Bundesamt für Strahlenschutz

Spotlight on EMF Research

Spotlight on "Thresholds and Mechanisms of Human Magnetophosphene Perception Induced by Low Frequency Sinusoidal Magnetic Fields" by Legros et al. in Brain Stimulation (2024)

Category [low frequency, human study]

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Competence Centre for Electromagnetic Fields (KEMF)

1 Putting the paper into context by the BfS

The current guidelines for limiting exposure to low-frequency magnetic fields [2] are based on scientifically established effects of magnetic field exposure. Since the retina is considered to be a part of the central nervous system and the induction of retinal phosphenes occurs at lower levels than the stimulation of nerves in the brain, it is consensus that protecting against this effect will also protect against any other possible health relevant effects on brain function. Phosphene thresholds are at minimum around 20 Hz and rise rapidly at higher and lower frequencies.

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

Current exposure limits for magnetic field exposure are based on two older studies with a low number of participants [3, 4]. The basic restrictions at power-frequencies (50 and 60 Hz) are derived by extrapolation, since no experimental data above 45 Hz were available yet. Furthermore, it has been suggested that magnetophosphene perception could also result from a direct stimulation of the visual cortex [5]. Therefore, the current study [1] aims to improve the state of knowledge by investigating the threshold of magnetophosphene perception and the location of magnetophosphene generation in a larger group of volunteers at and above power frequencies.

The perception of magnetophosphenes was investigated in 81 volunteers who were divided into four groups and stimulated with oscillating magnetic fields at 20, 50, 60, and 100 Hz. Magnetic field exposure was either applied locally to the eye region including the retina, or to the occipital part of the head including the visual cortex, or the whole head was exposed using coil systems at magnetic field densities between 0 and 50 mT. The stimuli were presented in random order following a double-blinded protocol.

Induced electric fields and current densities in the brain were calculated by applying an algorithm based on the finite element method on fourteen anatomical head models created from magnetic resonance images. The data analysis was performed using mixed logistic regression modelling separately for each coil position. The statistical analysis included a correction for multiple testing.

The magnetic field exposure system developed for these experiments was able to induce electric field strengths in the head that are similar to those produced by transcranial alternating current stimulation (tACS), but without galvanic contact with the head, and thus without the well-known tACS limitations, which include skin sensations beneath the stimulation electrodes.

Magnetic field stimulation of the retina or the whole head elicited magnetophosphenes at all applied frequencies. The results were statistically significant. Upon stimulation of the visual cortex, no magnetophosphenes at 20 and 50 Hz were detected, but statistically significant responses were observed at 60 and 100 Hz. Since there is no conclusive explanation for these responses of the stimulated visual cortex and these responses were relatively weak, Legros et al. state that false positives cannot be ruled out.

The volunteers described the phosphenes as colourless and occurring at the periphery of the visual field. Since at the perception threshold the calculated current densities in the retina were higher at the periphery, the results suggest that magnetophosphenes are elicited by the stimulation of the rods at the periphery of the retina.

The results point to an adaptation process, e.g. decreased response probability and increased perception threshold, due to repeated stimulation, darkness, or both, as already described in [3].

Further, the results suggest that the body-internal electric fields necessary to evoke magnetophosphene perception are higher than pervious expected. Legros et al. conclude, that the current basic restrictions recommended by ICNIRP (2010) are safe but too conservative.

3 Comments by the BfS

For the first time, the thresholds for magnetophosphenes have been determined in humans specifically at power frequencies. The results are in accordance with former studies [3, 4] at lower frequencies and extrapolations [2] from lower frequency results.

A particular strength is the detailed and robust dosimetry, which allows for comparison with electric fields and current densities occurring in the human head. Robust, well-established methods were used for statistical analyses. The likelihood of false positive findings was reduced by correction for multiple testing, but according to Legros at al. false positive findings cannot be ruled out.

The study results contribute to the evidence that the ICNIRP guidelines [2] for limiting the exposure to low-frequency magnetic fields are sufficiently conservative and safe by providing data at and above power supply frequencies. Furthermore, they provide insight into a potential mechanism and site of magnetophosphene generation.

References

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