Is Human Brain Activity Modulated by Powerline Frequency Magnetic Field Exposure?

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Introduction

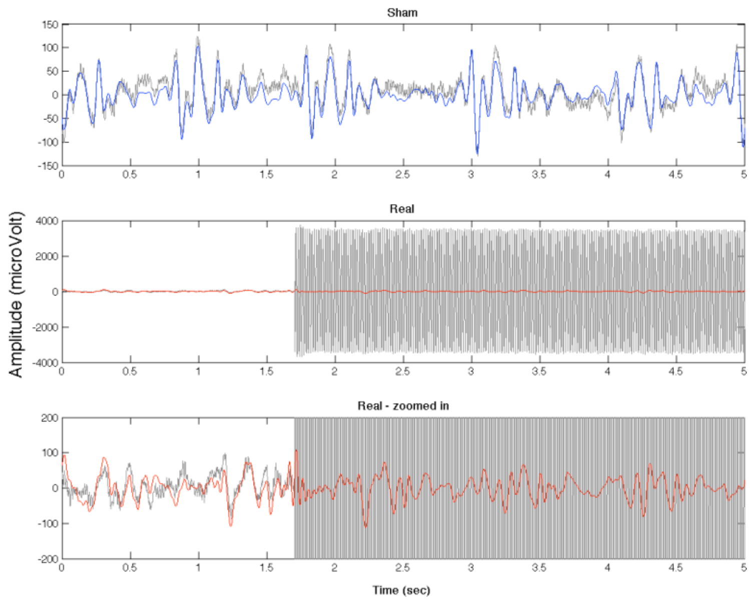
Long periods of exposure to strong electromagnetic power-line frequencies (50-60 Hz) may have harmful effects on occupational workers. Magnetophosphenes are among the known consistently reproduced biological effects of Extremely Low Frequency (ELF) Magnetic Fields (MF) (however, they are not the only manifestation - EEG and cognition are also affected [1,2,5]). Magnetophosphenes are induced perceptions of iridescent lights in the peripheral field of view, whose occurrence depends on MF frequency and flux density [4]. Research implicates this occurrence to synaptic polarizations in the retina resulting from MF exposure. Such neural stimulation brings forth concerns regarding the potential adverse effects of exposure on the central nervous system [3]. Magnetophosphene induction has thereby become one process for establishing MF exposure standards and guidelines by organizations such as the International Commission on Non-Ionizing Radiation Protection (ICNIRP) and the Institute of Electrical and Electronics Engineers (IEEE). Our goals are to determine the threshold of effect at 60 Hz and to study the neurophysiology during this phenomenon. Thus, we used the combined technolgoy of Magnetic Resonance Imaging (MRI) and electroencephalography (EEG) to investigate changes in brain activity during 60 Hz MF exposure.

Materials and Methods

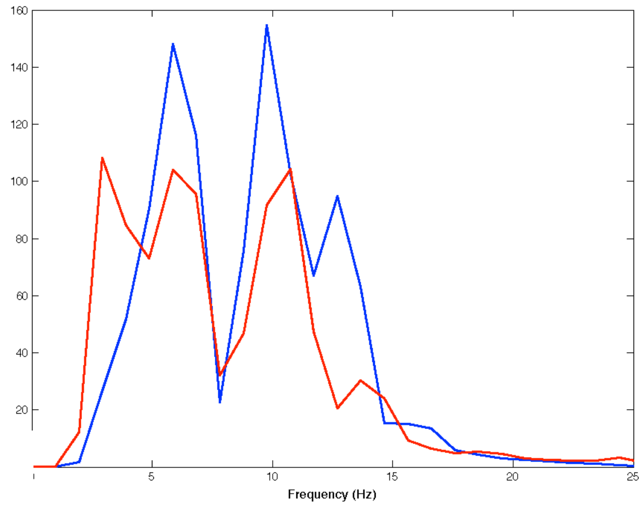
We are currently investigating the effects of 60 Hz MF exposure at 3 mT. A 64-channel MRI compatible EEG cap is used in a 3T MRI scanner. Participants are given head-only, centrally mediated exposures through the MR magnet. The protocol proceeds as follows: 3 repeated sequences of 1 minute, 30 seconds rest followed by 1 minute, 30 seconds exposure. This is the exposure sequence. Participants will then be given a sham sequence of 4 minutes, 30 seconds of rest. EEG data are collected throughout the entire experiment. Subsequently, participants are asked if they perceived magnetophosphenes. A sampling rate of 1 kHz was used and a Fourier transform was conducted on a 20-second segment of EEG during exposure. Data were filtered and analysed using MagLink RT and Matlab software. A band pass filter of 3-25 Hz was used; theta, alpha and beta power were extracted.

Results

Ten electrodes were included in the analysis: O2, OZ, C4, C3, CZ, PO4, PO3, C1, C2, and C5. Fig. 1 displays the EEG during sham and real exposure. For the sham exposure, the grey line represents raw EEG data and the blue represents filtered EEG. In the real exposure graphs, the grey represents raw EEG before and during 60 Hz exposure; the red represents the filtered data. The solid grey rectangle represents the 60 Hz artifact. Fig. 2 displays filtered 60 Hz with the frequency bands extracted for both sham (blue line) and real exposure (red line). The MF artifact was filtered without altering the original EEG waveform.



(1)



(2)

Summary and Conclusions

This pilot study is the first to investigate changes in human brain activity during 60 Hz MF exposure. Interestingly, alpha power increased in the real exposure condition (Fig. 2). We confirm that 60 Hz artifact can be successfully removed from EEG data so that MF effects can be examined. We have demonstrated that EEG amplifiers are not saturated by 60 Hz exposure and the data are available for analysis. Filtering high frequencies permits us to compare signals acquired with and without MF exposure. Furthermore, it allows investigating what is happening at the onset and offset of 60 Hz. However, the filtering procedure we have used thus far removes important information from EEG traces and needs to be refined.

Prospective work will be focused toward improving the filtering procedure and data analysis strategy (wavelet analyses may be considered). Although we will not be able to execute fMRI and EEG concurrently, we will implement a specific fMRI sequence which will include both the exposure signal (60 Hz, sinusoidal) and the BOLD sequence. Specifically, BOLD imaging will begin immediately at the offset of 60 Hz exposure so that any metabolic responses associated with MF exposure can be detected in the hemodynamic response delay. Lastly, other future we will include investigating event-related potentials (ERPs) and collecting fMRI data simultaneously with EEG.

References

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