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Effect of mobile phone radio waves on the brain of laboratory mice

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ABSTRACT
Many controversial studies have been conducted on the effect of the radio waves (RF) emitted from mobile phones on the health of animals and human beings. This present study I has been focused on the effects of radio waves on the brain of developing mice. For this purpose 15 mice of both sexes at their day of birth were divided into three groups. Two groups were exposed daily to RF for 30 or 60 min for 25 days consequently and one group left was treated as control group without any exposure. Animal's memory was tested by maze game for 5 days and all animal brains were tested by CT scans. Results show a significant difference in brain size and memory between exposed and non exposed animals (t =-2.677,df=6, p=0.037), (df=2,F=2.30 ,P=0.156) consequently. These data reveal that there are serious effects of the RF on the physiological and anatomical development of brains of the mice.

Keywords: Mobile Phone, Radiofrequency, Brain, Animal's Memory, CT Scan, Stereology.

INTRODUCTION

The dramatic increase in cellular phones usage raises the question of the existence of possible biological effects of radio-frequency electromagnetic radiation Stewart (2000). Although several studies reveal that there is a relation between a continual exposure to high frequency electromagnetic field or microwave and bio-effects in man such as headaches, fatigues, sleep and memory disruption (Santini, 1999; Bielski, 1994) and brain tumor (Schuz *et al.,* 2006).

In contrast to X-ray energy, RF energy is non-ionizing radiation because the energy of the Quanta that carry the energy is insufficient to knock electrons from atoms (the mechanism for injuries from ionizing radiation) (Valberg, 1997; Moulder *et al.*, 1999). The dominant mechanism by which RF energy affects biological systems is by heating (Foster and Moulder, 2000). The principal measure of dose for RF energy is the specific absorption rate (SAR), SAR is a measure of the rate of radio frequency energy absorption in the body expressed in units of watts per kilogram (W/kg). International Commission on Non-Ionizing Radiation Protection (ICNIRP) specifies both partial-body and whole-body SAR limits, which restricts the possible localized and whole-body heating and is defined as the power absorbed (W) per kilogram of tissue.

Portable or mobile phones operate in either the 900 or 1800MHz range. At this range the effect of microwave is on memory. The only evidence for a direct effect on memory was on brain slices from the hippocampus of rat that showed in long-term changes when exposed to 915MHz (Scott, *et al.,* 1998). Mild, *et al.* (1998) was looking for a subjective response in subjects, suggested an increased headache or sensations of warmth when using mobile phones. In an other study by Braune, *et al.* (1998) changes in blood pressure induced by exposure to the right side of the head when using mobile phones was demonstrated. Since no study has been conducted directly on the physiological and anatomical changes of effects of the RF on the brain, the presenthas been aimed to study examin whether mobile phone can affect the development of mice brain size and to explore the relation between their memory and RF.

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Material and methods

Fifteen new borne male and female Blab/c mice were divided into three groups. Animals were maintained in a temperature-controlled room (22 ± 2 °C) on a 12-hrs light/dark cycle (lights on at 7:00 am) with food and water available. Mice were divided into 3 groups of 5 animals each. Groups I served as control group and was not exposed to any of radiowave from mobile phones. Animals of groups II and III were exposed for half an hour and one hour consequently for missed calls per day for 25 days. RF from mobile phone was kept on a GSM (900/1800MHz) mobile phone in vibratory mode (no ring tone) in close mode to mice brains. Each missed call lasted for 1min.

A maze was used in this experiment to see the affect of RF on animal memory. The maze consisted of rectangle

box with 100X60X10 cm dimensions. Food was placed at the end of the maze (point B) and each fasting mouse had to start searching for its food from point A (Figure 1). Maze was covered with glass sheet during the experiment and the time for reaching the food was taken for each mouse for 5 sequential days.

CT image acquisition
CT brain images for all mice (control and study groups) were obtained with G.E 4MDCT system, spiral sequence with Kvp= 120 ,slice thickness= 0.5 mm ,mA =200.(Figure 2)

CT image analysis: Stereology
The Cavalieri method in combination with point counting was used to estimate the volumes of total brain volume in all mice included in this study. For three dimensional analyses, CT images were transferred to easy measure software. Volume estimation was achieved through sampling a series of equally spaced CT images, beginning with a random starting position. Each image was overlain with a test system comprising a regular array of test points, and the number of points lying within each transect through the brain was recorded. An unbiased estimate of structure volume was obtained as the sum of the estimated areas of the structure transects on consecutive systematic sections multiplied by the distance between sections (Figure 3)

Results and Discussion
After 25 days daily exposure by RF from mobile phone, mice were trained for how they can reach their food through a rectangular maze for 5 sequential days. It was possible to measure the times required for each mouse to reach their food starting from the starting point and terminate at the end of rectangular maze (Figure 1)

ANOVA was conducted to explore any difference in mice memory between normal subjects and exposed daily subjects to the RF radiations from the mobile phone. The ANOVA revealed that there were significant differences in the time required for mice to reach their food in study subjects was much longer than normal subjects mice memory in last day trail (fourth day) (df=2,F=5.27,P=0.04) while there is no significant difference in mice memory in the first, second and third day, which indicates that the mice memory in exposed subjects decreased as compared to the normal mice subjects.(see Figure 4)

Mice brains exposure to mobile telephony and effect on their memory. Significant differences were found between the groups after the fourth days. Table 1 shows the time required for individual mouse to reach as food starting from point A and finishing in point B as shown in figure 1 for all 12 control and exposed subjects to the RF radiation in ½ and 1. (Table 1)

Stereology:
Mean estimated brain volumes in mice controls and mice study subject were estimated. In controls, the estimated volume of the brain was found to be greater than that of the study subjects (t =-2.677,df=6, p=0.037). There were significant differences in estimated mice brain volume of the control group to the mice subject's studies.

The study revealed that there are significant differences between normal subjects and study subjects from the fifth day, while there were no significant variations on the first day, which can be interpreted as during the first day the normal and study subjects took take their time to explore the ways to get their food while in the last period (fifth day) the normal subjects consolidated their information in the cortex (since they have good memory and already learn how to reach their food as short as possible) while the study subjects failed to consolidate their information in their brain cortex which indicated impairment in their spatial memory depending on the hippocampus . A variety of paradigms were investigated such as spatial learning, and perhaps the most commonly used is the Morris water maze in which an animal's capacity to remember spatial cues is required to locate a hidden underwater platform.

Portable or mobile phones operate in either the at 900 or 1800MHz range and are known to significantly effect cerebral cortex and hippocampus activity of rat which induces spatial learning deficits in the radial-arm maze as reported by Wang and Lai, (2000).
Looking for subjects correlations between subjects exposed with RF from mobile phone and the their time required to reach their food in maze there are strong correlation in last time (r= 0.773; P=0.009).which indicated the normal animal have learn and memorize their way that they had to go through to get their food while study subject failed and this can be conclude that due to lesions of the hippocampal and parahippocampal areas which caused the rat to perform particularly poorly in spatial learning tasks (Wisman *et al.,* 2008; Talpos *et al.,* 2008).
The CT image analysis of measuring brain volume by using stereolgy reveals that brain volume of rat study subjects which were exposed to RF by mobile phones, significantly reduced their brains volumes which may be due to dendritic retraction, synaptic loss leading to their decreased cognitive function , suppressed neurogenesis and neuronal death. It may also be due to damage of myelinated fibers which is known to cause the loss of white matter volume (Wang, 2005).

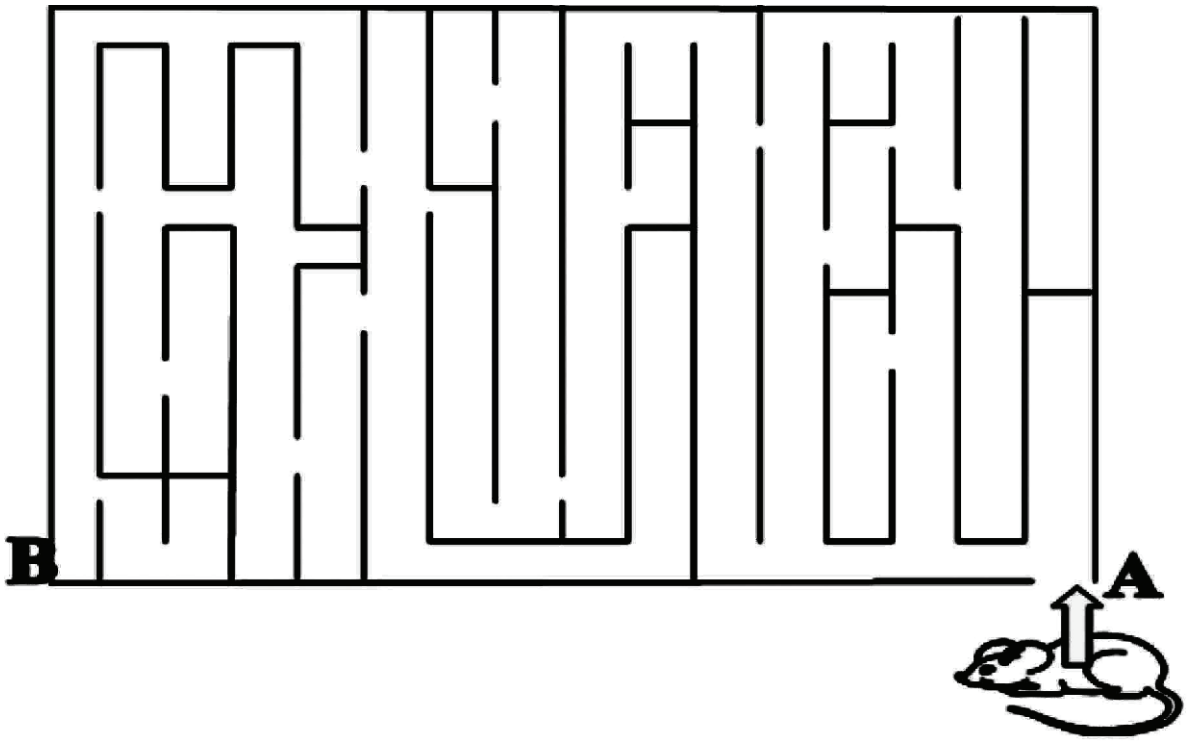

Figure 1. Mouse in maze at starting point “A” had to reach its food located at maze terminal point “B”.

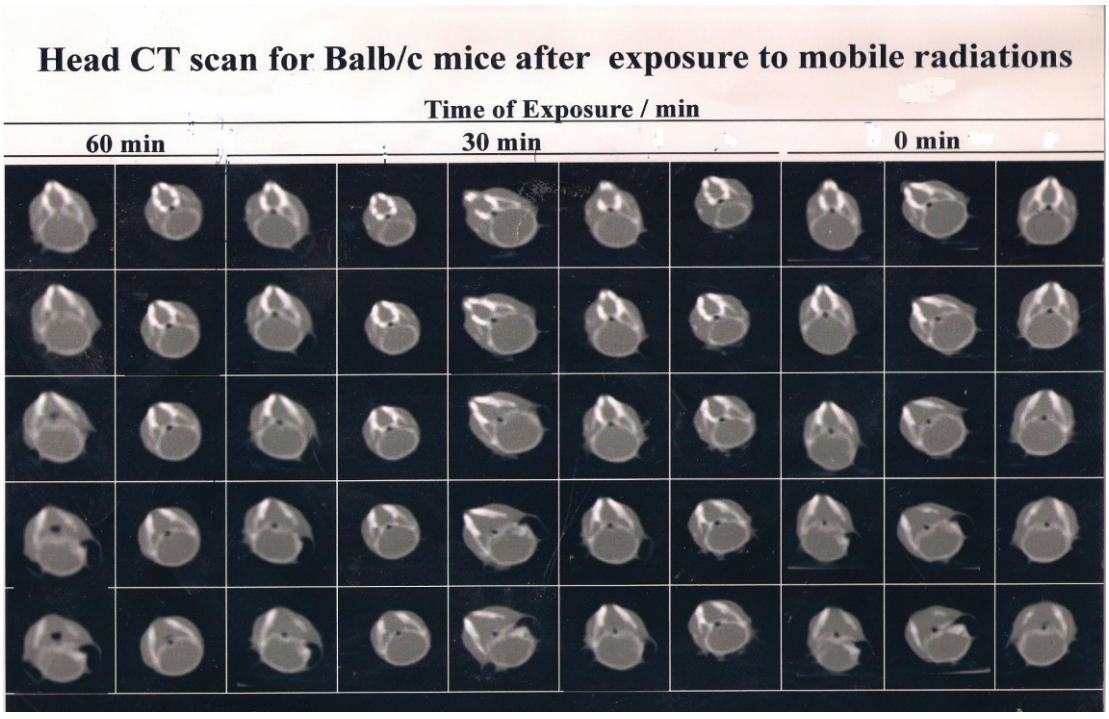

Figure 2. Mice CT brain scan after exposed 25 sequential daily to mobile radiations.

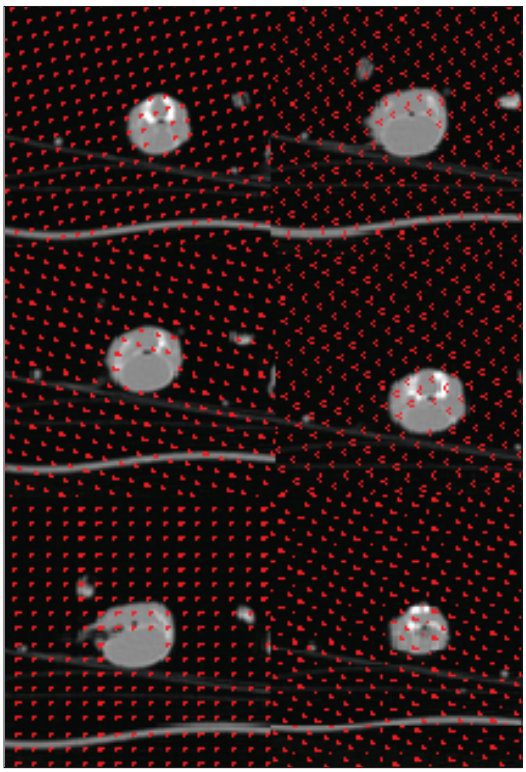

Figure 3. Point counting was used to estimate the volumes of total brain volume in all mice

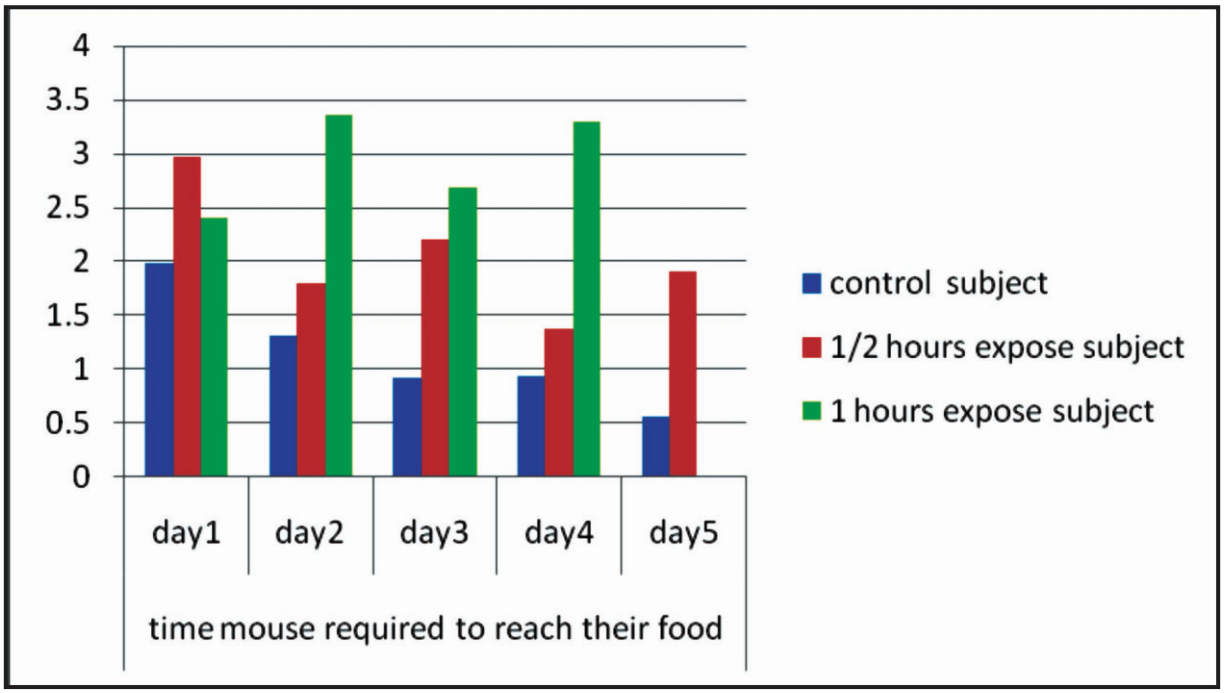

Figure 4. Radio frequency radiation affects radial-arm maze performance in the rat memory.
Mice brains exposure to mobile telephony and effect on their memory.
Significant differences were found between the groups in the forth days.

Mouse category	Required Time by mice to reach the food in maze Time				
Normal	1st day	2nd day	3rd day	4th day	5th day
1st mouse	1.1 min	0.51	1.16	1.1	0.22
2nd mouse	2.8 min	1.3	1.16	1.16	1
3rd mouse	1.47 min	2	0.44	0.53	0.46
4th mouse	2.55min	1.43			
½ hours					
	5.4 min	1.4 min	1.16 min	2.2 min	3 min
	1.45 min	2.43 min	2.21 min	0.41 min	1.5 min
	2.4 min	1.4 min	2.23 min	1.5 min	1.13 min
	2.2 min	1.5 min	1 min	1.3 min	2.52 min
	3.4 min	2.4 min	4.4 min	1.44 min	1.43 min
1 hours					
	2.56 min	1.47 min	1.43 min	5.2 min	
	2.33 min	6.2 min	2.3 min	1.43 min	
	2.3 min	2.41 min	4.3 min		

Table 1. Time required for mice to reach their food in different category groups.

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