Integrated MEG and fMRI Model: Synthesis, Analysis, and Validation using Auditory Data

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Abstract

We will present development and validation of an integrated model for magnetoencephalography (MEG) and functional Magnetic Resonance Imaging (fMRI). In the proposed model, neural activity is related to Post Synaptic Potentials (PSPs) which is the common link between MEG and fMRI. Each PSP is modeled by the direction and strength of its current flow which are treated as random variables. The overall neural activity in each voxel is used for equivalent current dipole in MEG and as input of extended Balloon model in fMRI. The model shows possibility of detecting activation by fMRI in a voxel while the voxel is silent for MEG and vice versa. Parameters of the model illustrate situations like closed field due to non-pyramidal cells, canceling effect of inhibitory PSP on excitatory PSP, and effect of synchronicity. In addition, the model shows that the crosstalk from neural activities of adjacent voxels in fMRI may result in the detection of activations in these voxels although they contain no neural activities. We use real auditory MEG and fMRI datasets from 7 normal subjects to estimate the parameters of the model. The MEG and fMRI data are acquired at different times but the stimulus profile is the same for both techniques. We use independent component analysis (ICA) to extract activation-related signal from the MEG data. The ICA component correlated with the stimulus is used to estimate the MEG parameters of the model. The temporal and spatial information of the fMRI datasets are used to estimate the fMRI parameters of the model. The parameters estimated for different subjects have reasonable means and standard deviations. Goodness of fit of the real data to the proposed model shows its ability to simulate realistic datasets for evaluation of integrated MEG and fMRI analysis methods. As such, the proposed model may play an important role in evaluating and comparing different analysis methods of MEG and fMRI. It may also be very useful in characterizing the upcoming combined methods for simultaneous analysis of MEG and fMRI.