EFFECTS OF A 60 HZ MAGNETIC FIELD EXPOSURE ON HUMAN BRAIN ACTIVITY DURING A MENTAL ROTATION TASK AS MEASURED BY fMRI

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INTRODUCTION

Studies using electroencephalography (EEG) have shown that extremely low frequency (ELF) magnetic fields (MF) can modulate human neurophysiology [1]. It has also recently been demonstrated that functional magnetic resonance imaging (fMRI) has the capacity to measure the effect of ELF MF on neuroprocessing [2]. A pilot study, using fMRI to investigate the effects of a 30 minute 60 Hz, 1800 μT MF exposure on brain activation during a tapping task, found that more activation was required to complete the task in the exposed condition compared to sham [3]. This pilot work has been extended in the current study to observe the effects of a 60 minute 60 Hz, 3000 μT MF on brain activation during: 1) rest; 2) a tapping task; and 3) a mental rotation task. Functional MRI studies of the mental rotation task have consistently found activation in several specific brain areas including regions involved in visual processing (Brodmann Area (BA) 19), integration of visual and motor information (BA7), and executive function and cognitive control (BA9) [4]. Since it has been reported that specific exposures to ELF MF may lead to a modulation of cognitive performances [5], we are hypothesizing that the functional brain activation associated with a mental rotation task will be modulated by the exposure.

MATERIALS AND METHODS

Nine healthy right handed participants (6 females, 3 males) were tested in a single blind study. Participants were randomly assigned to 2 groups: a real exposure group (5 subjects) and a sham exposure group (4 subjects). After obtaining informed written consent, each group completed a 1.5 hour fMRI session in a 3.0 Tesla MRI scanner (Siemens Verio, Erlangen Germany). The session began with a block of three different imaging conditions (16.5 minutes): rest; a tapping task; and a mental rotation task. This was followed by a 60 minute rest period in the MRI, where subjects remained awake and motionless in the scanner. During this rest period, the real exposure group was exposed to a 60 Hz, 3000 μT MF generated by the Z gradient coil of the MR scanner which was programmed to create the MF exposure (maximal at cortical level). An audio clip mimicking the sound of the MF was played for the sham exposure group during this 60 minute rest period to ensure a coherence of the auditory environment for both groups. A 2nd block of imaging conditions, identical to the 1st block, followed the 60 minute rest period.

For the mental rotation task each participant was asked to compare two 3-dimensional objects which were either the same or mirror images, rotated by a certain number of degrees in the x and y direction. Participants were asked to determine, as fast as they could, if these objects were the same or different.

The functional images associated with the mental rotation task, were processed using Brain Voyager QX 2.0.8.1480 (Brain Innovation, The Netherlands). Post minus Pre exposure comparison images were produced for each experimental group (sham, real). Regions of interest (ROI) were chosen based on *a priori* information of brain regions associated with the mental rotation task. Each ROI was analyzed separately using PASW Statistics 18 Release 18.0.0.

RESULTS

The pre exposure image (real + sham, n=9) displayed activation in BA7 (integration of visual and motor information), BA19 (visual processing), BA9 (executive function and cognitive control), which are all regions that have been associated with the mental rotation task in previous fMRI studies [4].

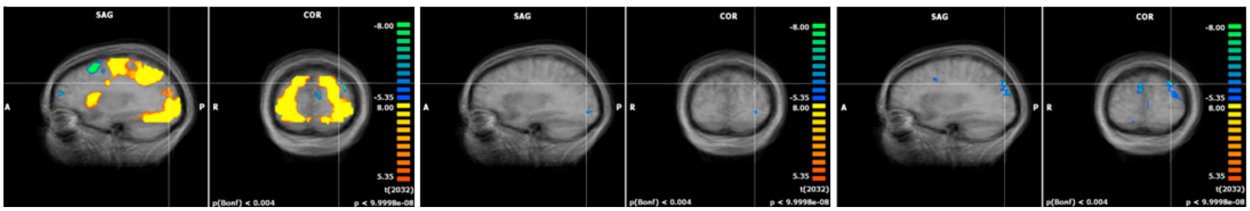

Figure 1. Intraparietal sulcus during mental rotation. Left: Pre exposure (n=9); Centre: Post minus Pre exposure in the sham exposure group (n=4); Right: Post minus Pre exposure in the real exposure group (n=5).

In the intraparietal sulcus, a region associated with visual attention, a significant interaction revealed a post exposure deactivation which was stronger in the real exposure group as compared to the sham exposure group ($F = 6.676$, $p=0.036$, df=1,7). In BA19, which is associated with visual processing, a significant interaction showed that the post exposure activation was stronger in the sham exposure group as compared to the real exposure group ($F=7.426$, $p=0.030$, df=1,7).

CONCLUSIONS

According to our results, one hour of ELF MF exposure can modulate neuroprocessing during a mental rotation task. The post-exposure activation of two brain regions associated with the performance of a mental rotation task is decreased post exposure. Notably, ELF MF exposure had a selective effect on brain regions associated with visual attention and processing. However, this is an ongoing study which currently has a small sample size, therefore, these results must be viewed with caution.

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SHORT SUMMARY
It has been reported that extremely low frequency (ELF) magnetic fields (MF) can modulate human neurophysiology. Functional magnetic resonance imaging (fMRI) was used to determine the effect of a 60 Hz, 3000 μT MF on brain activation associated with a mental rotation task. Significant interactions were found suggesting MF induced modulations of activation in the intraparietal sulcus and Brodmann Area 19, regions associated with visual attention and visual processing. Our results demonstrate that fMRI is a valuable tool capable of detecting modulation induced by ELF MF on certain brain processes such as those associated with a mental rotation task.