

Spotlight on EMF Research

Spotlight on “Sex-dependent impact of perinatal 5G electromagnetic field exposure in the adolescent rat behavior” by Bodin et al. in Environmental Science and Pollution Research (2023)

Category [radiofrequency, animal study]

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Competence Centre Electromagnetic Fields (KEMF)

1 Putting the paper into context by the BfS

The 3.5 GHz frequency is currently increasingly being used in the fifth generation of mobile communications (5G). It was previously used for wireless applications such as WiMax (Worldwide Interoperability for Microwave Access), but this technology has not become established. As a result, there is less research available on radiofrequency electromagnetic fields (RF-EMF) at this frequency than at the lower frequencies previously used for mobile telephony or other wireless network access technologies. The present study on pregnant rats and their offspring [1] investigated the influence of 3.5 GHz RF-EMF exposure during pregnancy of the dams and after birth on the development of the young animals.

2 Results and conclusions from the authors' perspective

Seven pregnant rats were randomly assigned to an exposed or sham-exposed group. The RF-EMF exposure was carried out using four antennas positioned above the cages and fed by a signal generator at a frequency of 3.5 GHz (continuous wave). For the incident electric field strength of 62.2 V/m determined by measurements, a whole-body SAR value of 0.07 W/kg was measured in a simplified mouse phantom [2]. This is slightly below the maximum permissible value for the general population (0.08 W/kg [3]). Exposure took place 22 hours per day from day eight of gestation until the pups were 43 days old. All litters were adjusted to six pups - three males and three females. The animals were pseudo-randomised and one male and one female from each litter were killed at nine, 21 and 43 days of age. In the young animals, growth, physical and neuronal development and motor activity assessed by the "open field" test, a behavioural test designed to measure locomotor and exploratory activity, were examined.

Exposure had no effect on the dams (weight, weight gain, water intake) and the pups at birth (number, weight, sex ratio, stillbirths). Weight gain, length growth, eye opening and ear detachment were not

affected by exposure. Teeth erupted one day later in exposed animals of both sexes than in controls; the difference was statistically significant.

Reflexes (supine righting, wire grasping, negative geotaxis) were significantly better developed in all young animals at seven days of age than at three days of age. No effect of exposure was observed.

The open field test was performed at 21 and 43 days of age. Exposed females had reduced total activity. With horizontal movement unchanged, exposed males showed more and exposed females less stereotypic movements compared to controls. Stereotypic movements are those that are repetitive, meaning- or purposeless.

According to the authors, these data support the hypothesis that 3.5 GHz 5G exposure at SAR levels below the permissible limit affects the development of rats.

3 Comments by the BfS

In general, the study was well conducted, especially in terms of randomisation and the timing of testing. Established methods were used to evaluate the development of the pups. However, for outcomes that were not sex-dependent, it remains questionable why both sexes were analysed together only for negative geotaxis. The statistical power could have been increased if the animals had been consistently combined. In addition, the lack of blinding during the measurements may have biased the data analysis.

The reported field strength and the calorimetrically determined SAR values are in a range where no exposure-induced temperature increases are to be expected. The magnitude of the determined whole-body SAR of 0.07 W/kg is plausible, even if though the reported value tends to be somewhat lower than the value to be expected on average for rats weighing 200-500 g at the given exposure parameters (plane wave incident from the top, frequency: 3500 MHz, electric field strength: 62 V/m). However, this whole-body SAR applies only to the dams. The whole-body SAR of the pups, which were also exposed after birth, could have been higher due to resonance effects. The authors did not report an investigation of the magnitude of this increase, but relevant exposure-related increases in body temperature are not expected in the pups either.

Statistical analysis of the data sets was performed using ANOVA followed by a t-test when the analysis of variance showed significant results. Correction for multiple testing was performed using the Sidak and Tukey test. This reduced the likelihood of false positive results.

Up to nine days of age, 21 males and 21 females were available. Except for the open field test, the physical development and behavioural tests were all completed by this time. A number of 7 animals per group is given in the figures of the results. This is presumably the number of litters, not the number of animals analysed. The percentages in Figure 4 indicate at least 14 animals per group and sex. The higher the number of animals analysed, the greater the statistical power of the results. The information in the publication is not clear in this respect, but even with 14 animals, the group size might not be sufficient to detect small effects.

The Gehan-Breslow-Wilcoxon test was used for the statistical evaluation of incisor eruption in accordance with the description of the methodology, while the log-rank test is used in the results section. The former is suitable for early events in an event time analysis, whereas incisor eruption is a very late event. Which test was ultimately used remains unclear. Together with the fact that incisor eruption in this study was observed about two days earlier (day 9), compared to a study on rats of the same strain cited by the authors [4], this finding remains highly uncertain.

The open field test was conducted in seven males and seven females at 21 and 43 days of age. Only pooled results from both tests are presented. It remains unclear what the results were in each age group, whether there was a trend during development, and whether the described differences in motor activity were present and statistically significant at both times. Furthermore, due to the designation of the considerably overlapping error bars as standard errors, it remains unclear whether the differences in the total activity in

females and in the increased stereotypic activity in males are actually statistically significant [5]. The corresponding values after exposure merely approach the respective level of the sham-exposed opposite sex. The authors do not discuss the difference they found in stereotypic activity between sham-exposed males and females. The biological significance of the substantial reduction in the stereotypic activity in females is also not sufficiently explained by the authors. The specific reduction in these movements could also be interpreted as favourable.

The study is one of the few in which exposure to 3.5 GHz RF-EMF was investigated on pre- and postnatal development and is therefore relevant for radiation protection. Most physical characteristics and reflexes were not affected by exposure. The findings of delayed tooth eruption and changes in motor activity need to be independently replicated, with attention to blinding and statistical analysis. Overall, the results show no health effects in the young animals.



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Bundesamt für Strahlenschutz

Postfach 10 01 49

38201 Salzgitter

Tel.: +49 30 18333-0

Fax: +49 30 18333-1885

E-Mail: spotlight@bfs.de

De-Mail: epost@bfs.de-mail.de

www.bfs.de

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