Characterizing Functional Maps in Human Neocortex

Jack L. Gallant, PhD
Professor, Psychology and Neuroscience
Programs in Bioengineering, Biophysics & Vision Science
University of California, Berkeley, USA

Abstract

Human neocortex consists of billions of neurons that are arranged in local circuits, cortical columns and spatial maps. The entire system forms a highly interconnected network with significant feedback. It should be possible to understand brain computation by identifying cortical maps and determining what is represented in each map. However, thus far functional mapping methods such as magnetic resonance imaging (fMRI) have not routinely been used to recover maps beyond primary sensory areas. Several lines of current research focus on developing better methods of functional data acquisition (e.g., particle magnetic imaging; voltage-gated paramagnetic taggants; functional near-infrared spectroscopy). However, the fastest way to improve functional mapping is to develop better methods for data analysis and modeling. Classical approaches for analyzing functional data are weak and do not generalize well. Newer approaches based on system identification and forward modeling are proving to be much more sensitive and robust. These system identification methods can also be used to build accurate reverse models that can decode brain activity with unprecedented levels of detail. Finally, new generative modeling methods can be used to quantify individual variability, producing objective probabilistic models of human brain anatomy. Functional cortical maps measured under a broad range of different stimulus and task conditions can provide information critical for the design of artificial cognitive systems.