OPTICAL IMAGING OF BRAIN FUNCTIONS AND NETWORKS: FROM MOUSE TO MAN

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This talk will discuss optical imaging of functional-connectivity in both humans and mouse models. For human applications, optical imaging technology is motivated by the clinical need for longitudinal monitoring of the brain at the bedside. While optical imaging has long held promise for bedside neuroimaging, image quality has been lacking, particularly in comparison to the gold standard of functional magnetic resonance imaging (fMRI). Moreover, traditional functional mapping requires subjects to perform tasks, which is very limiting in clinical populations. New high-density diffuse optical tomography (HD-DOT) methods provide one strategy for improving image quality. This talk will discuss challenges in HD-DOT including the development of large field-of-view photonics instrumentation, imaging arrays, and anatomical light modeling. The implications of the new technology for mapping of higher-order, distributed brain function such as language processing and resting-state networks will be discussed along with explorations of HD-DOT in the clinic.

In animal models, a pressing interest amongst the fcMRI community is development of a mouse equivalent measurement of functional connectivity so as to link human fcMRI with mouse models of disease. To satisfy this need, we recently developed a method for functional connectivity mapping in mice using optical intrinsic signal imaging (fcOIS). Highly detailed mapping of functional networks is achieved across most of the cerebral cortex. Synthesis of these multiple network maps through iterative parcellation and clustering provides a comprehensive map of the functional neuroarchitecture that is in agreement with histologic literature (e.g., the Paxinos atlas). Most recently we have been working to extend these methods to genetically encoded calcium indicators (GECI's) that provide a more direct measure of neural activity, with higher speed than hemoglobin contrasts. Finally, we are extending optical imaging to volumetric imaging of the full mouse brain using diffuse optical tomography of blood dynamics, and fluorescence molecular tomography of calcium dynamics. In principle, these new deep tissue optical methods enable new paradigms linking human cognitive neuroscience to mouse models where manipulations of disease, metabolism, and development are possible.