A2008-08, final summary

CELL PHONES, SLEEP AND COGNITIVE PERFORMANCE

Background

We have good evidence to belief that pulsed Electro Magnetic Fields (EMF) as used for mobile communication are able to interact with the sleep electroencephalogram, in particular in the slow wave (<4.5 Hz) and spindle (12-15 Hz) frequency ranges. We know that these interactions can continue after the exposure and that they seem to be dependent on the pulsed nature of the exposure. Moreover, some initial evidence exists that such pulsed EMF are able to directly induce cortical plasticity, which presumably represents the basic mechanism of learning and memory. There is increasing evidence for a close relationship between learning and sleep. Sleep-dependent performance improvements in specific learning tasks seem to be closely related to sleep spindles and to sleep Slow Wave Activity (SWA, EEG power between 0.75 and 4.5 Hz).

Method

Thus, a major goal of our project is to investigate whether the EMF-induced changes in the sleep EEG are capable of interacting with sleep-dependent learning processes. Modulation of these specific characteristics of Non-Rapid Eye Movement (NREM) sleep using pulse-modulated Radio Frequency Electro Magnetic Fields (RF EMF) and its consequences on post-sleep task performance might reveal further insights into the underlying mechanism. Children and adolescents show increased sleep need. At the same time numerous studies show an increased potential for cortical plasticity in children and adolescents. Together with the increasing concern that children and adolescents are more vulnerable to GSM EMF this provides us a conclusive rational to conduct our experiment in adolescents.

In our experiment, 16 male adolescents were trained on a challenging task immediately before they were allowed to sleep. During sleep, subjects were exposed to short square-pulses of the GSM carrier frequency every 1-3 seconds throughout the night. Next morning the subjects were again tested on the task to assess sleep-dependent performance improvement. Exactly the same procedure was repeated under spurious exposure. The experiment was carried out in the sleep facility of the Institute of Pharmacology and Toxicology at the University of Zurich in collaboration with Prof. Peter Achermann. The EMF exposure set-up was designed by the Foundation for Research on Information Technologies in Society (IT'IS).

Results

We found increased SWA towards the end of the sleep period during the night of exposure to pulse-modulated RF EMF in comparison to the imitation night. Moreover, subjects showed an increased RF EMF pulse-related response in the SWA range. No such changes were observed in the spindle frequency range. During field exposure, sleep-dependent performance improvement in the test task was reduced.

A recent hypothesis ("synaptic homeostasis hypothesis by Tononi and Cirelli, 2006) proposes that the reduction of SWA in the course of sleep reflects a reduction of cortical excitability. Thus, the changes in the time course of SWA during the exposed night may reflect an interaction of RF EMF with the normalization of cortical excitability during sleep, with a possible negative impact on sleep-dependent performance improvement.

Discussion and Conclusions

In summary, the results of our experiment provide insights into the mechanisms of how EMF pulses affect cortical activity during sleep and how this change might translate into changes in cognitive performance.