Can exposure to a 1800 µT magnetic field at 60 Hz modulate human neuro-behaviors?

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Abstract

High voltage power-lines, industrial processes, domestic electric appliances are among the numerous sources of daily exposure to extremely low frequency (ELF, below 300 Hz) magnetic fields (MF). ELF MF effects on humans have been studied over the past 20 years, and it has recently been found that they can affect human movements and brain electrical activity. Results however, remain controversial and the mechanisms involved are not well understood. This study seems to confirm the effect of a high intensity MF exposure (60 Hz, 1800µT) on human motor control, but not on brain electrical activity (analyzes still in process).

Introduction

Various aspects of human behaviours have been studied in response to acute exposure to Extremely Low Frequency (ELF) magnetic fields (MF). Recent results show an increase in occipital alpha rhythm of resting electroencephalographic activity (EEG) with exposure [1, 2]. 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 with exposure [3-7]. However, to establish a connection between these observations requires a project that, in one procedure, investigates physiological, neurophysiological and behavioural parameters. The main objective of this study is thus 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 oscillations, (4) not affect performance in voluntary movements of the hands, and (5) decrease physiological tremor amplitude.

Methods

93 subjects have been involved in the study and 73 of then completed the experiment (UWO REB # 11956E). The experiment consisted in 2 counterbalanced exposure sessions given on 2 separate days (with at least 2 days in between, Figure 1a): 1 active (real) and 1 control session (sham). A double blind computer driven procedure (National Instrument Inc., USA) controlling for

variables was used such that neither the participant nor the experimenter knew when the real or sham condition occurred. Each session included 4 blocks of testing (15 minutes each) spaced with 15 minutes rest in between (Figure 1a): Blocks of testing were given 15 minutes before the beginning of the exposure, 15 minutes and 45 minutes after the beginning of the exposure (i.e. during the exposure), and finally 15 minutes after the end of the exposure. During each block, recordings were 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. Specific indexes characterising the parameters above mentioned are computed for each experimental condition and are used as variables in the statistical analysis. 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.

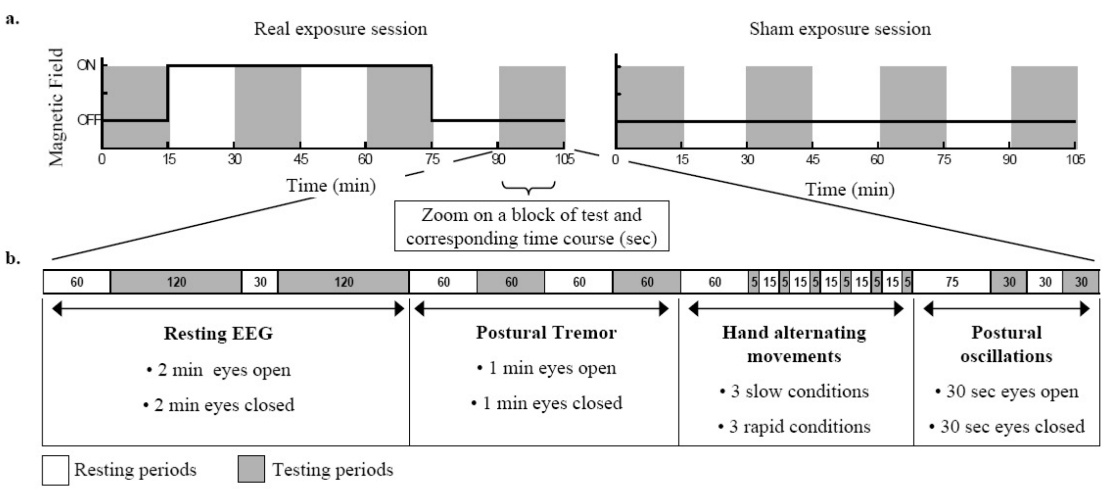

Figure 1: a. Time course of the real and sham exposure sessions. The horizontal black line represents the MF status (OFF when down, ON when up). Note that during the sham exposure session, the MF is never ON. Vertical grey bands represent the four 15-minute blocks of testing. **b.** Zoom on the time 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.

Results

Data are currently analyzed (SPSS 15.0, SPSS Inc., Chicago, USA). To date, analyses have been run on the EEG alpha rhythm amplitude in the occipital electrodes (root mean square of the time series in the 8-13 Hz frequency range, electrodes O1 and O2), on the sway area (area of the smallest polygon including the entire trajectory of the standing balance oscillations over a recording, i.e. postural oscillations), and postural tremor amplitude (root mean square of tremor time series filtered between 2 and 20 Hz). First, a within-subjects ANOVA 2 (session: sham or real) x 4 (block: 1, 2, 3, or 4) x 2 (eyes: open or closed), with α set at .05, is used to locate main effects.

Second, the analysis is then focused on the MF effect during the exposure by comparing the sham and the real exposure conditions (focusing only on blocks 2 and 3, which are occurring during the MF on condition, see Figure 1) using a within-subjects ANOVA 2 (eyes: open or closed) x 2 (MF: off or on) with α set at .05.

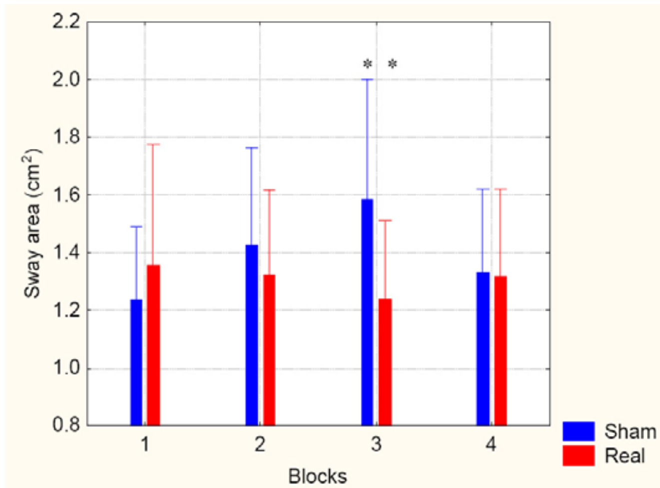

Figure 2: Interestingly, the within-subjects ANOVA 2 (session) x 4 (block) x 2 (eyes) have shown a session x block ($F=3$, $p<.05$) interaction, pointing a smaller sway area in the block 3 real condition than in the block 3 sham condition (Post hoc Tukey HDS, $p<.05$).

So far, results of our first analysis shows with eyes closed: a higher alpha EEG activity in the occipital electrodes (O1: $F=117.2$, $p<.01$), a larger tremor amplitude (amplitude: $F=56$, $p<.01$), and larger postural oscillations (sway area: $F=95$, $p<.01$). Interestingly, an interaction effect session x block has been found for postural oscillations ($F=3$, $p<.05$, see Figure 2) showing a smaller sway area in the block 3 with real exposure than in the block 3 with sham exposure (post hoc Tukey, $p<.05$). No other session or block effect has been found, but analyses are still in process. Our second analysis focusing only on blocks 2 and 3 (during MF exposure) confirmed the effect found on postural oscillations: the sway area was smaller in the real than in the sham exposure condition ($F=4.9$, $p<.05$, See Figure 2). No significant effect has been found yet on EEG or tremor.

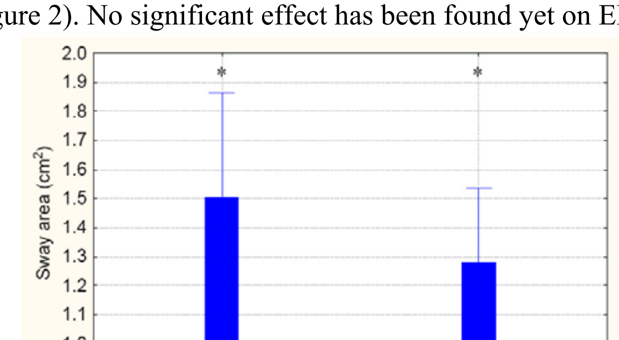

Figure 3: The within-subjects ANOVA 2 (eyes: open or closed) x 2 (MF: off or on) showed a smaller sway area in the real than in the sham exposure condition ($F=4.9$, $p<.05$).

Discussion

This multidimensional approach allows the detection of small changes modulating human neuro-behavior. Indeed, the suppression of the visual input (induced by closing the eyes) has neurophysiologial and behavioral consequences which are clearly detected and characterized by this protocol (decreased EEG alpha activity, increased postural tremor amplitude, increased postural oscillations). So far, no effect of a 60 Hz, 1800 μT MF exposure has been found either on EEG or on postural tremor (only electrodes O1 and O2 has been analyzed to date). However, we show a decrease of standing balance oscillations during exposure, which is consistent with the finding of Thomas et al. in 2001 [7]. Note that these are only the first results of our study and they will be completed by those on peripheral blood perfusion, ECG, and rhythmic voluntary movement of the hand. Full results will be presented and discussed at the meeting

Acknowledgments

Research funded by Hydro-Québec, EDF-RTE (France), ORDCF (Ontario), CIHR (Canada) and LHRI. The authors acknowledge Lynn Keenliside for building the exposure system and for all the technical support.

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