Effect of Pulsed Magnetic Field on fMRI Processing of Pain

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Introduction: The effects of a PEPSI gradient sequence on bipolar patients was described by Rohan *et al* (2004) following serendipitous anecdotal reports of decreased depression following the MRS study. Previous research in our lab has indicated that a specific pulsed magnetic field has an analgesic effect in snails, rodents, and humans. Shupak *et al*. (2006) have shown that head-only exposures can affect pain perception, while Cook *et al*. reports that pulsed magnetic field exposures affect EEG. These indicate that an effect on neural processing is present. For the present work, we investigate the effect of this specific pulsed magnetic fields on the processing of pain using functional magnetic resonance imaging (fMRI).

Methods: Right-handed normal adult subjects aged 18-60 were recruited to participate in a functional magnetic resonance imaging study. Exclusion criteria included claustrophobia, nerve damage to the hand, analgesic use on the day of the study, alcohol use on the day of the study, and the inability to lie still for an hour, as well as the standard MRI exclusion criteria (e.g.: cardiac pacemakers). Subjects were blinded to their condition of sham vs pulsed magnetic field exposed. Subjects were given acute thermal pain with a Medoc TSA-II (Medoc, Israel). A 1.6 x 1.6 cm Peltier thermode probe was attached to the hypothenar region of the right hand and heated under computer control (heat stayed on for 21 seconds, off for 24 seconds, with 3 second ramps in between). Temperatures varied between 48 and 51°C, depending on the subject's pain tolerance.

Single-shot echo-planar BOLD images were acquired (16 oblique slices, 64 x 64 resolution, 192 mm FOV, 3 s TR). fMRI images were acquired on a Siemens Avanto 1.5 T MRI while the thermal pain cycled on and off, 10 times for each round of functional imaging, and immediately afterwards the subjects were asked to rate their subjective pain verbally over the intercom. The subjects then had a 15 minute "rest" period within the MRI system during which time they could not move and were exposed to the pulsed magnetic field, or a sham condition. The functional imaging and pain process was then repeated to obtain "post-exposure" data, following which T1-weighted anatomical images were obtained (MPRAGE sequence, 1 mm isotropic voxels). Functional image processing was done with Brain Voyager (Brain Innovation B.V., the Netherlands) v1.9.9, and included 3D motion correction, temporal filtering (3 cycles/run high pass cutoff), and Talairach normalization.

The analgesic pulsed magnetic field exposure was delivered within the MRI system by programming the Z-gradient. The peak gradient strength was 2 mT/m, and the 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 (non-MRI) within our lab in the past with Helmholtz coils (Shupak *et al.*, 2004).

Results: 31 subjects (18 sham, 13 exposed) have been analyzed in a General Linear Model multisubject, multistudy analysis. Several regions showed significant changes in activation (using False Discovery Rate correction FDR q<0.05). In particular, the anterior cingulate showed a decrease in activity following pulsed magnetic field exposure, and an increase in activity following sham exposure. Also, the posterior cingulate had an increase in activity following pulsed magnetic field exposure.

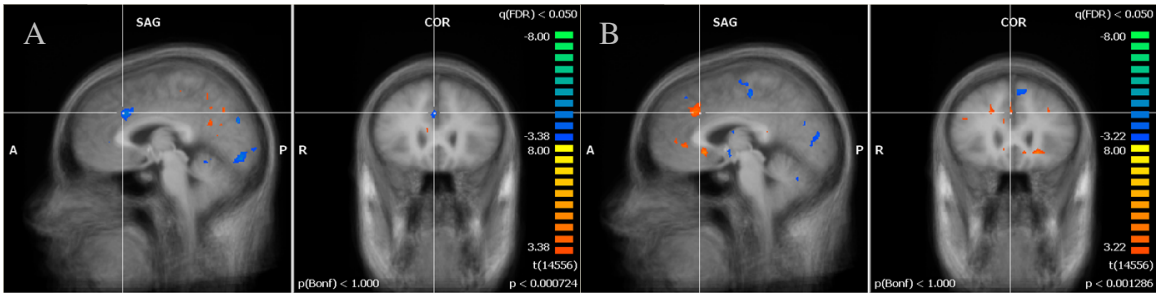

Figure 1: The change in activation following pulsed magnetic field exposure (post-pre) (A) and following sham exposure (post-pre) (B) in the anterior cingulate. There was a time effect (increase in activity following sham) that was reversed with pulsed magnetic field exposure.

Discussion: These results demonstrate an effect of pulsed magnetic field exposure on acute pain processing with fMRI. The effect seen in the posterior cingulate areas is interesting as this is a region not typically associated with acute pain. To the best of our knowledge, this is the first use of functional magnetic resonance imaging to demonstrate the effect of a weak pulsed magnetic field on neural functioning and/or brain blood flow.

References: M. Rohan *et al.* 2004 Am J Psych. 161(1):93-98
N. Shupak *et al.* 2004 Neurosci Lett. 363(2):157-162
N. Shupak *et al.* 2006 Pain Res Manag. 11(2):85-90
C. Cook *et al.* 2005 Bioelectromagnetics. 26(5):367-76