Constraining the inverse problem in EEG using dMRI

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Résumé

Sleep disorders are associated by other medical conditions such as neurodegenerative and cardiovascular illnesses. However, the mechanisms by which sleep disorders affect other illnesses is not always known.
The preferred tool for non-invasive exploration of brain activity during sleep is electroencephalography (EEG), which measures potential differences on the surface of the scalp. This modality is particularly well suited to sleep studies because EEG signals can be recorder throughout the night. The signals observed in EEG are directly related to the underlying bioelectric activity of the brain. EEG can therefore be used to observe which regions of the brain are activated during sleep. However, inferring the brain activity from EEG measurements is a difficult problem due to the limited number of electrodes that can be placed on the scalp. To improve the situation, all current methods simplify the problem using hypotheses, usually based on the subject's anatomy. A common assumption is that the cortex can be subdivided into regions where the activity is coherent. This idea could be pushed further by assuming that the cortical regions are connected by fiber going through the white matter. However, there are very few EEG models which support anatomical connections of cortical regions.
The advances of the past 20 years in diffusion Magnetic Resonance Imaging (dMRI) offers a new perspective on brain anatomy: the white matter fiber tracts. Indeed, we are now able to visualize and quantify anatomical connections in the brain. The information obtained in EEG and dMRI is therefore complementary, however there are very few available strategies which take advantage of both EEG and dMRI. Here, we present a new method to infer cortical activation and white matter information flow using joint EEG and dMRI measurements.

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