NEURO WORKSHOP

Wednesday, June 16 | 8:00AM-2:00PM EDT

GRADIENTS OF BRAIN ORGANIZATION

How is the brain organized? How do anatomy and physiology vary in space? Classic and recent research show smooth spatial trends - gradients - in many neurobiological features. Identification and analysis of gradients provides a framework to study brain organization across scales, species and time. In this workshop, we explore topographic principles of brain organization and how new discoveries are changing our understanding of brain function. We'll host a series of talks on stunning, new gradients research, and bring together early career and established researchers for panel discussions on this work.

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Passcode: 2342739077
Livestream link: https://vimeo.com/event/1041291

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10:30-10:45 Topographic gradients of intrinsic dynamics across neocortex
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12:30-12:45 Gradients of functional and structural connectivity in the mouse neocortex
Ludovico Coletta, Istituto Italiano di Tecnologica, Italy

12:45-13:00 Neuroimaging and transcriptomics trace the evolution and development of primate cortical circuitry
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Speaker Bios & Talk Abstracts

Seok-Jun Hong, Sungkyunkwan University, South Korea

Dr. Hong is a computational neuroimaging scientist with specialty in brain network modeling and data-driven subtyping of typical and atypical developmental conditions. He is currently Assistant professor in the Department of Biomedical Engineering at Sungkyunkwan University (SKKU), and in a full-time affiliation with IBS Center for Neuroscience Imaging Research (CNIR) in South Korea. Dr. Hong is also jointly affiliated as a research scientist to the Center for the Developing Brain at the Child Mind Institute in New York, USA. Building upon expertise in computer science, statistics and neuroinformatics, his research has conducted neuroimaging experiments to link cognitive/clinical neuroscience and machine learning algorithms for the last 10 years. At SKKU and CMI, he is expanding the research scope to apply advanced statistical and computational algorithms to model functional dynamics and analyze various behavioral and neuroimaging data of both human and non-human primate brains.

Mapping whole-brain spatiotemporal dynamics in autism spectrum disorder

Altered cortical hierarchy may be one of the potential mechanistic accounts to explain atypical behaviors observed in autism spectrum disorder (ASD). Supported by the “erroneous predictive coding” theory, indeed this pathological phenomenon has been related to a compromised crosstalk between the low-level sensory and high order transmodal systems in ASD. In this presentation, I would like to share new findings related to impaired spatiotemporal functional dynamics in ASD brains in order to provide a more precise picture of their cortical hierarchy deficit. I will show multimethod evidence from three different complementary analyses, targeting i) intrinsic timescales (i.e., receptive temporal window across the brain), ii) quasi-periodic patterns (i.e., spatial modes of whole-brain functional fluctuations) of resting-state fMRI and iii) a biophysical modeling (of excitatory-excitatory and excitatory-inhibitory connections across the whole-brain networks). Linking these findings from both experimental neuroimaging and computational modeling approaches, my talk aims at offering multi-scale neurobiological accounts for altered large-scale functional hierarchy and relevant behavioral features in ASD.

Casey Paquola, Forschungszentrum Jülich, Germany

Dr Casey Paquola is a postdoctoral fellow at INM-1, Forschungszentrum Jülich, working with A/Prof Timo Dickscheid and Prof Katrin Amunts. Previously, she obtained her PhD in Medicine from the University of Sydney, Australia and was a postdoctoral fellow at the Montreal Neurological Institute in the Multimodal Imaging and Connectome Analysis (MICA) lab of A/Prof Boris Bernhardt. Her research concerns the fundamental organisation and development of the cortex, with a special focus on combining histology and advanced neuroimaging to probe intracortical microstructure.

The Machine in the Ghost: Cytoarchitecture and wiring of the default mode network

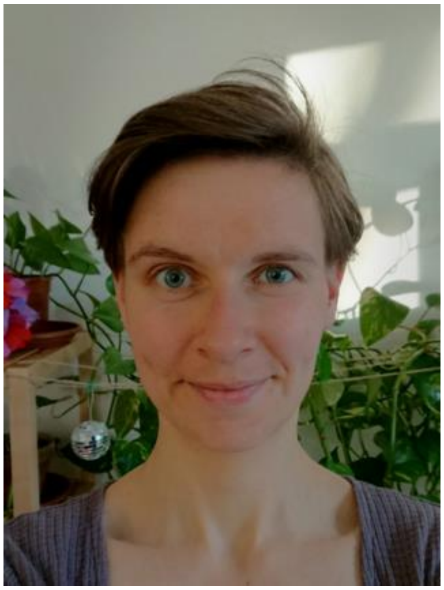
It is challenging to specify the role of the default mode network (DMN) in human behaviour. Contemporary theories, based on functional magnetic resonance imaging (MRI), suggest that the DMN is perceptually decoupled, which allows for integration of external and internal information towards the construction of abstract meanings. To date, the neuronal architecture of the DMN has received relatively little attention. Understanding the cytoarchitectural composition and connectional layout of the DMN will provide novel insights into its role in brain function. We mapped cytoarchitectural variation within the DMN using a cortical type atlas and a histological model of the entire human brain. Next, we used MRI acquired in healthy young adults to explicate structural wiring and effective connectivity. We discovered profound diversity of DMN cytoarchitecture, which was principally organised along an "outside-in" gradient. The outside anchor of the cytoarchitectural gradient is the prominent receiver, whereas the inside anchor is more insulated, especially from sensory areas. The structural heterogeneity of the DMN engenders a network-level balance in communication with external and internal sources, which is distinctive, relative to other functional communities. The neuronal architecture of the DMN suggests it is a protuberance from the sensory-fugal hierarchy that is able to integrate and broadcast diverse information about our interactions with the world.

Seán Froudist-Walsh, New York University, USA

During his PhD and early postdoc, Sean investigated the neuromodulators and networks underlying memory in human and non-human primates. He is now a postdoc in Xiao-Jing Wang's lab at New York University. He integrates multiple forms of anatomical and functional data to build connectome-based dynamical models of the brain. This work aims to understand how subtle differences in neuroanatomical properties lead to different brain networks producing distinct functions, and to shed light on how multiple cognitive functions interact in the brain.

Gradients of receptor expression in the macaque cortex

Dynamics and functions of neural circuits depend on synaptic interactions mediated by receptors. Therefore, a comprehensive map of receptor organization is needed to understand how different functions may emerge across distinct cortical regions. Here we use in-vitro receptor autoradiography to measure the density of 14 neurotransmitter receptor types in 109 areas of macaque cortex. We integrate the receptor data with other anatomical, genetic and functional connectivity data into a common cortical space. We uncovered a principal gradient of increasing receptor expression per neuron aligned with cortical hierarchy from early sensory cortex to higher cognitive areas. A second gradient, primarily driven by 5-HT1A receptors, peaks in the anterior and subcallosal cingulate, suggesting that the macaque may be a promising animal model for major depressive disorder. The receptor gradients may enable rapid, reliable information processing in sensory cortical areas and slow, flexible integration of information in higher cognitive areas.

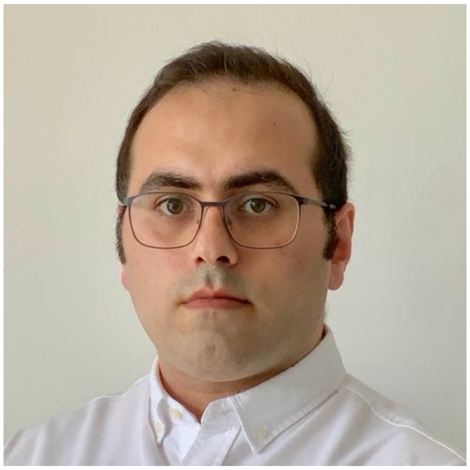


Katharina Glomb, University of Lausanne, Switzerland

My main interest is to understand the interplay between spatial organization, state and spectral dynamics in macroscopic brain networks. With a background in biology and computational neuroscience, I did my PhD on resting state fMRI in Barcelona before moving on to Lausanne, Switzerland, to work on EEG network neuroscience in 2017. Recently I moved back to my native Germany to apply the methods of network tracking that we developed over the past few years in a more clinical context.

Network harmonics and the structure-function relationship in fast network dynamics

EEG provides a unique tool to study spatial, temporal, and spectral organization of macroscopic networks simultaneously, due to its high temporal resolution and the possibilities of projecting EEG measured at the scalp into the grey matter. Multimodal approaches are essential in order to overcome the limitations posed by volume conduction and low spatial resolution in EEG data. Harmonic modes - basis functions derived from the structural connectivity graph - are a tool that allows to integrate additional information from structural and diffusin MRI into EEG data analysis. Thereby, harmonic modes capture certain properties of brain networks, like hierarchical organization and coexistence of integration and segregation. I will present recent results on how harmonic modes can be used to track fast network dynamics, and how this approach results in a sparse and interpretable representation of EEG task dynamics.



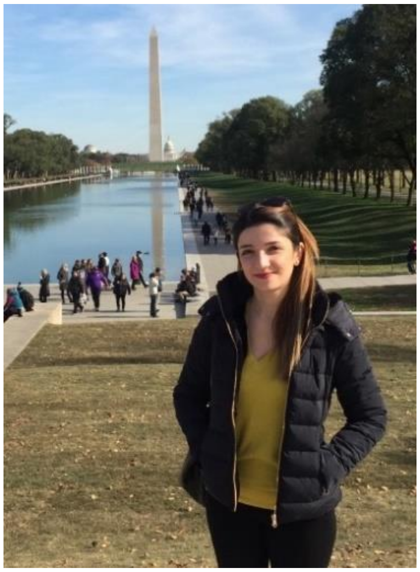
Keyvan Mahjoory, University of Muenster, Germany

I am a Postdoc researcher at the Max-planck institute for Empirical Aesthetics, Frankfurt, Germany. I obtained my PhD from the University of Genova, where I worked with Dr. Stefan Haufe on "Consistency of EEG source localization and connectivity estimates". After that, I was a Postdoc researcher in the Institute for Biomagnetism and Biosignal Analysis (IBB), working with Prof. Joachim Gross.

The frequency gradient of resting state brain oscillations along the cortical hierarchies

The human cortex is characterized by local morphological features such as cortical thickness, myelin content, and gene expression that change along the posterior-anterior axis. We investigated if some of these structural gradients are associated with a similar gradient in a prominent feature of brain activity - namely the frequency of oscillations. In resting-state MEG recordings from healthy participants (N = 187), we found that the dominant peak frequency in a brain area decreases significantly along the posterior-anterior axis following the global hierarchy from early sensory to higher order areas. This spatial gradient of peak frequency was significantly anticorrelated with that of cortical thickness, representing a proxy of the cortical hierarchical level. This result indicates that the dominant frequency changes systematically and globally along the spatial and hierarchical gradients and establishes a new structure-function relationship pertaining to oscillations as a core organization that may underlie hierarchical specialization in the human brain.

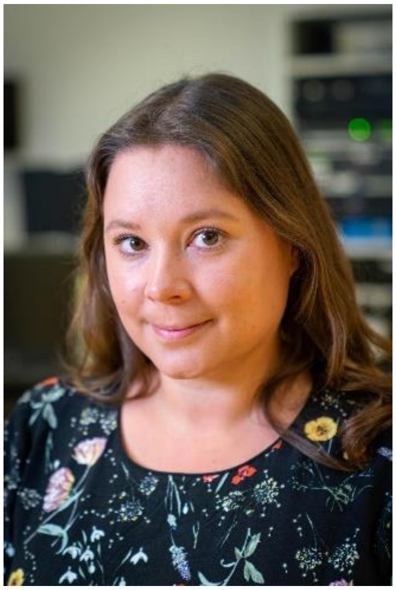
Golia Shafiei, McGill University, Canada



I am a PhD candidate at McGill University in the Integrated Program in Neuroscience (IPN), working under the supervision of Dr. Bratislav Misic at The Neuro. I received both my BSc and MSc degrees in Physics. I currently study how local neural activity is related to global brain network dynamics, and how the delicate balance between local and global information processing translates to individual differences in behavior.

Topographic gradients of intrinsic dynamics across neocortex

Neural activity and functional interactions between brain areas are naturally variable from moment to moment, resulting in dynamic configurations of brain activity. Connectome architecture and its spatial embedding shape local and global brain dynamics. Notably, the functional organization of the human cortex-as well as anatomical markers such as intracortical myelin, cortical thickness, and gene expression-display a hierarchical organization, principally along an axis that spans unimodal sensory/motor and higher order transmodal regions. However, less is known about how regional spontaneous neuronal activity is associated with large-scale brain network organization. In this study, we aim to characterize the link between the dynamic profile of cortical areas and their network embedding using temporal properties of localized brain activity. We obtained structural and functional magnetic resonance imaging (MRI) data of healthy young adults from the Human Connectome Project. The highly comparative time series analysis toolbox (hctsa) was used to extract over 7000 temporal features of the parcellated time series. Principal component analysis (PCA) was used to identify linear combinations of temporal features that vary maximally across the cortex. PCA results were compared with gene expression, morphological properties, and functional connectivity of the human cortex. Our analyses demonstrate that the dynamic fingerprint of regional brain activity is related to its network embedding. Local temporal properties are highly similar for pairs of regions that are structurally connected and belong to the same functional networks. These local dynamics recapitulate the unimodal-transmodal hierarchy frequently reported in the human neuroimaging literature. In a comprehensive, data-driven way, these results demonstrate a dominant hierarchical variation in the properties of spontaneous regional dynamics, shedding new light on the dynamical signature of hierarchical functional specialization in the human cortex.



Myrthe Faber, Donders Institute for Brain, Cognition and Behaviour, The Netherlands

Dr. Myrthe Faber is an assistant professor in the Communication and Cognition Department at Tilburg University and a research affiliate in the Statistical Imaging Neuroscience at the Donders Institute for Brain, Cognition and Behaviour. She is interested in the cognitive and neural underpinnings of discourse processing, with a specific focus on the role of spontaneous cognition in text comprehension.

Overlapping connectivity gradients underlie functional multiplicity in the anterior temporal lobe

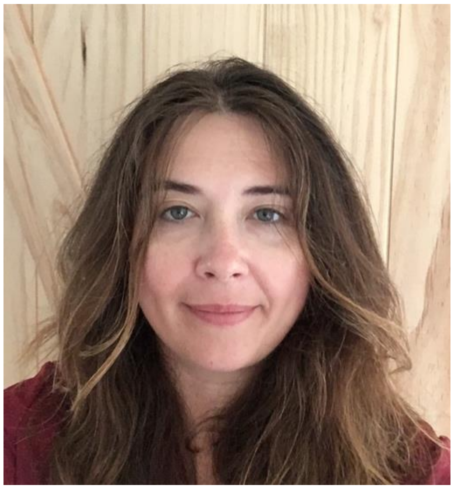
Convergent evidence from neuroimaging, computational, and clinical research has shown that the anterior temporal lobe (ATL) is critically involved in two key aspects of semantic cognition: the representation of semantic knowledge, and the executive regulation of this knowledge. In this talk, I will discuss how we used connectopic mapping to test the hypothesis that the ATL comprises (at least) two overlapping modes of functional connectivity that each predict distinct aspects of semantic cognition on an individual level. Our analysis revealed a gradient of connectivity change along the inferior-superior axis, and secondly, an anterior to posterior gradient. Multiple regression analyses revealed that individual differences in the inferior-superior gradient are predictive of differences in story comprehension, whereas the anterior-posterior gradient maps onto differences in picture vocabulary naming, but not vice versa. These findings indicate that overlapping gradients of functional connectivity in the ATL map onto differential behaviors, which is important for understanding how its functional organization underlies its multiple functions.

Ludovico Coletta, Istituto Italiano di Tecnologica, Italy

Ludovico Coletta obtained his MSc. in Psychology and Neuroinformatics from the University of Zurich before joining the Functional Neuroimaging lab in March 2017 as a research assistant, and is a PhD student since November 2017. His PhD project aims at unravelling the elusive relationship between brain structure and function, trying to understand how it underlies the establishment of brain connectopathies.

Gradients of functional and structural connectivity in the mouse neocortex

Understanding the principles driving cortical organization across species and modalities is a fundamental goal of systems neuroscience. Functional and structural investigations in humans and primates have shown that the spatial arrangement of cortical regions reflects superimposed, hierarchical gradients of connectivity. However, the degree to which these organizational features are evolutionarily conserved in lower mammalian species such as the mouse remains unclear. Leveraging a novel voxel-wise model of the mouse brain connectome, we recently showed that the murine cortical connectome is organized into unimodal-transmodal and modality-specific spatial gradients, broadly recapitulating organizational principles observed in primates and humans. Underscoring a tight relationship between structural and functional gradient organization, we found that axonal and fMRI connectivity gradients in the mouse cortex exhibit a very similar topographic organization. We finally found that mouse axonal gradients are differentially related to cortico-cortical laminar hierarchy, and shape the dynamics structure of fMRI networks, hence establishing a direct link between the mesoscale topography of the mouse connectome and its functional macroscale organization. These findings open the way to the use of rodent models to investigate the neural underpinnings of atypical gradient organization in neurological and developmental disorders.



Christine Charvet, Delaware State University, USA

Christine Charvet is an Assistant Professor in the Center for Neuroscience at Delaware State University. Christine acquired postdoctoral training in neuroimaging at Harvard Medical School and statistical genetics at Cornell University. Her research program leverages big data in genetics and neuroimaging to address fundamental questions in developmental and comparative neuroscience while providing practical applications to the biomedical community. For example, Christine and her colleagues developed a resource with which to find corresponding ages across humans and model organisms (http://translatingtime.org). This resource is often used by researchers who study model organisms (e.g., mice) and need to translate their findings to humans. Christine's work has also explored cytoarchitectural gradients across the the primate cortex and link cytoarchitecture with connections. Her appointment at Delaware State University is part of a cross-institutional NIH-funded effort to enhance the research infrastructure of Delaware and increase diversity in biomedical sciences.

Neuroimaging and transcriptomics trace the evolution and development of primate cortical circuitry

The neural circuits that support human cognition are a topic of enduring interest. Yet, the lack of tools available to map human brain circuits has precluded our ability to trace the human and non-human primate connectome. We know that there is systematic variation in cellular architecture across the primate cortex. We harnessed high-resolution connectomic, anatomic, and transcriptomic data to investigate the evolution and development in frontal cortex circuitry across its axes. We transcriptionally defined neural circuits by testing for associations between gene expression and white matter maturation over the course of development in humans. We then explored transcriptional, cellular, and connectomic variation across the anterior to posterior axis of the frontal cortex in primates. We found that frontal cortex circuitry development is extended in primates and is concomitant with an expansion in cortico-cortical pathways compared with mice in adulthood. We found little variation in these parameters within the frontal cortex across humans and studied primates. These data identify a surprising collection of conserved features in frontal cortex circuits across humans and Old World monkeys. Our work demonstrates that integrating transcriptional and connectomic data across temporal dimensions is a robust approach to trace the evolution of connections in primates

Graham Baum, Harvard University, USA

Graham Baum is a neuroscientist interested in the development and evolution of the human brain. I received my PhD in neuroscience under the mentorship of Drs. Ted Satterthwaite and Dani Bassett at the University of Pennsylvania. As a Postdoctoral Fellow at Harvard, my research aims to delineate the biological and environmental factors shaping individual variation in human neurocognitive development.

Development of structure-function coupling in human brain networks during youth

The human brain is organized into large-scale networks that evolve in childhood and adolescence to support the dynamic control of attention and behavior. However, it remains unknown how developing white matter connectivity supports coordinated fluctuations in neural activity underlying cognition. Leveraging diffusion-weighted imaging and n-back fMRI datasets from 727 individuals (ages 8 to 23 years old), we characterized marked remodeling of structure–function coupling in youth, which aligns with cortical gradients of functional specialization and evolutionary expansion. Further, we demonstrate that structure–function coupling in rostrolateral prefrontal cortex supports age-related improvements in executive ability. These findings have broad relevance for accounts of experience-dependent plasticity in healthy development and abnormal development associated with neuropsychiatric illness.

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Poster Abstracts

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Bin Wan	MPI CBS	Heritability and phylogeny of asymmetry of large-scale functional organization	
Christine Farrugia	University of Malta	Exploring Local Similarity Gradients in the Autistic Spectrum	Autism
Shinwon Park	Sungkyunkwan University	Atypical integration of sensory-to-high-order functional systems mediates symptom severity in autism	
Clara Weber	Yale University	Age-Related Changes of White Matter Microstructure in Autism Spectrum Disorder	
Valeria Kebets	McGill University	Multimodal neural correlates of childhood psychopathology	Behaviour, cognition, disorder
Ximing Shao	University of York	The relationship between individual differences in gradients in the semantic network and semantic cognition	
Mohamed Yousif	Western University	Macroscale cortical organization in Type 2 Diabetes Mellitus and Metabolic Syndrome: a 7T fMRI study	
Şeyma Bayrak	MPI CBS	Heritability of hippocampal microstructural and functional organization	Individual variation
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Reinder Vos De Wael	McGill University	Structural Connectivity Gradients of the Temporal Lobe Serve as Multi-Scale Axes of Brain Organization and Cortical Evolution	
Ane Gurtubay	Université Catholique de Louvain	Direct Structural connections between auditory and visual motion-selective regions	Structure-function
Joan Rué Querault	CHUV	The connectome spectrum as a canonical basis for a sparse representation of fast brain activity	
Yezhou Wang	McGill University	Microstructure gradients reflect distributed and integrative functional connectivity patterns	

Asymmetry

Tirso RJ Gonzalez Alam, University of York, UK

Title: Hemispheric differences in the principal gradient and their contribution to cognition

We characterised hemispheric differences in the position of large-scale cortical networks along the principal gradient and their functional significance. We collected rs-fMRI and task performance in 175+ healthy volunteers, extracted the principal gradient of connectivity for each participant and tested which networks showed significant hemispheric differences in gradient value. We investigated the functional associations of these differences by regressing participants' efficiency in tasks outside the scanner against their interhemispheric gradient difference for each network. LH showed a higher overall gradient value. One frontotemporal-control subnetwork was linked to individual differences in semantic cognition, and a dorsal attention subnetwork to visual reasoning.

Bin Wan, Max Planck Institute for Human Cognitive and Brain Sciences, Germany

Title: Heritability and phylogeny of asymmetry of large-scale functional organization

Asymmetry is a key feature of the human brain and related to the hemispheric preference of functional processes, for example language. However, to what extent functional network organisation of the cerebral cortex is asymmetric and whether this asymmetry is heritable is not known to date. The present study aims to investigate asymmetry of cortical functional organization in healthy humans, study its heritability using a twin-sample, and analyze the asymmetry of functional organization in macaque monkeys to map phylogenetic conservation. To capture the functional organization with gradients, we employed non-linear dimensional reduction techniques. Gradients describe organizational axes along which functional networks are integrated and segregated. Our findings revealed that large-scale functional gradients were asymmetric and the asymmetry was heritable (particularly the language network), indicating that individual variation in asymmetry of functional gradients is under genetic control. Notably, macaques showed reduced asymmetry of functional gradients, potentially indicating that asymmetry of functional organization is, phylogenetically, a relatively novel adaptation in functional brain organization. Functional decoding underscored the functional relevance of the observed patterns, with regions showing leftward asymmetry associated with language processing, whereas rightward asymmetry in organization related to cognitive control. Overall, our findings suggest a genetic and evolutionary basis for a hemispheric difference in intrinsic functional organization.

Autism

Christine Farrugia, University of Malta, Malta

Title: Exploring local similarity gradients in the autistic spectrum

The quest for identifying circumscribed brain areas, or parcels, has been a key concern for neuroscientists since at least the late 19th century. The Vogt-Bailey Index (VBI) was recently introduced as a measure of the smoothness of cortical feature boundaries. We propose that quantifying the change in local functional boundaries can be used to explore differences in brain functional architecture across patient groups, and can lead to novel insights into the cortical organisation of disease. We apply these methods to a cohort of healthy controls and patients diagnosed with autism spectrum disorder.

Shinwon Park, Center for Neuroscience Imaging Research, Institute for Basic Science (IBS), Sungkyunkwan University, Republic of Korea

Title: Atypical integration of sensory-to-high-order functional systems mediates symptom severity in autism

Autism spectrum disorder (ASD) is characterized by co-occurring deficits in low-level sensory processing and high-order social cognition. To investigate the pathological mechanism underlying their atypical functional interaction across the cortical hierarchy, we used an advanced connectopic mapping on primary sensory/motor areas, along with targeted seed-based intrinsic functional connectivity analyses in a multisite resting-state fMRI dataset. We found atypical functional connectome gradients in primary motor and visual regions as well as disrupted macroscale cortical hierarchies (i.e., decreased and increased connectopathies among subcortico-cortical and cortico-cortical networks), which showed associations with relevant ASD symptoms. Findings were largely replicated in an independent dataset

Clara Weber, Yale University, Department of Radiology and Biomedical Imaging, USA

Title: Age-related changes of white matter microstructure in autism spectrum disorder

We retrieved n=583 DTI images of four different studies from the National Database of Autism Research, representing the age cohorts of infants, toddlers, adolescents and adults. Using FSL, Fractional Anisotropy (FA), Mean-, Radial- and Axial Diffusivity maps were generated and analyzed using tract-based spatial statistics to assess the influence of age and autism diagnosis. There was pervasive, ubiquitous age-related FA increase across all cohorts and ASD-related FA reduction in the anterior and central corpus callosum in adults and adolescents, but not infants and toddlers. Corresponding changes in other diffusivity metrics were apparent only in adults. Tract-based comparisons supported voxel-wise findings.

Behavior, Cognition, Disorder

Valeria Kebets, McGill University, Canada

Title: Multimodal neural correlates of childhood psychopathology

Common forms of psychopathology can be explained by a general (p) factor, and higher-order dimensions. We applied multivariate associative techniques to the ABCD cohort (N=5251) to identify structure-function correlates of latent dimensions of subclinical psychopathology in typically developing children. We found 5 significant latent components (LC), which were replicated in an independent sample. LC1 recapitulated the p factor previously described, and reflected a unique pattern in structural and intrinsic functional variability. Notably, between-network RSFC loadings followed the sensory-transmodal functional gradient. Our work shows latent dimensions of brain-behavior relationships that may represent potential risk factors for future development of psychopathology.

Ximing Shao, University of York, UK

Title: The relationship between individual differences in gradients in the semantic network and semantic cognition

Contemporary accounts identify that semantic cognition is supported by semantic representation system and control processes. The current study examined how dimensions of semantic cognition might be related to gradients. We characterise individual's gradients from resting-state fMRI data and examined whether the magnitude of these gradients within the semantic network was related to specific aspects of semantic cognition. Participants with a better fit with Gradient 1 had faster identification of weak semantic associations. Furthermore, a better fit with Gradient 2 was linked to faster performance on picture semantic judgments. These findings show that individual differences in semantic cognition can be related to gradients in the semantic network.
Theme: Cognition

Mohamed Yousif, Western University, Canada

Title: Macroscale cortical organization in Type 2 Diabetes Mellitus and Metabolic Syndrome: a 7T fMRI study

The brain is one of the body's most metabolically active tissues consuming up to 20% of glucose-derived energy. Metabolic dysregulation through Type 2 Diabetes Mellitus (T2DM) and Metabolic Syndrome (MetS) is related to inflammation, vascular dysfunctioning and culminates towards impaired brain function. Previous studies have shown T2DM and MetS correlate with change in functional connectivity and hence, brain network characteristics, affecting cognitive performance. Recently, progress in the extraction of macroscopic functional hierarchies along the cortex allowed characterization of changes in neuropsychiatric disease. This work leverages these developments to explore brain organization changes as a function of metabolic profile and cognition

Individual Variation

Şeyma Bayrak, Otto Hahn Group Cognitive Neurogenetics, Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany

Title: Heritability of hippocampal microstructural and functional organization

Hippocampus is an anatomically unique region involved in diverse processes. However, the heritability of its structure and function is not fully known. Here, we extracted (HCP, S900) the functional connectivity (FC) gradients and microstructure (T1w/T2w) for hippocampal subfields (SUB-CA-DG). Microstructure was strongly heritable. We also obtained hippocampal-cortical structural covariance (SC) and its genetic correlations. Using FC and SC simultaneously, we computed fused gradients depicting an anterior-posterior trajectory, which aligned strongly with the cortical multiple demand axis. Our study shows that the hippocampal functional and structural organization is under genetic control and related to the neocortical functional axis.

Hadis Kalantar, McGill University – Douglas Mental Health University Institute, Canada

Title: Multivariate analysis of cortical morphometry across human brain development Understanding patterns of development across measures of brain structure is critical to developing a "normative" mapping that allows us to better understand instances of maladaptive development that lead to neurodevelopmental disorders. In our work, we investigated the inter-relatedness of morphometric brain features in the context of developing human brain anatomy, using a matrix decomposition technique, nonnegative matrix factorization. Finally, we tested how the identified cortical patterns of covariance are influenced by age, sex and demographics. A non-uniform relationship between morphometric measures exists throughout the cortex underlying fundamental neurodevelopmental processes that covary together. Sex differences captured in most cortical regions were driven mainly by sex differences in SA covariance maturation**.**

Esin Karahan, Cardiff University, UK

Title: Individual variability in the functional and structural connectomes

Individuals differ in their behavior and cognitive abilities, but to what extent the brain connectome vary between individuals remain largely unknown. By combining diffusion-weighted imaging (DWI), fMRI, and MEG, this study quantifies the individual variations of connectome and their consistency across imaging modalities. Furthermore, we associated individual variability in connectome with cortical myelin content and white-matter microstructure.

Mark Nelson, McConnell Brain Imaging Centre, Canada
Title: Patterns of subject-level variance in structural and functional brain connectivity

The human brain can be modelled as a network of anatomically connected neuronal populations. Communication along these structural connections gives rise to dynamic spatial patterns of neuronal activity. These patterns of functional brain activity are highly predictive of subject identity, especially in a fronto-parietal network, however, the extent to which the structural connectivity of the brain is unique to an individual remains unclear. Here, we use Principal Components Analysis to compare patterns of subject-level variance across functional and multiple weighted structural connectivity datasets. We discuss these findings in the context of a transmodal-unimodal gradient in subject-level brain connectivity.

Methods

Claude Bajada, University of Malta, Malta
Title: Geometric effects of volume to surface mapping

When making use of a surface-based preprocessing pipeline, volumetric data must first be projected to surface vertices. When analysing regional boundaries by calculating the changes in local neighborhood vertices, an anatomical pattern that follows the gyrification was observed, even when using stochastic data. We note three important points. First, the relative difference between the cortical surface vertex density and underlying voxel resolution is important to consider. Second, mapping to a relatively dense mesh has the potential to affect studies that are interested in local neighborhood connectivity. Last, the artefactual geometric patterns that follow the cortical gyrification can be mitigated.

Christine Farrugia, University of Malta, Malta
Title: VB Toolbox: Feature similarity gradients & VB index

The VB toolbox (github.com/VBIndex/py_vb_toolbox) is a freely-available Python software for extracting feature similarity gradients and the VB index from fMRI data. The underlying principle is the construction of an affinity graph for a neighbourhood of vertices. The Fiedler eigenvector of the graph Laplacian provides information about functional gradients. The VB index is the rescaled algebraic connectivity of the graph, and is used to quantify neighbourhood similarity. The toolbox can be used for full brain or clustered analysis, and also employs a searchlight VB index algorithm.

Regional Gradients

Peer Herholz, NeuroDataScience - ORIGAMI laboratory, The Neuro, McGill University, Canada

Title: Hearing rainbows - Functional gradients of auditory cortex organization

The human auditory cortex is presumptively exhibiting a hierarchical processing cascade from primary sensory towards non-primary association cortices, with diverging functional profiles evolving along with it and an anterior-posterior axis which is marked by hemispheric distinctions. To investigate these assumed properties we derived task-based macroscale functional gradients from a passive listening fMRI experiment and meta-analytic profiles using diffusion map embedding. Both fMRI and meta-analytic gradients revealed the suggested progression from primary to non-primary areas as the most important auditory cortex characteristic, indicating a transition from general to specific auditory function which deviated between anterior and posterior regions, but not hemispheres.

Meiqi Niu, McGill University, Canada

Title: Microstructure gradients reflect distributed and integrative functional connectivity patterns

The human cortex is microstructurally heterogenous, showing spatial variations in cyto- and myeloarchitecture. Here, we investigated the relationship between large-scale spatial trends in brain microstructure and topological properties of functional connectivity using novel dimension reduction techniques. Analysis of post mortem cytoarchitecture together with myelin-sensitive in vivo MRI identified spatial gradients depicted a trajectory evolving from primary sensorimotor areas progressing towards transmodal association and limbic cortices. Cortex-wise connectivity distance mapping revealed similar gradients, suggesting that local variations in functional connectivity parallel cortical microstructural organization. Our findings provide insights on the structure-function coupling of the human brain at multiple scales.

Reinder Vos De Wael, McGill University, Canada
Title: Structural connectivity gradients of the temporal lobe serve as multi-scale axes of brain organization and cortical evolution
The temporal lobe is implicated in higher cognitive processes and is one of the regions that underwent substantial reorganization during primate evolution. Here, we identified low-dimensional representations of structural connectivity variations in human temporal cortex and explored their microstructural underpinnings and associations to macroscale function. We identified three eigenmodes which described gradients in structural connectivity. These gradients reflected inter-regional variations in cortical microstructure derived from quantitative MRI and post-mortem histology. The identified gradients aligned closely with established measures of functional reconfiguration and areal expansion between macaques and humans, highlighting their potential role in shaping temporal lobe function throughout primate evolution.

Structure-Function

Ane Gurtubay, Université Catholique de Louvain, Belgium
Title: Direct structural connections between auditory and visual motion-selective regions
The occipital middle-temporal region (hMT+/V5) specializes in the processing of visual motion, while the planum temporale (hPT) specializes in auditory motion. These regions may communicate directly for optimal exchange of multisensory motion information. We investigated for the first time in humans, direct white matter connections between hMT+/V5 and hPT using a combined fMRI and diffusion MRI approach. Local tractography suggested the existence of direct white matter connections between them (not overlapping with the ILF/IFOF). We did not find similar projections between the FFA and hPT. Results were corroborated in a large sample of participants (n=114) from the human connectome project.

Joan Rué Queralt, Centre hospitalier universitaire vaudois, Switzerland
Title: The connectome spectrum as a canonical basis for a sparse representation of fast brain activity
Using a multi-modal imaging dataset (electroencephalography, structural MRI and diffusion MRI), we represent electrical brain activity at the cortical surface as a time-varying composition of harmonic modes of structural connectivity (the connectome spectrum). We provide statistical, functional and topological evidence supporting that by accounting for the brain' s structural connectivity fosters a more comprehensive understanding of large-scale dynamic neural functioning.

Yezhou Wang, McGill University, Canada

Title: Microstructure gradients reflect distributed and integrative functional connectivity patterns

The human cortex is microstructurally heterogenous, showing spatial variations in cyto- and myeloarchitecture. Here, we investigated the relationship between large-scale spatial trends in brain microstructure and topological properties of functional connectivity using novel dimension reduction techniques. Analysis of post mortem cytoarchitecture together with myelin-sensitive in vivo MRI identified spatial gradients depicted a trajectory evolving from primary sensorimotor areas progressing towards transmodal association and limbic cortices. Cortex-wise connectivity distance mapping revealed similar gradients, suggesting that local variations in functional connectivity parallel cortical microstructural organization. Our findings provide insights on the structure-function coupling of the human brain at multiple scales.

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