Quantifying Economy in Brain Networks

By Dani Bassett

University of Pennsylvania, Philadelphia

With High-Level Panel of Leaders in Science, Technology, On-the-Ground Action, and Policy

Friday, January 20, 2023 | 11 AM to 1 PM EST (2 hours in duration)

For Remote Participation, please register HERE

ABSTRACT: The human brain is organized as a network of interconnected components in the form of neural units, ensembles, areas, and regions. Across a range of spatial scales, that network is neither perfectly ordered nor perfectly random. Its heterogeneous organization supports complex activity dynamics while simultaneously constraining such dynamics. How does this constraint affect the cost of activity flow? In this talk, I will discuss the notion of network economy: the idea that the brain's network organization partially determines the cost of reaching a brain state, maintaining a brain state, and transitioning between brain states. I will draw ideas and examples from the field of network control theory, which provides a framework for calculating energy costs associated with network systems reaching, maintaining, and transitioning among brain states. The discussion will focus on basic principles and intuitions, and will point listeners to code repositories, primers, and methodological studies they might find useful in implementing the approach. I will close by broadening out to discuss how principles of network economy can inform our study

PRESENTER: Dani Bassett is the J. Peter Skirkanich Professor at the University of Pennsylvania, Departments of Bioengineering, Electrical & Systems Engineering, Physics & Astronomy, Neurology, and Psychia-try, and external professor of the Santa Fe Institute. They received a B.S. in physics from Penn State University and a Ph.D. in physics from the University of Cambridge as a Churchill Scholar and NIH Health-Sciences Scholar. Following a postdoc at UC Santa Barbara, Bassett was a Junior Research Fel-low at the Sage Center for the Study of the Mind. They have received multiple prestigious awards, in-cluding American Psychological Association's 'Rising Star' (2012), Alfred Sloan Fellow (2014), Mac-Arthur Fellow (2014), IEEE EMBS Early Academic Achievement Award (2015), Office of Naval Re-search Young Investigator (2015), National Science Foundation CAREER (2016), Popular Science Bril-liant 10 (2016), Lagrange Prize in Complex Systems Science (2017), Erdos-Renyi Prize in Network Science (2018), OHBM Young Investigator Award (2020), AIMBE College of Fellows (2020), Ameri-can Physical Society Fellow (2021), and Web of Science's most Highly Cited Researchers (2019-2021). Bassett is the author of more than 380 peer-reviewed publications (36,000 citations), and an aca-demic trade book co-authored with philosopher and twin Perry Zurn titled "Curious Minds: The Power of Connection" (MIT Press; 2022).

About the series: The precision convergence series is launched to catalyze unique synergy between, on the one hand, novel partnerships across sciences, sectors and jurisdictions around targeted domains of real-world solutions, and on the other hand, a next generation convergence of AI with advanced research computing and other data and digital architectures such as PSC's Bridges-2, and supporting data sharing frameworks such as HuBMAP, informing in a real time as possible the design, deployment and monitoring of solutions for adaptive real-world behavior and context.

The McGill Centre for the Convergence of Health and Economics (MCCHE) is a virtual world network of scientist, action and policy leaders promoting the weaving of digital-powered interdisciplinary science into person-centered domain-specific solutions at scale to global challenges faced by traditional and modern economy and society worldwide. The MCCHE stimulates lasting collaborations that bridge the many divides in the market, economy, and society that are at the root of these most pressing modern challenges through collaborative of modular convergence innovation platforms.

The Pittsburgh Supercomputing Center is a joint computational research center between Carnegie Mellon University and the University of Pittsburgh. Established in 1986, PSC is supported by several federal agencies, the Commonwealth of Pennsylvania and private industry. PSC provides university, government, and industrial researchers with access to several of the most powerful systems for high-performance computing, communications, and data-handling available to scientists and engineers nationwide for unclassified research. PSC advances the state-of-the-art in high-performance computing, communications and informatics and offers a flexible environment for solving the largest and most challenging problems in computational science.

Co-Chairs:

Laurette Dubé, PhD is the founding Chair and Scientific Director of the McGill Centre for the Convergence of Health Economics. She holds the James McGill Chair of Consumer and Lifestyle Psychology and Marketing. Her work has been published in top disciplinary journals in Psychology, Management and Medicine as well as in multidisciplinary journals. She holds an MBA in finance, and a PhD in behavioural decision making and consumer psychology. During her 2020-2021 sabbatical, she is a visiting scholar at the National Research Council of Canada and at the Pittsburgh Supercomputing Center, Carnegie Mellon, USA. https://thefutureeconomy.ca/interviews/ laurette-dube

Sergiu Sanielevici, Ph.D. is Director of Support for Scientific Applications at the Pittsburgh Supercomputing Center, a joint project of Carnegie Mellon University and the University of Pittsburgh. He has served as the Deputy Director of the Extended Collaborative Support Service of the US NSF XSEDE project and as the manager of its Novel and Innovative Projects program, fostering non-traditional and interdisciplinary applications of advanced computing and data resources since 2011. He is currently the Principal Investigator of the Bridges-2 project and co-Principal Investigator of the Neocortex project at PSC. Dr. Sanielevici is a proud alumnus of McGill University (Ph.D., Physics, 1986).

Panelists:

Martin Picard earned his PhD from McGill University, Canada and completed a postdoctoral fellowship at the Center for Mitochondrial and Epigenomic Medicine, University of Pennsylvania. He is an Associate Professor of Behavioral Medicine (in Psychiatry and Neurology) and directs the Mitochondrial Psychobiology group at Columbia University Irving Medical Center. His research program focuses on identifying organelle-to-organism processes that link the human experience to molecular processes within mitochondria – small intracellular organelles that power life and resilience. His translational and collaborative research combines clinical, cellular, and computational approaches to understand how energetic processes within the brain-body unit shape different domains of human health, and influence aging trajectories across the lifespan.

Jean Baptishte Poline is an Associate Professor in the Department of Neurology and Neurosurgery at McGill University; the co-Chair of the NeuroHub and Chair of the Technical Steering Committee for the Canadian Open Neuroscience Platform (CONP) at the Montreal Neurological Institute & Hospital (the NEURO); and a Primary Investigator at the Ludmer Centre for Neuroinformatics & Mental Health. Through his research, he has developed several novel data-analysis techniques in statistical modeling and inference for functional brain imaging (fMRI, PET) with applications to large imaging genetic datasets. He also participated in the development of the most widely-used fMRI software to date: Statistical Parametric Mapping (SPM). A strong proponent of data sharing and publishing, Dr. Poline led the biostatistics and bioinformatics components of the IMAGEN study. Dr. Poline is also the co-founder and was co-editor-in-chief of Frontiers in Brain Imaging Methods, which not only aims to advance novel brain imaging methods but to address reproducibility issues as well. He is an investigator in the ReproNim project, a large NIH funded effort to improve reproducibility in neuroimaging. Dr. Poline holds an engineering degree in computer sciences and electronics and Masters in Biomathematics and a Ph.D. in Image Analysis and Biostatistics.

Lauren N. Ross is an Associate Professor in Logic and Philosophy of Science at UC Irvine. Her research concerns causal reasoning and explanation in neuroscience and biology. A significant amount of her research explores causal diversity—different types of causes, causal relationships, and causal systems present in scientific contexts. This research has focused on causal systems such as mechanisms, pathways, and cascades, and causal relationships that differ with respect to their stability, specificity, and reversibility. Her work identifies the features characteristic of these causal systems and their implications for how these systems are studied and how they behave. Ross's research has received a National Science Foundation (NSF) CAREER award, a Humboldt Experienced Researcher Fellowship, and an Editor's Choice Award at The British Journal for the Philosophy of Science.

Ivan De Araujo majored in Philosophy at the University of Brasilia, followed by postgraduate work in Artificial Intelligence at the University of Edinburgh. Obtained his Doctorate (DPhil) in Medical Physiology and Imaging at the University of Oxford, under the supervision of Edmund T. Rolls. Performed postdoctoral work in Neurobiology at Duke University Medical Center, where he recorded in awake animals the activity of networks of neurons linked to the digestive tract. From 2007 through 2018, he directed his Neurobiology of Feeding Laboratory at Pierce Labs (Yale University), before joining Mount Sinai Hospital in August 2018. After describing the taste-independent calorie sensing phenomenon, his main interests revolve around the question of how the body communicates with the central nervous sys-

Karl Friston is a theoretical neuroscientist and authority on brain imaging. He invented statistical parametric mapping (SPM), voxel-based morphometry (VBM) and dynamic causal modelling (DCM). These contributions were motivated by schizophrenia research and theoretical studies of value-learning, formulated as the dysconnection hypothesis of schizophrenia. Mathematical contributions include variational Laplacian procedures and generalized filtering for hierarchical Bayesian model inversion. Friston currently works on models of functional integration in the human brain and the principles that underlie neuronal interactions. His main contribution to theoretical neurobiology is a free-energy principle for action and perception (active inference). In 2000 he was President of the international Organization of Human Brain Mapping. In 2003 he was awarded the Minerva Golden Brain Award and was elected a Fellow of the Roy-al Society in 2006. He became of Fellow of the Royal Society of Biology in 2012, received the Weldon Memorial prize and Medal in 2013 for contributions to mathematical biology and was elected as a mem-ber of EMBO (excellence in the life sciences) in 2014 and the Academia Europaea in (2015). He was the 2016 recipient of the Charles Branch Award for unparalleled breakthroughs in Brain Research and the Glass Brain Award, a lifetime achievement award in the field of human brain mapping. He holds Honorary Doctorates from the University of Zurich and Radboud University.

Cendri Hutcherson is the director of the Decision Neuroscience Laboratory, and an Associate Professor of Psychology at the University of Toronto, with a cross-appointment in the Department of Marketing at the Rotman School of Management and associate membership in the Graduate Department of Psychological Clinical Science. She received degrees in psychology from Harvard (B.A.) and Stanford (Ph.D.), and spent several years as a post-doctoral scholar studying neuroeconomics at the California Institute of Technology. She has received numerous awards for her scholarship, including a Tier II Canada Research Chair award from the Natural Sciences and Engineering Research Council, and an Early Career Award from the Society for Neuroeconomics. Her research focuses on revealing the psychological, neurological, and computational basis of
decision making, with the goal of understanding both why people make decisions they regret, and what strategies and technologies can be deployed to help them make better decisions for themselves and others.