

# Final Report: Effects of EMF of type GSM on sleep EEG and regional cerebral blood flow (rCBF)

Research Cooperation "Sustainable Mobile Communication"

Original title:

**Auswirkungen elektromagnetischer Felder des Typs GSM auf Schlaf, Schlaf-EEG und regionale Hirndurchblutung**

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## 1 State of Research

### 1.1 Research activities performed

**Background:** In two previous studies (Borbély et al., 1999; Huber et al., 2000) we demonstrated that electromagnetic fields (EMF) emitted by mobile phones affect brain physiology of healthy young subjects. They were exposed to EMF either during sleep or during the waking period preceding a daytime sleep episode.

**Sleep study:** One key question that remained open was whether the modulation or the carrier frequency were responsible for the observed EEG effects. This question was addressed in the present project. Sixteen subjects were exposed unilaterally to EMF (900 MHz; spatial peak SAR 1 W/kg) for 30 minutes or sham exposed prior to a nighttime sleep episode in a double-blind cross-over design. Two active conditions were applied: continuous wave (CW, no modulation) and pulse modulation (PM, 1/8 duty cycle, "handset-like"). The three experimental conditions (sham, CW and PM) were separated by one week.

**PET study:** We aimed to examine which areas of the brain are most affected by local exposure to EMF. Sixteen subjects were exposed unilaterally to EMF (900 MHz; spatial peak SAR 1 W/kg) or sham exposed for 30 minutes. Two active conditions were applied: a pulse modulated EMF with 1/8 duty cycle ("handset-like") and one with 7/8 duty cycle ("base-station-like"). Three H<sub>2</sub><sup>15</sup>O PET-scans were performed at 10-min intervals. Due to scanner problems only 12 subjects completed all 3 conditions. The remaining subjects underwent at least the sham and one active condition.

**Dosimetry:** The distribution of the specific absorption rate (SAR) within the head was simulated for the field conditions of two previous studies (symmetrical exposure: Borbély et al., 1999; unilateral exposure, corresponds also to present study: Huber et al., 2000).

### 1.2 Findings

**Sleep study:** "Handset-like" pulse modulated EMF exposure enhanced EEG power in the alpha frequency range in waking prior to sleep onset and in the spindle frequency range during stage 2 sleep. Exposure to EMF without pulse modulation did not enhance power in the waking or sleep EEG (Huber et al., J. Sleep Res., in press).

**PET study:** "Handset-like" pulse-modulated EMF exposure increased relative rCBF in the dorsolateral prefrontal cortex ipsilateral to exposure (Huber et al., J. Sleep Res., in press). Analysis of the "base-station-like" pulse-modulated EMF exposure is in progress.

**Conclusions:** Our results show for the first time that (1) pulse modulated EMF alters waking rCBF and (2) pulse modulation of EMF is necessary to induce waking and sleep EEG changes. Pulse-modulated EMF exposure may provide a new, non-invasive method for modifying brain function for experimental, diagnostic and therapeutic purposes.

**Dosimetry:** Simulations revealed that in both experimental conditions (symmetrical and asymmetrical exposure) exposure of deep brain structures (including thalamus) was comparable to that of the cortex. This may indicate that EMF-induced changes in deeper brain structures may be responsible for the observed EEG effects (Huber et al., submitted).

## 2 Publications

### 2.1 Papers

One paper has been accepted for publication and will be published in December 2002 (Huber et al., in press). It reports the main findings of the sleep and PET study, which were supported by the research cooperation. A reprint will be provided after the appearance of the paper.

Another paper (Huber et al.) has been submitted to *Bioelectromagnetics* (copy provided with intermediate report). The paper is currently in revision. The simulation of the distribution of the SAR within the brain was supported by the current grant. The actual experiments, which are reported in this paper, were funded by other sources.

An additional paper to report the effects of all EMF exposure conditions on rCBF is planned.

### 2.2 Abstracts

Abstracts of preliminary data have been published and reported at international scientific conferences:

13th Congress of the European Sleep Research Society (ESRS) in Reykjavik, Iceland, June 2002 (Huber et al., 2002a).

16th Annual Meeting of the Associated Professional Sleep Societies (APSS) in Seattle, USA, June 2002 (Huber et al., 2002b).

24th Annual Meeting of the Bioelectromagnetics Society (BEMS) in Quebec, Canada, June, 2002 (Schuderer et al., 2002).

## 3 References

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