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BRIEF NOTE

Anecdotal report of magnetophosphene perception in 50 mT 20, 50 and 60 Hz magnetic fields

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Abstract – Magnetophosphenes are described as flickering lights appearing in the visual field, due to retinal exposure to time-varying magnetic fields (MF). Human magnetophosphene perception (MP) serves as a scientific basis for international guidelines intending to limit exposure to electromagnetic fields in the extremely low frequency range. However, the flux density threshold at which MP occurs, as well as the dose and frequency responses of the phenomenon, are not clearly experimentally established. The 50–60 Hz threshold is extrapolated from data in the lower frequency range. The objective of this paper is to provide a descriptive anecdotal report of MP from 8 individuals exposed to 50 mT MF at 20, 50 and 60 Hz. They describe variations of flickering light perceptions in the visual field, matching the description by D'Arsonval (1896). This preliminary testing introduces a new experimental protocol, which will test the threshold for MP and other associated neurophysiological responses in humans.

Keywords: magnetophosphene / magnetic field / extremely low frequency / threshold / anecdotal report

1 Introduction

Guidelines developed by the International Commission on Non-Ionizing Radiation Protection (ICNIRP, 2010) are intended to protect individuals against adverse health effects of electromagnetic field exposure. In the extremely low frequency range (ELF, 1–300 Hz), guidelines are based on observed acute effects on the human central nervous system, specifically on the retinal magnetophosphene perception (MP) threshold. Magnetophosphenes are defined as a transient perception of light in the visual field, while exposed to high time-varying magnetic fields (MF), and are reported so far as unilateral or bilateral "points", "sparks", "lightning" or "flashes" of varying colour, topography, intensity and size in relation to induced fields and currents in the retina, which "is part of the CNS and is regarded as an appropriate, albeit conservative, model for induced electric field effects on CNS neuronal circuitry in general" (ICNIRP, 2010). Advancing knowledge on MP is thus critical to protect populations from any possible effects on brain function. Indeed, if MP is an established phenomenon, the dose-response relationship and perception threshold remain uncertain at power frequencies, as estimates are based on the extrapolation from experimental data acquired at lower frequencies (D'Arsonval, 1896; Lövsund *et al.*, 1980; Hirata *et al.*, 2011).

An exposure system was designed and set up at the Lawson Health Research Institute (LHRI) to produce a localized exposure of the head to ELF MF up to 50 mT as part of a research project aiming to i) determine the threshold for MP in healthy volunteers at 50 and 60 Hz, ii) simultaneously analyze EEG in the corresponding brain regions, and iii) study the impact on selected neurophysiological indicators. Eight volunteers, members of the research team or close associates, tested these exposure conditions in February 2013. The exposure system, controlled by a LabView™ program, consists of a coil of 6 cm internal diameter and 22 cm outside diameter, which can generate MF of 0–50 mT between 0 and 100 Hz (Fig. 1) 2 cm from its side, without noticeable heating, noise or vibrations.

Volunteers were tested under non-experimental conditions. Each volunteer had the right side of his/her head placed within 1 cm of the side of the coil (Fig. 2), in a dark room, and was exposed to 50 or 0 mT (sham) at eyeball level, with a single-blind procedure. All volunteers reported MP in their

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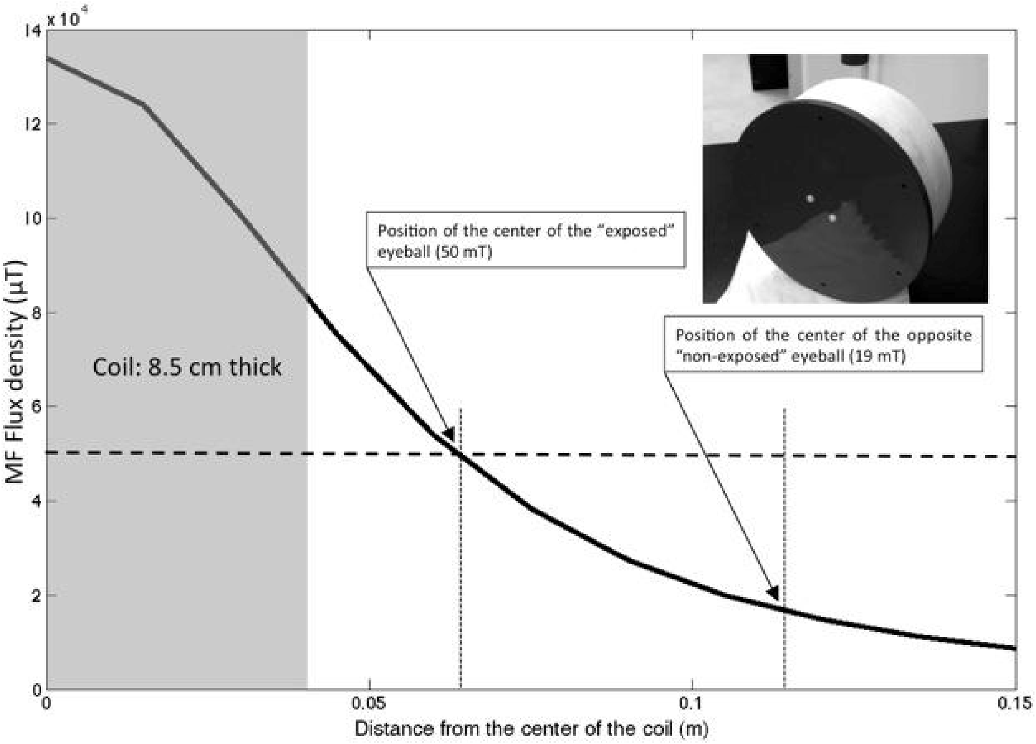

Fig. 1. MF flux density perpendicular to the centre of the coil as a function of the distance, with an illustration of the coil. The vertical grey rectangle represents half of the coil thickness, the horizontal dashed line represents the 50 mT level, and the black plain line represents the calculated flux density as a function of the distance from the coil. The position of the exposed eyeball matches the intersection of the plain and dotted lines, corresponding to the 50 mT flux density spot. The flux density 5 cm further from the coil, corresponding to the non-exposed eyeball position, is 19 mT.

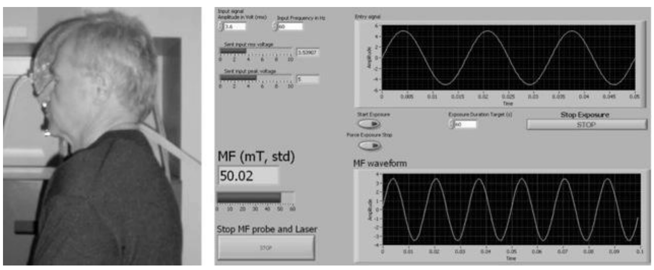

Fig. 2. On the left – when exposed, the volunteer has his temple parallel to the side of the coil (at 1 cm) with his eyeball aligned with its centre. On the right – view from computer screen controlling the MF exposure, showing the 60 Hz signal driving the amplifier (top graph) and the 50 mT (rms) simultaneously monitored MF at eyeball distance (bottom graph, measured from the other side of the coil).

exposed eye during real exposures, but the description of the phenomenon was different at 20 Hz (positive control), and at 50 and 60 Hz. No MP was reported in sham conditions. No MP was reported in the non-exposed eye (*i.e.* opposite to the coil), due to the rapid decrease in flux density with distance from the coil. Indeed, if the right eyeball centre is exposed to 50 mT, the centre of the left eyeball, which is 5 cm further from the coil, is exposed to 19 mT (Fig. 1). Note that the final formal experimental protocol will include homogeneous entire head exposure conditions, and will take into account MF orientations to appropriately characterize the effects.

Volunteer perceptions

V1: at 20 Hz, unambiguous MP as alternate black and white and sparkling concave (rounded down) lines in the lower part of the visual field. MP was more difficult at 50 and 60 Hz. It was more like a stroboscopic effect, no line was formed.

V2: at 20 Hz, MP is reported as vertical and narrow light lines alternating with dark lines in most of the lower visual field. These lines sparkled quickly and seemed stationary. MP was clear and strong enough to be unequivocal. At 60 Hz, the scintillating visual impression also appeared in the lower visual field but was more difficult to detect.

V3: instantaneous MP at 20 Hz, 50 mT (onset/offset of MP synchronized with stimulus onset/offset). MP described as interleaved, vibrating, horizontal dark and clearer grey lines in the bottom of the visual field. MP still instantaneous at 50 and 60 Hz, but subtler perception and horizontal interleaved lines appeared thinner.

V4: exposure of 50 mT at 60 Hz. MP described as a visual impression (similar to a stroboscopic effect) in the lower visual field, almost like a white rectangle, homogeneous and sparkling. Stimulus onset/offset were relatively easy to identify.

V5: at all frequencies, instantaneous MP with no residual MP after exposure cessation (but more pronounced at 20 Hz than 50/60 Hz). MP had two components: a thick and bright horizontal line and also a vibration of the bottom right visual field of the exposed subject.

V6: MP at 20 Hz and 60 Hz comes almost immediately in strobe light sequences, only during the exposure. MP ipsilateral to exposure only, without post-exposure afterglow.

V7: MP at 20 Hz, and less clearly at 50 Hz. MP as black and white spots of flashing light and white stripes with a stroboscopic effect (depending on the MF frequency).

V8: MP as flashing spots of white light arranged in diagonal lines in the middle third of the visual field between two horizontal lines of flashing lights in the top and the bottom thirds of the visual field. The sensation was more pronounced at 20 Hz and less obvious at 50 Hz.

In summary, all the volunteers reported light perception, similarly to the description provided by D'Arsonval (1896), as lines of different shapes, sparkling in black and white. Presumably, the difference in MP among the frequencies is related to the fact that 50 mT is closer to the MP threshold at 50 and 60 Hz than it is at 20 Hz. The LHRI will provide additional objective scientific data to firmly establish thresholds for MP at various frequencies.

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