Abstract

Today, most major programs in Neuroscience and Psychology have their own functional imaging systems and laboratories. We can assess hemodynamic changes with functional Magnetic Resonance Imaging (fMRI) and functional Near-Infrared Spectroscopy (fNIRS), broad regional electrical activity with magneto/electroencephalography (MEG/EEG), and metabolism/neurochemistry with Positron Emission Tomography (PET). And yet, despite this widespread adoption, the power of available human neuroimaging methods remains limited, leaving a gap between the macroscopic activity patterns available in humans and the rich, detailed view achievable in model organisms. Thus, a central challenge facing neuroscience today is leveraging these mechanistic insights from animal studies to accurately draw physiological inferences from noninvasive signals in humans, essentially asking the fundamental question: what information about neuronal circuit activity can we reliably determine from noninvasive functional imaging in humans? On the essential path towards this goal is the development of a detailed "bottom-up" forward model bridging neuronal activity at the level of cell-type-specific populations to noninvasive imaging signals. The general idea is that specific neuronal cell types have identifiable signatures in the way they drive changes in cerebral blood flow, cerebral metabolic rate of O_2 (measurable with quantitative functional Magnetic Resonance Imaging, fMRI), and electrical currents/potentials (measurable with magneto/electroencephalography, MEG/EEG). This forward model would then provide the "ground truth" for the development of new tools for tackling the inverse problem – estimation of neuronal activity from multimodal noninvasive imaging data.