Individual differences in the effects of the radiofrequency electromagnetic fields emitted by mobile phones on human sleep

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Introduction

The use of mobile phones is continually increasing throughout the world, with recent figures showing that there are currently more than 2 billion mobile phone users worldwide. However, despite the recognised benefits of the introduction and widespread use of mobile phone technologies, concerns regarding the potential health effects of exposure to the radiofrequency (RF) electromagnetic fields (EMF) emitted by mobile phone handsets have similarly increased, leading to an increase in demand for scientific research to investigate the possibility of health effects related to the use of mobile phones. An increasing amount of RF bioeffects research related to mobile phone use has focussed on the possible effects of mobile phone exposure on human brain activity and function, particularly as the absorption of energy in the head and brain region is much higher than in other body regions, which is a direct result from the close proximity of the mobile phone to the head when in normal use. In particular, the electroencephalogram (EEG) and the use of sleep research have become more widely used techniques for assessing the possible effects of mobile phones on human health and wellbeing. The advantage of using the sleep EEG as a measure of biological effects induced by RF fields emitted by mobile phones is that the EEG during sleep is well characterised and routinely used to identify the sleep stages and sleep cycle patterns that a typical healthy individual will move through during the night.

Previous research has shown that the EEG is affected by exposure to RF EMF, with the most consistent findings being an increase in EEG spectral power within the 8 - 14 Hz frequency range in both awake and sleep states during and/or following exposure [1-10]. In regards to sleep, the enhancements reported have not been entirely consistent, with some early studies failing to find an effect, while more recent studies have reported that the effect differs in terms of particular frequency range. We previously reported increased EEG power during the initial period of sleep in the 11.5 – 12.25 Hz frequeny range following 30 minutes of mobile phone exposure [9]. This supported changes in one frequency range that had been previously reported, however, did not confirm changes in other ranges that have also been reported in the literature previously. Therefore, it was hypothesised that this discrepancy could be due to the variation that occurs between different individual's alpha frequency in the EEG, and corresponding to this, different individuals alpha frequencies in the different studies. In order to test this possibility and ensure that such results were not merely chance, the current study re-tested a sample of participants who took part in the original study.

Materials and Methods

Nineteen volunteers (7 males, 12 females; mean age = 27.9 years, SD = 6.8) who had participated in the original study [9] consented to be retested in the current follow-up study. Participants slept three consecutive nights in a sleep laboratory - the first was an adaptation night, and the second and third nights were experimental nights. During sleep, EEG, ECG, EOG, EMG, SaO2 were monitored, with respiratory measures also monitored on the adaptation night. On the experimental nights a GSM mobile phone, either transmitting (active) or turned off (sham), was mounted on the right side of the head, in a position that simulated normal use, for a period of 30 minutes prior to sleep. The experiment was conducted double-blind in regards to the status of the phone. The mobile phone was a Nokia 6110 (pulse modulated at 217 Hz, 894.6 MHz output) which was set via laptop and manufacturer software to continuously transmit at a mean power output of 250 mW (peak power of 2 W). Measurements of specific absorption rate (SAR) were conducted inside a Specific Anthromorphic Mannequin (SAM) phantom using a precision robot RF Dosimetric Assessment System (DASY4). The resulting peak spatial SAR averaged over 1 g of the cortex was 0.19 W/kg.

EEG channel data were analysed to provide power spectral density estimates (FFT routine, Hanning window, averages of 4-second epochs) for the first 30 minutes of the first NREM period, from the same montage as was reported in Loughran et al, 2005 (the mean of C3 and C4). For statistical purposes, participants were divided into two groups based on whether their EEG power in the 11.5 – 12.25 Hz frequency range increased (Increasers) or decreased (Decreasers) in the original study [9]. Based on the results from Loughran et al, 2005, directional t-tests were employed to test for an overall increase in the 11.5-12.25 Hz band, and for more of an increase in this frequency range (active/sham ratio) in the Increasers group as compared with the Decreasers group.

Results

Of the nineteen participants that returned for the re-testing, 8 were Increasers and 11 were Decreasers. In spite of this, the nineteen participants as a group exhibited more 11.5-12.25 Hz power in the active exposure condition than the sham condition ($t[18]=1.77$; $p=0.038$). Further, the active condition resulted in more of an increase in the 11.5-12.25 Hz band in the Increasers than the Decreasers ($t[17]=1.84$; $p=0.042$).

Discussion

Employing a strong methodology, the current findings support previous research that has reported an effect of mobile phone exposure on the EEG during NREM sleep. Further, it provides strong evidence that the effect of exposure to the RF EMF emitted by mobile phones is different for different people. The current findings may help to explain why results have been somewhat inconsistent in the past, and suggests that rather than effect sizes being small, mobile phones may have large but differential effects on different people. This also highlights the importance of taking into consideration inter-individual variability in RF bioeffects research, particularly in relation to studies involving measurements of sleep and the EEG, as overall effects could be influenced by factors such as different individual responses to exposure or the indivdual alpha frequency in the EEG of the participants. For example, differences in response to RF EMF exposure could help to explain why some previous studies have shown overall effects of exposure on the EEG and others have not. Furthermore, differences in individual alpha frequency could also be an important factor, explaining why some previous studies have continued to find similar effects on the EEG during NREM sleep, with positive results tending to differ only in terms of frequency range.

The results of the current study add to the increasing evidence that exposure to RF EMF, such as that emitted by mobile phones, alters human brain activity during sleep. Additional analyses from this study are currently being conducted and will further assess various individual differences in relation to mobile phone exposure on the human sleep EEG and sleep architecture.

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