Pulse-modulated radio frequency electromagnetic fields affect human brain physiology

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Abstract

Pulse-modulated (pm) radio frequency electromagnetic fields (RF EMF), such as emitted by mobile phones, can alter brain physiology. In recent years, we investigated the effects of GSM like exposure on the electroencephalogram (EEG) during sleep and wakefulness, on waking regional cerebral blood flow (rCBF), and on cognitive performance. Exposure to pm RF EMF consistently increased spectral power of the non-REM sleep EEG in the spindle frequency range and in the alpha range of the waking EEG. A recent study revealed first indications of a dose-response relationship between RF EMF field intensity and the magnitude of change in the EEG. Relative rCBF was increased in the dorsolateral prefrontal cortex ipsilateral to the exposure side. Furthermore, cognitive performance was affected during exposure. Our data provide evidence that pulse modulation of RF EMF is crucial to induce changes in brain activity.

1. Introduction

Usage of mobile phones is rapidly increasing and there is rising concern about possible adverse health effects of radio frequency electromagnetic field (RF EMF) exposure at intensities even below the international exposure limits. In recent years we investigated the effects of RF EMF on the electroencephalogram (EEG) during sleep and wakefulness, on waking regional cerebral blood flow (rCBF), and on cognitive performance. In six studies, we applied different types of RF EMF: a pulse-modulated EMF (pm-EMF, 'handset-like' signal), approximating the spectral content emitted by GSM mobile phones, and a 'base station-like' signal, approximating the signal emitted by a GSM base station (carrier frequency 900 MHz). These two exposure conditions included the same ELF modulation components; however, the spectral power of these components was considerably higher in the handset-like signal (for signal characteristics see [1]). Furthermore, we used a non-modulated continuous-wave signal (cw-EMF), as well as a sham exposure, which served as a control condition. Most experiments were performed with a spatial peak specific absorption rate (SAR) of 1 W/kg [1-6]. The dose-response relationship was investigated with spatial peak SAR of 0.2 W/kg and 5 W/kg [7].

All experiments were performed in a double-blind, crossover design in the sleep laboratory of the Institute of Pharmacology and Toxicology at the University of Zurich. Healthy, young men were exposed during an entire night-time sleep episode to an intermittent radiation schedule [2] or for 30 min during the waking period prior to waking or sleep EEG recordings [1, 3-7].

2. Effects on the EEG

We consistently observed that exposure to pm RF EMF increased spectral power of the non-rapid-eye-movement (non-REM) sleep EEG in the spindle frequency range [2-5, 7]. In line with these findings, the most recent study revealed first indications of a dose-response relationship between RF EMF field intensity and the increase in spindle frequency activity [7]. Exposure to pm RF EMF also increased spectral power in the alpha frequency range prior to sleep onset [4] and 30 min after exposure in relaxed wakefulness [6]. No effects were observed for cw RF EMF exposure [4, 6].

3. Effects on regional cerebral blood flow (rCBF)

'Handset-like' RF EMF exposure increased relative rCBF in the dorsolateral prefrontal cortex ipsilateral to the exposure side [1, 4]. The effect depended on the spectral power in the amplitude modulation of the RF carrier such that only 'handset-like' RF EMF exposure with its stronger low-frequency components but not the 'base-station-like' RF EMF exposure affected rCBF.

4. Effects on cognitive performance

In a first study, we observed a significant 'condition' effect on speed during pm-, but not during cw-exposure in two out of five investigated tasks (2- and 3-back task). Moreover, in the 3-back task, accuracy improved with increasing exposure duration [6]. In a second study, including the same tasks, reaction speed decelerated with increasing field intensity in the 1-back task, while accuracy was not affected in a dose-dependent manner in any of the tasks [7].

5. Summary and Conclusions

Our results provide evidence that the pulse modulation of a RF EMF is crucial to induce changes in the EEG during waking and sleep. Moreover, these changes may outlast the exposure period and may be dose-dependent. Our findings indicate that pm RF EMF may have a non-thermal biological effect. While the effects on the EEG were consistent, results on cognitive performance remain rather inconsistent. However, the underlying mechanisms remain unknown. Thus, conclusions about health consequences of RF EMF exposure are premature.

6. References

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