Effects of 90min Exposure to 8mT Electromagnetic Fields on Memory in Mice

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Abstract: The aim of this experimental study was to investigate the effect of extremely low frequency electromagnetic fields (ELF EMF) on memory function in mice. Memory function was evaluated with passive avoidance learning in a standard wooden box that despite his natural tendency, mice learns to stay on a small platform to avoidant electric shock. 24h after learning session, laboratory animals were placed in a sinusoidal electromagnetic field created using a round coil, for 90 minutes to exposure to an 8mT, 50Hz. Then animals were placed on small platform again and step-down latency measured as memory index. The results showed that exposure to a 50 Hz, 8mT electromagnetic field for 90 minutes has devastating effects on memory function in male mice. [Parviz Askari. Effects of 90min Exposure to 8mT Electromagnetic Fields on Memory in Mice. Journal of American Science 2011; 7(7):58-61]. (ISSN: 1545-1003). http://www.americanscience.org.

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1. Introduction

Nowadays achieving new technologies, the human has created different intensities electromagnetic fields, communication services and various electrical devices. But there are worries about influences of electromagnetic fields on the metabolism and biological processes and molecular mechanisms and cellular organisms. The first report in 1979 about possible damaging effects of exposure to electric and magnetic fields by Whertteimer and Leeper was related to electrical fields and cancer in children [1]. In 1980 researchers investigated an increased risk of leukemia and brain tumors in people who were faced to exteremly low frequency electromagnetic fields (ELF EMF). Such evidence was led to increased attention to the risk of EMF [2]. Further research was focused on the risk of central nervous system disorders including Alzheimer and Parkinson diseases in people who were exposure to occupational electromagnetic fields and electric shock [3].

It was also found that occupational exposure to the same fields increases the risk of heart disorders, Cardial Arrhythmia-Related Conditions and Acute Myocardial Infarction [4].

The harmful effects of EMF on cognition, learning and memory in animals have been investigated using an assortment of cognitive and behavioral tasks, tests and exposure conditions [5]. Animal models and human designs have shown that ELF EMF can change peripheral and central nervous system activity. These changes include the increased activity of hypothalamic nuclei and intracerebral nuclei [6], neurotransmitter synthesis in synapses and Ganglya [7], changes in the activity of neuronal receptors including dopamine receptor and 5-HT (1B) [8] and such changes ultimately affect the learning and memory functions [9].

Behavioral and psychological studies have shown that exposure to ELF can affect human cognitive functions and behaviors of animals [10, 11, 12, 13]. For example exposed rats to 25 or 50 Hz fields in the short term (7 days) or long term (25 days) were examined in the Y form maze. The results indicated that neither short-term, nor long term exposure did not make a change in motor activity, but 50 Hz field exposure will decrease recognition of new arm of the maze [13].

In another experimental study Jadidi and his colleagues (2007) confirmed that 20 min exposure to 8 mT, 50 Hz field can impair spatial memory consolidation but such impaires can not created by a 2 mTesla field [14]. The researchers believe that ELF EMF can make changes in calcium ion homeostasis in neuronal tissues. Hippocampal regions of mouse brain which has exposed to 50 Hz field for 90 days (50 and 100 mT) were isolated and compared with the control group. it was found that exposure to ELF EMF increased Ca ions levels in cells [1].

In the other hand some researchers have reported that ELF fields have positive effects on cognitive functions. Liu et al (2008) examined spatial learning and memory changes using Morris water maze after 4 weeks exposure to ELF EMF (4hours daily with a 50 Hz, 2mT ELF). They reported that such exposure leads to reduced long-term delay in finding the hidden platform, and improved long-term memory, without effect on short term memory or motor activity [15]. Kavaliers et. All have observed behavioral improvement in mice water maze responses that is associated with biological opioid system [16].

Considering the above findings, it is not absolutely correct confirmed that the ELF fields can improve memory or impair it as a cognitive functions. This study investigated the effect of ELF EMF (50 Hz) on memory in adult male mice.

2. Material and Method

A. *Sbjects and Experimental Groups*

Adult male mice (25 - 30 g) were separately housed five per cage in a room with natural light cycle and constant temperature (24 ± 2 C). Food and water were available ad libitum. All procedures were conducted in agreement with the National Institutes of Health Guide for care and use of laboratory animals. Three groups were used: exposed to 8 mT(N=10), sham-exposed(N=10), control group(N=10).

B. *Behavioral Training*

This experimental study was aimed to examine one of the most stable kinds of learning's that named as avoidance learning. In this type of learning, animal not only does not receive reinforcement, but also receives a kind of stimuli or situations that may threat the survival of it. Since such irritating situations are a serious threat, generally only once experimental effort makes a long remain stable learning. In this study, to measure memory, laboratory animals (mice) were evaluated with inhibitory (passive) avoidance task.

Passive avoidance learning box is a wooden box with dimensions 30 * 30 * 40 cm and the floor of the 29 steel bars, the diameter of 0.3 cm. Bars are away from each other 1 cm. A wooden platform (4 x 4 x 4cm) is placed in the middle floor of the box. By an electric shock (1 Hz, 0.5 seconds, and 50 V, DC) can be controlled irritating situation (Grass S44-Quincy, Massachusetts.USA). In the learning stage, the animal was gently placed on the small wooden platform in the middle of box. Animal's natural tendency to coming down from the platform, make it to move in space of larger wooden box immediately.

A 15 seconds electric shock was given as soon as animal came down from the platform and placed on the floor of the box. Step-down latencies of the animals were used to assess

Memory retention. The training and testing sessions were carried out between 8:00 a.m. and 2:00 p.m. in a room with light and sound attenuated..

So despite his natural tendency, mice learn to stay on platform. After 24 hours and in test session, memory function, with step-down latency (second) was calculated [17].

C. *The Electromagnetic Field Exposure System*

Electromagnetic field was applied in a room adjacent to that used for behavioral experiments. A sinusoidal magnetic field was created using a round coil electromagnet made from a 1000 turned copper wire (0.50 mm). The electromagnet was supplied with a sinusoidal waveform signal generator (GFG-8019G, Good Will instrument Co.). Then amplifier output droved to coil, producing an ELF of 8 mT at the center of the coil. The desired intensity ELF (8 mT) calibrated using a Gauss meters (K72106-9-WALKER, USA) at the center of the coil. The heat generated by coil dissipated due to good ventilation in exposure area. The electrical apparatuses and exposure system adjusted on the laboratory non-metallic table.

90 min before test session in the inhibitory avoidance learning apparatus, experimental mice were exposed to electromagnetic field (in the center of round coil). Sham-control mice were placed in the same situation but there was not electrical current and electromagnetic field, and Control group did not experience it.

3. Results

Because of significant differences in behavioral learning of animals, non-parametric statistical methods were used for data analysis.

In the first step, differences in learning session between three groups were compared. Using SPSS software and non-parametric test (Kruskal Wallis test), results showed that there has not any significant difference between three groups in the learning session (Kruskal Wallis test, Chi-Square =0.923, dF=2, $p < .630$).

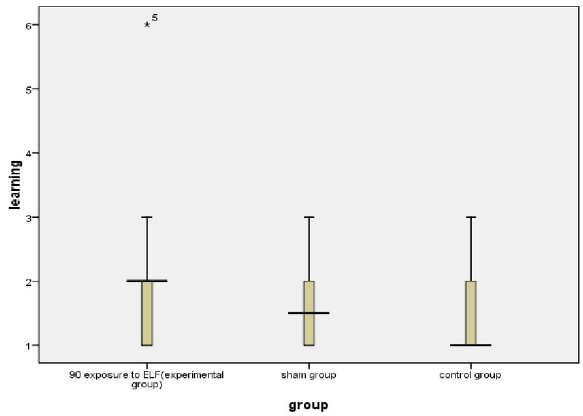

Fig1. Step-down latency in learning session

Compared the control group and experimental group (10 mice in each group) in the learning session was not significant (U Mann-Whitney = 38.50, p <.341). Similar result in sham-control group and experimental group was obtained (U Mann-Whitney = 45.00, p <.684). See fig 1.

The analysis of test session (memory function) data showed that the step-down latency in groups which mice exposed to electromagnetic Tesla 8 mT (50 Hz) were significantly lower than control groups. Comparison of experimental and control mice indicated significant differences between two control ane experimental groups (U Mann-Whitney = 16.00, p <.010) and also significant differences between sham-control and experimental too (U Mann-Whitney = 11.

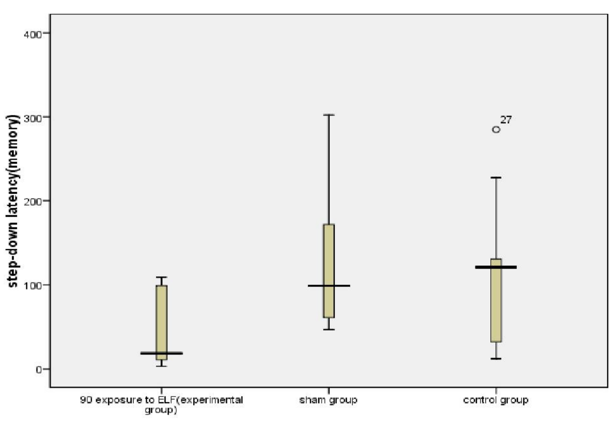

Fig2. Step-down latency in test session (memory)

00, p <.003). See fig 2.

4. DISCUSSION

Based on the results, it can be concluded that exposure to 8 mT, 50 Hz electromagnetic field impairs the memory function. So cognition and animal's memory will not be used and animal's step-down latency and avoiding the shock reduces. It is well-known that the differences between step-down latency on the platform in learning and test sessions are an index of the rate of memory function in inhibitory (passive) avoidance task. Staying on the platform in test session in control and sham-control group mice indicated that memory was remain, while experimental group performed significantly less than the other groups. Therefore it can be stated that exposure to electromagnetic field even in a single 90 minutes exposure, can impair memory in mice. These findings are in agreement with the results showing the impairing effects of ELF on cognitive functions [14, 9, 10, and 11].

Previous studies mainly focused on cognitive functions specially the memory and learning in different tasks and duration of expusure, so inconsistent results are predictable. Jadidi et al. (2007) provide evidence that exposure to a 50 Hz, 8 mT magnetic field for 20 min impaired consolidation spatial memory using a water maze but, not retrieval of learned information. Further, no effect was found in 2 mT magnetic field [14]. McKay and Persinger (2000) also found 60 min exposure to 200–500 nT ELF before training phase impaired spatial memory in the radial maze whereas exposure before testing phase decreased responding time of rats in this task [18]. Lai et al. (1998) showed that 60 min exposure to a 60 Hz, 1 mT ELF before training impaired spatial memory in a water maze [12]. Decreased perception, memory and cognition functions were found in 60 min exposure to 50 Hz, 1 mT magnetic field in a human study [9]. However, there are evidence which show no significant effects or a positive effect of ELF on learning and memory [19]. For instance, Kurokawa, Nitta, Imai, and Kabuto found no significant effects of a 50 Hz, 50 lT magnetic fields on human brain [20]. Also there were not any harmfull effects of 45 min exposure to a magnetic field at 0.75 mT on memory in mice [21]. This inconsistency may be due to differences in protocols (such as type of task, intensity of the applied ELF and exposure duration, etc.) among different studies.

The mechanisms underlying the harmful effects of magnetic field on learning and memory are not known. The brain cholinergic system plays a crucial role in learning and memory [22, 23]. It has shown that exposure to ELF decreased activities of cholinergic system in the frontal cortex and hippocampus; both regions are involved in memory processing [11]. Thus, one possibility is that the impairment of cognition processing can result from decrement in transmission of cholinergic system. Also exposure to ELF can change calcium ion [1], and EEG, GABA, and calcium ions in the brain and these changes may effect on cognition [24].

In summary, findings indicate that 90 min exposure to a 50 Hz 8 mT, electromagnetic fields can impair memory function in passive avoidance learning. In agreement with others our data indicates that exposure to ELF has impairment effect on learning and memory functions. Therefore, further studies are required to find out the underlying mechanisms.

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