Bundesamt
für Strahlenschutz

Spotlight on EMF Research

Spotlight on “Modulation of brain functional connectivity in healthy young adults following GSM radiofrequency exposure: A magnetoencephalography and magnetic resonance imaging study” by Iranfar et al. in Neuroscience (2025)

Category [radiofrequency, human study]

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Competence Centre for Electromagnetic Fields (KEMF)

1 Context

The human brain is potentially exposed to radiofrequency electromagnetic fields (RF-EMF) to a relevant extent when a mobile phone is operated close to the head. Therefore, possible effects of RF-EMF on brain function have been investigated for many years using electroencephalography (EEG). Effects were repeatedly observed in the alpha band of the resting-state EEG (8–12 Hz), but the results were incon-sistent: predominantly, EEG power increased in the alpha band, though in some studies it decreased or remained unchanged [2, 3]. Furthermore, the effects differed between the *eyes closed* and *eyes open* conditions [4].

2 Results and conclusions from the perspective of Iranfar et al.

In the present study [1], the effect of RF-EMF on human brain function was investigated using magnetoencephalography (MEG). This method provides better spatial resolution than EEG with respect to the active regions in the brain.

Thirty-two healthy, right-handed volunteers (15 males and 17 females) participated in the study. The experimental design was a crossover, randomised, double-blind, and counterbalanced study. Two sessions were performed one week apart at the same time of the day. Each session consisted of three periods: baseline (before exposure), exposure, and post exposure. EEG was recorded during all three phases. Because RF-EMF interferes with the MEG sensors, MEG was only recorded before and after exposure. For exposure, a modified Nokia mobile phone generating a GSM signal with a frequency of 900 MHz, modulated at 217 Hz, was used. Real or sham exposure was applied to the left side of the head for 25 minutes and 30 seconds. The phone was operated at 2 W maximum output power (250 mW average power) and the local maximum time average specific absorption rate (SAR) of the real exposure averaged over 10 g of tissue was 0.49 W/kg.

Sixty-eight brain regions were reconstructed from MRI scans of the volunteers' brains. The interconnectivity of these brain regions was measured using the corrected imaginary phase-locking value of the MEG signal, which quantifies phase synchronisation. Interconnectivity refers to the interaction and coordination of neuronal activity in different brain regions. The difference in connectivity between the pre- and post-exposure sessions was calculated in the alpha frequency band for both the sham and real exposures, with the subjects either having their eyes open or closed. The results were statistically evaluated using analysis of variance (ANOVA) with correction for multiple testing.

Following GSM-900 MHz RF-EMF exposure, the ANOVA results revealed 20 statistically significant intra- and interhemispheric connectivity changes in the eyes-closed condition and 8 in the eyes-open condition. After correction for multiple testing, three statistically significant intrahemispheric connectivity changes remained in the eyes-closed condition. All three were localised in the right hemisphere in the region of the temporal lobe. Differences in brain connectivity were statistically significantly greater after real exposure than after sham exposure.

Although the exposure was localised to the left hemisphere, changes in cortical connectivity were observed in the right temporal lobe. As this region belongs to the auditory cortex, Iranfar et al. attribute this finding to the predominantly contralateral processing of auditory information. Iranfar et al. conclude that their findings support previous reports indicating that the alpha frequency band is particularly susceptible to RF-EMF exposure. Given the small amplitude of the modulation of the brain's alpha band, Iranfar et al. assume that there may be short-term changes that are unlikely to have any significant effects on health. They suggest that future research could examine how differences in baseline neural activity between individuals may influence post-exposure responses.

3 Comments by the BfS

In accordance with previous publications, the results of Iranfar et al. [1] revealed statistically significant effects of head exposure to RF-EMF from a modified mobile phone on alpha wave brain activity.

MEG is rarely used to examine the effects of RF-EMF, because it cannot be used during exposure for technical reasons. However, it provides a better spatial resolution than EEG and enables a comparison of the activity in different brain regions. In general, the study adheres to good scientific practice by using a randomised, double-blind, sham-controlled crossover design with appropriate correction for multiple testing, and it innovatively applies state-of-the-art MEG-based source and connectivity analyses.

The observed effects are weak and their health relevance remains undetermined. It remains unclear whether a prolonged exposure would produce larger effects. The weak effects of RF-EMF exposure on brain activity, especially the EEG activity in the alpha band, have been described repeatedly for over twenty years [4]. However, the exact nature (thermal or non-thermal) of the possible action mechanism is still an open question. The findings from the present paper could suggest that effects on the auditory system may be involved. For radiation protection, these findings are relevant because they are in line with the long known weak effects on alpha activity and, by adding spatially resolved connectivity information, provide a basis for more precise, hypothesis driven investigations.

References

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