MAGNETIC FIELD EXPOSURE CAN ALTER NEUROPROCESSING IN HUMANS

John A. Robertson1,3, Jean Théberge1,2,3, Jodi Miller1,2,3*, Julie Weller1, Dick J. Drost1,2,3, Frank S. Prato1,2,3, Alex W. Thomas1,2,3

1. Imaging Program, Lawson Health Research Institute, London, ON
2. Diagnostic Imaging, St. Joseph’s Health Care, London, ON
3. Dept. of Medical Biophysics, University of Western Ontario, London, ON

*Corresponding author e-mail: jmiller@lawsonimaging.ca

INTRODUCTION

Previous studies have shown that magnetic fields have subtle effects on pain perception in animals as well as humans. Experiments with sinusoidal extremely low frequency magnetic fields as well as pulsed electromagnetic fields (PEMF) have indicated that PEMF may have a larger analgesic effect, and so may be more clinically relevant. Indeed, these effects have been demonstrated to be specific to the affective component of pain, not affecting the sensory thresholds in human volunteers [1]. Here, we use functional imaging to examine the underlying changes in neuroprocessing after pulsed magnetic field exposure.

MATERIALS AND METHODS

Normal human volunteers were recruited from around the university to participate in this study. After obtaining informed consent, subjects were tested for their individual tolerance to thermal pain using a Peltier thermode attached to the right hand (Medoc TSA-II; Pathway).

A functional imaging study (functional magnetic resonance imaging – fMRI) was then conducted with the heat cycling on and off 10 times during MRI data acquisition, after which the subjects verbally reported their average pain level. Subjects were then exposed to a pulsed magnetic field inside the MRI, delivered by the gradient coils of the scanner, or a sham condition, which involved lying still within the scanner without the gradient coils producing a time-varying field. The duration of the exposure condition was 15 minutes for “phase 1” and 45 minutes for “phase 2” of the study. The pulsed magnetic field exposure used Z-gradient coils (the gradient along the bore of the magnet). The peak gradient strength was 2 mT/m, and the patient table was offset 10 cm cranially from the isocentre so that the field at the brow level was set to be 200 μT, the same field strength used in whole-body exposures within our lab in the past with Helmholtz coils [1]. Following the exposure, a second fMRI scan was conducted, with the heat cycling on and off 10 times as before.

Functional images were analyzed within Brain Voyager (Brain Innovation B.V., the Netherlands), and then regions of interest (ROI) were selected based on a priori knowledge of the brain regions associated with pain processing as well as the difference maps from the fMRI analysis. Regions of interest were analyzed separately within SPSS.

RESULTS

For “phase 1”, the 15 minute exposure study, 31 subjects (17 sham, 14 PEMF) were analyzed; significant interactions were seen for neuroprocessing in the ipsilateral (right) insula, anterior cingulate, and bilaterally for the hippocampus/caudate region. No significant interaction was seen in the subjective pain scores. [2]
<table>
<thead>
<tr>
<th>Region</th>
<th>Interaction F</th>
<th>Interaction p</th>
<th>Partial eta-squared</th>
<th>Observed power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anterior cingulate</td>
<td>$F_{1,29} = 6.834$</td>
<td>$p &lt; 0.05$</td>
<td>0.19</td>
<td>0.72</td>
</tr>
<tr>
<td>Insula (ipsilateral)</td>
<td>$F_{1,29} = 5.204$</td>
<td>$p &lt; 0.05$</td>
<td>0.15</td>
<td>0.60</td>
</tr>
<tr>
<td>Hippocampus/Caudate (ipsilateral)</td>
<td>$F_{1,29} = 13.803$</td>
<td>$p &lt; 0.01$</td>
<td>0.32</td>
<td>0.94</td>
</tr>
<tr>
<td>Hippocampus/Caudate (contralateral)</td>
<td>$F_{1,29} = 6.055$</td>
<td>$p &lt; 0.05$</td>
<td>0.17</td>
<td>0.66</td>
</tr>
</tbody>
</table>

Table 1: Summary of significant interactions for ROI analysis.

![fMRI difference maps](image)

Figure 1: fMRI difference maps, centered on the right insula, showing the difference in activation between pre- and post-exposure for the PEMF exposed group on the left, and sham on the right.

The “phase 2” 45 minute exposure study was then undertaken to match up the exposure duration more closely with the previous studies that had found a subjective effect of PEMF exposure on pain. There was no significant interaction between subjective ratings and exposure condition, however a main effect of sleep (N=51, $p<0.01$) was observed.

CONCLUSIONS

These results indicate that PEMF exposure does alter the neuroprocessing of pain as measured by fMRI, and that the regions of the brain affected are those specifically dealing with the affective component of pain – purely sensory regions (e.g.: S1) did not appear to be affected. The use of functional imaging appears to be more sensitive to these subtle analgesic effects than subjective reporting, as significant interactions were found in the absence of a significant effect on the subjective scores with a 15-minute exposure (this was also the shortest exposure tested to date).

ACKNOWLEDGMENTS

The authors would like to thank Dr. Derek Mitchell, Dr. Dwight Moulin, Dr. Alexandre Legros, Dr. Keith St. Lawrence, and Mr. Lynn Keenliside for their assistance with this project. This project was funded by a grant from the Canadian Natural Sciences and Engineering Research Council and the Canadian Institutes of Health Research.

REFERENCES
