Intuition, deduction, and the art of picking up the pieces

Given recent technological and methodological developments, a liaison between neuroimaging and computational neuroscience becomes increasingly promising. Ultra-high field functional magnetic resonance imaging (fMRI) is increasingly informative with respect to cortical representations at intermediate spatial scales and hence moves fMRI closer to the realm of computational neuroscience. At the same time, increasing computational power allows for simulation of whole-brain dynamics thus moving computational neuroscience closer to the realm of fMRI. Drawing on these developments, I illustrated two approaches to conduct interdisciplinary research. This integration proved fruitful for testing existing theories of brain function as well as developing new theories.

The first part of the thesis presents research embedded within the neuroscience of vision and relies on advances with regard to ultra-high field fMRI and population receptive field mapping in order to perform comparative theory testing. Specifically, it is concerned with developing a framework suited for evaluating the detailed spatial activation profile predicted by a computational model of how the brain processes surfaces against neuroimaging data.

The second part of the thesis presents research aimed at understanding structure-function relationships in the brain. It exploits advances in parallel computing and neural mass models to build large-scale models which can be informed by fMRI data. Specifically, it is concerned with elucidating the role of the cortical rich club, a set of brain regions exhibiting very rich connectivity, in the globally coordinated integration of segregated brain regions into temporal functional networks.