NEURO SYMPOSIUM

LIFESPAN NETWORK NEUROSCIENCE MONTREAL 2023

EXAMINING THE TRAJECTORY OF HUMAN DEVELOPMENT IN HEALTH AND DISEASE

July 20, 2023

The Neuro, 3801 University Street | Jeanne Timmins Amphitheatre

Program Booklet

neuro
Institut-Hôpital neurologique de Montréal
Montreal Neurological Institute-Hospital

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The Lifespan Network Neuroscience Symposium

The Lifespan Network Neuroscience Symposium, a pre OHBM event is a one-day symposium bringing together a panel of international experts to share advances, innovations, and emerging ideas in network neuroscience from a lifespan perspective. Emphasis will be on developing recommendations and framework protocols to optimize network neuroimaging acquisition techniques, analysis, and modelling approaches. Speakers will also discuss the role of network neuroscience in understanding cognitive function and dysfunction across the lifespan as well as highlight opportunities for translational research and intervention.

The Neuro

The Neuro – The Montreal Neurological Institute-Hospital – is a bilingual, world-leading destination for brain research and advanced patient care. Since its founding in 1934 by renowned neurosurgeon Dr. Wilder Penfield, The Neuro has grown to be the largest specialized neuroscience research and clinical center in Canada, and one of the largest in the world. The seamless integration of research, patient care, and training of the world's top minds make The Neuro uniquely positioned to have a significant impact on the understanding and treatment of nervous system disorders. In 2016, The Neuro became the first institute in the world to fully embrace the Open Science philosophy, creating the Tanenbaum Open Science Institute. The Montreal Neurological Institute is a McGill University research and teaching institute. The Montreal Neurological Hospital is part of the Neuroscience Mission of the McGill University Health Centre. For more information, please visit www.theneuro.ca

Program

8:30 – 8:50 **Coffee and light refreshments**

8:50 – 9:00 **Symposium Opening**
Nathan Spreng
The Neuro, McGill University, Host and Chair

Session 1: Early Life Development

9:00 – 9:30 **Developmental Origins of Disease: A Fetal Brain Perspective**
Moriah Thomason
Barakett Associate Professor and Vice Chair for Research
Department of Child and Adolescent Psychiatry
New York University School of Medicine, USA

9:30 – 10:00 **Mental Effort in a Network Economy**
Dani Bassett
J. Peter Skirkanich Professor
University of Pennsylvania, USA

10:00 – 10:30 **Mapping Person-Specific Networks in Youth**
Theodore Satterthwaite
Associate Professor, Department of Psychiatry
Penn Lifespan Informatics and Neuroimaging Center (PennLINC), USA

10:30 – 11:00 **BREAK** (light refreshments onsite)

Session 2: Early Developmental Disorders

11:00 – 11:30 **Lifespan Network Neuroscience of Autism**
Lucina Uddin
Professor, Psychiatry and Biobehavioural Sciences
University of California, USA

11:30 – 12:00 **Multi-Scale Investigations of Typical and Atypical Brain Development**
Boris Bernhardt
Associate Professor
The Neuro, McGill University, Canada
Head, Multimodal Imaging and Connectome Analysis Lab

12:00 – 12:30 **Network Neuroscience and Early Life Development: Challenges and Directions**

12:30 – 1:30 **LUNCH** *(provided on site)*

Session 3: Adult Lifespan and Typical Aging

1:30 – 2:00 **Brain Network Aging Across Time, Space, and Species**
Gagan Wig
Associate Professor
Center for Vital Longevity, The University of Texas at Dallas, USA
Department of Psychiatry, The University of Southwestern Medical Center

2:00 – 2:30 **Individual Differences in Brain Aging**
Jessica Damoiseaux
Associate Professor
Department of Psychology & Institute of Gerontology
Wayne State University, USA

2:30 – 3:00 **BREAK** *with Refreshments*

Session 4: Atypical Aging and Neurodegenerative Disease

3:00 – 3:30 **Local and Global Contributions to Pathological Spreading in Brain Networks**
Bratislav Misic
Associate Professor & Canada Research Chair
The Neuro, McGill University, Canada
Head, Network Neuroscience Lab

3:30 – 4:00 **Unveiling the Neuroimaging-Genetic Intersections in the Aging Brain**
Jorge Sepulcre
Associate Professor, Division of Nuclear Medicine and Molecular Imaging
Massachusetts General Hospital
Harvard Medical School, USA

4:00 – 4:30 **Structure-Function Mapping in Neurodegenerative Disease**
Jesse Brown
Assistant Professor
Memory and Aging Center
Department of Neurology, UCSF, USA

4:30 – 5:00 **Network Neuroscience and Late Life Development: Challenges and Directions**

5:00 – 5:15 **Closing Remarks**

Speakers

Dani Bassett

Dani S. Bassett (they/them) is the J. Peter Skirkanich Professor at the University of Pennsylvania, with appointments in the Departments of Bioengineering, Electrical & Systems Engineering, Physics & Astronomy, Neurology, and Psychiatry. Bassett is also an external professor of the Santa Fe Institute. Bassett is most well-known for blending neural and systems engineering to identify fundamental mechanisms of cognition and disease in human brain networks. Bassett just completed a book for MIT Press entitled Curious Minds: The Power of Connection (2022), with co-author Perry Zurn, Professor of Philosophy at American University. The author of more than 400 peer-reviewed publications, Bassett has received multiple prestigious awards, including the Alfred P Sloan Research Fellow (2014), MacArthur Fellow Genius Grant (2014), Lagrange Prize in Complex Systems Science (2017), Erdos-Renyi Prize in Network Science (2018), AIMBE College of Fellows (2020), American Physical Society Fellow (2021).

Boris Bernhardt

Boris Bernhardt is Associate Professor of Neurology and Neurosurgery and a Canada Research Chair at the Montreal Neurological Institute, McGill University, in Montreal, Quebec, Canada. His lab studies the role of structural and functional brain network organization in higher-order human cognition in both healthy and diseased populations, notably people with epilepsy and autism. To this end, they develop neuroinformatics approaches that integrate macroscale connectome models with multimodal neuroimaging, 3D histology, and transcriptomics techniques. He has published more 180 peer-reviewed articles and his team made numerous tools and resources for multiscale neuroscience openly available. Dr Bernhardt is work package leader of the Hiball project and Associate Leader of the neuroinformatics and computational modelling theme of Healthy Brains Healthy Lives.

Jesse Brown

Jesse Brown studies human systems neuroscience and its application to mapping neurodegenerative disease onset and progression. His lab uses structural and functional neuroimaging, brain connectivity analysis, and machine learning to study patients with neurodegenerative disease and typical individuals. The lab's two main goals are to understand functional and anatomical brain connectivity, and to develop disease models for differential diagnosis, prognosis, and monitoring.

Jessica Damoiseaux

Jessica Damoiseaux is an Associate Professor in the Institute of Gerontology and Department of Psychology at Wayne State University. Dr. Damoiseaux received her MSc in Psychology from Utrecht University and PhD in Cognitive Neuroscience from VU University Amsterdam. She then went on to do a postdoctoral fellowship at Stanford University. She currently heads the Connect Lab. Her research investigates the application of MRI-derived brain measures, with an emphasis on brain network approaches, to study typical aging and early detection of neurodegenerative disease.

Bratislav Misic

Bratislav Misic is an associate professor at the Montreal Neurological Institute at McGill University and a Canada Research Chair in Network Neuroscience. He trained with Randy McIntosh at the University of Toronto and with Olaf Sporns at Indiana University. At the Montreal Neurological Institute, he leads the Network Neuroscience Lab (https://netneurolab.github.io). His team studies how global dynamics, cognitive operations and complex behaviour emerge from the connections and interactions among distributed brain areas.

Theodore Satterthwaite

Ted Satterthwaite is an Associate Professor in the Department of Psychiatry at the University of Pennsylvania Perelman School of Medicine. Ted completed medical and graduate training at Washington University in St. Louis, where he was a student of Randy L. Buckner. Subsequently, he was a psychiatry resident and a neuropsychiatry fellow at Penn, under the mentorship of Raquel E. Gur. Since 2019, he has directed PennLINC. His research uses multi-modal neuroimaging to describe both normal and abnormal patterns of brain development, in order to better understand the origins of neuropsychiatric illness. He has been the PI of eight R01s from NIH. His work has been recognized with the Brain and Behavior Research Foundation's Klerman Prize for Clinical Research, the NIMH Biobehavioral Research Award for Innovative New Scientists (BRAINS) award, the NIH Merit Award, as well as several teaching awards.

Jorge Sepulcre

1Jorge Sepulcre is a Lab Director and faculty member at the Gordon Center for Medical Imaging, Department of Radiology, Massachusetts General Hospital (MGH), and Harvard Medical School. After completing his M.D. and Ph.D. in Spain, he moved to Harvard University and MGH to continue his research in neuroscience and neurodegenerative diseases. Prof. Sepulcre is known for his contributions to developing cutting-edge connectomic and genetic approaches for human brain research. His work has been funded, among other institutions, by the Alzheimer's Association and the NIH (National Institute on Aging; National Institute of Biomedical Imaging and Bioengineering).

Nathan Spreng

Nathan Spreng is a James McGill Professor of Neurology and Neurosurgery at McGill University, Group Leader of the Cognitive Neuroscience Unit, and Director of the Laboratory of Brain and Cognition at the Montreal Neurological Institute. His research examines large-scale brain network dynamics and their role in complex cognition across the lifespan, both in health and disease. He is also actively involved in the development and implementation of multivariate and network-based statistical approaches to assess brain structure and function. Dr. Spreng has been recognized as a “Rising Star” by the Association for Psychological Science and recipient of the Vincent Di Lollo Early Career Award from the Canadian Society for Brain, Behaviour and Cognitive Science. He is a member of the Royal Society of Canada’s College of New Scholars, Artists and Scientists and he has been recognized as a “Highly Cited Researcher” by the Web of Science for the last four years. His research is funded by the Canadian Institutes of Health Research, Brain Canada Foundation, Natural Sciences and Engineering Research Council of Canada, Fonds de recherche du Québec – Santé, National Institutes of Health (USA), and the Alzheimer’s Association.

Moriah Thomason

Moriah Thomason, PhD, is the Barakett Associate Professor and Vice Chair for Research in the Department of Child and Adolescent Psychiatry at New York University Grossman School of Medicine. She formerly served as Director of the Perinatal Neural Connectivity Unit within the intramural Perinatology Research Branch of NICHD/NIH. Her published research addresses principals of neural development beginning in utero. Many of her studies address disparities experienced by minoritized individuals and she has written multiple commentaries about the importance of population representative and culturally sensitive science. She received her undergraduate training at UC Berkeley, and her graduate and postdoctoral training at Stanford and MIT in Neuroscience. She is a standing member of the CPDD study section, serves as an Associate Editor for the journal of Developmental Cognitive Neuroscience, and in 2019 received the PECASE award from the Office of the President of the United States.

Lucina Uddin

After receiving a Ph.D. from the Psychology Department at the University of California Los Angeles, Dr. Uddin completed a postdoctoral fellowship in the Child Study Center at New York University. For several years she worked as a faculty member in Psychiatry & Behavioral Science at Stanford University. She recently returned to UCLA where she currently directs the Brain Connectivity and Cognition Laboratory and the Center for Cognitive Neuroscience Analysis Core in the Semel Institute for Neuroscience and Human Behavior. Within a cognitive neuroscience framework, Dr. Uddin’s research combines functional and structural neuroimaging to examine the organization of large-scale brain networks supporting the development of executive function. Her current projects focus on understanding dynamic brain network interactions underlying cognitive inflexibility in neurodevelopmental conditions such as autism spectrum disorder. Dr. Uddin’s work has been published in the Journal of Neuroscience, Cerebral Cortex, JAMA Psychiatry, Biological Psychiatry, PNAS, and Nature Reviews Neuroscience

Gagan Wig

Dr. Wig earned a Bachelor of Science from the University of British Columbia and a Ph.D. in Cognitive Neuroscience from Dartmouth College, followed by post-doctoral fellowships at Harvard University and Washington University in St. Louis with the Human Connectome Project. Dr. Wig is currently an Associate Professor in the Center for Vital Longevity and School of Behavioral and Brain Sciences at the University of Texas at Dallas, and in the Department of Psychiatry at The University of Texas Southwestern Medical Center. Dr. Wig and his team use brain imaging to study healthy and pathological aging across the adult lifespan. This work is centered around measuring patterns of brain connectivity to understand how large-scale brain networks change as individuals age and determining how these changes impact cognitive function and dementia risk. Through this work Dr. Wig is isolating the factors that promote resilience to age-related cognitive decline and examining how an individual's social and economic conditions can expose vulnerabilities in their brain health as they grow older. Dr. Wig's research is presently supported by grants from the National Institute of Aging and the James S. McDonnell Foundation.

Talk Abstracts

Developmental Origins of Disease: A Fetal Brain Perspective – Moriah Thomason

Processes beginning before birth set the stage for life-long health and development. New advances in fetal MRI have opened windows into the emergence of functional neural networks before birth that can be leveraged to better understand the developmental origins of disease. We will present recent work that addresses stress, inflammation and chemical exposures in utero and the relation of these to offspring neurobehavioral development. We have discovered that maternal prenatal negative affect/stress is associated with alterations in fetal frontoparietal, striatal, and temporo-parietal connectivity. Further, our research shows that these associations are stronger in the context of positive health behavior and interpersonal support, and also that magnitude of stress-related differences in neural connectivity correlate with younger gestational age at delivery. Considerate of population level effects of COVID-19, we have also begun to address congenital exposure to the virus, and to explore the concept of 'uncertainty stress'. To the latter, we are pursuing the idea that uncertainty may be a bioenergetically expensive affective state with potential to uniquely contribute to maternal physiological health during pregnancy. We provide preliminary evidence of dissociable qualities of uncertainty stress and evidence that only in concert with psychological distress does COVID infection during pregnancy likely play an important fetal programming role. Overall, our data contribute to understanding of ways in which the perinatal environment may interact with the formation of neural networks in children, as well as insight into specific areas that may be targets for ameliorating perinatal risk.

Developmental Origins of Disease: A Fetal Brain Perspective – Dani Bassett

Mental effort can be operationalized as the engaged proportion of limited-capacity central processing. Although mental effort tends to track with task difficulty and novelty as well as a range of demographic variables, it is not identical with these variables, and neither can it be solely explained by motivation, attention, or cognitive control. Mental effort is commonly assessed using self-report or measurements of autonomic response and has also been probed using the relative magnitude or complexity of neural activity. Typically, such assessments provide correlative data but fall short of a causal account. Here we propose a novel causal account of mental effort by framing the brain as a network economy. Effort is defined as the energy needed to economically shuttle activity through a structural network or connectome to produce an activation state needed for the next cognitive process. The notion of network economy, then, is the idea that the brain's network organization partially determines the energetic cost of reaching a brain activation state, maintaining an activation state, and transitioning between activation states. Moreover, some means of shuttling activity will be more economical, requiring less energy, than others depending on the network's structure. We operationalize this energetic cost of orchestrating complex activity dynamics on a network using a branch of systems engineering known as network control theory. By calculating the energy costs associated with network systems reaching, maintaining, and transitioning among brain states, we see how network economy provides a formal causal explanation for mental effort. The account not only synthesizes prior work in this field but opens new avenues for inquiry regarding how—and more importantly why—mental effort varies across individuals, over tasks, throughout the lifespan, and in disease. More broadly, examining mental effort in a network economy opens new theoretical questions about exertion in complex systems.

Mapping Person-Specific Networks in Youth – Theodore Satterthwaite

This session will focus on inter-individual variation in the topography and connectivity of functional networks in youth. I will present a recent line of research that uses these tools to examine how person-specific networks evolve in youth, supports cognition, and may be impacted by psychopathology. Together, results are consistent with an account of development that both aligns with and refines the cortical hierarchy. Throughout, I will emphasize software that allows for reproducible and scalable processing of high dimensional, multi-modal neuroimaging data.

Lifespan Network Neuroscience of Autism – Lucina Uddin

Recent advances in network neuroscience have paved the way for discoveries into the neurobiology of autism. Network neuroscience has introduced tools and conceptual frameworks that permit exploration of dynamic aspects of brain function in vivo. Over the past decade, “under-connectivity” theories of autism have given way to more nuanced characterizations of the neural basis of the disorder. I will review our recent functional neuroimaging studies investigating functional brain connectivity in autism through a developmental lens. I will further illustrate how analysis of brain dynamics can contribute to understanding flexible behaviors in autism. The talk will conclude with a discussion of some of our recent work parsing heterogeneity and comorbidity in neurodevelopmental disorders using individual connectome mapping.

Multi-Scale Investigations of Typical and Atypical Brain Development – Boris Bernhardt

In his talk, Dr. Bernhardt will give an overview of the lab's recent research activities, focussing on multi-scale cortical cartographies in the adult human brain, and how these approaches can be used to better understand typical brain development and developmental disruptions in autism spectrum conditions.

Brain Network Aging Across Time, Space, and Species – Gagan Wig

Is aging-related cognitive decline a consequence of brain network failure? I will highlight efforts from my lab that have helped to develop and incorporate tools from network science to further our understanding of how the brain’s large-scale functional network organization changes across the lifespan. This work is revealing that functional brain network organization relates to an individual’s cognitive ability during healthy adulthood, and that brain network changes are uniquely prognostic of cognitive impairment (independent of structural atrophy and neuropathology). Our more recent observations have demonstrated that an individual’s environmental exposures exert an impact on their trajectory of brain network decline, which indicates that brain network organization can be used to measure disparities in brain health. Finally, I will touch on our initial steps towards developing non-human animal models of aging-related brain network changes, which we are pursuing in order to bridge the human aging work with efforts in other species. Collectively, these observations are offering a new perspective towards understanding healthy and pathological aging, spotlight a path for discovering vulnerabilities of brain aging that are linked to an individual’s past and present environmental exposures, and are catalyzing the development of a novel class of precision health measures which are based on patterns of large-scale brain network organization.

Individual Differences in Brain Aging – Jessica Damoiseaux

Typical aging is accompanied by changes in brain structure and function and an overall cognitive decline. However, even from personal experience we know that not everyone ages similarly. In this talk I will highlight some of my lab's work that examines individual differences in brain aging, such as our research examining the effects of subjective cognitive decline on cognitive and brain changes. Here, we found that cognitively unimpaired older adults with more subjective cognitive decline showed differences in brain structure and function in similar brain regions as observed in patients with early stages of dementia of the Alzheimer's type. In addition, we found that some of these differences were more prominent in individuals who had vascular and/or genetic risk factors, such as high blood pressure and APOE-e4 carriership. Furthermore, I will highlight our research examining the effect of environmental factors on brain and cognitive aging, specifically the effect of prenatal undernutrition in the Dutch Famine Cohort.

Local and Global Contributions to Pathological Spreading in Brain Network – Bratislav Misic

The brain is a network with intricate connection patterns among individual neurons, neuronal populations, and large-scale brain regions. The wiring of the network supports propagation of electrical signals, as well as molecules needed for growth and repair. This complex system is vulnerable to multiple neurological, psychiatric and neurodevelopmental disorders. Pathological perturbations—including altered cellular morphology, cell death, aberrant synaptic pruning and miswiring—disrupt inter-regional communication and manifest as overlapping sensory, motor, cognitive and affective symptoms. How different disorders are shaped by local and global vulnerability is unknown. Here I will present recent computational and empirical work to chart the spread and expression of multiple brain disorders. I will show how an interplay between molecular vulnerability and white-matter architecture can explain the spatial patterning of multiple cortical disorder profiles.

Unveiling the Neuroimaging-Genetic Intersections in the Aging Brain – Jorge Sepulcre

In recent years, critical developments in the integration of imaging and gene expression data have led to a revolution in how we uncover and investigate the underpinnings of the human brain. This nascent neuroscience discipline, the so-called neuroimaging-genetics, has enabled us to characterize the association between imaging patterns and neurobiological hallmarks of multiple neurological diseases. In this presentation, Dr. Sepulcre will introduce recent research data on the intersection of connectomics and genetics in normal and pathological aging.

Structure-Function Mapping in Neurodegenerative Disease – Jesse Brown

Cognitive deficits in Alzheimer's disease dementia (AD) and Frontotemporal dementia (FTD) depend on gray matter atrophy in specific brain regions. Brain functional connectivity alterations are also common in AD and FTD, involving both decreases and increases in connectivity when compared to cognitively unimpaired individuals. It is unclear how structural and functional alterations are related in AD and FTD how they contribute to cognitive impairment. I will describe a new approach for linking brain structure, function, and cognition across different atrophy subtypes and stages.

Committee

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