

Is finger tapping induced brain activation modulated by an exposure to a 60 Hz, 3000 μ T magnetic field?

Alexandre Legros^{1,2}, Jodi E. Miller^{1,2}, Julien Modolo^{1,2}, Michael Corbacio^{1,2}, John R. Robertson^{1,2}, Daniel Goulet³, Jacques Lambrozo⁴, Michel Plante³, Martine Souques⁴, Frank S. Prato^{1,2}, Alex W. Thomas^{1,2}
¹Bioelectromagnetics, Imaging Program, Lawson Health Research Institute, London, ON, Canada, ²Department of Medical Biophysics, University of Western Ontario, London, ON, Canada, ³Hydro-Québec, Montréal, QC, Canada, ⁴Service des Études Médicales, EDF, Paris, France.
*Corresponding author e-mail: alegros@lawsonimaging.ca

INTRODUCTION

Recent studies suggest that human exposure to Extremely Low Frequency (below 300Hz, ELF) Magnetic Field (MF) may interact with brain rhythms and motor functions. Electroencephalographic rhythms (EEG) and evoked potentials have been shown to be modulated by ELF exposure in healthy subjects [1, 2]. Spontaneous motor activity such as standing balance [3] and physiological postural tremor [4] also seem responsive to time-varying MF. Based on these observations, we recently proposed in a pilot study using functional Magnetic Resonance Imaging (fMRI) as a new tool to investigate if brain activation patterns induced by a finger tapping task can be modulated by 30 minutes of 60 Hz, 1800 μ T MF exposure [5]. Indeed, it is well documented that a simple finger tapping task activates the contralateral Supplementary Motor Area (SMA) and the contralateral Primary Motor Cortex (M1). The corresponding level of activation is known to be correlated with the frequency and the amplitude of the task [6]. Since our pilot work was successful in showing a higher task induced activation with MF exposure in specific brain regions (including the somatosensory cortex (S1)) [5], the aim of the current project was to extend our results to a longer exposure period and a higher field intensity (1 hour of 60 Hz MF at 3000 μ T). Based on our pilot results, we expect a higher task induced activation associated with MF exposure.

MATERIALS AND METHODS

Healthy right handed subjects (ongoing study, n=10 to date, mean age=23.9; range=19-35) were tested in a pseudo double blind experiment (the experimenter discovered the exposure condition only after the subject was set up in the scanner, no direct interaction between them was involved after this point). The experiment consisted of collecting functional brain images while participants tapped their thumb and index fingers together at a spontaneous rhythm, before and after a 1 hour resting period. During this resting period, 6 participants were exposed to a 60 Hz MF at 3000 μ T (at the cortical level). The exposure was produced by the Z gradient coil of the scanner, specially programmed by one of our physicists. The other 4 participants were not exposed to the field during the 1 hour rest period (sham group). BOLD images were acquired with a 3 Tesla MRI system (Siemens Verio, Erlangen Germany).

RESULTS

Data analysis was performed using Brain Voyager QX 2.0.8.1480 (Brain Innovation, The Netherlands). 3D motion correction, temporal and spatial smoothing, and trilinear interpolation were used. Functional and anatomical images were co-registered and normalized into a Talairach brain space. As expected, the tapping task induced activation of the contralateral primary and supplementary motor cortex (M1 and SMA), the primary

somatosensory cortex (S1) and of the anterior lobe of the ipsilateral cerebellum (M1, SMA and S1 activation are illustrated in Figure 1, Left). For each experimental group (sham and exposed), Post- minus Pre-exposure comparison images were produced. Interestingly, though no differences in activation between post- and pre-exposure conditions were found for either group in the premotor cortex and the cerebellum, the level of activation appeared to be higher post-exposure but not post sham in S1 (see Figure 1, Middle and Right respectively). S1 was defined as a Regions Of Interest (ROI) in Brain Voyager so that the corresponding Beta weight values could be exported into SPSS for further analysis. A within subjects ANOVA with a between subjects factor was then performed. No main effect was found (Group: $F=0.29$, $p>0.05$; Pre/Post: $F=1.28$, $p>0.05$). However, a significant interaction confirmed that the Post-exposure activation was higher than the post-sham activation as compared to their respective pre-exposure levels ($F=7.13$, $p<0.05$).

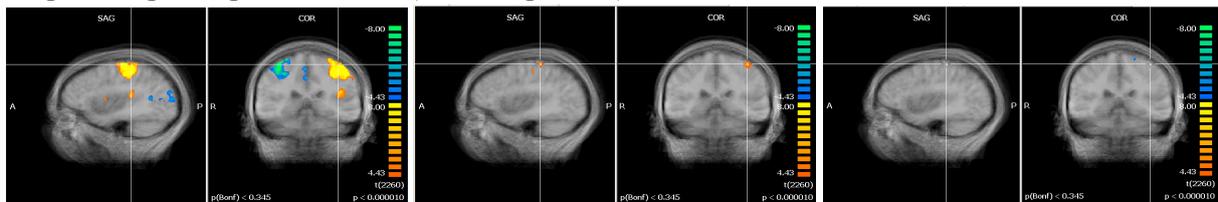


Figure 1: Left – Tapping: Pre exposure group image (n=10). Middle – Tapping: Post- minus Pre-exposure condition (exposed, n=6). Right – Tapping: Post- minus Pre-exposure condition (sham, n=4).

CONCLUSIONS

As expected the rhythmic thumb vs. index finger opposition task activated M1, SMA, S1 and the cerebellum. Our results demonstrate that after 1 hour of rest, the same level of activation is required in these areas to produce the same task, which supports the reliability of the test. However, if the subjects are exposed to a 60 Hz 3000 μ T MF during the rest period, this is not true anymore in S1, which shows a higher level of activation as compared to sham. Interestingly, this is coherent with the results of our previous work and suggests that the MF interacts more at the perceptive level (associated with S1) than with the motor command. This is an ongoing study and final results will be presented at the conference.

ACKNOWLEDGMENTS

The authors would like to thank Dr. Jean Théberge for programming the 60 Hz into the scanner's gradient coil allowing its use as an active MF exposure device. Research funded by Hydro-Québec (Canada), EDF-RTE (France), CIHR (Canada) and LHRI.

REFERENCES

- [1] C.M. Cook, A.W. Thomas, and F.S. Prato. Resting EEG is affected by exposure to a pulsed ELF magnetic field. *Bioelectromagnetics*, 25(3): 196-203, Apr 2004.
- [2] S. Ghione, C.D. Seppia, L. Mezzasalma, and L. Bonfiglio. Effects of 50 Hz electromagnetic fields on electroencephalographic alpha activity, dental pain threshold and cardiovascular parameters in humans. *Neurosci Lett*, 382(1-2): 112-117, Jul 1-8 2005.
- [3] A.W. Thomas, D.J. Drost, and F.S. Prato. Human subjects exposed to a specific pulsed (200 microT) magnetic field: effects on normal standing balance. *Neurosci Lett*, 297(2): 121-124, Jan 12 2001.
- [4] A. Legros, P. Gailliot, and A. Beuter. Transient effect of low-intensity magnetic field on human motor control. *Med Eng Phys*, 28(8): 827-836, Oct 2006.
- [5] A. Legros, J. Weller, J. Robertson, M. Corbacio, S. Dubois, et al. *Is human brain functional activation modulated by a 60 Hz, 1800 μ T magnetic field exposure?* *BIOEM Proceedings*, P-120: 439-440, June 2009.
- [6] N. Sadato, V. Ibanez, G. Campbell, M.P. Deiber, D. Le Bihan, et al. Frequency-dependent changes of regional cerebral blood flow during finger movements: functional MRI compared to PET. *J Cereb Blood Flow Metab*, 17(6): 670-679, Jun 1997.