HUMAN ACUTE EXPOSURE TO A 60 HZ, 1800 MICROTESLA MAGNETIC FIELD: PHYSIOLOGICAL, NEUROPHYSIOLOGICAL AND BEHAVIORAL EFFECTS

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Various aspects of human behaviours have been studied in response to acute exposure to Extremely Low Frequency (ELF) magnetic fields (MF). The more consistent results show an increase in occipital alpha rhythm of resting electroencephalographic activity (EEG) with exposure. Interestingly, other studies have demonstrated that human motor behaviour can be modulated by ELF MF, showing a reduction of standing balance amplitude and a decrease in physiological tremor intensity. However, to establish a connection between these observations would require a project that, in one procedure, investigates physiological, neurophysiological and behavioural parameters.

The main objective of this study is therefore to evaluate subtle effects of a 60 Hz MF exposure at 1800 μT on human physiology, neurophysiology and motor functions in a single procedure.

We hypothesize that MF exposure will (1) decrease peripheral blood flow but not affect ECG, (2) increase EEG power in alpha rhythm, especially in the posterior regions of the brain, (3) decrease of standing balance amplitude, (4) not affect performance in voluntary movements of the hands, and (5) decrease physiological tremor amplitude. Effects should appear after several minutes of exposure.

Methods

This is a currently ongoing study (University of Western Ontario Health Sciences Research Ethics Board # 11956E). To date, 31 subjects have completed the experiment. 70 healthy adults between 18 and 55 years of age will have completed the study by the end of April 2007. The experiment consist in 2 counterbalanced exposure sessions given on 2 separate days (with at least 2 days in between): 1 active (real) and 1 control session (sham) as (Figure 1a). A double blind computer driven procedure (National Instrument Inc., USA) controlling for variables is used such that neither the participant nor the experimenter know when the real or sham condition occurs.

Each session includes 4 blocks of testing (15 minutes each) spaced with 15 minutes rest in between (Figure 1a): Blocks of testing are given 15 minutes before the beginning of the exposure, and then 15 minutes and 45 minutes after the beginning of the exposure, and finally 15 minutes after the end of the exposure.

During each block, recordings are done following the time frame detailed in the Figure 1b: Resting EEG (Siesta, Compumedics Inc., USA), physiological tremor (tip of the dominant index finger, Micro laser sensor, Matsushita Electronic Work, Ltd., Japan), voluntary movements of the hands (Liberty, Polhemus inc., USA), and standing balance (OR6-7-1000, AMTI, USA). Local blood perfusion (tip of the non dominant middle finger) and systolic blood pressure, (PF 5010 Laser Doppler Perfusion and blood pressure Monitoring unit, Perimed, Sweden) as well as ECG (Siesta unit) are also collected.

Skin temperature is monitored throughout the experiment. After each block, the subject answers the Field Status Questionnaire to assess his ability to detect the presence of the field.

Results

As an ongoing study, data are still being collected and analyzed (SPSS 15.0, SPSS Inc., Chicago, USA). The full results will be presented at the BEMS meeting, but currently only preliminary data are available: Occipital EEG, postural tremor and postural oscillations have been analyzed in 6 subjects.

It has been chosen at this step to focus on data acquired in the blocks 1 and 3 (see Figure 1a). Within-subjects ANOVAs were conducted on selected computed characteristics: ANOVA 2 (eyes open vs. eyes closed) x 2 (block1 vs. block3) x 2 (sham vs. real).

No Block main significant effect has been found for EEG, postural tremor and postural oscillations. However, with eyes closed, subjects had significantly higher EEG alpha activity in the occipital region (O1: $F = 24.85$, $p < .01$, $Eta^2 = .86$; O2: $F = 20.54$, $p < .05$, $Eta^2 = .83$), larger and faster postural oscillations (sway area: $F = 35.14$, $p < .005$, $Eta^2 = .89$; sway velocity: $F = 51.47$, $p < .005$, $Eta^2 = .92$;), and higher index finger drift ($F = 12.19$, $p < .05$, $Eta^2 = .75$) with eyes closed than with eyes open. No interaction effect was found.

Conclusion

Preliminary results confirm that this protocol is adapted to detect subtle changes in the investigated characteristics, despite the small number of subjects analyzed at this point. Indeed, significant differences were found between open and closed eyes conditions in EEG, tremor and postural sway. Due to the small number of subjects tested so far, we did not detect any significant effect due to MF exposure. A sample size calculation has been conducted: 68 subjects would be required to obtain significant differences between the real and sham conditions for the sway velocity index (i.e. standing balance, p fixed at .05, power = .80). It suggests that our final results (including 70 subjects) may carry out effects of the exposure on specific human behaviours.

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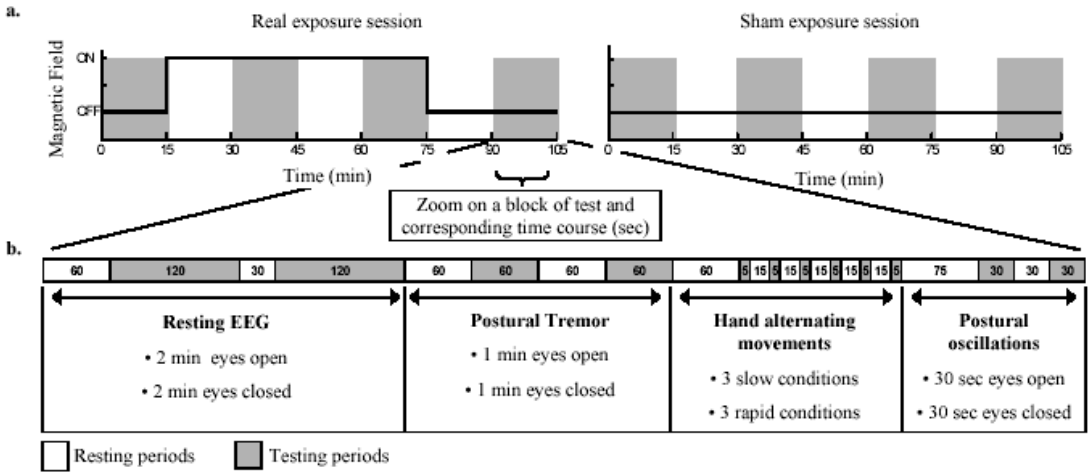

Figure 1: a. Time course of the real and sham exposure sessions. The horizontal black line represents the MF status (OFF when down, ON when up). Note that during the sham exposure session, the MF is never ON. Vertical grey bands represent the four 15-minute blocks of testing. **b.** Zoom on the time course of a block of testing (the same for each block). White cells represent resting periods and grey cells represent testing periods (duration is displayed in seconds inside the cells). The table below specifies the tests.

Appendix 1

Postural tremor characteristics:

Amplitude: Root Mean Square (RMS) of position time series centered on their mean (highpass and lowpass filtered, between 2 and 25 Hz).

Drift: RMS of the low frequency component of the time series (below .01 Hz), quantifying slow movements of the finger.

Median frequency: Determines the value at which 50% of the power spectrum is below this frequency, and 50% is above. It is computed on the power spectrum between 2 and 25 Hz.

Frequency concentration: Quantifies the degree of organization of tremor by computing the width of the interval containing 68% of the power of the spectrum between 2 and 25 Hz.

Postural sway characteristics:

Mean Sway: Average distance between the geometric center of all recorded forces and each point visited by the Center of Pressure (COP) during a test.

Sway Velocity: Average velocity of the COP displacements.

Sway Area: Area of the smallest polygon including the entire trajectory of the COP.

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