hypothalamus (H), and caudal part of brain stem (S) during training of rats with emotionally positive (A) and emotionally negative (B) reinforcement and during stress (C), compared with control (zero line).

## EXPERIMENTAL RESULTS AND DISCUSSION

Learning was accompanied by marked changes in the monoamine concentrations in the animals' brain. However, these changes differed in character depending on the reinforcement used.

During development of the reflex to emotionally positive (food) reinforcement an increase in the 5-HT and NA concentration was observed in all brain structures tested (Fig. 1A), especially in the cortex (by 50 and 80%, respectively). During training of animals with emotionally negative (pain) reinforcement, although the monoamine concentrations increased, it did so by a much lesser degree than in the previous case (Fig. 1B). Differences in the distribution of the monoamine will be noted: Whereas the 5-HT level during emotionally positive reinforcement increased most in the cortex, during training with emotionally negative reinforcements the maximal increase in 5-HT occurred in the diencephalon. In structures of the brain stem the 5-HT concentration actually fell somewhat compared with the control. The NA level in both experimental situations rose by the greatest degree in the cortex and the caudal part of the brain stem.

It can be postulated on the basis of data in the literature [5] that during the formation of a CAAR in rats the state of stress due to painful electrical stimulation may have a definite effect on the concentration of biogenic amines in the brain, in addition to the effect of training itself. It was therefore decided to study changes in the brain biogenic amine level in animals stimulated by an electric current with the same parameters as those used in the training experiments. Stimulation was applied 10 times at intervals of 30 sec. The brain monoamine concentration changed considerably under these circumstances (Fig. 1C) but, unlike in the training experiments the 5-HT level fell considerably whereas the NA level rose in all structures tested. The qualitative differences between the changes in concentration of the biogenic amines during stress and training suggest that elevation of the 5-HT and NA levels in the training experiment with painful reinforcement was due to the training process itself and not to the state of stress.

Training the animals with food reinforcement was accompanied by an increase in the 5-HT concentration mainly in the cerebral cortex, possibly reflecting active functioning of the serotoninergic system. This is in agreement with the results of the writers' earlier investigations in which preliminary injection of the serotonin precursor 5-hydroxytryptophan into animals improved the training process with food reinforcement, whereas injection of parachlorphenylalanine, which blocks 5-HT synthesis, prevented such training [7]. During training in a defensive situation the intensity of functioning of the noradrenergic system is increased as a result of stress [8]. Injection of the NA precursor D,L-dopa into animals facilitated the training process in that situation.

LITERATURE CITED

1. I. P. Anokhina and G. D. Zabrodin, in: Stress and Its Pathogenetic Mechanisms [in Russian], Kishinev (1973), pp. 11-13.
2. E. A. Gromova, in: Memory and Trace Processes (Abstracts of Proceedings of the Second Conference on Problems in Memory and Trace Processes) [in Russian], Pushchino-on-Oka (1970), p. 46.
3. E. A. Gromova, in: Memory and Trace Processes (Abstracts of Proceedings of the Third Conference on Problems in Memory and Trace Processes) [in Russian], Pushchino-on-Oka (1974), p. 111.
4. E. A. Gromova, N. A. Zemtsova, M. B. Zykov, et al., in: Stress and Its Pathogenetic Mechanisms [in Russian], Kishinev (1973), p. 62.
5. É. Sh. Matlina, A. M. Baru, and V. N. Vasil'ev, in: Progress in Science and Technology. Series: "Physiology of Man and Animals," Vol. 15, Physiology of Emotions [in Russian], Moscow (1975), p. 30.
6. N. B. Essman, in: Biology of Memory (Symposium), Budapest (1971), pp. 213-238.
7. E. A. Gromova, in: Second International Congress of CIANS, Abstract, Prague (1975), p. 135.
8. T. P. Semyonova (T. P. Semenova), in: Second International Congress of CIANS, Abstract, Prague (1975), p. 72.
9. B. Welch and A. Welch, Anal. Biochem., 30, 161 (1969).

# EFFECT OF COPPER, MANGANESE, AND COBALT IONS ON CHEMICAL SENSITIVITY OF INTEROCEPTORS

N. B. Pilipyuk

UDC 612.815.1-06:612.015.31:577.17.049

The effect of copper, manganese, and cobalt on the chemical sensitivity of interoceptors was studied in acute experiments on 82 cats. Injection of cuprous chloride was found to cause reversal of blood pressure and respiratory reflexes to acetylcholine, cobaltous chloride weakened these reflexes, whereas manganous chloride potentiated them. The changes observed in the interoceptive reflexes are considered to depend mainly on the direct action of the trace elements on interoceptor function.

KEY WORDS: *Trace elements; acetylcholine; blood pressure; reflex reactions.*

The role of trace elements in the physiological activity of man and animals is now firmly established [1-3]. However, the role of trace elements as biotic factors in control processes, including in the activity of the nervous system, is still inadequately understood. In particular, their effect on the functional properties of interoceptors, which play in important role in the self-regulation mechanisms of the organism, has hardly been studied.

In this investigation the action of vitally important elements (copper, manganese, and cobalt) was studied on functional properties of the chemoreceptors of the alimentary tract.

## EXPERIMENTAL METHOD

Experiments were carried out on 82 adult male cats superficially anesthetized with urethane (1 g/kg intraperitoneally).

Department of Physiology, Ivano-Frankovsk Medical Institute. (Presented by Academician V. N. Chernigovskii.) Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 82, No. 11, pp. 1287-1288, November, 1976. Original article submitted January 9, 1976.