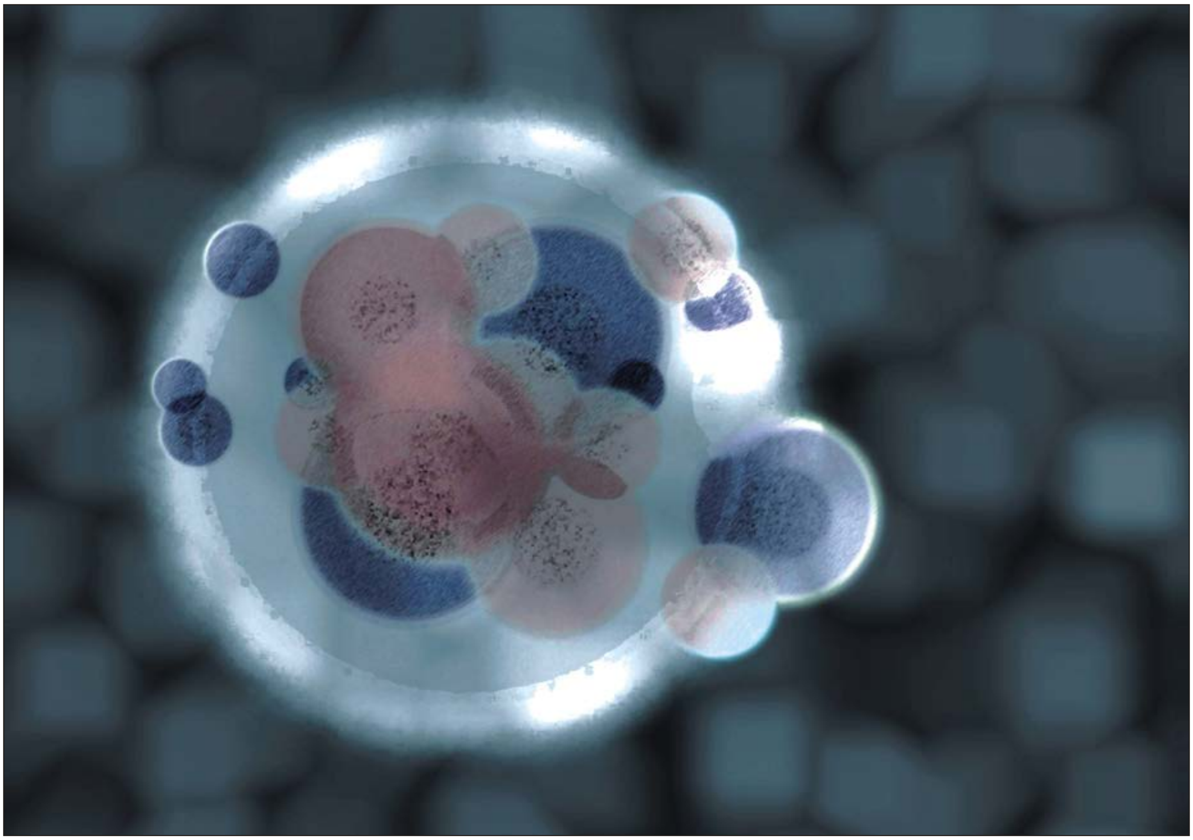

Journal of Biological Sciences

ISSN 1727-3048

science alert

ANSInet
an open access publisher
http://ansinet.com

Journal of Biological Sciences 10 (1): 67-70, 2010
ISSN 1727-3048

Effects of Exposure to Extremely Low-Frequency Magnetic Field of 4 μT Intensity on Spatial Memory and Learning in Mice

[1]M. Tehranipour and [2]M. Kafaee
[1]Department of Biology, Faculty of Science, Islamic Azad University, Mashhad Branch, Mashhad, Iran
[2]Young Researchers Club, Islamic Azad University, Mashhad Branch, Mashhad, Iran

Abstract: Extremely low-frequency magnetic fields (ELFMF) have been reported to produce a variety of biological effects. In the present study, the effects of extremely low-frequency magnetic field (ELFMF) of 4 μT intensity on spatial memory in mice brain (20 min) with using an platform finding task were examined. Thirty mouse were divided to control, experimental 1, 2 (n = 10). Comparable groups of mice were exposed for 20 min to ELFMF. For similar conditions control group were situated into set of ELFMFs for 20 min but with out exposure of magnetic field. The total time spent exploring the platform in the starting phase for all groups was estimated. Present results demonstrate (Experimental 1, 2) that exposed ELFMF are significantly better in practice related to spatial memory in comparison with control group.

Key words: Magnetic field, ELFMF, spatial memory

INTRODUCTION

Extremely low-frequency magnetic fields (ELFMF) have been reported to produce a variety of biological effects (Cecconi *et al*., 2000) that interfere with the activity of the brain (Jelenkovic *et al*., 2005) and may produce behavioral and cognitive disturbances (McKay *et al*., 2000). Some efforts have been to investigate the incidence of ELFMF on human health and animal physiology and behavior (Boorman *et al*., 2000). Reports suggest that ELFMF may act on the neurotransmitters releasing (Eun-joo and Jeong, 2007) such as analgesic (Naomi and Hensel, 2004), melatonin levels (Grlefahn *et al*., 2002), hypothalamic pituitary adrenocortical axis activity (Zhenguo *et al*., 2001) and alter the plasma corticosterone level (Mostafa *et al*., 2002). Such effects may interfere with memory per-formance as there is evidence suggesting impairing effects of corticosterone release on recognition in rats (Touitou *et al*., 2002). Studies showed exposure to a relatively weak (100 to 1000 μT) low frequency (<1000 Hz) specific pulsed magnetic field (CNP) has produced analgesia (anti nociception) in snails, mice and humans and altered normal resting EEG in human subjects. Others suggest that PEMFs (palse electro magnetic fields) exposure may produce an enhancement in cortical excitatory neurotransmission and PEMFs may produce functional changes in human brain (Capone *et al*., 2009). The aim of this study is to examination the effects of brain exposure to ELFMF of 4 μT intensity on spatial memory and learning in mice. The recognition task, based on exploratory activity of mice, was used as an appropriate model for assessing the effect of ELFMF on memory.

MATERIALS AND METHODS

All experiment was conducted in faculty of science, Islamic Azad University of Mashhad, Iran (2009).

Animals: Thirty male small mice (25-30 g, Razi institute of Mashhad, Iran) were used in this experiment. After 4 days of habituation to the laboratory (faculty of sciences, Islamic Azad university of Mashhad, Iran) environment, the animals were exposed in an ELMFs, or a similar solenoid without an electromagnetic field. They were kept in cage (width 30 cm, lengh 30 cm, height 30 cm).

The room was held under a 12 h light/12 h dark cycle and at 22±1°C. They had access to food and water. During their stay in the respective housing conditions, they were removed daily from their cages for water supply. The experimenter also handled the animals for about 3 min each day.

Platform recognition: The apparatus consists of a water maze; it consisted of a large, circular, galvanized steel pool (1.8 m in diameter, 0.6 m in height). A white platform (10 cm in diameter) was placed inside and the tank was filled with water (22°C) until the top of the platform was submerged 1 cm below the water's surface. A sufficient

Corresponding Author: Tehranipour Maryam, Department of Biology, Faculty of Science, Islamic Azad University, Mashhad-Branch, Mashhad, Iran Tel: +98511835050 Fax: +985118424020

Fig. 1: Solenoid

amount of white paint (Proline-Latex Flat; Martin Senour Company, Cleveland, OH) was added to make the water opaque and render the platform virtually invisible. In addition to the visual cues on the walls of the laboratory (shapes), five sheets of paper with black-and-white geometric designs attached to the sides of the tank served as additional cues. There was a camera above the maze that in all stages of the test record the animal paths. Morris water maze test was done for 5 days and each day with 4 trials (D'Hooge and DeDeyn, 2001).

Magnetic field chamber: Magnetic field chamber consisted of a cylindrical cage from fiber glass (2 mm thick) and was 6.5 cm internal a coil of 1760 turns from electrically insulated 0.75 mm copper diameter and 70 cm long wire were wound around the outer cylinder at equal distance. The cylinder was grounded and there was homogenous mag-within the chamber volume (Fig. 1).

Cube from copper was used to cover the cylinder. The coil was connected to signal generator (GFG-8019 G, Good Will instrument Co.) which its external current was connected to a 600 W Amplifier. The electromagnetic field inside the chamber was measured at different locations using a hand-held Gauss/Tesla Meter Model 101 (Iran). A probe P-102 (Iran) of ± accuracy was used to calibrate the magnetic field. The field frequency and strength can be varied by signal generator inside the homogenous zone with an increase the solenoid temperature (±0.1°C).

Thirty mice were randomly divided to two treatment and one control groups respectively. The number of mice was (n = 10) for each group. The magnetic field of the solenoid was 4 μT for the treatment groups and 0.01 μT for control group just for induce the same stressor condition. The magnetic field frequency was 10 Hz for the first and 30 Hz for the second treatment group.

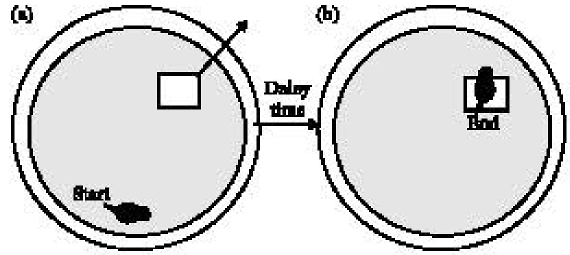

Fig. 2: Schematic representation of the testing procedure (a) starting phase and (b) ending phase

Treatments: Mice were exposed to ELFMF of 4 μT intensity while maintained inside the solenoid magnetic field. Each mouse was located for 20 min in a magnetic solenoid one session during a day for five days. Each time they were tested immediately in the Morris water maze test (Fig. 2).

Behavioral testing

Habituation: Animals were located on the plate before the each experiment of the test proper for 15-20 sec each day for five days. They were removed from the magnetic field solenoid for that period of habitation. Each mouse was allowed to see the environment and water maze for achieving a spatial description of it for that period.

Platform recognition test: The test was run in 24 h interval between each session. Each mouse was tested in one session. A session consists of a starting phase (mouse is located in water maze) and an ending phase (mouse explores the platform) with a time interval (The time is mouse swimming) between the two phases. The platform used during the spatial memory was invisible (radius 5 x height 23 cm) located 1-2 cm under the surface of maze water, fixed during all tests.

Performance measures and analyses: The basic measure was the time spent by mouse in exploring platform during the starting phase. Exploring the platform was defined as directing. The nose to the platform at a distance <2 cm and or sitting on it; conversely, turning around the platform was not considered as exploratory behavior. The ending phase was defined as exploring the platform or turning around it for 60 sec. Comparisons focused on the time spent by mice in exploring platform during the starting phase.

Statistics analysis: To determine significant differences between different groups, test one way Analysis of Variance (ANOVA) test was performed. All differences were considered significant at the $p<0.05$. ANOVAs and subsequent planned comparisons were conducted using Sigma Stat for Windows, version 2.03 (SPSS, Inc., Chicago, IL).To design graph was used EXEL software. Mean while the data as mean±standard error of the mean reported.

RESULTS AND DISCUSSION

Foundings show that the path of the motion in the first and third and fifth days in each group is completely different (Fig. 3).

There is a significant difference ($p<0.05$) in time for finding platforms in the starting phase between Experimental 1 and 2 groups in compare with control group (Fig. 4). In the starting phase, in both 10 and 30 Hz ELFMF-treated mice the time for finding platform was significantly less than control animals ($p<0.05$).

The first treatment group was exposed to 10 Hz and the second treatment group was exposed to 30 Hz electromagnetic fields. The field intensity was 4 μT for two groups, both the first and the second ELMF treated groups explored significantly less than control ($p<0.05$), whereas in the starting phase mice exposed to 10 Hz magnetic field explored less than those exposed to 30 Hz magnetic (Fig. 5).

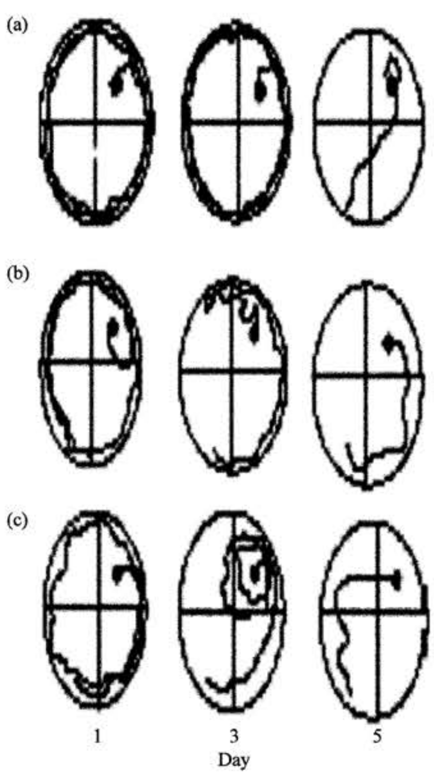

Fig. 3: Representation of the motion. Captured by an infra red camera, (a) Control group, (b) 10 Hz freq and (c) 30 Hz freq

Our results demonstrate that exposure to ELFMF produces a significant increase in the spatial memory of mice. These results add to the growing evidence of useful effects of ELFMF on human health in everyday life (for example, the effect of magnetic field on in human brain (Capone *et al*., 2009)).

Our results are in agreement to those reports (Johansen, 2004) which demonstrate the effects of ELFMF on learning activities while there is increased number of reports on the inconsistent (Johansen, 2004). Capone *et al*. (2009) suggested that PEMFs exposure may produce an enhancement in cortical excitatory neurotransmission and may produce functional changes in human brain. McKay *et al*. (2000) showed the exposure to ELF EMF of 1 μT intensity during 2 h for 9 days increased the duration of short-term memory of adult male Wistar rats up to 300 min and indicated that ELF EMF improves social recognition memory in rats. In conflict Yu *et al*. (2008) suggested that ELF magnetic

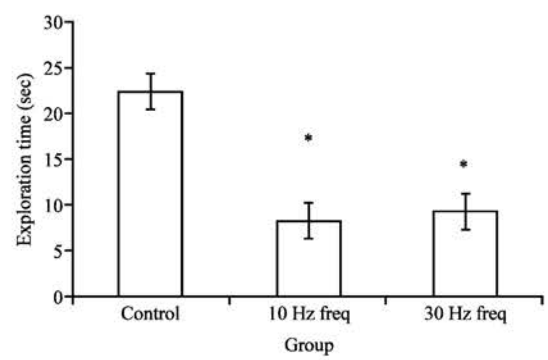

Fig. 4: Comparison of time spent by mice exploring platform between groups, both the 10 Hz freq and 30 Hz freq groups exploring time were less than control * ($p<0.05$)

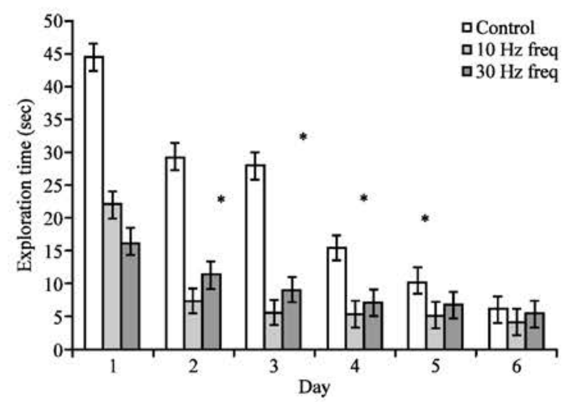

Fig. 5: Time spent by mice exploring platform in the starting phase several groups. Each group was compare with control

fields impair spatial recognition memory in the Y-maze depending on the field strength and/or duration of exposure (Sinczuk-Walczak *et al*., 2004).

This is probably due to the lack of standard parameters in the dosage and duration of exposure to magnetic fields (Touitou *et al*., 2002). In contrast to the worrying reports on the deleterious effects of ELMF on human health, other studies suggested beneficial effects of low magnetic or electromagnetic field in certain conditions. The present results demonstrate the possible cognitive and biological effects of exposure to ELMF and raise attention to the possible health hazard associated with domestic electric device. May be exposure to ELMF could progress fasilating path way and increase number of synapses that is very important in memory process. Further studies are underway to examine the effect of ELMF at different intensities and in comparable tasks that involve spatial memory and visual attention.

In total, it is concluded that exposure to ELFMF of 4 μT intensity have cognitive and biological effects on spatial memory and learning in mice and can improve spatial memory.

ACKNOWLEDGMENTS

This study was supported by Islamic Azad University of Mashhad, Iran. We thank Dr. H. Aghpiyma for his useful comments and Dr. Mahmudzade for valuable helps.

REFERENCES

Boorman, G.A., C.N. Rafferty, J.M. Ward and R.C. Sills, 2000. Leukemia and lymphoma incidence in rodents exposed to low-frequency magnetic fields. Radiat. Res., 153: 627-636.

Capone, F., M. Dileone and P. Profice, 2009. Does exposure to extremely low frequency magnetic fields produce functional changes in human brain? J. Neural Transmission, 116: 257-265.

Cecconi, S., G. Gualtieri, A. Di-Bartolomeo, G. Troiani, M.G. Cifone and R. Canipari, 2000. Evaluation of the effects of extremely low frequency electromagnetic fields on mammalian follicle development. Hum. Reprod., 15: 2319-2325.

D'Hooge, R. and P.P. De Deyn, 2001. Applications of the morris water maze in the study of learning and memory. Brain. Rev., 36: 60-90.

Eun-Joo, Sh. and J.H. Jeong, 2007. Exposure to Extremely low frequency magnetic fields enhances locomotor activity via activation of dopamine d1-like receptors in mice. Pharmacol. Sci., 105: 367-371.

Grlefahn, B., C. Kunememund, M. Blaszkewicz and A. Lerchl, 2002. Effects of electromagnetic radiation (bright light, extremely low-frequency magnetic fields, infrared radiation) on the circadian rhythm of melatonin synthesis, rectal temperature and heart rate. Ind. Health, 40: 320-327.

Jelenkovic, A., B. Janac, V. Pesic, D.M. Jovanovic, I. Vasiljevic and Z. Prolic, 2005. Effects of extremely low-frequency magnetic field in the brain of rats. Brain Resbull, 68: 355-360.

Johansen, C., 2004. Electromagnetic fields and health effects-epidemiologic studies of cancer, diseases of the central nervous system and arrhythmia-related heart disease. Scand. J. Work Environ. Health, 1: 1-30.

McKay, B.E., M.A. Persinger and S.A. Koren, 2000. Exposure to a theta-burst patterned magnetic field impairs memory acquisition and consolidation for contextual but not discrete conditioned fear in rats. Neurosci. Lett., 292: 99-102.

Mostafa, R.M., Y.M. Mostafa and A. Ennaceur, 2002. Effects of exposure to extremely low-frequency magnetic field of 2 G intensity on memory and corticosterone level in rats. Physiol. Behav., 76: 589-595.

Naomi, M. and J.M. Hensel, 2004. Analgesic and behavioral effects of a 100 μT specific pulsed extremely low frequency magnetic field on control and morphine treated CF-1 mice. Neurosci. Lett., 354: 30-33.

Sinczuk-Walczak, H., A. Bortkiewicz and M. Zmyslony, 2004. [Effects of electromagnetic fields generated by mobile phones on the nervous system]. Med. Pr., 55: 435-438.

Touitou, Y., B. Selmaoui, J. Lambrozo and A. Auzeby, 2002. [Evaluation of the effect of magnetic fields on the secretion of melatonin in humans and rats. Circadian study]. Bull. Acad. Natl. Med., 186: 1625-1639.

Yu, F.u., C. Wang, J. Wang, Y. Lei and M. Yuanye, 2008. Long-term exposure to extremely low-frequency magnetic fields impairs spatial recognition memory in mice. Physiol. Pharmacol., 35: 797-800.

Zhenguo, L., H. Qingguo and Z. Xiaoyun, 2001. Influence of magnetic field on nitric oxide and neuropeptide Y in rat adrenal gland. Chinese Sci. Bull., 46: 1969-1971.