A Look into the Human Brain: Neural Processing Representations of Behavior and Disease

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Functional neuroimaging studies attempt to identify spatially localized brain regions that drive the execution of experimental tasks targeting, for example, behavior, cognition, or emotion. These studies may also provide neural representations of the pathophysiology associated with psychiatric, neurological, and addiction disorders. There are numerous challenges in analyzing functional neuroimaging data. Neuroimaging studies produce massive data sets comprised of serial scans on each subject, with each scan containing hundreds of thousands of spatially localized measurement sites (voxels). Also, human brain function, viewed through functional magnetic resonance imaging (fMRI), presents complex patterns of spatial and temporal correlations. In this talk, we consider fMRI data from a study of inhibitory control among cocaine addicts. We propose a Bayesian hierarchical model that accounts for spatial correlations between voxels, both within and between designated neuroanatomic structures, while also capturing temporal correlations between repeated scans for each subject. Our model provides a framework to detect localized (voxel-level) changes in brain activity associated with cocaine addiction and its response to treatment, regional changes in brain activity, and measures of task-related functional connectivity.