SINGLE SUBJECT SPINAL FMRI USING SE-ZOOM-EPI

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TARGET AUDIENCE: Clinicians and researchers interested in spinal cord fMRI.

BACKGROUND AND PURPOSE: Functional MRI of the spinal cord is very challenging due its dimensions, physiological noise and its anatomy that cause distortions and loss of signal. The purpose of this study was to present a protocol to assess stimulus-related activation in the spine with SE-ZOOM-EPI to overcome some of these disadvantages.

MATERIALS and METHODS: Acquisition - Four healthy volunteers were scanned with a paradigm that involved localized sensory stimulation of the C6 dermatome over the palmar surface of the thenar eminence, using an MR-compatible electric rotating brush. The surface area of stimulation was 0.8x0.8cm^2. For each subject, left and right hands were stimulated in separate, consecutive fMRI sessions. All volunteers were right-handed, two women and two men (mean age=33). A 3T MRI scanner (Philips Achieva TX, Best, Netherlands) with a 16 channel neurovascular coil was used for this study. All scans were performed with the Spin Echo ZOnally-magnified Oblique Multislice EPI (SE-ZOOM-EPI) sequence *[1]*, using a reduced field of view for targeted areas of fMRI activations. The imaging parameters were TR=3600ms, TE=30ms, voxel size=1.19x1.19x4mm^3 with 1mm gap between slices (reconstructed to 1.19x1.19x4mm^3), acquisition matrix=64x40, 9 slices. The block design comprised 10 epochs of rest alternated with 10 epochs of activation, each one lasting 36 seconds. During each session 200 volumes were acquired in about 12 minutes. Scan coverage extended from the upper limit of C5 to the lower limit of C7 vertebral segments (Fig.1) and the slices were always centered transverse to the cord. Flow compensation was used in order to reduce artefacts from cerebrospinal fluid (CSF) flow. Data analysis - Data were processed by SPM8 software (http://www.fil.ion.ucl.ac.uk/spm/) to detect the voxels showing activation. After slice timing, each dataset was spatially realigned using a least-squares approach to estimate a six-parameter rigid body transformation for each individual dataset. The temporal datasets were smoothed using a Gaussian filter kernel having a full width half-maximum (FWHM) of twice the in-plane voxel size. No physiological motion regressors were used in this study. Average signal change for the activated voxels through the time course was computed using Matlab (MATLAB, The MathWorks Inc., Natick, MA).

RESULTS: 1) Spinal cord (C5/C6): The most consistent activity was found at C5/C6 vertebral level in each volunteer for right hand stimulation and in three out of four volunteers for left hand stimulation. These activations tended to be in ipsilateral grey matter and localized to the posterior horn of the grey matter butterfly (Fig.2). **2) Spinal cord (not C5/C6)**: In volunteers 1 and 2 there were no other activations inside the spinal cord. In volunteers 3 and 4 there were activations inconsistently seen at different spinal levels. **3) Extra-spinal activations**: Random and inconsistent areas of activations were found outside the spinal cord for all volunteers.

4) Significance of activation: Significant activity is reported at p<0.01 (uncorrected). **5) Average signal change:** 1.86 +/- 0.59 (mean+/-std).

DISCUSSION: The more consistent activation (in term of localisation) among subjects was detected at spinal cord level C6 where it was expected. These activations tended to localize to the posterior grey matter horns, reflecting the somatic sensory stimulus that was employed. The extra-spine activations, found at different levels of the spine, were random and never falling in the same voxels in different acquisitions and in different subjects. The average signal change is in agreement with the results obtained in previous studies by Stroman*[2]*.The ZOOM-EPI used is a Spin-Echo sequence, less sensitive than Gradient-Echo sequences to venous contribution and draining veins effects to the signal changes, which are known to contribute to fMRI signal in the spinal cord *[3]*. The high pixel bandwidth and reduced echo train length of the ZOOM-EPI sequence helped to reduce susceptibility artefacts *[4]*.

The results support the detection of stimulus-related activation in the spinal cord using our research protocol.

CONCLUSIONS: This is an ongoing research study about detecting spinal fMRI and further investigations implying different stimuli and group analysis statistics will follow. The ongoing project comprises improvements of the SE-ZOOM-EPI sequence and study of custom-made slice specific physiological regressors to be included in the General Liner Model.

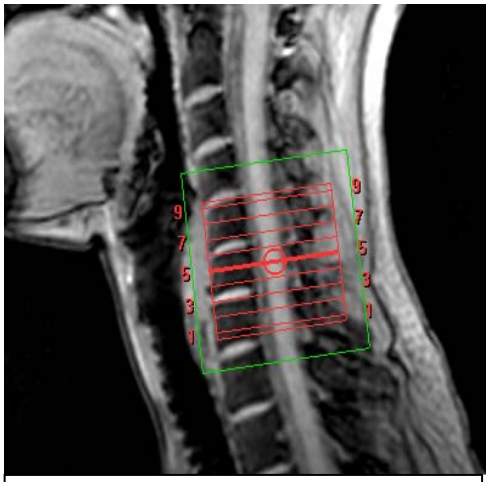

Fig.1: Screenshot showing the positioning of the 9 slices of the SE-ZOOM-EPI sequence.

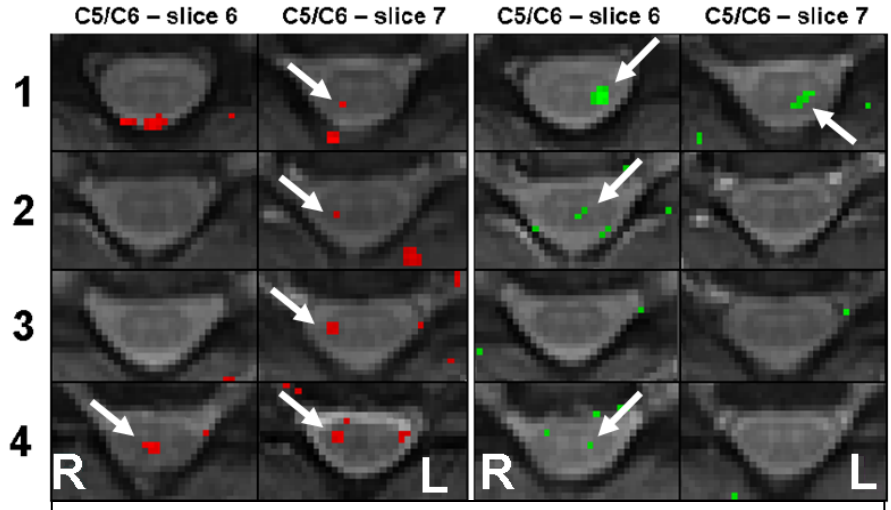

Fig.2: Activation at the C5/C6 vertebral level in all volunteers for right hand stimulation (in red) and for left hand stimulation (in green) with p<0.01 (uncorrected).

Acknowledgments: *MS Society of Great Britain and Northern Ireland, International Spinal Research Trust, The Department of Health's NIHR Biomedical Research Centre funding scheme.* **References:** *[1] Wilm BJ et al. ; NMR Biomed 2009, 22:174-181. [2]* Stroman et al. ; Magn. Res. Imag. 23 (2005):843-850. *[3]* Bandettini PA et al. ; NMR Biomed 1994, 7:12-20. *[4] Wheeler-Kingshott CAM et al. ; Neuroimage 16, 93-102 (2002).*