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The behavior and memory of rats irradiated with an electromagnetic field in the prenatal period

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Abstract

The aim of the research was to study the effect of 1800 MHz electromagnetic field on the behavior and memory of rats after prenatal irradiation. The research object was 20 white rats. The electromagnetic field, generated by the GSM system. Rat offspring irradiation was occurred every 10 minutes for 10 seconds, 5 days a week for 6 hours, the rats of the control group were in the same conditions, but without exposure to EMF. Three-week-old rats, the emotional-motivational behavior was studied with the "open field" and Elevated cross Maze, memory study with the Passive Avoidance Test. The study showed that the emotional and motivational behavior, memory of the animals in the experimental group fundamentally changed compared to the control group.

The results of the research show that during the prenatal development of a living organism, exposure to an electromagnetic field with a frequency of 1800 MHz has a negative effect, which is manifested in behavioral changes, anxiety, and memory deterioration. Therefore, it is important to regulate the impact of GSM system generators on the population.

Keyword: EMF; Behavior; Memory; Offspring rats

1. Introduction

The exploration of electromagnetic field effects is a significant concern for scientists due to its potential to induce notable alterations and adverse impacts on biological systems. Presently, the majority of individuals are exposed to a pervasive array of electromagnetic waves, originating from both natural phenomena and human-made sources. These electromagnetic fields play a crucial role in everyday life, emanating from various sources such as mobile phones, signal transmission towers, broadcasting facilities, radars, medical equipment, microwave ovens, radio frequency heaters, and a myriad of other devices [1,2]. Of particular concern is the increasing use of mobile phones, which adversely affects living organisms, with children and pregnant women being especially vulnerable to this radiation [3,4,5].

Given the significance of this issue, our study aims to investigate the impact of prenatal exposure to electromagnetic fields on the behavior and memory of rats.

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2. Material and method

2.1. Experiment Design

A total of 20 pregnant rats were assigned to two groups, with 10 rats in each group: control and experimental. These rats were housed in specialized cages. Throughout the pregnancy, the experimental group was exposed to a mains frequency electromagnetic field (EMF) at 1800 MHz, while the control group experienced the same conditions without EMF exposure. Three weeks post-delivery, the offspring were divided into two groups, with 9 rats in each: irradiated (experimental) and control groups. [5,6].

2.2. Electromagnetic Radiation Field

Following a 3-day adaptation period for the rats to their environment, test groups were placed in plastic cages measuring 80/80/30. The electromagnetic field, generated by the GSM system, was positioned 5 mm above the cage's center. The electromagnetic field frequency was measured using a specialized tool, the "Cornet microsystem, electrosmog meter," and was set at 1800 Hz during irradiation. This exposure occurred every 10 minutes, lasting 10 seconds each time, with regulation through software. The experimental group remained under EMF exposure for the entire duration of pregnancy, totalling 6 hours per session, 5 days a week. [6]. The control group experienced identical conditions but without exposure to EMF.

2.3. Behavioral Tests

The locomotor and emotional-motivational behaviors of offspring from both groups were assessed in the "Open Field". We observed their movement patterns, exploration behavior, and stereotypical activities. Parameters such as the number of lines crossed, vertical rises, grooming, time taken to enter the center, and instances of boluses and urination were evaluated.

2.4. Anxiety

Anxiety levels were evaluated using the ” Elevated cross Maze”, a widely recognized tool in rodent behavioral research. This test, conducted in a cross-shaped apparatus with two open and two closed arms elevated 40-70 cm above the floor, is effective in identifying brain structures involved in anxiety. Rats were placed at the intersection of the four arms, facing an open side, and their behavior was observed for 5 minutes. [7].

Memory Test**.** Short-term memory, based on a negative stimulus, was assessed using the “Passive Avoidance Test”**.** This test evaluates the animal's ability to perceive and remember the spatial environment. The passive avoidance chamber consists of two compartments: one illuminated and the other dark, separated by a partition with a special door. The dark compartment features an electrified floor, delivering a mild shock to the animal's limbs. Initially, the rat was placed in the illuminated chamber; upon entering the dark compartment, the door between the two parts was closed, and the latency period before entry into the dark area was recorded. Subsequently, the rats were returned to their home cage. After a 30-minute interval, a repeat test was conducted, and if the rat refrained from entering the dark chamber, it was considered to have remembered the irritative stimulus. [8].

2.5. Data analysis

For statistical analysis we used single Analysis of variable data (one-analysis ANOVA).

3. Results

In the open field, rats in the control group exhibited reduced mobility, remaining predominantly within one area. They engaged in prolonged grooming sessions and occasional stand-ups but did not lean against the wall. Conversely, rats in the experimental group displayed hyperactive behavior, moving along a consistent trajectory, often staying within the same square or remaining stationary for extended periods. We conducted a detailed analysis of open field parameters indicative of changes in motivational-emotional behavior, including the frequency of center entry, grooming episodes, defecation instances, and urination frequency. The control group rats demonstrated a higher frequency and duration of grooming $(4.25\pm1.1, 1.3\pm0.01)$, while those in the experimental group were distinguished by increased urination and defecation rates (1.6 ± 0.01, 5 ± 1.3). These findings suggest that exposure to the electromagnetic field induces behavioral alterations. (Figure 1)

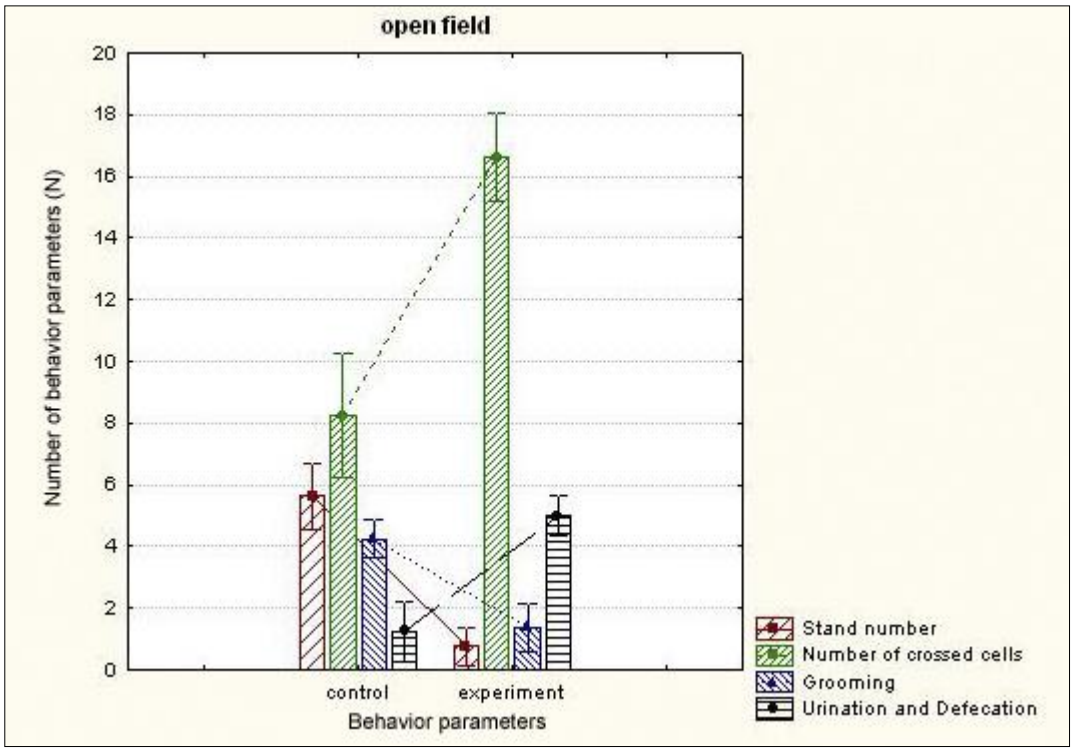
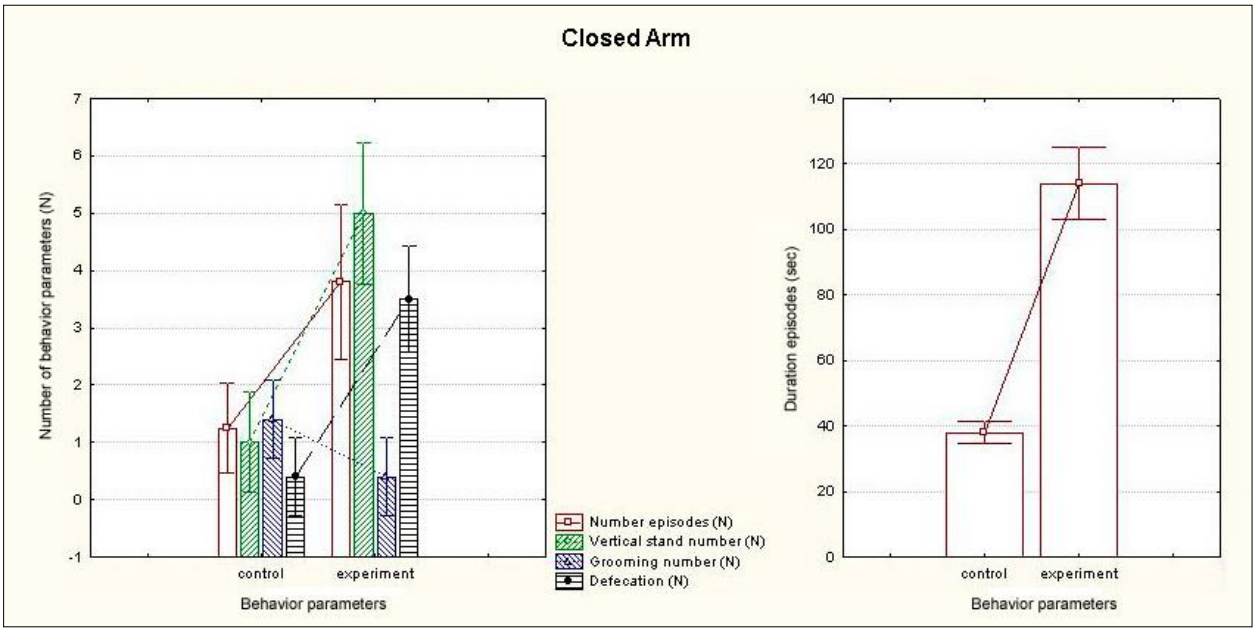


Figure 1 "Open Field" study of emotional-motivational behavior in control and experimental groups. ($p<0.005$)

3.1. Animal anxiety and emotionality

Were evaluated in a Elevated cross Maze, with behavior assessed based on the number of entries into open and closed arms, latency periods, vertical rises, grooming instances, and boluses. Experimental rats exhibited signs of anxiety, fear, and catatonia, spending a greater amount of time in the closed arm compared to control rats, which preferred the open arm ($n=9$, $p<0.005$). Additionally, experimental rats demonstrated increased instances of boluses and urination compared to the control group, reflecting heightened emotionality. (Figure 2)



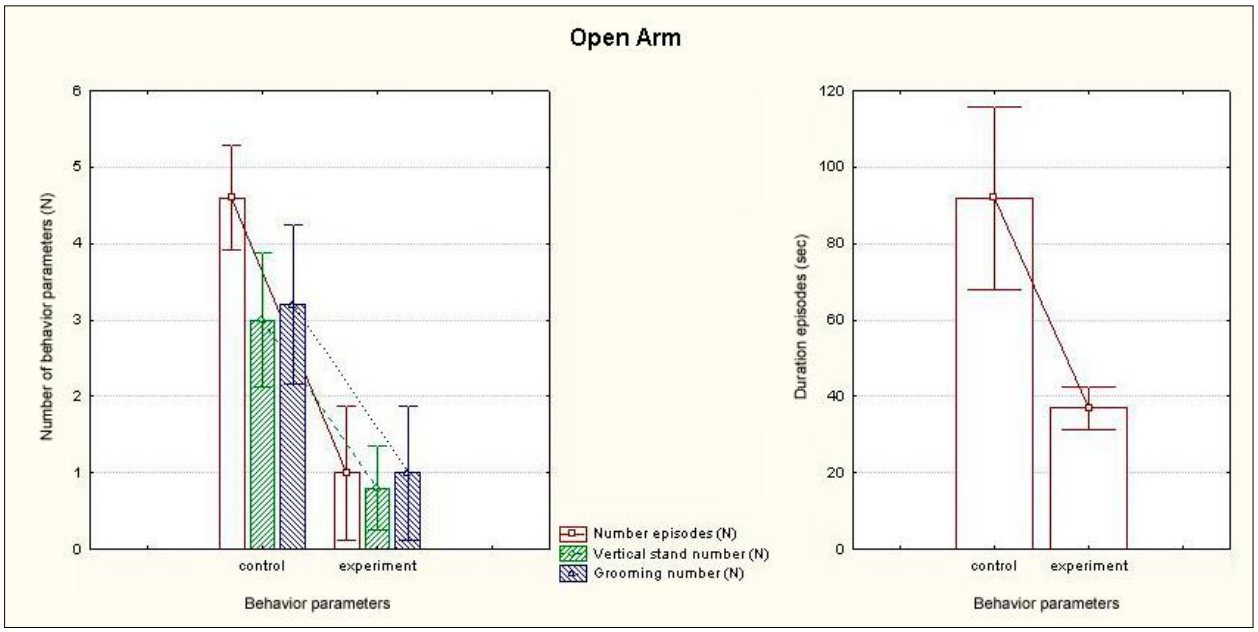


Figure 2 Evaluation of Anxiety Levels in the Elevated cross Maze in the experimental and control groups ($p<0.005$)

Memory was assessed using the passive avoidance test. As depicted in Figure 3, a notable distinction was observed between the control and experimental groups. All rats in the irradiated group were located in the dark chamber, indicating that exposure to electromagnetic fields leads to memory impairment. This deterioration may be attributed to alterations in attention and concentration resulting from the adverse effects of EMF exposure ($n=9$, $p<0.005$). (Figure 3.)

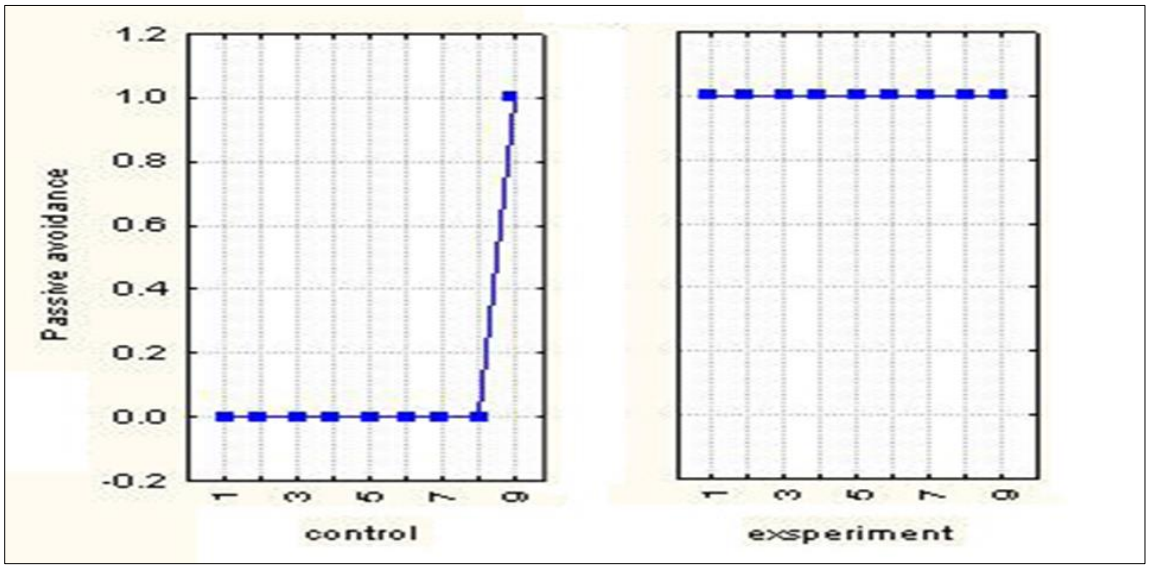


Figure 3 Evaluation of Memory - Passive Avoidance response in control and experimental groups ($p<0.005$)

4. Discussion

The objective of our study was to investigate the effects of electromagnetic field exposure during the prenatal period of rats and the resulting changes in their behavior and memory. It is widely recognized that the embryo is highly sensitive to both external and internal detrimental factors during development, a notion supported by our previous research on the impact of electromagnetic fields on pregnant rats [6,9], which demonstrated significant alterations in offspring number and weight. Subsequently, we examined the behavior and memory of three-week-old rats from the irradiated group, uncovering noteworthy changes.

Using the "open field method," we evaluated the emotional-motivational behavior of the animals. It is established that electromagnetic fields induce oxidative stress [9], which may explain the observed hyperactivity or immobilization of rats from the irradiated group. These rats spent more time near the walls than in the center, indicating alterations in behavioral parameters compared to the control group.

Our findings suggest that electromagnetic fields act as stressors, triggering behavioral changes. Stress is a vital protective response of the body to "non-standard" situations and is believed to contribute to the development of anxious responses, as evidenced by our results showing increased emotionality and anxiety in irradiated rats compared to controls in the cross-maze [10].

The stress response involves a complex interplay between the nervous and endocrine systems. Cortisol, for instance, plays a pivotal role, readily crossing the blood-brain barrier to affect learning and memory by binding to brain receptors in cognitive areas such as the hippocampus, amygdala, and frontal lobe. Cortisol also contributes to stress tolerance and participates in long-term memory consolidation [11,12], a correlation supported by our study results.

5. Conclusion

The findings of this research indicate that electromagnetic radiation exerts a detrimental impact on living organisms. It induces behavioral changes, heightened anxiety, and impairment of memory function. These results underscore the importance of further investigation into the potential hazards of electromagnetic radiation and the implementation of measures to mitigate its adverse effects on biological systems.

Compliance with ethical standards

Disclosure of conflict of interest

Authors have not declared any conflict of interests.

Statement of ethical approval

The Ethical Committee at I. Beritashvili Center of Experimental Biomedicine, Tbilisi, Georgia, N # 04/14.05.2023 approves the research activities conducted within the framework of this scientific research, which are in line with the ethical norms of research projects.

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