

Final Report

Project reference: FSM 2-02-6
Applicant's name: Peter Achermann
Project title: Dose-effect relationship of electromagnetic field strengths ("handset-like" GSM signal) on sleep and sleep EEG

1. State of Research.

1.1 Research activities performed, milestones and deliverables accomplished

Please list against the background of the research proposal.

The study protocol was submitted to the ethical committee on February 20, 2004 and approval was granted on March 6, 2004 with a request for additional information. The requested information was provided on March 30, 2004.

Subject recruitment started on March 9, 2004 and the screening of subjects started on March 24, 2004.

The exposure set-up was designed and constructed by IT'IS. The equipment was installed, tested and calibrated one week prior to the start of the experiments. Randomisation and blinding of the subjects was also performed by IT'IS.

The experimental phase took place between April 19, 2004 and June 11, 2004. Fifteen subjects were investigated under 3 different exposure conditions (0.2 W/kg, 5 W/kg, sham).

After completion of the experiments, visual sleep stage scoring was performed. Cognitive performance of the subjects during exposure and sleep and the sleep EEG following exposure were statistically analyzed. The manuscript was submitted on December 21, 2006.

1.2 Findings

Comment on achieved scientific insights.

Increasing evidence suggests that pulse-modulated radio frequency electromagnetic fields (RF EMF) may alter brain physiology. Whereas effects of RF EMF emitted by mobile phones on the human non-REM sleep electroencephalogram (EEG) have been consistent, information on the relation between field intensity and the magnitude of RF EMF induced effects on human brain physiology is still lacking. To establish a dose-response relationship, we investigated the influence of RF EMF exposure by varying the signal intensity in three experimental sessions. The exposure conditions were applied at weekly intervals in a randomized, double-blind crossover design. Immediately prior to an eight hour nighttime sleep episode, the head of fifteen healthy young men was unilaterally exposed for 30 min to either a handset-like RF EMF with a 10 g-averaged peak spatial specific absorption rate of 0.2 W/kg or 5 W/kg, or to a sham control condition. During exposure, subjects performed two series of cognitive tasks in a fixed order (simple reaction time task (SRT), two choice reaction time task (CRT), and N-back task). Nighttime sleep was polysomnographically recorded (EEG, EMG, EOG, ECG). Whereas sleep architecture was not affected by EMF exposure, analysis of the sleep EEG revealed a dose-dependent increase of power in the spindle frequency range in non-REM sleep. Reaction speed decelerated with increasing field intensity in the 1-back task, while accuracy in the CRT and N-back task were not affected in a dose-dependent manner. In summary, this study reveals first indications of a dose-response relationship between EMF field intensity and its effects on brain physiology as demonstrated by changes in the sleep EEG and in cognitive performance.

1.3 Problems

Expand on research, financial or schedule problems, if any. For the intermediate report: please include problems that might occur in the upcoming period.

This part of the report must not exceed one page (intermediate report) and two pages (final report).

The project was carried out as planned. No fundamental changes were made in the original proposal and no major problems were encountered.

In the original proposal, we intended to expose subjects at a SAR of 10 W/kg and of 0.1 W/kg. Because dosimetry is afflicted with uncertainty, we decided to expose subjects maximally at 5 W/kg and correspondingly at 0.2 W/kg. This way we could ensure that the exposure limit of 10 W/kg for occupational exposure was never exceeded. Furthermore, we enhanced the chances to obtain approval of the study by the ethical committee.

In addition to the original proposal, we included cognitive tests during exposure to assess whether cognitive performance is affected in a dose-dependent manner.

We could record only 15 subjects. Unfortunately, one subject dropped out of the study on short notice. We immediately screened another person who agreed to participate but then withdrew one day before the start of the experiment.

Polysomnographical data of one experimental night were lost due to a computer crash. The recording was repeated under the respective condition at the end of the experimental phase.

The start of the study had to be delayed, as other studies were ongoing in the laboratory (shortage of space) and as additional funding needed to be raised (funding by the Swiss Research Foundation on Mobile Communication covered only part of the project costs). An additional delay occurred because the research team was performing the TNO follow-up study (FSM Project A2004-0). Thus, the final analysis and writing of the paper was postponed until the follow-up study was completed and published.

2. Annex

2.1 Publications

Please enclose the scientific publications produced in the context of the project.

Preliminary results were presented at two scientific meetings:

Regel SJ, Tinguely G, Schuderer J, Adam M, Kuster N, Landolt H-P, Achermann P (2006) Dose-dependent effects of pulsed RF EMF on sleep, the sleep EEG and cognitive performance. In: Abstract Book, The Bioelectromagnetics Society, 28th Annual Meeting, Cancun, Mexico, pp. 451-452 (oral presentation).

Regel SJ, Tinguely G, Schuderer J, Adam M, Kuster N, Landolt H-P, Achermann P (2006) Pulsed electromagnetic fields: dose-dependent effects on sleep, the sleep EEG and cognitive performance. J Sleep Res 15(Suppl 1): 171 (poster presentation).

Final results were recently published in a peer-reviewed journal:

Regel SJ, Tinguely G, Schuderer J, Adam M, Kuster N, Landolt H-P, Achermann P (2007) Pulsed radio-frequency electromagnetic fields: dose-dependent effects on sleep, the sleep EEG and cognitive performance. J Sleep Res 16(3): 253-8.

2.2 Documents

In case publications are not yet available or cover only part of the funded research, please include:

- submitted papers (confidentiality is secured), or
- concise internal documents that inform about your research work, or
- a short progress (2-3 pages) or final report that summarises the state of research

Date and Signature



28. November 2007