# Functional Magnetic Resonance Imaging of Human Brain Exposed to a 60Hz, 1800$\mu$T Magnetic Field

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## Introduction

Human response to Extremely Low Frequency (below 300Hz, ELF) Magnetic Field (MF) exposure has been studied for the last 3 decades. It has been demonstrated that human physiology [1] and neurophysiology [2, 3] can be modulated by exposure to ELF MF. Recent studies suggest that central exposure can modulate brain rhythms and motor functions, reporting for example changes in the electroencephalogram (EEG) and evoked potentials of healthy subjects [2, 3]. Interestingly, it has also been shown that ELF MF exposure decreases the amplitude of spontaneous motor activity of healthy subjects such as standing balance [4] and physiological postural tremor recorded at the tip of the index finger [5]. The aim of this pilot work is to use functional Magnetic Resonance Imaging (fMRI) as a new tool to investigate if brain activation patterns can be modulated by a 30 minute exposure to a 60Hz, 1800 $\mu$T MF. Indeed, it is well documented that a simple finger tapping task activates the controlateral Supplementary Motor Area (SMA) and the controlateral Primary Motor Area (SM1). It has also been demonstrated that the level of activation of these areas is positively correlated with the frequency and the amplitude of the task [6]. Based on literature results, we hypothesize that for an index finger tapping task at natural frequency, a 60Hz, 1800 $\mu$T MF exposure will induce a decrease of Blood Oxygen Level Dependent (BOLD) activation in the involved brain regions.

## Methods

9 right handed subjects (mean age=25.5; range=21-33) were tested in a single blind pilot trial: functional brain images were collected while participants tapped their thumb and index finger together at a spontaneous rhythm before and after a 30 minute resting period. During this resting period, 4 participants were exposed to a 60 Hz MF at 1800 $\mu$T (real group, maximal at the cortical level, top of the head) by the Z gradient coil of the scanner itself (specially programmed by one of our physicists) and 5 of them have not (control group, see in Figure 1). BOLD images were acquired with a 1.5 Tesla Siemens Advanto MRI. High resolution anatomical images were also collected and co-registered with the functional images.

## Results

Participant data was analyzed using Brain Voyager QX 1.9.10 (BrainVoyager, Brain Innovation, the Netherlands). Data was corrected for potential movement artifacts using 3D motion correction, temporal and spatial smoothing, and trilinear interpolation. Functional images were co-registered to an anatomical, T1 weighted image, and normalized into a Talairach brain space. A Bonferroni correction of $p < .001$ was employed to correct for multiple comparison confounds, ensuring that the change in activation observed was not due to chance. The pre-exposure group image clearly showed the activation of the controlateral primary and supplementary motor cortex (M1 and SMA), primary somatosensory cortex (SI) and anterior cingulate (AC), and of the ipsilateral cerebellum, anterior lobe (the cortical activation is illustrated in Figure 2, Top). Post minus Pre exposure comparison images were produced for each experimental group and showed a deactivation in the controlateral SI and AC, and in the ipsilateral cerebellum, anterior lobe (see Figure 2, Middle, for the SI). Surprisingly, no Post minus Pre deactivation was found for the group actually exposed (see Figure 2, Bottom, for the SI). These three regions were defined as Regions Of Interest (ROI) and corresponding Beta weight values were extracted and exported into SPSS where within subjects ANOVAs with a between subjects factor (group) were conducted. Main effects showed a marginally lower activation Post than Pre exposure in the SI ($F=4.77$, $p=0.06$), in the AC ($F=4.31$, $p=0.76$) and in the cerebellum ($F=3.30$, $p=0.11$). Interestingly, in the AC, a significant interaction showed that the Post exposure deactivation was stronger in the control group than in the real group ($F=10.30$, $p<0.05$). The interaction was close to significance for the SI ($F=2.44$, $p=0.16$) and the cerebellum ($F=4.56$, $p=0.07$).

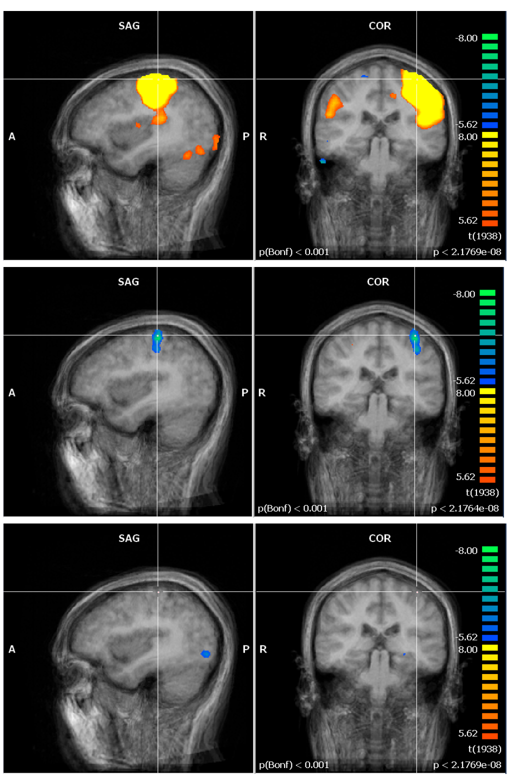


Figure 2: Top – Tapping: Pre exposure group image (n=9). Middle – Tapping: Post minus Pre exposure condition (control, n=5). Bottom – Tapping: Post minus Pre exposure condition (real, N=4).

## Discussion

Results seem to suggest that after a 30 minute period of rest, less activation is required to produce a rhythmic thumb vs. index finger opposition task, and that exposure to a 60Hz MF of 1800$\mu$T cancel this effect. Although these results, which will be discussed at the conference, have to be cautiously taken due to our small sample size so far, they demonstrate the potential of using fMRI as a new tool to study the effects of ELF MF on brain functions.

## References

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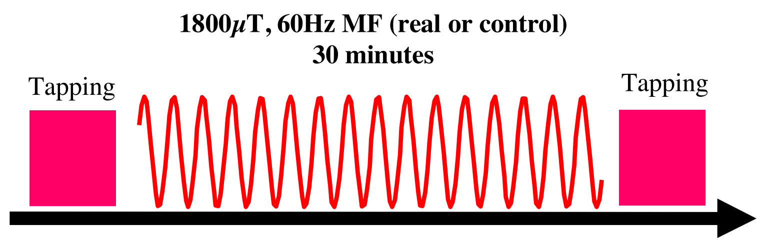


Figure 1: BOLD images were collected while performing the finger tapping task before and after a 30 minute exposure to the 1800µT MF at 60 Hz. In the experimental group (n=4) the subjects were actually exposed, in the control group (n=5) the 60Hz MF was never generated.