# The Effects of 884 MHz GSM Wireless Communication Signals on Self-reported Symptoms and Sleep — An Experimental Provocation Study

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**Abstract**— In the current study we assessed possible effects of prolonged (3 hours) exposure to 884 MHz GSM wireless communication signals on self-reported symptoms, cognitive function, and electroencephalographically (EEG) recorded sleep. The study group consisted of 36 women and 35 men. Twenty-two women and sixteen men reported symptoms they specifically related to mobile phone use (SG). The rest of the participants reported no mobile phone-related symptoms (NG).

Potential participants volunteering for the study were evaluated by physicians, including some biochemical assessments, to rule out medical conditions that could interfere with study variables of interest. Once selected, participants spent three different sessions in the laboratory. The habituation session was followed by two subsequent sessions. In these subsequent sessions, subjects were either exposed to sham exposure (sham) or 884 MHz GSM wireless communication signals for 3 hours (an average of 1.4 W/kg including periods of DTX and Non-DTX. Exposure directed to the left hemisphere). Data was collected before, during and following the exposure/sham sessions. Data collected included self-reported symptoms, including headache, cognitive function, mood, and electroencephalographic recordings.

During actual exposure, as compared to sham exposure, sleep initiated one hour after exposure was affected. There was a prolonged latency to reach the first cycle of deep sleep (stage 3). The amount of stage 4 sleep was also decreased in exposed subjects. NG subjects reported more headaches during exposures vs. sham exposure. Neither group (SG and NG) was able to detect the true exposure status more frequently than by chance alone.

The study indicates that during laboratory exposure to 884 MHz wireless signals, components of sleep, believed to be important for recovery from daily wear and tear, are adversely affected. Moreover, participants that otherwise have no self-reported symptoms related to mobile phone use, appear to have more headaches during actual radiofrequency exposure as compared to sham exposure. However, subjects were not able to detect the true exposure status more often than would have been expected by statistical chance alone.

Additional self-reported findings, biochemical, performance and electrophysiological data are currently being analyzed. Possible health implications from the findings will also be further explored.

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## 1. INTRODUCTION

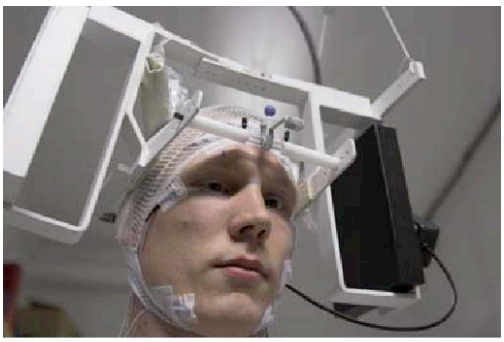
There have been a number of scientific reports concerning the possible relationship between exposure to radio frequency fields (RF) during mobile phone use and self reported symptoms, such as skin sensations, cognitive symptoms, headache, dizziness and sleep disturbances (1–9). However, prior laboratory-based RF exposure studies have been of short-term duration, commonly focusing only on a few outcome variables of interest, and rarely combined self-reported, performance, neurophysiological and neuroendocrine parameters. In order to better understand biological mechanisms behind a possible association between RF exposure and self-reported symptoms, neurophysiological and cognitive responses, we believe a more comprehensive exposure and assessment strategy is needed.

At the previous PIERS meeting in Cambridge, MASS, USA, 2006 we presented the design and methodology of an ongoing double-blind controlled laboratory study with the objective to establish whether RF during mobile phone use had any direct effects on: (1) self-reported symptoms,

(2) cognitive symptoms, (3) stress hormones, (4) performance and subsequent sleep and electroencephalogram (EEC). Furthermore, we wanted to establish whether the subjects with self-reported symptoms attributed to mobile phone use (SG) would be able to differentiate exposure conditions from sham, compared to the non symptomatic subjects (NG).

## 2. METHOD

The exposure set up exposed the left head hemisphere to a GSM signal (884 MHz) at an average of 1.4 W/kg including periods of DTX and Non-DTX (Fig. 1). The exposure was designed to be consistent with worst case exposure occurring in real-life situations, but with extended duration. The exposure laboratory consisted of two separate rooms. In each room, the respective exposure area was shielded with screens, covered with absorbing material. RF and EMF background assessments were conducted prior to initiating the actual study, and quarterly in order to ensure the background field environment in the laboratory was in agreement with specifications in the research protocol. All mobile phone use outside the exposure laboratory was eliminated during exposure sessions. Each exposure session lasted for 3 hours. Three sessions were conducted for each subject, one habituation session and two exposure sessions. The exposure sessions were randomly selected for Sham and RF exposure. During the sessions participants carried out performance and memory tests, scored self-reported symptoms and state of mood. Discrete Likert-type scales were used in the symptom scoring questionnaires. Typically the ratings ranged from 1, indicating "not at all" to 7, "a high degree" or from "disagree strongly" to "agree strongly". After completed exposure the subjects were EEG (electroencephalogram) recorded as they slept in a sleep laboratory. During the subsequent morning additional test were performed before they left the laboratory.



Subject during exposure

Figure 1: Picture of the actual exposure set up, showing the 884 MHz GSM wireless exposure unit (black box).

## 3. MATERIAL

The final study group consisted of 71 subjects, age between 18–45 years, where 38 subjects fulfilled the study criteria for SG (22 women and 16 men) and 33 subjects were classified as NG (14 women and 19 men). All subjects reported using their mobile phones daily. The speaking time ranged from five minutes to more than three hours.

## 4. RESULTS

Sleep initiated one hour after exposure was found to be affected. Under the RF exposure condition, participants exhibited a longer latency to deep sleep (stage 3, meanRF=0.37, (SD=0.33), meanSham=0.27 hours (SD=0.12); F=9.34, p=0.0037). The amount of stage 4 sleep was also decreased (meanRF=37.2 minutes (SD=28), meanSham=45.5 minutes (SD=28); F=10.7, p=0.0019).

For headache, random effects logistic regression was used. Preliminary results reveal a significant interaction effect for exposure and group. The NG reported less headache during sham exposure compared to the SG. The proportion of subjects who reported headache was higher during RF exposure than during sham exposure in the NG but not the SG group. Participants were not able to differentiate RF exposure conditions from sham exposures more often than would have been

expected by statistical chance alone. Neither were there any statistically significant differences between the SG and NG in reliable detecting results.

## 5. DISCUSSION

Our results suggest that RF exposure under these conditions is associated with adverse effects on sleep quality within certain sleep stages. The strengths of this study compared to earlier studies are the longer exposure time during worst conditions and a wider range of outcome variables, including self-reported, neuroendocrine, and neurophysiological variables. There are a number of possible factors that need to be considered when interpreting the results. One being that the exposure laboratory was not fully shielded. However, the shielding walls provided sufficient protection for indirect exposure between the two rooms. Considering this and other possible confounders, we still conclude that there are statistical associations between RF exposure and specific self-reported and neurophysiological variables, pertinent to the current discussions of possible effects from mobile phone-generated RF exposure. Future analysis of the current study will further assess various biological, neurophysiological, and cognitive outcome measures, e.g., spatial memory, performance, and EEG data. We will also attempt to assess the possible clinical relevance of the observed findings.

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