Combining EEG and fMRI data from a Wistar rat: a new tool for comparative neuroimaging

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INTRODUCTION

EEG and fMRI data fusion in humans has been useful in the past since these two modalities provide complementary information in time and space. However, EEG and fMRI concurrent recording in rodents has been limited in terms of the number and the characteristics of the utilized electrodes (Mirsattari et al., 2007). In this work, we introduce a methodology to obtain high-resolution scalp EEG data concurrently with high-field fMRI-BOLD signals.

MATERIALS & METHODS

Animal preparation: A male Wistar rat weighting 215g was used. The hair on its head was carefully removed and the skin was degreased by applying 70% ethanol. A tracheotomy was performed for mechanical ventilation. The muscle relaxant pancuronium (2mg/kg/hr) and the anesthetic α-chloralose (20mg/kg/hr) were administrated via tail-vein injection. Two small needle electrodes were inserted in the right forepaw for electrical stimulation. Electrophysiology: We prepared a MRI-compatible EEG mini-cap composed of 32 quasi perpendicularly movable electrodes which have been made from platinum wires (Fig. 1). The EEG and ECG signals were recorded with a commercially available MRI-compatible 32-channels BrainAmp system. Magnetic resonance imaging: The MRI data was acquired by a 7T PharmaScan with a 38mm volume coil. The fMRI-BOLD signals were obtained using single-shot gradient echo-planner images with the following parameters: TR=2sec, TE=15msec, effective spectral width=250kHz, FOV=2.5x1.5cm^2, in-plane resolution=200x200μm^2, 7 coronal slices, 1.5mm thickness.

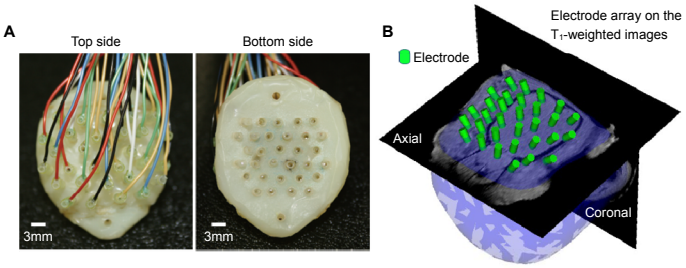

Fig. 1 (A) Photographs of the MRI-compatible EEG mini-cap taken from top (left) and bottom (right). The electrodes were regularly distributed covering the whole rat head, with distances between consecutive electrode rows of about 3mm. (B) A three-dimensional rendering of the electrodes (green cylinders) reconstructed from the T_1-weighted anatomical reference.

RESULTS & DISCUSSION

The EEG mini-cap did not produce any distortion on the T_2 mapping and EPI images although SNR for EPI images slight decreased (Fig. 2). Fig. 3A shows event-related EEG response with the three classical components and their scalp topographies. The SPM t-test mapping ($p<0.05$) for the used stimulation paradigm reveals a clear activation in the primary somatosensory region (Fig. 3B). By means of the proposed methodology, one can combine brain electrical source reconstruction and their coupled hemodynamic responses at the level of single voxels with pharmacological/genetic strategies.

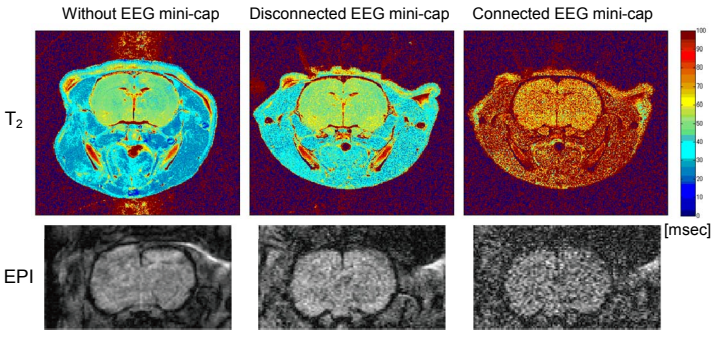

Fig. 2 Comparison of T_2 mapping and the EPI image for a single brain slice in several conditions: without the EEG mini-cap (left); with the EEG mini-cap disconnected from amplifiers (center); with the EEG mini-cap connected to the amplifiers (right).

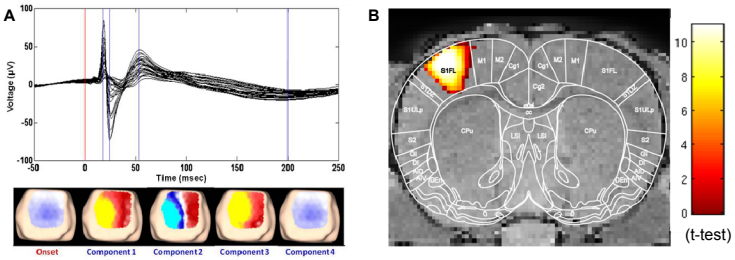

Fig. 3 (A) The average EEG signals for all electrodes and the topographic maps for four particular components are shown. The timings for these components are marked on the average time series with vertical blue lines. (B) The BOLD response associated with the forepaw stimulation under the concurrent EEG and fMRI experimental paradigm. The SPM t-test value is co-registered with a standard rat's atlas. The SPM t-test scale ($p<0.05$) is shown on the right side.

REFERENCE

Mirsattari, S.M., Ives, J.R., Leung, L.S. & Menon, R.S. EEG Monitoring during Functional MRI in Animal Models. *Epilepsia* 48, 37-46 (2007)