34th Annual Cambridge Neuroscience Seminar

CNS2024: SLEEP, CONSCIOUSNESS & COGNITION

Queens' College
5th April 2024

CAMBRIDGE NEUROSCIENCE

UNIVERSITY OF CAMBRIDGE

Welcome

We are very pleased to welcome you to the 34th Cambridge Neuroscience Seminar: **"Sleep, Consciousness and Cognition"**. CNS2024 will be interdisciplinary and far reaching in its breadth. From investigating the nature and function of consciousness in humans, animals and artificial intelligence to the interplay between sleep abnormalities and neurodegeneration; from how core brain networks organise thought and behaviour to the understanding of the neural mechanisms underlying altered states of consciousness; from how the brain makes predictions about the world to how placing physical constraints on an artificially-intelligent system allows it to develop features of the brains of complex organisms in order to solve tasks.

Last year, Cambridge Neuroscience launched its new and interactive website. Take a moment to update your profile and explore the site, where you will find information on funding opportunities, credibility in neuroscience, equality, diversity, inclusion & wellbeing, early career researchers, history, in addition to a whole new postgraduate training portal, which will enable prospective students to learn about the amazing work we are doing and come and join us! You will also see that your new and improved profiles will enrich your interdisciplinary experience at Cambridge allowing you to seek new collaborations in just a few clicks.

Cambridge Neuroscience is ever evolving and dynamic, with incredible researchers across multiple Schools, Departments, Institutes and Centres working together, committed to supporting new, multidisciplinary approaches to solving the mysteries of the brain. Collaboration is key and the discoveries, awards and successes of individuals are dependent on many – technical and administrative staff, college colleagues, students, post-doctoral researchers and other faculty members. Please do get in touch if you have any ideas of how to shape a brighter and bigger future!

Thank you so much for joining us today – we are delighted to welcome our plenary speakers Professors Athena Demertzi and Anil Seth as our guests. We are overjoyed to welcome back Dr Deniz Vatansaver as a guest speaker. Deniz, now at Fudan University, completed his PhD in Cambridge and was the founding President of CamBRAIN, which is celebrating its 10th birthday in 2024. Read more about the fantastic work that CamBRAIN have been doing across the Early Careers Research community over the last decade later in this brochure. Furthermore, we are grateful to all our speakers, chairs, poster presenters and data blitzers, poster judges, volunteers, exhibitors and sponsors and most of all to you, our membership!

Paul Fletcher
Ewan St John Smith
Dervila Glynn



Check out our website here

Contents & Practical arrangements

Contents

Practical Arrangements:

Registration: Angevin Room (4)

Welcome refreshments: College Bar Conservatory (9)

Lectures: Fitzpatrick Hall (4). Names badges must be worn at all times.

Lunch, posters and trade exhibition: Cripps Dining Hall (10)

Drinks reception: 18:40, Old Kitchens (17)

Dinner: 19:30, Old Hall (14), Queens' College, dress code is smart casual (pre-booking is essential)

Meeting organised by Dervila Glynn on behalf of Cambridge Neuroscience. We would like to thank all of our volunteers, especially our colleagues at CamBRAIN and all our local suppliers. Sponsors were not involved in the organisation of the meeting, selection of speakers, attendees or content.
Sponsors: We would like to thank all our sponsors for their generous support. Please take the time to go and visit their exhibits during the refreshment breaks.

We would like to thank the staff of Queens' College for their help in hosting CNS2024.

Twitter: @CamNeuro #CamNeuro2024

Programme

CNS2024 – Sleep, Consciousness and Cognition
Queens' Collge | Programme
5th April 2024

08:00-08:55 Registration and refreshments

Session One Chair: **Ewan St John Smith**, Pharmacology
@psalmotoxin




08:55-09:00 Welcome

09:00-09:25 **Henry Shevlin** – Leverhulme Centre for the Future of Intelligence
Investigating the nature and function of consciousness in humans, animals and AI

09:25-09:50 **Thomas Cope** – Clinical Neurosciences
How does the brain make perceptual predictions and update them when they are wrong?

09:50-10:30 Opening Plenary – **Athena Demertzi** – University of Liège
Deriving Aspects of Consciousness from Unconscious States

10:30-11:00 Coffee

Session Two Chair: **Amy Milton**, Psychology
@DrAmyMilton






11:00-11:25 **Nina Rzechorzek** – MRC Laboratory of Molecular Biology
Brain temperature dynamics and neural circadian clocks

11:25-11:50 **Zanna Voysey** – Clinical Neurosciences
The Sleep vs Neurodegeneration interface: Insights from a 12-year Study in Huntington's Disease

11:50-12:15 **John Duncan** and **Moataz Assem** – MRC Cognition and Brain Sciences Unit
A domain-general cognitive core in the human brain

12:15-12:40 **Emmanuel Stamatakis** – Clinical Neurosciences/Medicine
The complex relationship between the brain and (un)consciousness
12:40-13:10 Early Career Data Blitz, moderated by **Dervila Glynn**

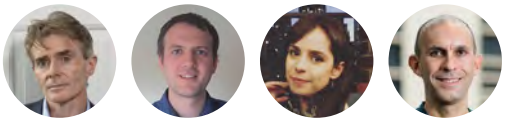
13:10-14:40 Lunch, Exhibition and Poster Session

Session Three Chair: **Alexandra Woolgar**, MRC Cognition and Brain Sciences Unit
@AlexWoolgar

14:40-15:05 **Sepiedeh Keshavarzi** – Physiology, Development and Neuroscience
Integration of head and visual motion for self-motion perception and spatial navigation
15:05-15:30 **Camilla Nord** – MRC Cognition and Brain Sciences Unit
Bodily beliefs: neurocomputational approaches to body-brain disruptions in mental health disorders
15:30-15:55 **Danyal Akarca** – MRC Cognition and Brain Sciences Unit
Spatially embedded recurrent neural networks: understanding how physical constraints shape structural and functional organisation during task solving.
15:55-16:05 **Ailie McWhinnie** – Physiology, Development and Neuroscience
Bitesize overview of CamBRAIN
16:05-16:30 **Deniz Vatansever** – Fudan University
The Unseen Orchestra: Mapping the Default Mode of Human Cognition

16:30-17:00 Afternoon break

Session Four Chair: **Paul Fletcher**, Psychiatry
@PaulPcf22



17:00-17:25 **Tom McClelland** – History and Philosophy of Science
Agnosticism About Artificial Consciousness
17:25-17:50 **Stephanie Brown** – Psychiatry
The role of sleep in Down syndrome Alzheimer's disease
17:50-18:30 Closing Plenary – **Anil Seth** – University of Sussex
Consciousness in humans and in other things

18:30-18:35 – Closing Remarks, Prizes and Acknowledgements

RECEPTION AND DINNER

18:40-19:30 Old Kitchens at Queens' College
19:30-21:30 Dinner, The Old Hall, Queens' College. After dinner comments from **Professor David Menon**

Sustainability at CNS 2024

Cambridge Neuroscience is committed to doing our part to protect our environment and work towards carbon neutrality. Here are somethings we are doing to make CNS2024 more sustainable.

Our venue:
We chose Queens' College to host CNS2024. The Queens' College Environmental Policy outlines their commitment to act decisively on the climate emergency, by mitigating our contribution to the climate emergency and crisis in biodiversity. In practical terms, this means reducing the College's carbon footprint and waste output and improving biodiversity on the College site. You can read more about their environmental policy and plan here: https://queens.shorthandstories.com/environmental-policy-plan/index.html

Reducing Waste:

- CNS 2024 is committed to going single use Plastic-Free
- We will not be using disposable crockery, cutlery or glassware
- We are using plastic free badges and are reusing signage where possible
- All food waste from Queens' College is composted
- Queens' College aim to maximise the proportion of waste that is recycled and minimise the quantity of non-recyclable refuse

Reducing Water Use:

- There will be opportunities to refill your water bottle on site

Sustainability:

- We are choosing greener food & beverages. Our lunch and snack menus comprise of >50% plant-based food options.
- We are using Fair Trade products where possible (tea, and coffee) and seasonal flowers.
- We are using local businesses for our suppliers where possible (photography, cloth poster recycling, flowers, taxi services, and printing)

Sustainability is the responsibility of all involved, each sector must make decisions at every step that support sustainable practices.

Here are some things you can do to further our sustainable effort
Think before you print a poster. Perhaps you can reuse a previously printed poster or reuse this poster at a future conference.
Repurpose your cloth poster into a useful tote bag with Mouse & Bear (see below)
Bring your own reusable water bottle
Consider how you will travel to CNS 2024 - On Silver Street immediately outside Queens' College is a bus stop for the University "Universal" bus route, offering a service to the University Biomedical campus and Addenbrooke's Hospital, the Cambridge rail station, the University Library, the University Mathematics Faculty, the University West Cambridge site, and the Madingley Road Park & Ride. See the **Universal bus timetable**.

CamBRAIN

The Cambridge Neuroscience Society

ARE YOU INTERESTED IN...

THEN JOIN :

CamBRAIN: The Cambridge Neuroscience Society

Please sign up to our mailing list at soc-cambrain-members, join our Facebook and LinkedIn groups and follow us on Twitter!

Website: http://cambrainsociety.com/

CamBRAIN is 10!

SOME OF WHAT WE DO

1 BUILD NETWORKS

CamBRAIN, the Cambridge University Neuroscience Society, is dedicated to bringing together student and early careers researchers with an interest in neuroscience across the university.

2 NEUROTALKS

Our flagship event is Neurotalks, a monthly pub talk series which runs throughout the academic year to spotlight the research of our community in a much more informal environment than academic talks - the perfect place to get to know fellow CamBRAINers

3 SOCIAL

CamBRAIN runs a series of social events which allow our members to share experiences and build successful networks - everything from Christmas parties to Summer garden parties.

4 SCI COMM

Throughout the year, we provide sci comm opportunities and training - equipping you with skills for presenting your work, writing, social media, public engagement and much, much more!

5 PUBLIC ENAGAGEMENT

A highlight of the CamBRAIN year is undoubtedly the Cambridge Festival where families learn how brains compare in different species; how a neuron works; and what we use different parts of our brains for.

6 EVENTS

We host info evenings about postgrad applications and careers; topical panel debates; outreach events at local festivals; quiz nights; exchanges with other universities, and more.

Website

CamBRAIN, the Cambridge Neuroscience Society, is committed to connecting its members, supporting personal and career development and providing a platform to share research. We celebrate the diversity of interests that fall under the this rapidly expanding and exciting field, and welcome perspectives from other related fields such as education, philosophy and history to our activities.

CamBRAIN was founded in 2014 by Dr Deniz Vatansaver (PhD student in Clinical Neurosciences at the time, now PI at Fudan University) who felt that although there were many students studying neuroscience in Cambridge, they were dispersed across the many departments and institutes and so disconnected. *"CamBRAIN is not just about academic talks and workshops, but about building connections and sharing experiences that transcend disciplines and backgrounds. We've cultivated an inclusive environment where everyone's voice is heard and valued."*

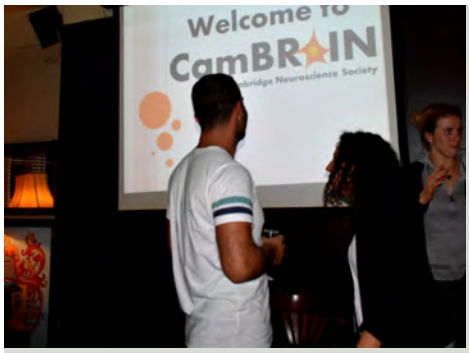
With 600 members, CamBRAIN remains one of largest early career researcher neuroscience societies in the UK and *"is more than just a society; it's a manifestation of our commitment to nurturing the next generation of neuroscientists and fostering a culture of collaboration and compassion within this field. It has given me invaluable friendships, mentorship opportunities, and a sense of purpose that transcends academic achievements."*

Reflecting on the legacy of CamBRAIN, Deniz commented *"I am filled with pride and joy knowing that our collective efforts have not only enriched the scientific community but have also touched hearts and inspired minds of young neuroscientists. The bonds forged within CamBRAIN will continue to ripple through the neuroscience landscape, shaping the future of the field for years to come."*

We work very closely with Cambridge Neuroscience. The CamBRAIN President sits on the Cambridge Neuroscience Steering Committee and Dr Dervila Glynn sits on the CamBRAIN committee acting as advisor and Senior Treasurer. Collaborative events between CamBRAIN and Cambridge Neuroscience, such as training days and garden parties, ensure that junior researchers are integrated into the wider researcher community.

Funded primarily by Cambridge Neuroscience, CamBRAIN has also received regular funding from the British Neuroscience Association (BNA). The CamBRAIN President serves as Local Student Representative to the BNA and this link to the wider UK community has generated collaborations with counterpart societies at other universities. Our members have enjoyed trips to London and Oxford through this.

Current President, Ailie McWhinnie, a PhD student in Physiology, Development and Neuroscience, says *"we are lucky to have such an engaged and active community here - feeling part of something bigger is really important to stay motivated. As I get closer to the end of my PhD I feel more prepared for the next steps thanks to all the connections and experiences I've had through CamBRAIN. I encourage everyone to get involved!"*


CamBRAIN





GAMING AND THE BRAIN
A NeuroEthics panel discussion
CamBRAIN
Start time: 7pm



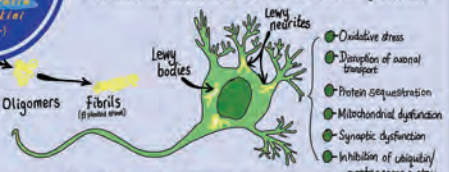



MARSHALL SOCIETY


A Short History of Cambri

Maria Grazia Spillantini (1951-)

Maria Grazia identified the protein alpha-synuclein as the major component of Lewy bodies, the characteristic protein deposit found in the brain in Parkinson's disease and dementia with Lewy bodies.



She also identified mutation in the MAPT gene as a heritable cause for frontotemporal dementia.

2000 onwards

Formed under the leadership of Alastair Compston, bringing together the University Units of Neurology and Neurosurgery are the Cambridge Centre for Brain Repair and the Wolfson Brain Imaging Centre. Compston's research focused on the clinical science of human demyelinating disease including the discovery of genetic risk factors for multiple sclerosis and the introduction of alemtuzumab.

Alastair Compston (1948-)

Pre 1900

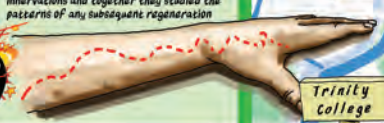
In an example experimental surgery in 1903, Henry Head, in collaboration with William Rivers, conducted pioneering work into the somatosensory system, by severing Head's own radial nerve and mapping the subsequent regeneration (until 1907).

William Rivers (1864-1922) — Henry Head (1861-1940)

Rivers was best known for his work treating First World War officers who were suffering from shell shock, a phrase coined during the war by Charles S. Myers, to describe a type of post traumatic stress

Charles S. Myers (1873-1946)

Dr Rivers cut and sutured all cutaneous branches of Dr Head's radial nerve at the left elbow, sparing any muscular innervations and together they studied the patterns of any subsequent regeneration

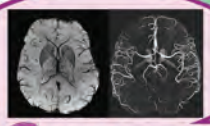


David Hartley (1705-1757)

Afel... Coll... was... who... Obse... in t... Engl... the...

2007 Formation of Cambridge Neuroscience

Alastair Compston (2007–2013)
Trevor Robbins (2007–2013)
Bill Harris (2013–2015)
Ed Bullmore (2013–2017)
Ole Paulsen (2015–2019)
Paul Fletcher (2017–)
Zoe Kourtzi (2019–2022)
Ewan St. John Smith (2022–)

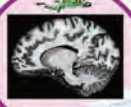


John Pickard (1946-)

In 1997 with colleagues, John Pickard established and was the first chairman and clinical director of the WOLFSON BRAIN IMAGING CENTRE (WIBIC).

The WIBIC opened with a GE PET SCANNER, followed soon after by a BRUKER 3T MRI SYSTEM. Since its inception it has provided research platforms for neuroscience themes, including dementia, stroke and neurosurgery as well as cognitive neuroscience. Its unique location has allowed research into acute head injury that is difficult or impossible in a more standard radiology unit.

The facilities now comprise a SIEMENS 7T TERRA MRI SCANNER in addition to other state of the art



CamBRAIN

The Cambridge Neuroscience Society

David Vatansever (1988-)

2014 CamBRAIN the largest Early Career Neuroscience Society in the UK, was launched in 2014. Its Founding President was Deniz Vatansever. The society continues to flourish today with >1000 members

The purpose of CamBRAIN is to directly support interdisciplinary research, collaboration, knowledge transfer, communication and early career development across graduate students and early career researchers working under the remit of Cambridge Neuroscience

1993 The Neurobiology Group or Division at the Laboratory of Molecular Biology (LMB) was formed

Eric Barnard (1927-2018)

1985 The MRC Molecular Neurobiology Unit under the Directorship of Eric Barnard opened on the Addenbrooke's site, adjacent to the Laboratory of Molecular Biology (LMB). Eric was a pioneer and Founding Father of the discipline of Molecular Neurobiology and as such the Unit reflected the emergence of molecular neurobiology – later termed molecular neuroscience – as a scientific discipline.

1980s/1990s

1960s/1970s

In recognition of the importance of their work, the Nobel Prize in Physiology or Medicine 1963 was awarded jointly to Alan Hodgkin, Andrew Huxley and John Eccles "for their discoveries concerning the ionic mechanisms involved in excitation and inhibition in the peripheral and central portions of the nerve cell membrane".

Colin Blakemore (1944-2022)

A world-renowned neuroscientist and a passionate advocate for physiology who significantly contributed to our understanding of VISION and how the brain develops and adapts. He was influential in establishing the concept of NEURAL PLASTICITY – how brain cells reorganise themselves in response to the environment after birth and even in adulthood

1977 The Department of Psychiatry opened under the leadership of Martin Roth. Roth was influential in re-establishing psychiatry more as a biological than psychoanalytical discipline

Martin Roth (1917-2006)

David Marr (1945-1980)

Three Levels of Analysis

Computational — Why things work the way they do?

Algorithmic — What representations can implement such computations?

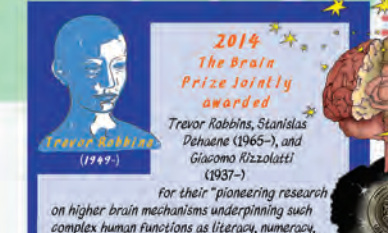
Implementational — How can such a system be built in hardware?

Marr integrated results from psychology, neuroanatomy, artificial intelligence, and neurophysiology into new models of visual processing. His work was very influential in computational neuroscience and led to a resurgence of interest in the discipline.

Marr's three levels of analysis promotes the idea that complex systems such as the brain, a computer or human behaviour should be understood at different levels (Computational, Algorithmic and Implementation).

Trevor Robbins (1949-)

2014 The Brain Prize Jointly awarded Trevor Robbins, Stanislas Dehaene (1965-), and Giacomo Rizzolatti (1937-) for their "pioneering research on higher brain mechanisms underpinning such complex human functions as literacy, numeracy, motivated behaviour and social cognition, and for their efforts to understand cognitive and behavioural disorders."



2016 – The Cambridge Neuroscience MPhil in Basic and Translational Neuroscience programme was launched

This interdisciplinary masters programme takes place across the whole of Cambridge Neuroscience and attracts stellar students from around the world

2017 Cambridge Neuroscience hosted BRAINFest, which brought together >170 neuroscientists from across Cambridge to present groundbreaking research through interactive exhibits, film, art, history, talks, lectures and more in a 3-day free public festival attracting 3000 visitors.

2017 The Brain Prize was jointly awarded to Wolfram Schultz, Peter Dayan and Ray Dolan for 'their multidisciplinary analysis of brain mechanisms that link learning to reward'. This has far-reaching implications for the understanding of human behaviour, including disorders of decision-making in conditions such as gambling, drug addiction, compulsive behaviour and schizophrenia.'

Wolfram Schultz (1944-)

The Brain Prize 2018 was awarded to Michel Goedert, Bart De Strooper, Christian Haass, and John Hardy for 'their groundbreaking research on the genetic and molecular basis of Alzheimer's disease, with far-reaching implications for the development of new therapeutic interventions as well as for the understanding of other neurodegenerative diseases of the brain.'

Goedert discovered that Tau is an integral component of the intraneuronal filaments/tangles of Alzheimer's disease.

Broadbent, trained by Bartlett developed a filter model of attention.

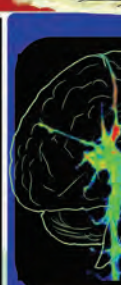
An early landmark Theory of Selective Attention which opened the way for theories on Information Processing

Baddeley's research on memory developed the 3 Component model of Working Memory

DIRECT... Kenneth C... (1916-1993) Frederic C. Ba... (1886-1979) Donald E Broa... (1926-1993) Alan Badde... (1934-)

Usha Goswami (1964-)

2019 Usha Goswami was awarded the Yidan Prize (the 'Nobel Prize for Education') for Education Research by the Yidan Prize Foundation in September 2019 for her work in educational neuroscience, language and literacy.



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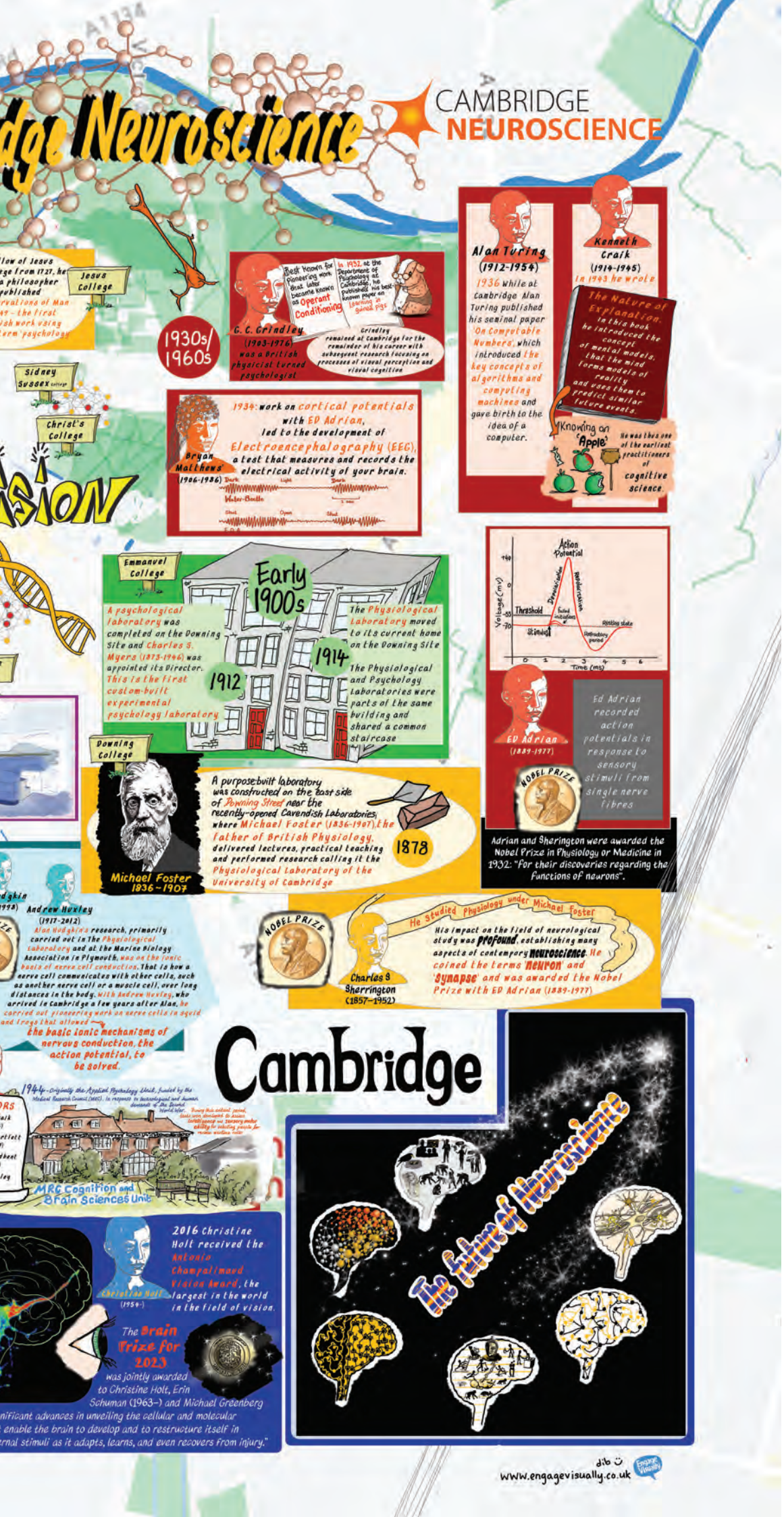


Short history map

History timeline

Credibility in Neuroscience

Robust

Repr

Increasing Credibility

- Study Pre-registration
- Preprint archiving
- Citizen Science
- Registered reports

Pre-registration of hypothesis encourages integrity

Credibility Toolkits

a. https: www.bnacredibility.org.uk toolkits – (links to practical guides to help in research)

b. Use Narrative CVs (A narrative CV encourages you to describe contributions and achievements that showcase a wide range of experiences and skills.)

c. Using Team Science approaches (Team science is a collaborative effort/interdisciplinary approach to address a scientific challenge that leverages the strengths and expertise of professionals, oftentimes trained in different fields.

d. Sign the DORA Declaration DORA

e. Use FAIR Principles (The FAIR data principles are a fundamental part of open science and describe some of the central guidelines to good data management and open access to research data. – there is lots of imagery being used on the web for this) F A I R

Awards & Bursaries

Barriers

Fear of being scooped

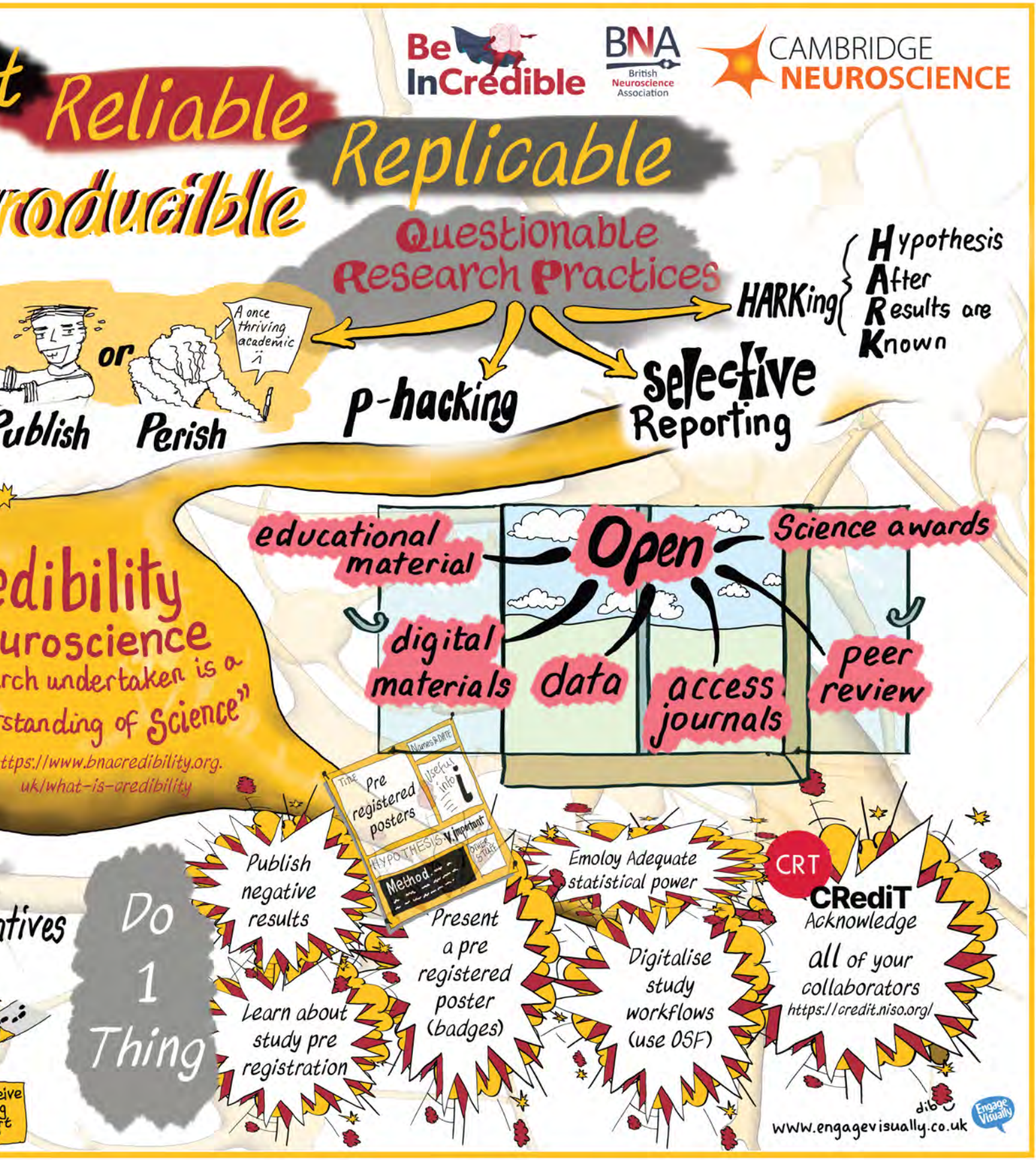
Lack of

- funding
- incen
- support
- training

Long and difficult road

Will we rec the trainin and suppo we need ?

"Where resea a true under


Be InCredible
BNA British Neuroscience Association
CAMBRIDGE NEUROSCIENCE
t Reliable
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Replicable
Questionable Research Practices
HARKing { Hypothesis After Results are Known
A once thriving academic
or
Publish Perish
p-hacking
selective Reporting
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educational material
Open
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digital materials
data
access journals
peer review
Names & DATE
TITLE
Pre registered posters
Useful info
HYPOTHESIS
V. important
Method
Publish negative results
Learn about study pre registration
Present a pre registered poster (badges)
Emoloy Adequate statistical power
Digitalise study workflows (use OSF)
CRT
CRediT
Acknowledge all of your collaborators
https://credit.niso.org/
Do 1 Thing
www.engagevisually.co.uk
Engage Visually

Touch Screen - Cognition or Open Modular

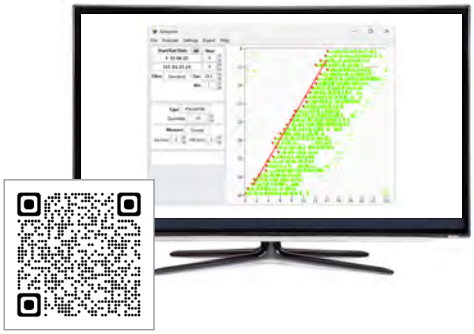
Since development in 2009, the Bussey-Saksida Chamber has been used to investigate a wide range cognitive processes. The current range of pre-written and validated tasks cover Attention, Motivation, Impulsivity. Learning and Memory. Distraction, Decision Making, Cognitive Flexibility and Response Inhibition, Emotional Cognition and Responding to Reinforcement and Executive Function. The number of available tasks is constantly expanding, and each one comes with a battery of training schedules.

Sleep Deprivation

The Sleep Fragmentation Chamber is suitable for sleep deprivation and sleep fragmentation studies in rats and mice. With food and water support, the environment is designed to function like a standard living chamber. Cycle times are easily maintained using the available control mechanism, and cycles can additionally be initiated by an external device such as a push button or relay.

Circadian Rhythm

Actimetrics Clocklab is your one stop for capturing and analyzing Circadian Rhythm data. The monitoring package will connect to almost any digital sensor such as a running wheel or infrared motion detector while the analysis package can read and analyze records obtained from almost any circadian data collection system or other text-based formats.



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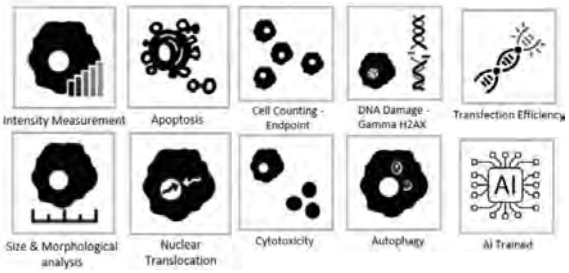
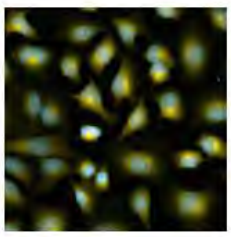
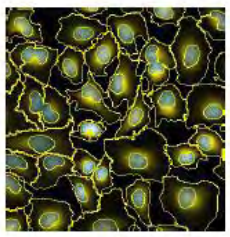
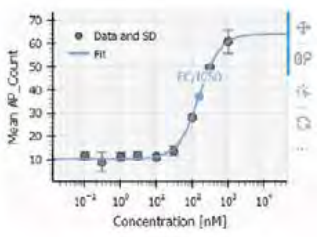


Visit our website to find out more and read application notes for all available assays!







AI from Acquisition to Analysis

If you want to learn more, visit us at our stand or contact **Agnes.Foeglein@nikon.com** for more information.

@dioscuri

Henry Shevlin
Leverhulme Centre for the Future of Intelligence

Consciousness, machines, and moral status

Session One: 09:00-09:25

Dr Henry Shevlin is the Associate Director of the Leverhulme Centre for the Future of Intelligence at the University of Cambridge, where he also serves as co-director for the Kinds of Intelligence programme. A philosopher of cognitive science and an AI ethicist, his research explores a range of themes connected to non-human consciousness and intelligence, including measurement of consciousness, moral patiency, well-being and welfare, creative intelligence, and anthropomorphism and folk psychology.

Abstract: In light of recent breakneck pace in machine learning, questions about whether near-future artificial systems might be conscious and possess moral status are increasingly pressing. I will argue that as matters stand these debates lack any clear criteria for resolution via the science of consciousness. Instead, insofar as they are settled at all, it is likely to be via shifts in public attitudes brought about by the increasingly close relationships between humans and AI systems. I will briefly lay out the current state of the science of consciousness and its limitations insofar as these pertain to machine consciousness, and claims that there are no obvious consensus frameworks to inform public opinion on AI consciousness. I will then examine the rise of conversational chatbots or Social AI, and argues that in many cases, these elicit strong and sincere attributions of consciousness, mentality, and moral status from users, a trend likely to become more widespread. I will then present an inconsistent triad for theories that attempt to link consciousness, behaviour, and moral status, noting that the trends in Social AI systems will likely make the inconsistency of these three premises more pressing. Finally, I will present some limited suggestions for how consciousness and AI research communities should respond to the gap between expert opinion and folk judgment.

Henry meeting Spot the Boston Dynamics robot at the Regional Centre of Excellence for Robotic Technology in Zagreb

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2. Shevlin H. All too human? Identifying and mitigating ethical risks of Social AI. 2024 ***https://philarchive.org/rec/SHEATH-4 (in review)***.

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@tccambs

Thomas Cope
Clinical Neurosciences

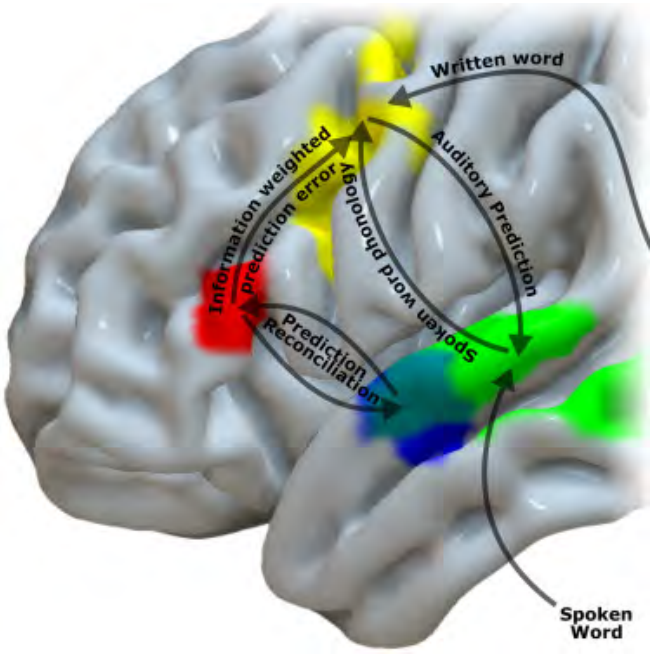
How does the brain make perceptual predictions and update them when they are wrong?

Session One: 09:25-09:50

Dr Cope is a neurology-trained neuropsychiatrist specialising in cognitive disorders and epilepsy. He is academic lead for epilepsy and clinical lead for neuropsychiatry at Addenbrooke's Hospital, and runs a complex dementia clinic. He has done extensive multimodal imaging work with patients who have difficulties with updating perceptual predictions due to rare focal neurodegenerative diseases, observing this process in its timecourse, location and brain representations.

Abstract: All perception is inference. It relies on the integration of sensory input with prior predictions. Effective prediction requires the brain to undertake multiple processing steps. Before sensory input, predictions must be neurally instantiated, based on a combination of lifelong experience of the environment and immediate context. At the time of a sensory event and immediately afterwards, the sensory input must be reconciled with the prediction to infer its content, resulting in perception. Finally, the prediction error must be analysed in order to learn, and improve the perception of future sensory events. This perceptual learning is the result of two distinct assessments: did I correctly guess what might happen and, if I did, were the sensory consequences as I expected?

In this talk I will present a series of experiments combining magnetoencephalography, multivariate 7-Tesla functional MRI, direct intracranial recordings and experimental psychology in rare patients with neurodegeneration or surgical disconnection of either frontal or temporal perceptual hubs. These data provide direct observation of the brain representations of predictions in key nodes of the perceptual network, and causal evidence for the neural and behavioural effects of their selective damage. Overall, they support the predictive coding framework and demonstrate distinct neural representations of verified and violated predictions in inferior frontal gyrus to support flexible perception and future learning. I conclude with a formal model for the interaction of frontal and temporal lobes in the perception of speech.



Graphical abstract

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@ADemertzi

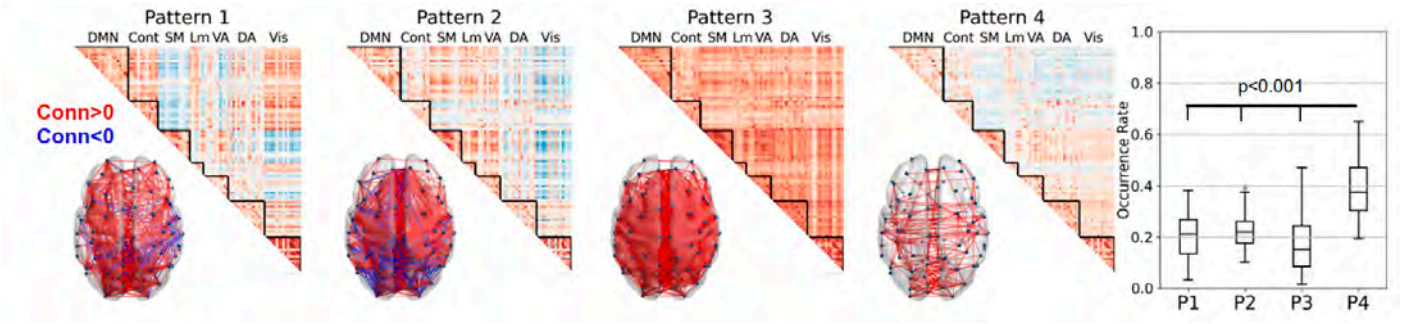
Athina Demertzi
University of Liège

Deriving Aspects of Consciousness from Unconscious States

Session One Opening Plenary: 09:50-10:30

Athena Demertzi is a tenured FNRS researcher at the University of Liege, Belgium. Trained as a psychologist (BS, Aristotle University of Thessaloniki, Greece), with specialization in cognitive neuroscience and neuropsychology (MSc, Maastricht University, The Netherlands), she obtained her PhD in Medical Sciences in 2012 (ULiège). As from 2018, she directs the Physiology of Cognition Lab. Her research contributes to the knowledge about the human mind, even when this cannot be communicated overtly. She has conducted behavioral and neuroimaging studies in physiological, pathological, pharmacological conditions as well as in extreme environments, like space travel. Currently with her team they investigate brain-body interactions as a proxy to human sentience in health and disease by means of high- and low-tech methodologies. In 2020 Dr Demertzi received the AstraZeneca Foundation Scientific Award in "Patient Care in the AI Era 2020" in recognition of her work with machine learning applications. Dr Demertzi's work has been featured in the National Georgraphic, and she has delivered a TEDx talk (2019).

Abstract: The definition of human consciousness has been variant along the past years. Now more than ever we are called to come closer to what we mean by conscious experience. In my lecture, I will try to determine some critical aspects of human consciousness as derived from our work with unconscious and noncommunicating states. I will show how brain and peripheral physiology alter in conditions where reportability is diminished, under the premise that these constitute necessary prerequisites of conscious human experience.serum will be presented, which suggests that this is a promising approach for early diagnosis of disease.



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@Neurocool

Nina Rzechorzek

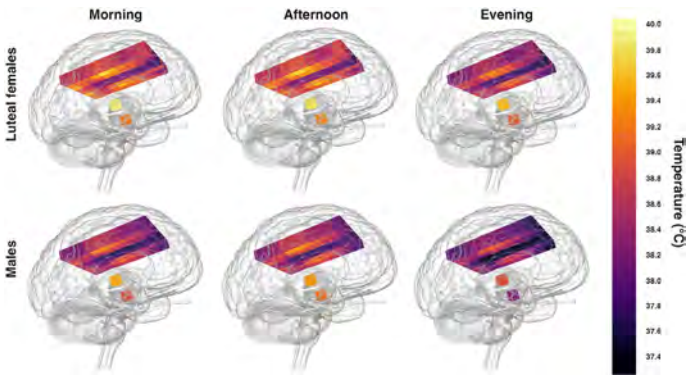
MRC Laboratory of Molecular Biology

Brain temperature dynamics and neural circadian clocks

Session Two: 11:00-11:25

Nina is an MRC Clinician Scientist Fellow, hosted by the O'Neill Lab at the MRC Laboratory of Molecular Biology, and currently seconded to AstraZeneca Neuroscience via an AZ-MRC Industry Partnership for Academic Clinicians. Having studied Physiology and Veterinary Medicine, Nina undertook a Wellcome Clinical Fellowship in Edinburgh including specialist training in Veterinary Neurology & Neurosurgery and doctoral work in the Chandran Lab on hypothermic preconditioning in human neural systems. Back in Cambridge, Nina is exploring interactions between human brain temperature and the neural circadian clock (relevant to acute & chronic brain disorders). Pioneering the first 4D map of human brain temperature (HEATWAVE), Nina demonstrated the prognostic power of daily brain temperature rhythms after traumatic brain injury. A founding member of BioClocks UK, and Diplomate of the European College of Veterinary Neurology, Nina has a keen interest in brain function and dysfunction across species. Beyond the lab, she provides undergraduate teaching support in physiology and neurology, and serves on the Management Committee for APEX (www.altitude.org). Nina is Chief Investigator for the RESET trial (ISRCTN76074900), testing a novel intervention to treat jetlag and improve sleep in the context of high altitude hypoxia.

Abstract: Brain temperature varies in time and space 1. Since neuronal physiology is temperature-sensitive 2-3, emerging data raise questions about how daily neural activity is regulated, how patient temperature is managed and, ultimately, how the brain works around the clock as we age. For example, might brain temperature variability influence the manifestation of chronic brain disorders? Circadian and sleep disruption are linked to these disorders, but causality is unproven. Moreover, whilst temperature is a universal timing cue for circadian clocks, the biological time set by a temperature shift is species-dependent 4, and neural circadian research has focused almost exclusively on the hypothalamus of nocturnal rodents. Here we show bona fide circadian rhythms in multiple human bioluminescent 'clock reporter' neural platforms; these rhythms are synchronized by physiological brain temperature cycles and their period lengths are temperature-resistant across the healthy brain temperature range1,5. Taking a multiomics approach with cerebral organoids at constant temperature, we uncover temporal consolidation of neural processes relevant to sleep and disease. Additionally, we confirm circadian variation in human neural functional activity. Finally, we simulate the impact of brain-permeant drugs and shift work on organoid circadian rhythms. Together with *in vivo* studies of brain temperature dynamics, our new clock reporter platforms represent complementary and tractable tools for exploring the emergence, disruption, and mechanics of the neural circadian clockwork. These systems fill a key translational gap and have the potential to transform our understanding of chronobiology, brain function, and brain health.



Heatwave-a 4D map of human brain temperature
Credit: N Rzechorzek, MRC LMB

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@zanna_voysey

Zanna Voysey
Clinical Neurosciences

A 12-year longitudinal study of sleep abnormalities in Huntington's disease: sleep maintenance insomnia is associated with greater cognitive deficits and disease activity

Session Two: 11:25-11:50

Dr Zanna Voysey is a Neurology Specialist Registrar clinician in the Cambridge Deanery, having previously trained in Oxford and London. Her prior research has included work in movement disorders, deep brain stimulation and sleep neurophysiology. In 2020 she gained a Research Fellowship from the Association of British Neurologists/Guarantors of Brain to undertake a PhD supervised by Professor Roger A Barker, in which she is investigating sleep abnormalities in Huntington's Disease and the degree to which they contribute to symptoms and disease progression.

Abstract: Increasing evidence points to a deleterious feedforward cycle between dementias and their associated sleep abnormalities. Treating sleep pathology therefore bears important, even disease-modifying, potential for these conditions. Huntington's disease (HD), as a genetic dementia presenting in mid-life, poses an opportunity to provide key insights into this area by allowing sleep-neurodegeneration associations to be studied longitudinally from the presymptomatic phase, and in the absence of confounders rendered by age or comorbidities. Moreover, it enables new sleep therapies to be trialled in cohorts at the earliest stage of disease. Here we present the first clinical longitudinal study of sleep in HD, and first interrogation of associations with disease activity, which serves to inform onward sleep therapy intervention studies. HD gene carriers (n=24) and controls (n=22) were studied at two timepoints with an interval of 11.9±1.1 years. All gene carriers were premanifest at baseline. Sleep metrics included polysomnography, two-week actigraphy and melatonin secretion curves, and their association was explored versus i) validated cognitive outcomes (Trail A/B task, Symbol Digit Modalities Task [SDMT], semantic/phonemic fluency) and ii) serum neurofilament-light (NfL) levels, providing a proxy of disease activity. Statistical analysis incorporated repeated measures linear models and regressions adjusted for multiple confounders including disease stage. Participants were stratified into gene carriers who converted to prodromal or early manifest disease by study completion ("converters"; n=16), those who remained premanifest ("non-converters"; n=8), and controls (n=22). Sleep maintenance insomnia was highly prevalent among converters at follow-up (88%) and was associated with greater cognitive deficits (Trail-A p=0.004, R^2=0.642; Trail-B p=0.031, R^2=0.547; SDMT p=0.033, R^2=0.292) and disease activity (NfL p=0.017, R^2=0.366). Moreover, greater gains in sleep maintenance insomnia during the study period were associated with worsened clinical outcomes at follow-up (Trail-A p=0.008, R^2=0.436; Trail-B p=0.004, R^2=0.419; NfL p=0.048, R^2=0.247). This was further supported by parallel elevated motor activity during the sleep period on actigraphy among converters at follow-up (p=0.005; η^2=0.302) which was associated with poorer cognitive outcomes (Trail-A p=0.009, R^2=0.436; Trail-B p=0.004, R^2=0.494; SDMT p=0.002, R^2=0.533). Converters also exhibited diminished melatonin secretion (p=0.022, η^2=0.469), which was associated with greater sleep maintenance insomnia (p=0.002, R^2=0.757). These results provide the first in-human evidence of an association between insomnia and worsened clinical outcomes in HD, which may be partly driven by diminished melatonin rhythms.

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@MoatazAssem

John Duncan and Moataz Assem

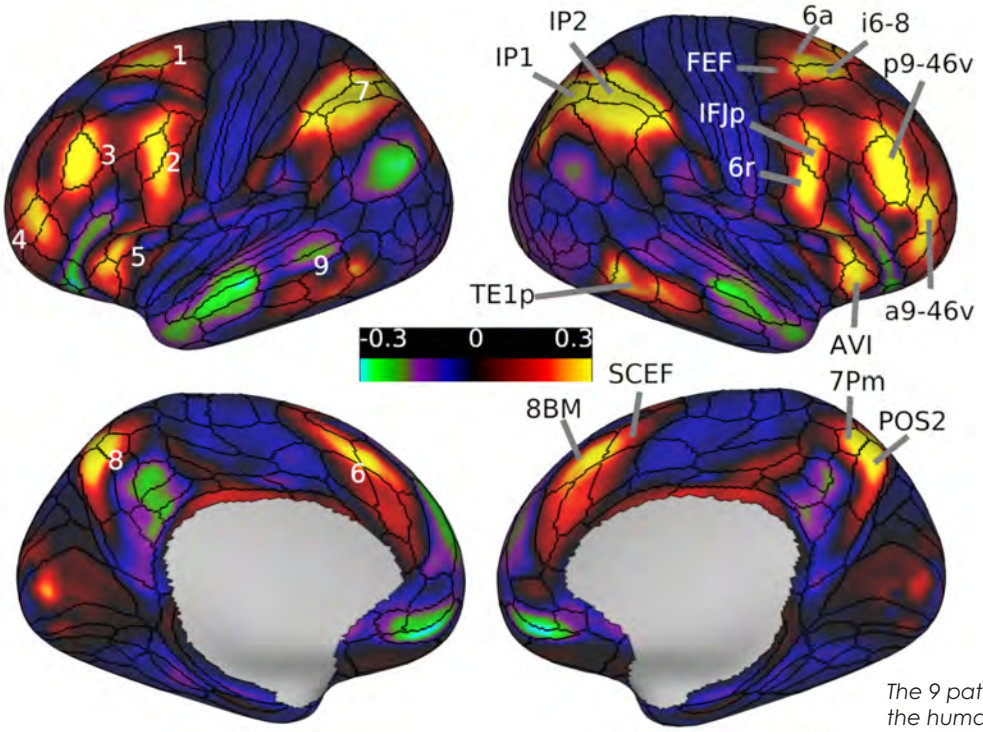
MRC Cognition and Brain Sciences Unit

A domain-general cognitive core in the human brain

Session Two: 11:50-12:15

John Duncan is a Research Programme Leader at the MRC Cognition and Brain Sciences Unit, University of Cambridge. Following first and second degrees at the University of Oxford (1970-1976), he spent two years at the University of Oregon working as a postdoc with Michael Posner before taking up a research position with the MRC. His research combines cognitive science, neuropsychology, neuroimaging, and single cell electrophysiology, addressing the neural mechanisms of attention, intelligence and complex problem solving. A collaboration with Robert Desimone introduced the concept of biased competition as the basis for visual selective attention, bringing together cognitive psychology and animal neurophysiology. Considering attention more broadly, Duncan has used human brain imaging data to define a cortical "multiple-demand" or MD system, recruited in solution of many different cognitive challenges and closely linked to measures of fluid intelligence. This work, again combining cognitive science with human brain imaging and macaque physiology, was summarised in the popular science book How intelligence happens. Duncan is a Fellow of the Royal Society and the British Academy, and winner of the 2012 Heineken Prize in Cognitive Science.

Moataz Assem is a Research Associate at the MRC Cognition and Brain Sciences Unit and the Isaac Newton Trust Research Fellow in Neuroscience at Murray Edwards college. He is the recipient of the 11th Frith Prize from the Experimental Psychology Society for his PhD work at the same unit. His research investigates the brain basis of human intelligence. Specifically, he investigates how a core multiple-demand (MD) circuit in the human brain organises our thoughts and behaviour. His research stands out for its anatomical precision, employing state of the art brain imaging approaches (Human Connectome Project style fMRI, intracranial EEG and more recently concurrent TMS-fMRI). Dr Assem is multidisciplinary trained in medicine (Alexandria University, Egypt), biomedical engineering at (Bogazici University, Turkey and MIT, US), and cognitive neuroscience (Cambridge). In parallel, since 2015, he has been involved in coordinating both the Egyptian and International Brain Bee competitions, the neuroscience olympiads for high school students.



The 9 patch multiple-demand system of the human brain

Abstract: Three decades of brain imaging consistently link the organization of thoughts and behaviour to circumscribed regions within the association cortices, commonly known as domain-general or multiple-demand (MD) regions. However, the imprecision of classical fMRI has impeded our understanding of how MD regions interact with distributed brain circuits. To address this challenge, we used the high-resolution multimodal MRI approach of the Human Connectome Project to scan participants performing 12 diverse cognitive tasks. The results reveal that, at the individual level, different cognitive demands converge within 9 domain-general territories, tightly circumscribed within frontal, parietal and temporal cortices. Each task exhibits a unique topography characterised by finely detailed activation gradients within domain-general territory, shifted towards adjacent resting-state networks. Importantly, the strongest activations arise at multimodal neurobiological definitions of network borders, where information may be intensively exchanged. These properties extend to specific subcortical and cerebellar structures, suggesting a brain wide system in cognitive control. In the behaving monkey, we have begun to delineate cooperation and differentiation between distinct MD regions within frontal cortex. The results suggest a novel framework whereby partially-specialised networks collaborate with neighbouring MD areas to generate the momentary contents of thought.

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@estamatakis
@ccig_cambridge

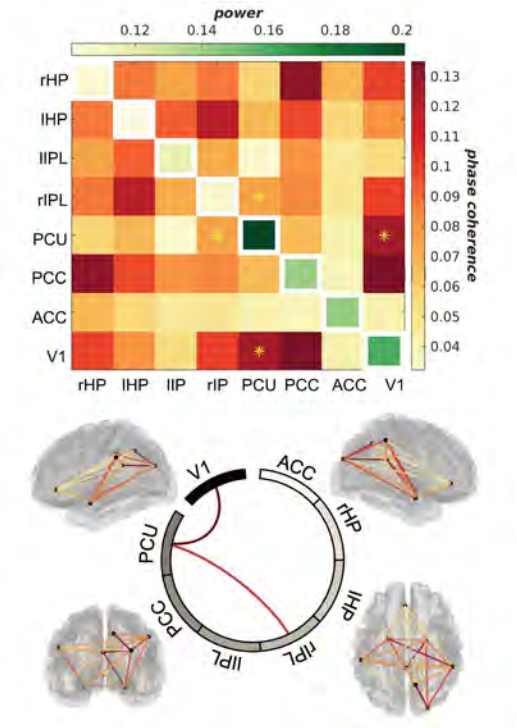
Emmanuel Stamatakis
Clinical Neurosciences
/Medicine

The complex relationship between the brain and (un)consciousness

Session Two:
12:15-12:40

Emmanuel A Stamatakis leads the Cognition and Consciousness Imaging Group (bit.ly/ccigcambridge) in the Departments of Medicine and Clinical Neurosciences at the University of Cambridge. His research seeks to determine how cognitive function arises from the functional organization and complex dynamics in the brain. Grounded in cognitive psychology, his approach incorporates computational methods such as network science, mathematical models, information theory, and machine learning to determine the systems-level mechanisms that govern cognitive function, both in health and disease. His most recent investigations focus on understanding the neural mechanisms underlying altered states of consciousness in healthy volunteers (induced by anaesthetics or psychedelics), and patients who have sustained brain injuries that result in disorders of consciousness (e.g. minimally conscious state). A significant aspect of his work involves delineating the neural foundations of internally versus externally oriented cognition and understanding how these processes are modulated by task demands.

Abstract: The neurobiological basis of consciousness has long been at the forefront of both philosophical and scientific discourse. Despite numerous notable contributions and recent advancements in neuroscience, there is still no emerging consensus or a comprehensive theoretical model regarding conscious processing. In order to identify universally applicable neurobiological markers of consciousness, we conduct comparative analyses of changes in brain function and dynamics during unconscious and psychedelic states. This comparison involves both healthy volunteers undergoing anaesthetic or psychedelic drug administration and patients diagnosed with a disorder of consciousness due to traumatic or hypoxic/ischemic brain injury. The presentation will delve into the overarching findings derived from these investigative approaches.



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@SepiKeshavarzi

Sepiedeh Keshavarzi

Physiology, Development and Neuroscience

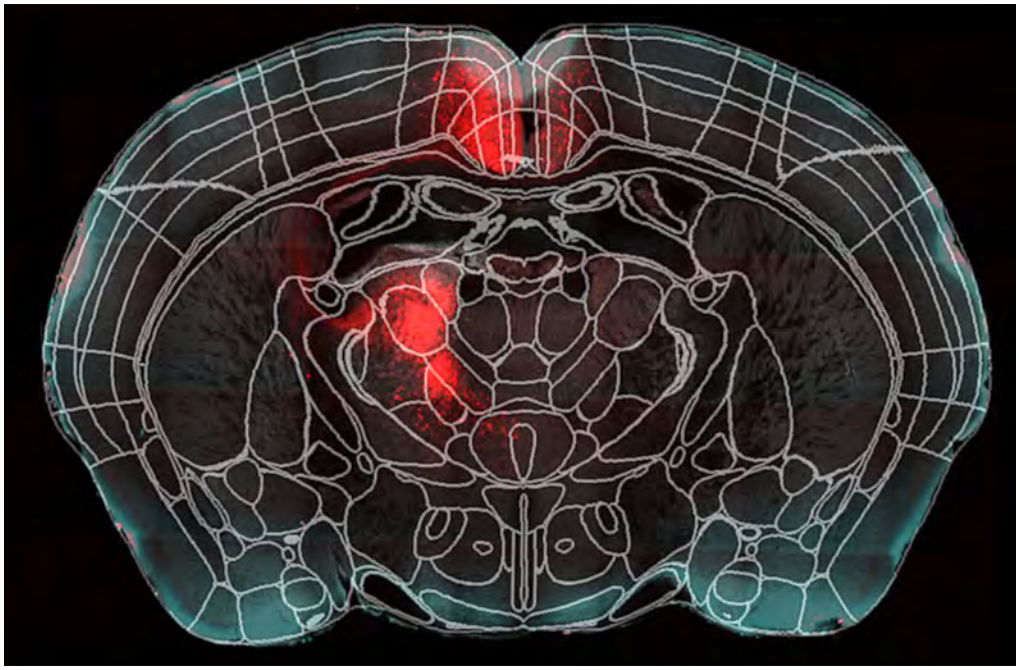
Integration of head and visual motion for self-motion perception and spatial navigation

Session Three: 14:40-15:05

Sepiedeh received her Medical Doctorate from Tehran University of Medical Sciences in Iran and her PhD in Neuroscience from the University of Queensland in Australia. During her PhD in the lab of Professor Panakj Sah, she uncovered the organisation of olfactory processing circuits within the amygdala of the mouse. She then joined Professor Troy Margrie's lab at the Sainsbury Wellcome Centre/University College London as a postdoc, where she investigated how cortical neurons combine internal and external sensory signals to encode self-motion. Sepiedeh's research adopts a wide range of cellular and systems approaches, utilising ex vivo and in vivo neural recording techniques, neural tracing and manipulation, behavioural analysis, and computational methods.

In 2023, Sepiedeh joined the University of Cambridge as an Assistant Professor and now leads her lab at the Department of Physiology, Development, and Neuroscience (PDN). She has been awarded a Wellcome Trust Career Development award, which supports the development of her lab and research on the neural circuit mechanisms of spatial orientation and self-motion perception.

Abstract: To successfully navigate the environment, animals rely on their ability to continuously track their heading direction and speed. In this presentation, I will share our data on sensory computations that underlie head motion coding in the rodent brain. Focusing on the retrosplenial cortex, I will demonstrate how the integration of vestibular and visual cues allows for the accurate estimation of head velocity during navigation. Additionally, I will discuss these findings in the context of retrosplenial cortex connectivity.



Whole brain rabies tracing in mouse.

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@camillalnord

Camilla Nord

MRC Cognition and Brain Sciences Unit

Bodily beliefs: neurocomputational approaches to body-brain disruptions in mental health disorders

Session Three: 15:05-15:30

Dr Camilla Nord is a Programme Leader at the MRC Cognition and Brain Sciences Unit, and Assistant Professor of Cognitive Neuroscience at the Department of Psychiatry, University of Cambridge. Her lab investigates brain-body interactions in neuropsychiatric disorders using methods from cognitive and computational neuroscience. She is also Director of the MPhil in Cognitive Neuroscience at Cambridge, and is Fellow and Director of Studies in Psychological and Behavioural Sciences at Christ's College Cambridge. Camilla studied Physiology and Psychology at Magdalen College, Oxford as an undergraduate before completing her doctorate at the Institute of Cognitive Neuroscience, University College London. After postdoctoral training at the University of Cambridge, she was appointed an MRC Programme Leader Track Scientist in 2021 and promoted to Programme Leader in 2023. Camilla's work has been recognised by various awards, including the European Society of Cognitive and Affective Science Young Investigator Award, and named a Rising Star by the Association for Psychological Science. She currently holds an eight-year Wellcome Career Development Award fellowship, and jointly leads an international team investigating the role of interoception in anxiety and depression via a Wellcome Mental Health Award. She is also the author of the popular science book The Balanced Brain: The Science of Mental Health (Penguin, 2023).

Abstract: To survive, organisms maintain homeostasis by predicting, detecting, and regulating the internal state of their body. Many neuropsychiatric disorders show profound disruptions in homeostatic processes, including appetite, circadian rhythm, and interoception. This talk will outline how cognitive neuroscience and formal computational approaches have revealed novel treatment targets for mental health, spanning both bodily signals and their higher-level interpretation. I will discuss our recent experimental medicine approaches to target bodily signals using psychopharmacology and identification of a 'neural locus' of interoceptive dysfunction in a transdiagnostic psychiatric population. I will then outline how experimental neuroscience informs broader theoretical perspectives on the role of interoception and bodily signals in mental health, including the possibility for novel augmentative treatment strategies informed by basic neuroscience.

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2. Nord CL, Dalmaijer ES, Armstrong T, Baker K, Dalgleish T. A causal role for gastric rhythm in human disgust avoidance. ***Current Biology*** 2021 31:629-634. https://doi.org/10.1016/j.cub.2020.10.087.

3. Nord CL, Lawson, RP, Dalgleish T. Disrupted dorsal mid-insula activation during interoception across psychiatric disorders. ***American Journal of Psychiatry*** 2021 178:761-770. https://doi.org/10.1176/appi.ajp.2020.20091340.

4. Nord CL, Garfinkel SN. Interoceptive pathways to understand and treat mental health conditions. ***Trends in Cognitive Sciences*** 2022 26:499-513. https://doi.org/10.1016/j.tics.2022.03.004.

5. Nord CL, Longley B, Dercon Q, Phillips V, Funk J, Gormley S, Knight R, Smith AJ, Dalgleish, T. A transdiagnostic meta-analysis of acute augmentations to psychological therapy. ***Nature Mental Health*** 2023 1:389–401. https://doi.org/10.1038/s44220-023-00048-6.

@DanAkarca

Danyal Akarca

MRC Cognition and Brain Sciences Unit

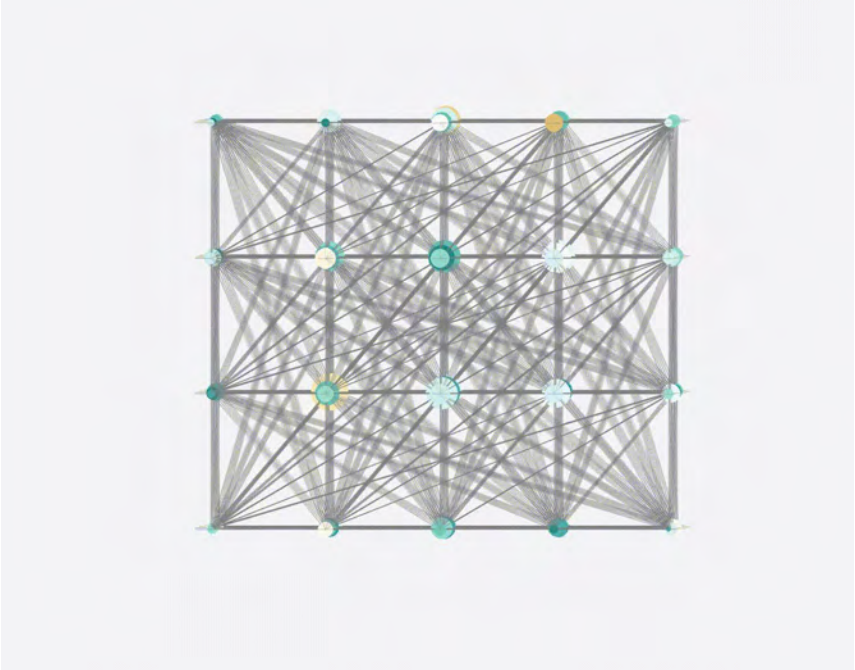
Spatially embedded recurrent neural networks: understanding how physical constraints shape structural and functional organisation during task solving.

Session Three: 15:30-15:55

Dr Danyal Akarca is a Postdoctoral Scientist at the MRC Cognition and Brain Sciences Unit (University of Cambridge) and Postdoctoral Research Associate of Pembroke College. He completed his PhD in Computational Neuroscience at the University of Cambridge, under the supervision of Professor Duncan Astle and advised by Professor Petra Vértes, focussing on building biologically-inspired mathematical models to understand the link between developing neural network organisation and structure to their computations and function. He previously trained as a Medical Doctor at the University of Southampton.

Abstract: Brain networks, across the animal kingdom, exist within the confines of metabolic and spatial limits while simultaneously implementing its required information processing. However, most computational work to date does not model how these competing structural and functional constraints are traded-off in real time. In his talk, Dr Danyal Akarca will introduce a new approach that aims to captures these effects: called spatially embedded recurrent neural networks (seRNNs) [1]. seRNNs learn basic task-related inferences while existing within a three-dimensional Euclidean space, where the communication of constituent neurons is constrained by a sparse connectome – converging on structural and functional features that are also commonly found in primate cerebral cortices. Specifically, they converge on solving inferences using modular small-world networks, in which functionally similar units spatially configure themselves to utilize an energetically efficient mixed-selective code [2, 3]. Because these features emerge in unison, seRNNs reveal how many common structural and functional brain motifs are strongly intertwined and can be attributed to basic biological optimisation processes.

University of Cambridge Press Release: https://www.cam.ac.uk/research/news/ai-system-self-organises-to-develop-features-of-brains-of-complex-organisms



An example of a representative seRNN network

1. Achterberg J, Akarca D, Strouse DJ, Duncan J, Astle DE. Spatially embedded recurrent neural networks reveal widespread links between structural and functional neuroscience findings. ***Nat Mach Intell***. 2023 5:1369–1381. https://doi.org/10.1038/s42256-023-00748-9

2. Bullmore E, Sporns O. The economy of brain network organization. ***Nat Rev Neurosci***. 2012 13:336–349. https://doi.org/10.1038/nrn3214.

3. Rigotti M, Barak O, Warden M, Wang X-J, Daw ND, Miller EK, Fusi S. The importance of mixed selectivity in complex cognitive tasks. ***Nature*** 2013 497:585–590. https://doi.org/10.1038/nature12160.

@AilieMcwhinnie

Ailie McWhinnie

Physiology, Development and Neuroscience

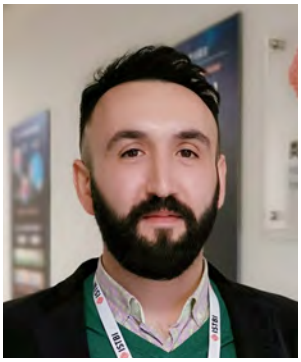
CamBRAIN at 10

Session Three: 15:55-16:05

Ailie McWhinnie is the President of CamBRAIN, and a third year PhD student in the Department of Physiology, Development and Neuroscience in the laboratory of Dr Elisa Galliano. She has worked with CamBRAIN since arriving in Cambridge in 2021 and loves all things science communication and community. Her research looks at the function of a strange bunch of neurons in the mouse olfactory bulb that continue regenerating throughout life and often have no axon!

Abstract: CamBRAIN is the junior researcher branch of Cambridge Neuroscience. Our focus is on connecting and supporting researchers in the early stages of their careers through regular events, socials and career development opportunities. Think pub talks (our Neurotalks!), neuroethics debates, careers evenings and public engagement and so much more!
Founded in 2014 by Dr Deniz Vatansaver and a group of keen postgraduate students, this year marks ten years of CamBRAIN. Our community has continued to grow since its founding, and we are now the biggest local neuroscience society in the UK!

Check out the CamBRAIN website at https://neuroscience.cam.ac.uk/early-career-researchers/cambrain/ and follow @cambraincns on X and Instagram, and subscribe to the mailing list at https://lists.cam.ac.uk/sympa/info/soc-cambrain-members



@neurodenizen

Deniz Vatansever

Fudan University

The Unseen Orchestra: Mapping the Default Mode of Human Cognition

Session Three: 16:05-16:30

Dr. Deniz Vatansever is an Associate Professor at the Institute of Science and Technology for Brain-inspired Intelligence (ISTBI), Fudan University. Prior to his move to Shanghai, he obtained his PhD from the University of Cambridge in Clinical Neurosciences at the Cognition and Consciousness Imaging Group, and later joined the Department of Psychology, Semantics and Mind-wandering Laboratory at the University of York for his post-doctoral work. Currently, he is leading a Cognition and Brain Imaging Laboratory at ISTBI, with a long-term ambition to unravel the neural mechanisms behind learning and memory, particularly focusing on the default mode network and its role in mental navigation. He further aims to apply brain-inspired intelligence to the development of future generation adaptable systems. His lab employs integrative, systems-level approaches from cognitive, and clinical and computational neurosciences, spanning research areas such as value-based decision making, and neural plasticity. Through his academic journey and current pursuits, Dr. Vatansever seeks to illuminate the complexities of the human mind and translate these insights into tangible advancements for both neuroscience and artificial intelligence.

Abstract: Since its identification as a network of brain regions exhibiting notable deactivations during goal-oriented tasks and displaying tightly coupled activity patterns during rest, the "default mode" brain network has prompted a persistent inquiry: Is there a default mode of brain function? Beyond its association with various internal processes such as mind-wandering, creativity, and a sense-of-self, its widespread alterations observed in various mental health disorders suggest a pivotal role for this network in human cognition.

In this presentation, I will showcase recent research elucidating the default mode network's contribution to our capacity to employ learned models of our environment, facilitating efficient and adaptive responses to external stimuli. I will posit that the principal functional role of this network may lie in the seamless navigation of a continuum of automated thoughts, decisions, and actions that govern our daily lives. This novel insight holds promise for enhancing our comprehension of ongoing cognitive processes and may offer valuable insights for addressing transdiagnostic dysfunctions across mental health disorders.

Deniz in the lab at Fudan University

1. Vatansever D, Smallwood J, Jefferies E. Varying demands for cognitive control reveals shared neural processes supporting semantic and episodic memory retrieval. ***Nature Communications*** 2021 12: 2134. https://doi.org/10.1038/s41467-021-22443-2.

2. Vatansever D, Karapanagiotidis T, Margulies DS, Jefferies E, Smallwood J. Distinct patterns of thought mediate the link between brain functional connectomes and well-being. ***Network Neuroscience*** 2020 4:637-657. https://doi.org/10.1162/netn_a_00137.

3. Vatansever D, Menon DK, Stamatakis EA. Default mode contributions to automated information processing. ***Proc Natl Acad Sci USA***. 114:12821-12826. https://doi.org/10.1073/pnas.1710521114.

4. Vatansever D, Bzdok D, Wang HT, Mollo G, Sormaz M, Murphy C, Karapanagiotidis T, Smallwood J, Jefferies E. Varieties of semantic cognition revealed through simultaneous decomposition of intrinsic brain connectivity and behavior. ***Neuroimage*** 2017 158:1-11. https://doi.org/10.1016/j.neuroimage.2017.06.067.

5. Vatansever D, Menon DK, Manktelow AE, Sahakian BJ, Stamatakis EA. (2015), Default mode dynamics for global functional integration. ***Journal of Neuroscience*** 35:15254-15262. doi: https://doi.org/10.1523/JNEUROSCI.2135-15.2015.

@TomMcClelland1

Tom McClelland

History and Philosophy of Science

Agnosticism About Artificial Consciousness

Session Four: 17:00-17:25

Tom recently joined Cambridge's Department of History and Philosophy of Science after three years at the Faculty of Philosophy. Before that he held posts at Warwick, Manchester and Glasgow and studied at Sussex, York and Cambridge. His research covers a range of overlapping topics in philosophy of cognitive science, metaphysics, aesthetics and applied ethics. His current work focuses on how social inequalities can shape perceptual experience in a way that perpetuates those inequalities. A recent paper co-authored with Paulina Sliwa argues that gender imbalances in the performance of domestic tasks may be underwritten by socially-mediated differences in how affordances for domestic tasks are perceived. More generally, he is interested in the idea that perceptual experiences (or patterns of perceptual experience) are ethically evaluable. His introductory book 'What is Philosophy of Mind?' is available from Polity Press.

Abstract: Artificial Intelligence is all around us but is any of it conscious? And if not, could there be conscious AI in the future? Since these questions have such significant ethical ramifications it's imperative that we find solid answers to them. However, I argue that no such answers are available. Although the science of organic consciousness continues to make progress, our findings can only be applied to artificial consciousness if we first solve the infamous 'hard problem' of consciousness. And in the absence of a solution to that problem, we're in no position to assess the prospects of artificial consciousness. I defend this agnostic view of artificial consciousness and explore what this means for the moral status of AI.

1. Crosby M (2019). Why Artificial Consciousness Matters. In Antonio Chella, David Gamez, Patrick Lincoln, Riccardo Manzotti, Jonathan Pfautz (Eds.) ***Papers of the 2019 Towards Conscious AI Systems Symposium***, CEUR Workshop Proceedings, Vol-2287.

2. Schneider S (2018) Artificial Intelligence, Consciousness, and Moral Status. In ***The Routledge Handbook of Neuroethics***, translated by L. Syd M Johnson and Karen S. Rommelfanger, 373-375. New York: Routledge.

3. Schwitzgebel E, Garza M (2020). Designing AI with Rights, Consciousness, Self-Respect, and Freedom. In ***Ethics of Artificial Intelligence***. New York, NY, USA: pp. 459-479.

4. Shevlin H. Non-human Consciousness and The Specificity Problem: A Modest Theoretical Proposal. ***Mind & Language*** 2021 36:297-314. https://doi.org/10.1111/mila.12338.

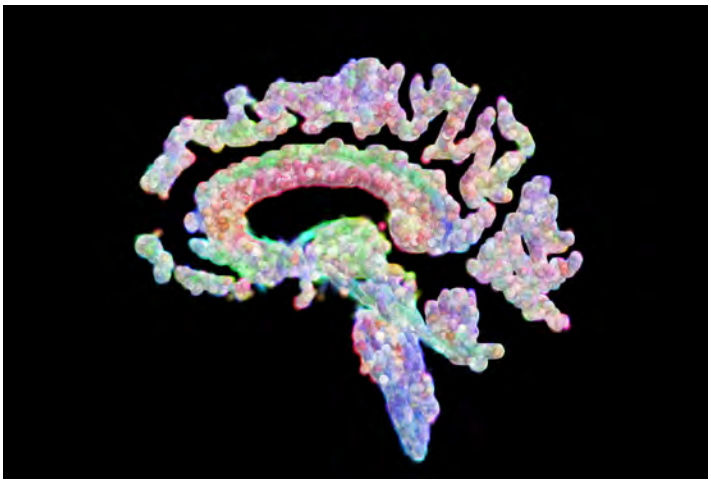
Stephanie Brown
Psychiatry

Hypothalamic structural involvement in the development of Alzheimer's disease in Down syndrome

Session Four: 17:25-17:50

Stephanie Brown is a Senior Research Associate and ARUK Fellow in the Department of Psychiatry. Her research leverages advanced MR technologies and 7 Tesla MRI to address pertinent questions in the fields of neurodegeneration and neurodevelopment. Particularly, her work focusses on the development of dementia in Down syndrome, sleep as a mediating factor in the onset of Alzheimer's disease and the neurological basis for difficult to manage behavioural aspects of Prader-Willi syndrome. She carried out both her undergraduate studies in Biomedical Sciences (Hons. Physiology) and Ph.D. in Psychiatry at the University of Edinburgh. She then undertook postdoctoral experience at the Icahn School of Medicine at Mount Sinai and the University of Cambridge. She also did a visiting scholarship with Massachusetts General Hospital and Harvard Medical school to train in PET imaging analysis.

Abstract: The hypothalamus is the only neuroanatomical site of orexin-producing neurones in the brain and modulates sleep and wakefulness behaviour. Due its small size and lack of defined contrast in conventional neuroimaging acquisitions, relatively little evidence exists as to the role of the hypothalamus in humans in neurodegeneration and sleep quality. A total of 353 participants with DS and 37 sibling controls underwent structural brain scanning at 3T as part of the ABC-DS international consortium research project. Hypothalami were segmented in the T1-weighted images and assessed volumetrically as proportional to intracranial volume (ICV) and grey matter volume. Whole hypothalamic volumes, when normalised to ICV, are significantly reduced in people with DS who have mild cognitive impairment (MCI) and dementia compared to those who are healthy ($p < 0.05$). Additionally, smaller hypothalamic volumes normalised to ICV were significantly associated with poorer cognitive performance ($p < 0.05$). When normalised to grey matter volume, we find that healthy people with DS disproportionally smaller hypothalamic nuclei developmentally. Specifically, hypothalamic volume in the anterior-inferior sub-nucleus is significantly smaller in people with DS with an AD diagnosis ($p < 0.05$) when normalised to grey matter volume, indicating an accelerated or preferential atrophy in this location. Larger hypothalamic volumes were associated with being overweight or obese. These preliminary findings suggest that the whole hypothalamic structure is sensitive to AD-related atrophic processes, which are not present in sibling controls, and that hypothalamus volume is closely associated with cognitive performance in DS. The finding of an anterior-inferior nucleus-specific atrophy in AD which is disproportionate to whole brain grey matter loss is supportive of this region having an accelerated decline which may be linked to sleep as a risk factor or sleep-related dementia symptomatology, as it is known to contain the suprachiasmatic nucleus.



"Sagittal Tractography" -
A sagittal slice probabilistic tractography image of the brain of a participant with Down syndrome, reconstructed from a diffusion-weighted MRI scan acquired on a PET-MR system, Wolfson Brain Imaging Centre.

1. Sabia S, Fayosse A, Dumurgier J, van Hees VT, Paquet C, Sommerlad A, Kivimaki M, Dugravot A, Singh-Manoux A. Association of sleep duration in middle and old age with incidence of dementia. ***Nat Commun*** 2021 12:2289. https://doi.org/10.1038/s41467-021-22354-2.

2. Portelius E, Soininen H, Andreasson U, Zetterberg H, Persson R, Karlsson G, Blennow K, Herukka SK, Mattsson N. Exploring Alzheimer molecular pathology in Down's syndrome cerebrospinal fluid. ***Neurodegener Dis***. 2014 14:98-106. https://doi.org/10.1159/000358800.

3. Brown SSG, Mak E, Zaman SH. Multi-modal imaging in Down's syndrome: maximizing utility through innovative neuroimaging approaches. ***Frontiers in Neurology*** 2021 11:1830. https://doi.org/10.3389/fneur.2020.629463.

@anilkseth

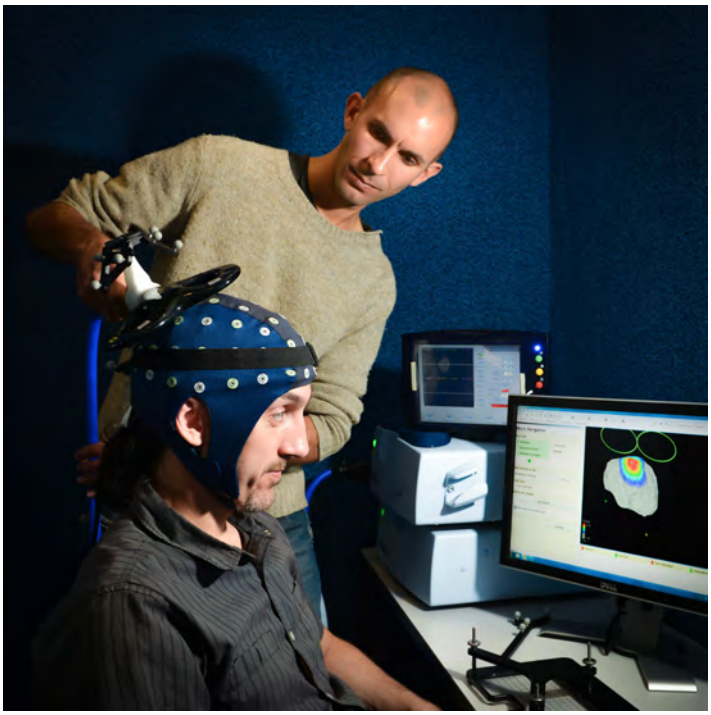
Anil Seth
University of Sussex

Consciousness in humans and in other things

Session Four Closing Plenary: 17:50-18:30

Anil Seth is Professor of Cognitive and Computational Neuroscience and Director of the Centre for Consciousness Science at the University of Sussex. He is also Co-Director of the Canadian Institute for Advanced Research Program on Brain, Mind and Consciousness, a European Research Council Advanced Investigator, and Editor-in-Chief of the journal Neuroscience of Consciousness. He has published more than 200 research papers, is a Clarivate Highly Cited Researcher (2019-2023), and in 2023 he received the Royal Society Michael Faraday Prize. Prospect listed him as one of the Top 25 thinkers in the world for 2024. His 2017 TED talk has been viewed more than fourteen million times, and his 2021 book Being You: A New Science of Consciousness was an instant Sunday Times Bestseller and a Book of the Year for The Economist, The New Statesman, Bloomberg Business, The Guardian, The Financial Times and elsewhere.

Abstract: Consciousness remains a central mystery in science and philosophy. In this talk, I will illustrate how the framework of predictive processing can help bridge from mechanism to phenomenology – addressing not the 'hard problem', but the 'real problem of consciousness'. I'll explore how conscious experiences of the world around us, and of being a self within that world, can be understood in terms of perceptual predictions - 'controlled hallucinations' that are deeply rooted in a fundamental biological imperative for physiological regulation. This view implies a deep connection between mind and life, suggesting that – contrary to the old doctrine of Descartes – we are conscious because we are living creatures. I'll explore implications of this view for the prospects (and pitfalls) of artificial consciousness, suggesting that conscious machines may need to be more similar to biological systems than is often thought.



1. Suzuki K, Seth AK, Schwartzman D. Modelling phenomenological differences in aetiologically distinct visual hallucinations using deep neural networks. ***Front Hum Neurosci***. 2024 17:1159821. https://doi.org/10.3389/fnhum.2023.1159821.

2. Why conscious AI is a bad, bad idea. ***Nautilus***, 2023 (https://nautil.us/why-conscious-ai-is-a-bad-bad-idea-302937/).

3. Seth AK, Bayne T (2022). Theories of consciousness. ***Nat Rev Neurosci***. 2022 23:439-452. https://doi.org/10.1038/s41583-022-00587-4.

4. Seth (2021) Being You – A New Science of Consciousness. Faber/Penguin.

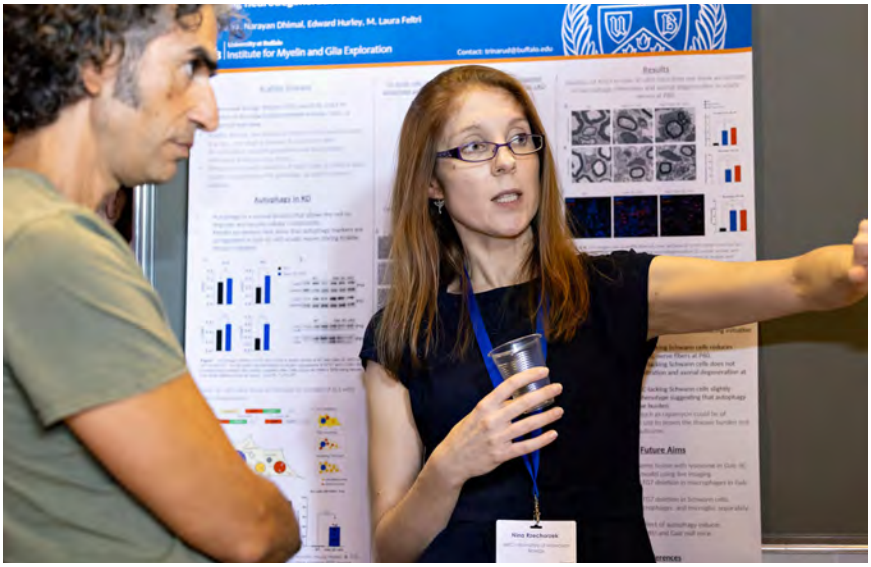
5. Seth AK, Tsakiris M. Being a Beast Machine: The Somatic Basis of Selfhood. ***Trends Cogn Sci***. 2018 22:969-981. https://doi.org/10.1016/j.tics.2018.08.008.

David Menon
Clinical Neurosciences

After dinner at Queens' College

David Menon is a Director of Research, Principal Investigator in the Wolfson Brain Imaging Centre, and Principal Investigator in the van Geest Centre for Brain Repair, at the University of Cambridge. Following two terms as a Senior Investigator in the National Institute for Health and Care Research (NIHR), he was appointed emeritus NIHR Senior Investigator in 2019. He is a Founding Fellow of the Academy of Medical Sciences, and a Professorial Fellow in the Medical Sciences at Queens' College, Cambridge.
He founded and was the first Director of the Neurosciences Critical Care Unit (NCCU) at Addenbrooke's Hospital, Cambridge, where he established the first recognised training programme for specialist neurocritical care in the UK. Protocols developed in the Addenbrooke's NCCU have been shown to improve clinical outcome in severe head injury and rationalise the management of acute intracranial haemorrhage. He jointly leads the EU-funded €30 million CENTER-TBI Consortium (https://www.center-tbi.eu/), the International Initiative on TBI Research (InTBIR; https://intbir.incf.org/), and the multi-funder UK national Traumatic Brain Injury (TBI) Research Platform (TBI-REPORTER; https://tbi-reporter.uk/). He jointly led the Lancet Neurology Commissions on TBI in 2017 (https://www.thelancet.com/commissions/traumatic-brain-injury) and 2022 (https://www.thelancet.com/commissions/traumatic-brain-injury-progress), and was Executive Editor of the UK All Party Parliamentary Group Report on Acquired Brain Injury (2019: https://ukabif.org.uk/resource/resmgr/campaigns/appg-abi_report_time-for-cha.pdf).

Professor Menon has been applicant or co-applicant on awarded grants totaling over $60 million. He has over 650 peer-reviewed publications, with a 'h' index of over 130 (Google Scholar) and has been continuously rated as a Highly Cited Researcher by Clarivate since 2021. The Acute Brain Injury Program at Cambridge, which he founded, has supported over 50 PhD studentships, and nurtured several senior investigators across clinical and basic neuroscience.



Meet the Poster judges

Head Judge
Ragnhildur Thóra Káradóttir @ThoraKaradottir
Veterinary Medicine
MS Society Cambridge Centre for Myelin Repair
Myelin
Multiple sclerosis
Glia

Andrea Luppi @loopyluppi
Engineering
Consciousness
Connectomes
Anaesthesia
Cognition

Edward Harding, @EdwardCHarding
WT-MRC Institute of Metabolic Science
Obesity
Dementia
Diabetes

John Apergis-Schoute, @ApergisJohn
Queen Mary University of London
Neural circuits
Emotion
Appeitite

Annemieke Apergis-Schoute, @Miek-cam
Queen Mary University of London
Obsessive Compulsive Disorder
Mental health
Psychiatric disorders
Human Imaging

Craig Brierley, @takanocraig
Office of External Affairs and Communications
Press releases
Science writing
Media

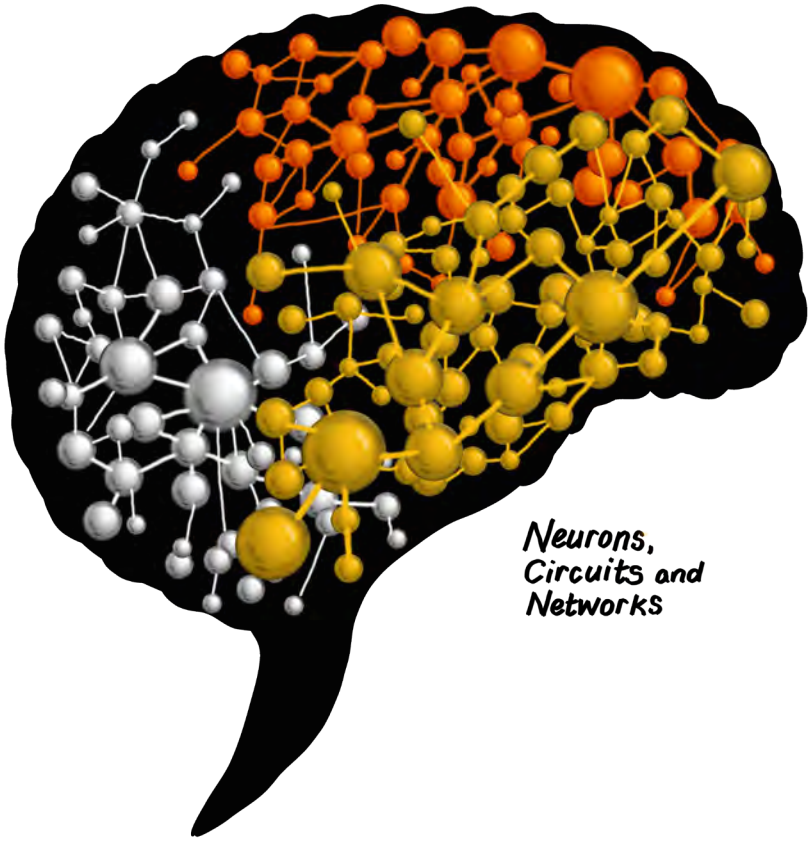
Neurons, Circuits and Networks

Neurons, Circuits and Networks (NCN) unites researchers working with radically different datasets and at distinct scales of investigation – from cellular signalling networks, to neuronal circuits, to large-scale networks of interacting brain regions. There are many research groups in Cambridge whose work is revolutionising our understanding of Neurons, Circuits and Networks across all scales.

This theme focuses on the structure and function of individual neurons, as well as their organisation into circuits and larger-scale networks of neuronal populations. We aim to understand how neuronal circuits give rise to complex behaviours and cognitive processes both in health and in disease. Ultimately, we believe that a mechanistic understanding of circuit function and dysfunction will help drive innovation both in treatments of brain disease and in biologically inspired artificial intelligence.

A major strength of the Neurons, Circuits and Networks community in Cambridge is that it isn't siloed, either by scale of investigation – from molecules to whole brains – or by conventional divisions between departments. Instead, we bring together a broad range of researchers from Cambridge-based institutes such as the MRC Laboratory of Molecular Biology and the Wellcome Sanger Institute, as well as many different University departments including Genetics, MRC Cognition and Brain Sciences Unit, Pharmacology, Physiology, Development and Neuroscience, Zoology, Medicine, Clinical Neurosciences, Psychiatry, Psychology, Engineering and Applied Mathematics & Theoretical Physics.

Together we investigate questions such as (i) the molecular mechanisms underpinning the function of individual neurons and synapses, (ii) communication between neurons, glia and other cell types, (iii) computational and algorithmic aspects of how neurons represent and manipulate information, (iv) mechanisms of neural network development, degeneration and regeneration – from axon guidance to plasticity, (v) the neuronal circuits underpinning physiological processes such as circadian rhythms or modulation of fertility hormones, and (vi) the neuronal and network mechanisms underpinning cognitive processes – from vision and navigation to attention, learning, decision-making and reward processing. Many research groups within the theme also focus on how neural circuits and networks differ in health and disease, and how neuronal function can be manipulated for therapeutic benefit. This includes applications to understanding and better treating chronic pain, addiction, obesity, dementias, mood disorders, and other neuropsychiatric disorders such as schizophrenia.



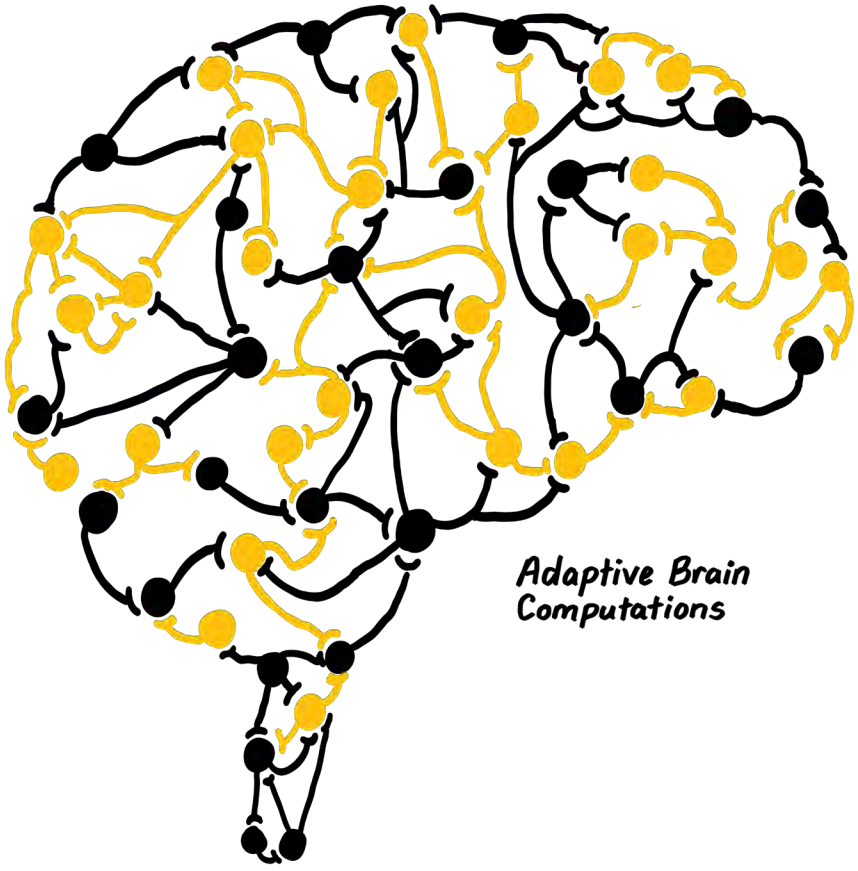
Adaptive Brain Computations (ABC)

The **Adaptive Brain Computations (ABC)** theme brings together a diverse group of scientists from across the University with shared interests in decoding how the brain senses, accumulates, maps, and combines present and past information to enable organisms adaptively to operate in their environments. This is a cross cutting theme with relevance for how the brain represents and computes information at different stages of development, instantiates social cognition, and in coordinating reflexive and higher-order behaviours, all of which depend fundamentally on neural circuits and networks, including neuronal-glial interactions. Moreover, elucidating how the brain captures and integrates information is imperative as a starting point to gain a richer mechanistic understanding of the biological and environmental pressures that extend the brain beyond its normal operating limits, ultimately to cause the outward expression of brain disorders such as autism spectrum disorder, schizophrenia, depression, ADHD, OCD, and addiction.

Research in this theme aims to elucidate the brain mechanisms that mediate neuronal plasticity and adaptive behaviour across species and scales. It works towards building a mechanistic understanding of how the brain senses, accumulates, maps, and combines present and past information about the external and internal environments, and uses them for decision-making, learning, and memory. It seeks to characterise the processes giving rise to flexible responses that adapt to changing environments and shifting goals, while maintaining operational stability and overall homeostasis. It also wishes to understand the principles and mechanisms by which evolution moulds brain circuits adaptively to distinct ecological niches and behavioural needs.

Adaptive Brain Computation researchers belong to more than 10 different department and institutes, including the Departments of Psychology, Psychiatry, Engineering, Physiology, Development and Neuroscience, Medicine, the MRC Laboratory of Molecular Biology and the MRC Cognition and Brain Sciences Unit. We work on theory and computation as well as experimental approaches, and aim to cover the full range of scales in neuroscience, from molecules to neurons and networks, to systems, to whole organism and behaviour.

Work in this theme strongly integrates with the “Neurons, Circuits and Networks” and “Brain and Machines” themes, creating further strong synergies between the Schools of Biological Sciences, Clinical Medicine, Physical Sciences, and Technology.

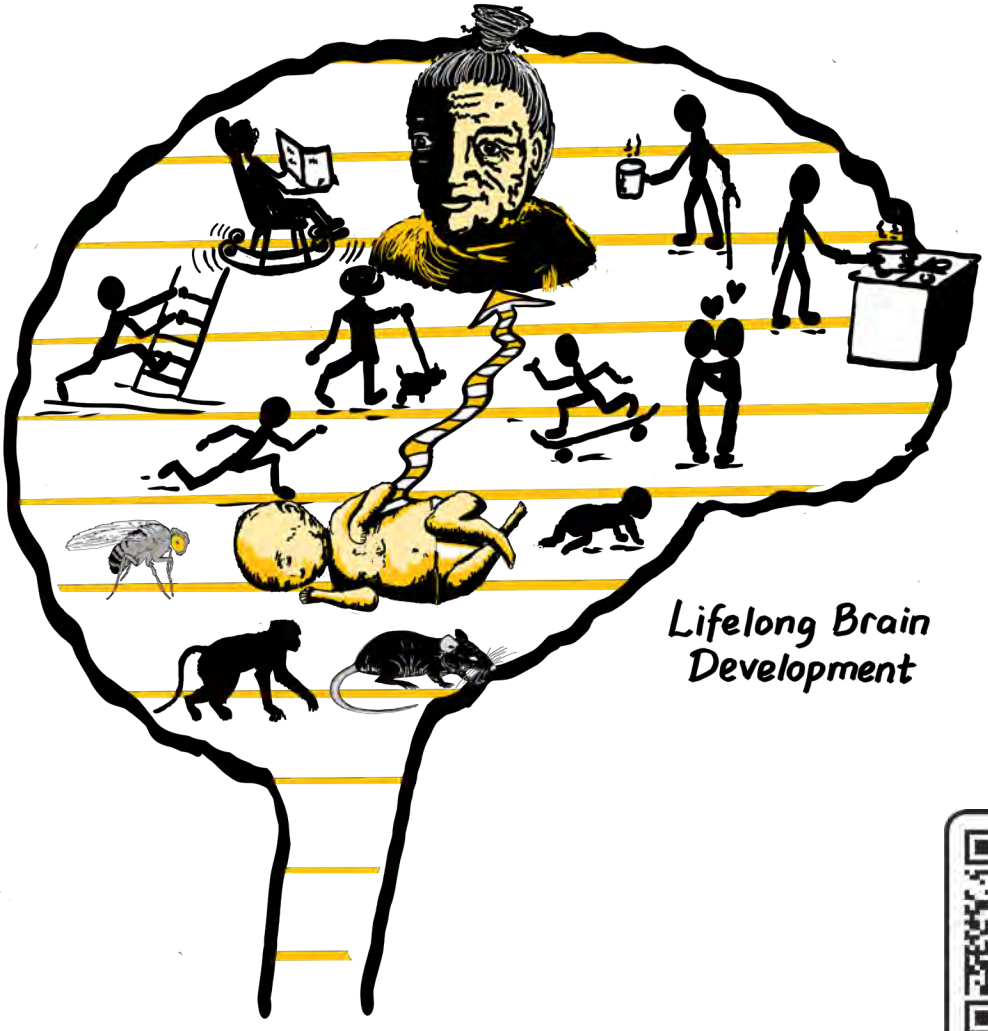


Lifelong Brain Development & Brain Ageing

Research into **Lifelong Brain Development & Brain Ageing** incorporates development from before birth to old age. The lifelong brain development community in Cambridge is made up of a diverse group of researchers working in a range of disciplines spanning the Departments of Biochemistry, Clinical Neurosciences, Chemistry, Chemical Engineering and Biotechnology, Genetics, Physiology, Development & Neuroscience, Paediatrics, Psychology, Psychiatry, Education and Zoology, as well as the Gurdon Institute of Developmental Biology, the MRC Cognition and Brain Sciences Unit, the Wellcome-MRC Cambridge Stem Cell Institute and the MRC Laboratory of Molecular Biology.

Teams of researchers working within and across departments and disciplines are investigating the development of the nervous system across the lifespan at a variety of levels and using a range of model systems, including embryos of different animal species (both vertebrate and invertebrate) and human cerebral organoids ('mini -brains'). Questions currently being investigated range from how individual neurons form and arrange themselves into a nervous system, to how brain, behaviour and cognition develop across the lifespan, from prenatal through childhood and adolescence to old age. Research at Cambridge is also focused on brain mechanisms and cognitive development in developmental conditions such as autism and ADHD, in mental health problems such as depression, anxiety and psychosis, and in degenerative conditions such as dementia and Parkinson's Disease. Cambridge leads research on brain ageing and dementia, which is the focus of CNS2023 and is discussed elsewhere in this programme.

We link closely to key partner NHS Trusts (Cambridge University Hospitals Trust and Cambridgeshire and Peterborough NHS Foundation Trust), the UK Dementia Research Institute, and Dementias Platform UK, and national NIHR infrastructure including the Clinical Research Network (CRN) and Join Dementia Research (JDR). Within the NIHR Cambridge Biomedical Research Centre our focus is on early stage translational studies, including novel repurposing studies and cell therapies.



The Social Brain

Social behaviour and communication are key to interactions between individuals and within groups. Interpersonal transmission of information builds relationships and sustains communities. Conversely, breakdowns in communication and social cohesion can precipitate harm and suffering for individuals and societies, with particularly powerful impacts on mental health. This theme seeks to forge cross-disciplinary research that will increase our fundamental understanding of these vital human interactions, and translate this understanding to benefit diverse individuals and groups.

Cambridge researchers allied to the **Social Brain** theme use a variety of techniques, including multi-method neuroimaging approaches and computational modelling, and study unique cohorts that face challenges to social behaviour and communication. This theme seeks to understand a range of cognitive processes contributing to language learning, decision making, kinship and group dynamics. Studies span the entire lifespan from development in early infancy to decline in healthy ageing or dementia; this work also encompass cross-species approaches and artificial intelligence methods that simulate, or support human communicative abilities. There are diverse opportunities for application of this research in medical, educational, technological and cultural spheres being actively developed in Cambridge.
Researchers contributing to this theme are widely distributed across the schools and departments of the University including Departments of Psychology; Zoology; Physiology, Development and Neuroscience; Psychiatry; MRC Cognition and Brain Sciences Unit; Clinical Neurosciences; Computer Science and Technology; Theoretical and Applied Linguistics; Engineering; and the Faculty of Education. This research theme is closely linked with the Cambridge Language Sciences Initiative: an Interdisciplinary Research Centre, which connects language researchers from these and other departments.

Brains and Machines

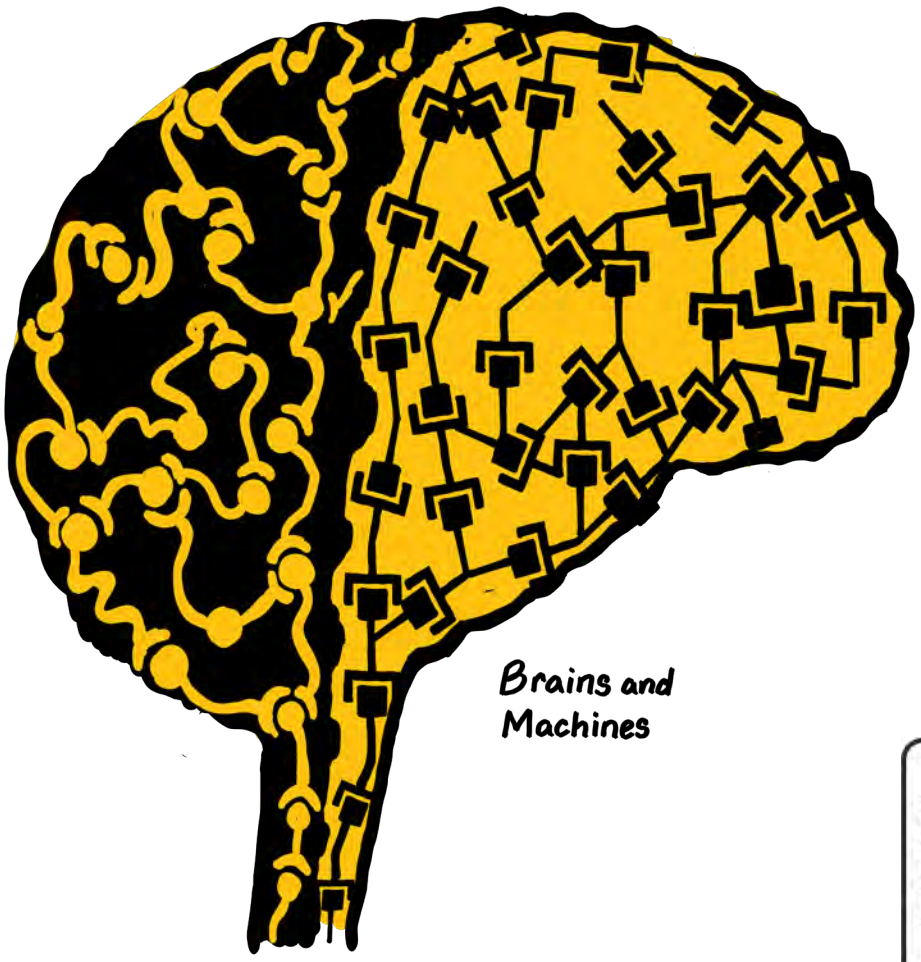
Why **Brains and Machines?** A brain is an organ, it has a purpose. And it's constrained by the laws of physics, the laws of probability – the laws of the known universe. It needs to fit within these laws to perform its function. So, it is subject to the same kinds of trade-offs, constraints and costs that 'machines' in the engineering sense are subject.

It is now possible to measure and manipulate signals in the brain at single-cell resolution, over extended periods and with minimal unwanted impact on nervous system function. This has resulted in tremendous progress in neuroscience in the last decade and a flurry of new research technologies, clinical interventions and diagnostic tools. At the same time, this progress has resulted in a number of era-defining challenges:

- analysing, interpreting and managing a deluge of new data
- designing biocompatible sensors, hardware and algorithms to interface with living nervous systems
- developing theoretical principles for understanding how brains process information
- anticipating societal challenges and disruption due to increased human-brain-machine interaction

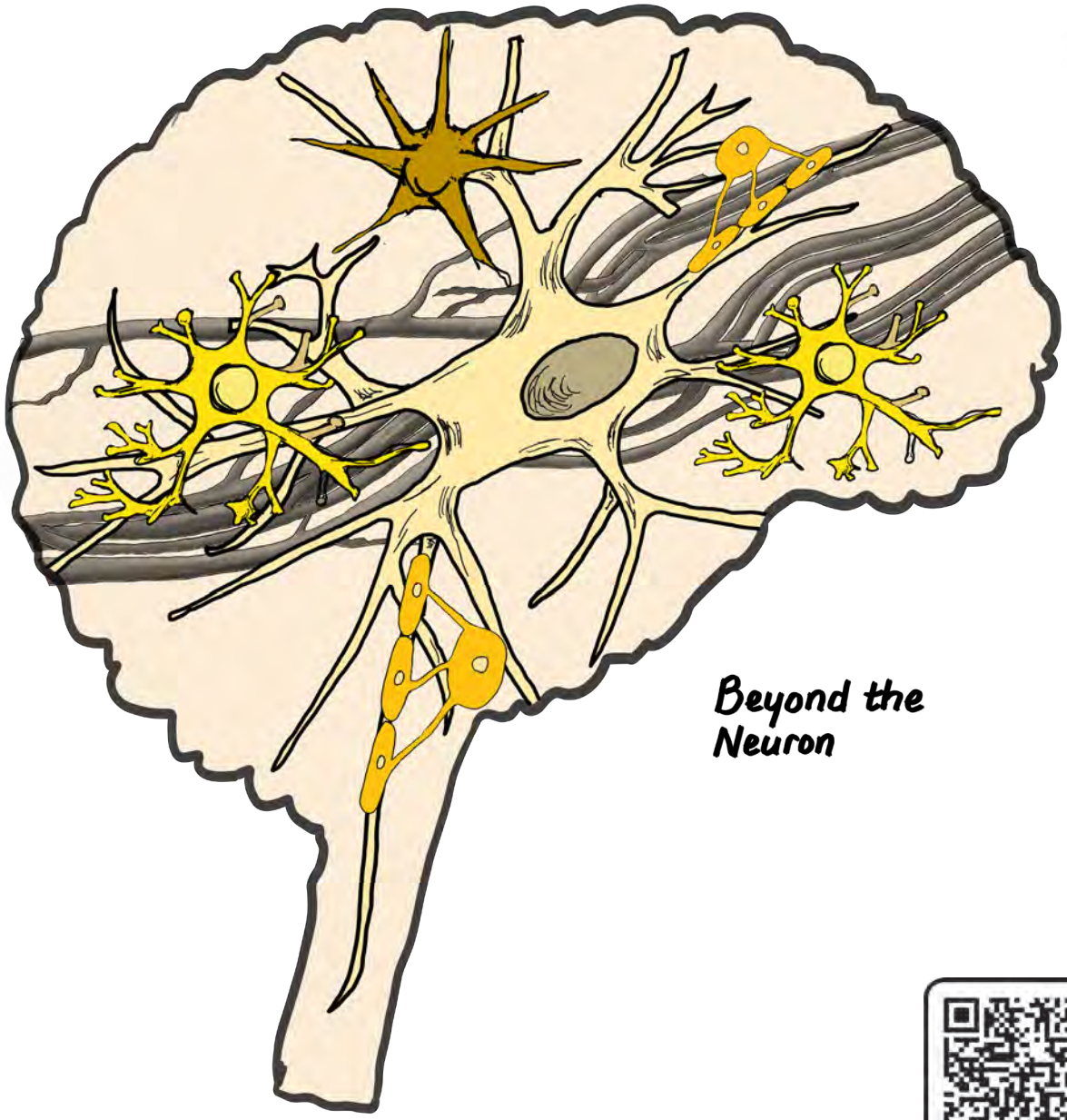
Conversely, many of the recent advances in information engineering and automation, particularly AI and Machine Learning, have been heavily inspired by neural architectures. This suggests an approach that marries traditional engineering disciplines with all domains of neuroscience. The Brains and Machines theme thus aims to exploit progress in neurally-inspired engineering and data science with major open challenges in neuroscience, biotechnology and biomedicine. This provides opportunities that move far beyond the traditional basic/translational divide in neuroscience to address emerging societal challenges that will define this century and the next.

Brains and Machines encapsulates the development of artificial intelligence approaches with applications in neuroscience and mental health, including computational neuroscience approaches and artificial networks to advance: a) our understanding of the workings of the brain, b) the design of neuro-inspired artificial systems, c) diagnosis of disease and prediction of treatment outcomes, paving the way to a personalised approach to mental health and brain disorder.



Beyond the Neuron

Neuroscience in the 21st Century is expanding beyond the traditional focus on the nervous system to consider how it interacts with the rest of the body and the role of non-neuronal cells in neurological diseases. Research in the Beyond the Neuron (BTN) theme seeks to understand the role of glia and immune cells in health and disease, particularly: (a) astrocyte, oligodendrocyte and microglia biology; (b) glia-neuronal interactions; (c) role of glia in neuroinflammation; and (d) characteristics of human immune cells in neuropsychiatric brain disorders. The theme also covers brain control of energy homeostasis. At Cambridge researchers take advantage of expertise in glial and stem cell biology to develop human models for studying the interactions between different cell types within the nervous system and identifying potential avenues for new interventions for disease. Ultimately, our aim is to translate fundamental discoveries to therapies for people with disease and in several areas that has already been achieved; for instance, we have shown that repurposing a cancer drug, which is an agonist of the retinoid X receptor, promotes remyelination in people with multiple sclerosis. This research community is highly collaborative across the Departments of Clinical Neurosciences, Physiology, Development and Neuroscience, Biochemistry, Medicine, Pharmacology, Engineering, Paediatrics and Wellcome-MRC Institute of Metabolic Sciences with close interactions with the Wellcome-MRC Cambridge Stem Cell Institute, MRC Laboratory of Molecular Biology, European Bioinformatics Institute and Sanger Institute.



Data Blitz

10. **A new predictive coding model for a more comprehensive account of delusions**
Presenting Author: Miss Jess Harding
Harding J, Wolpe N, Brugger S, Navarro V, Teufel C, Fletcher P
Keywords: Psychosis, delusion, predictive coding

16. **Neuroanatomical markers of psychotic experiences in adolescents: A machine-learning approach in a longitudinal population-based sample**
Presenting Author: Dr Joanne Kenney
Kenney JPM, Rueda-Delgado LM, O Hanlon E, Jollans L, Kelleher I, Healy C, Dooley N, McCandless C, Frodl T, Leemans A, Lebel C, Whelan R, Cannon M,
Keywords: machine learning, psychosis, adolescents, MRI, longitudinal

22. **Mental action, affordances, and attribution: the case of BCI technology**
Presenting Author: Ms Dvija Mehta
Mehta D
Keywords: mental action, mental affordances, brain implants, neuro-technology, conscious experience, agency

23. **Complete *Drosophila* adult CNS connectome allows thorough mapping of ascending neurons involved in locomotor circuits**
Presenting Author: Miss Ilina Moitra
Moitra I, Brooks P, Stuerner T, Team JFlyEMProj, Costa M, Jefferis GSXE
Keywords: *Drosophila melanogaster*, circuits, connectome

25. **Functional MRI reveals preserved unimodal-transmodal cortical differentiation in patients with blindsight**
Presenting Author: Mr Davide Orsenigo
Orsenigo D, Luppi A, Diano M, Willis HE, Petri G, Bridge H, Tamietto M
Keywords blindsight, visual awareness, resting-state, entropy Behaviour change in FTD

34. **Assessing receptor expression differences in the infralimbic cortex of PTSD-susceptible and PTSD-resilient rats**
Presenting Author: Miss Charlotte Rye
Charlotte S Rye, Amy L Milton
Keywords: PTSD, NMDA Receptors, Stress-Enhanced Fear Learning, Western Blotting

41. **Environmental Neuroscience Talks with the Trees: Green Cities, Neurobiological Health, and Consciousness**
Presenting Author: Ms Alexandra Strauss

Keywords: Environmental Neuroscience, Cognition, Consciousness, Stress, Attention

44. **Region-specific myelin changes along the mouse lifespan**
Presenting Author: Dr Sebastian Timmler

Timmler S, Pama EAC, Kaya C, Miessner H, Eser RA, Karadottir RT
Keywords: myelin, development, maturation

48. **Ketamine Dissociation Shows Structure-Function Decoupling of Brain Activity**
Presenting Author: Mr Milan Van Maldegem

Van Maldegem M, Luppi AI, Bonhomme V, Vanhaudenhuyse A, Demertzi A, Jaquet O, Al Bahri M, Alnagger NLN , Cardone P, Martial C, Stamatakis EA
Keywords: anaesthesia, consciousness, ketamine

50. Basis of human metacognitive efficiency in neural population coding
Presenting Author: Ms Xaiolu Wang

Wang X, Bays P
Keywords: metacognitive efficiency, confidence, neural population coding, working memory

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Poster Abstracts

1. **Machine Learning and Sampling Techniques to Enhance Radiological Diagnosis of Cerebral Tuberculosis**

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Cerebral tuberculosis (TB) is one of the neurological manifestations of tuberculosis infections responsible for devastating sequelae and mortality. It is a challenge to diagnose as it mimics other infectious and neoplastic pathologies of the brain. There is a need for a rapid and accurate diagnostic approaches, in order to prevent the dismal outcomes arising as a result of delayed or incorrect diagnosis. This study aims to develop a classifier to diagnose cerebral TB using various radiological features present on Magnetic Resonance Imaging (MRI) of the brain with the help of Machine Learning (ML). Cases of TB and non-TB conditions (including meningiomas, gliomas, fungal and bacterial brain infection) presenting to Aga Khan University Hospital, Karachi, Pakistan, were included and divided into training and test datasets. Features were selected using correlation, and besides age and gender, included multiple radiological features recorded from MRI of the brain. After the application of Synthetic Minority Over-sampling Technique (SMOTE), SMOTE-Tomek Links, Edited Nearest Neighbor (ENN) SMOTE-ENN, and Adaptive Synthetic (ADASYN) techniques for balancing the datasets, classifier accuracy was tested using two models: logistic regression and random forest. Highest accuracy (90.9%) was achieved using logistic regression along with SMOTE+TOMEK with 95.4% Area under the Curve while obtaining a F1 score of 92.8%.

Keywords: Cerebral tuberculosis, machine learning, SMOTE

2. **Distributed representations of prediction error signals across the cortical hierarchy are synergistic**

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Äijälä J 1, Gelens F 1 2, Roberts L 1 3, Komatsu M 4, Uran C 5 6, Jensen M 7, Miller, K 7, Ince R 8, Garagnini M 3 9, Vinck M 5 6, Canales-Johnson A 1 10
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An important question concerning inter-areal communication in the cortex is whether these interactions are synergistic. In other words, brain signals can either share common information (redundancy) or they can encode complementary information that is only available when both signals are considered together (synergy). Here, we dissociated cortical interactions sharing common information from those encoding complementary information during prediction error processing. To this end, we computed co-information, an information-theoretical measure that distinguishes redundant from synergistic information among brain signals. We analysed auditory and frontal electrocorticography (ECoG) signals in five common awake marmosets performing two distinct auditory oddball tasks and investigated to what extent event-related potentials (ERP) and broadband (BB) dynamics encoded redundant and synergistic information during auditory prediction error processing. In both tasks, we observed multiple patterns of synergy across the entire cortical hierarchy with distinct dynamics. The information conveyed by ERPs and BB signals was highly synergistic even at lower stages of the hierarchy in the auditory cortex, as well as between auditory and frontal regions. Using a brain-constrained neural network, we simulated the spatio-temporal patterns of synergy and redundancy observed in the experimental results and further demonstrated that the emergence of synergy between auditory and frontal regions requires the presence of strong, long-distance, feedback and feedforward connections. These results indicate that the distributed representations of prediction error signals across the cortical hierarchy can be highly synergistic, and that these synergistic interactions are likely to arise from recurrent connections within and between cortical regions.

Keywords: Predictive processing, prediction error, information theory, ECoG, computational modelling

3. **Exploring the Role of Threatening Contexts in Pavlovian-Instrumental Transfer Effects in Virtual Reality**

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Pavlovian-Instrumental Transfer (PIT) captures the phenomenon of pavlovian cues influencing instrumental behaviour, which can result in both general and specific transfer effects. Human PIT commonly focuses on appetitive procedures (using positive reinforcement), however the current study tests appetitive PIT in an aversive context in virtual reality (VR) and examines the differences between their effects on general and specific PIT and self-reported measures of trait differences. Using an aversive context with PIT models an OCD-like framework where habitual responding is used in an appetitive manner to avoid an aversive outcome. Forty participants were randomly assigned to the appetitive or aversive context version of a VR PIT procedure. Participants completed questionnaires assessing traits such as compulsivity, anxiety and impulsivity which were correlated with general and specific PIT in both contexts. The instrumental stage involved participants tilting a box left and right for two different rewards. The pavlovian phase involved four fractal images with a magic or medical box in front of them serving as conditioned stimuli (CS) predicting one of four outcomes. The transfer test occurred in extinction and participants responded to tilt the four CSs left or right. Mixed 2x2 ANOVA investigated the effects of context, and specific and general transfer on the rate of responding. Correlational analyses investigated the relationship between trait tendencies and general and specific PIT effects. There were no significant differences in specific and general PIT effects between appetitive and aversive conditions (Cohen's d > .810). In the aversive condition there were negative correlations between general PIT and checking (r = -0.446, p = 0.049), harmful thoughts (r = -0.492, p = 0.027) and anxiety (r = -0.452, p = 0.046). This research enhances PIT understanding in diverse motivational contexts, while VR technology introduces an immersive dimension to the investigation.

Keywords: Pavlovian-Instrumental Transfer, Virtual Reality, Learning, Behavioural Analysis, Memory, Reward Learning, Obsessive-Compulsive Disorder, Fear, Threat

4. **The effects of food insecurity on wellbeing in a large, representative survey of students in England**

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The United Kingdom (UK) has recently experienced rapid increases in energy, housing and food costs, fuelling a 'cost of living' crisis. Concerns have intensified regarding the number of children growing up in households that struggle to afford basic necessities, including food. Using data from the 2023 OxWell student survey, a large, diverse sample of 40,000 students aged 8-18 across England, we describe the prevalence of student-reported food insecurity and its association with mental health and general wellbeing measures. Post-stratification weighting was used to estimate the population prevalence of food insecurity. We found that 4-6% of students report sometimes experiencing food insecurity, and 1-2% report often experiencing it. Rates of food insecurity varied across school year, gender and ethnicity groups. Next, we looked at how students' food insecurity levels were associated with six different mental health and wellbeing measures. We used Bayesian mixed-effect ordinal regression models controlling for school year, ethnicity, gender, and socioeconomic status. We calculated the expected change in standard deviations in each wellbeing outcome when comparing students with low food insecurity to those with medium or high levels of food insecurity, using estimated marginal means. Compared to no food insecurity, students reporting moderate or high levels had increased RCADS depression and anxiety scores, reduced SWEMWBS wellbeing and positive thoughts. The size of these effects was in the range of 0.2 – 0.4 standard deviations, regarded as a small-to-medium effect. The effects of food insecurity on loneliness and self-reported cognitive processing were minimal. Our results highlight the urgent need to increase support for families struggling with the cost of living.

Keywords: socioeconomic status, food insecurity, mental health, wellbeing, depression, anxiety

5. **Negative emotions and sleep dysfunctions: insights from network analysis**

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Theoretical models propose an intertwined relationship between sleep dysfunction and maladaptive emotional processes. Relying solely on mass univariate analysis may be inadequate for exploring the intricate relationship between sleep and emotions. In a network comprising diverse emotions and sleep variables, it is unclear whether a single emotion is more important relative to others. By adopting a network approach and assessing centrality measures, we can enrich our understanding of the role of each variable. In addition, the uncertainty surrounding whether sleep dysfunction precedes or results from negative emotions underscores the need for deeper investigation. Bayesian statistics offer a robust framework for inferring causal relationships from cross-sectional data. To address this, we used data from the Human Connectome Project (HCP-1200). Our examination of negative emotions included NIH toolbox scales (sadness, anger, hostility, aggression, fear, and somatic arousal). We used the Pittsburgh Sleep Quality Index (PSQI) for sleep dysfunctions. Steps to explore interrelations: (1) Model selection and regularisation using the Gaussian Graphical Model (GGM) and the Least Absolute Shrinkage and Selection Operator (LASSO). (2) Robustness analysis through 10,000 bootstrapping iterations. (3) Calculating the centrality measures (betweenness, closeness, strength, and the effective influence). (4) Centrality stability using dropping sample methodology. (5) Bayesian causal network using Directed Acyclic Graph (DAG). Findings revealed that sleep dysfunction exhibits a positive correlation with fear, somatic fear, and anger. Centrality analysis underscored fear—characterised by anxious misery and hyperarousal—as the most influential node among others. DAG showed that sleep dysfunction is a by-product of fear. These findings offer insights for therapeutic

interventions, emphasising the significance of addressing anxious misery and hyperarousal in improving sleep quality.

Keywords: Sleep quality, negative emotions, network analysis, causal inference

6. **Information seeking without metacognition**

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Humans and other creatures seek information to improve their cognition and behaviour. Theories in cognitive neuroscience, developmental psychology and animal cognition tend to assume a strong connection between information seeking behaviour and explicit metacognition-conscious introspection about our mental states and subjective metacognitive feelings like confidence or uncertainty. However, recent developments in computational neuroscience have stressed that metacognition and uncertainty are not equivalent, and many forms of uncertainty may be monitored in the brain without generating subjective metacognitive feelings. Here, across a series of experiments in adult humans, we show that information seeking and subjective confidence are controlled by distinct forms of uncertainty. In particular, information seeking (but not confidence) is controlled by uncertainty in sampled sensory evidence while confidence (but not information seeking) is controlled by uncertainty caused by decision boundaries. This double dissociation suggests that separate computations in the mind and brain shape confidence and information seeking: undermining the idea that information seeking behaviour always depends on conscious introspection into our own states of mind.

Keywords: Metacognition, Information seeking, Confidence, Uncertainty, Consciousness

7. **Exploring the dynamics of Consciousness and Sleep disturbances in Alzheimer´s Disease through Integrated information decomposition**

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Recent shifts in Alzheimer's disease (AD) research frame it as a consciousness disorder, with sleep disturbances as early symptoms. This study, drawing on data from the Alzheimer's Disease Neuroimaging Initiative (ADNI) involving 418 Controls (CN), 108 AD patients, and 310 with Mild Cognitive Impairment (MCI), examines the link between sleep disruptions and consciousness in AD. Utilizing functional connectivity k-means clustering and Integrated Information Decomposition (ΦID), we assessed information processing across brain regions in sleep and wake states. Our analysis revealed no significant Sleep/Wake cluster differences across groups. However, a notable shift from redundant to synergistic information processing was observed, particularly in AD patients during sleep, indicating altered consciousness dynamics. Statistical significance was achieved in comparisons between DementiaSleep and CNSleep ($p = 0.037$), DementiaSleep and CNWake ($p = 0.008$), and DementiaSleep vs MCIWake ($p = 0.001$), underscoring a fundamental alteration in AD information processing. These findings highlight AD's impact on consciousness, marked by increased synergistic interactions during sleep. This shift may reflect a compensatory mechanism or a breakdown in normal brain activity pathways, potentially serving as a marker of AD progression. The study emphasizes AD as a disorder of consciousness, opening avenues for early diagnosis and intervention, with implications for understanding AD pathology and developing effective treatments.

Keywords: Alzheimer´s Disease, Consciousness, Sleep, Functional MRI, Information, Cognitive Impairment

8. **Natural statistics and stimulus representations in visual working memory**

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Visual working memory (VWM) refers to a limited capacity for the active retention of visual information over time. Between entering the visual system and being retrieved from VWM, memoranda undergo a series of representational transformations that leave an imprint on the recalled information. However, it is unknown at what stage of these transformations stimulus information is stored and maintained in VWM. Here, we leveraged Bayesian and efficient coding accounts of perceptual decision-making to predict how natural scene statistics at different stages of the visual processing pipeline should affect estimation bias and variability in a VWM task. We collected psychophysical data from an analogue report task testing memory for orientation, while varying the number of stored objects and the retention period. Consistent with previous research, increasing load and retention interval each increased variability of recall estimates, and a repulsive bias of estimates from the cardinals was apparent, in line with the over-representation of cardinal orientations in natural scenes. However, we saw no effects of set size or delay on the repulsive bias. This finding challenges previous theoretical accounts that predict a tight coupling between bias and variability. To provide a principled account of these observations, we devised competing ideal observer models. These models incorporated constraints from natural statistics in both encoding and decoding, but differed in the processing stages at which noise related to memory load and maintenance was introduced. Within this framework, the only model that could account for the empirical results was one in which these effects arise after the internal measurement is combined with the natural-statistics prior to form a posterior. These findings suggest that natural statistics shape internal representations at an early processing stage that precedes the capacity and maintenance limitations associated with working memory.

Keywords: Visual Working Memory, Bayesian inference, efficient coding

9. **The Acting Self: measuring self-other PFC activations and self-character distances in actors during a monologue performance**

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Background: Actors build a consciousness for their character upon their own consciousness. We hypothesise that this process may affect an actors sense of self. One way to measure the sense of self is via the mPFC's response to your own name compared to other names. Participants: 38 UK-based professional actors with 2+ years of industry experience. Equipment/Measures: Shimadzu LIGHTNIRS functional near-infrared (fNIRS) system with 22 channels across the PFC. Biosignalsplux physiology system measured breathing. We developed a 28-item questionnaire with responses coded on a 1 (strongly disagree) - 5 (strongly agree) and 0 (not at all) – 100 (complete overlap) Likert scale/slider about the actor's preparation of their monologue, how their experience may have differed from their stage/film performance and the distance between themselves and their character. We also asked the actors an additional 5 open-ended questions on similar topics. Procedure: Actors performed a monologue, coloured in a mandala colouring book (control), and read aloud from a telephone book (control). Each task was conducted whilst seated, lasted 2 minutes and was repeated 4 times in the same listed order. During each task, the actor's first name, character name and a stranger's name (control) were called out from a speaker at pseudo-random time intervals between 17-22 seconds. Neural Findings: Channel 4 (mPFC) revealed higher activation of actors hearing their own name compared to the stranger name during the monologue condition; also higher activation when actors heard their own name in the monologue condition compared to the telephone book condition. Interview Findings: Actors reported that distance from the character enables them to let go after performing the role, provides safety from morally bad characters and allows them to have self-awareness. Conclusions: Actors are grounded in their 'self' whilst in character and can create distance between their self and character intentionally.

Keywords: Sense of self, Theatre Neuroscience, Brain Imaging

10. **Optimizing tissue processing and AI tools for high-throughput myelin ultrastructure analysis.**

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Myelin is integral to proper neurobiological function. It plays a critical role in rapid neuronal signal transmission and its degradation is central to various neurological diseases such as multiple sclerosis (MS). Today, manual tracing of electron microscopy (EM) images is still the gold standard of quantifying the number of myelinated axons, axon diameter and myelin thickness. This process is both cost and labour-intensive and constrains our ability to study and better understand the development of myelin, its degeneration and restoration. We want to change that by applying deep-learning algorithms to segment, identify and measure axons and myelin in EM micrographs. We will test available machine-learning tools for their accuracy and precision and dependency on fixation, image quality and magnification. This approach promises to significantly enhance the throughput of myelin analyses, allowing us to handle larger image datasets with improved accuracy. By streamlining this process, we aim to unlock the high potential for broader applications in medical research, potentially aiding in the development of novel therapeutic strategies for neurological diseases.

Keywords: Myelin, AI, deep-learning, g-ratio, image segmentation

11. **A new predictive coding model for a more comprehensive account of delusions**

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Attempts to understand psychosis—the experience of profoundly altered perceptions and beliefs—raise questions about how the brain models the world. Standard predictive coding approaches suggest that it does so by minimising mismatches between incoming sensory evidence and predictions. By adjusting predictions, we converge iteratively on a best guess of the nature of the reality. Recent arguments have shown that a modified version of this framework— hybrid predictive coding— provides a better model of how healthy agents make inferences about external reality. We suggest that, in appealing to both amortised and iterative inferences, this more comprehensive model moves us towards a richer understanding of delusional phenomenology. The multilevel and instantaneous setting of prior beliefs by the feedforward amortised component leads to inferences that are both sudden and all-pervasive, and that confer a sense of deep insight and conviction. We see this model as providing a potentially powerful new framework for computational psychiatric approaches to psychosis.

Keywords: Psychosis, delusion, predictive coding

12. **Development of Pre-operative fMRI Paradigms for Language Assessment in Patients with Gliomas**

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The paradigm shift in management of brain tumours in eloquent cortex is maximizing the extent of resection whilst minimizing neurologic morbidity. Intra-operatively, using awake craniotomy for direct cortical stimulation (DCS) and testing of language production and comprehension has become the gold standard for testing to preserve functional outcomes. Current fMRI paradigms for presurgical language assessment are focussed on language lateralisation. There are significant differences in the tests that are conducted pre-operatively to those that are conducted intra-operatively. The aim of this study was to develop feasible and reproducible language specific task-based fMRI paradigms for assessment providing an alternative to intra-operative DCS in event

of failure to perform or complete an awake craniotomy. 15 English speaking healthy volunteers with no known intracranial pathology or surgery were recruited for this study. In addition to T1 weighted structural image, single echo resting state and diffusion weighted imaging, each participant was asked to do the following tasks – covert object naming, overt objecting naming, sentence completion, and semantics association. Task based fMRI images were analysed using SPM12®. 7 males and 8 females, right-handed English speaking was recruited for this study. All volunteers completed the structural and functional MRI within 50 minutes. This was important to ensure that patients were able to tolerate the entire duration of the scan without resulting in fatigability and errors during tasks. All tasks were completed in 15 volunteers. The newly devised protocol to perform the same intra-operative tasks in the pre-operative fMRI is feasible providing robust results which can be replicated across patients. Our data also provides information that can be applied to resting state analysis for those patients who may have severe deficits which prevents them from performing any tasks in the scanner.

Keywords: brain tumour, fMRI, language

13. **Characterisation of monoamine G-protein coupled receptors in Octopus vulgaris**

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Octopuses are an emerging model organism in neurobiology due to their unique nervous system and capacity for intelligence. However, due to this novelty, nothing is currently known about many of their receptors, including those involved in neuromodulation. Given the historical significance of dopamine action in the brain and our recent findings implicating it as one of the three main neurotransmitters used in the optic lobe, we have chosen to explore dopaminergic GPCRs in Octopus vulgaris. We have identified approximately twenty candidate octopus monoamine GPCRs, utilising protein sequence similarity network analysis and phylogenetics, and are using electrophysiology to characterise their ligands in Xenopus oocytes. Single-cell RNA sequencing datasets of the paralarval octopus brain and body are being applied to identify potential spatial associations between these GPCRs and the optic system. Fluorescent in situ hybridisation will then be executed to identify exact locations where these GPCRs are expressed. We have successfully characterised the first octopus dopaminergic GPCR, with RNA seq indicating that it is expressed in neurons in the central brain, as well as a serotonin binding GPCR with RNA seq indicating expression in the brain and muscle tissue. This process will be continued and will allow us to generate a more complete hypothesis regarding the integration of different types of receptors with other neurotransmission, especially relating to its use in processing visual information.

Keywords: G-Protein Coupled Receptor, octopus, cephalopod, dopamine, GPCR

14. **Expected volatility and belief updating in paranoia – a reinforcement learning approach**

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Belief formation and belief updating are greatly affected by how uncertain we perceive our environment to be (Yon and Frith, 2021, Curr Bio). Problems with estimating this volatility seems to be a key driver of aberrant belief updating in numerous psychiatric conditions (Gibbs-Dean *et al.* 2023). For instance, individuals with high levels of paranoia behave as though the world is a volatile and unstable place (Reed *et al.* 2020, eLife). Our study took a computational psychiatry approach and assessed how experienced and expected volatility affected learning and decision-making in individuals with high and low levels of paranoia. Participants completed a two-armed bandit task in different volatility blocks (true stable, true volatile, believe stable, believe volatile). In our critical 'believe' conditions, learners were exposed to environments with identical objective volatility, but different prior expectations about environmental uncertainty. This allowed us to isolate the effects of 'volatility priors' on learning and choice. We assessed task performance and switching rates and modelled the learning process with two reinforcement learning models (Findling *et al.* 2019). We found that prior beliefs about volatility and paranoia influenced. These effects correlated directly with the softmax inverse temperature parameters of the reinforcement learning models. Our results suggest that paranoid individuals tend to perceive the environment as more volatile, and that similar patterns of behaviour can be engendered in non-paranoid people through explicit communication about uncertainty in the world around us.

Keywords: Paranoia, belief updating, reinforcement learning, volatility, computational psychiatry

15. **First steps in using topographic deep artificial neural network models to generate hypotheses about not-yet-detected functional neural aggregates in the ventral stream**

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Although several types of spatially-aggregated neural functional selectivities have been reported in the inferior temporal (IT) cortex of humans and monkeys, such as face, place, and body selectivities, broad swaths of IT have yet to be similarly characterized. Here, we present the first steps of using Topographic Deep Artificial Neural Networks (TDANNs) as hypothesis generators of not-yet-detected spatially-aggregated IT functional selectivities. To isolate the shared selectivities across a population of TDANNs, we applied hyperalignment to the IT layer of ten TDANNs. We then analysed the shared underlying functional representations to identify eleven predicted neuronal functional selectivity clusters. After mapping these clusters back to the spatial IT maps in each TDANN, we find that face-selective units -- which spatially aggregate in TDANNs -- are strongly loaded on one of these functional clusters. On visual inspection, the other functional clusters appear to be selective for scenes, animal bodies, and mid-level object properties. Topographic ANNs, when analysed in this manner, could

be used to predict novel spatially-aggregated selectivities shared by all brains and to predict the spatial relationships between those functional aggregates. Both types of predictions could then be tested via targeted fMRI experiments.

Keywords: object vision, inferior temporal cortex, topography, selectivity, dimensionality, deep artificial neural networks

16. **Neural oscillations signify both sustained and transient computations**

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If brainwaves participate in neural computations, their non-invasive detection can advance neuro-technology and medical diagnosis. For a century, however, it has been debated whether such waves are involved in neural computation or are a side-effect of transient neuronal activity. We propose rhythmicity as key to settling this debate; if oscillations are essential for information processing, then they should be sustained. Using tools we developed to measure rhythmicity, we divided the electrophysiological spectrum of 721 people (age 18-88) collected at rest or during auditory, visual, or tactile tasks, into two supercategories: High-rhythmicity bands associated with sustained oscillations and overlapping with typically reported bands; and Low-rhythmicity bands dominated by brief oscillatory bursts. Computational simulations predicted these bursts to represent transient activity, a prediction confirmed through brain stimulation. We propose a synergistic framework in which transient bands signify the brain's response to change, whereas sustained bands signify continuous information maintenance.

Keywords: Oscillation, Brainwave, Cognition, EEG, MEG, Rhythmicity

17. **Neuroanatomical markers of psychotic experiences in adolescents: A machine-learning approach in a longitudinal population-based sample**

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It is important to identify accurate markers of psychiatric illness to aid early prediction of disease course. Subclinical psychotic experiences (PEs) are important risk factors for later mental ill-health and suicidal behaviour. This study used machine learning to investigate neuroanatomical markers of PEs in early and later stages of adolescence. Machine learning using logistic regression using Elastic Net regularization was applied to T1-weighted and diffusion MRI data to classify adolescents with subclinical psychotic experiences vs. controls across 3 timepoints (Time 1:11-13 years, n=77; Time 2:14-16 years, n=56; Time 3:18-20 years, n=40). Neuroimaging data classified adolescents aged 11-13 years with current PEs vs. controls returning an AROC of 0.62, significantly better than a null model, p=1.73e-29. Neuroimaging data also classified those with PEs at 18-20 years (AROC=0.59;P=7.19e-10) but performance was at chance level at 14-16 years (AROC=0.50). Left hemisphere frontal regions were top discriminant classifiers for 11-13 years-old adolescents with PEs, particularly pars opercularis. Those with future PEs at 18-20 years-old were best distinguished from controls based on left frontal regions, right-hemisphere medial lemniscus, cingulum bundle, precuneus and genu of the corpus callosum (CC). Deviations from normal adolescent brain development in young people with PEs included an acceleration in the typical pattern of reduction in left frontal thickness and right parietal curvature, and accelerated progression of microstructural changes in right white matter and corpus callosum. These results emphasise the importance of multi-modal analysis for understanding adolescent PEs and provide important new insights into early phenotypes for psychotic experiences.

Keywords: machine learning, psychosis, adolescents, MRI, longitudinal

18. **Exploring the circuitry of visual projection neurons that control jumping and backward walking in *Drosophila* using connectomics**

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In the model organism *Drosophila*, a set of neurons exists known as Visual Projection Neurons (VPNs). VPNs contain dendrites in the optic lobe and extend their axons into the central brain, acting to relay information from the optic lobe to the central brain. They will have to connect directly or indirectly to descending neurons (DNs) which carry information from the brain into the ventral nerve cord, the locomotor center of the fly. However, little is known about how visual stimuli are transformed into locomotion for a majority of VPNs. I have selected three types of lobular columnar neurons (LC) for detailed study. LC neurons typically have a small receptive field. LC16 promotes backward walking, while LC4 and LC6

contribute to jumping. Since these LC neurons drive different behaviors we expect there to be differences in downstream circuits. For example, LC4 and LC6 neurons drive jumping, which is a quicker movement than backward walking, meaning they may eventually control different premotor circuits and muscles. Connectomics allows us to construct a neuronal map to visualize the morphology of all neurons, as well as identify their partners and the number of synapses between them. To investigate the circuitry of the VPNs of interest, I will be using the fully reconstructed FlyWire connectome derived from a serial-section electron microscopy of a whole fly brain volume. This densely reconstructed data set allows us to identify the downstream partners of the three LC neurons in the central brain. Additionally, we can identify at what point in the circuit LC neurons provide output to DNs. This information will give us insight into the similarities and differences of circuitry behind these neurons. I will examine what other sensory information is integrated in the central brain by descending neurons or their inputs. This could give us more insight into how the different behaviours are controlled in more complex environments by a range of sensory information.

Keywords: *Drosophila*, Brain, Circuits, Behaviour

19. **Mechanisms of interoceptive-exteroceptive integration during cardio-audio synchrony**

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Interoceptive-exteroceptive integration has been hypothesised to occur via different mechanisms, i.e., active inference (Banellis & Cruse, 2021), predictive processing (Banellis & Cruse, 2020; Pfeiffer & De Lucia, 2017) or dynamical coupling (Palmer *et al.,* 2022). In this preregistered study (osf.io/6fvuw), we are testing the mechanisms supporting interoceptive-exteroceptive integration during cardio-audio synchrony. To do so, we ran two experiments using the same within-subject 2x2x2 factorial block design. We recorded reaction times (n=10) and multi-modal physiological responses (n=38; ECG, EEG, EMG, EDA, respiration, pupil size) to auditory deviants that varied in terms of a) cardio-audio synchrony (synchronous or asynchronous with the heartbeat), b) deviant's type (rare tone or omission) and c) predictability (regular or random). The behavioural experiment revealed that reaction times depended on deviants' type (β=0.07, p<0.001) and predictability (β=0.22, p<0.001) with an interaction between both (β=0.05, p0.05 for other tests). On the contrary, the physiological experiment revealed that cardiac responses depended on synchrony (β=0.07, p<0.001), showing a cardiac deceleration upon the presentation of deviants in the synchronous (z-value=-1.09, corrected p0.05). Our results reveal a dissociation in behavioural and physiological responses and extend previous observations with omitted sounds (Pelentritou *et al.,* 2024). We propose here that cardiac deceleration to deviants might reflect automatic parasympathetic action (Roelofs, 2017) when stimuli are synchronised with internal variables like heartbeats (Sel *et al.,* 2017), indexing self-related processing that can be probed in absence of behavioural reports in sleep or disorders of consciousness.

Keywords: cardio audio synchrony, ECG, reaction times, omission, oddball

20. **Cardiac responses to the auditory local-global paradigm reveal variations of hierarchical mismatch processing across sleep states**

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Cardiac signals, despite being typically recorded in experiments investigating cognitive processing during sleep, are usually neglected from analyses. We advocate here that they contain meaningful information about sleep functions above and beyond that obtained from cerebral activity. To do so, we performed secondary analyses of cardiac responses from two published datasets presenting the auditory local-global paradigm during sleep – a modified version of the classic oddball testing for mismatch detection at two hierarchical levels of error complexity (https://doi.org/10.1073/pnas.1501026112 and https://doi.org/10.1093/sleep/zsac199). We found during wakefulness (n=50) that cardiac activity was not modulated by deviants (corrected Wilcoxon test for local: z=-0.02, p=0.58 and global: z=0.01, p=0.32). However, during NREM sleep (n=43), our observations were in line with cerebral findings with a cardiac acceleration in response to local deviants in Non-Rapid Eye Movement (NREM) sleep (z=-0.39, corrected p=0.029) and no significant modulation by global deviants (z=-0.10, corrected p=0.23). Finally, in Rapid Eye Movement (REM) sleep (n=37), cardiac activity differed from cerebral findings with no significant modulation by local deviants (z=-0.26, corrected p=0.16) but a deceleration in response to global deviants (z=0.32, corrected p=0.038). Overall, our results show a dissociation in cardiac responses across sleep stages and types of auditory deviants, revealing the cardiac correlates of auditory mismatch detection at different levels of complexity during sleep. Our findings further extend and differ from previous observation obtained with magnetoencephalographical and electroencephalographical recordings. We provide here a new set of empirical evidence for the embodied nature of auditory processing and support the relevance of including cardiac responses to sensory stimuli to better understand the variations of cognitive processing during sleep.

Keywords: sleep, local-global, cardiac, ECG, mismatch detection

21. **Examining dynamic functional connectivity during sleep in infants using high density diffuse optical tomography**

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Background: Sleep is a critical factor in early brain development due to its impact on memory consolidation, synaptic plasticity, and neural network maintenance. High density diffuse optical tomography (HD-DOT) has been

used to investigate static functional connectivity during active sleep (AS) and quiet sleep (QS) states in term-aged infants. Dynamic functional connectivity extends this approach by revealing time- varying patterns in brain activity which may clarify the non-stationary nature of resting state brain functionality. One method proposed for this objective identifies recurring co-activation patterns (CAPs) using clustering algorithms. These CAPs represent instantaneous brain configurations at single time points and provide insight into the dynamics of spontaneous brain activation. Methods: HD-DOT data was acquired from sleeping neonates born at the Rosie Hospital (n=28, mean postmenstrual age=40+3). These datasets were classified as AS or QS based on behavioural analysis of synchronized video footage. The top 25% of frames of the seed signal for somato-motor and frontal networks were selected for each participant. Activation maps at these frames were clustered using the K-means algorithm into CAPs. CAP consistency was assessed by measuring intra-CAP spatial correlation. Other metrics such as CAP presence and CAP transition rate were compared in AS and QS datasets using rank sum t-tests to investigate how sleep states may modulate resting state networks. Results: Distinct CAPs were identified, characterizing unique connectivity dynamics within somato-motor and frontal regions. Across iterations of the CAP analysis, consistent trends emerged. Notably, global activation and deactivation were frequently organized into two distinct CAPs, while bilateral patterns resembling the seed networks also appeared in various CAPs. Preliminary examination of the CAP metrics reveal potential differences between AS and QS states.

Keywords: Functional connectivity, fNIRS, HD-DOT, sleep, neonate

22. **Breathwork-induced psychedelic experiences modulate neural dynamics**

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Breathwork is a term for an understudied school of practices that involve the intentional modulation of respiration to induce an altered state of consciousness (ASC). We map here the neural dynamics of mental content during breathwork, using a neurophenomenological approach by combining Temporal Experience Tracing, a quantitative phenomenological methodology that preserves the temporal dynamics of subjective experience, with low-density portable EEG devices for every session. Fourteen novice participants completed a series of up to 28 breathwork sessions - of 20, 40 or 60 minutes - in 28 days, yielding a neurophenomenological dataset of 301 breathwork sessions. Using hypothesis-driven and data-driven approaches, we found that positive 'psychedelic-like' subjective experiences that occurred within the breathwork sessions were associated with increased neural Lempel-Ziv complexity. Further, exploratory analyses showed that the aperiodic exponent of the power spectral density (PSD) - but not oscillatory alpha power - was also associated with these psychedelic-like phenomenological substates. We demonstrate the strength of this neurophenomenological framework, maximising the simultaneous data acquisition of brain activity and phenomenological dynamics in multiple experiential dimensions. Non-linear aspects of brain dynamics, such as complexity and the aperiodic exponent of the PSD, neurally map both a data-driven complex composite of positive experiences, and hypothesis-driven aspects of psychedelic-like experience states such as high bliss.

Keywords: Breathwork, Psychedelics, Altered States of Consciousness, Neural Complexity, Neurophenomenology

23. **Mental action, affordances, and attribution: the case of BCI technology**

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Recent advances in neurotechnology like brain computer interface (BCI) and brain implants have brought attention to questions of mind, consciousness, and mental action (Peacocke, 2021). For instance, person X having Neuralink's implant "telepathy" can move their prosthetic arm simply by thinking of it. The neural activity in X's brain associated with wanting to move the arm allows for the implant to perform this action through its ability to read said neural activity and respond respectively. But is X's neural activity an effect of X's intentional action of wanting to move his arm or an effect of X's affordance of knowing the arm can be moved, i.e., being aware of the arm's "move-ability"? (McClelland, 2019) Is X's thought or Telepathy's response considered mental action in such cases? The time is ripe for a blueprint of mental action when it comes to brain implants. Therefore, here, I cover four cases to answer three crucial questions: (i) whether actions caused by a brain implant can be considered as mental action, (ii) whether X's affordance of the arm, i.e., X's knowledge of the move-ability of the arm, is a mental action?, and (iii) whether the definition of mental action itself changes once the implant is a part of X's brain, assuming the extended mind hypothesis. This framework is not paramount with regards to what mental action or mental affordances are, nor does it explicitly state that X's brain implant is capable of agential action. What I rather propose is an in-depth study of whether X's brain implant is capable of mental action. Here, I dwell deeper into the notion of mental action, affordances, and the case of recall to further understand 4 cases in which one can ascribe mental action to the agent, and in some cases to the brain implant. Finally, I consider the ethical implications of such cases wherein BCI contributes to the patient's mental actions.

Keywords: mental action, mental affordances, brain implants, neuro-technology, conscious experience, agency

24. **Complete *Drosophila* adult CNS connectome allows thorough mapping of ascending neurons involved in locomotor circuits**

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Synaptic resolution connectomes have been produced using volumetric electron microscopy for both larval and adult fruit flies (*Drosophila melanogaster*), providing invaluable insights into neural circuits that regulate complex behaviours. The *Drosophila* central nervous system (CNS) comprises a brain and a ventral nerve cord (VNC). The VNC contains locomotor circuits that control movements such as walking, grooming, flying, courtship, and copulation. To regulate movement, it is imperative that there is seamless communication between the brain and VNC. This is primarily carried out by descending and ascending neurons (DNs and ANs, respectively). DNs carry motor commands from the brain to the VNC. ANs relay information from the VNC to the brain but their function remains more elusive - we know little about the type of information they carry to the brain or the circuits in which they participate. The MANC dataset that we released with collaborators in 2023 is a complete and comprehensively annotated VNC connectome. Here, we use a new complete whole adult male CNS connectome (MCNS); this provides morphology of both brain and the VNC, allowing study of AN connectivity for the first time. I am focusing on two sets of ANs identified in MANC that strongly input onto motor neurons (MNs) in the VNC amongst other components of locomotor circuits, but likely receive distinct input. I will identify the same sets of ANs in MCNS and characterise their downstream partners in the brain: determining what DNs they connect to (and whether these DNs are known to be involved in locomotion) and what inputs they receive in the VNC (potentially via neurons involved in premotor or locomotor circuits). Thus, in addition to detailing the specific roles of these ANs and the characterisation of circuits they are a part of, we show how invaluable comparative connectomics within species is, in allowing cross-verification of previous findings and in unearthing new information.

Keywords: *Drosophila melanogaster*, circuits, connectome

25. **What's your type? Investigating Insect Connectome Stereotypy**

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The recently completed 140,000 neurons "FlyWire" connectome represents the largest synapse-resolution, whole-brain connectome of an adult animal, a female Drosophila melanogaster. To facilitate exploration and maximise utility of this resource for the wider neuroscience community, we generated a hierarchy of salient annotations, including ~8k cell type which were defined using a novel approach that takes biological variability into account. Here, we use a second, yet-to-be-published connectome of the brain of a male fly to validate our cell typing strategy and to generate sets of robust, transferable labels that allow the comparison of neurons and circuits across brains. Our analyses focus on neuronal morphology and connectivity in the antennal lobes, a centre for early olfactory processing in insects. We show that while - as expected - insect brains are highly stereotyped, the devil often lies in the details and individual neurons/types can vary significantly in morphology and connectivity.

Keywords: Whole-brain connectomics, synapse resolution, cell typing, stereotypy.

26. **Functional MRI reveals preserved unimodal-transmodal cortical differentiation in patients with blindsight**

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Damage to the visual cortex leads to clinical blindness. Yet some patients retain visual functions and respond to stimuli they do not consciously perceive; a condition known as blindsight. Recent neuroimaging advancements suggest that variations in consciousness can alter functional connectivity across the brain's spectrum from unimodal/sensorimotor to transmodal/association areas. We assessed blindsight using a two-interval detection task in individuals with visual cortex damage, dividing them into blindsight-positive (B+) and blindsight-negative (B-) groups. Resting-state functional MRI data were collected in all participants and in age-matched healthy controls. We analysed functional connectivity using joint entropy to quantify the shared information between pairs of regions covering the entire human cortex. B+ retained a preserved sensory-association organization of their cortical activity that differentiated brain areas along the unimodal/transmodal axis, unlike B- participants who showed altered hierarchical organization compared to controls. A significant correlation was found between patients' proficiency to detect stimuli non-consciously and preserved organization of functional connectivity along the sensory-to-association axis. This decline in hierarchical organization was determined by increased entropy within the somatosensory and visual networks. Despite similar lesion sizes and locations, blindsight functions are associated with a preserved large-scale functional organization in intact brain areas, whereby primary sensory-motor and transmodal regions are situated at opposite endpoints of the spectrum. Differences in joint entropy of the posterior thalamus, position compatible with LGN, correlate with blindsight and preserved functional segregation in cortical areas. The resilience and adaptability of the brain's functional architecture in B+ suggest plastic changes that enable compensation for cortical damage and non-conscious processing capacity.

Keywords blindsight, visual awareness, resting-state, entropy Behaviour change in FTD

27. **Neural correlates of auditory predictions and its modulation during sleep in cats**

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Recently, it has been proposed that during wakefulness (W), organisms can predict changes in the environment moment by moment through a process called adaptive prediction. Neural correlates of auditory predictions can be obtained using Oddball paradigms, in which deviant stimuli are presented intermittently in a background of standard repetitive sounds. This generates a prediction error in the brain. Contradictory information exists about how these correlates are modulated during sleep stages: rapid eye movement (REM) sleep and non-REM (NREM) sleep. In this work, we aim to study how the neural dynamics underlying prediction errors (sound deviations) are modulated during W, NREM, and REM sleep. We implanted three cats for polysomnographic recordings with intracranial electrodes in the main cortical areas (including auditory, prefrontal, motor, somatosensory, and visual cortices) and geniculate nuclei. Two different Oddball paradigms, Roving and Global Local, were presented repetitively across W and sleep. Evoked Response Potentials (ERPs) were computed per condition (standard and deviant) and state (W and NREM or REM sleep), obtaining the Mismatch Negativity (MMN) and the Local Effect (LE), the two neural markers obtained with the Roving and Global Local paradigms respectively. For statistical analysis, we used linear models including the condition and the state, and we also included the interaction between them. We found that both neural markers are still present during NREM and REM sleep, but there is a significant reduction in amplitude compared to W. Additionally, we found a significant interaction between state and condition in most of the cortices studied. In conclusion, our results suggest that the adaptive prediction process is still present during sleep, although it is reduced during both NREM and REM sleep stages. Although the prediction error is present in all the brain regions studied during W, it is differently modulated during sleep.

Keywords: Sleep, Adaptive prediction, Mismatch Negativity, Local Effect

28. **Methylphenidate's role in modulating cognitive function and resting-state connectivity in patients with chronic Traumatic Brain Injury**

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Traumatic Brain Injury (TBI) can result in diffuse damage including diffuse axonal injury (DAI). These undermine structural, functional, cognitive processes. TBI often results in cognitive impairments including problems in working memory (WM), sustained attention (SA), and executive planning (EP). Methylphenidate (MPh) is an established treatment of such cognitive impairments in ADHD. Our groups previously investigated the behavioural and functional effects of MPh on patients with chronic TBI across multiple cognitive domains using various tasks. Cognitive improvements are more evident in task-based paradigms, but patients can have difficulty engaging with tasks, thus making measuring responses to treatment challenging. Passive biomarkers are needed to detect neurocognitive consequences. Resting-state functional MRI (rs-fMRI) and diffusion MRI (dMRI) may be useful and are affected after TBI. Few studies have related rs-fMRI and dMRI to cognitive function following TBI with MPh treatment. Volunteers with a history of mild-to-severe TBI (n=15), participated in a randomised, double-blinded, placebo-controlled, MRI study to investigate the neurobiological consequences and correlates of TBI and related cognitive function after MPh administration. TBI-placebo had lower resting-state intrinsic connectivity of the insulae versus healthy controls (HCs) (n=18). The insula's functional connectivity (FC) was upregulated in TBI-MPh. TBI-MPh normalised differences of TBI-placebo. Left insula and IFG FC increases in TBI-MPh to frontal, striatal, and cerebellar regions even over HCs. Left-lateralised changes in FC with MPh from left insula to left cerebellum related to MPh-driven changes in WM, SA, and EP. Additionally, TBI patients had reduced fractional anisotropy (FA) versus HCs in white matter regions crucial for cognitive processes i.e., corpus callosum, corona radiata, and external capsule. This regional residual integrity related to changes during WM, SA, and EP with MPh.

Keywords: Traumatic Brain Injury, Methylphenidate, Resting-state fMRI; Diffusion MRI; Cognition

29. **Predicting ongoing fluctuations in behavioural variability and subjective attentional state**

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Our behaviour is highly variable no matter what task we are performing. Behavioural fluctuations appear to be driven largely "endogenously" – i.e., driven by fluctuations in our own internal system. Intuitively, variability is often linked to fluctuations in attentional state. However, their exact link remains unclear as previous electroencephalography studies on attentional state have not examined the direct link with processes of behaviour. In the current study, we combine magnetoencephalography, eye and head tracking, temporal dynamics, and metacognitive reports in order to identify predictors of endogenous variability in reaction time (RT). Furthermore, we investigate to what extent RT variability and attentional state have similar predictors, as to examine the (dis)similarities of their underlying

processes. Participants performed the Metronome Task, in which they are instructed to press a button in synchrony with a tone that is presented every three seconds. During the task, they pseudo-randomly received thought probes, on which they rate their attentional state and their perceived performance just prior to the probe. Trial-wise regression and correlation analyses were conducted separately for each participant, to predict RT variability from: attentional state ratings, subjective performance ratings, time-on-task, mean amplitude-amplitude functional connectivity, mean head movement, mean and variability in pupil size, and cumulative blink rate. RT variability correlated with all these variables except mean pupil size, but explained variance was low. The strongest correlates of both RT variability and attentional state ratings were performance ratings and time-on-task. When we removed the variance of performance ratings from RT variability, RT variability and attentional state ratings no longer correlated – suggesting the relationship between attentional state ratings and RT variability may be mediated by performance monitoring.

Keywords: magnetoencephalography, functional connectivity, metacognition, mind wandering, intra-individual variability

30. **Reactive microglia phagocytose synapses in response to focal demyelination**

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We have recently established that focal demyelination of the caudal cerebellar peduncle (CCP) evokes elevated numbers of microglia in the distant grey matter of the inferior olive (IO), proximal to the lesion site. Local depletion of these microglia impairs remyelination efficiency in the CCP. However, their role and function remain unknown. Using a toxin-based focal demyelination model in the rat brain, we explore microglia-synapse dynamics by characterising the cellular, morphological, and functional profile of microglia in the IO using immunohistochemical, confocal microscopy, and RNA-sequencing techniques. We find that IO microglial cell count increases dramatically following demyelination. Peak cell count coincides with both a reactive morphological transformation and up-regulation of the phagocytic lysosome CD68. We then demonstrate microglial phagocytosis of both pre-and post-synaptic proteins of the acutely demyelinated neurons. What function, if any, phagocytosis has is not certain. Taken together, our results reveal a unique relationship between grey matter microglia and synapses of demyelinated neurons and may provide new mechanistic insight into remyelination.

Keywords: myelin, remyelination, microglia, multiple sclerosis, neuroimmunology

31. **Movement: a Python Toolbox for Analysing Pose Tracking Data**

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The recent emergence of markerless pose estimation tools, such as DeepLabCut, SLEAP, and LightningPose, has revolutionised the study of animal behaviour. However, despite their popularity, there is currently no user-friendly, general-purpose approach for processing and analysing the pose tracks that these tools generate. To address this, we are developing movement, an open-source Python package that offers a unified interface for analysing pose data from multiple major pose estimation packages. During movement's early development, we are focusing on implementing versatile and efficient methods for data cleaning, filtering, and kinematic analysis. However, we plan to eventually include modules for more specialised applications, such as pupillometry and gait analysis. Other planned features involve analysing pose tracks within the spatial context of an animal's environment and integrating movement with neurophysiological data analysis tools. Importantly, movement is being designed to accommodate researchers with varying coding skills and computational resources, and will soon feature an intuitive graphical user interface. In addition, movement's development is transparent and robust, with dedicated engineers ensuring its long-term maintenance. Ultimately, we envision movement evolving into a comprehensive, all-around software suite for analysing animal behaviour.

Keywords: Project standardization, data management, open science, reproducibility, systems neuroscience

32. **Ascending sensory neurons in the brain: cerebral projections and modal implications**

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Connectomics is a field focused on the production of accurate 3D models mapping the network of neuronal connections, referred to as the Connectome. Recent advances have made it possible to trace nervous systems at synapse level resolution. The first complete connectome was of the roundworm (*Caenorhabditis elegans*), however this organism doesn't display much behavioural complexity. *Drosophila melanogaster* however, displays an astonishing array of behaviours including courtship, mating rituals, feeding preferences, learning, memory formation, social interactions, grooming, aggression and territoriality. The emergence of these behaviours from a neural population of only 160 000 neurons designates it as an ideal candidate for Connectomics. A subset of the population are the Ascending Sensory Neurons (ASN's) which come in from the body via peripheral nerves, through the ventral nerve cord (analogous to vertebrate spinal cord) and project into the brain. These neurons that traverse the neck connective bring impulses encoding sensory information about the environment from the body up into various cerebral regions of interest for higher processing. Although connectomes of the female and the male ventral nerve cord have been completed, we are only now able to fully reconstruct the male central nervous system with brain and ventral nerve cord intact. This enables not only a comparison of the number and

origin of ASN's across these 3 datasets, it also permits an unprecedented inspection of ASN's in their entirety and an investigation into which neuropils they innervate in the brain. From this we may be able to infer the nature of the sensory modality they convey, in one comprehensive system. By looking at the sidedness, entry nerve and synaptic weight of neuropil innervation by the ASN's, we hope to shed light on how these connections allow the fruit fly to centrally integrate crucial multimodal sensory information originating in the environment.

Keywords: Connectomics, Sensory

33. **Reduced conscious level associated with increased redundancy and reduced synergy in the human brain**

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Understanding how consciousness is encoded in the brain remains a central question in neuroscience, with previous studies successfully linking informational measures (e.g. the Lempel-Ziv compression algorithm) to conscious states. Although there is substantial evidence that informational values reduce as conscious level does, why this is the case remains unclear. We extend this investigation to a large dataset of resting-state fMRI scans (Cam-CAN) from healthy adults, which included reductions in conscious level from alert to drowsy. By applying recent advances in information theory, we split information into redundancy, i.e. common information held across areas, and synergy, i.e. information between areas, over and above that held by each of them separately. Encoding synergistic and redundant interactions between areas into weighted graphs, we revealed a global decrease in synergistic information and an increase in redundancy for drowsy participants. Additionally, we found that the global efficiency of the drowsy redundant graph increased (indicating improved redundant information flow), while it decreased for the synergistic graph. On the other hand, modularity (reflecting community structure) rose for both synergy and redundancy during drowsiness. The majority of the redundant contribution for all participants was within brain networks but minimally between networks, while the contrary happened for synergy. Finally, we ranked brain regions according to their increase of redundancy or decrease of synergy from the alert to drowsy state, with visual, somatomotor, and dorsal attentional networks mainly driving this effect. These results suggest that conscious level reductions are not only related to increases in redundancy and decreases in synergy, but that even a subtle loss of consciousness (e.g. from normal wakefulness to drowsiness) can strikingly alter the structure of the informational content in the brain.

Keywords: consciousness, drowsiness, brain network, information theory, graph theory, redundancy, synergy

34. **Behaviour changes in frontotemporal dementia and their cognitive and neuroanatomical correlates**

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Behavioural changes are a common manifestation of frontotemporal dementia (FTD). They are typically associated with behavioural-variant FTD (bvFTD) and prefrontal atrophy yet are common in semantic dementia too, where volume loss is centred on the anterior temporal lobe. The (i) range of abnormal behaviours across FTD syndromes, (ii) differences/similarities in behavioural profiles between bvFTD and semantic dementia and (iii) precise roles of the prefrontal cortex vs anterior temporal lobe in supporting controlled social behaviour are not clear. We used a battery of informant questionnaires to explore behavioural changes in FTD. A transdiagnostic approach was used, which included bvFTD, semantic dementia and "mixed" intermediate cases to capture the full FTD clinical space. Eighteen age-matched healthy controls were also recruited. Participants completed detailed neuropsychological assessments and structural MRI, to explore the association between behavioural changes with cognition and grey matter volume. Behaviour changes were common across both bvFTD and semantic dementia syndromes, albeit more severe on average in bvFTD. There was no evidence for qualitative differences in behavioural profiles between FTD subtypes. A principal component analysis extracted three behavioural dimensions - apathy, challenging behaviours, and activities of daily living. Apathy was associated with volume loss in the anterior cingulate cortex volume and impaired executive function. Logistic regression revealed that neuropsychological measures had better bvFTD vs semantic dementia discriminative accuracy than behavioural measures. Overall, these results demonstrate there are a range of behavioural changes in FTD, and these occur in both FTD subtypes.

Keywords: Neural Confidence

35. **Assessing receptor expression differences in the infralimbic cortex of PTSD-susceptible and PTSD-resilient rats**

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While many individuals experience traumatic events during their lifetimes, only some go on to develop post-traumatic stress disorder (PTSD). This susceptibility and resilience to developing PTSD can be modelled in rodents using the stress-enhanced fear learning (SEFL) procedure, in which rats are exposed to session of massed, unpredictable footshocks and subsequently assessed on tasks of adaptive fear learning. We have previously observed (Van Assche *et al.,* 2022) subpopulations of rats that are susceptible and resilient to showing the PTSD-like phenotype following SEFL, and that these rats show differences in glutamate receptor expression in the basolateral amygdala. The current study aims to determine whether differences in glutamate receptor expression are also observed in the prelimbic and infralimbic cortices, striatum, and hippocampus.

Keywords: PTSD, NMDA Receptors, Stress-Enhanced Fear Learning, Western Blotting

36. **Reward processing in restrictive Anorexia Nervosa: A meta-analysis of fMRI studies**

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Individuals with anorexia nervosa (AN) are typically anhedonic and find little in life that is rewarding. It has therefore been suggested that intrinsic disturbances of reward processing may represent a trait marker of AN. Previous studies have used task-based functional magnetic resonance imaging (fMRI) to investigate reward- related brain activity in AN and reported altered activation in the prefrontal cortex (PFC), dorsal posterior cingulate (PCC) and rostral anterior cingulate cortex (ACC). However, due to the varied paradigms and methodologies used, as well as the heterogeneity in sample characteristics, results have proved inconsistent. To this end, we searched The Web of Science (2009-2023) and PubMed (2007-2023) and conducted a meta-analysis of 14 tasked-based fMRI studies of reward-processing. The aim was to investigate brain activation patterns in AN patients with the restrictive subtype (AN-r) at different illness stages and matched healthy control subjects (HCs). We employed the seed-based differential mapping (SDM) technique which has been fully validated in several studies and has greater power than alternative approaches. Overall, there was a significant difference in reward-related brain activity between AN-r and HCs, with patients exhibiting hyperactivity in reward- related brain regions. When subgroup analyses were conducted, there were significant differences in brain activation depending on illness duration and recovery status. Individuals recovered from AN-r showed no significant differences in reward-related functional brain activation compared to HCs. These findings suggest that altered reward-processing is unlikely to be a defining trait variable of AN-r. Rather, it may represent a state marker of acute/chronic undernutrition which is not significantly pronounced following weight recovery.

Keywords: Anorexia Nervosa, functional magnetic resonance imaging, reward processing

37. **Automated quantification of white matter confluence on T2 MRI scans**

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White matter hyperintensities (WMH) are a histopathologically heterogeneous entity that appears hyperintense on FLAIR images and are the consequences of chronic ischemia due to small vessel disease (Prins & Scheltens, 2015). They have been linked to an increased risk of stroke, dementia and death (Debette *et al.,* 2018). The conglomeration of discrete WMH is referred to as confluence and evidence suggests that it is a clinically useful concept since it reflects different etiologies and severities of white matter disease (Fazezkas *et al.,* 1993). WMH and their confluence are thus of great interest in the context of cognitive neurodegenerative diseases and are also of practical relevance since patients with confluent WMH are often excluded from clinical trials for AD immunotherapy due to an increased risk of adverse effects. However, there is currently no method to automatically quantify WMH that takes confluence into account. Automatically quantifiable measures of WMH are volume or number of clusters (Griffanti *et al.,* 2016; Jiang *et al.,* 2018), and neither method carries information about confluence. Clinical trials mostly rely on manual scoring with the Fazekas scale (Fazekas *et al.,* 1987) which is time-consuming and subjective. Here we propose an algorithm which on the basis of WMH segmentations quantifies the degree of confluence and expresses it as a value between 0 and 1. The algorithm was applied to data from QMIN-MC (Quantitative MRI in the NHS – Memory Clinics), a natural history cohort study, in order to examine the relationship between WMH confluence and clinical measures. The algorithm performs well in terms of automatically quantifying a concept that has previously been rated only manually with visual scales. Results indicate that the confluence score is increasing with age but does not differ significantly between different kinds of neurodegenerative diseases. Importantly, it is selectively sensitive to changes in fluency assessed with an ACE-R subtest.

Keywords: MRI, dementia, white matter disease

38. **Enhancing experimental design through bayes factor design analysis: insights from multi-armed bandit tasks**

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Bayesian statistics are gaining in popularity across research fields due to their ability to incorporate prior knowledge and their flexibility. Although Bayesian methods are well established for retrospective analysis, their applications to prospective analysis are less well developed, and effective methods for testing and optimising experimental designs prior to data acquisition need to be established. One proposed framework for a prospective approach is Bayes factor design analysis (BFDA), which evaluates the distribution of Bayes factors for a given experimental design. This study combined BFDA with latent variable modelling using the binary multi-armed bandit task (MAB) as an example of human decision-making to investigate the feasibility of differentiating latent variables between groups as a function of different design parameters. We examined how sample size, number of games per participant and effect size affect the strength of evidence for a difference in means between two groups, as well as the ability to accurately estimate this difference. To further assess how these parameters affect experimental results, metrics of error were evaluated, including the likelihood of supporting a false hypothesis and overestimating an effect. Our simulations demonstrated that BFDA can be combined with latent variable modelling to evaluate and optimise experimental designs. A Bayesian approach was developed for parameter estimation in a MAB task, where the agent has information about both available options before making the first choice. The approach proved to be effective in estimating the mean degree of random exploration in a population, as well as between groups. However, BFDA indicated that, even with large samples and effect sizes, there may be some circumstances where there is a high likelihood of errors and a low probability of detecting evidence in favour of a difference when comparing random exploration between two groups

performing the bandit task.

Keywords: Bayes factor design analysis, bandit task, Bayesian methods

39. **Does theta synchronicity of sensory information enhance associative memory? replicating the theta-induced memory effect**

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The binding of information from different sensory sources is critical for associative memory. Previous animal research suggested that the timing of theta oscillations in the hippocampus is critical for long-term potentiation, which underlies associative and episodic memory. Studies with humans showed correlations between theta oscillations in the medial temporal lobe and episodic memory. Clouter *et al.* (2017) directly investigated this link by modulating the intensity of the luminance and the sound of the video clips so that they 'flickered' at certain frequencies and with varying synchronicity between the visual and auditory streams. Better memory was found for the synchronous theta (4Hz) flickering compared with no-flicker, asynchronous theta, or synchronous alpha and delta flickering. This effect – called the Theta-Induced Memory Effect (TIME) – is consistent with the importance of theta synchronicity for long-term potentiation. Electroencephalography data showed that synchronicity was achieved in neuronal oscillations. Given its theoretical and practical importance, the present work attempts to replicate TIME while addressing two alternative explanations. The results could not replicate the advantage of over any other conditions with no-flicker condition resulting in better performance. Experiment 2 with magnetoencephalography is underway to confirm that theta synchronicity is neurally achieved. We suggest a reinterpretation of TIME to accommodate this non-replication.

Keywords: associative memory, entrainment, episodic memory, flickering, theta

40. **The Fisher information metric, phase transitions and dynamic simple geometric visual hallucinations**

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We investigate the dynamics of simple geometric visual hallucinations seen under the influence of psychomimetic drugs using a master equation formulation of the Wilson-Cowan model. As a direct association between divergences in the scalar curvature of the Fisher Information metric and second-order phase transitions has been identified, we utilise the Fisher Information Metric, both empirically and analytically, to distinguish points of patterning in the control parameter space and also temporal points of patterning change.

Keywords: Information Theory, Fisher Information, Hallucinations, Psychedelics, Wilson-Cowan model

41. **The effect of reward distribution on risk preferences**

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Risk preferences are influenced by the context under which decisions are framed. Prospect theory posits that risk-seeking and risk-averse behaviours occur in response to decisions framed by losses and gains respectively: a so-called 'Reflection Effect'. Risky decisions can further be influenced by the probabilities and magnitudes of outcomes. Classic two-armed bandit tasks used to shed light on these behaviours, pose decisions between a risky, probabilistic, variable outcome and a safe, static, fixed outcome. Moreover, they tend to rely on a single reward distribution. Here, we demonstrate that risk preferences are further influenced by the experienced reward distribution. Using a two-armed bandit task, we implemented a within-subject design, ensuring the experience of two independent reward distributions, with a variable safe option. A gaussian reward distribution led to subjects' exhibiting the classic reflection effect in their risk attitudes, with risk-seeking and risk-averse behaviours accompanying those decisions associated with higher and lower reward magnitude respectively. A bimodal reward distribution however led to consistently risk-averse behaviours. This was found to be the case irrespective of the order in which reward distributions were experienced. We further identified through a series of reinforcement-learning and exploration-exploitation model comparisons, that these behaviours are best explained when learning of distributions occurs as a result of two asymmetric learning rates for positive and negative outcomes. This asymmetry in learning rates further appears to flip between reward distributions. Gaussian blocks demonstrate a higher positive learning rate, whilst learning rates for negative outcomes are higher for bimodal blocks. We consider how this asymmetry in learning rates reflects a pessimism-optimism bias and elucidate how dopamine and noradrenaline may be contributing to this reward distribution-dependant modulation of risk attitudes.

Keywords: Decision-Making, Risk-Preferences, Reward Processing, Reinforcement Learning, Neuromodulation, Dopamine, Noradrenaline, Prospect Theory

42. **Environmental neuroscience talks with the trees: green cities, neurobiological health, and consciousness**

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A principal challenge facing humans today, "climate change" receives extensive scientific, economic, and political attention. Beyond recapitulations forecasting a rise in global temperatures as a result of industrialization and agriculture, anthropogenic environ- mental impact threatens ecology, biodiversity, and air quality. Furthermore, as up to 70 percent of the global population is expected to reside in urban areas by 2050, scientific investigation regarding environmental impact of urban living is existentially imperative. Currently in its infancy, Environmental Neuroscience seeks to understand how the threat of human imposed environmental impact affects neurobiology from a developmental, cognitive, and physiological perspective. Chiefly, Environmental

Neuroscientists have amassed evidence relating urban greenspace to integrative neurobiological health. This project outlines the documented neurophysiological effects of urban greenspace as measured by physiological, psychological, and cognitive outcomes relating to two dominating theories: Stress Reduction Theory and Attention Restoration Theory. Further, possible underlying neurobiological mechanisms explaining these theories are explored, laying ground- work for future validation. Finally, the intriguing role of greenspace in human consciousness is scrutinized, giving rise to a third theory, Consciousness Expansion Theory, thus approbating a compelling facet of the function of greenspace. We hope that this theoretical framework will influence the formation of collaborative efforts of communication and investigation in Environmental Neuroscience, thus motivating policies relating urban greenspace to human cognition and health as well as the health of the planet.

Keywords: Environmental Neuroscience, Cognition, Consciousness, Stress, Attention

43. A thalamic perspective of consciousness in pharmacological and pathological states in humans

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The thalamus is involved in modulation of arousal (M. Shine *et al.,* 2023). Few human studies differentiated the cytoarchitectonically and functionally distinct thalamic nuclei in altered states of consciousness (Setzer *et al.,* 2022). We investigated thalamic nuclei and their functional relationship to cortex using fMRI in healthy anaesthetised volunteers in deep sedation (N=16) and DOC patients (N=22). We used a parcellation segmenting the thalamus into 7 ROIs (pulvinar, anterior, medio-dorsal, ventral-latero-dorsal, central-lateral/lateral-posterior/ medial-pulvinar, ventral-anterior, and ventral-latero-ventral) matching anatomical subparts (Najdenovska *et al.,* 2018). Seed-to-voxel functional connectivity was computed between nuclei and the whole brain, with voxel level threshold of p<;0.005 (uncorrected) and cluster level p<;0.05 (FWE-corrected for multiple comparisons). Cortical SPM-t maps were derived from contrasts of FC (deep sedation vs. awake and DOC vs. control). To investigate which nucleus had the greatest magnitude of change in FC with loss of consciousness, we computed the average difference in FC (dFC) across the whole brain for the contrasts. Cortical SPM-t maps revealed that Pu and VLV nuclei, but not others, increase their FC with DMN regions and decrease their FC with SM regions with loss of consciousness in both anaesthesia and DOC. All other nuclei exhibited reversed effects with concomitant loss of consciousness. Pu had the greatest magnitude of dFC in anaesthesia and VLV had the greatest magnitude of dFC in DOC. Linear mixed models were used to compare magnitude of change in FC. In anaesthesia, the dFC for Pu was found to be significant in comparison to the rest of nuclei (t = 2.081, p = 0.038). In DOC, the dFC for VLV was also found to be significant when tested against the rest of nuclei (t = 12.336, p = 2.2e-16). We demonstrated differentiated patterns of thalamic FC in anaesthesia and DOC, with implications for potential targets for DBS.

Keywords: Neuroimaging, fMRI, anaesthesia, disorders of consciousness

44. Neuronal activity regulates myelin patterns

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Wrapping around the axon, myelin sheaths ensure fast transmission of action potentials and provide metabolic support to neurons. Usually, axons can be unmyelinated, fully myelinated interrupted only by the nodes of Ranvier, or intermittent myelinated with long unmyelinated gaps. Myelin and gaps of various lengths, as well as different thicknesses of myelin sheaths, collectively form unique myelin patterns in individual neurons. These patterns fine-tune the conduction speed of axons to synchronize neuronal circuits. Moreover, recent evidence indicates that myelin exhibits great plasticity throughout the lifespan. However, our understanding of myelin patterns is very limited and molecular mechanisms of pattern formation and plasticity remain completely unknown. Neuronal activity can adjust myelin sheath morphology and placement by regulating oligodendrocyte generation and axon targeting, might be a regulator of the myelin patterns. In this project, I will combine light microscopy (LM) and electron microscopy (EM) with specific genetic labelling to study the plasticity of long-range myelin pattern plasticity and, therefore, test the hypothesis that neuronal activity alters pattern myelin. To address this question, I have designed the following plans: Firstly, I will study central nervous system CNS myelin pattern abundance and plasticity during the mouse lifespan, by imaging different brain regions. Secondly, I will modulate neuronal activity to study activity-dependent myelin modulation in vivo. Finally, I will determine the molecular mechanism of how neuronal activity regulates myelin patterns. These planning experiments are currently undergoing. I have found axons with intermittent myelin patterns in the heavily myelinated corpus callosum region, with 3D serious scanning electron microscope. Also, by comparing myelin in the visual cortex of the mouse brains that underwent retinal chemogenic stimulations, different levels of activity input could affect myelin content

Keywords: myelin pattern, neuronal activity

45. Region-specific myelin changes along the mouse lifespan

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Myelin sheaths are multilayer membrane segments on axons that speed up the action potential propagation. In the brain and spinal cord, oligodendrocytes form multiple sheaths on different axons. Myelin is plastic - sheaths can be newly formed and existing sheaths can be modified throughout life. Interestingly, grey matter axons can be myelinated intermittently with distinctive patterns of unmyelinated and myelinated axonal segments. How these patterns are achieved remains unclear, but emerging data imply that the addition of new myelin is essential for learning and memory and suggest that myelin is modulating neuronal

networks. This is supported by animal and human studies that highlighted myelin as a major player in shaping behaviour. To better understand how myelin develops in different brain regions during life, we analysed the myelin content in white matter (corpus callosum) and grey matter (motor cortex and somatosensory cortex) regions of mice at key time-points reflecting human childhood, adolescence, adulthood and aging. We found that myelination progresses differently in different brain regions and cortical layers, indicating that local myelination might be suppressed, permitted or promoted at different points in time. We found that variability of myelin sheath length increases with age, indicating an age-dependent shift in sheath length. To unmask this shift, we used conditional reporter lines to compare sheaths that were added during development (opalin-cre) versus sheaths added during adulthood (PDGFRA-cre). Indeed, in somatosensory cortex, later-formed sheaths are shorter than early-formed, indicating functional significance beyond maintenance, e.g., in circuit modulation or learning and memory. Complementary to human data, we show that region-specific myelination is not a unique feature of primate brains. Furthermore, this cross-sectional view on myelination serves as an important benchmark for research on regulators of myelin plasticity (e.g., environment).

Keywords: myelin, development, maturation

46. **Changes in brain hierarchy following acute and chronic use of DMT and cannabis**

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Background: Psychedelics are thought to flatten the brain's hierarchy, resulting in increased flexibility of brain states through disintegration of the default mode network. Limited yet compelling evidence suggests this is the mechanism behind the action of psychedelics, but changes in the hierarchy of the brain under psychedelics are not yet well understood. Furthermore, it is not known what the effects of chronic use are on the acute psychedelic experience. Aims & Objectives: This study examined changes in the hierarchical organization of the brain during acute DMT experience in occasional users and ayahuasca in chronic users. We distinguished effects from cannabis in chronic and occasional users to identify key drivers of alterations in brain hierarchy under psychedelics. Methods: 24 long-term users of ayahuasca, 20 psychedelic naïve users of DMT, and 26 infrequent or frequent users of cannabis, respectively, were imaged at baseline/placebo and after drug administration. Non-reversibility through pairwise time-shifted correlation of the forward and reversed timeseries was evaluated and followed by application of a Hopf whole-brain model, yielding the effective connectivity for each participant. Trophic coherence was evaluated, providing the directedness of the brain's functional hierarchy and regional changes in hierarchical level. Results: Irreversibility decreased significantly under ayahuasca and cannabis in chronic users, but not in DMT or cannabis in occasional users. Directedness was significantly decreased under both ayahuasca and DMT, while an increase was found for cannabis in occasional users. Regional hierarchy broadly and significantly decreased during ayahuasca and cannabis in chronic users, but not for DMT and cannabis in occasional users. Under DMT, this was reflected in greater variation in regional hierarchy. Discussion & Conclusion: We establish different signatures of acute and chronic use of psychedelics and cannabis regarding alterations.

Keywords: psychedelic, whole-brain model, consciousness, neuroscience, irreversibility

47. **Neuronal activity bidirectionally regulates myelin plasticity**

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Oligodendrocytes produce myelin, a lipoproteinic substance, extension of their plasma membrane, that wraps around axons and supports neuronal function, in a process called myelination. Myelin is being added throughout life and it is known to plastically adapt to changes in neuronal activity. However, the bilateral influence of activity on pre-existing as well as newly differentiated oligodendrocytes is not yet described, especially within the white matter. Here we show that we were able to manipulate neuronal activity in retinal ganglion cells (RGCs) bidirectionally, by expressing Designer Receptors Exclusively Activated by Designer Drugs (DREADDs). Increasing activity in RGCs led to an increase in newly differentiated oligodendrocytes in the optic nerve, while decreasing the activity of RGCs had the opposite effect. Interestingly, the internodes of both newly differentiated and pre-existing oligodendrocytes were extended when activity increased and shortened when activity decreased, while internode number per oligodendrocyte decreased in both manipulations and groups. Moreover, myelinated optic nerve axon ultrastructure was significantly affected in opposite ways. Finally, by visual evoked potential recordings, we have obtained strong evidence that manipulating RGC activity and the subsequent myelin plasticity, bidirectionally affect the latency of VEPs in higher brain areas. Together, our work shows for the first time not only that cells of the oligodendrocyte lineage are responsive to both positive and negative activity manipulations, but also that both pre-existing and newly differentiated oligodendrocytes participate in activity-mediated myelin plasticity, leading to the alteration of the physiological properties of the visual pathway.

Keywords: myelin, oligodendrocyte, plasticity, activity, DREADD, retina

48. **Choroid plexus volume as a proxy for neuroinflammation – evaluation of its trans-diagnostic, prognostic and therapeutic biomarker potential in Parkinsonism**

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Neurodegenerative disorders have a substantial immune component, implicating both peripheral and central immune systems. Despite neuroinflammation being linked to greater dementia risk, the interaction of central and peripheral inflammatory processes to influence disease courses remain ill-understood. A key site-of-interest for this interaction is the choroid plexus. Beyond secreting cerebrospinal fluid (CSF), it has been proposed as a gateway for peripheral immune cell entry into the central nervous system (CNS). As such, increases in choroid plexus volume measurable with structural magnetic resonance imaging may provide a non-invasive, low-cost measure to identify pathological neuroinflammation – and may capture both peripheral and central immune components. Previous research in multiple sclerosis and psychosis demonstrated increased choroid volumes being related to neuroinflammation, greater disease burden, and lymphocyte incursion. However, it has not been systematically mapped how peripheral and CNS inflammation relate independently and synergistically to choroid plexus volume, and how this captures disease progression. Taking a cross-diagnostic approach, we are performing blinded high-fidelity segmentations of choroid volume in T1-weighted MRI scans from participants with Parkinson's Disease (n=40) and Progressive Supranuclear Palsy (n=17). Using multimodal statistical approaches, we test the relationship of these data to I) biospecimen measures of inflammation (lymphocyte phenotypes from flow cytometry and cytokine profiles from ELISA in blood and CSF); II) microglial activation measured with TSPO positron emission tomography; III) CSF chemokine measurements relevant to peripheral and central immune cell chemotaxis; and IV) longitudinal cognitive measures. This research will inform the diagnostic and prognostic utility of the choroid plexus volume in typical and atypical Parkinsonian disorders.

Keywords: Neuroinflammation, Parkinson's disease

49. Ketamine dissociation shows structure-function decoupling of brain activity

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Ketamine is classified as a dissociative anaesthetic that, in sub-anaesthetic doses, can produce an altered state of consciousness characterised by dissociative symptoms, visual and auditory hallucinations, and perceptual distortions. Given the double nature of this compound, it is expected to have different effects on brain dynamics in anaesthetic doses than in low, sub-anaesthetic doses. We investigated this question using connectome harmonic decomposition (CHD), a recently developed method to examine the structure-function dependence of brain activity. Previous research using this method has shown that structure-function coupling is a generalisable indicator of consciousness and responsiveness, with increased coupling in anaesthesia and disorders of consciousness and decreased coupling under the influence of classic psychedelics and sub-anaesthetic doses of ketamine. After applying the CHD analysis to resting-state fMRI data of volunteers during ketamine-induced dissociative anaesthesia, we found that the decreased coupling seen in sub-anaesthetic doses can be generalised to two different anaesthetic doses of the compound. This is different from GABAergic anaesthetics, where structure-function coupling increases with higher doses. In addition, ketamine's harmonic signatures show higher correlations with those seen in an LSD-induced psychedelic state than those seen in unconscious individuals, whether due to propofol anaesthesia or brain injury. Together, the results indicate that ketamine-induced anaesthesia, which does not necessarily suppress conscious experience, seems to influence the structure-function dependence of brain signals in the opposite way compared to GABAergic hypnotics. We conclude that structure-function dependence, as quantified by CHD, tracks alternations in subjective experience rather than behavioural responsiveness – a discovery made possible by ketamine's unique property of decoupling these two facets.

Keywords: anaesthesia, consciousness, ketamine

50. Novel signatures of consciousness from brain dynamics

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Finding indices for the absence or presence of consciousness based on physical properties of the brain is a significant scientific challenge with important clinical and ethical implications. Contemporary research has stagnated due to an overemphasis of the role of particular regions, when perhaps a more productive research agenda may be to characterise particular large-scale neural processes and dynamical regimes. Here, we introduce two new measures to distinguish levels of consciousness from multivariate empirical brain data, borrowing tools from information theory, statistical physics and network science. The foundation of our method is a novel way to characterise the structure of information flow in the brain, which we term 'entropic cascades', that identifies spatiotemporal clusters of consecutive large excursions in local differential entropy. Our first measure, 'Ignition Hierarchy', quantifies the variability in node-wise abilities to initiate entropic cascading processes. The second, 'Workspace Coefficient', is an attempt to unify the core commitments of the Global Workspace Theory (GWT) into a scalar measure and quantifies the extent to which there is a central processing space in entropic cascading processes. We apply these measures to primate intracranial electrocorticography data during wakefulness and sleep, and show both measures to significantly increase when macaques are awake. This work lays the foundations toward precise formalisations of GWT for application in real-world scenarios, including the diagnosis and treatment of sleep-wake disorders and disorders of consciousness.

Keywords: consciousness, entropy, hierarchy, workspace, sleep, macaque

51. **Basis of human metacognitive efficiency in neural population coding**

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Humans' metacognitive ability to introspect self-performance is essential to perceptual decision making. Although existing work has demonstrated the relation between subjective confidence and behavioural performance, how confidence is encoded in a neural population code remains unclear. Here, we associate subjective confidence with neural codes based on a Bayesian probability framework, with mutual information (MI) between error and neural uncertainty as a measure of metacognitive efficiency. In particular, we focus on two alternative accounts of neural variability: one is the classical Poisson noise model, with independent Poisson spike counts; the other assumes additive Gaussian noise with fixed variance. Previous work has found both models can successfully reproduce patterns of behavioural error, but here we examined their ability to additionally predict subjective confidence. Through numerical simulations, we demonstrate that both Poisson and Gaussian models predict an inverted U-shape relationship between MI and mean spike rate, while the Poisson model consistently predicts higher MI compared with the Gaussian model. Furthermore, we test the models by fitting to data across 6 studies of delay-estimation working memory tasks. Results show that both Poisson and Gaussian models present excellent fits to error distribution. However, regarding the confidence measures, the Poisson model outperforms the Gaussian model in terms of accuracy, bias, inter-subject variability and effect of set size. These results hold for both colour and orientation stimulus features, as well as for both continuous and discrete subjective confidence reports. Together, our findings show how subjective confidence may arise in probabilistic representation by neural codes and identify limitations of the Gaussian approximation to neural spiking statistics when accounting for metacognitive efficiency.

Keywords: metacognitive efficiency, confidence, neural population coding, working memory

52. **Investigating sexual dimorphism in the front leg circuits downstream of two descending neurons in Drosophila melanogaster**

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A connectome is the highest resolution map of all neurons, their shape and the connections between them in the central nervous system. In *Drosophila melanogaster*, electron microscopy can be used to create images of thin layers of the whole adult fly brain and ventral nerve cord (VNC, analogous to a spinal cord in mammals) which can be reconstructed into a 3D volume. Using machine learning and human expertise, the morphology of neurons and their synapses can be fully reconstructed. Descending Neurons (DNs) are those which receive input in the brain and relay signals through the neck to the ventral nerve cord, which is the motor centre of the fly. The involvement of DNs in a variety of behaviours has been documented, but their downstream circuitry onto motor neurons has not yet been fully mapped. We have reconstructed the DNs in the Female and Male Adult Nerve Cord datasets (FANC (Phelps *et al.,* 2021) and MANC (Takemura *et al.,* 2023) respectively) and matched neurons between the two datasets with the goal of identifying DNs and circuits involved in sexually dimorphic behaviours. I focused on two DN types: DNp13, which is sexually dimorphic, and DNp37, which is female-specific. They are primarily involved in reproductive activities (eg. egg laying and abdominal bending). They also have some axons in the VNC neuropil which is involved in front leg movement. This project aims to analyse the downstream connectivity of DNp13 and DNp37 down to front leg motor neurons. I investigated if there are differences in circuitry between the two datasets which may be related to their function. I will present a detailed circuitry of each DN, identifying potential sexual dimorphisms as well as similarities in downstream connectivity.

Keywords: drosophila, connectomics, connectome

53. **Interpreting the fruit fly brain**

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Recent advances on imaging and segmentation technologies, compounded with a concerted global effort, has led to the comprehensive wiring diagram of the adult fruit fly brain ('connectome'), containing more than 130,000 neurons, and more than 100 million synaptic connections. This provides an unprecedented resource for multiple research disciplines, from foundational neuroscience to the development of brain-inspired algorithms for machine learning. However, the sheer complexity of this connectome presents a significant analytical challenge. Unlike simpler neural systems, each neuron in the fruit fly brain typically receives input from, and outputs to over 100 other neurons, necessitating innovative approaches for data interpretation. I propose to interpret the connectome using tools already developed to interpret artificial neural networks. In particular, I employ 'activation maximisation', a technique designed to identify the optimal activation patterns of sensory neurons to maximally activate neuron(s) of interest. Through this, I hope to uncover pathways of information processing, by observing how the network integrates different types of information through connectivity. Here, I will introduce the 'Connectome Interpreter', a tool I developed to apply activation maximisation technique to the fruit fly's neural circuitry. I also provide validations of the method, and an instance of its usage. By translating techniques from machine learning to biological data, my work seeks to offer mechanistic interpretability in biological neural networks.

Keywords: connectomics; machine learning; neural circuit; fruit fly

54. **Spatiotemporal dynamics of lifelong oligodendrogenesis**

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Oligodendrocyte progenitor cells (OPCs) differentiate into oligodendrocytes (OLs), forming myelin around neuronal axons in the central nervous system (CNS) to enable fast and synchronised action potential propagation and to metabolically support neuronal function. Myelination is a longitudinal process that progresses throughout life. However, myelin is not a static element of the CNS. Existing myelin sheaths can be remodelled and new myelin sheaths can be added over time, demonstrating myelin plasticity. However, how myelination progresses among distinct brain regions at different time points is not known. Here, we have characterised regional differences in oligodendrogenesis in the mouse brain. Using a transgenic mouse line that specifically labels newly differentiated OLs, we have carried out histological analyses of whole, sagittal brain sections at different ages. Following microscopic analysis, we annotated regions based on the Allen Mouse Brain Atlas, and quantified the number of new OLs per region, as an indicator of the rate of oligodendrogenesis. Our preliminary data suggest that in the first month (two to four weeks) of life, oligodendrogenesis is prominent throughout the brain, with the hippocampus and the corpus callosum having the highest density of new OLs. The overall rate of oligodendrogenesis sharply reduced in the second month (six to nine weeks), with new OLs being mostly generated in forebrain regions such as the corpus callosum and the hippocampus. This decrease in oligodendrogenesis rate persists into the first year of life, where myelinating OLs are primarily observed in hindbrain regions such as the medulla. The next steps of this project will focus on earlier time points with higher temporal resolution, as well as later time points, to understand where and when oligodendrocyte differentiation takes place throughout life.

Keywords: ageing, brain development, brain regions, myelin, myelination, oligodendrocyte, oligodendrogenesis

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