Methods for Dynamic Causal Interactions in Human Brain Function and Dysfunction

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Principal Investigators

MENON, VINOD

Institution

STANFORD UNIVERSITY

Contact information of lead PI
Country

USA

Title of project or programme

Methods for Dynamic Causal Interactions in Human Brain Function and Dysfunction

Source of funding information

NIH (NINDS)

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€ 2,403,901.83

Start date of award

01/07/2014

Total duration of award in years

3

The project/programme is most relevant to:

Parkinson's disease & PD-related disorders

Keywords

dynamic system, Markov Chains, Markov chain Monte Carlo methodology, connectome, Functional Magnetic Resonance Imaging

Research Abstract
DESCRIPTION (provided by applicant): In the past two decades, functional magnetic resonance

imaging (fMRI) has emerged as a powerful tool for investigating human brain function. Although fMRI research has primarily focused on identifying brain regions that are activated during performance of cognitive tasks, there is growing interest in examining how cognitive functions emerge as a result of context-dependent, dynamic causal interactions between distributed brain regions. Devising and validating methods for investigating such interactions has therefore taken on great significance. The first major goal of this proposal is to address a critical need in fMRI research by developing novel algorithms for identifying context-dependent dynamic causal interactions between distributed brain regions. To this end, we will develop and validate novel computational methods using Multivariate Dynamical Systems based Markov chain Monte Carlo (MDS-MCMC) algorithms that overcome major limitations of existing methods for investigating dynamic causal interactions and connectivity in the human brain. A comprehensive validation framework will be use evaluate MDS-MCMC and compare it with existing dynamic causal estimation methods. The second major goal of this proposal is to use the MDS-MCMC framework to investigate dynamic causal interactions underlying cognition in normal healthy adults, and in patients with Parkinson's disease (PD). Cognitive impairment is one of the most devastating symptoms in PD. Once thought of as an insignificant feature of the disease, it is now clear that cognitive impairment is present in the majority of PD patients and that this impairment is significantly linked to increased disability and the risk of mortality, yetlittle is known about the brain basis of cognitive impairment in PD. The computational algorithms we develop, validate, and apply here will allow us to rigorously investigate brain dynamics support critical cognitive processes in the human brain, leading to a more complete understanding of fundamental mechanisms underlying human brain function and dysfunction. Our proposed studies will also, for the first time, examine casual interactions in simulated, open-source, opto-genetic, experimental and clinical brain imaging data using state-of-the-art sub-second high-temporal resolution fMRI, based on the Human Connectome Project (HCP). Critically, we will maintain a tight link between our computational and systems neuroscience goals algorithms to solve important problems in cognitive, systems and clinical neuroscience. Together, our proposed studies will lead to new and improved computational tools for examining dynamical causal interactions between distributed brain regions, with broad applications to the HCP and clinical neuroscience. The proposed studies are highly relevant to the mission of the NIH Innovations in Biomedical Computational Science and Technology and the Big Data to Knowledge Programs, which seek to encourage development and dissemination of innovative advanced computational tools for brain imaging and neuroscience. We will disseminate our algorithms and software to the research community via NITRC .

Lay Summary

PUBLIC HEALTH RELEVANCE: In the past two decades, functional magnetic resonance imaging (fMRI) has emerged as a powerful tool for investigating human brain function and dysfunction. Although fMRI studies of brain function have primarily focused on identifying brain regions that are activated during performance of perceptual or cognitive tasks, there is growing consensus that cognitive functions emerge as a result of dynamic context-dependent interactions between multiple brain areas. Developing new computational methods for investigating causal interactions in fMRI data has therefore taken added significance; the overall goal of this proposal is to address this critical need by developing new methods for studying causal interactions and brain connectivity between distributed brain regions during cognition.

Further information available at:

Types:

Investments > €500k

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United States of America

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Parkinson's disease & PD-related disorders

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