Environmentalist
DOI 10.1007/s10669-007-9066-z

EEG bioeffects on cochlear deaf from cellular phones

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Abstract
Objectives This paper aims to provide evidence of an inductive electromagnetic bioeffect on the human brain, which is independent from sound waves and produced by mobile phones, in proximal field, through correlating the EEG data obtained from electrodes placed on both normal and cochlear deaf individuals.
Methods Two groups of subjects are placed under controlled electromagnetic conditions inside a Faraday chamber, 12 healthy and another 12 suffering from cochlear deafness). Each is sitting on a chair, fitted with additional support, and holding a cellular phone 2 cm away form the right auricular, in order to avoid a thermal effect as much as possible. All of them, relaxed and with their eyes closed, are EEG recorded in a basal state with their mobile phones off. Then, each of them is again recorded under the same conditions but with the mobile on and listening to the same conversation. In order to assess the observed EEG changes, a statistical analysis by means of the FFT (Fast Fourier Transform) was carried out.
Results For both, healthy and cochlear deaf, assimilation or integration of the mobile phone signal by some electrodes is to be found. This is due to the increase of amplitudes for alpha and theta waves, whereas the signal is not integrated in other electrodes. By correlating the spectra of frequencies of corresponding EEG records for the same brain areas, we have not observed significative differences for both groups.
Conclusions A possible electromagnetic direct inductive, non-thermal, bioeffect on the human brain is observed. This effect is produced by the use of mobile phones and it bears no relation to the sound waves.

Keywords Electromagnetic field · Bioeffects · Electroencephalogram · Mobile phone · Cochlear deaf

1 Introduction

Recent technological advances in telecommunications have led to the use of electromagnetic fields (EMF) to man's own convenience, such as in Telemedicine, in the field of Medicine (Ramos and Monteagudo 2006) or for diagnosis and treatment as well, within the field of medical specialities (Bardasano and Elorrieta 2000; Rosch and Markov 2004). Nevertheless, electromagnetic fields from GSM mobile phones (Global System Mobile Communication) and from their base stations can have an effect on living beings and man, in particular, in different ways. More and more often we find proof from different fields of knowledge of this environmental electromagnetic pollution, which might involve the health of human and other living beings, (Navarro et al. 2003; Santini et al. 2003; Balmori 2004, 2005; Hutter et al. 2006). Neurons can respond to electromagnetic fields, (Beasond and Semm 2002) and different degrees of neurological and other kinds of alterations, which may change the physiology of the brain, can also be found and are associated to mobile phone radiofrequencies, (Hossmann and Hermann 2003; Westerman and Hocking 2004; Huber et al. 2002; Maby et al. 2005; Szyjkowska et al. 2005; Papageorgiou et al. 2006). Evidence of alterations in the permeability of the hemato-encephalic barrier in rats from mobile phones has been

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presented (Fritze et al. 1997) as well as histological changes due to neural damage in the cortex, hippocampus and basal ganglia in the brain of exposed rats (Salford et al. 2003) and changes in the EEG of the rabbit (Marino et al. 2003). It have been reported alterations in the brain of rats not only at the biochemical level but also at that of the glial cells. There is evidence of molecular alterations in the rat's brain due to GSM mobile phones after an acute exposure to high power 900 MHz micro waves (Mausset-Bonnefont et al. 2004). Also, the effects of 900 MHz electromagnetic exposure on cochlear cell functionality in rats are evaluated as a distortion product due to otoacoustic emissions by Galloni et al. (2005). In this work, in order to evaluate the influence of mobile phones on the human brain, we give the EEG recording an essential role as a working tool, (Krause et al. 2004; Lin 2004; Curcio et al. 2005; Loughran et al. 2005). The EEG is a representative signal containing information about the condition of the brain. The shape of the wave may contain useful information, hence Croft et al. (2002), found that EMF exposure decreased 1–4 Hz activity in right hemisphere sites, and was associated with increasing 8–12 Hz activity as a function of exposure duration in the midline posterior sites. Along the same lines, Kramarenko and Tan (2003), used a telemetric EEG, and found that within 20–40 s of exposure to a 900 MHz phone signal subjects showed slow-wave activity in the contralateral, frontal and temporal areas. They lasted for one second and were repeated every 15–20 s. When the signal stopped, the slow waves progressively disappeared in the next 10 min. Furthermore, Cook et al. (2004), suggested that 30% of the variation in alpha activity seen in their study were due to the pulsed magnetic field exposure and also, Papageorgiou et al. (2004), found that baseline EEG energy was greater in males, while exposure to EMF decreased EEG energy of males and increased that of females. There were not statistically significant differences in memory performance between men and women, nor was there any difference between exposed and non-exposed states. Additionally, in a small pilot study, Hamblin, et al. (2004), found some evidence of neural activity as a result of mobile phone exposure during an auditory task. Moreover, the effects of EMF emitted by mobile phones on human EEG were studied during an auditory memory task. The energy was found concentrated at the four basic bands. The results show evidence of a strong gender radiation interaction effect on the EEG energy and on the peak amplitudes within each of the four rhythms (Nanou et al. 2005). The EEG analysis performed with three different methods showed that statistically significant changes occur in the EEG rhythms, energy and dynamics between 12 and 30% of subjects. The results suggest that microwave exposure affects part of the population and can have an impact on health (Hinrikus et al. 2006). This research is aimed at providing evidence of electromagnetic induction from mobile phones, in proximal field, to the human brain by comparing the EEG of healthy normal individuals with that of cochlear deaf, regardless of sound stimulus (sound waves).

2 Materials and methods

We have followed the protocol (patterns), as in previous experiences in our laboratory, as to the subjects, procedures, materials (Faraday screen, mobile phones, electroencephalograph and recording), etc. For more details, see Bardasano et al. (2005, 2006), Goya (2007).

2.1 Subjects

We have carried out this study on 24 individuals in two groups, (12 healthy individuals and 12 suffering from cochlear deafness).

2.2 Procedure

Each subject is placed inside the Faraday chamber and comfortably seated on a plastic chair. The mobile phone is held over the right ear by an insulated device 2 cm from the auricular to avoid a thermal effect as much as possible. By means of the EEG, we tested the effects of the mobile phone on the subjects as follows: basal EEG activity, with eyes closed, for 5 min; each subject was recorded while listening to a 5-min conversation with the phone placed on the right ear.

2.3 Materials

2.3.1 Mobile phone

Technical specifications: Global System Mobile Communication (GSM) class 4 (2 W), 880–960 MHz frequency band, *which* is a proximal field in relation to the subject. Specific Absorption Rate (SAR), highest value, 0.955 W/kg.

2.3.2 Electroencephalograph and recording

A digital EEG, with system plus software, model: SAM 32 FOFC I (latest version) by Micromed®, which incorporates *amplitude* and frequency maps, was employed. EEG signals were collected from 18 channels and filtered with a band filter.

2.3.3 Statistical analysis

In order to assess our EEG results, we have applied the FFT (Fast Fourier Transform) mathematical analysis.

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3 Results

In healthy and cochlear deaf individuals, we find assimilation or integration of the mobile phone signal in some electrodes. This is due to the increase of the amplitudes of alpha and theta waves. By correlating the spectra of frequencies of corresponding EEG records for the same areas, significative differences for both groups are not observed (see Fig. 1).

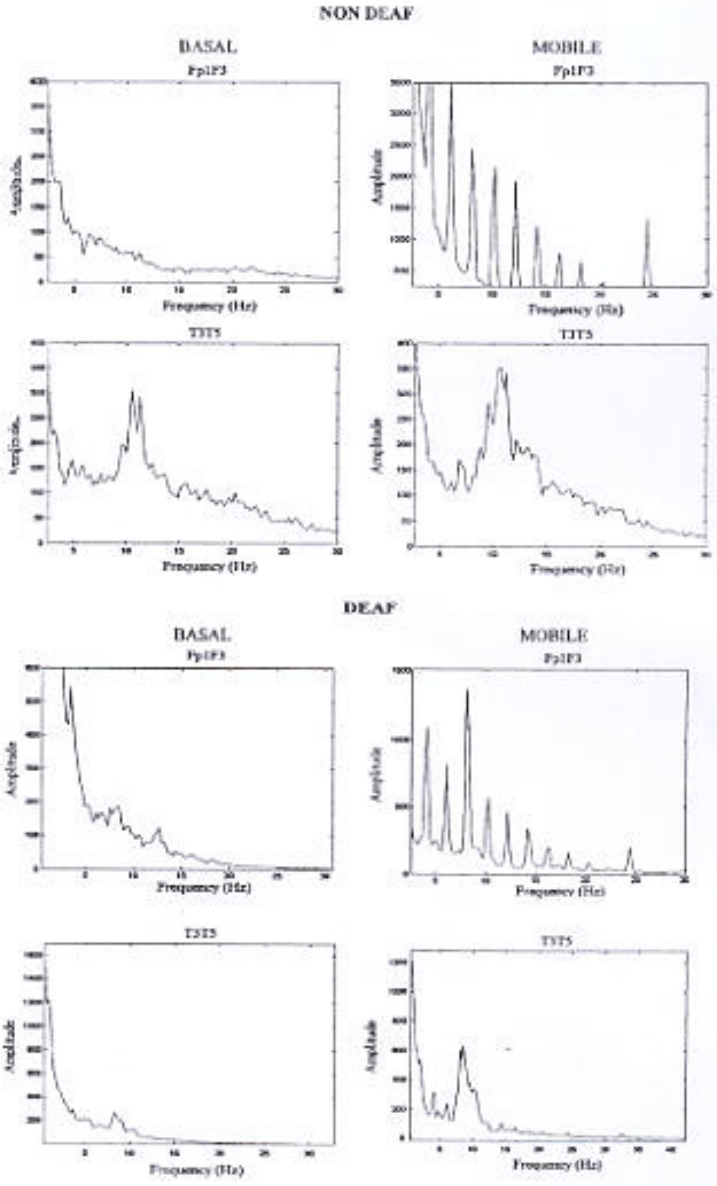

Fig. 1 Spectrum of EEG frequencies obtained: BASAL—in basal position (electrodes Fp1F3 and T3T5), MOBILE—with the mobile on and listening (electrodes Fp1F3 y T3T5), for both, deaf and non-deaf

4 Discussion

Our discussion focuses on physiological interpretation and on methodological observation.

4.1 Physiological interpretation

During transduction of external signals, FFT analysis shows that a healthy subject's brain behaves in two ways to

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the signal from the mobile phone. It rejects the incoming signal or integrates it by making it its own, and generates another signal as a response. This is done by increasing the spectral power density of the incoming signal which implies an increase of energy without altering the frequencies. This means that a larger number of neurons are being activated underneath than at the basal phase for the same activated frequencies. In short, the brain responds by yielding signals which lead to the generation of alpha and theta rhythms. The EEG response of the cochlear deaf is similar to that of the healthy subject with the phones on. For both groups, the behaviour of the EEG towards the signal from the mobile shows that it can either be integrated in the brain or it appears in the spectrum of frequencies of the typical peaks of mobile phones which overwhelm the normal brain signal, on the same recording electrode and for the same subject at a given time. Let us call *integration* the capacity for assimilating, processing an incoming signal, and for emitting another signal as a response. Given that, the sound waves do not seem to affect the integration of such a signal in the brain.

4.2 Methodological observation

Research on the harmful bioeffects of mobile phones on the brain faces one of its challenges; that is, to avoid suffering, lesion, and death of the neurons. Neuroprotection is a way of guarding neurons which, for different reasons, have their death scheduled. We find several programs in the central nervous system which schedule the death of mobiles, which are activated by internal alterations (genetic features of the patient) or external (biological, chemical, such as exposure to toxins, heavy metals in drinking water, pesticides, and others, and physical elements such as artificial and uncontrolled electromagnetic fields. (Bardasano et al. 2005) The EEG shows the influence of mobile phones on man. In the field of Biomedical Engineering, research should contemplate at least the following aspects: (a) The General Adaptation Syndrome to changes in the state of mater and energy. Those changes take place in the environment of living beings, bearing in mind the threesome 'oppressor, depressor, stressor', adverse hypersensitive reactions and the microwave syndrome. (b) Electromagnetic Compatibility. In the field of the modern theory of the signal, the task is to observe machines or systems in good working condition and the human body, itself as a system, (the inductive influence of electromagnetism from a mobile phone and the bioelectromagnetism of the human brain). (c) The Physiology of Regulatory Systems and Chronobiology. To avoid alterations in the permeability of the hematoencephalic barrier or chronopathologies due to alteration of circadian rhythms, (waking and sleeping states), among others, due to this inductive influence. By comparing the EEG data from mobile telephones, an increase in amplitude of alpha and theta waves, regardless of the sound, has been observed. This suggests an inductive direct non-thermal effect on the brain from the mobile telephone signal.

Acknowledgements This project was carried out thanks to the collaboration of Bioelectromagnetism European Foundation (BEF), BIOECODEFENSA 7, L.S. and sponsored by SIEMENS, AG.

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