FINAL REPORT: EXAMINATION OF THE EFFECTS OF LOW FREQUENCY MOBILE PHONE EMISSIONS ON EEG-RECORDED BRAIN ELECTRICAL ACTIVITY

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1. STATE OF RESEARCH

1.1 Research activities performed, milestones and deliverables accomplished

Work began on the project in December, 2002 and during the first year, Jon Dobson's PhD student, Ms. Sarah Verscheuren, began work on the project together with Profs. Wieser and Dobson. First year work consisted primarily of re-building the exposure system and writing new software to control the electronics with embedded protocols for blind experiment conditions. In addition, we made some measurement of low frequency phone signals and conducted a literature review on the nature of these signals. After re-designing and programming the exposure system, experiments were performed on seven mesial temporal lobe epilepsy (MTLE) patients at the University Hosptial – Zurich in Year 1. In Year 2, three more MTLE subjects were evaluated. The bulk of the data analysis was conducted at Keele using newly purchased Focus EEG software to analyze spectral power density changes due to 2Hz DTX simulated exposure.

During the course of the project, the research produced several significant results and one major conference publication. We are currently preparing a further paper for submission to an international peer-reviewed journal. The following milestones were achieved:

- Re-build, calibration and testing of the human EMF exposure system
- Software design and programming for exposure system control and embedded exposure protocols
- Preliminary analysis of low frequency field components from a variety of phones
- Literature search and review on the nature and magnitude of discontinuous transmission (DTX) signals
- Presented results at the 3rd International Workshop on Biological Effects of EMFs, Kos, Greece, 2004.

1.2 Findings

1.2.1 Introduction and Protocol

In this study, the brain electrical activity of a total of 10 subjects with MTLE were evaluated from EEG recordings from both scalp and implated (foramen ovale) electrodes. Patients were exposed to 2 Hz pulsed magnetic fields of 60 µT [1,2] using a modified Helmholtz coil system under computer control (Please see annex for details of the exposure system). Subjects were exposed to the following protocol designed to simulate DTX exposure during normal mobile phone use. The protocol was embedded into the control software so that the experimenter did not have any control over the application of magnetic fields, providing blind experimental conditions.

Initial magnetic stimulation experiments conducted on three subjects, were exposed to a protocol consisting of a 5 min. control period, followed by two trains of 900peaks of a 60µT / 2Hz magnetic field, separated by a 1 min. control period. This was then followed by another 5 min. control period (Fig. 1).

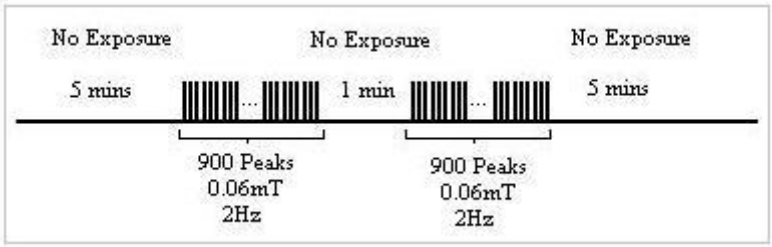

Fig1: Protocol of DTX exposure as applied to 3 subjects (BK, RJ, BJ)

All three subjects (BK, RJ, BJ) underwent the experiment twice, the first experiment separated from the next by a 24-hour interval of rest. After a preliminary evaluation of results, the protocol was adjusted to allow for a higher number of exposures. Subsequent patients were subjected to three sets of experiments using the protocol shown in Figure 2 to produce N=12 exposures.

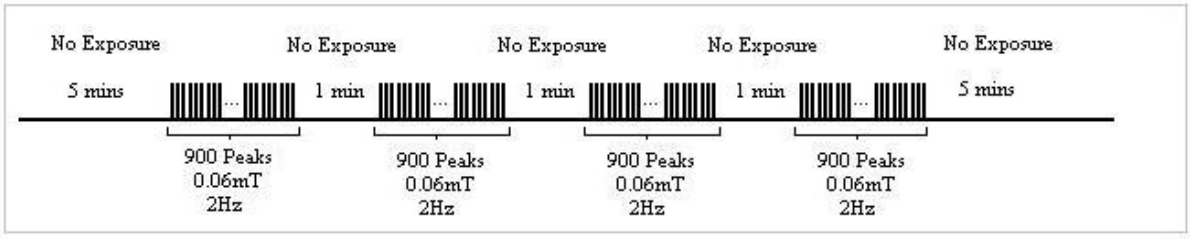

Fig2: Protocol of DTX exposure as applied to 2 subjects (SG, IR)

1.2.2 Results

Subjects exposed to the first protocol showed significant increases and decreases in EEG power spectral density at various brainwave frequencies. The most consistent results was a demonstrated increase in electrical activity in the gamma band [3].

Statistical analysis of the patients exposed to the second protocol were more robust due to the higher number of exposure and control periods. The main finding from this group is that EEG activity appears to be depressed with exposure in some patients, particularly in the delta and theta bands and increased in other. Though these results are significant, it highlights the fact that individual responses are likely to vary.

1.2.3 Conclusions

At this stage of preliminary analysis several observations can be made. Significant differences between the average spectral power density prior to and after the application of 900 peaks of a 0.06mT 2Hz DTX signal seem to occur mostly on the side of the brain where the epileptic focus can be found. SG and BJ both have the epileptic focus on the left side, and we see a general decrease in electric neuronal activity (power density) at this side of the brain. RJ, however, has an epileptic focus in both left and right temporal lobes, and though the results were not significant following the Mann-Whitney test for differences, changes can be seen on both sides for 4 of the 5 frequency bands. Again, the response follows a pattern of decreased power density. This trend, however, does not seem to be followed by BK and IR. Both have the epileptic focus on the right, and though significant differences are seen on both right and left side in BK, the only significant response in IR seems to occur in the left FO. Instead of a decrease, we here see an increase in power density after the application of DTX.
Pin-pointing a time-point at which the response to these magnetic fields occurs is difficult. These seem to differ from subject to subject and vary for different frequency bands. More detailed analysis to clarify this is underway.

It is obvious from the results that the ability to register the EEG via semi-invasive electrodes offers a great advantage as much of the electrical activity in the brain is attenuated in scalp electrodes. Although some responses are picked up by the scalp electrodes, most of the information gathered in this experiment is derived from the more sensitive FO electrodes. As such, the application of these electrodes as a tool of measurement for the effects of environmental magnetic fields is a success. It is crucial, however, to perform these experiments on healthy subjects as a control, though the sensitivity of the measurements will be limited to the use of scalp electrodes. Work is currently underway to gather both more invasive recordings as well as control data.

References:

1. Pedersen G.F., Andersen J.B., (1999) "RF and ELF exposure from cellular phone handsets: TDMA and CDMA systems", *Rad.Prot.Dos.* 83, 131-138.
2. Dobson J, St.Pierre TG (1996) Application of the ferromagnetic transduction model to D.C. and pulsed magnetic fields: effects on epileptogenic tissue and implications for cellular phone safety. Biochem.Biophys.Res.Comm. 227, 718-723.
3. Verschueren, S, HG Wieser, J Dobson (2004) Preliminary analysis of the effects of DTX mobile phone emissions on the human EEG. *Proceedings of the 3rd International Workshop on the Biological Effects of EMFs* Kos, Greece, In Press.