Magnetophophene perception and EEG response in humans exposed to 50 and 60 Hz magnetic fields of up to 50 mT

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***Abstract*- This work is aiming to establish magnetic flux density thresholds for systematic human neurophysiological responses to 50 and 60 Hz exposures. In order to do so, magnetophosphene perception and electroencephalographic responses are tested under 50 and 60 Hz magnetic field exposure conditions between 0 and 50 mT. So far, preliminary data indicate a lowest magnetophosphene perception threshold at 20 mT for a 60 Hz exposure, and suggest a decrease of associated EEG alpha activity (8-12 Hz) with higher flux densities. This protocol allows the detection, in humans, of systematic effects related to 50 and 60 Hz magnetic field exposures between 0 and 50 mT.**

I. Introduction

Guidelines from the International Commission for Non-Ionizing Radiation Protection (ICNIRP) and standards from the Institute of Electrical and Electronics Engineers (IEEE) are providing international recommendations regarding human exposure to Extremely Low Frequency Magnetic Fields (ELF MF, below 300 Hz [1], [2]). For power-frequency exposures, these recommendations are based on the extrapolation of existing experimental data on magnetophosphene perception thresholds, as reported by Lövsund in the early eighties [3]. However, uncertainties persist regarding the threshold for magnetophosphene perception in humans at power-frequency [4], [5]. Indeed, this threshold is reported to be the lowest at 20 Hz (between 5 and 10 mT), and to increase with frequency [3], [6]. However, the threshold is only extrapolated at 60 Hz and no experimental data acquired in humans are actually available. The current project is therefore aiming to establish the thresholds for systematic acute, objective and quantifiable responses in humans exposed to 50/60 Hz MF of up to 50 mT. The selected outcomes include magnetophosphene perception and associated brain electrical activity as measured by electroencephalography (EEG).

II. Materials and Methods

Two groups of healthy volunteers (n = 25 at 60 Hz, n = 5 at 50 Hz) are each tested in 2 localized exposure conditions (eyeball and occipital cortex using a small coil) and 1 global head exposure condition. Each frequency condition (different for each group) is scanning 11 magnetic flux density conditions (0 to 50 mT, 5 mT increments) lasting five seconds each. Flux density conditions are each repeated 5 times (random order) and separated with five seconds without exposure. During this protocol, tested volunteers are sitting eyes closed in a dark room, and are asked to report magnetophosphene perception by button-press, while their occipital EEG activity is continuously recorded. A MRI-compatible EEG system/cap/cable (Neuroscan-Compumedics Inc, Melbourne, Australia) is used, which allows EEG recording during 50 mT MF exposure. It is expected that magnetophosphene perception will be associated with a decrease in EEG alpha (8-12 Hz) spectral power in the visual/occipital cortex. This protocol is approved by the Health Sciences Research Ethics Board of Western University (HSREB #18882).

III. Preliminary Results

Pilot testing has begun for this project and so far, all participants reported magnetophosphene at 60 Hz for retinal (n=4, Fig. 1) and global (n=1, Fig. 2) exposures, at flux densities reaching 50 mT. During the occipital exposure condition however, no magnetophosphenes were reported (n=4). Although no statistical tests were conducted at this stage, the button-press data points at a magnetophosphene perception threshold between 20 mT (global exposure condition – Fig. 2) and 25 mT (local exposure condition – Fig. 1). The EEG data show a noticeable trend towards a decrease in alpha EEG power with higher flux densities both for the local (Fig. 3) and the global (Fig. 4) exposure conditions.

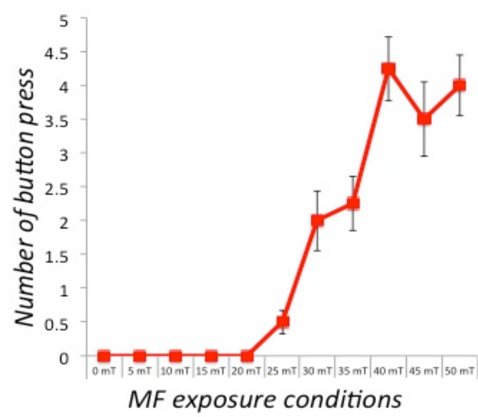

Fig. 1. Averaged number of button-press in 4 preliminary subjects as a function of MF flux density - retinal exposure. It shows a magnetophosphene threshold at 25 mT. Higher flux densities lead to a higher detection rate.

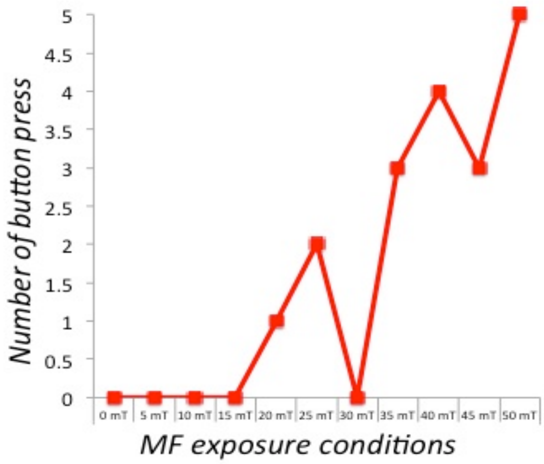

Fig. 2. Averaged number of button-press in 1 preliminary subject as a function of MF flux density – global head exposure. It shows a magnetophosphene threshold at 20 mT. Higher flux densities are associated with a higher detection rate.

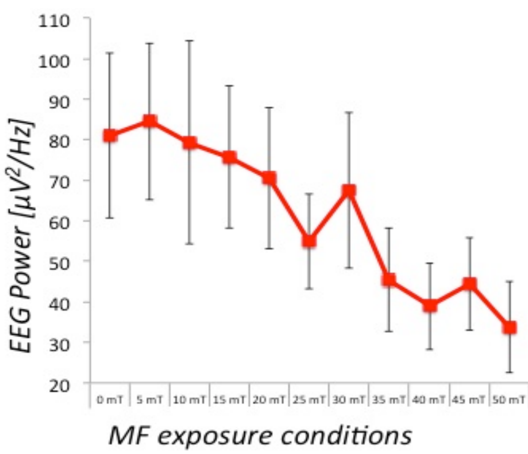

Fig. 3. Average EEG Power in the alpha frequency band (8-12 Hz – O2 electrode) in 4 preliminary subjects as a function of MF flux density – retinal exposure. It shows a noticeable trend towards a decrease of EEG alpha power as the MF flux density increases.

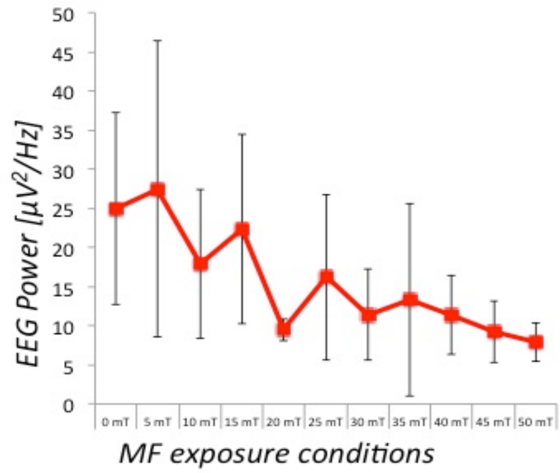

Fig. 4. Average EEG Power in the alpha frequency band (8-12 Hz – O2 electrode) in 1 preliminary subject as a function of MF flux density conditions – global head exposure. It shows a noticeable trend towards a decrease of EEG alpha power as the MF flux density increases.

IV. Conclusions

This project allows the experimental testing of power-frequency MF exposures of up to 50 mT in humans. It investigates concomitantly a self-reported perception (magnetophosphenes) and an objective neurophysiological outcome (EEG), both acquired during the exposure. Based on these preliminary data, the threshold for magnetophosphene perception at 60 Hz seems to be between 20 and 25 mT in humans, and to be associated with a decrease of EEG alpha activity as the MF flux density increases. We are expecting to provide with this work an objective threshold for neurophysiological responses to power-frequency MF exposure, with the opportunity to reach a conclusive N-size (an attempt to increase the final group size is in process). This project will provide solid experimental data acquired in humans available to refine exposure guidelines, which may also offer opportunities for translational research.

V. Acknowledgements

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VI. References

[1] ICNIRP, "Guidelines for limiting exposure to time-varying electric and magnetic fields (1 Hz to 100 kHz)". (Health Phys number 99(6), Dec 2010, pages 818-836).
[2] IEEE, "C95.6 - IEEE Standard for safety levels with respect to human exposure to electromagnetic fields, 0-3 kHz". (IEEE: New York number 2002).
[3] P. Lovsund, P.A. Oberg, S.E. Nilsson, et al., "Magnetophosphenes: a quantitative analysis of thresholds". (Med Biol Eng Comput number 18(3), May 1980, pages 326-334).
[4] R. Kavet, W.H. Bailey, T.D. Bracken, et al., "Recent advances in research relevant to electric and magnetic field exposure guidelines". (Bioelectromagnetics number 29(7), Oct 2008, pages 499-526).
[5] R.D. Saunders and J.G. Jefferys, "A neurobiological basis for ELF guidelines". (Health Phys number 92(6), Jun 2007, pages 596-603).
[6] J. Silny. The Influence of the Time-Varying Magnetic Field in the Human Organism. in Biological Effects of Static and Extremely Low Frequency Magnetic Fields. 1986. Neuherberg: MMV Meizin Verlag München.