

Ecology

The Effect of Cell Phone Frequency (900/1800 MHz) Electromagnetic Field on Passive-Avoidance Response and Distribution of Amino Acids in the Cerebral Cortex of Hemispheres in Rats

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ABSTRACT. The exposure to cell phone frequency electromagnetic fields provokes significant changes in the concentration and distribution of amino acids in the cerebral cortex of hemispheres that find their reflection on the psychoneurotic memory of animals. Namely, the exposed rats show impaired memory, complicated performance of a behavioral act and depressive effect on the development of passive-avoidance response. © 2007 Bull. Georg. Natl. Acad. Sci.

Key words: electromagnetic field, cell phone, rats, memory, passive-avoidance response, amino acids

In the second half of the 20th century, especially during the last two decades, the interest of science in ecological factors influencing animate nature, such as electromagnetic field radiation, greatly increased [1-4]. There are numerous scientific studies by now that confirm the possibility of causing in living beings by the effect of anthropogenic electromagnetic fields (EMFs) such disorders as tumors, behavioral changes, memory impairments, deterioration of fertility, abnormalities in the development of fetus and newborns, Alzheimer's and Parkinson's diseases, etc. [5-7].

Currently existing data indicate that major groups of the population frequently using mobile communication are prone to marked effects of cell phone frequency electromagnetic field (CPF EMF), beginning with reversible functional changes and ending with the so-called "acoustic neuroma" [8].

Despite existing incompatible data, it may be presumed as a well-established fact that EMF effects are mostly observable in the hippocampal complex, manifesting themselves in a stationary irritation of limbic structures. There are findings that confirm a harmful effect of

cellular phone radiation on mental activity, auditory perceptual ability, short-term and long-term memory. Our studies have shown that CPF EMF significantly changes the emotional-motivational behavior of rats in the "open field" [9].

Data available today in the literature indicate the necessity of looking for ways and means to prevent the deteriorating effect of cell phone EM fields and to continue research of the mechanisms of such an effect at all levels of the biological systems' organization [10]. From this point of view, identification of the physiological and neurochemical correlates of the effect on memory acquires special topicality. Given this, we have decided to investigate memory changes of psychoneural nature and the quantitative distribution of amino acids in the cerebral cortex of hemispheres in Wistar rats by subjecting them to a daily 6-hour exposure of CPF EMF during 2 weeks.

Proceeding from all the above, elucidation of these problems will deepen a modern understanding of the regularities of behavior of rats subjected to regular exposure of emissions from cell phones and of the distribution of free amino acids in the cerebral cortex of hemispheres.

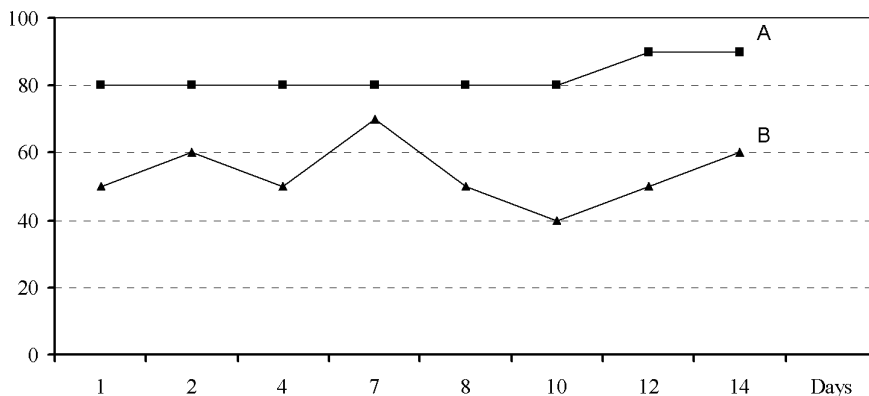


Fig. 1. Effect of CPF EMF on the maintenance of the fear response; the abscissa indicates the number of days; the ordinate axis shows percentage of the fear response maintenance; control rats – A, experimental rats – B

The test subjects were Wistar rats being supplied with feed and water under standard conditions. The tests were carried out in the second half of the day. The rats were divided into two groups: control group A and experimental group B. The rats were confined in Plexiglas boxes and cell phones (of GSM 900/1800 type) were placed at a 10 cm distance from the boxes. In real tests (group B), by means of a computer program (Dialing), which has been developed at our Center, a stereotype exposure was carried out: duration of ringing – 1 min; break – 10 min; exposure duration – 6 hours daily for 2 weeks.

Formation of passive-avoidance response was investigated in Esmann chamber (shuttle box) [11] that consisted of two boxes: dark and light. As a rule, the rat placed in the light box goes immediately, in a minute at

least, into the dark box where it receives a single electric shock. The control group rats learn the experience and for over 3 weeks avoid entering the dark box.

The log-linear analysis technique was employed for statistical processing of the obtained data. The effect of CPF EMF was assessed during 14 days after completion of the two-week exposure by comparing the total obtained data subsets. Statistical difference between the control and experimental animals was calculated by Pearson's χ^2 -criterion. Statistical processing was conducted by a standard program STATISTICA-6, module Log-Linear Analysis. The quantitative distribution of free amino acids in the cerebral cortex of hemispheres was determined using a Czech-made amino acid autoanalyzer (AAA-333) [8].

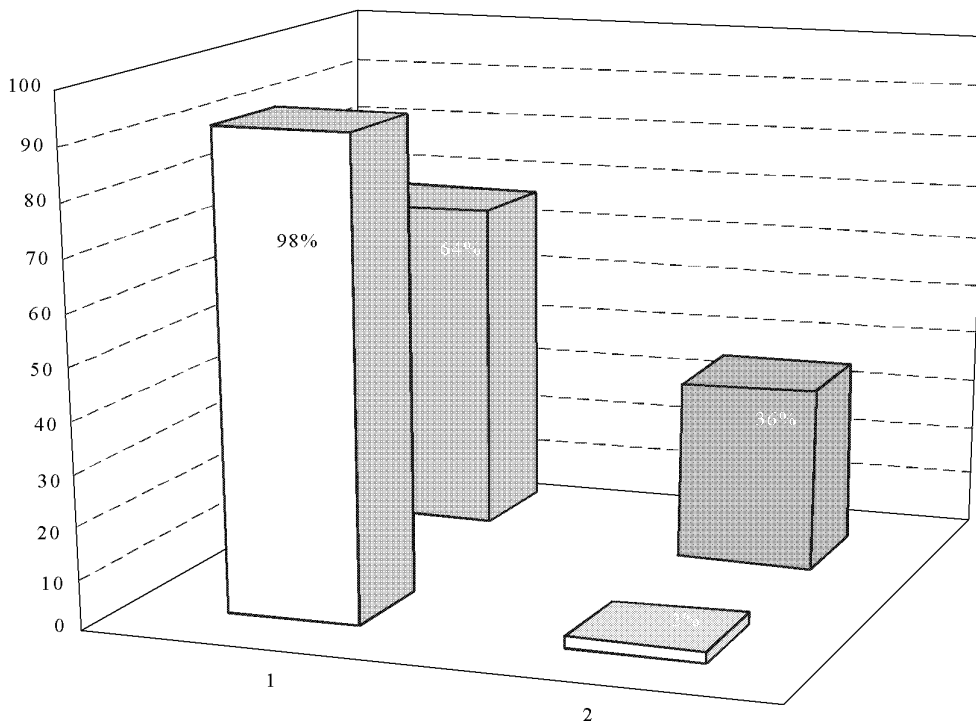


Fig. 2. Effect of CPF EMF on the maintenance of the fear response: Line 1 – control; line 2 – effect of CPG EMF

As a stability criterion of conditioned avoidance response we took 95-100% adequate reactions during the last three days. As regards the experimental animals exposed to cell phone frequency EM fields, the observation made in 20 minutes after formation of the fear response showed that the subjects that had preserved the fear response made only 64%. It should be mentioned that the experimental animals were distinguished for a particular behavior: always used to gather in one place of the light box, eat little and were slow-moving. Further observation from the first to the 14th day inclusive showed that the rats that were entering the dark box did it quickly, whereas the rats that avoided entering used to sit without movement and reveal only orientation responses.

The effect of the cell phone frequency EMF on the maintenance of the fear response is given in Figure 1. It should be noted that every next day the dark box used to be entered not by the same rat but by different rats. Thus, almost every rat had once found itself in the dark box at different time. It should be mentioned that the animals that not enter the dark box or had already formed a fear of the dark box, still started entering on the 7th day

and on the subsequent days of the observation; and, vice versa, the animals that had been subjected to electrical shock in the dark box but had not formed the fear response, no longer entered the dark box on the fifth and sixth day of the observation and on the subsequent days of the tests. Therefore, the results of each observation are expressed as a mean.

As can be seen from Figure 1, already on the 20th minute of testing distortions in the fear response maintenance were revealed: the maintenance of the fear response in the experimental animals was 35% less against the control. Such a tendency holds true for the whole observation period.

Such different behavior of the animals may be explained by the circumstance that the neurotropic effect of CPF EMF is associated with the impairment of decision-making and activity. Presumably, the exposure to CPF EMF leads to the deterioration of the functional systems that have retained the unpleasant memory of the single subjection to the painful electric shock. This difference is clearly seen in Figure 2 and is statistically reliable according to Pearson's χ^2 - criterion ($p < 0.001$).

Table 1.

Changes in the content of free amino acids upon effect of cell phone frequency EMF
(amino acids mic/mol/g, out of 9 tests, M±m)

Amino Acids		A - Control	B - experimental Cell phone effect	Statistical reliability of differences $p \geq 1-2$
		1	2	
Cystic acid	M±m	0.0328±0.0015	0.0325±0.0006	p>0.5
Taurine	M±m	0.5052±0.246	4.7260±0.262	p<0.01
Urea	M±m	0.882±0.036	0.445±0.054	p<0.001
Aspartic acid	M±m	3.21±0.079	1.559±0.018	p<0.001
Serine	M±m	0.811±0.0309	0.726±0.021	p>0.5
Glutamic acid	M±m	10.022±0.126	14.688±0.267	p<0.001
Glutamine	M±m	4.6625±0.122	6.258±0.386	p<0.001
Glycine	M±m	0.711±0.025	0.5457±0.009	p<0.001
Alanine	M±m	0.711±0.025	0.678±0.017	p<0.01
Tyrosine	M±m	0.135±0.002	0.05±0.007	p<0.001
Phenylalanine	M±m	0.0605±0.002	0.065±0.013	p>0.5
GABA	M±m	1.796±0.028	1.475±0.023	p<0.001
Histidine	M±m	0.0564±0.001	0.0272±0.0002	p<0.001
Ammonia	M±m	1.17±0.009	1.216±0.008	p<0.01

Thus, the effect of CPF EMF provokes with statistical significance the formation and maintenance of the passive-avoidance response in rats.

Biochemical studies have shown that in contrast to the control A-group rats, the content of amino acids in the B-group rats markedly changes after their exposure to EMF radiation. As Table 1 indicates, there is statistically significant increase in the content of taurine, glutamic acid, glutamine and asparagines in the cerebral hemispheric cortex of the B-group animals exposed to EMF radiation; as concerns the concentrations of aspartic acid, serine, glycine, alanine, urea, tyrosine, gamma-amino-butyric acid, phenylalanine, and histidine are also statistically significantly decreased. As has been mentioned, the emotional state and behavior of the rats are significantly conditioned by the concentration and ratio of free amino acids that participate in the processes of excitation and continence [12]. In this respect, the aspartic acid+glutamic acid ratio to taurine+glycine has shown that in the B-group rats excitation processes prevail. Here the ratio almost four times exceeds the similar indicator of the control (A) group.

Especially notable are the changes in the content of ammonia and urea. As seen from Table 1, the content of ammonia in the B-group rats decreases. This fact is of special significance, for the effect of various factors (radiation, poisons, noise, etc.) is known to be always as-

sociated with an increase in ammonia [8]. It should be mentioned that such changes of ammonia in the cortex resulting from the effect of CPF EMF radiation are described in many literary sources [13]. In particular, they indicate that cell phone frequency electromagnetic field radiation causes reduction in the content of ammonia in the cortex, being associated with an increase in the level of glutamine. In fact, a dramatic increase in the level of ammonia is observable in the B-group rats with the concurrent sharp decrease in the level of ammonia. Presumably, the compensative mechanisms of the organism manage to reduce the level of ammonia by transamination by means of forming glutamine and urea therefrom.

Thus, our experiments have confirmed significant reductions of the content of amino acids in the cerebral cortex of hemispheres as a result of the CPF EMF radiation, which affects the psychoneural memory of animals. In particular, the B-group rats demonstrated excitation processes developed as a result of exposure to radiation from cell phones and leading to the depressant effect on not only the working out of passive-avoidance response but also on general behavior in the rats. The emotional stress, anxiety confusion, and the inability to make a right decision to solve the given task are evidently manifested in the animals as a result of the effect of the cell phone frequency electromagnetic field.

ეკოლოგია

საკომუნიკაციო სიხშირის (900/1800 MHz) ელექტრომაგნიტური ველის გავლენა ვირთაგვების პასიური განრიდების რეაქციაზე და თავის ტვინის ჰემისფეროების ქერქში ამინომჟავების განაწილებაზე

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სს ემე-ის მოქმედების შედეგად თავის ტვინის ჰემისფეროების ქერქში ვლინდება ამინომჟავების შემცველობის მკვეთრი ცვლილებები, რაც თავის ასახვას პპოებს ცხოველთა ფსიქონერეული ხასიათის მქსიერებაზე. კერძოდ, დაქვეითებულია მქსიერება, გაძნელებულია ქცევითი აქტის განხორციელება და შეიმჩნევა დამორგუნეული გავლენა პასიური განრიდების რეაქციის გამომუშავებაზე.

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Received September, 2007