BIOMAG 2022
Birmingham UK

THE 22ND INTERNATIONAL CONFERENCE ON BIOMAGNETISM

28 AUGUST - 1 SEPTEMBER 2022
UNIVERSITY OF BIRMINGHAM
BIRMINGHAM, UK

CONFERENCE BROCHURE

BIOMAG2022.ORG

CONTENTS

WELCOME
TO BIRMINGHAM!

Dear all,

I would like to welcome you to the 22nd International Conference on Biomagnetism in Birmingham. The conference was first planned for 2020 but was postponed twice due to the Covid19 pandemic. We are therefore particularly excited that we finally can go ahead and welcome our dear friends and colleagues to Birmingham. The conference will be in a hybrid format to allow for delegates to partake who cannot travel due to existing Covid19 restrictions or CO2-related travel concerns.

Due to the hard work of the Scientific Committee, we have an exciting and scientifically strong program. Our keynote speakers are international leaders in their respective fields. The topics in the programme cover amongst others cognitive neuroscience, clinical neuroscience and cardiology, as well as the development of software tools and new sensor technology. The researchers selected to present include a diverse group of exceptional researchers. In particular there is a strong representation of young talent from all over the globe which vouches good for the future of our field.

The Biomag2022 conference will be held at the campus of the University of Birmingham. The city of Birmingham has a strong research community on MEG including researchers from Aston University and the University of Birmingham. The MEG and OPM research at the University of Birmingham is conducted at Centre for Human Brain Health. Please come visit us. The conference itself will be hosted in the historical Aston Webb buildings. I hope you will get a chance to explore the university campus as well. The Green Heart is a new parkland in the centre of the university with a range of wildflowers, trees, and water features. If you get a chance to visit, I am sure you will be impressed by the Winterbourne Botanical Gardens as well as The Barber Institute of Fine Arts.

I hope you will also find some time to explore the Birmingham city centre and the surrounding areas. The city is one of the most multicultural in the UK, which is contributing to an eclectic vibe as well as a rich cultural life. The city has been in rapid transition over the last decade and the downtown area has recently been rejuvenated. There are plenty of sites to explore around the centre including the canals intersecting the city.

Over the years the Biomag meetings have been my favourite conference where I have enjoyed learning about the recent developments in our field as well as making new friends and collaborations. It is therefore a great privilege for me to chair the Biomag2022 meeting. I would like to thank the many people involved in organising the Biomag conference. Researchers from the 10 MEG sites in the UK have provided invaluable support as well as the Event Management Team at the University of Birmingham.

I wish you all an inspiring Biomag2022 conference!

Professor Ole Jensen
Centre for Human Brain Health,
University of Birmingham

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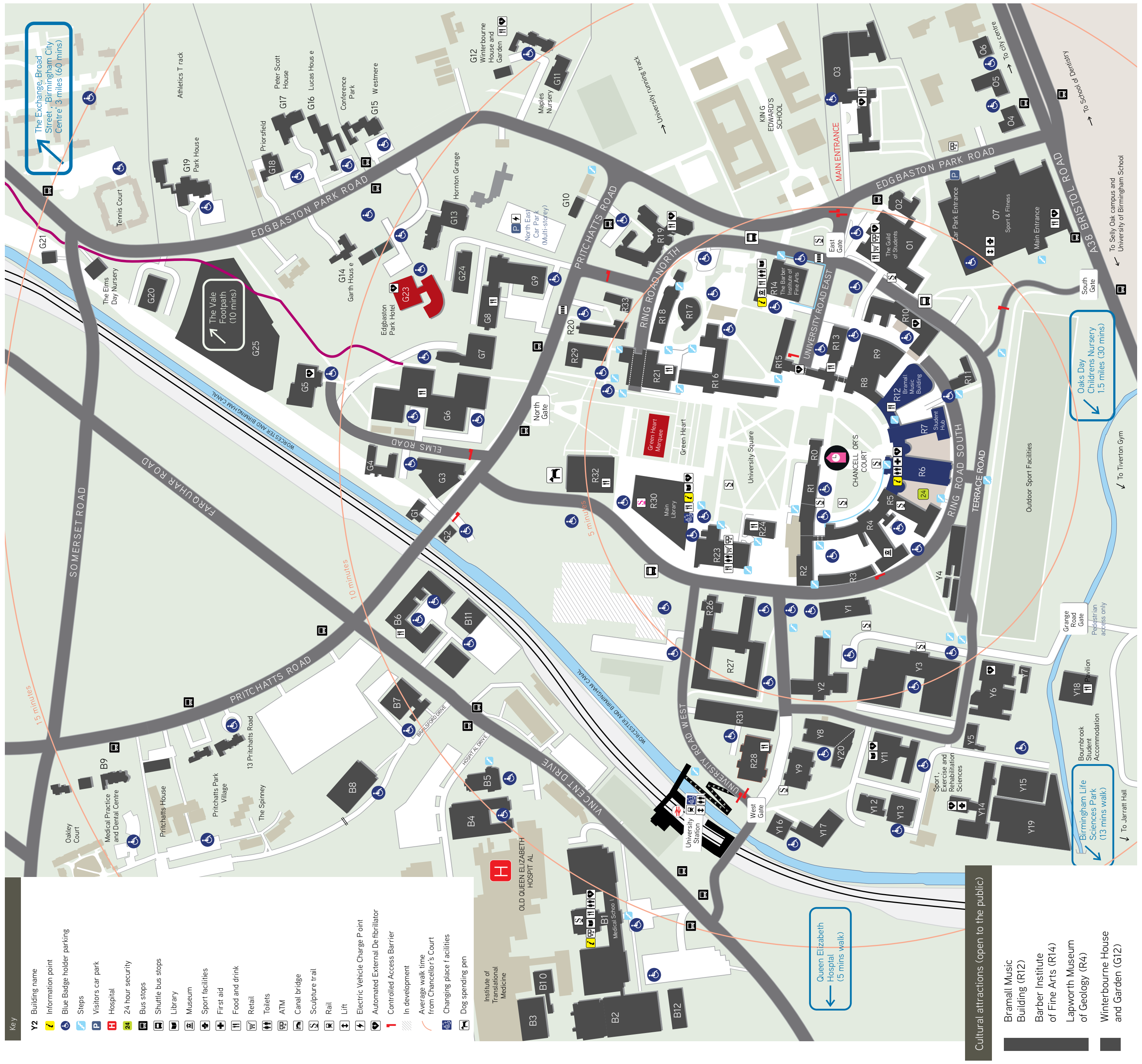


Edgbaston Campus Map

- Main hall and breakout rooms
- Green Heart Marquee Exhibition, Catering and registration

R0 The Harding Building
R1 Law Building
R2 Frankland Building
R3 Hills Building
R4 Aston Webb – Lapworth Museum
R5 Aston Webb – B Block
R6 Aston Webb – Great Hall
R7 Aston Webb – Student Hub
R8 Physics West
R9 Nuffield
R10 Physics East
R11 Medical Physics
R12 Bramall Music Building
R13 Poynting Building
R14 Barber Institute of Fine Arts
R15 Watson Building
R16 Arts Building
R17 Ashley Building
R18 Strathcona Building
R19 Education Building
R20 J G Smith Building
R21 Muirhead Tower
R23 University Centre
R24 Staff House
R26 Geography
R27 Biosciences Building
R28 Murray Learning Centre
R29 The Alan Walters Building
R30 Main Library
R31 Collaborative Teaching Laboratory
R32 Teaching and Learning Building
R33 Fry Building
R34 Cuore

B1 Medical School
B2 Institute of Biomedical Research including IBR West
B3 Wellcome Clinical Research Facility
B4 Robert Aitken Institute for Clinical Research
B5 CRUK Institute for Cancer Studies and Denis Howell Building
B6 Research Park
B7 90 Vincent Drive
B8 Henry Wellcome Building for Biomolecular NMR Spectroscopy
B9 Medical Practice and Dental Centre
B10 Advanced Therapies Facility
B11 BioHub Birmingham
B12 Health Sciences Research Centre (HSRC)

O1 The Guild of Students
O2 St Francis Hall
O3 University House
O4 Ash House
O5 Beech House
O6 Cedar House
O7 Sport & Fitness

G1 32 Pritchatts Road
G2 31 Pritchatts Road
G3 European Research Institute
G4 3 Elms Road
G5 Computer Centre
G6 Metallurgy and Materials
G7 IRC Net Shape Laboratory
G8 Gisbert Kapp Building
G9 52 Pritchatts Road
G10 54 Pritchatts Road – Institute for Global Innovation
G11 Maples Nursery
G12 Winterbourne House and Garden
G13 Horton Grange
G14 Garth House
G15 Westmere
G16 Lucas House
G18 Priorsfield
G19 Park House
G20 Wolfson Advanced Glasshouses
G22 Elms Day Nursery
G23 Edgbaston Park Hotel and Conference Centre
G24 Centre for Human Brain Health
G25 EcoLab

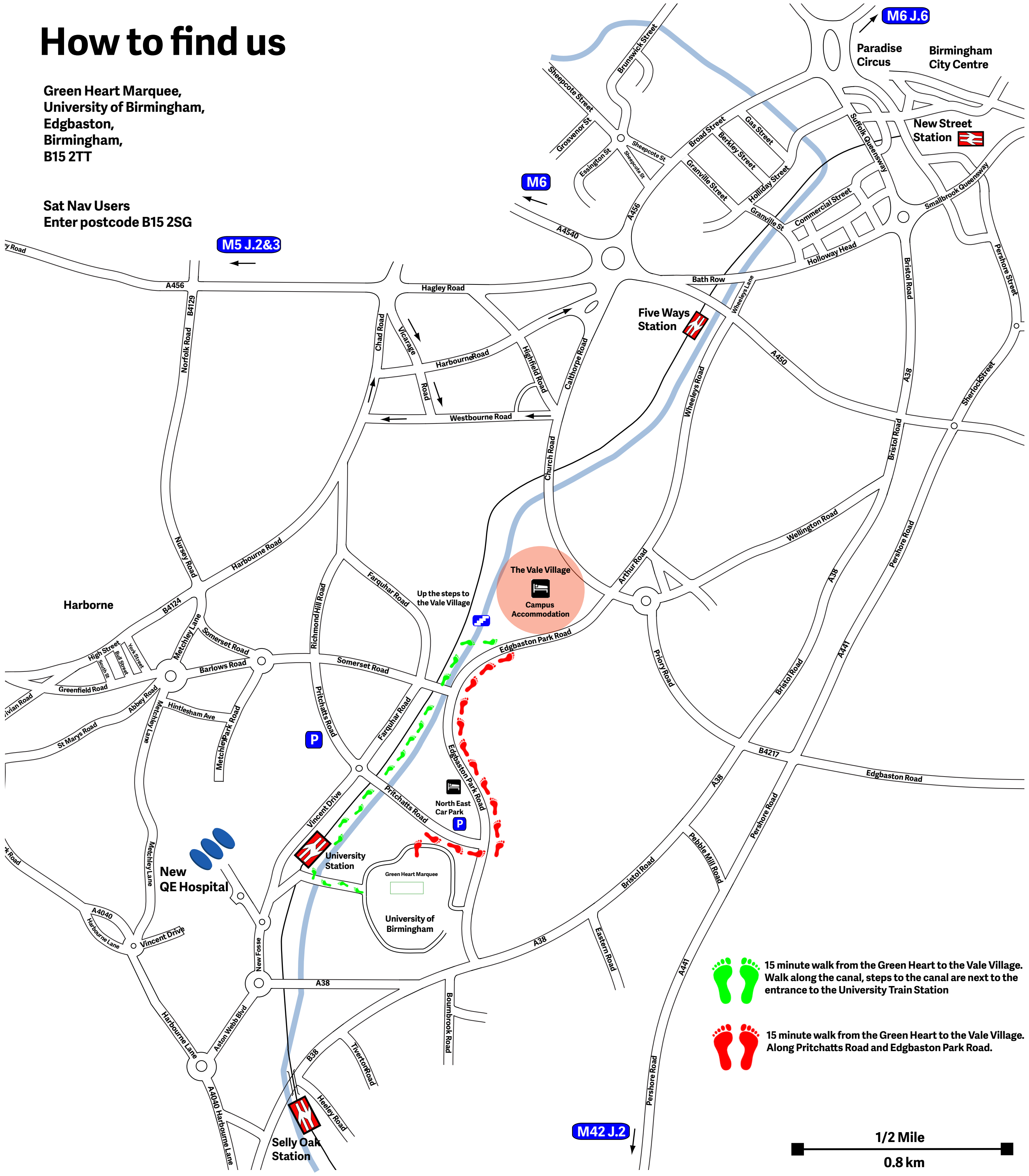
Y1 The Old Gym
Y2 Haworth Building
Y3 Engineering Building
Y4 Terrace Huts
Y5 Estates West
Y6 Maintenance Building
Y7 Grounds and Gardens
Y8 The School of Engineering
Y9 Computer Science
Y11 Chemical Engineering
Y12 Biochemical Engineering
Y13 Chemical Engineering Workshop
Y14 Sport, Exercise and Rehabilitation Sciences
Y15 Civil Engineering Laboratories
Y16 Institute of Occupational and Environmental Medicine
Y17 Public Health
Y18 Bournbrook Student Accommodation
Y19 NBIF
Y20 UKRRIN

UNIVERSITY OF BIRMINGHAM

How to find us

Green Heart Marquee,
University of Birmingham,
Edgbaston,
Birmingham,
B15 2TT

Sat Nav Users
Enter postcode B15 2SG



CONFERENCE PROGRAMME

SATURDAY 27 AUG

17.00 - 22.00	Workshop on Optically-Pumped Magnetometers (WOPM) and dinner	Edgbaston Park Hotel

SUNDAY 28 AUG

<table>
<tr><td rowspan="3">09.00 - 17.00</td><td colspan="3">Satellite Meetings</td><td rowspan="3">Edgbaston Park Hotel</td></tr>
<tr><td>Workshop on Optically-Pumped Magnetometers - WOPM</td><td>Algorithms in Biomagnetism</td><td>Hands-on Workshop on Human Neocortical Neurosolver</td></tr>
<tr><td>Connecting to the networks of the human brain</td><td></td><td>European MEG Society one-day satellite workshop</td></tr>
<tr><td>17.00 - 18.30</td><td colspan="3">Opening Ceremony and reception, Great Hall (in person only)
Opening address: Paul Furlong, Emeritus Professor of Clinical Neuroimaging, President for the Association of Neurophysiological Scientists</td><td>Great Hall</td></tr>
</table>

CONFERENCE PROGRAMME

MONDAY 29 AUG

09.00 - 11.00	In-person Registration, exhibition, and poster viewing (hybrid)			Green Heart Marquee
09.00 - 11.00	WOPM sessions (hybrid)			Great Hall
11.00 - 11.15	Welcome address (hybrid) Professor Ed Wilding, Head of the School of Psychology, College of Life & Environmental Sciences, University of Birmingham, and Prof. Ole Jensen, Centre for Human Brain Health, University of Birmingham and Biomag 2022 Chair			Great Hall
11.15 - 12.15	Keynote: Neural Dynamics of the Primate Attention Network. Professor Sabine Kastner			
12.15 - 13.15	Oral poster presentations (hybrid)			
12.15 - 13.15	Poster session (virtual only)			Online
13.15 - 14.15	Lunch and exhibition viewing			Green Heart Marquee
14.15 - 16.15	Symposium 1: Great Hall Advances and applications in the field of dynamic functional connectivity (hybrid)	Symposium 2: C-block LT Biomagnetic Imaging in Dementia (hybrid)	Symposium 3 (hybrid): Bramall Optically Pumped Magnetometers for Magnetoencephalography	
16.15 - 17.30	Poster session with refreshments – (in person only)			Green Heart Marquee
16.15 - 17.30	Virtual exhibition			Online
17.00 - 18.00	Data analysis competitions: results and discussion			C-block Lecture Theatre

TUESDAY 30 AUG

08.15	Morning refreshments (in-person only)			Green Heart Marquee
08.45 - 10.45	Symposium 4: Great Hall Rhythms in Auditory, Visual, and Audiovisual Speech Processing: Multisensory representations in unisensory cortices and beyond (hybrid)	Symposium 5: Bramall Recent advances in biomagnetic applications of optically pumped magnetometers beyond MEG (hybrid)	C-block LT Early Career Researchers Award Presentations (hybrid)	
10.45 - 11.30	Refreshment break, exhibition and poster viewing (hybrid)			Green Heart Marquee
11.30 - 12.30	Keynote: Professor Stan Dehaene			Great Hall
12.30 - 13.30	Oral poster presentations (hybrid)			Great Hall
12.30 - 13.30	Poster session (virtual only)			Green Heart Marquee
13.30 - 14.30	Lunch, exhibition viewing and poster viewing (hybrid)			Green Heart Marquee
13.30 - 15.30	International Advisory Board meeting (IAB only - hybrid)			Rose Sedgewick
14.30 - 15.30	Poster session (in person only) and Virtual exhibition time			Green Heart Marquee
14.30 - 15.30	Virtual exhibition time			Online
15.30 - 16.00	Refreshment break, exhibition and poster viewing (hybrid)			Green Heart Marquee
16.00 - 18.00	Symposium 6: Bramall How can we study social cognition in the MEG lab? The tug-of-war between experimental control and ecological validity (hybrid) deep brain recordings (hybrid)	Symposium 7: C-block LT Magnetocardiography (hybrid)	Symposium 8: Great Hall New insights from animal and human studies into the functional role of sensorimotor beta burst dynamics (hybrid)	
19.00 - 22.00	Aston University social event			Aston University

CONFERENCE PROGRAMME

WEDNESDAY 31 AUG

08.15	Morning refreshments			Green Heart Marquee
08.45 - 10.45	Symposium 9: Great Hall Time-resolved cortico-subcortical connectivity in patients with deep brain recordings (hybrid)	Symposium 10: Bramall Symposium 10: Multivariate methods to disclose brain networks in multiple functional neuroimaging modalities (hybrid)	Symposium 11: C-block LT Applications of MEG in Psychiatry: The Past, Present and the Future (hybrid)	
10.45 - 11.30	Refreshment break, exhibition and poster viewing (hybrid)			Green Heart Marquee
11.30 - 12.30	Keynote: Prof. Margot Taylor			Great Hall
12.30 - 13.30	Oral poster presentations (hybrid)			Green Heart Marquee
12.30 - 13.30	Poster session (virtual only)			Online
13.30 - 14.30	Lunch, exhibition viewing and poster viewing (hybrid)			Green Heart Marquee
14.30 - 15.30	Poster session (in person only)			
14.30 - 15.30	Virtual exhibition time			Online
15.30 - 16.00	Refreshment break, exhibition and poster viewing (hybrid)			Green Heart Marquee
16.00 - 18.00	Symposium 12: Great Hall Infant MEG: Examining normal and abnormal brain development (hybrid)	Symposium 13: Bramall Oscillations and memory: From local to large-scale synchronization, from working memory to long-term memory, from correlation to causation (hybrid)	Symposium 14: C-block LT Contribution of MEG, EEG and TES to the pre-surgical diagnosis and treatment of epilepsy (hybrid)	
19.00 - 23.00	Conference social event (in-person only)			Custard Factory

THURSDAY 01 SEPT

08.15	Morning refreshments			Green Heart Marquee
08.45 - 10.45	Symposium 15: Great Hall The pathophysiology of mild Traumatic Brain Injury (hybrid)	Symposium 16: Bramall Insights into the laminar basis of neural oscillations: multimodal and multi-species approaches (hybrid)	Symposium 17: C-block LT Tracking neural development of cognitive functions (hybrid)	
10.45 - 11.30	Refreshment break and exhibition viewing (hybrid)			Green Heart Marquee
11.30 - 12.30	Town Hall (hybrid)			Great Hall
12.30 - 13.30	Keynote: Professor Mark Woolrich			

13.30 - 14.15	Lunch and exhibition viewing (hybrid – exhibition closes after lunch)		Green Heart Marquee
14.15 - 15.45	Symposium 18: Great Hall Open source and the MEG community: advancing science together (hybrid)	Symposium 19: Bramall Predicting clinical endpoints from M/EEG: Challenges and opportunities of large-scale data analysis (hybrid)	
15.45 - 16.00	Closing remarks		Great Hall
16.00	Conference closes		

Sabine Kastner,

Professor of Psychology, Princeton Neuroscience Institute, Princeton University

Sabine Kastner is a Professor of Neuroscience and Psychology at Princeton University. She studies the neural basis of visual perception, attention, and awareness in the healthy, adult primate brain, in patients with brain lesions and during development. Kastner is a Fellow of the American Academy of Arts & Sciences, the American Psychological Society, the Society for Experimental Psychology and a Member of the German National Academy of Sciences (Leopoldina). Kastner is passionate about public outreach such as fostering the careers of young women in science, promoting neuroscience in schools and public education and exploring the intersection of visual neuroscience and art.

Neural Dynamics of the Primate Attention Network

The selection of information from cluttered sensory environments is one of the most fundamental cognitive operations performed by the primate brain. This process engages a large-scale network that consists of multiple nodes, distributed across cortical and subcortical regions. The lecture will focus on temporal dynamics within this network that shape both the sampling of and responses to our environment, with an emphasis on thalamocortical interactions. The lecture will also discuss the importance of comparative electrophysiology and neuroimaging in human and monkey brains.

Stan Dehaene,

Professor, Experiential Cognitive Psychology, College De France

Stanislas Dehaene, PhD, is a French psychologist and cognitive neuroscientist. He holds the Chair of Experimental Cognitive Psychology at the Collége de France in Paris. He directs the NeuroSpin center in Saclay, south of Paris, France's advanced brain imaging research center. His research investigates the neural bases of human cognitive functions such as reading, calculation and language, with a particular interest for the differences between conscious and non-conscious processing, and for the impact of education on the brain. Prof. Dehaene is a member of six academies and a recipient of the Brain Prize. In 2018, he became the president of the newly created French Scientific Council for Education, which advises the French government on scientific approaches to learning and teaching. He is the author of multiple books including Reading in the Brain: The Science and Evolution of a Human Invention (2009) and How We Learn: Why Brains Learn Better Than Any Machine...For Now (2020), which were translated into more than fifteen languages.

Tracking mental languages with magnetoencephalography

Natural language is often seen as the single factor that explains the cognitive singularity of the human species. Instead, we propose that humans possess multiple internal languages of thought, akin to computer languages, which encode and compress structures in various domains (mathematics, music, shape...). These languages rely on cortical circuits distinct from classical language areas. Each is characterized by (1) the discretization of a domain using a small set of symbols, and (2) their recursive composition into mental programs that encode nested repetitions with variations. I will present several tasks of elementary shape or sequence perception in which minimum description length in the proposed languages demonstrably captures human behaviour and brain activity, and where magneto-encephalography tracks the postulated mental structures in real time.

Dr Margot J. Taylor,
Director of Functional Neuroimaging, Hospital for Sick Children and Professor, University of Toronto

Dr. Taylor is the Director of Functional Neuroimaging and Senior Scientist at the Hospital for Sick Children and Professor in Medical Imaging and Psychology at the University of Toronto. Dr. Taylor's research has centred on the neural bases of social-cognitive development using MEG, fMRI and MRI. She and her team assess functional and structural brain correlates of high-level cognitive skills from early childhood into adulthood, in typically developing, autistic and very preterm-born populations. Her current focus is the application of OPMs to investigate emerging neural signatures of autism in toddlers.

MEG over time: brain function over the years, the lifespan and across disorders

Understanding brain functioning across the age spectrum is fundamental to advancing our knowledge on both typical and atypical development.
In this presentation, I will review some of our studies using MEG throughout development, determining source, connectivity and oscillatory differences between typical development and children and adults with autism or children born very preterm. The protocols include a range of social-cognitive tasks, such as emotional processing, theory of mind and working memory, which have protracted development normally and show deficits in these clinical populations.

Prof Mark Woolrich,
Professor of Computational Neuroscience, Oxford Centre for Human Brain Activity (OHBA), University of Oxford

Mark Woolrich is a Professor of Computational Neuroscience at the University of Oxford, Head of Analysis and Associate Director at the Oxford centre for Human Brain Activity (OHBA), and a Group Leader in the Wellcome Centre for Integrative Neuroimaging (WIN). His background is in engineering science and his early research career was in fMRI analysis, through which he became a key contributor to FSL. His research now focuses on the development of new computational methods for analysing neuroimaging data, including functional MRI and MEG/EEG data; allowing novel questions to be asked about the function and dysfunction of the human brain.

Dynamic Brain Networks and Machine Learning in MEG

This talk will describe how machine learning methods can be used to infer the dynamics of large-scale networks at sub-second timescales from MEG data. This can be used to describe the dynamics of large-scale phase locking networks in rest and task, to infer transient spectral events (e.g. beta bursts), and to provide a link between phenomena such as replay and the activity of resting state networks. The talk will finish with a look at new deep-learning-based approaches, which are offering exciting new possibilities for the future.

SATELLITES

SATELLITE MEETINGS

Algorithms in Biomagnetism: From Sensing, Forward Modeling, Imaging to Advanced Analytics

In this satellite workshop to Biomag2020, leading scientists in our field will provide brief talks on their cutting-edge algorithms for biomagnetic signal analyses. The scope of the workshop will span advances in forward modeling, sensor-level analytics and interference suppression, source localization, functional connectivity, multimodal fusion, kernel reconstructions, and stimulus decoding. This workshop should provide a friendly atmosphere for discussion and exchange of ideas for the expert audience as well as an educational opportunity for students and fellows.

Organizer: Srikantan Nagarajan, UCSF, San Francisco, USA

Workshop on Optically-Pumped Magnetometers (WOPM-2020)

We are pleased to announce the 8th Workshop on Optically-Pumped Magnetometers WOPM-2020 as a satellite workshop at BIOMAG. In this workshop, we will cover all aspects and applications of optically pumped magnetometers (OPMs).

OPMs are highly sensitive magnetometers which are based on optical pumping and laser interrogation of an atomic vapour (typically rubidium or cesium). OPMs are operated at temperatures ranging from room-temperature to a few 100 degrees Celsius and can achieve high sensitivity in the fT/sqrt(Hz) range. Recent technological advances has led to highly sensitive OPM sensors now being commercially available, which has opened up new and exciting possibilities. In this workshop, leading researchers will present their recent results on OPM sensors, novel magnetometry methods and applications of OPMs.

The workshop will specifically focus on OPMs and biomagnetic applications including magnetoencephalography (MEG). We would like to especially encourage the biomagnetic community to participate to enhance communication between the users and developers of OPMs.

WOPM-2020 will include oral presentations and poster presentations. The selection of talks and posters will be done by the WOPM Scientific Programme Committee. The workshop will also include a tutorial on OPM sensors for non-OPM experts and tutorial on MEG for non-MEG experts.

Organizer: Kasper Jensen, University of Nottingham, Nottingham, United Kingdom

SATELLITE MEETINGS

Hands-on Workshop on Human Neocortical Neurosolver: A New Tool for Cell and Circuit Level Interpretation of MEG/EEG signals

MEG/EEG signals are correlated with nearly all healthy and pathological brain functions. However, it is still extremely difficult to infer the underlying cellular and circuit level origins. This limits the translation of MEG/EEG signals into novel principles of information processing, or into new treatment modalities for pathologies. To address this limitation, we have built the Human Neocortical Neurosolver (HNN): an open-source software tool to help researchers and clinicians without formal computational modeling or coding experience interpret the neural origin of their human MEG/EEG data. HNN provides a graphical user interface (GUI) to an anatomically and biophysically detailed model of a neocortical circuit, with layer specific thalamocortical and cortical-cortical drives. Unique to HNN is an underlying neural model that accounts for the biophysics generating the primary electric currents underlying MEG/EEG signals, enabling visual and statistical comparison of model output to source localized data (in Am). Users can change model parameters in the GUI for testing hypotheses on signal differences under varied experimental conditions. Further, visualizations are shown of detailed circuit activity including layer specific responses, cell spiking activity, and membrane voltages.
In this hands-on workshop we will teach users how to apply HNN to study the circuit origin of some of the most commonly measured signals, including sensory event related potentials (ERPs) and low frequency oscillations in the alpha, beta and gamma bands. Data and parameter sets will be provided. Additionally, we will work with attendees to apply HNN to their data and individual questions of interests.

Organizer: Stephanie Jones, Brown University, Providence, USA

European MEG Society one-day satellite workshop: "Investigation of human language with MEG: from research to clinical applications"

This one-day satellite workshop aims at giving a novel start to the European MEG Society (EMEGS).This one-day workshop will start from a historical and general perspective about what MEG brought to the understanding of the neural bases of human language, and then move on to more advanced research fields investigating the cortical tracking of speech and the development of wearable MEG for language investigations. It will finish by clinical applications of MEG for language presurgical functional mapping and for understanding the pathophysiology of language-related disorders. The workshop will close with a collective discussion about the future of EMEGS.

Organizer: Riitta Salmelin, Aalto University, Espoo, Finland

SATELLITE MEETINGS

Connecting to the networks of the human brain: combining TMS with EEG or MEG for closed-loop neurostimulation

In conventional transcranial magnetic stimulation (TMS), the stimulation site (locus) can be changed only slowly and real-time neurophysiological information cannot be taken into account, limiting TMS therapies to a single brain site and open-loop mode. Major efforts have recently begun to develop electronically controlled multi-locus closed-loop TMS. The new approach requires two advances: 1) Multilocus TMS (mTMS) coil array for fast and precise control over the location, direction, and intensity of TMS pulses; 2) real-time analysis of brain activity and connectivity from EEG or MEG for brain-state-dependent and closed-loop stimulation. This symposium will start by introducing two ways to measure brain state in real time during brain stimulation: TMS combined with EEG (Silvia Casarotto) and with MEG (Yoshio Okada). The challenge of developing optically pumped magnetometers (OPMs) for large sensor arrays and for concurrent MEG recordings with TMS will be discussed by Svenja Knappe. Joana Cabral will give insights on brain network dynamics and how information of the ongoing dynamics can be extracted in real time from MEG or EEG signals. In the afternoon, the ERC Synergy project (2019–2025) ConnectToBrain will be portrayed; this project aims at making a breakthrough in mTMS and its use in closed-loop brain stimulation. The speakers from Aalto, Tübingen and Chieti-Pescara Universities will explain details of the mTMS technology, the approach towards brain-state-dependent and closed-loop mTMS, the use of MEG and fMRI data as a priori information for stimulus targeting, and experiments that will pave the way to a new era of brain stimulation.

Organizer: Risto Ilmoniemi, Aalto University, Espoo, Finland

SYMPOSIUMS

SYMPOSIUM NUMBER: 01

Advances and applications in the field of dynamic functional connectivity

Co-chairs:
Arjan Hillebrand, Amsterdam UMC, Vrije Universiteit Amsterdam, Department of Clinical Neurophysiology and MEG Center, Amsterdam, Netherlands, and Prejaas Tewarie, Amsterdam UMC, Vrije Universiteit Amsterdam, Department of Clinical Neurophysiology and MEG Center, Amsterdam, Netherlands

Symposium description:
Cognitively relevant fluctuations in oscillatory neuronal activity typically occur at the millisecond time scale. Interactions between distinct neuronal populations take place at similar time-scales. Magnetoencephalography offers the temporal resolution to characterise these fast fluctuations in functional connectivity. The last decade has brought the field new insights on the estimation of dynamic connectivity, its relevance for cognition, and clinical applications. This ranges from in-depth analysis of sliding window approaches, use of Hidden Markov models, application of Kalman filtering and the use of high temporal resolution metrics of functional connectivity. This symposium will shed light on new methods, but also on applications of dynamic connectivity in cognitive neuroscience and neurological disorders.

Speakers:
Dissociation between phase and power correlation networks in the human brain is driven by co-occurrent neuronal bursts
Rikkert Hindriks, Department of Mathematics, VU University, Amsterdam, Netherlands

Characterization of dynamic resting-state electrophysiological functional connectivity fluctuations: application to clinical populations
Pablo Nunez, Biomedical Engineering Group, University of Valladolid, Spain and Coma Science Group, University of Liege, Belgium

Hidden Markov Modelling of time-varying functional connectivity: implementation and interpretation
Christine Ahrends, Department of Clinical Medicine – Center of Functionally Integrative Neuroscience, Aarhus University, Aarhus, Denmark

Mixtures of large-scale functional brain networks in MEG revealed by DyNeMo
Chetan Gohil, Department of Psychiatry, OHBA, University of Oxford, Oxford, United Kingdom

SYMPOSIUM NUMBER: 02

Biomagnetic Imaging in Dementia

Chairs:
Dr Srikantan Nagarajan, UCSF, San Francisco, USA

Symposium description:
Biomagnetic Imaging has revealed a multitude of impact of neural oscillations in various types of Dementia, including Alzheimer's disease. This symposium seeks to highlight the latest work in this burgeoning field of biomagnetic imaging in Dementia. Speakers included here have made important contributions in this research area and hearing updates on their latest work should be of broad interest to the Biomag 2022 community.

Speakers:
Resting state slowing in dementia: relationships to functional activation and cognitive status
Dr. Jed Meltzer, Baycrest, and University of Toronto, Canada

Hypersynchronization in the early stages of AD: the X model
Fernando Maestu, Complutense University, Center for Biomedical Technology, Madrid, Spain

Neurophysiological signatures in Alzheimer's disease distinctly associated with tau and amyloid-beta accumulations and cognitive decline
Dr. Srikantan Nagarajan, UCSF, San Francisco, USA

Magneto-encephalography as a routine diagnostic tool in memory clinic patients
Dr. Alida Gouw, Amsterdam UMC, Amsterdam, Netherlands

A magnetoencephalographic platform for experimental medicine in dementia
Professor James Rowe, University of Cambridge, United Kingdom

SYMPOSIUM NUMBER: 03

Optically Pumped Magnetometers for Magnetoencephalography

Co-chairs:
Kasper Jensen, University of Nottingham, Nottingham, United Kingdom and
Gareth Barnes, UCL, London, United Kingdom

Symposium description:
For over forty years, the fundamental building block of magnetoencephalography (MEG) systems has been the superconducting quantum interference device (SQUID). SQUIDs offer extremely high sensitivity to the small magnetic fields generated by the human brain. However, they are also limited by a requirement for cryogenic cooling, meaning MEG systems are cumbersome, static, 'one-size-fits-all' and expensive to buy and run. In recent years, a number of new technologies have emerged that offer similar sensitivity to SQUIDs, but without the requirement for cooling. Arguably the most advanced of these is the optically pumped magnetometer (OPM). OPMs exploit the quantum properties of alkali metals, and a technique known as optical pumping, to measure magnetic fields with a noise floor <10 fT/sqrt(Hz). Recent miniaturisation and commercialisation means that OPMs are now available in self-contained packages enabling multiple sensors to be mounted within a lightweight helmet on the scalp. With appropriate control of background magnetic fields, OPMs enable "wearable" MEG systems, with a subject able to move their head freely during data acquisition. This new technology therefore offers the potential of a new generation of MEG scanner, with higher sensitivity, improved spatial resolution, and novel neuroscientific experimentation as the constraints on subject movement are lifted.

In this symposium, we will assemble talks from leading groups which span the gamut of OPM-MEG development and application. We will introduce the technical challenges that are faced by the introduction of OPM systems, and the new technologies that are beginning to meet those challenges. We will describe the latest multi-channel OPM systems in operation, and showcase recent data, with an emphasis on comparison to established (SQUID based) recordings. Finally we will highlight the unique opportunities that OPM based measurement affords, in particular the promise of MEG recording during subject movement, enabling a paradigm shift in experimental design.

Speakers:
A 50-channel whole-head OPM system for MEG measurements
Dr Elena Boto, Sir Peter Mansfield Imaging Centre, University of Nottingham, United Kingdom

Magnetic field mapping and correction for moving OP-MEG
Stephanie Mellor, University College London, London, United Kingdom

Functional-Brain-Imaging with an Optically-Pumped-Magnetometer-Based agnetoencephalography System
Dr. Peter Schwindt, Sandia National Laboratories, Albuquerque, USA

Optically pumped magnetometers (OPMs) for brain-computer interference (BCI)
Prof. Fan Wang, Institute of Biophysics, Chinese Academy of Sciences, and University of Chinese Academy of Sciences, Beijing, China

Towards a wearable MEG system for clinical MEG
Prof Xavier De Tiege, ULB Neuroscience Institute, Université libre de Bruxelles, Brussels, Belgium

From OPM sensors to MEG applications: Where are we now?
Prof. Lauri Parkkonen, Aalto University, ESPOO, Finland

SYMPOSIUM
NUMBER: 04

Visual perception of lip movement entrains auditory brain oscillations and drives auditory perception

Chair:
Hyojin Park, University of Birmingham, Birmingham, United Kingdom

Symposium description:
Our perceptual experiences in everyday life are mostly multi-modal and we perceive the environment more efficiently when combining multi-sense inputs. This is particularly true when we are surrounded by multi-talkers (cocktail party effect). We have seen a large number of studies that had tried to uncover how our brain integrates information from multi-modal speech inputs, however, how multimodal speech signals are represented in unisensory cortices and higher-order structures and how they interact along the hierarchical streams of feedforward/feedback information processing still remains to be answered. These questions are important not only to understand neural bases of multisensory integration and its attentional modulation but also crucial to understand underlying neural mechanisms of patients with sensory deprivation (e.g. hearing loss) as well as their adaptive brain reorganization (cross-modal plasticity).

This symposium gathers five outstanding speakers who will address this issue by exploiting M/EEG data which provides excellent temporal resolution and spectral features from healthy volunteers as well as clinical population (deafness). We hope to present not only the best research in this topic but also inspire BIOMAG attendees to consider the meaning of physiological and anatomical observations of interactions between our senses in the multisensory world of our daily lives.

We also have strived for a fair balance of diversity in terms of career stage (1 Senior PI, 2 Early-career independent PIs, 1 Post-doctoral researcher, and 1 PhD student), gender (3 females, 2 males) and geographical location (England, Scotland, Spain, Austria) of speakers.

Speakers:
The temporal relationship between auditory and visual speech signals in naturalistic speech and their interactive spatial representations in the brain
Dr Hyojin Park, School of Psychology, Centre for Human Brain Health (CHBH), University of Birmingham, United Kingdom

Synthesizing auditory features of silent speech
Dr. Nicola Molinaro, BCBL, San Sebastian, Spain

Visuo-phonological transformation of information from lip movements in visual cortex and its implications for speech processing
Nina Suess, University of Salzburg, Salzburg, Austria

Hippocampal theta tracks audio-visual integration in natural speech and predicts episodic memory formation
Emmanuel Biau, University of Birmingham, United Kingdom

Neural mechanisms of unisensory and multisensory speech perception
Dr Anne Keitel, University of Dundee, Dundee, United Kingdom

SYMPOSIUM NUMBER: 05

Recent advances in biomagnetic applications of optically pumped magnetometers beyond MEG

Co-chairs:
Daniel Baumgarten, UMIT - University for Health Sciences, Medical Informatics and Technology, Hall in Tirol, Austria, and Tilmann Sander, Physikalisch-Technische Bundesanstalt, Berlin, Germany

Symposium description:
Optically pumped magnetometers (OPM) have made significant progress in terms of performance and applicability. The recent commercial availability allows to study benefits beyond typical SQUID setups, which are more flexible positioning and the omission of cryogenic cooling. However, they are still trailing SQUIDs in noise performance and bandwidth. Beyond the field of MEG, where OPMs have already attracted significant attention, a variety of biomagnetic applications will benefit from OPMs. In this symposium, the application of OPMs for characterization and imaging of magnetic nanoparticles, magnetocardiography, magnetomyography and low field NMR will be covered, and recent advances will be demonstrated.
Magnetic nanoparticles (MNP) open novel pathways in cancer therapy and non-invasive diagnostics. Magnetorelaxometry allows for their characterization and quantitative imaging. OPMs offer benefits in terms of flexible positioning and measurement in background fields.
One method to produce MNPs is microfluidics, where a reaction mixture is passed through capillary test tubes. The transit time and temperature, among other factors, determine the physical properties of the MNPs. An instant method to measure the magnetic susceptibility using OPMs is being developed.
Fetal magnetocardiography was early on identified as potentially benefitting from OPMs. Comparing OPM magnetocardiography recordings with existing SQUID data in terms of metrics such as heart rate variability has shown good agreement, but at much simpler device operation.
Magnetic measurements of periphery limbs offer a non-invasive probe of muscle activity with comparably high temporal resolution as electromyograms. We use an array of optically pumped magnetometers to detect muscle activity in the human hand, evoked via transcranial magnetic stimulation.
Nuclear magnetic resonance at ultra-low magnetic fields offers a specifically pronounced contrast in the longitudinal relaxation time to characterize pathogenic tissue. Measurements on phantom samples show the potential for this type of OPM NMR.

Speakers:
Magnetorelaxometry imaging of magnetic nanoparticles using optically pumped magnetometers
Aaron Jaufenthaler, Private University for Health Sciences, Medical Informatics and Technology (UMIT), Hall in Tirol, Austria

T1 Relaxation at Ultra-low Magnetic Fields using an Optically Pumped Magnetometer
Dr. Stefan Hartwig, Physikalisch-Technische Bundesanstalt, Berlin, Germany

Low Frequency AC Susceptometry with Optically Pumped Magnetometers
Prof. Oswaldo Baffa Filho, Universidade de São Paulo, Ribeirão Preto, Brazil

Optically pumped magnetometer based magnetomyography of muscle potentials evoked with transcranial magnetic stimulation
Mr. Yinan Hu, Johannes Gutenberg University, Mainz, Germany

Recording and Quantification of Fetal Magnetocardiography Using Optically-Pumped Magnetometers
Dr Hari Eswaran, University of Arkansas for Medical Sciences, Little Rock, USA

SYMPOSIUM NUMBER: 06

How can we study social cognition in the MEG lab? The tug-of-war between experimental control and ecological validity

Chair:
Prof Ole Jensen, University Of Birmingham, United Kingdom

Symposium description:
This symposium aims at exploring the challenges of investigating the neuronal mechanisms of complex social behaviour using magnetoencephalography. Neuroscientists often study social cognition by measuring how the brain responds to simplified social stimuli, such as static pictures of faces. Whereas this approach allows for well-controlled studies with high experimental reliability, the resulting findings might not generalize to real-life social experiences. In recent years, the field has moved towards increased ecological validity. In particular, new studies have focused on capturing the dynamic and interactive nature of social behaviour, narrowing the gap between how we investigate social cognition in the lab and how we experience real social interactions. However, these novel approaches bring along their own set of challenges and confounds to do with the use of complex stimuli and open-ended experimental designs. Consequently, research on social cognition is characterized by a tension between experimental control and ecological validity. In this symposium, we will hear from researchers who are negotiating this tension in their work. The talks will cover multiple distinct approaches to the study of the neural basis of social cognition, from the analysis of neuronal responses to simplified social stimuli, to simultaneous MEG recordings from two participants who are interacting in real-time. The symposium will offer a unique space to discuss how to best harness magnetoencephalography methods to advance the field of social cognition. Furthermore, we hope to foster a broader discussion on how to study complex human behaviour – with high ecological validity – inside the constraints of the MEG lab.

Inclusivity Statement: The symposium features a panel of female and male speakers. It comprises talks by a doctoral student, a postdoctoral researcher, as well as several established academics working in different countries.

Speakers:
Oscillatory dynamical correlates of social contact
Dr Nathalie George, Institut du Cerveau et de la Moelle Epinière (ICM), Inserm, U 1127, CNRS, UMR 7225, Sorbonne Université, and Ecole Normale Supérieure, ENS, Centre MEG-EEG, Paris, France

Synchrony and coupling in social interactions
Professor James Kilner, UCL, London, United Kingdom

Social binding: Is social interaction more than the sum of actions?
Prof Ole Jensen, University Of Birmingham, Birmingham, United Kingdom

Modulating social-emotional control by synchronizing rhythmic brain circuits
Bob Bramson, Donders Institute for Brain, Cognition and Behaviour, Centre for Cognitive Neuroimaging, Nijmegen, Netherlands

Studying natural interaction with MEG: Possibilities and pitfalls
Prof. Lauri Parkkonen, Aalto University, ESPOO, Finland

SYMPOSIUM

NUMBER: 07

Magnetocardiography

Co-chairs:
Matti Stenroos, Aalto University, Espoo, Finland, and Jens Haueisen, Ilmenau University of Technology, Ilmenau, Germany

Symposium description:
Magnetocardiography (MCG) assesses the cardiac electrical activity via the magnetic field measured outside the chest. MCG studies have typically been done using SQUID-based sensors in a magnetically shielded room. In such studies, MCG has shown promise, for example, in assessing post-infarction arrhythmia risk and exercise-induced ischemia. Thanks to the introduction of optically-pumped magnetometers (OPM), there is now increasing new interest in MCG: the OPMs and other new sensors that do not need cryogenic cooling enable measurement closer to the chest, potentially increasing the sensitivity and resolution of the measurement while also decreasing the cost of the MCG system. Another focus of interest has been in techniques that facilitate measuring outside a magnetically-shielded room. Together, these developments open new opportunities for the application of MCG especially in clinics but also in basic research.

In this symposium, we have collected recent work of five innovative research groups, including three groups that have not previously been present in Biomag MCG sessions. Our selection focuses on application of new sensor techniques and artefact removal, ranging from sensor design and small-animal measurements to fetal MCG and a movable clinical MCG system that operates outside the shielded room. These talks are complemented by a clinically-motivated SQUID-MCG work that extends from conventional signal-averaged analysis to beat-to-beat analysis of atrial dynamics.

Speakers:
Magnetocardiography on an isolated animal heart with a room-temperature optically pumped magnetometer
Dr Kasper Jensen, University of Nottingham, Nottingham, United Kingdom

First MagnetoCardioGraphic (MCG) recordings at room temperature with Helium 4 Optically Pumped Magnetometers (4He OPM)
Dr Etienne Labyt, CEA LETI, Grenoble, France

Fetal Long QT Syndrome and Stillbirth
Ronald Wakai, University of Wisconsin, Madison, USA

Magnetocardiography in assessing cryptogenic stroke
Ville Mäntynen, BioMag Laboratory, HUS Medical Imaging Center, Helsinki University and Helsinki University Hospital, Helsinki, Finland

Unshielded magnetocardiography using signal correlation noise removal
Dr Ben Varcoe, School of Physics and Astronomy, University of Leeds, United Kingdom

SYMPOSIUM NUMBER: 08

New insights from animal and human studies into the functional role of sensorimotor beta burst dynamics

Chair:
Catharina Zich – University College London, London, United Kingdom

Symposium description:
Sensorimotor beta activity (13-30Hz) is a hallmark feature of healthy and pathological movement and sensory processing, yet its functional role remains unclear. Recent work in animals and humans has revealed that this activity comprises high amplitude, transient, and aperiodic bursts, whose contribution to the classical sensorimotor beta activity as well as their functional role remains largely undetermined. This symposium will review recent developments on the detection, soatio-temporal characteristics and putative functional role of transient sensorimotor beta events, across a range of species and methodologies.

First, Cagnan will review recent work in rodents and patients with Parkinson's Disease on the temporal dynamics of beta burst activity within cortico-striatal circuits, and the relevance of these signals for healthy and pathological movement. Silva will discuss cross-species commonalities of beta burst activity, their putative neurocomputational role using novel biophysical network modelling approaches, and the putative relevance of transient beta events for sensory processing. Bonaiuto will review recent work on high-precision MEG and new source localization approaches that has allowed for resolving the laminar profile of beta bursts in sensorimotor cortex. Finally, Mullinger will discuss novel analytical approaches using Hidden Markov Modelling (HMM) to identify beta bursts across cortex and the dynamics of these beta events across different cortical regions, as well as leveraging HMMs to provide novel insights aboute the functional role of post-stimulus beta responses (occurring after stimulus cessation).

The purpose of this symposium is to highlight the current state of the field and new approaches for studying the physiological and behavioural foundations of healthy and pathological movement, and to identify forthcoming challenges and open questions about the functional relevance of sensorimotor activity in the beta range, and beyond.

Speakers:
High precision MEG for time-resolved laminar analysis of sensorimotor beta bursts
Dr. James Bonaiuto, CNRS, Lyon, France

The role of transient beta events in tactile perception revealed through integrated human imaging, modeling and animal studies
Danielle Sliva, Brown University, Providence, RI, USA

Using Hidden Markov Models in the quest to increase understanding of dynamic brain function ("beta bursts")
Dr Karen Mullinger, University of Nottingham, Nottingham, and University of Birmingham, Birmingham, United Kingdom

Beta bursts and Parkinson's disease
Dr. Hayriye Cagnan, University of Oxford, Oxford, United Kingdom

SYMPOSIUM NUMBER: 09

Time-resolved cortico-subcortical connectivity in patients with deep brain recordings

Co-chairs:
Chunyan Cao, Jiao Tong University, Shanghai, China and Vladimir Litvak, UCL, London, UK

Symposium description:
Simultaneous MEG and local field potential recordings in patients undergoing deep brain stimulation surgery have established the existence of multiple cortico-subcortical coherent resting networks and mapped their topography. The next stage in the study of these networks is understanding their function and one way to address this is to find out how their strength varies over time and how it is modulated by cognitive tasks. The deep structures that one can study in patients are not reachable for MEG alone and thus coherence between deep brain structures and cortical signals measured by MEG is free from confounds that hinder its use in non-invasive studies and can provide unparalleled insights into the role of dynamic modulation of neurophysiological connectivity in the human brain.

Only a handful of groups worldwide have the possibility to do this kind of studies and the proposed symposium will bring together representatives from all of them.

Speakers:
Dynamic changes in cortico-subthalamic connectivity studied with Hidden Markov Models
Prof. Dr. Esther Florin, Heinrich-Heine University, Duesseldorf, Germany

Viewing negative images induces specific responses in habenular activity and cortico-habenular connectivity of psychiatric patients
Dr. Chunyan Cao, Shanghai Jiaotong University School of Medicine affiliated Ruijin Hospital, Shanghai, China

Conflict detection in a sequential decision task is associated with increased cortico-subthalamic coherence and prolonged subthalamic oscillatory response in the beta band
Dr. Zita Patai, MRC, Brain Dynamics Unit, University of Oxford, United Kingdom

Cortico-subcortical beta coherence during the regulation of movement inhibition
Dr. Bernadette van Wijk, University of Amsterdam, Amsterdam, The Netherlands

Dorsomesial prefrontal-subthalamic communication during reactive task-switching
Dr. Julien Bastin, Univ. Grenoble Alpes, Inserm, U1216, Grenoble Institut Neurosciences, GIN, Grenoble, France

SYMPOSIUM NUMBER: 10

Multivariate methods to disclose brain networks in multiple functional neuroimaging modalities

Chair:
Laura Marzetti, University of Chieti-Pescara, Chieti, Italy

Symposium description:
The development of methods to improve our understanding of the temporal dynamics of brain networksfrom functional neuroimaging is one the current challenges in the neuroscience community. In this framework, MEG and non-invasive electrophysiology at large are currently gaining an important role, nevertheless they still have an unexploited potential.

In this symposium, we will introduce current advances in multivariate methods that are crucial forcharactering brain networks by taking advantage of all information contained in the data from one or more neuroimaging modalities. Indeed, the vast majority of currently available methods relies on bivariate approaches. For instance, connectivity between brain regions is usually estimated by computing the correlation or coherence between their activities commonly reduced to univariate time series, e.g. after averaging across voxels or by imposing functional or anatomical priors.

Conversely, multivariate methods have the potential to:

1) exploit the full information contained in the data by directly addressing relationships between multiple timeseries, e.g., in a region or parcel;

2) provide a unified framework for multimodal integration of MEG data with other imaging modalities.

This symposium will present methodological studies that describe and apply multivariate approaches in MEG, EEG, fMRI and their combinations in a 120 minutes format with 4 presenters and an introduction from the chair.

This symposium will present methodological studies that describe and apply multivariate approaches in MEG, EEG, fMRI and their combinations in a 120 minutes format with 4 presenters and an introduction from the chair. Given that, together with novel methods, the presenters will show also relevant neuroscience applications, this symposium is of interest for the community at large. Presenters will be from laboratories in different countries (1 Italy, 1 Belgium, 1 U.S.A, 1 Canada), of different nationalities (Italian, Indian, Iranian, Belgian), gender (2 females, 2 males) and carrier stages (from post-doc to faculty).

Speakers:
Individual Resting-State Brain Networks enabled by Massive Multivariate Conditional Mutual Information
Padmavathi Sundaram, Martinos Center for Biomedical Imaging, Massachusetts General Hospital, Harvard Medical School, Boston, USA

Multivariate methods to characterise functional connectivity between pairs of regions in MEG/EEG
Laura Marzetti, University of Chieti-Pescara, Chieti, Italy

Time-Lagged Multidimensional Pattern Connectivity (TL-MDPC): A novel EEG/MEG Connectivity Metric
Setareh Rahimi, University of Cambridge, UK

Decoding feedback representations in ventral visual pathway
Yalda Mohsenzadeh, The University of Western Ontario, London, Canada, and The Vector Institute for Artificial Intelligence, Toronto, Canada

SYMPOSIUM NUMBER: 11

Applications of MEG in Psychiatry: The Past, Present and the Future

Co-chairs:
Peter Uhlhaas, Charite Universitätsmedizin, Berlin, Germany, and Krish Singh, Cardiff University, United Kingdom

Symposium description:
The application of neuroimaging to provide mechanistic insights into circuit dysfunctions in major psychiatric conditions and the development of biomarkers are core challenges in psychiatric research. This symposium will provide a state-of-the-art overview on current and future applications of MEG in psychiatry. Tal Kenet (MGH/HMS Martinos Center for Biomedical Imaging) will present an overview on applications of MEG in Autism Spectrum Disorders with a focus on changes in local and long-range connectivity in resting-state recordings and during sensory- and face-processing paradigms. Current perspectives of MEG-research for affective disorders will be discussed by Jessica Gilbert (NIH). She will summarise recent studies that examined the possibility to develop MEG-biomarkers for responses to ketamine in major depression and suicidal ideation. James Rowe (University of Cambridge) discusses MEG-applications for understanding dementias. He will present studies that integrated computational modelling, pharmacology and MEG to identify circuit dysfunctions in frontotemporal dementia. Peter Uhlhaas (Charite/University of Glasgow) will provide a synthesis and perspective on the application of MEG towards identifying circuit dysfunctions and biomarkers in schizophrenia and emerging psychosis, with a particular focus on at-risk populations. In the final presentation, Alex Shaw (Cardiff) discusses the combination of pharmacological modelling, computational modelling and advanced MEG-approaches towards the identification of neurobiological mechanisms in psychiatry.

Speakers:
Pharmacological modelling, computational modelling and advanced M/EEG -approaches towards the identification of neurobiological mechanisms in psychiatry
Dr Alexander Shaw, Cardiff University Brain Research Imaging Centre, Cardiff, United Kingdom

Using Magnetoencephalography to identify circuit dysfunctions and biomarkers in schizophrenia
Peter Uhlhaas, Charite, Berlin, Germany, and University of Glasgow, Glasgow, United Kingdom

From MEG to biophysical models of dementia and its treatment
Professor James Rowe, University of Cambridge, Cambridge, United Kingdom

Developing MEG Biomarkers of Ketamine Response in Major Depression
Dr Jessica Gilbert, National Institute of Mental Health, Bethesda, USA

The Pattern of Functional connectivity Abnormalities in ASD: It depends
Assistant Professor Tal Kenet, Massachusetts General Hospital, Boston, USA

SYMPOSIUM

NUMBER: 12

Infant MEG: Examining normal and abnormal brain development

Co-chairs:
Yuhan Chen, The Children's Hospital of Philadelphia, Philadephia, USA, and Julia Stephen, The Mind Research Network, Albuquerque, USA

Symposium description:
Prenatal brain growth occurs at an astonishing rate and continues through early infancy. This rapid brain development allows for rapid acquisition of skills but has also been associated with "sensitive periods." Alterations in brain development during these periods may lead to long-term consequences for behavioral and cognitive functioning. Therefore, understanding how brain dynamics change through infancy may provide opportunities to better understand the critical features of brain development, identify early markers of altered brain development with long-term consequences on cognitive and behavioral function and open opportunities for early intervention. This symposium covers recent infant MEG research focuses on understanding early brain development, examining basic sensory processes as well as examining precursors to higher-level cognitive processes. with a focus on large sample studies. Presenting infant data from well over 100 infants, Dr. Yuhan Chen will discuss the creation of normative infant databases (auditory, visual, resting-state, and face processes). Moving to pathology, Dr. Julia Stephen will present findings on atypical brain development in at-risk infants, Dr. Heather Green brain abnormalities in infants at-risk for developmental disorders, and Dr.PäiviNevalainen will discuss the somatosensory cortical responses in term and preterm infants. Finally, moving to clinical patient population, Dr. Banu Ahtam will discuss about utilizing baby MEG for pre-surgical localization of epileptiform activity in pediatric populations. It is hoped that the symposium facilities discussion the methods used to identify clinically relevant infant MEG measures.

Speakers:
Somatosensory cortical responses in term and preterm infants
Dr Päivi Nevalainen, HUS medical imaging center, University of Helsinki and Helsinki University Hospital, Finland

Infant brain development: Differential maturation of auditory, visual and resting-state systems
Dr. Yuhan Chen, The Children's Hospital of Philadelphia, USA

Examining the effects of prenatal exposures on infant brain development
Dr. Julia Stephen, Mind Research Network, Albuquerque, USA

Auditory latency a potential biomarker for infants at-risk for developmental disorders
Dr. Heather Green, Children's Hospital of Philadelphia, USA

BabyMEG for Pre-surgical Localization of Epileptiform Activity in Pediatric Populations
Dr. Banu Ahtam, Boston Children's Hospital, Harvard Medical School, USA

SYMPOSIUM
NUMBER: 13

Oscillations and memory: From local to large-scale synchronization, from working memory to long-term memory, from correlation to causation

Chair:
Satu Palva, University of Glasgow, United Kingdom

Symposium description:
Several prior studies using MEG, EEG and iEEG have shown that local brain oscillations as well as large-scale connectivity in multiple frequency bands are modulated during tasks calling on working memory (WM) and long-term memory (LTM) in humans. Yet the specific functional roles of these oscillations in the representation of different kinds of sensory information in memory as well as their differential contributions to WM and LTM are poorly understood. This symposium will discuss recent results using source-reconstructed MEG / EEGdata on the macroscale, as well as invasive recordings in monkeys and humans on the microscale during WM and LTM tasks. We will first discuss the specific fingerprints of large-scale networks underlying the maintenance of feature-specific information and contents of visual WM as well as its executive control. We will show usingsource-reconstructed MEG datathat narrow-band large-scale synchronization predicts WM maintenance but only narrow-band alpha synchronization was correlated with feature-specific information. We next present studies using humans MEG and monkey LFP data showing role of beta oscillations in ensemble formation involved in maintenance of information in WM as well as subsequent decision in discrimination task. We then extendthe discussion to the relationship between LTM and WM. We will present data on how alpha/beta and theta/gamma oscillations are related to memory formation and retrieval, with an emphasis on the role of gamma oscillations in the hippocampal system. Finally, we discuss the causal relationship between fronto-parietal theta oscillations and working memory performance by presenting studies combining information-based neuromodulation (rhTMS/visual rhythmic stimulation/MEG/EEG) and longitudinal WM training. We will show how such optimized noninvasive brain stimulation procedure (targeting functional relevant oscillatory metrics) can enhance brain plasticity and improve behaviour. In summary, in our symposium we will speak about how different oscillations and their within-frequency and cross-frequency interactions coordinate memory formation.

Speakers:
A role for beta oscillations in flexible ensemble formation
Saskia Haegens, Columbia University, New York, USA, and Donders Centre for Cognitive Neuroimaging, Nijmegen, Netherlands

Alpha-band network synchronization in maintenance of working memory contents
Prof. Satu Palva, University of Glasgow, Glasgow, United Kingdom, and University of Helsinki, Helsinki, Finland

Driving working memory with information-based neuromodulation
Dr Philippe Albouy, Laval University - Psychology department, CERVO brain research centre, and BRAMS-CRBLM, Montréal, Canada

How synchronization and de-synchronization processes in the human brain form and retrieve episodic memories
Dr. Simon Hanslmayr, University of Birmingham, Birmingham, United Kingdom

SYMPOSIUM NUMBER: 14

Contribution of MEG, EEG and TES to the presurgical diagnosis and treatment of epilepsy

Co-chairs:
Carsten Wolters, Institute for Biomagnetism and Biosignalanalysis, Münster, Germany, and Stefan Rampp, Department of Neurosurgery, University Hospital Erlangen, Erlangen, Germany

Symposium description:
Our session will present new methods and their successful application for the diagnosis and treatment of epilepsy. It will start with MEG source analysis successfully used to localize epileptic foci and high-frequency oscillations in adult and pediatric populations. It will include the largest MEG source analysis epilepsy patient cohort study performed up to date (Rampp et al., Brain, 2019). In the second part, multimodal MEG, EEG and MRI source analysis methods based on individualized and calibrated head models will be proposed and successfully applied in the context of epilepsy and their superiority over standard approaches will be demonstrated. Finally, a new targeted (using combined MEG/EEG source analysis) multi-channel transcranial electric stimulation (TES) optimization approach will be proposed to be used for patients who are unsuitable surgery candidates and for whom a series of stimulation sessions over a longer period of time are planned with the goal to inhibit epileptic activity and thereby reduce the number of seizures.

Speakers:
MEG detection of HFOs and stereo-EEG validation in pediatric epilepsy surgery
Dr Elaine Foley, Aston University, Birmingham, United Kingdom

Combined EEG/MEG targeting and optimized transcranial electric stimulation in an inoperable epilepsy patient
Marios Antonakakis, Institute for Biomagnetism and Biosignal Analysis, Münster, Germany

Combined EEG/MEG beamforming can outperform single modality EEG or MEG in presurgical epilepsy diagnosis
Frank Neugebauer, University of Münster, Münster, Germany

Magnetoencephalography for epileptic focus localization: A series of 1000 cases
Dr. Stefan Rampp, University Hospital Erlangen, Department of Neurosurgery, Erlangen, Germany, and University Hospital Halle (Saale), Department of Neurosurgery, Halle (Saale), Germany

Neuromagnetic evidence of remote functional suppression from temporal lobe epilepsy to primary sensory cortex
Nobukazu Nakasato, Tohoku University School of Medicine, Sendai, Japan

MEG exploring epileptic discharges in insula
Hiroshi Otsubo, The Hospital for Sick Children: Toronto, CA

SYMPOSIUM NUMBER: 15

The pathophysiology of mild Traumatic Brain Injury

Chair:
Paul Furlong, Aston University, Birmingham, United Kingdom

Symposium description:
Despite the world-wide high incidence of mild traumatic brain injury (mTBI), estimated to be > 600 per 100,000 people annually, its diagnosis remains challenging. The pathophysiology of mTBI is poorly understood but neurochemical, metabolic, and structural damage are thought to lead to post-concussive symptoms (PCSs). These complaints spontaneously resolve in about 80% of cases within three months, but the rest show persistent long-term cognitive, emotional and/or behavioural impairments, often without trauma-specific changes in structural brain imaging (MRI and CT).

As there are currently no unequivocal brain imaging markers available for mTBI, the diagnostic criteria are based on clinical findings, and assessing treatment efficacy is based on patient report of symptom remission. In the absence of objective trauma indicators, healthcare professionals may fail to recognize these patients. In addition, follow-up is often difficult to determine as there are no objective measures to gauge brain recovery. Finally, regarding the interpretation of brain imaging findings in mTBI, it is of note that co-morbidity of Post Traumatic Stress Disorder (PTSD) adds complexity to the mTBI diagnosis due to a substantial overlap in the symptoms of these two disorders.

This symposium explores recent advances in the development and application of MEG in mTBI. Topics include studies in the acute and chronic phases post injury, in both paediatric and adult populations, as well as military and civilian cohorts. We will explore how PTSD and mTBI can be differentiated using MEG.

Data will show how changes in local and large-scale neural network synchrony and in source magnitude measures, are related to symptoms and scores in neuropsychological exams in mTBI patients. Furthermore, we explore the application and value of machine learning techniques on MEG data to aid differential diagnostics and prognosis. This symposium will frame future priorities to aid in diagnosis and prognosis of a 'silent epidemic'.

Speakers:
Neural injury in adolescents with concussion: a longitudinal study
Dr Yu-han Chen, Children's Hospital of Philadelphia, Philadelphia, USA

MEG can reveal aberrant oscillatory activity after mild traumatic brain injury
Dr. Hanna Renvall, Department of Neuroscience and Biomedical Engineering, Aalto University, Espoo and BioMag Laboratory, Helsinki University Hospital, Helsinki, Finland

The Role of Magnetoencephalography and Dynamic Functional Connectivity For Building Biomarkers tailored to mild Traumatic Brain Injury
Dr Marios Antonakakis, Cubric Neuroimaging Centre, School of Psychology, Institute of Psychological Medicine and Clinical Neurosciences, School of Medicine, School of Psychology, Neuroscience and Mental Health Research Institute, MRC Centre for Neuropsychiatric Genetics and Genomics,School of Medicine, and Neuroinformatics Group, Cardiff University Brain Research Imaging Center (CUBRIC), School of Psychology, United Kingdom

Resting-State MEG source Imaging with deep-learning neural network for accurate classifications of combat-related mild TBI
Dr. Mingxiong Huang, University of California San Diego, and VA San Diego Healthcare System, San Diego, USA

Mild traumatic brain injury results in spontaneous and motor-circuit beta burst deficits in the subacute phase
Dr. Benjamin Dunkley, Hospital for Sick Children, Toronto, Canada

SYMPOSIUM NUMBER: 16

Insights into the laminar basis of neural oscillations: multimodal and multi-species approaches

Co-chairs:
Mathilde Bonnefond, Inserm, Lyon, France, and James Bonaiuto, CNRS, Lyon, France

Symposium description:
One of the major challenges of systems neuroscience is to determine whether brain oscillations serve any functional role in local computations and brain communication or whether they are simply an epiphenomena of recurrent neural circuitry. To tackle this challenge, it is crucial to study oscillations at the level of cortical layers since specific, falsifiable predictions can be derived from different theoretical frameworks at this scale. In light of these frameworks, this symposium will introduce different methodological approaches to investigate the laminar profile of oscillations within the visual cortical hierarchy, from laminar fMRI-EEG and high precision (laminar) MEG, to laminar electrode recordings in both monkeys and humans.

Speakers:
Feature specific cortical oscillations on a laminar scale: High resolution fMRI and simultaneous EEG unveil differential high and low frequency-band responses in different cortical layers in human visual cortex
Tommy Clausner, Inserm, Lyon, France, Donders Institute, Nijmegen, Netherlands

Frequency and laminar specificity in visual and sensorimotor cortical dynamics
James Bonaiuto, CNRS, Lyon, France

Laminar dynamics of beta activity in premotor and primary motor cortex in humans and nonhuman primates
Siqi Zhang, Institut des Sciences Cognitives – Marc Jeannerod – CNRS, Lyon, France

Laminar interactions in the generation of visual and motor event-related fields
Maciej Szul, Institut des Sciences Cognitives – Marc Jeannerod – CNRS, Lyon, France

Multi-modal approaches of inferring laminar origins in cortical speech processing
Saskia Helbling, Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany

SYMPOSIUM

NUMBER: 17

Tracking neural development of cognitive functions

Co-chairs:
Margot J. Taylor, Hospital for Sick Children, Toronto, Canada and Charline Urbain, Université Libre de Bruxelles, Brussels, Belgium

Symposium description:
Unravelling the developmental bases of high-level cognitive functions is critical to understand brain function and dysfunction across the lifespan. MEG studies show tremendous age-related changes in brain activity, its localisation, timing and oscillation frequencies. The challenge is developing neuroimaging tasks that assess complex cognitive functions across age ranges that can also be applied to clinical paediatric populations. We present cutting-edge MEG investigations of cognitive function in typically developing and clinical youth, focussing on cognitive and social-cognitive processing through four presentations:

1) The role of sleep in memory formation, using a task completed pre- and post a 90minute nap or wakeful rest, all while in the MEG. Sleep impacts theta-band brain synchronization (connectivity) mechanisms associated with the delayed retrieval of new declarative memories in children; its role will be discussed with regard to children with epilepsy who have accelerated long-term forgetting.

2) The importance of theta oscillations, anchored in the temporo-parietal junction, is studied in embodied perspective taking in adults and adolescents, highlighting the embodied origins of high-level social and spatial cognition. In contrast, adolescents with autism utilise alpha oscillations, suggesting a distinct strategy.

3) Functional networks that underlie emotional face processing were determined in a large series of youth (300 participants, 5-19years of age) including typically developing and three groups of neurodevelopmental disorders (ASD, ADHD, OCD). Results highlight frequency-specific differences as well as significant overlap across groups.

4) Creative analyses of phonological and semantic interactions during language processing in high-functioning autism show distinct temporal-parietal delays. Current studies are extending this work to minimally verbal ASD and Fragile-X populations. A link between motor and language development is highlighted.

All these aspects of cognition have protracted maturational courses. Determining their development, in both typical and atypical populations, facilitates the understanding of these abilities, brain-behaviour relations across age and future translational clinical applications.

Speakers:
Orchestrating sound and meaning in language development: Insights from MEG
Dr. Maria Mody, MGH Athinoula A. Martinos Center for Biomedical Imaging, and Harvard Medical School, Boston, USA

Rhythm makes the world go round: MEG oscillatory analysis of embodied perspective taking in typical and autistic individuals
Prof Klaus Kessler, Aston University, Birmingham, United Kingdom

Functional networks underlying emotional face processing in children with neurodevelopmental disorders
Dr. Kristina Safar, Hospital for Sick Children, Toronto, Canada

Investigating the developmental advantage of slow sleep oscillations on memory-related brain connectivity mechanisms
Dr Charline Urbain, Université Libre de Bruxelles, Brussels, Belgium

SYMPOSIUM NUMBER: 18

Open source and the MEG community: advancing science together

Co-chairs:
Britta Westner, Aarhus University, Aarhus, Denmark, and Caroline Witton, Aston University, Birmingham, United Kingdom

Symposium description:
Data analysis in MEG research relies heavily on open source toolboxes. Their openness makes them transparent data analysis tools and they are one of the main pillars for reproducible research and open science. However, while sharing of data and open access publishing is often discussed in the MEG community, the contribution to open source projects seems to be less in the focus and is often limited to a relatively small pool of developers. In this symposium, we aim to bring open source efforts closer to the MEG community. Rather than summarising the capabilities of the existing toolboxes, which are well-documented, we focus on the broader ecosystem of open source tools in MEG and how user communities and developers can work together to advance our science. We investigate how open source development can enable and catalyze reproducible research efforts, within and beyond the toolboxes' horizons. Maintainers and contributors will share their experiences and their vision of the open source community in MEG research, giving insights into the inner workings of open source efforts and toolbox development. We hope to motivate a greater number of people of different groups and diverse backgrounds to contribute to open source software development efforts. We also hope to advocate for a greater recognition of the value of open source efforts in our scientific field.

Speakers:
Alone you go fast but together we go far": the reason for community-driven MEG/EEG open source software
Dr Alexandre Gramfort, Inria, Palaiseau, and CEA/Neurospin, Gif-sur-Yvette, France

Maintaining open source code for scientific impact that lasts
Dr. Robert Oostenveld, Radboud University, Nijmegen, Netherlands, and Karolinska Institutet, Stockholm, Sweden

The perspective and motivations of a contributor to two different open source packages
Dr Johanna Zumer, Aston University, Birmingham, United Kingdom

The Brain Imaging Data Structure (BIDS), a common standard to advance neuroimaging
Dr Guiomar Niso, Universidad Politecnica de Madrid, Madrid, Spain

Reproducible results across open-source toolboxes and commercial software!?
Prof. Lauri Parkkonen, Aalto University, Espoo, Finland

SYMPOSIUM
NUMBER: 19

Predicting clinical endpoints from M/EEG: Challenges and opportunities of large-scale data analysis

Co-chairs:
Denis Engemann, Inria / Neurospin, Paris, France, and Riitta Salmelin, Aalto University, Aalto, Finland

Symposium description:
MEG/EEG offer a unique window on brain functions in both health and disease through its coverage of brain dynamics across vast temporal scales. Combined with novel computational analysis, M/EEG provides great potential to improve clinical diagnostics and prognostic modeling in pathologies such as autism spectrum disorders, multiple sclerosis, disorders of consciousness and in sleep medicine. However, M/EEG-based development of clinical biomarkers incurs multiple methodological issues.

Progressing from group-level commonalities to proper sensitivity in detecting individual differences is difficult, and SNR issues are aggravated in the clinical settings due to the patient-related limitations, increasing the importance of data denoising and preprocessing techniques. Ideally, the data processing pipelines should be automatised to minimize human processing time and the level of needed expertise, both extra costly in the clinic. Source localization may not be always available in practice, hence, alternative procedures are necessary to account for volume conduction. Multimodal analysis, including behavioral, clinical, and other neuroimaging measures, pose additional challenges. Finally, the assumption of stationarity made by source localization and spatial filter methods may occlude important information, which calls for a careful assessment of methodological limits and possible alternative approaches.

In this symposium, we bring together research combining MEG/G with predictive modeling in neurology and clinical neuroscience. Special emphasis is put on how recent results from machine learning and statistical modeling can enhance processing challenging clinical data at scale. The symposium will both demonstrate the recent advances in the field and, hopefully, generate the synergies needed to further advance the practical utility of MEG/EEG in clinical settings by increasing the cross-talk between researchers in M/EEG, clinical neuroscience and data science.

Speakers:
Brain spatiospectral fingerprints: Exploring heritable and individual characteristics in MEG data
Dr. Hanna Renvall, Department of Neuroscience and Biomedical Engineering, Aalto University, Espoo, Finland, and BioMag Laboratory, Helsinki University Hospital, Helsinki, Finland

Getting the most out of single-subject data by combining machine learning with expert knowledge
Dr. Marijn van Vliet, Aalto University, Espoo, Finland

Challenges in M/EEG-based biomarker development: Multimodal models with missing data, predicting from source power without MRI, cross-site/protocol generalization
Dr Denis Engemann, Inria, and Neurospin, Paris, France

Probabilistic models to bridge brain data and clinical phenotypes
Diego Vidaurre, Aarhus University, Aarhus, Denmark, and University of Oxford, Oxford, United Kingdom

Orals

All oral presenters have been allocated a day to present. These will take place on:

- Monday: 12.15 – 13.15
- Tuesday: 12.30 – 13.30
- Wednesday: 12.30 – 13.30

Please view this **document** to see the list of oral presentations and when they will take place.

All oral presentations are 10 minutes long and will be presented in the order they appear in the above document.

OM1 The relationship between gamma-band oscillations, BOLD dynamics and $GABA_A$-receptor density in visual working memory

Jan Kujala[1], Carolina Ciumas[2,3], Julien Jung[2,4], Sandrine Bouvard[3,5], Françoise Lecaignard[2,5], Amélie Lothe[2], Romain Bouet[2], Philippe Ryvlin[2,3,6], Karim Jerbi[7]

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[2]Lyon Neuroscience Research Center, Lyon, France.
[3]Institute for Child and Adolescent with Epilepsy, Lyon, France.
[4]Department of Epileptology and Functional Neurology, Lyon Neurological Hospital, Lyon, France.
[5]CERMEP imaging center, Lyon, France.
[6]Department of Clinical Neurosciences, CHUV, Lausanne, Switzerland.
[7]Department of Psychology, University of Montreal, Montreal, Canada

Distinct brain imaging techniques provide complementary insights into brain function by tapping into distinct signatures of brain activity at multiple levels. The downside is that the diversity of modalities has also led to a fragmented view of the neural bases of cognition. A handful of studies have sought to overcome this limitation by combining insights from multiple imaging modalities, such as methods that probe hemodynamic and oscillatory responses as well as GABA concentration. However, previous work exploring the links between such measures has focused on primary sensory or motor areas. How these measures relate to one another in the case of higher-order cognitive processes, such as working memory (WM), is still poorly understood. Here, we collected multimodal data within the same subject cohort in a standard n-back WM study, using magnetoencephalography, functional magnetic resonance imaging and Flumazenil positron emission tomography. This allowed us to probe the relationship between $GABA_A$-receptor distribution, electrophysiological and hemodynamic modulations during WM task performance. Our results revealed that GABAA-receptor density in higher-order cortical regions correlated positively with the peak frequency of gamma-band power modulations and negatively with BOLD amplitude. Furthermore, significant correlations between neural measures and behavioral outcomes were observed exclusively between $GABA_A$-receptor density and reaction times. These finding extend previous work by characterizing the link between GABAergic inhibition, gamma oscillations, hemodynamic and behavioral responses during WM performance.

OM2 Neurochemistry-enriched dynamic causal models of magnetoencephalography, using magnetic resonance spectroscopy

Amirhossein Jafarian[1], Laura Hughes[1], Natalie E Adams[1], Ms Juliette Lanskey[1], Ms Michelle Naessens[1], Mr Matthew Rouse[1], Alexander Murley[1], Karl J Friston[2], James B Rowe[1]

[1]University of Cambridge, Cambridge, United Kingdom. [2]University College London, London, United Kingdom

We propose a hierarchical empirical Bayesian framework to test hypotheses of neurotransmission, illustrated by the combination of magnetoencephalography (MEG) and ultrahigh field magnetic resonance spectroscopy (7T-MRS). At the first level, dynamic causal modelling of cortical microcircuits is used to estimate the parameters of generative models of the MEG observations. At the second level, empirical priors on synaptic connectivity are introduced, using 7T- magnetic resonance spectroscopy (MRS) estimates of regional neurotransmitter concentration. We compare the evidence for different distributions of these neurotransmitter priors over subsets of synaptic connections, each defined as monotonic functions of the spectroscopy. For efficiency and reproducibility, we use Bayesian model reduction (BMR), parametric empirical Bayes (PEB) and variational Bayesian inversion. BMR was used to compare alternative models of how spectroscopic neurotransmitter variance influence synaptic connectivity. We apply this approach to a multimodal resting-state MEG (i.e., task free paradigm) and 7T-MRS dataset from healthy adults. Predictive validity was assessed by split-sampling of the MEG dataset. We confirm that GABA concentration influenced local recurrent inhibitory intrinsic connectivity in deep and superficial cortical layers. In contrast, glutamate influenced excitatory connections between superficial and deep layers and connections from superficial to inhibitory interneurons. We suggest that such neurochemistry-enriched dynamic causal models have diverse applications in magnetoencephalography or electroencephalography studies, and are well-suited to reveal the mechanisms of neuropsychiatric disorders, and their treatment.

OM3 Functional connectivity changes during working memory in autism spectrum disorder: 2-year longitudinal MEG study

Julie Sato[1,2], Kristina Safar[1], Vanessa M. Vogan[1,2], Margot J. Taylor[1,2]

[1]Hospital for Sick Children, Toronto, Canada. [2]University of Toronto, Toronto, Canada

Background: Working memory (WM) deficits are associated with symptom severity in children with autism spectrum disorder (ASD). Successful WM relies on the interaction among brain regions to support the maintenance and retrieval of information. However, little is known about developmental changes in the underlying WM network connectivity in ASD.

Methods: Using MEG we investigated longitudinal differences in whole-brain connectivity during a 1-back visual, abstract pattern WM task, testing twice with a 2-year interval, in 17 children with ASD and 15 age- and sex-matched typically developing (TD) children (7-14 years). A mixed ANOVA design was used, with time (repeated factor: Time 1 [T1], Time 2 [T2]) and group (between-group factor: ASD, TD), controlling for age. Functional connectivity between pairs of the 90-region Automated Anatomical Labelling atlas was computed using the phase-lag index.

Results: Significant main effects of time in the theta (4-7 Hz), alpha (8–14 Hz), and gamma (30–55 Hz) frequency bands were found during the WM recognition period (0-300ms), such that connectivity within these networks increased between T1 and T2. All networks had hubs in prefrontal regions known to be involved in WM (e.g., left dorsolateral prefrontal cortex), as well as temporal (left middle temporal gyrus, right hippocampus) and occipital regions. No significant main effect of group, nor group-by-time interaction was found reflecting similar developmental trajectories in ASD and TD children.

Discussion: Our results show increased network connectivity over a 2-year period in children with and without ASD, demonstrating the continued development of WM mechanisms over middle childhood.

OM4 The effect of age on neuronal power spectra; results across 4 large datasets and over 1,000 participants.

Andrew Quinn, Ms Jemma Pitt, Anna Nobre, Mark Woolrich

Oxford Centre for Human Brain Activity, Oxford, United Kingdom

Background: Brain network changes across the adult lifespan are observable in electrophysiological recordings of human brain activity. Here, we identify markers of ageing in neuronal oscillations and explore whether they are robust to differences in physiology, acquisition and recording modality.

Methods: We analyse sensor power spectra using a temporal General Linear Model (GLM) at the individual subject level, by using the output from a sliding window Fourier Transform at each frequency separately as the dependent variable while controlling for covariates such as blinking and scan duration. A group GLM then models between-subject factors such as head-size, sex, acquisition site and age. We explore four datasets: CamCAN, MEGUK Megin VectorView data, MEGUK CTF-275 data and the EEG LEMON dataset.

Results: All four datasets show a similar power spectrum, with a 1/f type slope interrupted by a prominent alpha oscillation and a more subtle beta oscillation. Three of the four datasets show a decrease in low frequency power around 5Hz in older adults. All four datasets show a pronounced decrease in alpha peak frequency in older adults and three of the four show a decrease in alpha power as well. Finally, all four datasets show marked increase in beta power in older adults relative to younger adults.

Discussion: The effect of ageing in neuronal power spectra across healthy ageing is robust and reproducible at the group level. Covariate effects such as sex, head-size and acquisition site also have an impact on power spectra but do not confound the effect of ageing.

OM5

P300 is modulated by the concurrent changes in alpha rhythm amplitude

Alina Studenova[1], Denis Engemann[1,2], Tilman Hensch[3,4,5], Christian Sander[3,5], Ulrich Hegerl[6], Arno Villringer[1,7], Vadim Nikulin[1,8]

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[5]Department of Psychiatry and Psychotherapy, University of Leipzig Medical Center, Leipzig, Germany.
[6]Department of Psychiatry, Psychosomatics and Psychotherapy, Goethe University Frankfurt, Frankfurt, Germany.
[7]Department of Cognitive Neurology, University Hospital Leipzig, Leipzig, Germany.
[8]Neurophysics Group, Department of Neurology, Charite-Universitätsmedizin Berlin, Berlin, Germany

Introduction. P300 is the most extensively studied cognitive evoked response, yet the exact mechanism of its generation remains unclear. Aside from P300, the presentation of the target stimulus triggers attenuation of the alpha oscillations amplitude. Here, we tested whether P300 origin is attributed to a concurrent modulation of the alpha rhythm.

Methods. We analysed the data set of elderly participants (N=2308, 60-82 y.o.), using their resting-state EEG recordings to compute the baseline-shift index (BSI) and amplitude fluctuation asymmetry index (AFAI) quantifying vertical asymmetry of the alpha rhythm. From the event-related data, we extracted parameters of P300 and alpha rhythm amplitude envelope. The data was processed both in sensor and source space.

Results. According to our predictions, we showed that the P300 is linked to alpha amplitude in the following ways - (1) the sign of the BSI and AFA indices at Pz electrode was predominantly negative across participants which agrees with the positive polarity of P300 and decrease of alpha amplitude, (2) time courses of P300 and alpha envelope were correlated in a manner that was predicted by BSI and AFAI, (3) there was a similarity in the spatial locations of P300 and alpha modulation.

Discussion. Our results suggest that P300, at least partly, is generated by modulation of alpha oscillations. Therefore, changes in P300 related to different cognitive conditions, age or neuropathologies should be interpreted against the background of oscillatory neuronal dynamics.

OM6

The Oscillatory Dynamics Serving Verbal Working Memory are Altered in Preclinical and Prodromal Alzheimer's Disease

Amy Proskovec[1,2], Natalie Bell[1,2], Heidi Rossetti[1], Munro Cullum[1], Zabecca Brinson[1,2], Jarett Berry[1], Joseph Maldjian[1,2], Elizabeth Davenport[1,2]

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Background: In healthy adults, oscillatory dynamics within a predominantly left-lateralized network of brain regions underlie verbal working memory (VWM) performance, but how the preclinical (subjective memory complaint [SMC]) and prodromal (mild cognitive impairment [MCI]) stages of Alzheimer's disease (AD) impact these dynamics is not well characterized. We investigated the effects of SMC and MCI on the oscillations serving specific phases (encoding, maintenance) of VWM.

Methods: One-hundred-eight adults (50 cognitively healthy [CH], 34 SMC, 24 MCI, 60 female, M age = 61.46) completed a VWM task during MEG. All MEG data underwent standard preprocessing, were transformed into the time-frequency domain, and significant oscillatory responses relative to baseline were imaged using a beamformer. To determine the effect of group (CH, SMC, MCI), ANCOVAs were performed on the resulting whole-brain maps with age as a covariate, and follow-up t-tests were performed. Multiple comparisons were corrected for using a spatial extent threshold (k=500) based on the theory of Gaussian random fields.

Results: Across groups, decreases in alpha-beta (9-16 Hz) activity were seen in left fronto-temporal regions throughout encoding and maintenance. Significant group differences emerged in the anterior cingulate, inferior frontal, frontal eye field, and superior parietal cortices during encoding ($p<.05$, corrected). Both SMC and, to a lesser degree, MCI individuals exhibited increases in theta (4-7 Hz) activity within these regions, while these responses were largely absent in CH individuals.

Conclusions: Adults with preclinical and prodromal AD recruited additional neural resources during VWM performance. Our results support the compensation-related utilization of neural circuits hypothesis.

OT7 Motor-related oscillations change in schizophrenia according to phase of illness and clinical symptom profile

Lauren Gascoyne[1], Matthew Brookes[1], Mohanbabu Rathnaiah[1], Mohammad Zia Ul Haq Katshu[1], Loes Koelewijn[2], Gemma Williams[2], Jyothika Kumar[1], James Walters[2], Mrs Zelekha Seedat[1], Lena Palaniyappan[3], J F William Deakin[4], Krish Singh[2], Peter Morris[1], Peter Liddle[1]

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Background: The movement-related beta decrease (MRBD) and the post-movement beta rebound (PMBR) are well-characterised effects in MEG, with the latter relating to long-range connectivity. PMBR is diminished in schizophrenia patients, however little is known how this decrement relates to illness phase and symptom profile. Here we investigate this relationship and use burst analysis to characterise the signal underlying PMBR.

Methods: 29 recent-onset schizophrenia patients, 35 established patients, and 42 control cases undertook a MEG finger movement paradigm. PANSS clinical scores were recorded for patients. The MEG data were beamformed into the beta band (13-30 Hz) and averaged across trials to obtain PMBR amplitude. A hidden Markov model analysis was conducted to identify underlying pan-spectral burst states in each trial. The state that best correlated with the beta envelope was further examined.

Results: PMBR was diminished in both recent-onset and established cases compared to matched controls (corrected post hoc, $q<0.05$). In established cases, PMBR was significantly negatively correlated ($p<0.05$) with clinical severity of disorganization symptoms. Burst characteristics underlying PMBR also differ between healthy controls and patients, with amplitude and duration of bursts showing a greater degree of abnormality in established cases (corrected post hoc, $q<0.05$).

Discussion: Our findings confirm PMBR is diminished in different phases of schizophrenia compared to controls, with established cases showing a relationship between PMBR decrement and clinical severity of disorganization. Burst analysis extends this finding to show greater diminishment of bursts in established cases, indicating a relationship between persistent symptoms and reduced efficiency in long-range networks.

OT8 A multi-site magnetoencephalography resting-state dataset to study dementia: The BioFIND dataset

Richard Henson[1], Mr Delshad Vaghari[2]

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Early detection of Alzheimer's Disease (AD) is vital for developing effective treatments. Neuroimaging can detect early brain changes, such as hippocampal atrophy in Mild Cognitive Impairment (MCI), a prodromal state of AD. Machine learning can utilise the many features from high-dimensional neuroimaging data, but many cases are required. While large, public datasets of MCI/AD exist for Magnetic Resonance Imaging (MRI), eg "ADNI", comparable datasets are lacking for Magnetoencephalography (MEG). MEG offers advantages in its millisecond resolution, potentially revealing physiological changes in brain oscillations or connectivity before structural changes are evident with MRI (and unconfounded by vascular changes in functional MRI). Here we describe the "BioFIND" dataset of 324 individuals, approximately half MCI and half controls, who have at least 2 mins of resting-state MEG, plus a T1 structural MRI, from one of two sites (Cambridge and Madrid). To our knowledge, this is the largest publically available MEG dataset for dementia research, available in BIDS format on DPUK platform: https://portal.dementiasplatform.uk/Apply. Initial analyses using Multi-kernel Learning (MKL) of Support Vector Machines (SVM) show that MEG sensor covariance adds complimentary information for MCI classification beyond grey-matter volume from structural MRI. Future possible analyses include source space, measures of functional connectivity (e.g, amplitude or phase), dynamic as well as static connectivity, more advanced classifiers (e.g, deep learning); future plans include adding new participants from ongoing projects, and follow-up diagnoses and other biomarkers where available.

OT9 Dynamic causal modelling of the neurophysiology of Alzheimer's disease

Ms Juliette Lanskey[1], Amirhossein Jafarian[2], Melek Karadag[2], Ece Kocagoncu[2], Anastasia Klimovich-Gray[3,2], Andrew Quinn[4], Ms Jemma Pitt[4], Vanessa Raymont[5], Krish Singh[6], Mark Woolrich[4], Anna Nobre[4], Richard Henson[1,7]

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[4] Oxford Centre for Human Brain Activity, University of Oxford, Oxford, United Kingdom.
[5] Department of Psychiatry, University of Oxford, Oxford, United Kingdom.
[6] Cardiff University Brain Research Imaging Centre, Cardiff University, Cardiff, United Kingdom.
[7] Department of Psychiatry, University of Cambridge, Cambridge, United Kingdom

Background: Alzheimer's disease affects neurophysiology by loss of neurones, synapses and neurotransmitters, e.g. acetylcholine. A mechanistic understanding of the human disease will facilitate new treatments. Recent developments in biophysically-informed dynamic causal models enable inferences around laminar and cell-specific disease effects from human non-invasive imaging.1 Based on pre-clinical models and effects of cholinesterase inhibitors, we predicted Alzheimer's disease would affect superficial pyramidal cell gain and extrinsic connectivity in hierarchical cognitive networks.2

Methods: Magnetoencephalography was recorded during a mismatch negativity (MMN) task from healthy adults (n=15, amyloid-biomarker negative) and people with Alzheimer's disease (n=47, amyloid-biomarker positive) at baseline and 16 months. Sensor data confirmed group differences in MMN amplitude. For each participant, we inverted MMN responses to dynamic causal models. Second-level parametric empirical Bayes tested the effect of group, pTau-181 level and session (baseline vs follow-up) on pyramidal cell gain and extrinsic connectivity.

Results: Alzheimer's disease reduced the mismatch negativity response. Parametric empirical Bayes confirmed that (1) Alzheimer's disease reduced extrinsic connectivity and superficial pyramidal cell gain; (2) these parameters were conditional on pTau-181; and (3) changed further during follow up.

Discussion: Dynamic causal models confirmed that reduced superficial pyramidal cell gain and extrinsic connectivity can explain the observed physiological effect of Alzheimer's disease. These effects are opposite to the effects of galantamine.2 This approach to non-invasive magnetoencephalography data may be used for experimental medicine studies of candidate treatments and bridge human disease to preclinical models of drug efficacy.

1. Adams 2021 Brain
2. Moran 2013 JNeuroSci

OT10 Tau protein spreads through functionally connected neurons in Alzheimer's disease

Deborah Schoonhoven[1,2], Emma Coomans[2,3], Ana Millan[1], Anne van Nifterick[1,2], Denise Visser[2,3], Rik Ossenkoppele[3,4], Hayel Tuncel[3], Wiesje van der Flier[2], Sandeep Golla[3], Philip Scheltens[2], Arjan Hillebrand[1], Bart van Berckel[3], Cornelis Stam[1], Alida Gouw[1,2]

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[4] Clinical Memory Research Unit, Lund, Sweden

Several mechanisms could be behind tau-spread through the brain in Alzheimer's disease (AD): spreading between strongly interacting brain regions (functional connectivity); through the pattern of anatomical connections (structural connectivity); or simple diffusion to spatially adjacent regions. We investigated this by modelling tau-spreading on different networks, and compared the modelled tau-depositions with tau-depositions in several stages of the AD-continuum as measured with in-vivo 18F-flortaucipir PET. We collected eyes-closed, whole-head magnetoencephalography (MEG) recordings from 82 subjects with and without Aβ-pathology (CSF-Aβ42 and/or amyloid-PET). Subjects were classed as controls (subjective cognitive decline ((SCD) Aβ-,n=25), preclinical AD (SCD Aβ+,n=16), mild cognitive impairment (MCI) due to AD (n=16) or AD dementia (n=25). Tau-propagation was modelled as an epidemic process (susceptible-infected model) on a structural network, a diffusion network, or two functional networks in alpha (8-13Hz) and beta (13-30Hz) bands, derived from the source-reconstructed MEG data. The group-level control network was used as backbone for the model to predict tau spread in the next stages of the AD-continuum; parameters were tuned to produce an optimum correlation to the group-specific tau propagation patterns as measured with 18F-flortaucipir PET. Tau propagation was modelled to start from one seed region in the temporal cortex. The functional networks predicted tau-spread with highest accuracy in the preclinical AD stage (alpha r=0.59; beta r=0.58), followed by the structural network (r=0.45) and simple diffusion (r=0.44). Prediction accuracy declined for the MCI and AD dementia stages. Our results suggest that tau spreads through functional connections, rather than structural connections or simple diffusion.

OT11 MEG screening for mild cognitive impairment and dementia

Hideyuki Hoshi[1,2], Yoko Hirata[3,4], Momoko Kobayashi[5], Yuki Sakamoto[5], Víctor Rodríguez González[6,7], Carlos Gómez Peña[6,7], Jesús Poza Crespo[6,7,8], Yoshihito Shigihara[2,5]

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[5] Precision Medicine Centre, Kumagaya General Hospital, Kumagaya, Japan.
[6] Biomedical Engineering Group, University of Valladolid, Valladolid, Spain.
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[8] IMUVA, Instituto de Investigación en Matemáticas, University of Valladolid, Valladolid, Spain

Background: Dementia is one of the major health problems among elderly individuals. As a new clinical application of magnetoencephalography (MEG), we are developing a MEG screening method for dementia and mild cognitive impairment (MCI). We have collected over 300 resting-state MEG recordings from healthy controls and patients with dementia and MCI. In order to discriminate different pathological categories (dementia due to Alzheimer's disease, Lewy body dementia, frontotemporal dementia, MCI, and healthy controls, among others), sensor- and source-level MEG data have been analyzed by means of advanced signal processing algorithms. In this talk, preliminary results will be presented.

Method: We have recorded resting-state MEG data from 149 healthy controls, 64 patients with dementia, and 41 MCIs. The data acquisition protocol was patient-friendly: each participant undertook only 5 minutes MEG recording with eyes-closed condition. Spectral and entropy-related measures (e.g., relative power in the typical frequency band, mean frequency, Shannon's entropy) are calculated for each data. We also assessed the relationships between these variables, participants' age, cognitive level (MMSE score), and pathological labels.

Results: We have corroborated previous findings that spectral-related variables can capture the cognitive decline associated with dementia. We also found that the spatial distribution of the measures reflects pathological differences between subtypes of dementia.

Discussion: Resting-state MEG can capture dementia-specific cognitive decline, which may be useful for clinical screening. We discuss the pathological mechanisms which describes the relevance of resting-state MEG to dementia.

OT12 A multiple graph Gaussian embedding method with uncertainty quantification for predicting Alzheimer's disease progression

Mengjia Xu[1], David López Sanz[2], Pilar Garcés[2], Fernando Maestú[2], Quanzheng Li[3], Dimitrios Pantazis[1]

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Characterizing the subtle changes of MEG functional brain networks associated with the pathological cascade of Alzheimer's disease (AD) may be a key for early prediction of AD progression prior to overt clinical symptoms. We developed a deep learning-based graph Gaussian embedding method for identification and characterization of the early stages of AD using eye-closed resting state MEG data. Specifically, the deep neural network model can learn highly informative MEG brain network node-wise patterns by embedding high-dimensional MEG resting state brain networks into a latent probabilistic space (i.e., multivariate Gaussian distributions). The MEG brain network embedding signatures enable quantitative capturing of subtle and heterogeneous node-wise brain connectivity patterns as well their uncertainty quantification. Moreover, the embedding signatures can be used as input to traditional classifiers for various downstream graph analytic tasks (e.g., AD risk stratification, statistical evaluation of between-group significant changing regions, etc.). Experimental results show that our method could provide a novel quantitative approach to extract node-wise probabilistic Gaussian distribution embeddings that can lead to accurate and informative forecasting of AD progression prediction at diverse preclinical stages. Additionally, statistical evaluation results for the between-group significant brain regions facilitate better understanding of the underlying heterogeneous pathogenesis in AD progression, and may aid to improve the design of precision behavioral interventions. In general, our method motivates a wider adoption of deep learning-based stochastic graph embedding methods to other neuroimaging data. In the future, we will consider extensions to multimodal data (e.g., fMRI, MEG and PET) for more robust inference.

OW13 Fast processing during natural reading: rapid invisible frequency tagging reflects parafoveal semantic integration

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Semantic processing unfolds rapidly during natural reading. Emerging evidence has shown that semantic information can be activated for parafoveal words. But little is known about to what extent those semantic activations can be used — i.e., can be integrated with the emerging text and can shape later processing and behaviour.

Participants (n=34) read one-line sentences silently while brain activity and eye movements were recorded. Each sentence contained either a congruent or an incongruent target word (e.g., The purchase of a blue jacket/brother leads to…). The target words could not be predicted from the sentence context. We tagged the target word with an underlying patch that flickered at 60 Hz. The patch was invisible and did not interfere with natural reading. Coherence between tagging signal and brain activity during the pre-target fixation indexes the neural excitability associated with the parafoveal target word.

We found that the pre-target coherence was significantly weaker when the parafoveal target word was incongruent relative to congruent with the context. A negative correlation was found between the degree of parafoveal semantic violation (i.e., the pre-target coherence difference) and reading speed. These findings suggest that covert attention regresses backwards due to the interruption of reading when an incongruent word is pre-processed thus reducing reading speed.

Our study shows that semantic information is not only extracted before we saccade to the word but is also integrated into the context. This extensive parafoveal processing supports the fast semantic processing required for natural reading.

OW14 MEG, myself, and I: individual identification from neurophysiological brain activity

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Large, openly available datasets and current analytic tools promise the emergence of population neuroscience. The considerable diversity in personality traits and behaviour between individuals is reflected in the statistical variability of neural data collected in such repositories. This variability challenges the sensitivity and specificity of analysis methods. Yet, recent studies with functional magnetic resonance imaging (fMRI) have concluded that patterns of resting-state functional connectivity can both successfully identify individuals within a cohort and predict their individual traits, yielding the notion of a neural fingerprint. Here, we aimed to clarify the neurophysiological foundations of individual differentiation from features of the rich and complex dynamics of magnetoencephalography (MEG) resting-state brain activity in 158 participants. The resulting neurophysiological functional connectomes enabled the identification of individuals with similar identifiability rates to fMRI. We also show that individual identification was equally successful from simpler measures of the spatial distribution of neurophysiological spectral signal power. Our data indicate that identifiability can be achieved from brain recordings as short as 30 seconds, and that it is robust over time: individuals remain identifiable from recordings performed weeks after their baseline reference data was collected. Our results emphasize the value of MEG-based neural fingerprints. We can anticipate a vast range of diverse applications in the personalized, clinical, and basic neuroscience of individual differentiation from large-scale neural electrophysiology, in future longitudinal and cross-section studies.

OW15 Pre-stimulus oscillation phase predicts visual perception

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Perception of and attention to visual stimuli has been proposed to fluctuate rhythmically. In line, correlation between pre-stimulus alpha and theta phase with stimulus detection and attention has been reported in frontal and posterior brain areas. However, the results are inconclusive as no prior studies have tested whether fluctuation in perception and attention are present concurrently. Moreover, the cortical sources underlying these putative phase-behavior relationships have remained scarcely addressed.

We used three visual threshold stimulus detection tasks together with magnetoencephalography (MEG) and individual-cortical-anatomy based source modeling to (1) test the hypothesis of pre-stimulus oscillations biasing stimulus detection and attention in separate frequencies and, importantly, (2) to identify the underlying cortical sources. Phase Opposition Sum (POS) was used to quantify phase-behavior coupling.

We found that the pre-stimulus phase in alpha and theta frequency bands was significantly predictive of visual detection performance in all three tasks. The phase-behavior correlation of theta oscillations was stronger in the task condition with a pre-stimulus attention cue, implying a functional role for theta in top-down attentional processes. Source modeling showed that the phase-behavior correlations arose predominantly in the fronto-parietal and cingulo-opercular control systems and in the hierarchy of task-relevant processing systems, i.e., the dorsal attention system and visual system.

These findings thus extend prior art by revealing that the pre-stimulus phase effects arise in the co-operation of brain systems achieving control and processing functions. Moreover, these findings corroborate the predictive nature of pre-stimulus phase in visual threshold stimulus detection in a comparable set of experimental paradigms.

OW16 Computational modeling of MEG evoked responses during visual word recognition using a convolutional neural network

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Neuroimaging studies have provided a wealth of information about when and where changes in brain activity might be expected during reading. We sought to better understand the brain processes that give rise to this activity and evaluated the suitability of a convolutional neural network as a model of the macro-scale computations performed by the brain during visual word recognition.

The model was a VGG11 network trained to recognize images of rendered text. It was compared to MEG evoked responses to written words, pseudowords, consonant strings, letter-like symbol strings, and noise embedded words. The same stimuli were presented unmodified to both the model and human volunteers. Guided equivalent-current-dipole (ECD) modeling was used to isolate three evoked components commonly observed during reading. The amplitude of these components was compared to the mean activity in each layer of the model.

In contrast to traditional models of reading, our model directly operates on the pixel values of a stimulus image, allowing for a simulation of the early (< 200 ms) responses that are associated with the detection and segmentation of letter shapes. Furthermore, the scale afforded by the deep learning architecture allows the model to have a large vocabulary of 10k Finnish words, facilitating/enabling a simulation of the N400m response to word-like versus non-word-like letter strings.

We conclude that the deep learning techniques that revolutionized models of object recognition can also create powerful computational models of reading, which will greatly facilitate testing and refining theories on language processing in the brain.

OW17 Travelling beta burst activity in the human sensorimotor cortex

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Beta oscillations in the human sensorimotor cortex are hallmark signatures of healthy and pathological movement. In single trials, beta oscillations include bursts of intermittent, transient periods of high-power activity. These burst events have been linked to a range of sensory and motor processes, but their precise spatial, spectral, and temporal structure remains unclear. Specifically, a role for beta burst activity in information coding and communication suggests spatiotemporal patterns, or travelling wave activity, along specific anatomical gradients. We here show in human magnetoencephalography recordings that burst activity in the sensorimotor cortex occurs in planar spatiotemporal wave-like patterns that dominate along two axes either parallel or perpendicular to the central sulcus. Moreover, we find that the two propagation directions are characterised by distinct anatomical and physiological features. Finally, our results suggest that sensorimotor beta bursts occurring before and after a movement share the same generator but can be distinguished by their anatomical, spectral and spatiotemporal characteristics, indicating distinct functional roles.

OW18 Interindividual variability in multimodal connectome

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Individuals are different in behavioural responses and cognitive abilities. Neural underpinnings of individual differences are largely unknown. Here, by using multimodal imaging data including diffusion MRI, functional MRI and MEG, we show the consistency of interindividual variation in connectivity across modalities. We calculated structural connectome from probability of connections estimated from tractography, functional connectome based on correlation of BOLD time series and envelope amplitude correlation of alpha and beta oscillations from MEG signals projected on cortical surface. We demonstrated that regional differences in individual variability of structural and functional connectomes is characterized by higher variability in association cortices and lower variability in sensory and visual cortices. This pattern is consistent across all modalities at varying degrees as shown by significant alignment between functional and structural connectome variabilities at several clusters of brain regions. Variability in connectivity was associated with cortical myelin content and microstructural properties of connections. Our findings contribute to understanding of individual differences in functional and structural organization of brain and facilitate fingerprinting applications.

Posters

All posters are numbered with two letters and a number.

The first letter indicates whether they are being presented In-Person (I) or Virtually (V).

The second letter indicates which day they are presenting on, Monday (M), Tuesday (T) or Wednesday (W).

For in-person posters, the number represents which poster board you will find the poster on. This is less important for the virtual posters but will help you to identify which virtual poster room to join.

POSTER THEMES

MONDAY:
Development and life span
OPM, MCG and hardware
Working and long-term memory

TUESDAY:
Clinical applications
Data analysis and modelling

WEDNESDAY:
Attention and higher cognition
Language, reading, speech and music
Motor system
Resting-state and network dynamics
Sensory system

IM-1

Periodic/Aperiodic Parameterization of Transient Oscillations (PAPTO) reveals novel adult lifespan changes in sensorimotor activity in the Cam-CAN open access dataset

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Background
Open-access big data is reshaping how we study and understand the healthy ageing human brain. At the same time, new neurophysiological signal analysis approaches (transient spectral events and aperiodic signal parameterization), are starting to bridge non-invasive recordings directly with behavior and thalamocortical network dynamics.

Methods
In this work, we investigate adult lifespan changes in sensorimotor transient beta (15–30Hz) events and aperiodic 1/f-like activity in M1/S1-localized neuromagnetic recordings from the open-access Cam-CAN dataset (n=600, ages=18-88). We unify the transient events framework with aperiodic signal parameterization in a technique we call the periodic/aperiodic parameterization of transient oscillations (PAPTO). PAPTO is available open access.

Results/Discussion
During a simple cued button press task, the occurrence rate and central frequency of beta events decreases linearly with age. These changes correlate to the known age-related changes in the induced beta rhythm responses associated with a sensorimotor task.

In resting state data from the same population, we discover quadratic ageing trajectories in several characteristics of transient events and 1/f-like aperiodic activity. These trajectories typically reach an extremum around 60 years, suggesting that 60 years is an age of critical significance in the ageing thalamocortical network.

PAPTO improves the sensitivity to beta events and reveals that the resting state occurrence rate of beta events nearly doubles across the adult lifespan. This finding may help explain age-related decline in sensory perception.

This work reveals a vast assortment of age-related changes in sensorimotor neuromagnetic signals that expand our understanding of the healthy ageing brain.

IM-2

Individual signatures of oscillatory brain activity in the maturing brain

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The variability of spectral power structure in cortical activity has recently been associated with genetic factors using Bayesian reduced-rank regression (BRRR) for extracting a low-dimensional representation of familial data features in siblings (Leppäaho et al. in Hum Brain Mapp. 2019; 40: 1391–1402). This approach has shown that the MEG spectral power structure is highly consistent within participants irrespective of experimental state, suggestive of subject-specific cortical fingerprints. How well the approach generalizes to more noise-prone and low-resolution clinical EEG data and, e.g., during brain maturation is not known.

Here we applied BRRR on 19-channel sleep EEG recordings (sleep stage N2) of ~800 healthy Finnish children (3 weeks -19 years of age) for finding the spatiospectral components that would maximally differentiate between subjects. The data were filtered at 1-40 Hz, and power spectral estimates, divided into 14 frequency bands, were calculated from four 1-minute data parts. Two spectral estimates per participant were randomly used for addressing the model accuracy, by calculating L1 distances between participants in the latent space.

Using 10-fold cross-validation, the test participants were distinguished from each other with > 85% average accuracy using 12 spatiospectral components. The latent space structure correlated with increasing age, possibly reflecting the decrease in total spectral power. The components were generally not consistent with participants' additional data but restricting analysis to the oldest subjects (>7 years) yielded within-subject accuracy of 65%. Future studies will address the effect of higher-density EEG recordings and of combined M/EEG recordings for within-subject model performance.

IM-3

Spectral signatures of cross-modal attentional control in the adolescent brain and its link with physical activity and aerobic fitness.

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Physical activity (PA) and aerobic fitness (AF) have been associated with improved attention, but most studies have focused on unimodal tasks. Cross-modal attention paradigms allow studying the potential influence of PA/AF on the brain basis of attention in a more naturalistic context. We studied the possible link between PA/AF and the neural correlates of cross-modal attention in the adolescent brain. Magnetoencephalography (Elekta Neuromag) was measured in 54 teenagers (13-16 years old). Participants were presented with a continuous and simultaneous stream of visual and auditory noise signals, with luminance/amplitude modulation at 15 and 40 Hz, respectively. As an active task, visual (a square either in the left or the right hemifield) and auditory (simple tones delivered either to the left or the right ear) stimulation were presented. A visual or auditory cue indicated which modality should be attended and the participant's task was to report on which side (left or right) the target appeared. A reliable peak in the power spectrum at the domain-specific tag frequency was detected in all (for visual cortex) and 37/54 (for auditory cortex) individuals. Participants in the high PA group showed stronger 15 Hz spectral entrainment of the bilateral occipital areas than the participants in the low PA group, independent of the attended modality. No significant effects were found for AF. Regular PA may thus influence the general entrainment of particularly visual areas with external stimulation, but current data do not evidence differential effects in cross-modal attention by PA or AF.

IM-4

Paediatric multiple sclerosis patients outperform typically developing children on a simple response motor task

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Paediatric multiple sclerosis (MS) patients commonly have motor movement and timing impairments possibly related to the impact of white matter damage on neural synchrony. A clear connection between motor-performance, motor-gamma-power (60-90Hz; known to play a key role in movement), and asynchrony has yet to be established in paediatric MS.
Nine children with MS (Mage 15.58yrs; 11-19.1yrs) and 11 controls (Mage 17.22yrs; 15.2-18yrs) completed two motor tasks (simple and complex choice) by identifying the direction a central arrow pointed on the screen by responding with their corresponding hand during magnetoencephalography (MEG) scanning conducted using a whole-head 151-channel system (CTF). Measures of reaction time, accuracy, and anticipation were derived. Motor-regions were selected from Fieldtrip's AAL atlas. Data was collected at sample rate of 600Hz, band-pass filtered from 1-150 Hz, baseline corrected, and divided into epochs (-2.0 to 2.0 s), with 0.05 defined as movement onset (i.e., response). Analysis was completed using R and a MATLAB Fieldtrip pipeline and artifacts rejected with visual inspection.
Patients exhibited less anticipatory button presses during both tasks, $ts > 2.249$, $ps < .005$, $ds > 1.499$, and greater correct responses during the simple choice left task, $t(14.88) = 2.506$, $p = .024$, $d = 1.103$. No other differences showed.
As all participants had similar peak motor-gamma frequencies, we plan to investigate motor-network integrity using network analysis to determine the root neural origins of observed performance differences. Further regions to consider include vision associated areas as common symptoms of MS include optic neuritis which may impact task performance.

IM-5

Different MEG peak alpha frequency in young children with and without autism spectrum disorder: a pilot study

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Background
Peak alpha frequency(PAF) is defined as the maximum power value in the frequency spectrum between 7.5 and 12.5 Hz. PAF reflects connectivity between the cerebral cortex and thalamus, and is known to increase as the brain matures. A recent animal study has shown that premature growth of neurons corresponded to later cognitive impairment. Interestingly, in humans, PAF is higher in adolescence with ASD compared to those who without, possibly implying the premature growth of the ASD brain. In younger individuals, however, the association between ASD and higher PAF remains to be tested.

Methods
We recruited 10 typically developing children (5 males, 60-89 months old) and _10children with ASD (5 males, 60-91 months old). After signal sources were localized onto the Desikan-Killiany brain atlas, we checked PAF in each brain region for each child. We compared PAFs between two groups and explore an association between PAFs and autistic symptoms.

Results
Atypical maturation of PAFs were observed in children with ASD in some brain regions possibly involved in social information processing. The associations between PAFs in those regions and autistic symptoms, however, were nonsignificant.

Discussion
Atypical PAFs of ASD were observed even in early developmental stages. The nonsignificant association between PAFs and autistic symptoms were possibly due to the small sample size. Those preliminary results are promising, but more participants are needed.

IM-6

Using Magnetoencephalography to evaluate the impact of psychological intergroup interventions

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Magnetoencephalography (MEG) has been long known to efficiently capture complex mechanisms underlying cognitive and affective processes. Surprisingly, MEG has been rarely applied in the field of social neuroscience. Here, we outline a novel approach using MEG recordings to assess the impact of intergroup interventions and thereby contribute to a major societal challenge of intergroup conflicts. This approach was implemented in two studies: Study 1 was framed within a violent and intractable conflict, with 45 participants undergoing MEG before and after an eight-week intervention to assess a neural marker of prejudice. The group receiving the intervention showed attenuation of the neural prejudice response, indexed by sustained occipital alpha that was no longer detected at post-intervention. Importantly, change in the neural prejudice response predicted attitudes of compromise and active engagement in peacebuilding 7 years later. Study 2 was framed within the timely context of attitudes towards unvaccinated individuals during the covid19 pandemic, with 36 participants undergoing MEG after an intergroup intervention versus control. Participants receiving the intervention, not the control condition, showed attenuation of implicit prejudice response - similar to the attenuation that was observed in Study 1. The findings reported in the two studies have societal implications for moderating the polarized attitudes in prolonged violent conflicts such as the Israeli-Palestinian conflict, as well as during new within-society conflicts such as the one of vaccinations of the covid pandemic. Furthermore, these findings highlight the innovative usefulness of MEG in studying social phenomena and in addressing timely societal challenges.

IM-7 Infant brain imaging using magnetoencephalography: Challenges, solutions, and best practices

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The excellent temporal resolution and advanced spatial resolution of magnetoencephalography (MEG) makes it an exceptional tool to study the neural dynamics underlying cognitive processes in the developing brain. Nonetheless, several challenges exist when using MEG to image infant populations. There is a persistent belief that collecting MEG data with infants presents a number of limitations that are difficult to overcome. Due to this notion, many researchers either avoid conducting infant MEG research or believe that, to collect high-quality data, they must impose limiting restrictions on the infant or the experimental paradigm. In this paper, we discuss the various challenges unique to imaging awake infants and young children with MEG and share general best-practice guidelines and recommendations for data collection, acquisition, preprocessing and analysis. The current paper is focused on methodology that allows investigators to test the sensory, perceptual, and cognitive capacities of awake and moving infants. We believe that this methodology opens a pathway for using MEG to provide mechanistic explanations for the complex behavior observed in awake, sentient, and dynamically interacting infants, thus addressing core topics in developmental cognitive neuroscience.

IM-8 Resting multispectral connectivity differences across development

Nathan Petro[1], Christine Embury[1,2], Lauren Ott1, Samantha Penhale[1], Maggie Rempe[1,3], Giorgia Picci[1], Yu-Ping Wang[4], Julia Stephen[5], Vince Calhoun[6,5], Gaelle Doucet[1,7], Tony Wilson[1,7]

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Background:
Assessing brain connectivity during rest has become a widely used approach to determine changes in functional brain organization during development. Generally, this work has demonstrated that brain regions become more interconnected from childhood into adolescence. However, the majority of this work has been based on fMRI measures, whereas multispectral functional connectivity, as measured using M/EEG, is less well characterized.

Methods:
Spontaneous cortical activity was recorded using MEG from 108 typically developing youth (9-15 years-old; 55 female) during eyes-closed rest. MEG source images were computed and connectivity was estimated in the canonical delta, theta, alpha, beta, and gamma bands. Connectivity was estimated using the imaginary part of the phase coherence, which was computed between 200 brain regions defined by the Desikan-Killiany cortical atlas. Connectivity maps were then submitted to regression models, with permuted significance thresholds, to identify differences as a function of age and sex.

Results:
Delta, theta, and alpha connectivity was stronger in older youths. These differences were most prominent in the alpha-band, with visual regions being primarily implicated. While these connections were stronger overall in females, males tended to show a stronger age-related increase in these connections.

Conclusions:
The age-related differences in resting multispectral connectivity are consistent with previous work where the brain becomes more integrated across development. Given that differences were most abundant in visual regions and within the alpha frequency band, the current results highlight integration of visual sensory regions with other brain networks across development.

IM-9

Normal and Pathological Transient Events in Ageing: Observations from Big MEG Data

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Background: Transient events - short bursts of brain activity - have been studied in recent years. However, there is little work observing trends in large datasets. Here, we characterize age-related spatiotemporal trends in normal and pathological transient events in a large population of healthy participants. Functional and clinical significance are considered.

Methods: MEG data from approximately 600 participants (18-88 years) were provided by the Cambridge Centre for Ageing and Neuroscience. Sensorimotor beta bursts were localized using novel source localization methods, and age-related changes in the spatial localization were assessed. Additionally, repeating spatiotemporal motifs were learned for each participant using convolutional sparse coding (CSC), and clustered across participants to reveal age-related trends in transients across the whole brain. Finally, pathological slow wave events were detected, and trends relating event characteristics to age and cognitive ability were explored.

Results: Transient beta bursts localized to the primary sensorimotor cortices exhibited a significant anterior shift in peak position with age. CSC automatically detected similar task-related transients across clusters of participants, indicative of occipital alpha and sensorimotor mu and beta bursts, and age-related changes in spatiotemporal characteristics were explored. As well, pathological slow wave events showed increased prevalence with age and an association with reduced cognitive performance.

Discussion: The current work employs a set of novel detection and localization methods to investigate transient events in normal ageing. This work demonstrates correlation between transient events and ageing and highlights the importance of investigating MEG signals in the raw data to learn more about normal and pathological neurophysiology.

IM-10

Neurotoxic effects of home radon exposure on oscillatory dynamics serving attention in children and adolescents

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Background:
Radon is a naturally occurring gas that contributes significantly to radiation in the environment and is the second leading cause of lung cancer globally. Previous studies have shown that other environmental toxins have deleterious effects on brain development, though radon has not been studied to date. This study explored the impact of home radon exposure on the neural oscillatory activity serving attention in youths.

Methods:
50 participants (ages 6-14 years) completed a Posner task during MEG, and home radon levels were measured for each participant. Time-frequency spectrograms indicated increased theta activity (3-7Hz, 300-800ms) and decreased alpha (9-13Hz, 400-900ms) and beta activity (14-24Hz, 400-900ms) during the task relative to baseline. Source reconstruction of each significant oscillatory band was performed, and then subtraction maps comparing task conditions (invalid-valid) were computed. These subtraction maps were examined for correlations with home radon exposure, controlling for age.

Results:
Children with greater radon exposure showed aberrant oscillatory activity in dispersed areas critical for attentional processing including theta activity in bilateral prefrontal cortices and left anterior insula, and beta activity in the anterior cingulate and right inferior parietal (r_s = -.499-.468). Generally, youths with greater radon exposure exhibited an inverse validity effect in all regions and showed greater overall power relative to peers with lesser radon exposure. Interestingly, there were no associations between radon exposure and task performance.

Discussion:
The data suggest disrupted, but potentially compensatory neural processing as a function of increasing home radon exposure in areas critical for supporting attention and higher order cognition.

IM-11

The effect of age on neuronal power spectra; results across 4 large datasets and over 1,000 participants.

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Background:
Brain network changes across the adult lifespan are observable in electrophysiological recordings of human brain activity. Here, we identify markers of ageing in neuronal oscillations and explore whether they are robust to differences in physiology, acquisition and recording modality.

Methods:
We analyse sensor power spectra using a temporal General Linear Model (GLM) at the individual subject level, by using the output from a sliding window Fourier Transform at each frequency separately as the dependent variable while controlling for covariates such as blinking and scan duration. A group GLM then models between-subject factors such as head-size, sex, acquisition site and age. We explore four datasets: CamCAN, MEGUK Megin VectorView data, MEGUK CTF-275 data and the EEG LEMON dataset.

Results:
All four datasets show a similar power spectrum, with a 1/f type slope interrupted by a prominent alpha oscillation and a more subtle beta oscillation. Three of the four datasets show a decrease in low frequency power around 5Hz in older adults. All four datasets show a pronounced decrease in alpha peak frequency in older adults and three of the four show a decrease in alpha power as well. Finally, all four datasets show marked increase in beta power in older adults relative to younger adults.

Discussion:
The effect of ageing in neuronal power spectra across healthy ageing is robust and reproducible at the group level. Covariate effects such as sex, head-size and acquisition site also have an impact on power spectra but do not confound the effect of ageing.

IM-12

Spontaneous cortical activity across the lifespan

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Background:
There has been a recent surge in the characterization of resting-state spontaneous activity and its temporal dynamics using magnetoencephalography (MEG). Currently, the resting-state MEG literature lacks studies capturing the full lifespan with good spatial specificity. Here, we address these pitfalls using the largest lifespan sample to date.

Methods:
434 participants between the ages of 6 and 84 years-old completed an eyes-closed resting-state MEG recording. ANCOVAs were performed on whole-brain relative and absolute power maps across the entire cortex testing the effects of age and sex. Further, power values were extracted from the peak of significant clusters and used to test quadratic relationships in age effects using a hierarchical regression approach.

Results:
We found spatially specific age-related differences in delta, theta, alpha, beta, and gamma frequency bands ($pFWE<.05$) in both relative and absolute power maps. In addition, we identified sex differences specifically in absolute power in delta, theta, and alpha frequency bands ($pFWE<.05$). Finally, age-related effects were found to be quadratic in many frequency bands, though these patterns of results differed between absolute and relative power maps.

Conclusions:
As the largest MEG resting-state lifespan study to date, we characterize spatially specific age and sex-related differences in spontaneous cortical activity. Moreover, we identified key differences between relative and absolute power maps regarding the presence of age and sex differences. These findings provide critical new data on the trajectories of neural activity across the full lifespan, as well as novel insight on how different methodological approaches can lead to disparate conclusions.

IM-13

Maturation of movement-related brain activity in early childhood during a passive movement task

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Motor control is essential for daily life and promotes independence. However, the underlying maturational trajectory of motor control in children is not well understood. Previous MEG studies (Cheyne et al., 2014; Johnson et al., 2020) found that brain activity during self-paced movements in children does not resemble adult-like activity up to 7 years of age. In the current study, we examined whether similar developmental trends are present for passive movement-related brain activity in children aged 6 to 10 years. Neuromagnetic activity was recorded in six children who watched a video while a pneumatically-powered cylinder lifted their right index finger with a random interstimulus interval (3 to 3.2 s). Beamformer analysis revealed movement evoked fields during passive movements (MEFI - MEFIII) in the contralateral motor cortex. The amplitude of MEFI during passive movements increased with age, however the waveform appeared similar to adults only after 8 years of age. This is in agreement with similar studies of active movements in children. Beta modulation in the contralateral motor cortex was also observed following movement onset. Comparable to previous findings, peak frequency of beta rebound increased with age. Recordings are ongoing to confirm these preliminary results, indicating a relationship between age and movement-related brain activity.

IM-14

Hidden Markov Modelling of neural activity supporting expressive language in development

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Background
Hidden Markov Models (HMMs) can identify “neural states” with unique temporal, spatial, and spectral properties, in MEG. Here, we characterize network dynamics supporting expressive language in childhood with HMMs.

Methods
Data were acquired on 275-channel CTF system (BC, Canada) at 1200Hz. Eighty participants, 4-18 years old, performed verb generation, involving covert production of action words following auditory concrete nouns. Alternately, participants listened to speech-shaped noise. Data were analyzed with HMM-MAR toolbox (Oxford, UK; Vidaurre, Quinn, Baker, et al., 2016) in MATLAB. Line noise was filtered. Artifacts were removed using ICA. HMMs with 2 to 8 states were generated. Contrasts between conditions revealed probability of state occupancy. State time-courses were concatenated and sources in delta/theta, alpha, and beta spectral modes were estimated using LCMV beamformer for 39 brain locations. Coherence was calculated between locations. Free energy (fit) was computed for each model, and performance was assessed with model complexity as a penalty (AIC procedure).

Results
Time-courses of statistical difference, spectral power, and coherence were consistent with literature. Variation across state dwell times and AIC penalized free energy suggests optimal language network represented in HMMs with 3 to 6 states. These models show a dominant state at 700-1300 ms, which maps to canonical language regions.

Discussion
Language involves a complex interplay of neural activity. HMMs can be used to isolate regions supporting expressive language processing in an unsupervised data driven manner. AIC procedure provides a desirable balance between under- and over-fitting.

IM-15

Alterations in resting-state activity and functional connectivity in children at high genetic risk of neurodevelopmental disorders

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Background
22q11.2 deletion syndrome (22q11.2DS) is a copy number variant (CNV) syndrome affecting approximately 1 in 4000 live births. It has a variable phenotype with physical, cognitive and psychiatric manifestations. Children with 22q11.2DS have high rates of neurodevelopmental disorders, particularly autism spectrum disorder (ASD) and attention deficit hyperactivity disorder (ADHD) as well as a substantially increased risk of schizophrenia in adulthood. The mechanisms underlying the risks of psychopathology in 22q11.2DS are not well-understood. Alterations in neural integration and cortical connectivity have been linked to the spectrum of neurodevelopmental disorders seen in 22q11.2DS and may be a mechanism by which the CNV acts to increase risk.

Methods
Magnetoencephalography (MEG) was used to investigate resting-state cortical oscillatory patterns in 34 children with 22q11.2DS and 25 controls. Oscillatory activity and functional connectivity across six frequency bands were compared between groups. Regression was used to explore the relationships between these measures, IQ and neurodevelopmental symptoms.

Results
Children with 22q11.2DS had atypical oscillatory activity and functional connectivity across several frequency bands (delta, beta and gamma bands). In the 22q11.2DS group, IQ was positively associated with alpha band activity while neurodevelopmental symptoms were negatively associated with functional connectivity in this frequency band as well as alterations in gamma activity/connectivity.

Conclusions These findings suggest that haploinsufficiency at the 22q11.2 locus alters both local and long-range cortical circuitry, which could be a mechanism underlying the increased risk of neurodevelopmental disorders in children with this CNV.

IM-16

Healthy Aging Modulates Entrainment Responses in the Primary Visual Cortices

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For decades, visual entrainment paradigms have been widely used to investigate basic visual processing in healthy individuals and those with neurological disorders. While healthy aging is known to be associated with alterations in visual processing, whether this extends to visual entrainment responses is not fully understood. Such knowledge is imperative given the recent surge in interest surrounding the use of flicker stimulation and entrainment in the context of identifying and treating Alzheimer's disease (AD). In the current study, we examined visual entrainment in eighty healthy aging adults using magnetoencephalography (MEG) and a 15 Hz entrainment paradigm. MEG data were imaged using a time-frequency resolved beamformer and peak voxel time series were extracted to quantify the oscillatory dynamics underlying the processing of the visual flicker stimuli. We found that, as age increased, the mean amplitude of entrainment responses decreased and the latency of these responses increased. However, there was no effect of age on the trial-to-trial consistency in phase (i.e., inter-trial phase locking) nor amplitude (i.e., coefficient of variation) of these visual responses. In addition, we discovered that the relationship between age and response amplitude was fully mediated by the latency of visual processing. These results indicate that aging is associated with robust changes in visual entrainment responses, which should be considered in studies examining neurological disorders such as AD and other conditions associated with increased age.

IM-17 Developmental Trajectories Modulate Neural Oscillatory Dynamics Serving Selective Attention

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Introduction:
The brain undergoes tremendous structural and functional changes between late childhood and early adolescence (e.g., 6 – 13 years old). This results in the maturation of multiple cognitive domains, including selective attention which is crucial for healthy executive functioning later in life. While the key brain regions are reasonably understood, their developmental trajectory and inherent functional dynamics remain largely unknown.

Methods:
Utilizing magnetoencephalography (MEG) and structural MRI, we investigated the developmental trajectory of selective attention circuitry in 91 typically developing youth (6 – 13 years of age; 52 males). Participants completed a number-based Simon task during MEG. We used a data-driven approach to identify windows for beamforming, which resulted in an alpha (8 – 14 Hz, 350-650 ms) and two gamma (60 – 98 Hz, 75-275 ms; 64 – 84 Hz, 500-700 ms) beamformer maps per condition. To identify the Simon interference effect, we computed whole-brain subtraction maps (i.e., Simon condition – control condition). Utilizing these maps, we probed effects using correlational and connectivity analyses.

Results:
Our key findings revealed that age was negatively correlated with the alpha interference effect in the superior frontal gyrus and in the early gamma window in the dorsolateral prefrontal cortex. Conversely, age was positively correlated with the gamma interference effect in the middle occipital gyrus. Finally, connectivity analyses revealed developmental multispectral differences in functional connectivity between multiple sources.

Discussion:
The current data suggests that development modulates the neural impact of Simon interference through more efficient recruitment of specific brain regions involved in vision and attention.

IM-18 Brain response to human voice in very preterm children at preschool age

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Background
Preterm birth is associated with altered brain development and is a leading cause of neurodevelopmental impairments. However, the development of brain cortical processing for human voice is still not well known. The aim of this study was to investigate the characteristics of the brain response to human voice in preterm birth children at preschool age.

Methods
We examined auditory evoked response in very preterm birth and full-term typically developing control children using a child-customized magnetoencephalography (MEG). Voice-evoked P1m response were acquired from 25 preterm and 18 full-term children at 5-6 years of age.

Results
We observed significantly increased P1m response in the left banks of superior temporal area in very preterm birth children compared to controls.

Discussion
P1m evoked by auditory stimuli is a prominent component in early childhood, and decreases after peaking at 60 months in typically developing children. Our result suggests that the cerebral cortex involved in human voice processing is still immature even preschool age in preterm birth children.

VM-128

A reusable benchmark of brain-age prediction from M/EEG resting-state signals

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Population modeling can define quantitative measures of individual aging by applying machine learning to large volumes of brain images. These measures of brain age helped characterize disease severity in neurological populations, improving estimates of diagnosis or prognosis. Magnetoencephalography (MEG) and Electroencephalography (EEG) have the potential to further generalize this approach towards prevention and public health by enabling assessments of brain health at large scales in socioeconomically diverse environments. To investigate machine learning approaches that can handle the complexity of M/EEG signals across diverse real-world contexts, we proposed reusable benchmarks of classical pipeline methods and deep learning architectures in 4 international M/EEG cohorts from diverse countries and cultural contexts, including recordings from more than 2500 participants. Our benchmarks were built on top of the M/EEG adaptations of the BIDS standard, providing tools that can be applied with minimal modification on any M/EEG dataset provided in the BIDS format. Results suggest that, regardless of whether classical machine learning or deep learning was used, the highest performance was reached by methods involving spatially aware representations of the M/EEG signals, leading to R^2 scores between 0.60-0.74. Hand-crafted features paired with random forest regression provided robust benchmarks even in situations in which other approaches failed. Taken together, we hope that this set of benchmarks, accompanied by open-source software and high-level Python scripts, will serve as a starting point and quantitative reference for future efforts at developing M/EEG-based measures of brain aging.

VM-130

Optimization of SQUID sensor arrays for magnetoneurography in terms of pick-up coil diameter

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We are developing superconducting quantum interference device (SQUID) biomagnetic measurement systems for magnetoneurography (MNG) for the non-invasive functional imaging of spinal cords and peripheral nerves. Compared with magnetoencephalography (MEG), the signal intensity originating from spinal cord is lower than those from the cortex. This is because the origin of the signal from spinal cord is located deeper inside the body. Therefore, SQUID sensors equipped with a large-diameter pick-up coil are advantageous. However, peripheral nerves are often located at shallow depths from the body surface and stronger signals are obtained. Moreover, the spatial frequency of the magnetic field distribution over the body surface is higher than that for MEG; Therefore, SQUID sensors equipped with a small-diameter pick-up coil that provide small sensor intervals are effective. For the optimization of the MNG sensor array, we discussed the required sensor intervals for it in terms of the spatial frequency of the magnetic field distribution and the signal intensity in Biomag 2018. In addition, we discussed the optimization of the sensor array in terms of the diameter of the pick-up coil and the intrinsic noise of the sensors. Considering the balance between magnetic field resolution and spatial resolution, SQUID sensors equipped with a 21-mm-diameter pick-up coil were fabricated, and their effectiveness was evaluated in comparison with a conventional 16-mm-diameter pick-up coil. The spatial resolution of magnetic source analysis of shallow sources, using larger pick-up coils, is also discussed. [Acknowledgment] We thank Miki Kawabata for her artisan works to fabricate and evaluate sensors.

VT-152

A SQUID biomagnetic measurement system for magnetospinography and magnetoneurography and its clinical applications

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We developed a SQUID biomagnetic measurement system for magnetospinography/magnetoneurography (MSG/MNG). Its system configuration was similar to the conventional magnetoencephalograph (MEG). However, to detect MSG/MNG signals that are smaller and faster than MEG signals, various improvements were added to the measurement system; the system consists of an array of vector-type SQUID gradiometers, a uniquely-shaped cryostat, and a digital data acquisition unit with higher sampling rate. Especially, the cryostat design was optimized for fitting the sensor array to the posterior of a supine subject. Owing to the structure of the cryostat, on-site X-ray imaging became applicable to obtain the skeletal structure of the subject from lateral and anterior sides. The obtained X-ray image was effective for further magnetic source analysis.
We combined the MSG/MNG system with a closed-cycle helium recondensing system, which could recycle almost 100% of liquid helium (LHe). It enabled the system to work without refilling LHe for more than one year and drastically suppressed its operational cost.
The MSG/MNG system noninvasively visualizes the transition of the neural current distribution and provides functional information of spinal cords and peripheral nerves, which is expected to be applicable for the diagnosis of nerve degenerative diseases such as myelopathy or multiple sclerosis. The prototype system is being operated for years at Tokyo Medical and Dental University (TMDU). Several applications for clinical use of the MSG/MNG system recently established through the joint research by Kanazawa Institute of Technology, TMDU, and RICOH will be introduced in the presentation.

IM-22

Quantification of biomagnetic field oscillations using transmitted Rotary EXcitation (tREX) in magnetic resonance imaging

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Background
Spin-lock based magnetic resonance imaging (MRI) enables the detection of ultra-weak magnetic field oscillations [1]. In this work, we report on a novel concept for spatially-resolved magnetic field quantification using transmitted-Rotary-EXcitation (tREX). Here, the standard built-in gradient system of a clinical MRI scanner is utilized to emulate neuronal activity. After calculating a tREX calibration function, biomagnetic field oscillations can be quantified.

Methods
The new method was tested in vivo on a clinical 3T scanner. The tREX function was determined by two calibration measurements in brain tissue of a healthy volunteer. Subsequently, spatially-resolved magnetic field quantification of emulated fields in the range 10...50nT was carried out.

Results
The tREX calibration map clearly indicates tissue-dependent properties. The measured amplitudes AREX are in good agreement with the calibration function (R2>0.987). The quantification maps of the emulated field oscillations are mainly homogeneous and provide high quantification accuracy. The mean quantification error was 2.5%.

Discussion
The calculation of a spatially-dependent calibration function based on tREX allows quantification of ultra-weak magnetic field oscillations via MRI. Currently the limit of our technique is ≈1nT. Since this concept is fully capable in vivo, tREX paves the way for a new branch of research in Biomagnetism. Possible applications include the investigation of alpha-activity or steady-state-visual-evoked-potentials.

[1] Ito et al. Sci Rep. 2020 Mar 25;10(1):5463

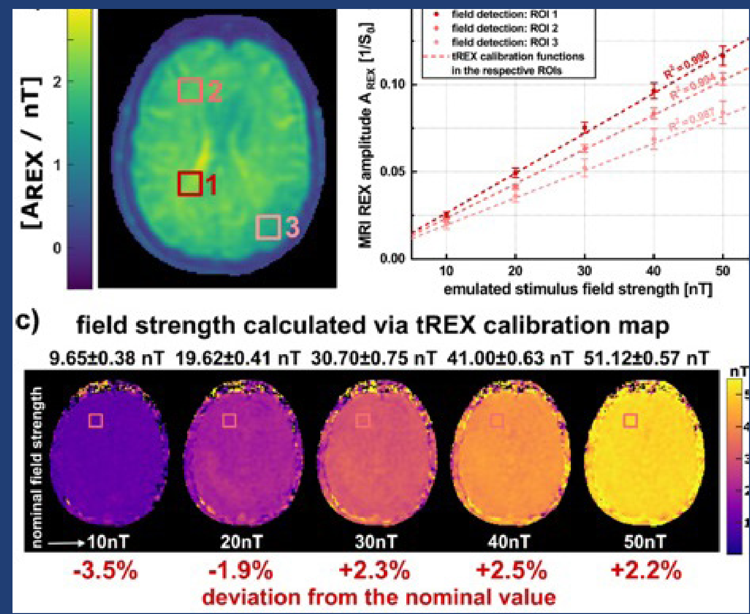

Figure 1) The tREX calibration map is shown in (a). The calibration is in good agreement with measured signal amplitudes (b). The quantification maps are homogeneous and provide high quantification accuracy (c).

IM-23 Ambulatory OP-MEG for navigating virtual environments

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Optically pumped magnetometer-based magnetoencephalography (OP-MEG) can be used to measure neuromagnetic fields while participants move within a magnetically shielded room. Using a 90-channel (45-sensor) whole-head OP-MEG system and concurrent motion capture, we recently demonstrated that auditory evoked fields can be successfully measured while participants are standing still and making large, natural, continuous head movements (maximum translation 120cm; maximum rotation 198°). Low-frequency interference caused by head movement was removed through a data pre-processing pipeline combined with beamforming. There are many exciting cognitive and clinical neuroscience questions that could benefit from the types of behaviour enabled by large head movements while standing, with walking being of particular interest. To test the feasibility of ambulatory OP-MEG, we have developed a setup that allows participants to interact with virtual reality environments. This involves participants performing a modified 'walk-in-place' locomotion technique, in which the heels of the feet are raised and lowered in turn, while keeping the front of both feet on the ground. Real-time motion capture of foot position is then translated into a forward motion in virtual reality using methods developed in Unity, a game engine software. Here we present preliminary whole brain OP-MEG data recorded during participant locomotion through a virtual town. We demonstrate that utilisation of established pre-processing techniques combined with beamforming results in ambulatory OP-MEG signals that are amenable to analysis. This method will benefit naturalistic OP-MEG experimental setups involving locomotion, including those using virtual environments, such as navigation and autobiographical memory paradigms.

IM-24 Auditory Steady-state Response Measured with Optically Pumped Magnetometers

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Magnetoencephalography (MEG) is a non-invasive neuroimaging technique that measures the magnetic fields generated by neurons in the brain. The conventional MEG uses Superconducting QUantum Interference Devices (SQUIDs) to measure brain magnetic fields. SQUIDs-MEG requires a cryogenic environment involving liquid helium and Dewar. It results in a fixed sensor position as well as a greater distance between cortical sources and sensors. Recently, small-sized optically pumped magnetometers (OPMs) have been developed and commercialized. OPMs do not require cryogenic cooling and can be placed as close to the scalp as millimetres. We recruited 22 healthy participants and placed six OPM sensors on their temporal area to measure auditory-related brain activity. We found the M50 and M100 components of auditory-evoked fields by presenting the auditory stimuli of 1-kHz pure tone with 200-ms duration. We observed the auditory steady-state responses at 40 Hz by delivering the periodic stimuli with a 40-Hz repetition rate. Our results indicate the feasibility of using OPM sensors to detect auditory brain responses at 40 Hz.

IM-25

Validation of a Mobile Magnetoencephalography System

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Dalhousie University (Halifax, NS, Canada) is home to a novel mobile optically pumped magnetometer (OPM) system. In brief, the OPM system consists of a cylindrical shield on a moveable cradle, with a 128-slot helmet-shaped sensor array mounted on a retractable participant support bed. Our objective is to quantify the system's performance as an MEG device.
The ability of the passive shielding to attenuate environmental magnetic fields (i.e., no participant) was determined by making 3-axis field measurements at regular intervals along the central axis of the shield. The shield performance was quantified based on field attenuation as a function of frequency. Active shield performance was determined by measuring the additional attenuation achieved by manually tuning field compensation coils. Validation as a functional neuroimaging device was achieved by performing right median nerve somatosentory evoked field (SEF) mapping on ten healthy adults with 16 OPMs, and comparing localization to the expected location.
Field attenuation by the passive shielding reached 30-40dB depending on the frequency but prominent artefacts remain in the 10-100 Hz range. Preliminary gradiometry reduces these artefacts to within the background noise. Active shielding reduced the DC field in the sensor array from 20-25nT to 3-5nT. The grand-average SEF clearly reveals reversing dipolar patterns for the N20m and P35m peaks, with dipole localization to left central areas.
We show that mobile MEG is a viable platform, providing sufficient shielding and efficacy in human recordings. However, artefacts still limit data quality. Increasing the sensor count may provide avenues for offline artefact removal.

IM-26

Dynamic field compensation increases the precision of somatosensory evoked field responses in OPMs

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Small ambient magnetic fields perpendicular to the measurement axis of optically pumped magnetometers (OPMs) developed for magnetoencephalography (MEG) introduce effective amplitude and phase errors in the measured signal (Borna, et al, 2021). To mitigate these sources of error and improve measurement precision, we developed cross-axis dynamic field compensation (DFC) by dynamically maintaining null along the OPM transverse axes (Robinson et al, Biomag 2022). Here, we evaluated DFC in recovering somatosensory responses. Using a GalileoTM pneumotactile stimulator, we delivered simultaneous air pulses (100 ms) to the right index, middle and ring fingertips (run duration 240 s; 500 trials; mean ISI = 496 ms). Responses were recorded with 19 FieldLine v2 OPMs (1 kHz sampling rate; dc-300 Hz) arranged in a 4x4 grid over left somatosensory cortex (3 were excluded due to malfunction), plus three reference OPMs, which were fixed orthogonally and centered 5 cm above the grid. This arrangement allowed us to synthesize first-order gradiometers. In closed-loop operation, we collected data with and without DFC. Data were band-pass filtered (1-110 Hz) and channel-wise time-frequency representations were created with the MNE python package. With DFC, OPMs show a more focal response in sensor space in the beta frequency band relative to when DFC is not used. This indicates that DFC reduces the contribution of unwanted field fluctuations. Gradiometer responses do not show higher focality or signal-to-noise with DFC in the time-frequency domain. Taken together, we have shown that DFC benefits magnetometer measurements, making it a promising method for high resolution source localization.

IM-27

Optimization of OPM sensors for MEG system

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Portable and compact optically pumped magnetometers (OPMs) offer new research possibilities inaccessible to superconducting quantum interference devices (SQUIDs). For example, OPM-based systems allow studying previously unreachable biomagnetic signals (Westner, 2021; Tierney, 2021; Holmes, 2021). The most attractive advantage of the OPMs is the possibility to place them directly on the subject's head, which results in a 5 fold increase of the measured brain signal compared to SQUIDs (Boto, 2016). However, in this case, the amount of unwanted brain activity sensed by OPMs also increases, and in order to create an accurate model of an OPM-MEG system, all the brain activities must be accounted for.
In this work, we present a realistic model to optimize the OPM-MEG system in terms of the number of sensors and the dimensions of the sensing volume of OPMs, while maintaining good source localization accuracy (Vrba, 2002) and time course reconstruction accuracy (Brookes, 2021) We show that with an on-scalp sensor placement the recorded brain noise can be ~10 times larger in magnitude than sensors intrinsic noise and it has a significant effect on both metrics. Without the noise from the brain included in the model, the localization accuracy is constantly decreasing with an increasing number of sensors in the array. However, with brain noise included in the model only about 70 sensors are needed to reach full localization accuracy.
Our model can be used to guide the design of OPM sensor/sensor arrays.

IM-28

A VR-TMS-EEG integrated system, is it feasible?

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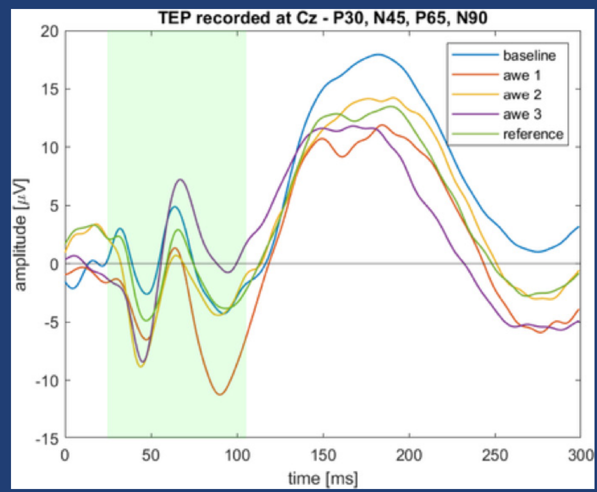
Background:
The study of the neurobiology of virtual reality (VR) experiences using electroencephalography (EEG) is arousing great interest in neuroscience. However, the integration of transcranial magnetic stimulation (TMS) with this system, which can provide unprecedented knowledge of VR-induced brain connectivity, has never been accomplished. For the first time, we developed and tested an integrated VR-TMS-EEG system to assess the awe experience neural correlates elicited by different VR environments (VRE).

Methods:
The novel VR-TMS-EEG protocol enables simultaneous TMS-EEG acquisitions on subjects wearing the VR oculus. In our study, due to the difficulty in tracking the target site during the VRE, single pulse TMS-EEG recordings targeting the dorsolateral prefrontal cortex were performed before (baseline) the experience and after each VRE while keeping the same experimental setting to allow reproducibility. We administered three awe-inducing VRE and one reference scenario. EEG data from a pilot subject were pre-processed to remove artifacts and extract TMS evoked potentials (TEPs).

Results:
At Cz, we found TEP peaks of interest (figure). The comparison among different VR conditions showed that baseline and reference scenario TEPs were very similar but differed from the TEPs relative to the awe-inducing scenarios.

Discussion:
Here, we present the first research protocol combining VR, TMS, and EEG. The feasibility of the VR-TMS-EEG integrated system has been demonstrated by the results. In particular, the baseline TEPs are in line with former literature and the TEPs differences found among different scenarios showed the possibility of our setup to capture awe-induced brain activity right after the VRE.



IM-29

Impact of Cross-Axis Projection Error of Optically Pumped Magnetometers on Calibration Accuracy of OPM-MEG Systems

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In [1], we reported on a systematic error, i.e. Cross-Axis Projection Error (CAPE), encountered in optically pumped magnetometers (OPMs) operating in the spin-exchange-relaxation-free (SERF) regime. In brief, multi-axis magnetic signals in the presence of small remnant static magnetic fields, not violating the SERF criteria, can introduce phase and gain errors. Here, we investigate the impact of CAPE on calibration accuracy of OPM-MEG systems. One of the main advantages of wearable OPM-MEG systems is conforming the sensors to the subject's scalp which maximizes the signal to noise ratio (SNR) by minimizing the distance between the brain source space and the sensors. However, the channels' positions need to be calculated rapidly and precisely, which is part of the calibration process. However, due to phase and gain errors introduced by CAPE, the calibration accuracy is compromised. In this work, we investigate the degradation of calibration accuracy due to the CAPE and will compare our simulation results with that of the measurement.

[1] https://doi.org/10.1016/j.neuroimage.2021.118818

IM-30

Brain co-registration to external head coordinate system for M/EEG data analysis without MRI

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Background:
Analyzing M/EEG data for investigating brain function is a well-established procedure. Recently, there has been growing interest in using anatomically informed source locations for this, e.g. to study brain network connectivity. The accuracy of results relies on co-registration of anatomical MRI data with the external coordinate system, e.g. as supplied by the nasion/pre-auricular point coordinates known as the Head coordinate system. However, in many cases, anatomical MRI data are simply not available.

Methods:
In this study, we first investigate the variability of the positioning of the brain center and the main brain axes relative to external landmarks. Then, known structures, namely the primary auditory and visual cortices, are mapped in individual subjects, to finally provide an individualization of the transformation between Head coordinate system and brain-based AC-PC coordinate system. This is achieved by optimizing the transformation in a least-squares fit approach to match the reconstructed brain locations for auditory and visual processing to their atlas locations.

Results and Discussion:
Three main parameters of the transformation emerged as the most variable between subjects. The feasibility of the approach is tested by using data from 15 healthy volunteers where auditory and visual stimulation was recorded with MEG. Grand average data in brain source space at seeded locations is compared between a standard transformation, and the individually computed transformation.
The improved co-registration can contribute to an improved understanding of brain connectivity in various conditions, and facilitate the comparability between fMRI-based and M/EEG-based studies of brain function.

IM-31

Triaxial OPMs: Next generation of wearable MEG?

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Background:
MEG systems based on SQUID sensors typically measure one component of the neuromagnetic field, due to the complexity of the required geometry of flux transformers. However, newly available commercial OPMs offer the possibility to measure a full 3D neuromagnetic field vector. Here, we aimed to test the suitability of such sensors for MEG.

Methods:
Using 4 triaxial zero-field magnetometers (QuSpin[MB(1] www.quspin.com), two experiments were performed: 1) Sensors were placed at multiple locations above a participant's chest to measure the heart's magnetic field. 2) A single participant wearing a cap holding the 4 triaxials and 14 additional dual-axis OPMs, undertook a right index finger abduction task. After beamforming, a beta-burst analysis was performed to visualise the 3D neuromagnetic field vector.

Results:
In both experiments, sensors showed excellent sensitivity to the biomagnetic field, across all three available axes. In the MEG experiment, brain activity localised to the left somatosensory cortex, and the field generated by a burst of beta activity, showed the expected pattern: a 3D vector rotating around the localised dipole.

Discussion:
Triaxial sensors offer similar performance to the conventionally available dual-axis OPMs, but with the added benefit of an additional measurement. They detect biomagnetic field signals with high accuracy and sensitivity, whilst providing a full picture of the magnetic field vector. This study shows the clear utility of triaxial sensors for MEG.

IM-32

Paediatric OPM-MEG with triaxial sensors

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Background:
The use of OPMs for MEG measurement is now well established. Nevertheless, OPM technology is evolving rapidly, and recent developments have enabled the introduction of triaxial sensors. Previous work suggests that triaxial measurements would be advantageous for rejecting interference (Brookes 2021). Here, we focus on how triaxial OPMs might be particularly useful for studying the infant brain.

Methods:
We simulated a MEG system based on triaxial sensors and compared the array sensitivity to a simulated radial-only system. In addition, we demonstrate feasibility of triaxial measurement during a MEG experiment: using an ergonomic, child-friendly, 3D-printed helmet holding 43 triaxial OPMs, a 3-year-old was scanned during a maternal touch paradigm. A template MRI was used to beamform the source of beta-band activity.

Results:
As the brain of an infant is closer to the sensors than that of an adult, a radial-only system results in gaps in coverage. However, a triaxial array fills these gaps, providing more uniform coverage. In the MEG experiment, brain activity localised to the contralateral somatosensory area, showing the expected reduction in beta-band power during the touch period.

Conclusion:
One of the biggest advantages of OPM-MEG over conventional scanners is the ability to make high-fidelity MEG measurements in infants. We believe triaxial OPMs will show utility in scanning infants due to improved coverage, whilst also offering improved rejection of interference.

IM-33

Towards active magnetic field cancellation on a moving array of OPMs

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Background:
Recent developments in OPMs and magnetic shielding have enabled sensors to be mounted in a wearable helmet, allowing natural movement during a MEG scan. However, large movements through non-zero magnetic fields induce artefacts in the recordings and can send OPMs outside of their narrow dynamic range. Magnetically shielded rooms and electromagnetic coils are needed to reduce the magnetic field over the sensor array. The active field cancellation techniques currently used in OPM-MEG involve measuring and then nulling the local field at the start of the experiment, restricting movement to a relatively small, nulled region. If the nulled volume were able to move with a participant a larger range of motion would be possible. To achieve this, knowledge of the field per unit current produced by the coils at each sensor is needed for each movement.

Methods:
Here we present steps towards continuous coil calibration and magnetic field cancellation using an active shielding system comprising six, 37x37cm2 square coils mounted onto the inside faces of a 55x55x55cm3, single-layer mu-metal box. Simultaneously driving the coils at 31-36Hz and measuring the magnetic field with a triaxial fluxgate, reveals the field per unit current generated by each coil. The currents needed to cancel the static magnetic field at the sensor can be calculated and applied to the coils.

Results:
The magnitude of the magnetic field was reduced from 173±2nT to 9.2±0.6nT.

Discussion: Future work will aim to continually calibrate the coil system to compensate field changes as the sensor moves.

IM-34

Feasibility of a Semi-Shielded OPM Platform in Super Paramagnetic Magneto-Relaxometry (SPMR) Based Cancer Cell Detection.

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Background:
Superparamagnetic iron-oxide nanoparticles (SPIONs) undergo delayed magnetic relaxation when immobilized compared to free-state. Superparamagnetic Magneto-Relaxometry (SPMR) can be used to detect and locate SPIONs bound to cancer cells as a non-invasive detection method. Traditional SPMR approaches used Superconducting Quantum Interference Devices (SQUID) coupled to magnetometers. Here we report an investigation of SPMR feasibility using non-cryogenic Optically Pumped Magnetometers (OPMs).

Methods:
A semi-shielded OPM system was used to conduct in-vitro SPMR detection of 10, 5, 2.5, and 1µg breast cancer cell targeted SPION phantom samples at distances between 30 and 60mm, representing SPION concentrations and depths relevant for the clinical setting. A SPION positioning fixture controlled sample placement and an excitation coil was used to magnetically excite the sample. Experimental controls over the shield and sensor system were used along with a novel magnetic pulsing technique to maintain stable environmental conditions during SPMR pulsing. SPION presence was evaluated via multiple in-situ control vs sample SPMR runs. A proposed method of integral calculations to quantify SPION relaxation data from baseline relaxation data was also evaluated.

Results:
10 and 5µg SPION samples can be differentiated from baseline runs at distances between 30 and 60mm, exhibiting 26.7-171 pT·s of separation, while 2.5 and 1µg samples can be differentiated up to distances of 45mm, exhibiting 26-84 pT·s of separation.

Discussion:
SPMR detection of in-vitro SPIONs was demonstrated using an integral calculation method and a semi-shielded OPM platform. The results provide a foundation for non-invasive detection of tumor-bound nanoparticles in-vivo using non-cryogenic OPMs.

IM-35

Localization of head position indicator coils based on the Signal Space Separation model

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Background
Due to the absence of an analytical solution for the magnetic inverse problem of the current loop dipole, the traditional approach for localization involves a non-linear minimization of the mismatch between the data and the forward dipole equation. This method works reliably if the signal-to-noise ratio measured by the SQUID sensors is big enough, then the outside noise can be ignored in the localization procedure.

Methods
We present a novel approach that employs the Signal Space Separation decomposition basis to perform a numerical approximation of the location of the coil. Specifically, this method exploits the fact that the lowest order term of the inner basis should explain the inner volume signal most accurately when its origin of expansion is at the true dipole location. By construction, this method can incorporate the outside signal expansion of the SSS to mitigate the effects of external noise.

Results
In a scenario where the average signal is five times greater than the noise and the coil is located at 7 centimeters from the sensor array, the traditional method yielded a relative error of 6%. In contrast, the SSS localization resulted in a 0.02% error.

Discussion
When external noise is commensurate with the average signal and the coil is embedded deeply in the sensor array, the localization fails to produce accurate results as the signal does not present any sharp components that contrast with background noise. The SSS localization overcomes this situation by removing the external noise without distorting the inner volume dipole signal.

IM-36

Optically pumped magnetometers vs. cryogenic magnetoencephalography for epilepsies in school-aged children

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Introduction:
Magnetoencephalography (MEG) is an established method to detect and localize focal interictal epileptiform discharges (IEDs). Current MEG systems house hundreds of cryogenic sensors in a rigid, one-size-fits-all helmet, which results in several limitations, particularly for children. This study aims to determine if on-scalp MEG based on optically pumped magnetometers (OPMs) alleviate this limitation of cryogenic MEG.

Methods:
Five children (4 female; median age 9.4y; age range 5-11 years) with self-limited idiopathic (n=3) or refractory (n=2) focal epilepsy were included. Participants underwent cryogenic (102 magnetometers, 204 planar gradiometers) and on-scalp (32 OPMs placed on EEG-like caps) MEG. The two modalities for the detection and localization of IEDs were compared. T-tests were used to compare IED amplitude and signal-to-noise ratio (SNR). Distributed source modelling was performed on OPM-based and cryogenic MEG data.

Results:
IEDs were identified in all children, with comparable sensor topographies for both MEG devices. IED amplitudes were 2.3 to 4.8 times higher ($p < 0.001$) with on-scalp MEG, and SNR was 27% to 60% higher (p-value range: 0.001-0.009) with on-scalp MEG in all but one patient with pronounced head movements ($p = 0.93$). The neural source localization of averaged IEDs showed approximately 5 mm (n=3) or higher (8.3 mm, n=1; 15.6 mm, n=1) distance between OPM-based and cryogenic MEG.

Discussion:
Despite the limited number of sensors and scalp coverage, OPM-based MEG detects IEDs in school-aged children with epilepsy with a higher amplitude, higher SNR, and similar localization value compared to cryogenic MEG.

IM-37

Recording of ictal epileptic activity using on-scalp magnetoencephalography with optically pumped magnetometers

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Introduction:
Magnetoencephalography (MEG) is rarely used for ictal recordings in patients with refractory focal epilepsy (RFE) due to technical challenges associated with cryogenic MEG. Optically pumped magnetometers (OPMs) alleviate some of those challenges by allowing on-scalp MEG recordings. We describe here a case of on-scalp ictal video-MEG recording based on OPMs (OPM-MEG).

Methods:
A 10-year-old boy suffering from RFE with frequent (> 5/day) bilateral polymorphic electro-clinical (dialepsis, abnormal ocular movements) or electrical occipito-parietal seizures underwent one-hour of video-MEG with 24 tri-axis alkali OPMs (QZFM Gen 3, QuSpin, USA) placed posteriorily on the scalp using adapted EEG-like cap. OPMs were localized on the patient's head using a 3D-scanner. Recording took place in a magnetically shielded room (OPM-compact MuRoom, MSL) with active compensation. Interictal epileptiform discharges (IEDs) and seizures were visually detected. Ictal band-limited power changes (13–40Hz) were assessed by comparison with periods of background activity devoid of IEDs. Distributed source localization was performed with dSPM on the first 500ms of each seizure and at the peak of IEDs averaged based on their spatio-temporal dynamics.

Results:
Fifteen polymorphic electro-clinical or electrical seizures were detected on the OPM-MEG recording. Source-localized ictal power increases showed a left parieto-occipital onset in 11 seizures and a right parieto-occipital onset in 4 seizures. IEDs were localized at the left parieto-occipital region.

Discussion:
This case report demonstrates the feasibility of ictal recordings using on-scalp video-OPM-MEG and the potential interest of this technological innovation for the presurgical evaluation of RFE.

IM-38

Non-invasive direct detection of oscillating biomagnetic fields using spin-lock based magnetic resonance imaging

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Background
A new concept based on spin-locking-MRI for the spatially-resolved direct detection of biomagnetic fields in the 1…100Hz regime with nano-Tesla-sensitivity is introduced [1]. Here, neuro-electro-magnetic oscillations are detected by an endogenous and phase-sensitive contrast via the Rotary-EXcitation (REX) effect. In the following, we demonstrate how robust detection can be realized in vivo by improved balanced-spin-locking techniques [2]. In addition, a novel validation method is applied in which biomagnetic fields are emulated with the built-in MRI gradient system.

Methods
In vivo experiments were carried out in brain tissue of healthy volunteers on a standard clinical 3T scanner. REX-MRI was performed for different phases of emulated stimulus fields (50Hz, 1…100nT). Detected amplitudes AREX were compared for standard-spin-locking, balanced-spin-locking and control measurements without stimulus.

Results
Field detection with standard-spin-locking and balanced-spin-locking provides sinusoidal contrast modulations, which highly correlate with the stimulus phase ($R2>0.99$). Balanced-spin-locking ensures reduced susceptibility to field inhomogeneities and significantly higher detection amplitudes (+63%) in subcortical structures. The lowest detectable magnetic field oscillations ranged from 1…2nT.

Discussion
Direct imaging of ultra-weak field oscillations is possible using spin-locked MRI. Due to its high robustness, our new concept paves the way for spatially-resolved detection of Biomagnetism even in subcortical structures.

[1] Truong et al.Magn Reson Med. 2019 Jun;81(6):3462-3475
[2] Gram et al.Magn Reson Med. 2021 May;85(5):2771-2780

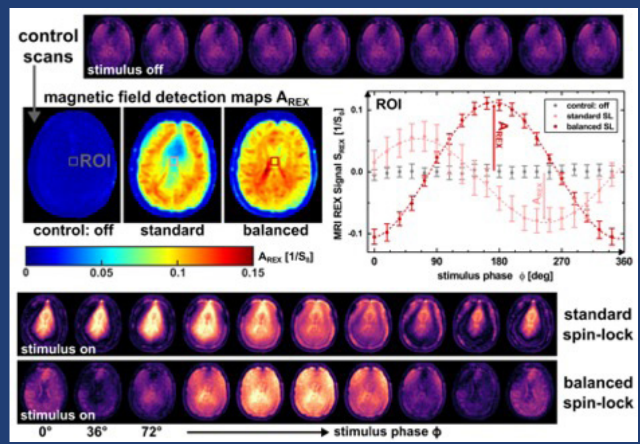

Figure 1) REX-MRI scans of emulated field oscillations and calculated detection maps. Compared to control scans, sinusoidal modulations were observed. Balanced-spin-locking provides a more robust detection in subcortical structures.

IM-39

Measurement and characterisation of human visual gamma-band responses with on-scalp magnetoencephalography

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Magnetoencephalography (MEG) is a non-invasive functional neuroimaging modality used in neuroscientific research and clinical medicine. Recently, sufficiently sensitive optically pumped magnetometers (OPMs) have become an attractive alternative to the conventionally used superconducting quantum interference devices (SQUIDs). As OPMs do not need a cryogenic environment to operate, they can be placed directly on the scalp, which increases signal amplitude and spatial resolution. With this improvement, weak neural activity that until now predominantly has been measured invasively could potentially also be studied with on-scalp MEG. For example, gamma-band (_30–150 Hz) activity is clearly visible in invasive recordings, whereas in non-invasive recordings only specific gamma-band responses are robustly measurable. In this study, gamma-band responses were induced in the visual cortical areas by showing ten healthy human subjects images of gratings, uniform colours and natural scenes. The uniform colours were either red, green or blue. The natural scenes had a dominant colour of either red, green or blue, while greyscale scenes were also shown. Stimuli were displayed for 0.5s with an inter-stimulus-interval of 1.5±0.1 s and 80 trials per category. We measured the responses with 14 OPM sensors placed above the occipital part of the head. We observed that gratings and uniform colours induced narrow-band, i.e. oscillatory gamma responses, while all stimuli induced aperiodic, i.e. broad-band gamma responses. The longer-wavelength colours induced stronger responses. Additionally, the dominant gamma frequency was stimulus-dependent. In summary, we demonstrated that gamma-band responses, that have until now been predominantly measured invasively, can be measured with on-scalp MEG.

IM-40

A cross site comparison of OPM-MEG data

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Background:
OPM-MEG offers significant advantages over conventional cryogenic systems, including improved data quality, lifetime compliance, uniformity of coverage and flexibility. However, it remains very new technology and, to inspire confidence within the MEG community, cross-site validation of systems will be essential. Here, using near identical commercial OPM-MEG systems, we compare quantitatively OPM-MEG data recorded multiple times in the same participant at two sites.

Methods:
At both sites, we captured OPM-MEG data during a visuo-motor task (known to generate oscillatory effects in the beta- and gamma-bands), and a face processing task (known to generate evoked responses from both primary and lateral visual areas). The same participant was scanned 5 times. At both sites, interference was managed using a combination of dynamic nulling and homogenous field correction (Hill et al., 2022). Results from both sites were compared quantitatively, at the sensor level and following source reconstruction.

Results:
We were able to record robust, high-quality MEG data at both sites. Specifically, we were able to reconstruct both beta- and gamma-band modulation in our visuo-motor task, and evoked responses in our face processing paradigm. On average, the spatial discrepancy between localisations at the two sites was of order 10 mm (likely driven by co-registration variance). The temporal correlation of responses between sites was 0.82 ± 0.06 (collapsed across runs and tasks).

Discussion:
Both sites showed highly comparable MEG responses, demonstrating that OPM-MEG systems can yield equivalent results, even when operated in different environments. Our results pave the way for wider deployment of OPM-MEG technology.

IM-41 Controlling magnetic interference for OPM-MEG

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Background:
Optically pumped magnetometers (OPMs) are revolutionizing MEG, offering wearable technology with improved performance and lifespan compliance. However, OPMs are very sensitive to static and time varying magnetic fields from non-neural sources, and these must be eliminated for successful OPM-MEG operation. Here, we demonstrate that, with appropriate shielding technologies, high-quality OPM-MEG data can be collected, even at sites with high levels of magnetic interference.

Methods:
We implemented the hardware and software required for Dynamic Stabilisation (DS) with electromagnetic coils to control <3Hz field drifts during a recording and applied Homogeneous Field Correction (HFC) in post-processing to compensate remaining artefacts (Hill et al., 2022). 5 minutes of empty-room data were recorded at two sites with differing interference.

Results:
* Site 1 (city-centre): Without DS, background field drifts (>5nT) cause the OPMs to exceed their operational range. DS keeps sensors within range but raises the noise floor. HFC removes this interference, bringing the noise floor to ~16 fT/sqrt(Hz).
* Site 2 (quiet environment within OPM-optimised shield): Without DS, sensors are well within their operational range. DS reduces the amplitude of the low frequency interference but again increases interference above 3Hz. HFC corrects the noise floor to ~10 fT/sqrt(Hz).

Discussion:
We demonstrated that OPM-MEG systems can be sited in a magnetically noisy environment – a clinical setting in a major city – and yield noise data comparable to that from an optimised setup. DS and HFC are critical to this, keeping the OPMs within their operational range and removing non-neuronal interference.

IM-42 OXiNEMS - Oxide Nanoelectromechanical Systems for Ultrasensitive and Robust Sensing of Biomagnetic Fields

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The OXiNEMS project (H2020 FET-Open GA N°828784) aims to develop a new class of nanoelectromechanical systems (NEMS) to be used in a new generation of ultrasensitive and robust magnetometers for biomagnetic measurements.
To boost the sensitivity of the OXiNEMS sensor, we use a high-Q mechanical resonator coupled to an optimized field focuser realized with a nanostructured superconducting YBCO pickup loop. If an external magnetic field is applied, the supercurrent flowing in the loop generates a strong and non-uniform magnetic field nearby the resonator, causing a shift of its mechanical eigenfrequency. The resonator oscillations are detected through optical readout. Expected specific features of this new class of detectors are: operation in a simplified cryogenics setup at 77 K, allowing detection at a stand-off distance < 10 mm, thus increasing the signal strength and reducing the maintenance costs with respect to liquid He systems; detection limit about 10 ft/sqrt(Hz), which is suitable for on-scalp recording of the brain activity; bandwidth near DC-10 kHz allowing the application of different imaging modalities with the same setup (e.g. MEG and ULF MRI); robustness to static and pulsed magnetic fields, even those used in ULF MRI and TMS; scalability and reproducibility; operation with an all-optical readout, allowing dense sensor packing with a negligible crosstalk. Thanks to the field robustness, the OXiNEMS sensors may pave the way to novel integrated system supporting MEG, ULF/VLF MRI and Transcranial Magnetic Stimulation (TMS) on the same set-up.

IM-43

Bench-top magnetic field control for optically pumped magnetometers (OPMs)

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Background:
Many OPMs require an ultra-low ambient magnetic field to operate at maximum efficiency. Here, we develop a system for shielding multiple OPMs on a bench-top in a noisy background magnetic environment.

Methods:
The system consists of nine nested active field-generating continuum coils housed on flexible PCBs, interior to a four-layer cylindrical mu-metal passive shield of inner radius 10 cm and length 30 cm. The coil designs account for the electromagnetic response of the magnetic shielding, including shield entry holes. We also use a genetic algorithm to maximise the passive shielding efficiency, while minimising Johnson noise and maintaining shield portability.

Results:
The system is designed to control magnetic fields over half the diameter and length of the inner shield, and contains 24 transverse entry holes of radius 7.5 mm. Prototypes of the coil system generate three uniform fields and six gradient fields, with deviations of less than 0.4% and 2%, respectively, over the field control region. The passive axial and transverse static shielding efficiencies are expected to be above 2.5 _ 105, with an expected shield-induced Johnson noise below 5 fT/sqrt(Hz). We expect the shielding efficiency to increase by two orders of magnitude when using the coils and shield in tandem. The system is currently finishing manufacture and we are preparing for final tests.

Discussion:
The large control region is specifically designed for measurements using arrays of OPMs. The same design techniques may be applied to design custom, human-sized, shielding systems for magnetoencephalography, magnetocardiography and magnetomyelography.

IM-44

Perspectives on coil design in cylindrical magnetic shields for optically pumped magnetometers (OPMs)

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Background:
Cylindrical passive magnetic shields, augmented by interior electromagnetic coils, are a cost-effective method of reducing ambient magnetic field noise for OPMs. However, challenges, such as the requirement for large open ends for patient throughput, may hamper the widespread adoption of these systems for bio-magnetic measurements, by introducing magnetic noise and errors in coils designed using standard techniques. Moreover, miniaturised systems require coils to be housed closer to the target region, causing heating, increased current noise, and increasing inaccuracies from discretisation of surface currents.

Methods:
Using theoretical tools which incorporate the effect of the shield into the coil design, we provide perspectives on how these issues may be overcome.

Results:
We design and construct coupled cylindrical and planar surface coils which generate uniform axial and transverse fields in open-ended cylindrical magnetic shields. We measure the fields generated by a test system in an open-ended shield to deviate by less than 0.1% along 30% of the shield's length. We also present an analytic optimisation of shielded target coils, composed of simple coil units, which are well-suited for placement close to the target region. In this context, discrete coil units match equivalent surface coils in terms of the field quality and offer up to a fourfold enhancement in field strength.

Discussion:
By understanding interactions with shielding materials, coils designed using various techniques may be combined to maximise shielding performance. This has the potential to reduce the number and extent of additional shielding layers, making systems cheaper, lighter, and more adaptable.

IM-45

A lightweight magnetically shielded room with active shielding for wearable MEG

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Background:
OPMs have significant promise for MEG, but impose stringent requirements on the magnetic environment (<1nT static magnetic field required). Magnetically shielded rooms (MSRs) use multiple layers of MuMetal to screen fields that would otherwise interfere with recordings, but they are expensive, heavy, and difficult to site. Electromagnetic coils further cancel the field, but current designs are challenging to engineer and occupy useful space within the MSR. Lightweight MSRs, which can be easily sited, are crucial for the widespread deployment of OPM-MEG systems. Here, we present a lightweight MSR which takes significant steps towards overcoming these challenges.

Methods:
We reduced the amount of shielding material used in a standard OPM-optimised MSR from four MuMetal layers to two. For construction in environments where space is constrained, layer spacing was also reduced. These changes reduce weight, cost and installation time but decrease the shielding factor. To recover this lost performance, we designed a 'window coil' active shielding system. A series of rectangular coils were optimally placed on each face of the MSR. Coil currents were chosen to generate a magnetic field which is equal and opposite to the field in the MSR.

Results:
A 30% reduction in weight and 40-60% reduction in external dimensions was achieved. The combined active and passive shielding leaves a remnant field of just 670pT over the central cubic metre of the MSR. OPM noise recordings verified suitability for MEG.

Discussion:
Good performance is achieved in a lightweight design. Future work will focus on further improvements to deployability.

IM-46

Naturalistic hyperscanning with wearable MEG

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Background:
Hyperscanning allows simultaneous assessment of brain function in two interacting individuals, thus allowing neuroscientists to probe neural substrates underlying social interaction, and how such interactions are affected by disorders. However, present technologies are limited by performance (e.g. EEG), or unnatural scanning environments (e.g. fMRI). Here, we showcase a new way to undertake naturalistic hyperscanning using wearable OPM-MEG.

Methods: We placed 16 OPMs over the left motor cortex of two participants. To minimise motion artefacts, we used a matrix-coil, active magnetic shielding system to compensate the background static magnetic field over the two heads, simultaneously. The participants stood facing each other and performed two experiments:
1) a guided touch task where participant 1 reached out and stroked the back of the hand of participant 2, repeating and reversing roles.
2) a two-person ball game where participants hit a table-tennis ball back and forth.

Results:
A reduction in beta oscillatory power was observed during all movements and source localisation revealed activation in the motor cortex in both tasks, suggesting high-quality MEG data was collected. Specifically, in the touch task the touching participant showed a reduction in beta power that commenced earlier and persisted longer than that seen in the passive participant. In the ball-game task the beta envelopes evolve in anti-phase, with a lag of ~0.6s between participants.

Discussion:
Results suggest OPM-MEG, supported by matrix coil technology, is a powerful tool for hyperscanning; and more generally for enabling naturalistic paradigms. Future work aims to extend the range of participant motion.

IM-47

Using matrix coils to enable unrestricted movement in wearable MEG

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Background:
As OPMs move through a non-zero magnetic field, artefacts are induced which mask MEG signals, introduce sensor gain changes and, potentially, saturate outputs. Previous experiments involving moving arrays of OPMs have been restricted to small, fixed volumes at the centre of an electromagnetic coil system; limiting opportunities for experiments involving naturalistic/ambulatory motion. Here, we use a flexible 'matrix coil' system, which dynamically re-designs itself to shift the region over which magnetic fields are produced to compensate motion artefacts.

Methods:
An optical tracking camera is used to identify the position of an array of OPMs placed in a rigid helmet with respect to the matrix coils (24 square, 40-cm-side coils in an overlapping pattern (a 3x3 grid of coils overlaid onto a 4x4 grid, central coil excluded) mounted onto two large planes (48 coils total)). From this information, the magnetic field produced by each coil at each OPM is calculated. Magnetic field measurements from the OPMs in the helmet are taken and decomposed into low-order spherical harmonics (to avoid compensating brain activity). Coil currents are continually updated (at 20Hz) to compensate the background field changes experienced by the OPMs as they move.

Results:
Results show reduction of motion artefacts induced by helmet rotations by a factor of 4 (compared to the same movements repeated without matrix coils).

Discussion:
Previous designs restricted movements to a 40-cm cube, the ability to conduct experiments with a wider range of motion will be crucial if OPM-MEG is to realise its full potential.

IM-48

Calibration and localization of optically pumped magnetometers using electromagnetic coils

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Optically pumped magnetometers (OPMs) provide the opportunity to personalize sensor placement to minimize the source-to-sensor distance in magnetoencephalography (MEG). However, this requires a method for rapidly calibrating OPM locations and orientations before the measurement which is not required for fixed array SQUID-based systems. Here, we describe how large electromagnetic coils can be used to determine the positions, orientations and gains (jointly referred to as calibration) of OPMs. We first measure the magnetic fields of the coils at multiple positions with a well-calibrated magnetometer, e.g., a fluxgate. We then fit vector spherical harmonics (VSH) models to the field measurements. To calibrate an OPM sensor, we then excite the coils, measure the fields with the OPM, and minimize the difference between the VSH models and the measured coil field amplitudes. We used 17 coils embedded in a cylindrical magnetic shield to localize and calibrate a 48-channel OPM array. We first obtained the VSH models of the coil fields using a fluxgate magnetometer. Using the fluxgate and the obtained VSH models, we estimated the RMS position, orientation, and gain errors of the method to be 1.0 mm, 0.2° and 0.8%, respectively. Last, we calibrated the OPM array and used it to localize magnetic dipoles in a phantom with an average position error of 3.3 mm. The results demonstrate the feasibility of using coils to calibrate OPMs for MEG. This is attractive as most of the OPM-MEG systems already employ large electromagnetic coils for nulling the background magnetic field inside a magnetic shield.

IM-49

Validating quantum enabled imaging in a driving simulator

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Background:
Despite tremendous technological advances in neuroimaging, it remains unclear how the brain supports cognition in complex tasks. The recent development of whole-head OPM-MEG allows the recording of high-fidelity brain signals in the presence of head movements, making it possible to image complex real-world tasks, such as driving.

Methods:
We integrated a 50-channel whole-head OPM-MEG device with a head-free eye tracker, and a MEG-compatible driving unit, to provide a simulated driving environment. We evaluated the driving system with an increasingly complex set of experiments, ranging from pedal presses and steering wheel turns in the absence of external stimuli, to acceleration and braking on a linear track, to complex scenarios where participants drive under a range of different conditions (e.g. rural vs urban, introduction of hazardous events).

Results and Discussion:
We successfully acquired robust OPM-MEG data and maps of ocular movements in a simulated driving environment. We measured beta-band oscillatory modulation in the motor network and found a post-movement rebound linked to pedal presses. We obtained OPM signals related to eye movements (saccades and fixations) made during simulated driving. Our data are the first to validate the use of OPM technology in driving research and provide an essential first-step for using quantum enabled imaging to understand mechanisms such as visual search - a cognitive process that is critical to driving performance and safety. We plan to use this system to explore senescent changes in driving performance and how cognitive training might be used to improve function.

IM-50

Simultaneous multi-channel measurements of magnetoencephalography using optically pumped magnetometers comparing between a multi-channel OPM and multiple OPM modules

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Introduction
While the current sensor used for magnetoencephalography (MEG) is the array of superconducting quantum interference devices (SQUIDs), optically pumped magnetometers (OPMs) are focused as alternative ones recently. To apply OPM to MEG system, it requires simultaneous multi-channel measurements to estimate signal sources. Therefore, we investigated the feasibility of OPM-MEG with two approaches: a multi-channel OPM and multiple OPM modules.

Method
With multi-channels OPMs, we measured event-related desynchronizations (ERDs) associated with eyes open and closed and auditory evoked fields (AEFs). On the other hand, using multiple OPM modules, we measured the ERDs and the visually evoked fields (VEFs).

Result
On multi-channel OPMs, we observed changes in alpha-wave powers at several channels in some subjects, while we were not able to observe significant difference in neuro-magnetic fields with and without auditory stimuli. Meanwhile with multiple OPM mudules, we also observed similar ERDs to those by multi-channel OPMs as well as VEFs such as N75m, P100m, and N145m.

Discussion
The sensing direction of multi-channel OPMs are the same, which makes easy to calibrate magnetic fields to zero. In addition, it is easy to increase the sensor density, while that of multiple OPM modules is limited by module size. On multiple OPM modules, the flexibility of sensing points is attractive, which makes possible to place each OPM in the vicinity of the activated area. Hence, the challenge of multiple OPM modules is individual difference. By overcoming this issue, OPM-MEG may realize affordable system and sufficient performance for neuro-magnetic field measurements.

IM-51

Reliable Assessment Of Evoked Brain Responses Targeted by Transcranial Alternating Current Stimulation (tACS) Using Optically Pumped Magnetometers (OPMs)

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Background:
Millisecond-precise targeting of ongoing brain oscillations with electric stimulation is an important goal to uncover brain-behavior relationships or to treat neurological and psychiatric disorders related to abnormal brain activity. The main challenge to implement such a paradigm is to reliably assess ongoing brain activity despite stimulation artifacts that often exceed physiological signals by many orders of magnitude. Recently, we have introduced stimulation artifact source separation (SASS) to recover brain electric signals using electroencephalography (EEG) during transcranial alternating current stimulation (tACS). Due to volume conduction and susceptibility to muscle artifacts, EEG remains limited to establish millisecond- and millimeter-precise closed-loop or adaptive brain stimulation. Here we tested the feasibility of using optically pumped magnetometers (OPMs) to assess visually evoked brain responses targeted by tACS.

Methods:
Visually-evoked responses related to flickering visual stimuli with random intertrial intervals were assessed using 16 OPM sensors (FieldLine Inc., Boulder, USA) fitted into a custom 3D-printed array. tACS stimulation pads were placed over occipital brain regions and stimulation signals applied at random phase angles relative to the visual stimuli. Brain-evoked responses were recovered using SASS.

Results:
We found that (1) tACS-related stimulation artifacts remain well within the dynamic range of the OPM sensors, (2) visually evoked brain responses could be successfully recovered, allowing for real-time closed-loop stimulation paradigms

Conclusion:
We found that combining OPMs and tACS is feasible and may pave the way for millisecond- and millimeter-precised closed-loop neuromodulation.

IM-52

Detection of 3-axis biomagnetic-field direction using optically pumped magnetometer by continuous variation of pump and probe beam direction

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Introduction
Optically pumped magnetometers (OPMs) are ultra-high sensitive and achieve a theoretical sensitivity of 10 aT/√Hz under the spin-exchange relaxation-free (SERF) conditions. Recently, OPMs are actively studied as sensors for the biomagnetic-field measurements alternative to superconducting quantum interference devices (SQUIDs). It is effective to measure the field direction for identifying the signal sources accurately in biomagnetic-field measurements. Therefore we demonstrated 3-axis measurements with changing sensing direction of OPMs theoretically and experimentally.

Method
The sensing direction of the pump-probe OPMs is the surface vector made by pump and probe beams, therefore we can estimate the field direction by measuring the variance of the signal intensity changing the direction of the beams. In our method, we varied the direction of the pump and probe beams in 4 ways, that is, the magnetic field was measured in a total of four directions, called mode_1 to mode_4. We verified this method with changing the mode discretely and continuously by numerical simulation.

Results and discussion
When the direction was varied discretely, we found that the direction of the field could be estimated accurately. On the other hand, when the direction was varied continuously, it is necessary to correct the data to estimate the direction accurately depending on the frequency of beam flipping. In the future, it is necessary to take noise and other factors into account to match the actual experimental environment.

IM-53

Towards a commercial wearable whole-head OPM-MEG system

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Background:
Optically-pumped magnetometers (OPMs) bear many promises for MEG due to their non-cryogenic operation, and ability for conformal placement directly on the scalp. These include the option to move during the recording, opening possibilities for studies in children, potentially higher source separation, lower cost of entry, and mobile systems. While higher signal amplitudes have been measured previously by several groups, the ability and limitations of source localization are more difficult to assess experimentally. This is partially due to the lack of dense whole-head OPM-MEG setups with high enough sensor counts and errors induced by moving small numbers of sensors between positions on the head.

Methods:
Data is presented from a dense conformal whole-head MEG system consisting of 112 commercial OPMs from FieldLine Medical, mounted in an adjustable helmet to placed them in contact with the scalp. All sensor locations were measured automatically with magnetic localization. A global active shield was used to bring the ambient remanent field into the operating range of the OPMs. Basic sensory-evoked field were recorded from the visual, auditory, and somatosensory cortices on a group of six healthy adult subjects. The OPM data were cross-validated with measurements of the same subjects in a cryogenic MEG system.

Results:
We evaluate the data quality and localization accuracy specifically in light of OPM system parameters, such as crosstalk, linearity, response bandwidth, cross-axis sensitivity, and accurate knowledge of the sensor positions and orientations. In addition, challenges specifically related to OPMs due to varying background fields and co-registration are discussed.

IM-54

Minimising interference between OPMs: design of actively shielded internal coils

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Background:
Optically pumped magnetometers (OPMs) offer a path towards more precise magnetoencephalography (MEG). Unlike superconducting quantum interference devices (SQUIDs), OPMs do not require cryogenic cooling. This allows bringing OPMs closer to the scalp, greatly increasing measured brain magnetic fields. The current OPMs, however, cannot be packed as densely as SQUIDs, reducing the attainable number of sensors. This is because each OPM needs to generate its internal magnetic field to define the sensor's sensitive axis. The stray magnetic fields of the on-board-sensor coils cause undesired interference between adjacent OPMs (such as rotation of their sensitive axis) affecting measurement accuracy.

Methods:
In an actively shielded coil, parts of the coil winding are used to reduce the stray magnetic fields. With mixed-integer programming, we designed a robust and miniaturisable design for an actively shielded coil for OPMs. We manufactured such a coil for our nonlinear magneto-optical rotation (NMOR) OPM sensor using a flexible printed circuit board.

Results:
Compared to our previous bias coil, the actively shielded bias coil reduces the stray magnetic field by a factor of 10 when two sensors are directly adjacent (from 10% to 1% interference), and by a factor of 100 at two sensor diameters (from 1% to 0.01% interference). The field homogeneity of the new coil over the OPM vapour cell is comparable to an identically sized Helmholtz coil.

Discussion:
We developed a method to design miniaturisable, yet optimally actively shielded coils for OPM sensors. Such coils reduce the interference between adjacent OPM sensors to negligible levels.

IM-55

Recording of Interictal epileptic activity with 4He OPM: validation by simultaneous Intracerebral EEG recording and SQUID-MEG.

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Background:
Current clinical use of MEG for presurgical evaluation of epilepsy remains limited due to constraints of cryogenic SQUID technology. Alkali Optically Pumped Magnetometers (OPM) tackle some of these drawbacks but still have some limitations. 4HeOPMs offer significative improvements: no heating, a large dynamic range (>200 nT) and frequency bandwidth (0-2000Hz), a 3 magnetic field components measurement. Preliminary data recorded in two epileptic patients are presented.

Methods:
One epileptic patient was recorded with a 15 channels 4HeOPM system and a classical SQUID-MEG, simultaneously to stereo-EEG (SEEG). The second patient was recorded with 4HeOPM system and SQUID-MEG. 4HeOPM were used in standard magnetic shielded room, without field nulling system. Patients were recorded in a resting state condition. The resulting signals were denoised using ICA for head movement artefact correction.

Results:
Interictal spikes were detected on OPM and SQUID-MEG data, with a comparable correlation to events simultaneously recorded in SEEG. Signal to noise ratio were similar between 4He OPM and SQUID-MEG. In the second patient, interictal spikes were compared between 4HeOPM and co-localized sensors from SQUID-MEG. A similar morphology and signal to noise ratio was found.

Discussion:
These results demonstrate that 4HeOPM-MEG system presents a promising alternative to the current MEG technologies for the presurgical evaluation of epileptic patients. Operating at room temperature, 4He OPM can be placed directly on the scalp without discomfort for the patient and can be adapted to any head shape and size, making easier MEG recordings in epileptic children, without loss of performance.

IM-56

Shaking mu-metal shields to improve magnetic screening properties

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Background
Measurements of biomagnetism require shielding of the measurement apparatus from static/low-frequency magnetic fields using layers of high permeability material, e.g. mu-metal. Shielding efficiency is strongly dependent on shield permeability, and this can be increased by applying an oscillating flux (typically at ~50Hz) to the shield, using coils threaded through the shield. This approach, known as shaking, was tested in early implementations of shielding for magnetoencephalography, but has not been widely exploited in modern systems. Here we investigated the improvement in shielding that can be achieved by shaking in a single layer, cubic mu-metal shield (side 555mm; 1.5mm thickness).

Method
A square coil (1665-mm side) mounted in a horizontal plane through the centre of the shield was used to apply interference (~8uT) fields at a range of frequencies (0.05-125Hz). The field at the centre of the shield was measured using a 3-axis fluxgate magnetometer (SENSYS), while oscillating currents with different frequencies (12.25-153Hz) and amplitudes (0-1.6A) were applied to the built-in degaussing coils.

Results
The shielding efficiency of the cube was in the range 120-320, increasing with frequency up to ~10Hz. The increase in shielding efficiency on shaking was sensitive to the frequency of the shaking and interference fields, and shaking current. Gains in shield efficiency of 2-3.5 times were obtained for shaking frequencies (12.25–51Hz) and interference fields of <10Hz.

Discussion
Significant gains in shielding efficiency were obtained by shaking a small mu-metal shield. Shaking could be used in future to reduce the weight and size of passive shields.

IM-57 Ergonomic design of a wearable magnetoencephalography helmet for multiple users

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Optically pumped magnetometers (OPMs) enable a wearable, adaptable, and motion-robust magnetoencephalography (MEG) system. Because each OPM sensor is a compact standalone unit that needs to be fixed to the head, a key to the success of OP-MEG technology is a mounting design that provides both high-quality signals and practicality. Using digital fabrication and 3D printing, we prototyped an ergonomic helmet based on a head-form model that accurately represents Australian, our study population's, scalp shape. The anthropometry-based helmet fitted target users' heads so sensor-to-head distances could be reduced. Adding onto the helmet, we designed a sensor retaining system that serves as a sensor holder when being attached to the helmet and a sensor protection gear when being outside the helmet. We created a "stepped press-fit mechanism" for sensor attachment. Switching sensor positions was straightforward (simply squeezing and pushing holders in/out the helmet) and fast (<10 seconds to change a sensor position) so experimenters can efficiently place flexible sensor arrays. The attachment mechanism also allows sensors to travel radially to the helmet, which minimises sensor-to-head distances in different head sizes and shapes. Further, we applied heat-dissipation design and adjustable helmet padding and straps to ensure safety and comfort. We plan to test the helmet by measuring auditory mismatch negativity and will compare data quality with existing mounting designs. In sum, our multiple-users helmet enables accurate, flexible, and fast sensor positioning, whilst being adjustable for most head sizes and shapes, hence it opens up a wider range of possible applications.

IM-58 Neural activity in human eyeblink conditioning: an optically pumped magnetometer-based MEG study

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Background:
The cerebellum is essential for the acquisition of classical eyeblink conditioning. Learning is assumed to be achieved through complex spikes of Purkinje cells which 'teach' the association between unconditioned and conditioned stimuli. Yet human electrophysiological evidence about this activity is largely lacking. Previously we showed that we could use optically pumped magnetometer-based MEG (OP-MEG) to detect human cerebellar activity during stimulated eyeblinks. Here we investigated cerebellar OP-MEG during eyeblink conditioning.

Methods:
We used a 500 ms binaural tone as the conditioned stimulus (CS) followed by a brief air-puff delivered to the participant's eye as the unconditioned stimulus (US). A session consisted of a 200-trial baseline block (140 US-only trials, 50 CS-only trials, 10 paired CS-US trials) and 4x200 trial acquisition blocks (190 CS-US trials and 10 CS only trials), total 800 trials. 12-14 OPM sensors were used across the cerebellum in 4 participants.

Results:
As has been shown previously, we identified baseline cerebellar responses evoked by the US. Additionally, in the acquisition phase, evoked fields at 50-150 ms post-CS were found but their source locations were outside the cerebellum. In trials showing anticipatory conditioned blinks, we identified a cerebellar evoked component immediately before blinking. However, the same evoked field was found before unconditioned blinks. We thus could not conclude the pre-blink evoked response was evidence of a learned response.

Discussion:
We replicated early work in showing that OP-MEG is effective for detecting baseline cerebellar evoked activity, but could not find conclusive evidence of complex spikes or learned responses.

IM-59 Magnetic field compensation coil design and control for magnetoencephalography

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Optically pumped magnetometers (OPMs) allow for highly sensitive recordings of the human magnetoencephalogram (MEG). However, they have a rather limited operational range of about 5 nT and request a zero remnant field. Attaching such sensors to the head of participants puts exceptional demands on the within-sensor remnant field compensation. Without active suppression of the remnant field, head movements would disable the OPMs. We propose 8 compensation coils on 5 sides of a cube with a side length of approximately 2 m optimized for operation inside a magnetically shielded room (MSR). Compared to previously built bi-planar compensation coils, our coils are more complex in geometry and achieved smaller errors for simulated compensation fields. Hence, they will allow for larger head movements or smaller movement artifacts in future MEG experiments compared to existing coils. We characterized the background field in our three-layer MSR with measurements and developed a concept for the control of external compensation coils. We plan to use four two-dimensional QZF-sensors to span an 8-dimensional data space and thereby allow for control of our 8-dimensional compensation coils. We investigated and tested a two-channel compensation of Bx and dBx/dx over 30 minutes. Field suppressions of the 0th-order x-component from 20 nT to 81 ±2 pT (max. Bx) and of the 1st-order component to 420 pT/m (max. dBx/dx) were achieved. Amplitude fluctuations (peak-to-peak) below 10 Hz were attenuated from 201±49 pT to 15±2 pT within the target volume.

IM-60 Magnetospinoencephalography: Concurrent spinal and brain imaging with optically pumped magnetometers

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The spinal cord and its interactions with the brain are fundamental for movement control and somatosensation. However, brain and spinal cord electrophysiology in humans have largely been treated as distinct enterprises, in part due to the relative inaccessibility of the spinal cord. Consequently, there is a dearth of knowledge on human spinal electrophysiology, including the multiple pathologies of the central nervous system that affect the spinal cord as well as the brain. Here we exploit recent advances in the development of wearable, optically pumped magnetometers (OPMs) which can be flexibly arranged to provide coverage of both the spinal cord and the brain concurrently in unconstrained environments. Our system for magnetospinoencephalography (MSEG) uses a custom-made spinal scanning cast to distribute sensors over the neck and back in coordination with recording of cortical activity. We record simultaneous spinal and cortical evoked responses to median nerve stimulation, demonstrating the novel ability for concurrent non-invasive millisecond imaging of brain and spinal cord.

IM-61

Comparing different measuring components of SQUID- and OPM-MEG: a simulation study

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Recent advancements in optically pumped magnetometers (OPM) made them suitable for magnetoencephalography (MEG). OPMs have several advantages over standard SQUID MEG systems, the main being that they do not need cooling with cryogenics. They can be placed closer to the head. Some commercial OPMs can measure all three orthogonal components simultaneously. In this work, we performed a simulation of dipolar-like sources inside the brain for several configurations of SQUID and OPM-based MEG systems using different realistically shaped 3-shell boundary element models constructed from MRI of 8 subjects. To the calculated magnetic fields, we added different levels of spontaneous brain noise and ambient noise. To test the performance of a given MEG configuration, we performed an equivalent current dipole fit and additionally calculated the signal-to-noise ratio (SNR). We found out that both types of noises had on average higher impact (higher localization error and lower SNR) on the SQUID- than on the OPM-MEG configuration. Radial components performed better than the tangential components for both systems (SQUID and OPM), the best results were obtained when we combined all three orthogonal components of the OPM-MEG. Next, we calculated how several OPM-MEG configurations perform for low sensor counts and found out that using a triaxial OPM magnetometer is highly advantageous. Lastly, we checked the performance for localizing deeper sources. When adding the ambient noise, OPM-MEG configurations significantly outperformed SQUID-MEG configurations, while this is not the case when adding the spontaneous brain noise.

IM-62

A robotic open-source platform for navigated transcranial magnetic stimulators

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Transcranial magnetic stimulation (TMS) is a non-invasive brain stimulation technique widely used to investigate human brain functions. TMS employs a stimulation coil to deliver an intense magnetic field for a short time interval, inducing an electric field in the cortical tissue capable of eliciting and modulating neuronal activity. Small coil displacements may change the TMS-evoked brain responses considerably (Hallett, 2000). Collaborative robots (cobots) have been used to improve the accuracy and the reproducibility of TMS targeting (Goetz, 2019). However, the robotic TMS coil positioning is not common due to poor portability, high cost, and closed-source software development platforms. To narrow this gap, we developed an open-source platform for robotized TMS. The robotic control was implemented in our software InVesalius Navigator (Souza, 2018) for navigated TMS and with the cobot Elfin-E5 (HAN*S-Robots). To ensure the safety of the TMS robotic control, we developed four security layers: 1) securing the visibility of the patient's head markers; 2) filtering sudden fluctuations of the tracking-determined device coordinates, 3) pre-defining the volume where the coil is allowed to move; 4) restricting the coil trajectory. Lastly, we evaluated the stability and reproducibility of the robotic control and its ability to follow a moving target. The resulting cobot stability was 0.03 ± 0.01mm and 0.02 ± 0.01°. The stability was defined as the Euclidean distance between a target and the actual cobot positioning for 15 minutes in 3 trials. Our new platform is an important step to increase the accuracy and reliability of TMS procedures for brain investigation.

IM-63

Magnetomyography in a mobile setup

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In clinical neurophysiology the measurement of electrical potential differences with invasive or surface electrodes is well established and in daily use for methods as electroencephalography (EEG), electroneurography (ENG) and electromyography (EMG). Since the underlying processes are electrodynamic, recording the biomagnetic fields poses an alternative measurement option. It is beneficial in terms of spatial resolution of functional processes, as has been demonstrated in Magnetoencephalography (MEG) [1] and delivers information on the vectorial direction of the field. With the miniaturization of highly sensitive optically pumped magnetometers (OPM) the sensors can be placed as flexible as electrodes and thus enable to adapt to the individual anatomy. As we have demonstrated [2-3] this makes it possible to bring sensors close to the skin even in strongly individual geometries as needed for Magnetomyography (MMG). But to measure the tiny biomagnetic fields in single trails, proper shielding of surrounding magnetic fields is crucial. For MMG on the limbs in many cases a small compact shielding can be sufficient, as we will report based on our recent measurements with commercial OPMs mounted inside a table-top cylindrical shield. From these first measurements we deduce the requirements on magnetic shields and magnetic field sensors specially dedicated for the needs in MMG, to enable MMG even in urban environments such as a hospital. [1] Joachim Gross, Neuron, 104, 189 (2019) [2] Broser, Middelmann, Sometti, Braun., J. Electromyography Kinesiol., 56, 102490 (2021) [3] Marquetand, Middelmann, Dax, Baek, Sometti, Grimm, Lerche, Martin, Kronlage, Siegel, Braun, Broser, Clinical Neurophysiology, 132, 2681 (2021)

IM-64

Remnant magnetic field mapping of a cylindrical shield OPM system

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Background:
With advancements in sensor technology, the ability of optically pumped magnetometers (OPM) to measure neuromagnetic signals has been prominent. The Biosignal Lab is home to a small-footprint OPM system sited within a cylindrical shield. The efficacy of this approach depends on the remnant magnetic field inside the shield, as movement of sensors (e.g. caused by vibration of the shield) through this field introduces artefacts, which decrease data quality. Field mapping is necessary to assess the effect of the remnant field on the fidelity of OPM data.

Methods:
OPM sensors were placed at known locations inside the shield, and DC fields were recorded to capture a 3D vector field map (30x30x30 cm3). First-order gradients were determined based on the field variation across known locations within our cylindrical shield.

Results:
Field components up to 10nT were measured, with gradients up to 40–60nT/m. These values are higher than the ~5-10nT/m values, reported by others using active compensation in a full-sized shielded room. Although fixed-sensor MEG recordings have been successful with the cylindrical system, sensor movements in an inhomogeneous field likely produce the observed near-DC artefacts.

Discussion:
While previous findings support the use of cylindrical shields in OPM systems, the current data buttress that the shielding requirement near-DC frequencies present challenges to the collection of high-quality MEG data in a cylindrical shield. Hardware (e.g., coils) and software (e.g., gradiometry, post-processing) compensation approaches will be explored to improve data quality.

IM-65 The ability of a dense OPM array to resolve simultaneous sources: A simulation study

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Invasive intracranial electrocorticography (ECoG) is the gold standard for high spatial and temporal resolution brain mapping. Unfortunately, ECoG can only be utilized in conditions such as presurgical planning for epilepsy, where the potential benefits outweigh the substantial risks. While magnetoencephalography (MEG) has superior spatial resolution to electroencephalography (EEG), traditional superconducting quantum interference device (SQUID) MEG systems cannot approach the resolution of ECoG. Optically pumped magnetometers (OPMs), which (like EEG) can be placed directly on the scalp, enable the construction of dense arrays that could potentially rival ECoG in resolution. We consider an array of 56 adjacent OPMs sensors, through exhaustive simulation, and assess the ability of the array to differentiate between multiple simultaneous sources in the presence of ongoing background brain activity. We explore the effects of crosstalk, as well as errors in the sensor sensitive axis, gain, and sensor position. While an ideal OPM array significantly outperforms a conventional MEG system, we find that while even 5-10% crosstalk may be acceptable, angular errors of 3 degrees or gain errors of 5% results in unacceptable degradation in the performance of the array. Likewise, errors in sensor positions can be no larger than 0.25mm. As we increase the number of independent sources in our simulations, we find that traditional SQUID MEG cannot differentiate 32 simultaneous sources, while our OPM array can differentiate 64 simultaneous sources with reasonable accuracy. We conclude from these simulations that an accurately calibrated dense OPM array can vastly outperform SQUID systems for precision, high resolution MEG.

IM-66 Combining video telemetry and wearable MEG for naturalistic imaging

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Background:
Wearable MEG systems now allow us to perform naturalistic experiments in both neuroscientific and clinical settings relatively unconstrained by head and body movement. As a result, new methods to assess experimental behaviour need implementing to better explain naturalistic MEG data. Here we investigate whether video telemetry can be utilised in mapping of eloquent cortex.

Methods:
Subjects participated in a simple block-designed motor task, where they were instructed to move one of their four limbs for 4 seconds, whilst wearing a wearable whole-brain OPM-MEG system. Simultaneously, video of the participants performing the task were recorded. In addition, two subjects also performed a task where they danced to the Hokey Cokey whilst also being recorded with MEG and video. The video was processed with deep learning methods to identify individual states of limb movement. The timing of these derived states was incorporated into the analyses of the MEG data.

Results:
Timings of limb movement derived from video were in close agreement with the original trial conditions of the motor task. As a result, localisation of beta-band power changes in the motor cortex were also similar between the block-design and video-derived analyses. Similarly, in the complex dance task we could localise motor areas corresponding to the limbs based on the video data alone.

Discussion:
We have shown the utility of video telemetry in augmenting MEG analyses, in both a simple and complex motor tasks. We believe it has the potential to be a powerful tool for naturalistic and challenging clinical studies.

IM-67

Optically Pumped Magnetoencephalography (OP-MEG) for language mapping: lateralised responses to visual and auditory cues

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Background:
One of the most exciting applications for wearable OP-MEG is to study neural activity in the developing brain. So far, we have been using visual presentation of nouns to elicit verb generation. In order to assess the lateralisation of language in pre-literate children, we piloted an auditory version of the standard verb generation task.

Methods:
Stimuli consisted of 95 nouns in a pseudorandomised order, and participants were asked to covertly generate a corresponding verb. The full list of words was presented first visually, then auditorily. Changes in magnetic field were measured using a whole-head OPM array. We used a beamformer to estimate changes in power within frequencies 13-30 Hz in the one second interval post-stimulus presentation.

Results:
Power changes were typically left lateralised in both auditory and visual conditions. This was maximally significant in left inferior frontal regions in both conditions.

Discussion:
The robust lateralisation observed during both visual and auditory verb generation tasks suggests that OP-MEG has promise for pre-surgical language mapping in adults and children.

IM-68

A small ferrite shield to enhance the performance of optically pumped magnetometers for fetal magnetocardiography and magnetogastrography

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We have shown that a cylindrical person-sized magnetically shielded chamber along with an array of optically pumped magnetometers (OPMs) provides a compact, affordable alternative to SQUID-based systems for fetal magnetocardiography (fMCG). However, a drawback of such systems is that environmental and biological interferences are substantial because the shield has an open end. In this work, we investigated whether the addition of a small shield enclosing the OPMs attenuates the interferences, including maternal cardiac interference. This would lessen the need for signal processing and potentially reduce the required number of sensors. Other applications, such as magnetogastrography (MGG), could also benefit from this approach. The small shield consisted of a ferrite cylinder of height 12.5 cm, diameter 15 cm and thickness 1 cm, which was deployed within a cylindrical three-layer mu-metal shield of 2 m length and inner diameter 75 cm. We characterized the performance of the ferrite shield by comparing the noise amplitude and signal-to-noise ratio along the long axis of the person-sized shield with and without the ferrite shield. Two coils were used to simulate the fetal signal and maternal interference of fMCG, and the stomach signal and cardiac interference of MGG. The data show that the ferrite shield reduces the interferences and improves the fMCG and MGG signals in simulations. Preliminary data from human studies show similar results. The findings suggest that the addition of a small ferrite shield can increase the performance and/or reduce the cost of OPM-based systems for applications using a small array of sensors.

IM-69

Assessment of Fetal Arrhythmias via Simultaneous Echocardiography and Magnetocardiography

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Arrhythmias arise from abnormal electrical activity in the heart and in some cases can lead to sudden death. Fetal echocardiography (fEcho) is the most widely used method of diagnosing fetal arrhythmia, but relies on assessment of mechanical activity to infer electrical rhythm. Conversely, fetal magnetocardiography (fMCG) records electrical rhythm, but cannot assess mechanical function. In this work we develop methodology to combine fEcho and fMCG. This provides a more comprehensive evaluation of fetal arrhythmias and also allows assessment of electromechanical coupling, a fundamental aspect of cardiac physiology. Simultaneous fEcho and fMCG were recorded from pregnant subjects within a person-sized mu-metal cylindrical shield. Optically pumped magnetometers (OPMs) were used to record the fMCG, and a battery-powered ultrasound scanner was used to record the fEcho. Penetrations were made in the person-sized shield so that the sonographer could reach inside to scan the patient. In this way the interference from the scanner electronics was fully attenuated by the shield. The signals were time-aligned to within 4 ms precision, allowing precise measurement of electromechanical indices. This was accomplished by superimposing the fMCG onto pulsed-Doppler ultrasound tracings. Electromechanical indices (atrial activation time, pre-ejection period, isovolumic contraction time) were measured for each subject. We have evidence that the electromechanical delays may be prolonged in some arrhythmias. For example, atrial activation is significantly longer for reentrant premature atrial beats than for sinus beats. This discrepancy between the electrical and mechanical rhythm implies that evaluation based on fEcho alone can potentially result in misdiagnosis.

IM-70

Background magnetic field control inside a lightweight magnetically shielded room for wearable MEG

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Background:
Optically-pumped magnetometers (OPMs) for magnetoencephalography (MEG) require high-performance magnetic shielding, due to their zero-field operation. Magnetically shielded rooms (MSRs) optimised for OPM-MEG employ four layers of high-permeability material to screen external magnetic fields, but are expensive, heavy and difficult to site. Recently, a lightweight, two-layer MSR has been developed for OPM-MEG with integrated electromagnetic coils for active shielding. Here we describe how these coils are used to generate a low-field environment and enable wearable MEG recordings.

Method:
The background magnetic field is mapped over the central cubic metre of the MSR by rotation and translation of two triaxial fluxgate magnetometers. The movements of the magnetometers are recorded using optical tracking, and the motion and magnetometer data combined to obtain an estimate of the magnetic field, using a third order spherical harmonic model. Calibration of these coils characterises the field per unit current generated by each coil in each component of the model, enabling the selection of coil currents to cancel out the remnant magnetic field over the central region, where an OPM-MEG participant could be seated or standing.

Results:
The magnitude of the three uniform magnetic field components was reduced from |__|=6.13±0.15 nT to |__|=0.67±0.16 nT, and the five field gradient components reduced from |__|=2.67±0.30 nTm-1to |__|=1.02±0.46 nTm-1. OPM noise spectra demonstrate the suitability of this low-field environment for biomagnetic recordings.

Discussion:
Effective compensation of the remnant magnetic field inside a lightweight MSR is achieved, fulfilling the low-field requirement for high performance wearable MEG recordings of participants flexibly positioned inside the MSR.

IM-71

Precision magnetic field modelling and control for wearable MEG

Molly Rea[1], Niall Holmes[1], Ryan M. Hill[1], Elena Boto[1], James Leggett[1], Lucy J. Edwards[1], David Woolger[2], Eliot Dawson[2], Vishal Shah[3], James Osborne[3], Richard Bowtell[1], Matthew J. Brookes[1]

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Background:
Magnetoencephalography (MEG) systems based on wearable arrays of optically-pumped magnetometers (OPMs) have the potential to enable lifespan compliance and unrestricted participant movement. However, the small dynamic range of QuSpin OPMs, and their zero-field requirement, mean this potential can only be realised if magnetic fields are well controlled. Active magnetic shielding using electromagnetic coils can cancel the background magnetic field inside the magnetically shielded room surrounding an OPM array, but performance is limited by the accuracy with which the remnant field is measured. Here we report a magnetic field mapping technique that uses a moving array of OPMs worn in a rigid helmet.

Method:
The background magnetic field is sampled by making head movements that rotate and translate the OPM array. The magnetometer and movement data are combined to determine the field and gradient coefficients of the magnetic field using a spherical harmonic model. An equal and opposing field is then applied via an array of bi-planar electromagnetic coils. To validate the efficacy of our field mapping and nulling method for OPM-MEG, a visual steady-state evoked response experiment with 6Hz stimulation was performed.

Results:
A remnant magnetic field of 0.27±0.09nT was achieved, with gradients <1nTm-1. This led to a five-fold reduction in motion artefact (0_2Hz) during the MEG demonstration, and the signal-to-noise ratio of the 6Hz response was increased by a factor of eight.

Discussion:
This technique could be used to improve OPM-MEG data quality, particularly in paradigms measuring low-frequency oscillations, or where head movement is encouraged.

IM-72

The frequency response of OPM-MEG

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Background:
OPM-MEG ostensibly offers better data quality compared to SQUID-based technology. However, whilst OPMs get closer to the brain and detect a higher amplitude signal, they also have a higher noise floor. This is particularly important at low frequencies, where magnetic interference is difficult to shield. Here, we employ a steady-state visual evoked response paradigm to compare the sensitivity of OPMs and SQUIDs, across the 2–30Hz frequency range.

Methods:
Ten participants were scanned using SQUID- and OPM-based systems. For OPM-MEG, participants were free to move; to minimise motion artefact, magnetic field nulling was employed. Participants passively observed a flickering visual stimulus; A single trial comprised seven frequencies each shown for 2s, followed by 5s rest. 30 trials were presented. The sensor with the highest SNR at each frequency was identified and plotted the OPM-system SNR against the SQUID-system SNR, across subjects. We predicted a linear response, where a gradient >1 suggests higher SNR for OPMs.

Results:
At flicker-frequencies of 6Hz, 10Hz and 15Hz, a significant ($p < 0.05$) linear relationship was observed, showing that OPM and SQUIDs were measuring a similar response. The gradients were 1.84, 1.48 and 1.60, respectively. At the other frequencies, no significant linear response could be demonstrated, although trends were observed at 4Hz and 20Hz, with gradients of 1.22 and 1.30, respectively.

Discussion:
Results suggest that OPMs outperform SQUIDs across a range of frequencies, down to the theta band (4-8Hz). This supports the application of OPM-MEG, even for measurement of low frequency oscillations.

IM-73

Measuring frontal theta activation during a working memory task using OPM-MEG

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Background:
During working memory tasks, an increase in oscillatory power in the theta band (4–8Hz) is measured in the frontal cortex. However, this is challenging to image using OPM-MEG, where low frequency artefacts (both inherent to sensors and due to subject movement) fall within the theta band, masking brain signals. Here, we provide evidence that frontal theta can be detected by an OPM array.

Methods:
Eleven participants (average age 25, 7 male) were scanned using an OPM-MEG system (26 QuSpin dual-axis sensors and 17 QuSpin triaxial sensors, totalling 103 channels) with magnetic field nulling. All subjects were free to move throughout. An n-back task (20–seconds of letter presentation followed by 20–seconds rest) was presented for 25 trials. Participants pressed a button if the letter presented matched that shown 2 letters previously (2-back condition). Data were theta-band filtered and beamformed using a scalar beamformer, contrasting the task window (5 – 20s) with the rest period (24 – 39s).

Results:
The averaged beamformer image, normalised to standard MNI space, localised the peak theta-change to the frontal cortex. A “virtual electrode”, identified by creating a mask from the positive peak, showed an average percentage power increase in the theta band of (270±80)% during the task relative to rest ($p < 0.05$).

Discussion:
Results show that an OPM-MEG system can measure the challenging frontal theta oscillations with high fidelity, supporting the use of OPMs in measuring low-frequency neuronal signals.

IM-74

Neural dynamics measured during a trail making task: An OPM study

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Introduction
Recent advances in wearable magnetoencephalography (MEG) allow more naturalistic neuroscientific experiments. However, to ensure that the wider research community can adopt this technology with confidence, the repeatability of OPM-MEG must first be shown. Here, we make repeated OPM-MEG measurements during a trail-making task to demonstrate both the scan-to-scan reliability and flexibility of OPM-MEG.

Methods
We employed a trail-making task, where optical tracking of hand movements enabled the steering of a virtual pointer through a series of randomly generated mazes. Six volunteers each completed two runs of the experiment on consecutive days. We assessed within-subject repeatability by performing a spatial fingerprinting analysis: We source-localised task-induced beta desynchronization and transformed the activation maps onto a template brain. Subsequently, activation patterns from each subject’s initial run were correlated with all secondary recordings; the paired recordings with the highest correlation were chosen for each subject. A successful “fingerprint” required that matched pairs of patterns came from the same subject.

Results
Despite potential variability introduced by head movement in wearable MEG, our maze traversal paradigm reliably induced movement-related beta desynchronization. The “neural fingerprints” derived from this beta-band activity enabled the accurate identification of individual subjects from a database of activation maps, with 100% of subjects being identified correctly.

Conclusion
Our results suggest that wearable OPM-MEG provides assessments of motor function with high repeatability even when using complex tasks and removing the limit on free head movement required for conventional cryogenic MEG

IM-75

Visual gamma and emotional face responses using optically-pumped magnetometers

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Background:
Optically-pumped magnetometers (OPMs) offer tremendous improvements in signal-to-noise sensitivity, data quality, and movement tolerance compared to traditional cryogenic MEG. These advancements allow for novel recordings in young developmental populations. However, as an emerging technology, the replicability and reliability of well-established neural responses are essential. In this proof-of-principle study, we replicated visual gamma and emotional face responses using OPMs in 20 adults.

Methods:
OPM data were recorded using 40-dual-axis zero-field magnetometers during the presentation of emotional faces (to elicit evoked responses) and contracting concentric circles (to elicit robust gamma oscillations). Faces data were filtered between 2-40Hz; source activity was estimated for each of the first 90 AAL locations. For visual gamma data relative change following stimulus onset (250-800ms) compared to baseline between 40-50Hz was assessed.

Results:
An M170 evoked faces response was observed in the bilateral fusiform gyri, which was larger in the right hemisphere, with peak amplitude 39.5nAm (SD=25) and peak latency 166ms (SD=14.5). For visual gamma, we observed a 26.8% (SD=3.13%) increase in amplitude relative to baseline in the right middle occipital gyrus, and 25.0% (SD=2.85%) increase relative to baseline in the left middle occipital gyrus. The peak relative change ranged from 18.5% to 48.4% for participants in bilateral middle-occipital areas. Data from cryogenic MEG in these same subjects were analyzed, establishing comparability.

Discussion:
We demonstrated characteristic M170 faces response and visual gamma using OPMs, comparable in morphology and localization to those typically seen with conventional MEG. These findings are foundational for future developmental paediatric studies.

*equal contributions

IM-76

A new generation of OPM for high dynamic and large bandwidth magnetoencephalography: the 4He OPMs

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A promising and original alternative to alkali OPMs has emerged at CEA Leti [Labyt et al 2019, Fourcault et al. 2021]: the 4HeOPMs. These sensors have unique advantages: i) no heating, ii) a large resonance linewidth giving access to: a large dynamic range (>200 nT) and a large frequency bandwidth (0-2000Hz), iii) a measure of the 3 components of the magnetic field giving access to a better description of high spatial frequency structure in the field, iv) a closed loop control guaranteeing very stable and homogenous sensors performances. We report here results showing the experimental capabilities of 4HeOPMs for the study of normal spontaneous and evoked brain activities. Methods: 5 subjects were recorded with a 15 channels 4He OPM system and a classical CTF MEG. We performed auditory, visual, somesthesic stimulations, motor and resting state tasks. The signals were processed with MNE python 1) to denoise raw data, 2) to compute evoked fields and 3) to analyse the frequency composition of the signal. Results: The resulting 4HeOPMs evoked fields showed peaks similar to the classical MEG ones in the same subjects. SNR were comparable between the two modalities (from 5 to 10). In the same way, the frequency composition of the motor task was similar to the classical MEG results. Discussion: These results show that a MEG system based on 4HeOPMs present a viable alternative to the current generation of MEG technology and to the alkali OPM based. Moreover it is usable in currently existing magnetic shielded room without modifications.

IM-77

A 128-Channel Commercial OPM-MEG System

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Background
The value of MEG in the diagnosis and treatment of epilepsy is well established. However, conventional MEG systems require sensors to be cryogenically cooled in a one-size-fits-all helmet with sensors several centimetres from the head. Because the position of the head relative to the sensors must not change throughout a scan, patients are required to remain still, posing a challenge for paediatric patients. Children also have smaller heads leading to signal loss due to the increased distance between sensors and head. Here, we report the first commercial-grade wearable 128-channel optically-pumped magnetometer (OPM) MEG system, which overcomes these challenges.

Methods
The system comprises 64 dual-axis OPM sensors (QuSpin, inc.) mounted in a wearable helmet and housed inside a novel lightweight magnetically-shielded room equipped with electromagnetic coils for field control (Cerca Magnetics Limited). As an initial validation of the system, we scanned 10 healthy adults (mean age 44 ± 18yrs, 6 female), who undertook a right-index-finger abduction task.

Results
The movement-related beta desynchronisation and post-movement beta rebound were observed with a percentage change from baseline of 35±4% (mean±std) decrease and 37±8% increase, respectively. Results compared well to previously published work using cryogenic MEG in the same tasks.

Discussion
This system allows patients to wear OPM sensors on the scalp, resulting in increased signal-to-noise-ratio and dramatically improved comfort and practicality, as patients can move their heads. Now the system has been validated in adults, we plan to move forward in scanning both healthy children and children with epilepsy.

IM-78

Optically-pumped magnetometry evidence for cortical, cerebellar, and spinal interactions during human stepping

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The ability to register the spatio-temporal dynamics of brain activity in humans during large-scale, natural movement has previously proven challenging due to the current methodological limitations of existing neuroimaging techniques. For example, conventional magnetoencephalography (MEG) requires participants to lie or sit still, rendering the study of brain dynamics during whole-body movement inaccessible. This preliminary work used a new method using wearable optically-pumped magnetometer sensors (OP-MEG) to study brain activity during stepping and standing as models for large scale, natural movement. We demonstrate the first use of OP-MEG during whole-body movement and show that the method can reproduce features of oscillatory cortico-muscular connectivity demonstrated previously with other established neuroimaging modalities. We also present initial results supporting that OP-MEG is able to capture oscillatory cerebellar connectivity with the cortex and muscle during movement. This method may represent an opportunity for fundamental progress to be made in understanding how sensorimotor brain networks function to coordinate movements and how these functions break down in motor disorders.

IM-79

Spherical harmonic based noise rejection and neuronal sampling with multi-axis OPMs

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Background
Modern Optically Pumped Magnetometers (OPMs) are capable of providing full vector measurement of the brain's neuromagnetic field. In this study we explore the trade-offs encountered in terms of spatial sampling, interference rejection and SNR, when using vector OPMs versus purely radial or dual axis configurations.

Methods
We explore these issues in simulation using both vector spherical harmonics and eigenpectra to quantify how well a given array can separate neuronal signal from environmental interference while adequately sampling the entire cortex.

Results
We found that vector OPMs have superb noise rejection properties allowing for very high orders of interference to be accounted for while minimally affecting the neural space. To adequately model the signals arising from the cortex, we show that at least 11th order (143 spatial degrees of freedom) irregular solid harmonics or 95 eigenvectors of the lead field are needed to model the neural space for OPM data (regardless of number of axes measured). This can be adequately sampled with 75-100 equidistant triaxial sensors (225-300 channels) or 200 equidistant radial channels.

Discussion
In other words, ordering the same number of sensors in vector (rather than purely radial) configuration gives significant advantages not only in terms of external noise rejection but also minimizes cost, weight and cross-talk.

IM-80

Measuring high frequency signals with zero field magnetometers

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Background
In zero field Optically Pumped Magnetometer (OPM) designs there is typically a trade-off between bandwidth and sensitivity. In order to overcome this issue, we operate our sensor in Radiofrequency mode (RF-mode). In this mode the sensitive bandwidth is shifted from a 0Hz central frequency to a new central frequency that is proportional to an applied DC magnetic. In this study we characterise the bandwidth, sensitive axis, sensitivity and SNR gain from changing the sensor to operate in RF-mode.

Methods
Bloch simulations were used to characterise the sensitive axis of the sensor. A Helmholtz coil was then used to calibrate the sensor, establish sensitivity, verify the bandwidth using a frequency sweep and establish the SNR gain from operating in RF-mode.

Results
The centre frequency of the sensor's bandwidth was shifted from 0Hz to 500Hz using a ~70nT DC field. The bandwidth was found to be twice the zero-field bandwidth (500Hz +/-150Hz) in line with theoretical predictions and the sensitivities were equivalent (SNR was improved by a factor of 3-4 in RF-mode.

Discussion
RF- mode offers a promising way to enhance high frequency SNR for zero field magnetometers and may have relevance in the study of high frequency oscillations in epilepsy or for the study of sensory signals known to have a high frequency component.

IM-81

The comparison between spin-lock preparation sequences and acquisition-integrated spin-lock sequences

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Background
The functional MRI is measurement of brain function with MRI scanner. The conventional principle visualizes hemodynamics emerging 2-3 seconds after neural activation, which limits temporal sampling. Then, the electrophysiological principle are effective to overcome these problems, and we investigate spin-lock sequences, which makes contrast on MR image with magnetic resonance between magnetization and target oscillatory magnetic fields. In this study, we investigated the detectable limitation of spin-lock sequences with and without spoiler in 0.3-T MRI scanner.

Methods
We performed the phantom study with spin-lock preparation sequences including gradient spoilers such as stimulus-induced rotary saturation (SIRS) and spin-locked Mz (SL-Mz), and acquisition-integrated spin-lock sequence without spoilers like spin-lock oscillatory excitation (SLOE). The cylindrical phantom was filled with saline solution with 1.0-mM meglumine gadopentetate (Bayer AG., MAGNEVIST), its diameter is 100 mm, and T1 and T2 values are 114.39 ms and 133.14 ms, respectively. The target magnetic field was generated with a Helmholtz coil whose diameter is 160 mm.

Results
We detected 10.0 nT with SIRS, 2.00 nT with SLOE, and 1.50 nT with SL-Mz. Despite our theoretical expectation that SLOE is the most sensitive among three, SL-Mz detected the smallest magnetic field.

Discussion
The disagreement can come from two causes; the first one is stimulated echo due to RF pulses and the second is possibility of misalignment between the center of the readout and that of spin-echo. On the latter, the spoiler of SIRS and SL-Mz seems to play an important role to prevent extra echoes generated by RF pulses.

IM-82

Fetal Magneto/Echo-Cardiography Using Optically-Pumped Magnetometers

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Clinical evaluation of the fetus relies primarily on ultrasound techniques. In recent years, however, fetal magnetocardiography (fMCG) has been shown to be a highly effective method of assessing fetal heart rate and rhythm. One drawback of fMCG, however, is the difficultly of combining it with ultrasound and other modalities due to its susceptibility to interference. Here we demonstrate how optically-pumped magnetometers (OPMs), in combination with a person-sized magnetic shield, enable simultaneous recording of fMCG and echocardiography. By placing the scanner outside the shield, the electronic interference from the scanner is greatly attenuated. In this presentation, we describe various arrangements of the transducer and OPM sensors, and their performance trade-offs. Applications of this research include direct comparison of magnetic and mechanical rhythm for diagnosis of fetal arrhythmia and the combination of fMCG and pulsed Doppler ultrasound for assessment of electromechanical function.

IM-83

Fast online estimation of head tissues' conductivities using Reduced Order Modelling applied to Electrical Impedance Tomography

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Background:
Parametric Electrical Impedance Tomography (pEIT) is an ill-posed imaging method that allows us to non-invasively estimate the conductivity of tissues in a human head - information that is essential for other imaging methods such as Electroencephalography. However, the post-processing of pEIT measurement data is computationally expensive, making it prohibitive in some cases.

Methods:
We have used Reduced Order Modelling (ROM) to split the computational effort into an expensive offline stage and an inexpensive online stage, allowing us to estimate the conductivity of each tissue quickly and in real time after measurements are taken, saving the bulk of the work for the offline training stage. ROM achieves this by reducing the dimensionality of the problem needing to be solved by describing a solution manifold over the parameter space that is being searched for optimal conductivity parameters.

Results:
We have shown that ROM can be applied to pEIT effectively using a realistic 6-layered head model, with minimal errors in numerical simulations. We also demonstrate its potential use in developing areas of the field, such as estimating the conductivity with different current injection patterns and including the anisotropy of different head tissues in the model.

Discussion:
Our proposed method shows a significant reduction in time to estimate tissue conductivity once the training stage is complete, for which this method could prove very useful to researchers and clinicians. There is still work to be done, such as including more adaptive algorithms, and reducing the training time.

IM-84

Optically pumped magnetometers (OPMs) for motor imagery-controlled brain-computer interfaces (BCIs)

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Background
Brain-computer interfaces (BCIs) translate brain signals into control commands of external devices, e.g., computers or exoskeletons, restoring communication or movements in paralysis. However, current non-invasive tools to record brain signals have limited spatial resolutions and bandwidth reducing their applicability and efficacy. Optically pumped magnetometers (OPMs) promise to overcome these limitations, but it is unclear whether OPMs can be reliably used in such a paradigm, e.g. motor imagery-based control of an exoskeleton.

Methods
To assess reliability of OPMs in a motor imagery-controlled BCI paradigm, we used a real-time processing pipeline to analyze event-related synchronization/desynchronization (ERS/ERD) related to motor imagery of right hand movements (relax vs. grasping motion). 17 OPM sensors (FieldLine Inc.) were used in a custom 3D-printed sensor fixture placed over sensorimotor regions. The modular processing pipeline performed automatic retraining during the experiment without interruption and provided feedback to the user.

Results
We found that motor imagery-related ERDs could be reliably assessed, analyzed and classified in real-time using the OPMs. The experimental setup could enable reliable control of an external device providing online feedback to the user.

Discussion
Here, we presented evidence for reliable operation of a motor imagery-controlled BCI system, e.g., to operate a hand exoskeleton. Future studies should investigate whether OPM-based BCIs can achieve more degrees of freedom, e.g. to perform different exoskeleton-enabled movements, compared to established methods, such as electroencephalography (EEG).

IM-85

MEG-MRI technology and applications: results from the first full-scale prototype

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MRI is well established in its conventional form with Faraday detection and a static tesla-range uniform magnetic field applied inside a cylindrical bore. Besides the strong static magnetic field, high levels of both magnetic and acoustic noise are present during the measurement. In contrast, alternative MRI technologies can be free of such constraints, making also hybrid MEG–MRI possible. Our MRI implementation differs from conventional MRI in all parts, including coil design, detection, pulse-sequence electronics, reconstruction and software. For example, the traditional main magnet is separated in two: a superconducting magnet for polarizing the target spins, and a microtesla-range readout field. This allows accurate theoretical modeling of the signal, as well as detection with superconducting quantum-interference devices (SQUIDs) that can also measure MEG. This is the basis for our technique for submillimeter MEG–MRI spatial registration/calibration. We present, to our knowledge, the first MEG–MRI system with full-scale coverage of a helmet-shaped sensor arrangement, exposing 120 magnetometers to MRI pulses in essentially all directions. We describe improvements to different parts of the technology with the aim of, one by one, solving the problems that prevent its use in commercial devices. We also demonstrate pulse-waveform coupling, a.k.a. DynaCAN, able to solve several problems. With the significant hurdles in getting MEG–MRI technology to the next level finally unraveling, a new look can be taken at related technologies such as zero-field-encoded current-density imaging (Z-CDI), which has potential in improving electrical models for MEG source reconstruction and targeting stimulation.

VM-127

Assessment of hardware higher order gradiometers for OPM measurements

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OPMs are configured as magnetometers or 1st-order gradiometers, but there is potential to construct higher-order gradiometers. The advantage of higher-order gradiometers is that far-field noise sources decay faster with increasing gradient order compared to near-field sources. The drawback is attenuation of the near-field signal. We present simulations to determine effects of higher-order gradiometers on signal attenuation. A semi-circle of sensors along a plane (radius=10cm), with a current dipole along the axis of symmetry in a spherical conductor (radius=9cm) was simulated. Dipole depth was varied relative to the conductor surface. Magnetometers, 1st and 2nd-order gradiometers (5cm baselines) were constructed. To compare SQUID geometries, sensors at 11cm radius were also simulated. The computed signals were normalized relative to the peak response of the 10 cm OPM magnetometer array. Results of the relative peak signals are shown. Note that at a depth of 6cm, a planar gradiometer (1.5 cm baseline) will have a relative peak signal of < 30%. Source Depth (cm) 1 3 6 Magnetometer OPM 100% 100% 100% 1st-order OPM 87.1% 81.9% 64.1% 2nd-order OPM 84.9% 78.7% 57.3% 1st-order SQUID 50.8% 49.5% 46.6% 2nd-order SQUID 49.1% 46.7% 40.9%

The results indicate that there is less signal attenuation for sensors closer to the head surface and the signal for second-order gradiometers is reduced by up to 7% compared to first-order gradiometers. The results support the potential for the use of second-order gradiometers for better far-field cancellation.

IM-87

Theta-gamma phase amplitude coupling in human hippocampus supports auditory short-term memory retention.

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Background:
Phase Amplitude Coupling between theta and gamma oscillations has been hypothesized to implement the retention of information during short-term memory. However, the role of theta-gamma coupling in short-term memory functions, still needs to be confirmed. In this study, we investigated if hippocampal theta-gamma PAC supports memory retention, as compared to simple perception, and if theta-gamma coupling in the human hippocampus can predict behavioral performance.

Methods:
Stereotaxic EEG recordings were obtained in 16 pharmaco-resistant epileptic patients who performed delayed match-to-sample tasks for tone sequences, and a passive listening control condition with the same material. To investigate working memory functions, the duration of the silent retention period between the to-be-compared sequences was manipulated (2000, 4000, 8000 ms).

Results:
Time frequency analyses during the encoding period of the task show that each tone was encoded by a transient gamma burst in the auditory cortex, while the entire sequence elicited sustained theta oscillations in the ventral auditory stream. During the retention period, theta-gamma coupling increased in left hippocampus during memory trials as compared to perception trials. Importantly, theta-gamma coupling strength was correlated with participant's performance and high coupling stability (gamma burst nested to the theta trough) was observed in both left hippocampus and secondary auditory cortex.

Conclusion:
This result suggests, that hippocampal theta-gamma coupling supports the retention of memorized items in auditory short-term memory. This expands our knowledge of the general role of cross-frequency coupling as a global biological mechanism for brain information processing and integration in the human brain.

IM-88

Magnetoencephalography can reveal deep brain network activities linked to memory processes

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Recording from deep neural structures such as hippocampus non-invasively and yet with high temporal resolution remains a major challenge for human neuroscience. Although it has been proposed that deep neuronal activity might be recordable during cognitive tasks using magnetoencephalography (MEG), this remains to be demonstrated as the contribution of deep structures to MEG recordings may be too small to be detected or might be eclipsed by the activity of large-scale neocortical networks. In the present study, we disentangled mesial activity and large-scale networks from the MEG signals thanks to blind source separation (BSS). We then validated the MEG BSS components using intracerebral EEG signals recorded simultaneously in patients during their presurgical evaluation of epilepsy. In the MEG signals obtained during a memory task involving the recognition of old and new images, we identified with BSS a putative mesial component, which was present in all patients and all control subjects. The time course of the component selectively correlated with SEEG signals recorded from hippocampus and rhinal cortex, thus confirming its mesial origin. These findings complements previous studies with epileptic activity and opens new possibilities for using MEG to study deep brain structures in cognition and in brain disorders.

IM-89 Dynamic resource allocation in working memory through oscillatory coupling in the human cortex

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To function in our daily lives we need to select and prioritise relevant information from our environment while ignoring others. Furthermore, we need to hold this information in mind for later use; this temporary storage of selective information is known as working memory (WM). The operations comprising WM have been shown to be implemented by a distributed network including the occipital pole during visual perception and information selection, the parietal and temporal regions for higher order visual processing and information storage and the prefrontal cortex for top-down guidance. How such a monitoring component is implemented in the human brain, however, is unclear. Here, I will present a potential mechanism that enables such flexible resource allocation. According to this long-rang oscillatory coupling mechanism the phase of a slow rhythmic activity is critical for information processing in parietal areas. Our combined transcranial magnetic stimulation – electroencephalography (TMS-EEG) results causally demonstrate that clustering of posterior fast frequency activity (gamma) into specific phases of a frontal slow oscillation in the theta frequency range depends on task difficulty; i. e. the amount of cognitive resources needed. Moreover, TMS over task-relevant posterior brain areas during WM maintenance did only disrupt behaviour when the TMS pulse fell into the relevant phase of a frontal theta cycle but had no impact if it fell into any other phase. In sum, long-range cortical communication across distant brain regions but also local processing in the theta frequency seem to be key in the implementation of top-down control during WM maintenance.

IM-90 Sleep-dependant oscillatory dynamics associated with the consolidation of motor learning

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Background:
The brain networks associated with motor learning start to get well defined. However, sleep-dependent oscillatory dynamics within these networks and their functional impact on memory consolidation are still unclear.

Methods:
Magnetoencephalographic (MEG) recordings were used to characterize the oscillatory correlates of sleep-dependent motor sequence memory consolidation. Participants were recorded in the MEG during i) an initial practice of a sequential finger-tapping task, performed with the left non-dominant hand, and during ii) a retest session three days later, with either sleep or total sleep deprivation during the first post-training night.

Results:
During initial motor sequence learning, time-frequency analyses show a progressive decrease in mu/beta (10-25 Hz) oscillatory power at the source level over the primary motor cortex. A sleep-dependent increase in beta oscillatory activity was also observed, between training and retest sessions, over the same region during both practice and inter-tapping rest periods following practice of the learned sequence. In contrast, no changes in oscillatory activity were observed in sleep-deprived subjects between training and retest sessions. Behavioural data expressed as the coarticulation between consecutive button presses confirmed this sleep dependant effect, with a significant difference between groups during the retest session.

Discussion:
These results provide evidence of the impact of sleep on oscillatory activity characterizing motor sequence learning and suggest that sleep can increase the amplitude of task-relevant oscillatory activity during motor sequence memory consolidation.

IM-91

Using Hidden Markov Models to Identify Post-Stimulus Responses in MEG Recordings across Visuomotor and Working Memory Tasks.

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Background
Hidden Markov Models (HMMs) are an attractive method for analysing Magnetoencephalography (MEG) data, requiring no a priori assumptions about the frequency content of responses. We used univariate, time-delay embedded HMMs, which derive states at each brain location based on autocovariance patterns in a moving time-window. We hypothesise that Post-Stimulus Responses (PSRs) in MEG data represent neural processes that are distinct from those that occur during a stimulus/task and should therefore result in separate HMM states with unique properties.

Methods
We applied HMMs to two tasks, a visuomotor (VM) task (15 healthy subjects, 27±3yrs, 10 F) and an n-back task (20 healthy subjects, 26±4yrs, 10 F). Both tasks contained long (30s) rest periods to enable measurement of PSRs. For each brain region, task and post-stimulus HMM states were assigned by finding the state with the highest mean probability in the relevant time-window.

Results and Discussion
Results showed that HMMs were able to identify distinct task and PSR states with differing spatiotemporal characteristics. For both tasks, the PSR states were present across most of the left hemisphere, whereas task states mostly occupied bilateral posterior regions. In the VM task, PSR states had significantly ($p<0.05$) shorter lifetimes than task states (0.6±0.2s [task], 0.41±0.05s [PSR]), whereas n-back state lifetimes did not differ significantly between task and PSR states (0.4±0.2s [task], 0.36±0.06s [PSR]). We show that PSRs over different tasks have distinct electrophysiological profiles to primary task responses and represent a unique measure of brain activity.

IM-92

Investigating the Unique Properties of Post-Stimulus MEG Responses in Higher Cognitive Regions using a Bespoke N-Back Working Memory Task

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Introduction
Post-stimulus responses (PSRs) are recorded using a variety of neuroimaging techniques including magnetoencephalography (MEG). Beta-band PSRs in the motor cortex are well-studied with MEG and have been shown to modulate with task parameters as well as in various patient populations. Previous studies have proposed that beta PSRs inhibit task-positive networks to enable a return to resting brain activity, thus scaling with cognitive demand. It is currently unknown whether PSRs occur in higher-order brain regions or if they are specific to primary sensory regions.

Methods
Here, we record the oscillatory responses to an n-back task (0-back, 1-back, 2-back) with 20 healthy participants (26±4yrs, 10 F) using MEG (275 channels, CTF system). A single block contained 30s of a task condition followed by 30s rest. A total of 16 blocks/condition were recorded per subject.

Results and Discussion
Our results revealed PSRs in the theta, alpha and beta bands across many regions of the brain, including the Dorsal Attention Network (DAN) and lateral visual areas. These PSRs increased significantly ($p<0.05$) in magnitude with working-memory load. Reaction Times (RT) were predictive of alpha-band PSR amplitudes in left lateral visual ($p<0.05$) and left parietal ($p<0.1$) regions. Task-period oscillatory responses in the same regions did not correlate with RT, suggesting that PSRs may be uniquely related to behavioural measures of cognitive demand. Together these results support the hypothesis that PSRs are unique signatures of brain activity which may serve to inhibit task-positive activity to enable a return to rest.

IM-93

Distinct roles for alpha and beta oscillations in information maintenance in working memory.

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Background
Working memory enables the brief holding of information for its later manipulation. Neural oscillations in the alpha (8–14 Hz) and beta range (15–30 Hz) are proposed to play an important role in subserving working memory. However, their distinct contributions remain unclear. Here, we investigated how alpha and beta oscillations interact with three aspects of a working memory task: memory load, behavioral performance, and strength of sensory representations (maintained information) as indexed by decoding performance.

Methods
Magnetoencephalography (MEG) was recorded from 51 healthy human subjects performing an N-back working-memory task (0-, 1-, and 2-back conditions).

Results
We demonstrate that increasing memory load led to an occipitotemporal power decrease (desynchronization) in both alpha and beta power, with alpha desynchronization being more prominent and persistent. Fast behavioral responses coincided with a prominent occipitoparietal alpha (but not beta) decrease. Importantly, alpha and beta oscillations had differential impacts on stimulus decodability, with low alpha power boosting the maintenance of stimuli representations, versus high beta power boosting the strength of these representations.

Discussion
Our results highlight distinct roles of alpha and beta oscillations in working memory, with alpha gating the information flow and beta recruiting task-relevant neuronal ensembles.

IM-94

Glycemic Control Level Alters Working Memory Neural Dynamics in Adults with Type 2 Diabetes

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BACKGROUND:
Type 2 diabetes (T2D) has been associated with several complications, including detrimental effects on the brain and cognition. The current study examines the impact of glycemic control level on the cognitive and neural dynamics underlying working memory processing in adults with T2D.

METHODS:
We probed the relationship between neural dynamics and A1c level using MEG. Participants (N=34) performed a 6-load, letter-based working memory task, specifically designed to examine the dynamics of encoding and maintenance separately.

RESULTS:
Adults with T2D and high A1c levels showed diminished encoding activity across left temporal and bilateral precentral regions. During maintenance, those with high A1c levels showed increased activity in left lateral occipital, left cerebellar, and left superior temporal regions, and diminished right occipital dynamics. Further, left temporal encoding dynamics related to behavior, where diminished activity led to longer reaction times, driven by the high A1c group (Fisher's Z=2.13, p=.033, high A1c: r=.61, p=.009). Left lateral occipital activity during maintenance predicted accuracy (r=.48, p=.005) and reaction time (r=.42, p=.017), such that greater activity in this region led to lower accuracy and longer reaction times across all participants.

DISCUSSION:
Distinct effects were found by A1c level across encoding and maintenance phases of working memory. Several effects related to behavior, such that suppressed activity in encoding and increased activity in maintenance—a pattern of activity largely found in the high A1c group—led to worse behavior. These findings suggest a strong impact of glycemic control level on cognitive and neural outcomes in adults with T2D.

IM-95 The role of theta oscillations in curiosity-driven memory enhancements

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Curiosity reflects the intrinsic motivation of an individual to seek information in order to acquire new knowledge. Research has demonstrated that high levels of curiosity enhance memory formation. It has been suggested that brain areas important for memory and reward processing are involved, but the strength of connections between these brain areas predicts the magnitude of curiosity-driven memory enhancements. The underlying oscillatory mechanisms of curiosity-driven memory enhancements – as an indicator of communication between brain areas – remain to be explored. The present pre-registered study aims to investigate how brain oscillations, especially theta oscillations that play a crucial role in memory and reward processing, coordinate curiosity-driven memory enhancements. As outlined in our pre-registration on OSF, forty participants took part in a trivia paradigm while their MEG was recorded. In the trivia paradigm, participants were presented with trivia questions and the respective answers, to which they had previously rated their curiosity. Memory of the trivia answers was tested in a cued recall test 24 hours later. We expect that participants remember trivia answers associated with high curiosity better than trivia answers associated with low curiosity. With regard to MEG analyses, theta power is expected to be more pronounced for the encoding of high curiosity answers compared to low curiosity answers. Furthermore, theta power is anticipated to correlate with the curiosity-driven memory enhancements. These results are expected to shed light onto how theta oscillations coordinate curiosity-driven memory enhancements, offering an opportunity to harness the memory-enhancing aspects of curiosity in everyday life.

IM-96 Theta-band resting-state functional brain connectivity shapes declarative memory retrieval performance in school-aged children

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Introduction.
Baseline resting-state functional brain connectivity (rsFC) modulates subsequent cognitive processes in humans. Given the demonstrated role of theta-band brain synchronization in declarative learning and memory processes, we tested here the hypothesis that theta-band rsFC is associated with declarative memory performance in school-aged children.

Methods.
Magnetoencephalography (MEG) was used to investigate the relationship between pre-learning rsFC and subsequent immediate retrieval of newly-learned declarative information (associations between non-objects and their function) in 32 typically developing school-aged children (15 girls; mean age ± SD: 10.0 ± 1.14 years). After MEG data preprocessing and source projection by minimum-norm estimation, theta-band (4-8 Hz) power envelope correlation was computed amongst 75 nodes involved in declarative memory. Correlations between pre-learning rsFC and immediate retrieval performance were sought using maximum-based statistics including age, sex, number of learning trials and signal power at each node as covariates of no interest.

Results.
Positive correlations emerged between pre-learning theta-band rsFC and immediate retrieval performance, with stronger rsFC within a set of occipital (right superior occipital gyrus), frontal (right medial frontal cortex, left orbital inferior frontal gyrus), and temporal (right inferior temporal gyrus, right fusiform gyrus, right amygdala) regions associated to higher immediate retrieval performance (maximum statistic, pcorr = .0076).

Discussion.
Inter-individual variations of theta-band rsFC within a fronto-temporo-occipital network appear critical for subsequent declarative memory retrieval performance in school-aged children. This study opens new avenues to investigate the pathophysiological brain processes underlying learning and memory deficits in children with neurodevelopmental disorders.

IM-97

Alpha band synchronization characterizes feature-specific information in visual working memory

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Large-scale synchronization of neuronal oscillations at multiple frequency bands have been observed during visual working memory (VWM) maintenance. However, whether network synchronization would mediate the representation of visual information and reflect WM contents is not known. We aimed to resolve the frequency bands in which inter-areal synchronization would code for specific visual features and object representations. We recorded concurrent magneto- and electroencephalography (MEEG) from 20 human participants during a delayed-match-to-sample VWM task in which participants memorized individual features (Shape, Color, or Location) or their conjunctions of the stimuli. We used a data-driven approach and estimated phase synchronization among 400 cortical parcels for the retention period activity from source-reconstructed MEEG data for all frequencies between 3-120 Hz and for all conditions. Graph theory was then used to characterize the structures of the networks and to identify connections and graphs specific to the visual features. A sustained increase in delta and alpha synchronization and decrease in theta and beta synchronization characterized the retention of all features and feature conjunctions. Identification of feature specificity showed that alpha-band synchronization was feature selective. Alpha band synchronization networks were correlated with individual behavioral performance and predicted classification accuracy in multivariate random forest classifier for feature-specific information. These findings show that alpha synchronization characterizes the maintenance of feature information and may underlie the representation of the contents of visual information in VWM.

IM-98

The relationship between gamma-band oscillations, BOLD dynamics and GABAA-receptor density in visual working memory

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Distinct brain imaging techniques provide complementary insights into brain function by tapping into distinct signatures of brain activity at multiple levels. The downside is that the diversity of modalities has also led to a fragmented view of the neural bases of cognition. A handful of studies have sought to overcome this limitation by combining insights from multiple imaging modalities, such as methods that probe hemodynamic and oscillatory responses as well as GABA concentration. However, previous work exploring the links between such measures has focused on primary sensory or motor areas. How these measures relate to one another in the case of higher-order cognitive processes, such as working memory (WM), is still poorly understood. Here, we collected multimodal data within the same subject cohort in a standard n-back WM study, using magnetoencephalography, functional magnetic resonance imaging and Flumazenil positron emission tomography. This allowed us to probe the relationship between GABAA-receptor distribution, electrophysiological and hemodynamic modulations during WM task performance. Our results revealed that GABAA-receptor density in higher-order cortical regions correlated positively with the peak frequency of gamma-band power modulations and negatively with BOLD amplitude. Furthermore, significant correlations between neural measures and behavioral outcomes were observed exclusively between GABAA-receptor density and reaction times. These finding extend previous work by characterizing the link between GABAergic inhibition, gamma oscillations, hemodynamic and behavioral responses during WM performance.

IM-99

Linking brain and behavior: evidence from working memory and inhibitory control processing in the elderly

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Although one of the core aims of neuroscience research is to understand the brain basis of behavior, we are still far from understanding this relationship, particularly concerning inter-individual variability. During aging the inter-individual variability in both the neural and behavioral functions is likely to be emphasized, and decreased competence particularly in working memory and general executive control compromise many aspects of the quality of life also within the non-clinical population. We aimed, first, to clarify the brain basis of visual working memory and inhibition during multi-stage natural-like task performance, and, second, to identify associations between variation in task-related neural activity and relevant cognitive skills, namely inhibition and general working memory capacity. We recorded, using magnetoencephalography, the neural modulations associated with encoding and maintenance, as well as interference suppression during a visual working memory task in the among 71–82-year-old men and women. We quantified the neural correlates of these two cognitive processes through two complementary approaches: evoked responses and oscillatory activity. We revealed statistically significant correlations between neural activity associated with retrieving an item from memory and suppressing irrelevant sensory information and behavioral measures of efficient task switching and general executive functions. Our results suggest that modulations particularly in phase-locked evoked neural activity can be reliably associated with explicit measures of age-related cognitive decline. We also show that by exploiting the inherent inter-individual variability in neural measures and behavioral markers of cognition in the aging populations can help establish reliable links between specific brain functions and their behavioral manifestations.

IM-100

Multiple and Dissociable Effects of Sensory History on Working-Memory Performance

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Behavioural reports of sensory information are biased by stimulus history. The nature and direction of such serial-dependence biases can differ between experimental settings – both attractive and repulsive biases towards previous stimuli have been observed. How and when these biases arise in the human brain remains largely unexplored. They could occur either via a change in sensory processing itself, post-perceptual maintenance or decision-making processes, or both. Here, we analysed behavioural and magnetoencephalographic data from a working-memory task in which participants were sequentially presented with two randomly oriented gratings, one of which was cued for recall at the end of the trial. Behavioural responses showed evidence for two distinct biases: 1) a within-trial repulsive bias away from the previously encoded orientation on the same trial, and 2) a between-trial attractive bias towards the task-relevant orientation on the previous trial. Multivariate classification of stimulus orientation revealed that neural representations during stimulus encoding were biased away from the previous grating orientation, regardless of whether we considered the within- or between-trial prior orientation – despite opposite effects on behaviour. These results suggest that repulsive biases occur at the level of sensory processing and can be overturned at post-perceptual stages to result in attractive biases in behaviour.

IM-101

Decoding 'Replay' during working memory manipulation in humans

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Background:
Working memory (WM) implies the storage and manipulation of sequentially organized items. To date, WM functions have been associated with load-dependent increase of brain activity. However, WM manipulation likely also requires the segregation of individual memorized items into distinct neural activity patterns. Here, we investigated if item-specific brain activity patterns can be replayed to support WM performance. Replay is the reactivation of learning-related neural activity during offline brain states. It has been observed in humans during motor learning and episodic memory. However, the relationship between replay and WM performance is unknown. Here, we aimed to identify replays during WM manipulation via the application of machine-learning pattern classification algorithms to MEG data. Methods: During MEG recordings, participants learned to associate sounds with letters. They then performed a testing phase: a letter was displayed, and participants mentally generated the corresponding sound. Finally, participants performed a WM task based on the learned association. We trained classifiers during the learning phase and validate them using the testing phase.

Results:
Univariate analyses revealed learning-associated functional changes in the beta range: desynchronization over frontotemporal regions for the comparison post vs. pre-learning. Classifiers trained during the learning phase showed high decoding accuracy (50% above chance) in the testing phase. We now aim to use these classifiers to make probabilistic predictions of the sequential reactivation of memorized patterns during the WM task.

Conclusion:
This project provides several significant outcomes about the mechanisms supporting memory functions in humans.

IM-102

Executive resting-state network and its relationship with working memory and executive functioning: a MEG study

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Resting state networks have shown to be relevant biomarkers for several mental health alterations. It is therefore necessary to understand its relationship to cognitive functions, especially in the developing brain. In this study we investigated the executive resting-state network and its relationship cognitive functions. A sample of 80 (+-14.5 years old) healthy adolescents have been assessed by resting-state magnetoencephalography (MEG). In addition, their performance on a battery of 10 computerised neuropsychological tasks was measured. A functional connectivity (FC) analysis was performed using the Phase Locking Value (PLV) method. We performed seed based correlation using predefined regions of interest (ROI) to asses the neuropsychological variables. The results suggest that working memory and planificacion proceses could be related to different patterns of connectivity at Inferior Medial Frontal Gyrus on alpha and Left Superior Parietal Gyrus on theta frequency bands. Such findinds support previous works proposing that resting state brain activity is sustained on large scale heteromodal associative parieto-frontal networks (Mazoyer, 2001)

IM-103 Characterizing oscillatory phase and waveform characteristics in human memory replay

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Recent methodological advances have enabled memory replay to be studied in human magnetoencephalography. In particular, replay of learned sequences has been shown to occur during wakeful rest at time lags of 50ms (Liu et al., 2019), and to be related to activation of the Default Mode Network (DMN) and Parietal Alpha Network (PAN), characterised by high coherence in the delta/theta band and alpha band, respectively (Higgins et al., 2021). Here, we investigate the oscillatory phase of these bands, and others, timelocked to replay occurrence. We used MEG data previously analysed in Liu et al. (2019) and Higgins et al. (2021). The experiment consisted of a functional localiser, a sequence learning task, and a period of wakeful rest. Replay events were defined by detecting consistent intervals of high classification accuracy in the resting state data using classifiers trained on the localiser data (Liu et al. 2019). We then computed inter-trial phase coherence (ITPC) time locked to replay onset to characterise the timing of replay with respect to ongoing oscillatory activity. We further used empirical mode decomposition (EMD) to investigate whether the waveform shape of ongoing oscillatory activity is different during replay. Our analysis did not reveal any differences in waveform shape during replay, but we did find increased ITPC around replay onset, predominantly in the alpha/beta band in visual cortex, suggesting a consistent timing of replay with respect to alpha/beta phase. Further investigations will focus characterisation of the preferred phase of replay and ITPC in sequences of replay.

IM-104 Alpha oscillations protect working memory against distracters in a modality-specific way

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Background:
Previous work has shown that alpha oscillations are involved in suppressing distracters in working-memory tasks. Yet, it is unclear whether such suppression reflects a domain-general inattentiveness mechanism, or occurs in a stimulus- or modality-specific manner within cortical areas most responsive to the distracters.

Methods:
Twenty-five healthy human participants performed a working-memory task while their brain activity was recorded using magnetoencephalography (MEG). Participants had to memorize a set of six digits (i.e., the target stimulus), and report the digit at the probed location. In three conditions we manipulated the type of distracters presented while participants maintained the target in memory: in the no distracters condition, we had a 4.45-s blank window without experimental stimulations; in the visual (or auditory) distracters condition, we sequentially presented six digits visually (or binaurally) in this window.

Results:
Participants were less accurate reporting the probed digit under the auditory and visual distracters conditions than the no distracter condition. Sensory areas (functionally defined for each participant) showed significant alpha power increase after the presentation of distracters (i.e., around the time when probed). Specifically, alpha power in visual areas was significantly higher under the visual distracters condition compared to the auditory; in contrast, alpha power in auditory areas was significantly higher under the auditory distracters condition compared to the visual. Moreover, higher alpha power led to lower memory accuracy.

Discussion:
Our results suggest that alpha oscillations underly distracter suppression in a stimulus/modality-specific manner.

VM-105 Altered age-related alpha and gamma prefrontal-occipital connectivity serving distinct cognitive interference variants

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The presence of conflicting stimuli adversely affects behavioral outcomes, which could either be at the level of stimulus (Flanker), response (Simon), or both (Multisource). Briefly, flanker interference involves conflicting stimuli requiring selective attention, Simon interference is caused by an incongruity between the spatial location of the task-relevant stimulus and prepotent motor mapping, and multisource is the combination of both. Irrespective of the variant, interference resolution necessitates cognitive control to filter irrelevant information and allocate neural resources to task-related goals. Though previously studied in healthy young adults, the direct quantification of changes in oscillatory activity serving such cognitive control and associated inter-regional interactions in healthy aging are poorly understood. Herein, we used an adapted version of the multisource interference task and magnetoencephalography to investigate age-related neural dynamics uniquely governing both divergent and convergent cognitive interference in 78 healthy participants (age range: 20-66 years). We identified weaker alpha connectivity between bilateral visual and right dorsolateral prefrontal cortices (DLPFC) and left dorsomedial prefrontal cortices (dmPFC), as well as weaker gamma connectivity between bilateral occipital regions and the right dmPFC during flanker interference with advancing age. Further, an age-related decrease in gamma power was observed in the left cerebellum and parietal region for Simon and differential interference effects (i.e., Flanker-Simon), respectively. Moreover, the superadditivity model showed decreased gamma power in the right temporoparietal junction (TPJ), with increasing age. Overall, our findings suggest age-related declines in the engagement of top-down attentional control secondary to reduced alpha and gamma coupling between prefrontal and occipital cortices.

VM-106 Evaluation of Neural Oscillatory Changes and Microstructural Brain Tissue Changes in a Biological Parametric Modeling (BPM) Correlation analysis using Magnetoencephalography (MEG) and Diffusion Kurtosis Imaging (DKI) in Youth Football Players.

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Background:
Previous studies demonstrated significant relationships between MEG delta power and head impact exposure (HIE), as well as between DKI (mean kurtosis, kmean) and HIE. We sought to investigate the spatially specific associations between MEG and DKI in youth football players.

Materials and Methods:
105 youth football players (all male; mean age = 13.23y) and 22 control participants (all male; mean age = 11.6y) were included. Multi-shell diffusion MRI (dMRI) and resting-state MEG data were acquired pre- and post-season for all participants. MEG data underwent standard pre-processing and source localization in Brainstorm, while DKI metrics were derived from dMRI. The relative power per frequency band and the kmean images were normalized to MNI standard brain space. The Biological parametric mapping (BPM) toolbox was then used to perform voxel-wise correlation analyses for DKI and MEG (post and pre-season).

Results:
The BPM analysis showed that delta and theta band yielded the strongest correlations with kmean in the football players (p-value<0.0001, FWE). Fewer significantly correlated clusters were seen between kmean and alpha, beta, low gamma, and high gamma (p-value<0.0001, FWE). For the controls, weak correlations were found in between kmean and delta, theta, beta, low gamma, and high gamma bands (p-value<0.0001, FWE). There was an increase in significantly correlated clusters in the football players over the course of season, especially in delta and theta with kmean.

Discussion:
These findings suggest an interrelated association between microstructural and functional neural changes in adolescents experiencing head impacts.

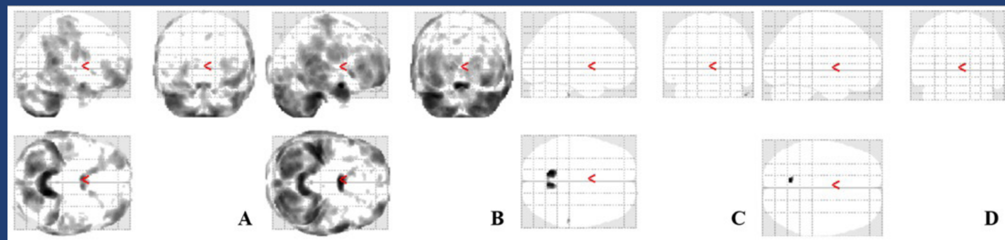

Figure 1. Voxel-Wise Correlation Analysis Between DKI kmean and MEG Delta (1-4 Hz) neuronal activity.
For the football group, positive correlations were found in the pre-season scan (A), as well as the post-season scan (B), but in the post-season scan the amount of positively correlated clusters increased when compared to the pre-season scan. For the control group, correlations were found in certain clusters of the pre-season scan (C), as well as the post-season scan (D), but in the post-season scan the amount of positively correlated clusters decreased when compared to the pre-season scan.

VM-107

Neural and cognitive function in a pediatric brain injury model: the impact of task complexity

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Pediatric acquired brain injury (PABI) results in aberrant neural communication and slower information processing speed (IPS) that contributes to difficulty performing tasks of minimal (MC) and greater complexity (GC). It is unknown whether dysfunction exists during increasing complexity. We studied pediatric brain tumor survivors (PBTS) to investigate neural and cognitive dysfunction during an increasingly complex reaction time (RT) task. During magnetoencephalography recording (whole-head 151-channel CTF), PBTS typically developing children (TDC; n=57, 13.25 years) pressed a button with their left/right thumb after an arrow pointed in the corresponding direction. The arrow pointed in a single direction (MC conditions) or alternated direction randomly (GC condition). Data was collected at a sampling rate of 1200Hz or 600Hz and band-pass filtered from 1-150Hz. Activity was estimated for 90 Automated Atomic Labelling Atlas sources using LCMV beamformer and filtered into frequency bands. The weighted phase lag index (wPLI) estimated functional connectivity between regions of interest and other sources. RTs <100ms and >3SD were removed, and means were calculated. Group differences in the wPLI and mean RT were assessed using the tmax statistic and linear regression. During the GC condition, PBTS demonstrated reduced functional connectivity in theta (4-7Hz), alpha (8-12Hz) and gamma (60-100Hz) frequencies (ps<0.01), and increased RT (p=0.02) relative to TDC. This suggest PABI disrupts neural and cognitive resources needed to meet increased demands of GC tasks while sufficient resources are available for MC. Given that most life domains involve GC, understanding patients' ability to recruit such resources is crucial to improve functional outcomes.

VM-108

Brain markers of distractibility in children and adults

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Background:
Distractibility is a state allowing one to focus while ignoring distracting information. Attention can be endogenously oriented toward relevant objects through Top-Down (TD) brain mechanisms. But attention can also be exogenously captured by a salient and unexpected irrelevant event (i.e. a distractor) through Bottom-Up (BU) brain mechanisms. TD and BU attention brain networks undergo significant development in childhood. However, it is not yet clear how brain changes may relate to attention skills during childhood.

Method:
To address this question, we used a recently developed paradigm, the Competitive Attention Test (CAT) to characterize the electrophysiological (EEG) and behavioral development of auditory distractibility from childhood to adulthood (6-7,11-13 and 18-25-years-old; N=45), and analyzed behavioural and EEG brain responses to relevant and irrelevant auditory events occurring during the CAT. More particularly, we analyse the CNV and P3b to targets, as well as the P3 complex and the RON following distracting sounds.

Results:
Analysis of evoked response potentials suggests that attentional control shifts from a reactive to a proactive strategy from 6-years-old to adulthood. More specifically, the reorienting mechanisms that enable one to refocus on the task at hand following a distraction are still maturing in children aged 6 to 13. These changes in brain functioning in childhood are associated with a behavioural increase in sustained attention, a decrease in distraction, phasic arousal, and impulsivity.

Discussion:
Together, these findings suggest that multiple facets of attention contribute to distractibility and explain how distractibility in the developing brain can shape the child's behaviour.

VM-109 Altered cortical activation as measured with magnetoencephalography (MEG) exhibits cognitive and inhibitory control deficits in children with trauma exposure

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Background:
Childhood trauma may impact neurodevelopment and induce neuro-cortical dysfunction which provides the neurobiological basis for impairment of executive function. Pathological changes in neocortical activity with trauma exposure may be more influential in sensitive periods of development (mid-childhood) that increase the risk of cognitive effects and susceptibility to post-traumatic stress disorder (PTSD).

Method:
We reported data from sixty-five typically developing children (TDC) with the age range of 9-15 years who self-reported childhood trauma exposure during their first visit and we defined groups into high/low trauma groups based on trauma exposure and severity. From each participant, cortical responses were recorded with magnetoencephalography (MEG) while performing sustained attention to response task (SART), a go/nogo paradigm. MEG data were preprocessed and source analyzed using dSPM in Brainstorm. We identified regions of interest (ROIs) in the frontoparietal network and measured the peak amplitude and latency of task-evoked cortical responses.

Result:
Our result revealed significantly ($p < 0.05$) faster latency in high trauma group compared to low trauma group in non-target stimuli (No-Go trials) in left prefrontal and left parietal cortex. We observed reduced amplitude in left parietal cortex in the high trauma vs. the low trauma group ($p = 0.01$) during recognition of inhibitory (No-Go) stimuli.

Conclusion: Frontal and parietal regions of the executive function network show impairment during SART that indicate impaired selective attention and inhibitory control in traumatized children which may explain cognitive differences. Future studies need to examine if these effects also lead to susceptibility to developing PTSD in adulthood.

VM-110 Using magnetoencephalography to characterize neural responses to parental touch in school-aged children

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Touch is considered crucial in promoting healthy social and cognitive development, but little is known about the mechanisms that underlie the perception of touch in the developing brain. The aim of the current project is to develop a MEG task that could be used to identify the timing and location of brain activation in response to affectionate parental touch in children. We expect stroking of hairy skin to preferentially activate brain areas associated with social perception due to the prevalence of CT-afferents in hairy vs. glabrous skin. MEG data were acquired from 8 children (Mage = 9.7 years) using a 275-channel system and co-registered to a T1-weighted structural MRI prior to analysis. Affectionate touch was presented to the palm (glabrous skin) and forearm (hairy skin) by the child's caregiver who was trained to present the stimuli. The onset and offset of each trial were marked using a three-axis accelerometer worn by the caregiver. Data analyses were conducted in Brainstorm. Source activations were estimated using dSPM (unconstrained; overlapping spheres head model). Noise covariance was estimated using the pre-stimulus interval (-1 to -0.2 s). dSPM source analyses revealed activation in the primary somatosensory cortex (SI), secondary somatosensory cortex (SII), and superior temporal sulcus (STS) across participants. In the first 500 ms following touch onset, SI activation was greater for palm vs. forearm, in line with the greater representation of the palm in somatosensory cortex ($p <. 01$). Ongoing analyses are comparing patterns of activation in other ROIs including SII, STS, and insula.

VM-111

Abnormal cortical tracking of speech in children with developmental language disorder

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Successful speech perception requires tracking of the acoustic signal and translating it to lexical and semantic representations. One hypothesized underlying cause for the disruption of language comprehension and learning in developmental language disorder (DLD) are low-level acoustic-phonetic processing deficits. We set out to investigate whether children with DLD display impaired cortical tracking of sound acoustics, and whether this deficit is specifically observed for speech. Cortical responses to high-frequency spoken words and environmental sounds with the same meanings (e.g. the word cat, a cat meow) were measured with MEG in children with DLD and typically developing (TD) children, aged 10-13 years. The sound acoustics were modeled with non-time-varying (frequency spectrum, modulation power spectrum) and time-varying descriptions (amplitude modulations and spectrogram). The time-varying features were modeled as time-locked to the sound features. Based on preliminary data of 10 DLD children and 11 TD children, the amplitude envelope and spectrogram of spoken words, but not environmental sounds, showed markedly good decoding with the time-locked model in both participant groups, with best decoding accuracy at ~100 ms lag between the unfolding stimulus sound and the MEG signal. Group differences were found at longer lags: In the TD group, amplitude envelope was tracked additionally at ~300 ms lag, whereas in the DLD group detailed spectral information of spoken words was encoded in cortical responses even at long latencies. Typically developing children seem to display more efficient encoding of the amplitude modulations of speech, whereas language-impaired children may have to rely more on spectrally detailed information.

VM-112

Experience of creating a first-of-its-kind MEG system in a Hospital

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Despite nearly two decades of demonstrated clinical utility of magnetoencephalography (MEG), system choices have been limited. The past few years have seen a resurgence of new hardware and software configurations to provide more choices and expand the clinical utility of MEG. We present our experience developing a clinical MEG center in the United States utilizing a first-of-its-kind system.

The prototype system was installed in 2019 and includes 186 Double-Relaxation Oscillation SQUID (DROS) axial gradiometers in a coil-in-vacuum configuration, and continuous closed-loop helium reliquification. The system was FDA cleared in 2020. The system can simultaneously record MEG and up to 128 electroencephalography (EEG) channels at rates up to 10 KHz alongside a high resolution camera feed. A single software package is used for acquisition and analysis of MEG, EEG, and evoked responses.

We discuss the challenges and successes of implementing innovative MEG technology in a clinical environment, including site evaluation, integration of system components, hardware and software troubleshooting, development of system performance benchmarks, and validation of magnetic and electrical source imaging results. We will also present data from healthy and epileptic populations to demonstrate system functionality.

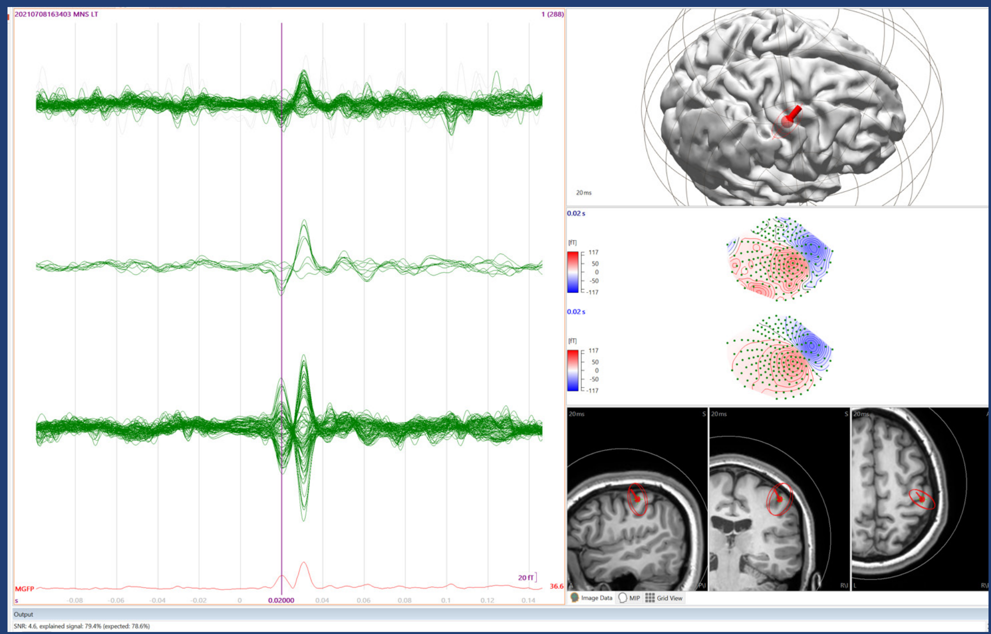

FIGURE: Example of somatosensory evoked field dipole localization from a healthy volunteer. The 20ms component of the MEG waveform was fit with a single equivalent current dipole using a single sphere model and visualized on the participant's individualized anatomy. MEG data were simultaneously acquired with 128 EEG, 4K camera feed, and static HPI while the participant received electrical stimulation to the left median nerve.

VM-113 Optically pumped magnetometer based magnetomyography of muscle potentials evoked with transcranial magnetic stimulation

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Non-contact measurements of magnetic fields produced by periphery muscles can provide detailed clinical information for studying motor-system diseases. In this work, we show that the versatility and portability of optically pumped magnetometers enables fast, clinically relevant measurements in a regular hospital room. Using transcranial magnetic stimulation (TMS) to evoke repeatable muscle responses, we recorded magnetomyograms (MMG) with an array of optically pumped magnetometers (OPMs) inside a portable shield that encompasses only the forearm and hand of the subject. Results were compared with simultaneously acquired surface electromyograms (EMG) and electroencephalograms (EEG). The biomagnetic signals recorded in the MMG provides detailed spatial and temporal information that is complementary to that of the electric signal channels. This system demonstrates the value of biomagnetic signals in TMS-based clinical approaches and widens the scope and practical potential of OPMs.

VM-114 Design of MEG-MRI field coils free of the ordinary geometrical constraints

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An MEG–MRI device implements two conventionally incompatible methods in a single instrument, thus enabling the imaging of brain activity and structure at once, and combining their analysis with high accuracy. Coils are used to generate differently shaped magnetic fields, such as B0 and gradient fields. The geometry of a coil affects the types of field shapes that it can produce. Usually, planar or cylindrical (bent planar) surfaces have been used for the coils. The bfieldtools PyPI package generalizes the stream function formalism and related techniques to arbitrary surfaces, allowing the design of free-form coils.   Aiming at a generalized set of field patterns, we use bfieldtools to find stream-function representations of surface-current density and then discretize the stream functions into coil windings. The coils can be constrained on arbitrary triangle-mesh surfaces, which we create with the help of the Autodesk Fusion 360 software. Care must be taken to find geometries that enable the desired set of field shapes to be generated. As an additional constraint, we limit the stray field at the shielded-room walls.   In this work, coils of different geometries were designed and analyzed using bfieldtools, and the parameter space explored. We find that the geometrical freedom can benefit technological aspects as well as the usability of the scanner: the structure of coils should be open and patient-friendly, enabling natural and effortless brain imaging while providing accurate fields with little stray effects. A set of coils designed in this work is fabricated for the first MEG–MRI hospital installation.

VM-115 Automatic smartphone-based EEG electrode digitization and augmented reality

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Background
Digitizing electroencephalography (EEG) electrode positions is critical for accurate source localization and connectivity analysis. It can also be used to evaluate the fit and positioning of EEG caps. Multiple systems for electrode digitization are commercially available, but are cost-intensive, often bulky, and require substantial amounts of skilled labor. Affordable alternatives have been proposed based on photogrammetry using consumer cameras. From images taken around the subject, a dense 3D head model is calculated, and the sensors are manually labeled in that 3D model. Yet, the manual post-processing and the computational effort hamper widespread application of this approach. Here, we present an approach with live electrode identification from smartphone camera images, and sparse reconstruction of the 3D electrode coordinates, without the need for dense model calculation. Sensor information is augmented on the live camera images.

Methods
We developed custom image processing for automated electrode detection and identification (C++, OpenCV) and an Android app (Kotlin). 3D reconstruction from sparse electrode locations was performed using the structure from motion approach (COLMAP library).

Results
Electrode detection, labeling, and 3D reconstruction runs live (30+ frames/second) on a mid-tier smartphone (Xiaomi POCO X3Pro). Sensor labels and template coordinates can be stored for different cap layouts.

Discussion
Our smartphone app facilitates widespread sensor digitization in medical research and clinical routine. Augmented reality can provide operators with quick guidance and allows further extensions e.g., displaying interfacial impedance values. Extensive testing and validation (accuracy, repeatability, various head shapes) are ongoing. The tested software will be released as open-source.

VM-116 Real-time brain computer interface for controlling smart robots based on optically pumped magnetometers (OPMs)

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Brain-computer interface (BCI) provides a direct connection between a brain and external devices, making possible the use of brain-controlled robots. In many BCI studies, scalp mounted electroencephalography (scalp-EEG) is widely used due to its portability and non-invasiveness. Recently, building BCI systems using emerging optically-pumped magnetometers (OPMs) have been attempted worldwide due to the fact that OPMs not only preserve the portability and non-invasiveness of scalp-EEG, but also eliminate the unavoidable effect of volume conduction in EEG measurements to a certain extent. In this study, a newly developed commercial OPM (MagtechX-4 from Beijing X-Mag Technologies Limited) was used to build a BCI system in an open-ended magnetic shield for detecting the signal of steady state visual evoked potentials (SSVEPs). Real-time control of smart robots was then achieved using detected SSVEP signals with acceptable repeatability and accuracy. This novel application of a non-invasive OPM-BCI system reveals its potential of manipulating smart robots using only the brain, which could pave the way for better integrating intelligent technology into people's daily life as well as improving the quality of life for people with disabilities.

VM-117

Combined EEG/MEG Imaging of Transcranial Photobiomodulation (tPBM) Effects on Healthy Normal Controls: Source Imaging and Granger Causality Connectivity Analysis

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Background:
The purpose of this study is to better understand and localize the effects of transcranial photobiomodulation (tPBM) on healthy human subjects. This was achieved by using combined electroencephalography (EEG) and magnetoencephalography (MEG) to localize the significant effects of tPBM using a sham-controlled protocol.

Materials:
Healthy normal participants (n=15 currently, n= ~40 planned) were asked to come in for 2 separate measurements on non-sequential days to prevent effect overlap. One experimental visit consisted of 6 minutes of resting-state EEG/MEG recording prior to randomized transcranial light stimulation or sham stimulation, 8 minutes of EEG recording during right side stimulation/sham, followed by another 6 minutes of resting-state EEG/MEG recording post randomized stimulation/sham. Participants' data were then analyzed in the source space using unconstrained minimum norm dSPM forward modeling for both experimental visits followed by a Welch PSD analysis then tested for significant differences using a power F-test analysis. Spectral Granger causality analysis was also performed between stimulation and sham experimental visits then compared for significance between real and sham stimulation using a power F-test.

Results:
Alpha(7-12 Hz) and beta (13-29Hz) frequency band results show significant activation in both the source space and directional connectivity indicating light stimulation has a significant effect on select regions of the brain during and after tPBM.

Discussion:
Transcranial photobiomodulation significantly alters neuronal activation and directional connectivity in healthy participants. Frequency bands found to be the most significant in the tPBM activation were alpha(7-12Hz) and beta (13-29 Hz).

VM-118

Comparison between a dry electrode EEG system with a conventional wet electrode EEG system: A new tool for clinical applications

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Background:
EEG is one of the most common and used neuroimaging techniques by non-invasive and cheap cost characteristics, being the gel-based (wet-EEG) type electrodes the gold standard for clinical recordings; however, advances in technology are looking for options that improve portability and facilitate fast and straightforward application. One of these alternatives is dry electrodes (dry-EEG). This study compares the novel dry electrodes with standard wet electrodes in terms of signal acquisition performance.

Methods:
Our study included 19 healthy participants who underwent a 5 min eyes-closed resting-state recording during two differentiated sessions: one evaluated with a gel-based electrode EEG device and a second measure from a dry-based electrode EEG system. To assess the comfort level and usability of the dry-EEG, the subjects answered a series of questions. Estimation of data quality was assessed by computing signal-to-noise ratio (SNR). and the percentage of signal loss represented as channel and trials loss.

Results:
The majority of the subjects preferred Dry-EEG. Also, it presented less SNR and showed more channel loss than the wet-EEG system. Nevertheless, the two systems did not show significant differences in the number of trials' loss.

Discussion:
Although dry-EEG presented lower SNR than wet-EEG, there was not a significant percentage of signal loss. Thus, the dry-EEG system used in the current preliminary study has promise and should be further studied for its potential in-home and clinical settings. Notably, most participants preferred the dry electrodes and reported that the dry headset was more suitable for self-application and potential home usage.

VM-119

Mitigating OPM Cross-Axis Projection Error by Dynamic Field Compensation

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Precision measurement of the magnetoencephalogram (MEG) by optically pumped magnetometer (OPM) sensors is limited by errors induced by offsets from zero field (Borna, et al, 2021). Our prototype array consists of 16 primary and three orthogonal reference sensors (v2 OPM, FieldLine Inc) operating in closed-loop mode along their sensing axis and statically nulled in their transverse axes. We developed cross-axis dynamic field compensation (DFC) to mitigate nonlinearity by dynamically maintaining null along the OPM transverse axes. Our control electronics firmware and software were modified to permit dynamic compensation of the transverse axes. Compensation was computed as the dot product of each OPM field coil vector with the reference field measurements. 300-second datasets were acquired (1 kHz sample rate, dc-300 Hz). A 27 Hz test field was applied to the array from a calibration coil to observe changes in effective gain with ambient field fluctuations. Without DFC, we observed a maximum test signal change of 5.96 percent (2.05 ±1.93) for a 704 pT ambient field change. After applying DFC at a 1 kHz update rate, test signal modulation was reduced significantly to a maximum 0.68 percent (0.33 ± 0.16) for a 904 pT field change. We also demonstrate that DFC significantly reduces the effective gain change induced by motion of the sensor array. Furthermore, compensation computed for the sensing axis was used to synthesize 1st-gradient response that further reduces magnetic artifacts. Together, DFC and synthetic gradiometry enable precision OPM MEG, even in the presence of ambient field fluctuations and motion.

VM-120

Modulation of auditory steady-state responses measured using superconducting self-shield and zero boil-off MEG

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Magnetoencephalogram (MEG), which measures a very weak magnetic fields generated from the brain activity using a superconducting quantum interference device (SQUID). In order to keep the SQUID sensor in a stable superconducting state, liquid helium, which is expensive and difficult to obtain, is required, and liquid helium must be refilled periodically. Therefore, the running cost becomes expensive. The magnetic field generated from the brain is very small and a magnetically shielded room made of permalloy which has high magnetic permeability, is required for measurement. We developed a novel MEG system that features both a superconducting magnetic self-shield and a zero boil-off system. We examined ASSR using a sequence of sinusoidal AM tones of 0.78 s in length with various tone frequencies of 440 to 990 Hz in about one octave variation with our novel MEG system. When the sound level of AM tones was changed with tone frequencies in the same range of 440 to 990 Hz, the amplitude of ASSR varied in a proportional manner to the sound level. We successfully detected auditory steady state responses (ASSR) magnetic fields in human subjects using our MEG system. These results indicate that brain activity is being captured correctly compared to a previous study.

VM-121 Patient Positioning Device for Sumitomo Heavy Industries' Magnetoencephalography

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Background:
Sumitomo Heavy Industries, Ltd. (SHI) has developed a magnetoencephalography (MEG) system that employs superconducting magnetic self-shielding, which doesn't require an expensive magnetically shielded room. The problem with such a system, however, is that the superconducting magnetic shield covers the subject entirely, causing difficulties for a subject getting into and out of the machine. The goal of this project is, therefore, to design and build a patient positioning system that satisfies the requirements of SHI's MEG system.

Methods:
This system consists of an adjustable patient chair that can roll and articulate along a predetermined track into the MEG. The use of the track avoids the mechanical complexity associated with an independently actuated multiple degree-of-freedom chair design.

Results:
In order to determine if all the functional requirements where met, static position testing was conducted to confirm that the device meets patient size compatibility, and is comfortable enough to support a patient. Patients tested the chair for the full 30-minute duration and reported no significant discomfort. Dynamic testing was also conducted, by checking that the device was able to do 50 continuous insertions with no discernible variance in its placement within the machine.

Discussion:
Since this track and chair system requires the patient to begin lying down on the floor, some patients may find it difficult to position themselves on the chair to undergo a scan. In order to accommodate a wider range of people for improved comfort, it may be worthwhile to explore alternate cushion designs and foot placement positions.

VM-122 Using optically pumped magnetometers to measure auditory response in the human brainstem.

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Background: Magnetoencephalography (MEG) is a functional neuroimaging technique that noninvasively detects the brain magnetic field from neuronal activations. Recently, MEG based on commercial optically pumped magnetometers (OPMs) have been developed. OPMs do not require a low-temperature superconducting environment and can be placed closer to the scalp. In this study, we validated the ability of OPM-MEG to probe the deep brain regions.

Method: We used OPM probe arrays arranged around the occipital brain to form the OPM-MEG and measured the auditory brainstem response (ABR) in a magnetic shielding room. A total of 3 healthy subjects participated in the experiment. Subjects received monaural sound stimulation of 10ms duration and tone of chirp at intervals randomly varying from 800 to 850ms. ABR signals in brainstem regions were localized using a modified beamforming method. Conconfirmatory contrast measurements were performed using SQUIDs MEG.

Result: We detected multiple auditory-evoked field signals, and the source localization showed that its source reflects the activation of the auditory pathway from the auditory nerve to the brainstem, similar to the SQUID-MEG results.

Conclusion: We found that the performance of the OPM-MEG was comparable to the SQUID-MEG in the detection of the deep brain regions. Moreover, since the OPM-MEG probe arrangement is more flexible and closer to the skull, OPM-MEG has greater development prospects than SQUID-MEG when detecting deep brain regions.

VM-123 A Lamp-pumped Atomic Magnetometer for Human Heart Magnetic Fields

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Magnetocardiography (MCG) is a noninvasive technique allowing to measure the cardiac magnetic fields generated by the electrical activity of the heart. Conventionally, the commonly used superconducting quantum interference devices (SQUIDs) for MCG usually requires a big cryogenic Dewar vessel, which limit the motion of the subjects. In this paper, we introduce an unshielded wearable MCG system based on lamp-pumped atomic magnetometers. This system can be operated at room temperature and geomagnetic field. By operating the magnetometers in a gradiometric mode, the magnetic field noise from surroundings is suppressed and a noise floor of 0.6 pT/Hz1/2 is achieved under a geomagnetic field of ~47,000 nT. We measured the MCG signals of several subjects with the magnetometers and all these results are consistent with electrocardiogram and photoplethysmogram.

VM-124 Effects of transspinal electrical stimulation estimated by transcranial magnetic stimulation

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Transspinal direct current stimulation (tsDCS) represents a non-invasive technique to modulate spinal cord activity, but the effects of this stimulation are currently not clearly understood. The purpose of the research is to investigate the effect of anodal tsDCS at the level of the cervical enlargement of the spinal cord on corticospinal excitability, as assessed by means of transcranial magnetic stimulation (TMS) of the primary motor cortex (M1). Twenty-four healthy subjects (22+/-4 years old) were divided into 2 groups. The first group was subjected to anodal tsDCS. One anode electrode was positioned at cervical level above the C7 segment, cathode return electrode was positioned on the collarbone. tsDCS parameters: 1,5 mA for 12 minutes. The second group was subjected to sham tsDCS. TMS was used to register MEP from FDI muscles hotspot activation (controlled using a navigation system) in M1 by single pulse (115% intensity from the resting motor threshold). The effects of tsDCS were assessed using the ratio of MEP before, immediately and 15 minutes after tsDCS in both groups. Additionally, the effects were estimated by means of a linear mixed-effect model. The results are shown in the figure 1 and table 1. Immediately after stimulation, the MEP amplitude increases, and after 15 minutes, the MEP decreases. After sham stimulation, there is no statistically significant difference in MEP amplitude changes. This is additionally confirmed using results of the linear mixed-effect model. Conclusion: tsDCS leads to a short-term increase in corticospinal conduction immediately after stimulation and its normalization in 15 minutes.

VM-125 Temporal Dynamics of Episodic Memory Formation: an MEG-study

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Episodic memory processing portrays different neural activation during the presentation (online) and withdrawal (offline) of visual stimulus. The modulation of neurophysiological oscillations during this process are still poorly investigated. Here we describe the temporal dynamics of memory formation for visual stimuli of different emotional load. We collected the MEG in 19 healthy subjects actively attending emotionally negative and neutral stimuli selected from the IAPS database. The experimental paradigm consisted of an encoding phase (284 stimuli, 50% negative, 1 s presentation) and a retrieval phase (416 stimuli, 50% negative, 1 s presentation) separated by a 20 minutes break. According to the memory performance in the retrieval phase, we sorted encoding trials in Hits and Misses. We analyzed epoched data in source space (LCMV beamformer) in the theta (4-8 Hz), alpha (8-15 Hz) and beta (15-30 Hz) from -0.5 to 2 s around the stimulus onset. In theta band, we observed fronto-temporal synchronization at 0-500 ms and parieto-occipital desynchronization at 500-1500 ms extending to orbitofrontal areas after stimulus offset. In alpha band, parieto-temporal desynchronization unfolded at 0-250 ms window spreading frontally around 400-500 ms and persisting until 1500 ms. In beta band, parietal and occipito-temporal desynchronization arising at 100 ms spread anteriorly in ventral and dorsal areas to fade away after stimulus offset. Therefore, we characterized online and offline neural activity contributing to successful memory formation. The delineation of oscillatory dynamics sensitive to stimulus offset may guide tailored stimulation protocols aimed to facilitate memory performance.

VM-126 Spatial and Temporal Working Memory rely on distinct oscillatory activity

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BACKGROUND
Persistent oscillatory activity in working memory (WM) varies according to information content (Manoach, 2009). Different activation has been associated with the retention of temporal and spatial information (Delogu, Nijboer & Postma, 2012). However, little is known about the relation between neural oscillations and performance. We hypothesized that specific oscillatory patterns maintaining spatial and temporal information are related to WM performance.

METHODS
We recorded by MEG 20 subjects performing a WM task with two conditions (Roberts et al., 2013). In each trial, four geometrical items were presented sequentially for 1.5 s each, followed by 4 s retention period and probe item. In the spatial/temporal condition, the trial was cued by the question "Where?"/ When?" We performed time-frequency decomposition to study the induced power modulation during the retention period and applied FOOOF normalization. Spatio-spectral cluster analysis was conducted by non-parametric cluster analysis, correlation between power and accuracy was assessed by Spearman correlation coefficient.

RESULTS
The retention of spatial information elicited higher parieto-occipital alpha and gamma, while temporal information was characterized by higher temporo-parietal beta. High spatial accuracy was associated with suppression of parietal theta and gamma power and enhancement of parietal beta, while high temporal accuracy related with suppression of posterior alpha/beta power and enhancement of occipital theta and gamma power.

DISCUSSIONS
We observed that spatial and temporal WM rely on common and distinct neural modulations. The findings shed a light at specific architecture of the WM processing and targeted stimulation approaches.

IT-1

Validation of the 1/f ratio as a marker of excitation/inhibition balance through benzodiazepines use in multiple sclerosis

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Introduction
Recent research combining neurocomputational modelling with measurements of local field potentials has indicated that the slope with which the spectrum rolls off (i.e. the exponent a in (1/f)a) is a non-invasive biomarker of the excitation/inhibition (E:I) balance. We aim at validating this technique in a dataset of multiple sclerosis patients. MS patients have often prescribed benzodiazepines as a symptomatic treatment which reinforces the inhibitory effects of GABA and should therefore decrease the E:I balance.

Methods
MEG data were acquired of 64 MS patients during resting-state eyes-closed condition; 14 patients treated with benzodiazepines (MS(BZD+)) and 50 not treated (MS(BZD-)). Data were preprocessed using the OSL library. After downsampling, filtering, and artifact rejecting, a beamformer was used for source reconstruction and then parceled into 42 parcels. We used "fitting oscillations and one over f" (FOOOF) algorithm to estimate the 1/f exponent. We extracted the slopes and compared them using a two-sided two-sample t-test. The comparisons have been done for the whole brain and then re-done at the parcel level. All results were corrected for multiple comparisons to control the false discovery rate.

Results
We observe a significant difference in 1/f slope when comparing MS(BZD+) vs MS(BZD-) in which MS patients treated with benzodiazepines have a steeper roll (p-value = 0.006, Cohen's d =1.22).

Discussion
We validate that 1/f ratio has potential value as a biomarker of E:I balance through analyzing the MEG data of two cohorts of MS patients.

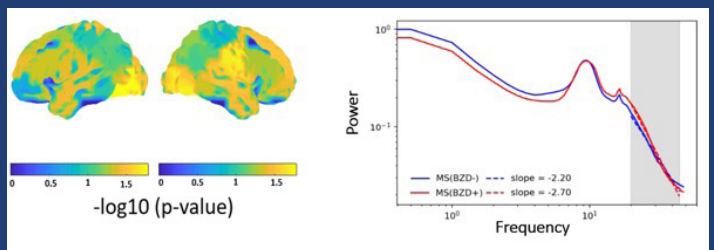

Figure 1. On the left, we see the -log10 of the p-value (>1.3 indicates a p-value < 0.05) after comparing MS patients who did or did not receive benzodiazepines. By enhancing the effect of the inhibitory neurotransmitter GABA, benzodiazepines decrease the E-I ratio. P-values were calculated through a two-sided two-sample t-test and corrected for comparison across parcels through Benjamini-Hochberg's procedure to control the false discovery rate. On the right, we see the average spectra of both cohorts on a log-log scale and the corresponding 1/f slopes (p-value = 0.006, Cohen's d =1.22). The grey box indicates the area within which the roll-off was calculated [20-45 Hz].

IT-2

Is magnetoencephalography sensitive to cognitive functioning following paediatric autoimmune encephalitis?

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Background
Paediatric autoimmune encephalitis (AE) is an inflammatory brain disease that causes cognitive deficits, psychiatric symptoms, seizures, MRI and EEG abnormalities. Patients can experience residual cognitive difficulties after acute illness. Magnetoencephalography (MEG) can examine neural changes in the absence of frank structural abnormalities, and may help identify factors predicting children at risk of long-term cognitive deficits. We predicted that M300 evoked responses and brain network connectivity would correlate with processing speed and working memory in children with AE.

Methods
Participants were children previously diagnosed with AE and recruited from Birmingham Children's Hospital, UK, two or more years after disease onset. They completed MEG scanning (Elekta Neuromag Triux), at rest and during an auditory oddball task; structural MRI; and cognitive evaluation. MEG recordings were preprocessed using Fieldtrip, with epochs time-locked to target stimuli in auditory recordings. Brainstorm was used for coregistration with MRI scans and source modelling. M300 amplitude, latency, and delta and theta network connectivity (amplitude envelope correlation) at rest were computed and correlated with processing speed and working memory scores (measured using WISC-V).

Results
To date, five children with AE (aged 11.05±4y, 4F and 1M) have participated. Neither M300 amplitude nor measures of network connectivity were significantly correlated with working memory or processing speed, but M300 latency was (r=.992, p=.001; r=.884, p=.047).

Discussion
MEG-captured M300 latency may be an indicator of how fast children process information and how much they can store in memory during tasks. MEG is an appropriate tool for assessing children with AE.

IT-3

Functional Connectivity States of Alpha Rhythm Sources in the Human Cortex at Rest: Implications for Real-Time Brain State Dependent EEG-TMS

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Background
Alpha is the predominant rhythm of human electroencephalogram, but it is still unclear how connectivity patterns change between its cortical generators. Furthermore, it is unknown whether alpha serves its role of opening states of greater cortical excitability following a pulsed-inhibition or pulsed-facilitation mechanism. Therefore, we still cannot describe what an alpha-phase brain state is and which are possible metrics quantifying a brain-state change. This has a relevance for brain-state dependent EEG-TMS. We propose that, to interpret EEG-TMS results, a network connectivity overview at rest could provide information for the definition of an 'instantaneous state'.

Methods
We studied functional coupling at rest in 203 healthy subjects with MEG data. Sensor signals were source localized and connectivity was studied at the Individual Alpha Frequency (IAF) between three cortical areas (occipital, parietal and pre-frontal). Two different phase-coherence metrics were used for this purpose (WPPC and WPLI were chosen for their complimentary features).

Results
Our results show a consistent connectivity at rest between parietal and prefrontal regions whereas occipito-prefrontal connectivity is less marked and occipito-parietal connectivity is extremely low.

Discussion
This understanding of phase-dependent connectivity patterns at rest is essential 1. to reach clearer results when investigating the effects of stimulation triggered by the phase detected on a different ROI from the targeted one; 2. to explain changes in connectivity following plasticity protocols. Considering not only the EEG trigger-state but also general connectivity-state between ROIs is useful for predicting plasticity protocols' efficacy as well as for interpreting results.

IT-4

Neurophysiological differentiability relates to motor and cognitive decline in Parkinson's disease

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Neural fingerprinting is transforming neuroscientific research on individual differences and population neuroscience through the prediction of meaningful variations in cognitive abilities from brain imaging phenotypes. To date, few studies have explored the potential of neural fingerprints for predicting clinical features in neurological disorders. We use this approach to advance the neurophysiological characterization of Parkinson's disease (PD) in resting-state magnetoencephalography (MEG) recordings of 154 participants, 79 of whom were diagnosed with PD. We estimate power spectral densities (PSDs) computed at the source level in addition to frequency-defined estimates of rhythmic and arrhythmic cortical brain activity to differentiate individuals. We find that PD fingerprinting between patients is more challenging than differentiating between healthy controls. This remains true across all frequency bands, with the delta band showing the largest decrement in performance between groups. Intraclass correlation analyses highlight important spectral features for individual differentiation concordant with previously reported neurophysiological signatures of PD in the theta, gamma, and high gamma bands in somatomotor regions. We also show that our ability to fingerprint patients relates to both motor and cognitive symptoms as measured by the Unified Parkinson's Disease Rating Scale (UPDRS) and Montreal Cognitive Assessment (MoCA). We validate our neural PD fingerprint by demonstrating that the same brain regions used to differentiate individuals also robustly decode clinical disease progression measured by Hoehn & Yahr scores. Together, these results highlight the clinical relevance of neurophysiological fingerprinting in PD and showcase the potential of the neural fingerprinting approaches to transform clinical research.

IT-5

Alpha power modulation via tACS for a potential treatment in Alzheimer's Disease

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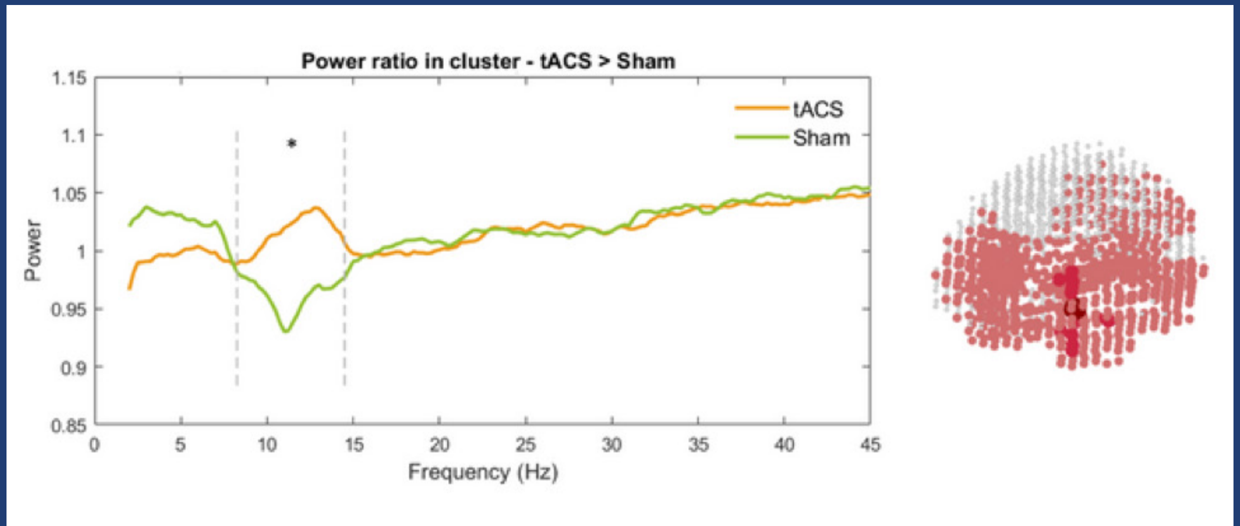
Among other electrophysiological biomarkers, power reduction in the alpha frequency band (8-12 Hz) is characteristic of Alzheimer's Disease (AD). Thus, restoring power in this band could help improve the performance of related functional networks and the cognitive state in AD patients. Transcranial alternate current stimulation (tACS) stands as a promising tool in this regard, given its capacity to entrain neural activity at a particular frequency. The objective of this study is to examine the capacity of tACS to modulate the alpha-band power and evaluate its potential application for the restauration of alpha activity in AD. 27 healthy participants with ages ranging from (22 to 55 years/ 32.80 ± 8.52) were recruited for this study. The neurophysiological activity of each participant was initially captured by two successive 5-minute eyes-closed resting state MEG recordings, with a 10-minute time interval between the two sessions. After being randomly assigned to verum or sham group, each participant was stimulated through tACS at the Cz and Oz electrodes at his own Individual Alpha Frequency (IAF) for 20 minutes. A third MEG recording was extracted to measure the effects of the stimulation. Later, a Cluster Based Permutation Test (CBPT) searched for differences in power clusterized both spatially and spectrally. After performing the CBPT analysis, the tACS group showed an increase in power from 8.25-14.5 Hz in a cluster of bilateral frontal, temporal and occipital cortical sources ($p<0.01$).



These results lead us to hypothesize that tACS might be an appropriate approach for restoring alpha-band power in AD patients.

IT-6

Armed forces operators exposed to occupational repetitive subconcussive blast results in neural slowing, burst dynamic deficits, and transpectral functional coupling dysregulation

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Background:
Blast-induced mild traumatic brain injury (mTBI) results in neurological impairment, neuropsychiatric comorbidity, and neurocognitive sequelae. Similarly, exposure to repetitive low-level subconcussive blasts presents a serious health risk for military members, who often present with symptomatology consistent with chronic neurotrauma. In this pilot study, we assessed the mental health status and functional neural circuits in a group of Canadian Armed Forces (CAF) personnel with and without occupational exposure to repetitive low-level blast.

Methods:
We used MEG resting state and scanned 34 participants – 17 with a history of repetitive occupational blast exposure, and 17 age and sex matched CAF controls without a history of repetitive blast exposure. We captured symptoms of PTSD, anxiety, depression, and mild traumatic brain injury/concussion.

Results:
We observed similar levels of anxiety, depression and PTSD symptoms in blast-exposed members compared to controls, and significantly greater severity and number of mTBI symptoms. In the occupational blast group we observed pathological slowing of neural activity, including elevated low frequency power in the delta range and diminished gamma activity in frontal cortices, as well as reduced beta burst amplitude during the transient burst state. Moreover, we found widespread patterns of altered transpectral neural coupling, including both functional hyper- and hypoconnectivity, which was distributed across a multitude of brain areas.

Discussion:
These findings suggest that military operators exposed to occupational low-level subconcussive overpressure results in elevated symptoms of mTBI, as well as dysregulated and pathological changes to rhythmic neural activity and cortical communication, consistent with chronic neurotrauma.

IT-7

The role of the brainstem in pathological beta-oscillations of Parkinson's disease: a new perspective on previous MEG studies

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Brain oscillations in the beta band are a hallmark of Parkinson's disease (PD) and robustly correlated with movement difficulties, but how they impact the brain circuits for movement is an open question. In previous work combining subthalamic local field potentials with magnetoencephalographic (MEG) recordings in PD patients at rest (Litvak et al, 2011), we identified two oscillatory networks linking the basal ganglia to a temporoparietal-brainstem and a predominantly frontal network. Nevertheless, we found no evidence for subthalamic driving of the cortical or subcortical components of these networks. One reason may have been our lack of focus on the specific connection between the basal ganglia and the brainstem. Dysfunction of the basal ganglia-brainstem system is often considered the primary basis for PD-induced impairments and we hypothesise that pathological brain oscillations of the basal ganglia may propagate to the brainstem. However, the brainstem is a complicated and deep-seated structure, making it hard to study its oscillatory dynamics. In a reanalysis of this dataset, we used a novel technique combining signal source separation and region-of-interest analysis to increase the signal-to-noise ratio of the brainstem. Our results show a clear and separate brainstem component of the STN coherence network in the individual beta band of ten out of fourteen patients. Of these patients, in eight we found nonparametric Granger Causality from the STN to the brainstem. Our results provide evidence for a possible role of the brainstem in causing PD impairment and open future directions for PD research.

IT-8

Data-driven approach for the delineation of the irritative zone in epilepsy in MEG

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The reliable identification of the irritative zone (IZ) is a prerequisite for the correct clinical evaluation of medically refractory patients affected by epilepsy. Given the complexity of MEG data, visual analysis is highly time consuming and might leave clinically relevant information undetected.We implemented an innovative pipeline for the detection of interictal spikes and the delineation of the IZ. First, we detected candidate timestamps from "peaky" ICA components, then extracted spatio-temporal patterns applying convolutional sparse coding. We used our library of patterns to create IZ maps computed at the amplitude peak (PEAK), and at the 50% of the peak ascending slope (SLOPE). We validated our approach one the MEG recording of eight epilepsy patients by spatially comparing IZ maps with visually marked spikes (VIS) and with the surgically resected area (RA).We successfully identified spatiotemporal patterns mimicking the underlying interictal activity in all patients. The accuracy in the delineation of RA was 95% in both SLOPE and VIS, while it was 92% for PEAK. The distance of the IZ from resection margin was lower for the SLOPE than PEAK. In 5 patients, we observed more precise and clinically relevant pattern in SLOPE than in VIS. Therefore, we validated here the performance of an innovative data-driven approach for the automated detection of interictal spikes, and semiautomatic delineation of IZ. This computational framework provides the basis for reliable, reproducible, bias-free analysis MEG recordings in epilepsy.

IT-9 Motor-related oscillations change in schizophrenia according to phase of illness and clinical symptom profile

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Background:
The movement-related beta decrease (MRBD) and the post-movement beta rebound (PMBR) are well-characterised effects in MEG, with the latter relating to long-range connectivity. PMBR is diminished in schizophrenia patients, however little is known how this decrement relates to illness phase and symptom profile. Here we investigate this relationship and use burst analysis to characterise the signal underlying PMBR.

Methods:
29 recent-onset schizophrenia patients, 35 established patients, and 42 control cases undertook a MEG finger movement paradigm. PANSS clinical scores were recorded for patients. The MEG data were beamformed into the beta band (13-30 Hz) and averaged across trials to obtain PMBR amplitude. A hidden Markov model analysis was conducted to identify underlying pan-spectral burst states in each trial. The state that best correlated with the beta envelope was further examined.

Results:
PMBR was diminished in both recent-onset and established cases compared to matched controls (corrected post hoc, $q<0.05$). In established cases, PMBR was significantly negatively correlated ($p<0.05$) with clinical severity of disorganization symptoms. Burst characteristics underlying PMBR also differ between healthy controls and patients, with amplitude and duration of bursts showing a greater degree of abnormality in established cases (corrected post hoc, $q<0.05$).

Discussion:
Our findings confirm PMBR is diminished in different phases of schizophrenia compared to controls, with established cases showing a relationship between PMBR decrement and clinical severity of disorganization. Burst analysis extends this finding to show greater diminishment of bursts in established cases, indicating a relationship between persistent symptoms and reduced efficiency in long-range networks.

IT-10 Interhemispheric network connectivity is altered in focal hand dystonia

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Background:
Focal Hand Dystonia (FHD) is a neurological movement disorder arising due to repetitive stress, which leads to impaired use of the hand and problems in daily life. It is thought that FHD relates to abnormal neural signalling, particularly affecting interhemispheric cortical networks. Post-movement beta rebound (PMBR) is related to long-range cortical networks. Here we measure bilateral PMBR and underlying bursts in FHD patients and controls, and relate these to behavioural measures of spatial acuity.

Methods:
9 control and 11 FHD patients undertook a finger movement task and a behavioural spatial acuity task during MEG. Data were beamformed into the beta band (13-30 Hz) and averaged across trials to obtain PMBR amplitude and latency for both hemispheres. A hidden Markov model was used to identify underlying burst states per trial. The state best correlating with the beta envelope was further examined. Behavioural and MEG metrics were correlated.

Results:
PMBR amplitude in FHD was diminished for contralateral ($p<0.05$, uncorrected) and ipsilateral ($p<0.025$, corrected) hemisphere compared to controls. PMBR amplitude was correlated with spatial acuity scores for both groups in contralateral ($p<0.05$) and ipsilateral hemisphere ($p<0.05$). Burst analysis indicated diminished FHD burst duration ($p<0.05$, corrected) only in the ipsilateral hemisphere in FHD group.

Discussion:
Our findings confirm bilateral diminished PMBR amplitude in FHD patients compared to controls, indicating a reduction in network connectivity. Bursts showed reduced activity in FHD, but only in the hemisphere ipsilateral to the affected hand. These results could indicate that FHD is associated with inefficiency of interhemispheric connectivity.

IT-11

Effect of dentatothalamocortical DBS on cortico-cerebellar interactions in chronic, post-stroke patients.

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Novel therapies to promote post-stroke rehabilitation are in great need. We are investigating deep brain stimulation (DBS) of the dentatothalamocortical pathway as a method to modulate cerebral cortical activity and promote long-term motor recovery. Given the anticipated lack of acute behavioral effect(s), understanding the connectivity between the surgically-targeted cerebellar dentate nucleus (DN) and the ipsilesional cortex may be crucial to the development of biomarkers to facilitate therapeutic programming. We present electrophysiological data collected during the implant and explant phase of the study while patients performed a motor control task. Ten patients underwent scalp EEG and local field potential recording from the externalized, 8-contact DN DBS lead during a visuo-motor grip (20% MVC) block tracking task. Each trial (total n≈76) consisted of movement onset, isometric hold and offset. Routine preprocessing and source estimation were performed before computing cortico-cerebellar coherence (CCC). At implant, significant CCC was observed in the low-_ band which was critical for maintaining task accuracy. At explant, we observed 1) a significant decrease in CCC with concomitant improvement in the ipsilesional low-_ event-related-desynchronization (ERD) during offset and 2) ipsilesional offset ERD, but not CCC dictated task accuracy. The results represent first-in-human electrophysiological evidence of communication between the DN and ipsilesional cortex in the low-_ band during motor control. In the post-stroke state, patients heavily relied on CCC to perform the task. The decreased involvement of DN and increased involvement of ipsilesional cortex provide evidence for impact of DN DBS treatment on motor cortical excitability.

IT-12

MEG for the early detection of mild cognitive impairment (MCI)

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Background:
Alzheimer's Disease (AD) is a type of dementia that effects 50 million people worldwide. This is a progressive disease that affects memory loss and cognitive dysfunction. Magnetoencephalography (MEG) is a noninvasive functional brain imaging technique that measures the magnetic brain waves arising from neuronal activity during rest or during a cognitive task. MEG may help detect AD in its early stages, when confusion first starts to happen.

Methods:
Resting state MEG data from 20 patients with mild cognitive impairment were compared to 20 control subjects. MEG data were filtered into 4 different frequency bands: theta 4-7Hz, alpha 8-13HZ, beta 14-30Hz, and gamma 30-85 Hz. Network brain activity for each frequency band was mapped for the strength of connectivity across 27 regions in each hemisphere, resulting 1431 pairings in the brain. Only the most statistically significant connections between the control group and the patient group where further analyzed, these were based on p-value of less than 0.05.

Results:
Patients with MCI had more hyperexcited/coherent activity in the default mode network compared to controls. The two most statistically significant pathways differences in the beta band frequency were found in the frontal to occipital and frontal to temporal connections.

Discussion:
MEG was able to detect clear differences in active networks during rest in patients with MCI compared to controls. This will have future applications to improve or tailor treatments during the early diagnosis of dementia. Our next step will be to determine the identification of AD network differences from MCI.

IT-13

Automated epileptic spike search in MEG-EEG using sparse dictionary learning

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Presurgical epilepsy evaluation using magnetoencephalography (MEG) is typically based on detection and localization of interictal epileptic spikes. In clinical work, spike detection is often performed manually, which can be time-consuming. We suggest and evaluate here an automated machine-learning-based approach for spike detection: sparse dictionary learning (SDL). We analyzed MEG-EEG data measured from 17 epilepsy patients during their routine presurgical epilepsy work-up. After conventional preprocessing and bandpass filtering, we applied multivariate shift-invariant SDL, also known as convolutional sparse coding (CSC) to learn spatiotemporal features, or atoms, from unlabelled MEG-EEG time-series data, for each patient separately. Each SDL atom is associated with a spatial and temporal pattern as well as an activation time series indicating the atom amplitude (weight) at each occurrence across the data. Atoms were visually reviewed for selecting the spike-associated atom, and the corresponding activation time instants exceeding a patient-specific threshold were regarded as spike candidates. The suggested method detected spikes from all 17 patients: however, spike detectability depended on spike-SNR, similarity between spikes, and on how frequently spikes appear, and required individual changes in method parameters. Automated methods for spike search can save a considerable amount of analysis time. Although the suggested method itself is automatic and works without a-priori information of the spike, it still requires case-dependent adjustments of parameters, which can be especially important for successful detection of low-SNR infrequent spikes. Case-dependent parameter optimization is a target for future development.

IT-14

MEG reveals spike-locked high-frequency oscillations in epilepsy patients with focal cortical dysplasia type 2

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High-frequency oscillations (HFO, >80 Hz) are suggested to mark epileptogenicity better than interictal spikes. However, noninvasive detection of HFOs is challenging due to their very low signal-to-noise ratio (SNR) and difficulty to distinguish pathological HFOs from physiological high-frequency activity. HFOs related to spikes are considered purely pathological by nature, and could potentially serve as a reliable biomarker for the epileptogenic zone. We analyzed MEG-EEG data measured from 17 consecutive focal cortical dysplasia (FCD) type 2 patients during their routine presurgical epilepsy work-up. Interictal spikes during sleep were marked with a machine-learning-based automated method (see a separate abstract) and confirmed by a clinical MEG specialist. MEG data were preprocessed to suppress uncorrelated sensor noise using oversampled temporal projection (OTP), temporal signal-space separation, and movement compensation. To reveal spike-locked HFOs, average time-frequency representations (TFRs) were estimated using Stockwell transformation for each channel. TFR z-scores revealed a significant increase at > 80 Hz around the time of the spike, clearly distinct from the frequency composition of the spike, in 14/17 patients. While low-SNR HFOs could be detected from unprocessed magnetometer TFRs in all 14 cases, OTP enabled detection in gradiometer TFRs in 9/14 cases, and greatly increased the overall statistical significance of HFOs. The 3/17 patients without significant HFO had < 50 detected spikes. By enhancing the SNR at HFO-band using OTP and TFR averaging, we reliably detected pathological HFOs in MEG data of FCD2 patients. Detection and localization of HFOs could potentially add clinical value that MEG brings to the epilepsy surgery planning.

IT-15 Estimation of the whole brain distribution of excitation-inhibition balance in Parkinson's Disease

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Parkinson's Disease (PD) is known for its motor symptoms (MS). However, many reasons (non-motor symptoms, complexity of brain regions (BRs) interactions) suggest that many BRs are simultaneously affected in PD. Despite that, most research on PD is concentrated on basal ganglia and sensorimotor BRs. In this study, we aim at getting more insights into neuronal activity changes distributed across the whole brain in PD. To do so, we performed a source level analysis on resting state magnetoencephalogram (MEG) from two groups: PD patients and healthy controls. After a spectral analysis, we quantified the aperiodic activity by fitting a power law (_ / f_) to the spectrum of MEG and then studied its relationship with age and UPDRS. Consistent with previous results, we found that across all the BRs, most prominent spectral changes were observed in the low alpha band (8-10 Hz). The aperiodic part of the spectrum, which is usually ignored, may be linked with Excitation-Inhibition (EI) ratio according to recent works. We found that in all but frontal regions, _ was much bigger in PD patients than in control subjects. Furthermore, _ was correlated with patient age and UPDRS score. A bigger value of _ in PD implies reduction in excitation or increased inhibition or both. Thus, our results for the first time indicate that PD is associated with change in EI ratio across the whole brain. Moreover, our results provide means to extract new information from MEG which can be developed into a new biomarker of PD.

IT-16 Exploring preclinical signatures of HIV associated neurocognitive disorder using MEG functional connectivity and state dynamics

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Background
Despite the high prevalence of human immunodeficiency virus (HIV)-associated neurocognitive disorder (HAND), its pathogenesis remains unclear and efficient diagnostic tools are lacking. This study seeks to identify neuromagnetic signatures of HAND in spontaneous brain activity of HIV positive patients (HIV+) in a preclinical setting.

Methods
Resting-state MEG was recorded prospectively in 21 young asymptomatic HIV+ men (normal immunity, undetectable viral load), 21 men HIV-, matched for age and recreational drugs usage; and 21 age-matched healthy men, healthy controls (HC). Brain functional connectivity was assessed using the band-limited envelope correlation technique among source signal reconstructed using minimum-norm estimation and spatial leakage correction. Network fast dynamics was investigated using Hidden Markov Modeling (HMM) of broad-band source time series. Group effects on connectivity and HMM state parameters were analyzed statistically using Kruskal-Wallis ANOVA.

Results
No significant differences in neither connectivity nor their fast dynamics were found between HIV+ and HIV-, and between HIV- and HC. When compared to HC, HIV+ displayed a significant higher global power in the gamma band and higher global connectivity in the beta band, with a predominancy in fronto-parietal regions. The HMM analysis revealed a temporal destabilization of the precuneus along with a temporal stabilization of temporo-parietal junctions (TPJs) in HIV+ compared to HC.

Conclusion
Differences in fronto-parietal connectivity, on precuneus and TPS (de)activation might be explained by an interplay between HIV and recreational drugs usage. Increased fronto-parietal connectivity in preclinical HAND may indicate a compensatory effect before clinical stage, as seen, e.g., in Alzheimer's disease.

IT-17 A multi-site magnetoencephalography resting-state dataset to study dementia: The BioFIND dataset

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Early detection of Alzheimer's Disease (AD) is vital for developing effective treatments. Neuroimaging can detect early brain changes, such as hippocampal atrophy in Mild Cognitive Impairment (MCI), a prodromal state of AD. Machine learning can utilise the many features from high-dimensional neuroimaging data, but many cases are required. While large, public datasets of MCI/AD exist for Magnetic Resonance Imaging (MRI), eg "ADNI", comparable datasets are lacking for Magnetoencephalography (MEG). MEG offers advantages in its millisecond resolution, potentially revealing physiological changes in brain oscillations or connectivity before structural changes are evident with MRI (and unconfounded by vascular changes in functional MRI). Here we describe the "BioFIND" dataset of 324 individuals, approximately half MCI and half controls, who have at least 2 mins of resting-state MEG, plus a T1 structural MRI, from one of two sites (Cambridge and Madrid). To our knowledge, this is the largest publically available MEG dataset for dementia research, available in BIDS format on DPUK platform: https://portal.dementiasplatform.uk/Apply. Initial analyses using Multi-kernel Learning (MKL) of Support Vector Machines (SVM) show that MEG sensor covariance adds complimentary information for MCI classification beyond grey-matter volume from structural MRI. Future possible analyses include source space, measures of functional connectivity (e.g, amplitude or phase), dynamic as well as static connectivity, more advanced classifiers (e.g, deep learning); future plans include adding new participants from ongoing projects, and follow-up diagnoses and other biomarkers where available.

IT-18 Spectral Abnormalities Delineate the Pediatric Epileptogenic Zone

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Background:
In selected cases, treatment of pediatric focal epilepsy requires successful delineation and resection of the epileptogenic zone (EZ). Pre-surgical identification of this region is a persistent challenge. Magnetoencephalography (MEG) is used in some centers for this purpose, but marking interictal events is time-consuming, prone to human errors, and of debated clinical value. Here we explore the potential of detecting abnormal variants of source power spectral density (PSD) in pediatric epilepsy cases relative to a large normative database, as a novel marker for EZ delineation.

Methods:
We used MEG rest recording of 97 pediatric epilepsy patients and obtained brain maps from the delta to gamma bands. We applied the same procedure to create a normative distribution of PSD brain maps in healthy controls from the Open MEG Archive (n=200). Each patient was contrasted against this normative distribution to identify deviations from healthy variants.

Results:
Preliminary results from 20 pediatric cases show a concordance between frequency-specific power and spike localizations in 85% of cases, with delta band being the most consistent (75% of cases). We will present the complete set of results with respect to normative controls and discuss the prediction of surgical outcomes from spectral deviation maps.

Discussion:
Spectral deviation mapping does not require review of patient recordings by professionals. It is therefore time-efficient, reproducible, and may require shorter recordings from patients. Relating these findings to individual surgical resection zones, patient outcomes, and histopathology will advance our understanding of aberrant in-vivo human neural dynamics in epilepsy.

IT-19 Epileptiform discharges relate to altered functional brain networks in autism spectrum disorders

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Background
Many individuals with autism spectrum disorders (ASD) have comorbid epilepsy. Even in the absence of observable seizures, interictal epileptiform discharges(IEDs) are common in individuals with ASD. However, how these IEDs are related to autistic symptomatology remains unclear.

Methods
We analysed 70 children with ASD (52 boys, 18 girls, 38–92 months old) and 19 typically developing children (16 boys, 3 girls, 48–88 months old). After assessing the participants' social reciprocity using the Social Responsiveness Scale, we constructed graphs of functional brain networks from frequency band separated task-free magnetoencephalography recordings. Nodes corresponded to Desikan–Killiany atlas-based 68 brain regions. Edges corresponded to phase lag index values between pairs of brain regions.

Results
In children with ASD, the average clustering coefficient (C) in the theta band was significantly higher in children who had IEDs. Moreover, children with ASD who had no IEDs had a significantly lower average C in the theta band than typically developing children had. However, the difference between typically developing children and children with ASD who had IEDs was not significant. Furthermore, the higher average C in the theta band corresponded to severe autistic symptoms in children with ASD who had interictal epileptiform discharges.

Discussion
The alteration of functional brain networks in children with ASD depends on the existence of IEDs. IEDs might 'normalize' the deviation of altered brain networks in ASD, increasing the C. However, when the effect exceeds tolerance, it actually exacerbates autistic symptoms.

IT-20 Cortical oscillatory activity associated with motor control abilities in pediatric stroke

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Cognitive impairments related to reduced executive functions are more likely to incur in children who develop dystonia following an ischemic stroke than those without dystonia. An emerging hypothesis suggests that this reflects a loss of inhibitory control as a result of maladaptive neuroplasticity in both motor and cognitive networks. Using MEG and MRI, the present study examines induced oscillatory activity associated with dystonia in post-stroke patients with dystonia, post-stroke patients without dystonia and healthy controls. All participants perform a go/no-go task with both hands to assess inhibitory control. Beamformer-based source analysis was carried out in an initial sample of six patients (3 with dystonia and 3 without) and eight healthy controls. Time-frequency analyses of frontal theta (4-8 Hz), motor beta (15-30Hz) and sensorimotor gamma (60-90 Hz) bands were examined. Dystonia patients showed higher theta power and higher error rates for 'no-go' trials, suggesting more cognitive effort but less effective ability to withhold movement. Interestingly, non-dystonia patients did not show any behavioral differences across both hands, but theta power was greater in the hand associated with the lesioned hemisphere. Beta suppression and rebound (beta reactivity) differed across participant groups: dystonia patients showed absent beta rebound when using their affected hand, and significantly reduced beta reactivity for their unaffected hand, while non-dystonia patients showed no difference compared to healthy controls. Sensorimotor gamma activity was only present in healthy controls and non-dystonia patients, but completely absent in dystonia patients. Recordings in pediatric stroke patients are ongoing to confirm these initial findings.

IT-21

Simultaneous Transcutaneous Vagus Nerve Stimulation (tVNS) and Magnetoencephalography (MEG)

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Background: Transcutaneous vagus nerve stimulation (tVNS) is a type of non-invasive brain stimulation used increasingly in the treatment of a number of different conditions. Currently there is no conclusive evidence concerning the optimal set of stimulation parameters. Variation of these parameters may lead to a difference in brain response to stimulation which gives potential for the development of personalised stimulation parameters for the targeted treatment of different conditions and may improve treatment efficacy.

Methods: Seventeen healthy participants were recruited and underwent simultaneous tVNS and magnetoencephalography (MEG) to measure brain response to different pulsed stimulation protocols. Different frequencies and sites of stimulation were investigated. An interpolation method and various preprocessing steps were utilised to allow the retrieval of underlying brain response despite strong electrical interference from simultaneous tVNS and MEG.

Results: We show that variation of the pulse stimulation frequency can lead to a difference in the brain response, with the brain also responding in different anatomical regions depending on the frequency. Responses in a number of deep brain areas were observed, including many regions that have been implicated in the pathology of depression and other mood disorders.

Discussion: We have demonstrated the feasibility of simultaneous pulsed tVNS and MEG recording, which allows the direct investigation of changes in brain activity that results from different stimulation parameters. This is the first study that has successfully performed auricular tVNS with simultaneous MEG, due to the presence of large stimulation artifacts that are produced by the electrical stimulation.

IT-22

Changes in cortical oscillatory activity in Parkinson's Disease

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Cortical oscillatory activity is changed in MEG resting-state recordings of patients with Parkinson's disease (PD). Low frequency power in posterior brain regions is increased (Stoffers et al., 2007) but the pattern of change is less clear for motor cortical beta power (Boon et al., 2019). In the present study we investigate PD-related power spectral changes and their underlying network dynamics in resting-state MEG. Resting-state MEG scans from 36 healthy controls and 28 PD patients were source reconstructed using an LCMV beamformer, voxel time-series were parcellated into 52 regions and a power spectrum was calculated for each region and subject. General linear models (GLMs) were applied to assess power spectral differences across participants at each frequency bin and region while controlling for confounds. Power spectra were also regressed onto Bradykinesia/Rigidity and Tremor scores. A time-delay embedded Hidden Markov Model (HMM) was used to describe network dynamics in the data with the same GLMs applied to summary measures of the dynamics. PD-patients demonstrated significantly increased theta to low-alpha activity in posterior regions of the brain, decreased low beta power in inferior parietal regions, and decreased high beta activity in the superior and supplementary motor areas. None of these regions showed significant associations with motor scores. We next explored the richer network dynamics perspective using the HMM and show that summary measures of the dynamics, such as the lifetime and frequency of occurrence of state visits appear to provide more sensitivity markers than the simpler power spectral measures.

VT-30

Modulation of sensory cortical activity by deep brain stimulation in advanced Parkinson's Disease.

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The beneficial effect of deep brain stimulation applied to the subthalamic nucleus (STN DBS) in advanced Parkinson's disease (PD) patients is well known; however, its neurophysiological basis remains poorly understood. In addition to motor symptoms, PD patients show a variety of non-motor symptoms in different sensory domains. STN DBS has been suggested to affect sensorimotor modulation in PD and relate to motor improvement in patients. However, observations on the relationship between sensorimotor activity and clinical improvement have remained sparse. Here we investigated the effect of STN DBS on somatosensory processing in advanced PD patients. We measured somatosensory evoked magnetic fields in thirteen patients before initiation of DBS and 7 months afterward. Somatosensory processing was addressed with magnetoencephalography (MEG) during alternated median nerve stimulation at both wrists. We focused on the possible changes in the most prominent deflection at ~60 ms at the contralateral primary somatosensory cortices and its' correlation with the patients' clinical profile. The response strengths did not differ between preoperative and postoperative conditions with DBS on. However, the relative change in the response strengths between those conditions suggestively correlated with the alleviation of patients' motor symptoms measured with the motor part of the Unified Parkinson's Disease Rating Scale. MEG provides an effective tool to explore non-motor effects in patients with PD, and it may help in understanding the neurophysiological basis of DBS. However, a larger sample size and measurements in non-medicated patients are needed in further studies.

IT-24

Slowing of fronto-central beta oscillations in atypical Parkinsonism: An MEG study

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Background
The cortiobasal syndrome (CBS) and the progressive supranuclear palsy (PSPS) are both diseases that belong to the atypical Parkinson spectrum (APS). Diagnosis relies on clinical presentation and structural imaging, yet little is known about their electrophysiology. By means of magnetoencephalography (MEG) we explored disease-specific spectral signatures that could potentially aid differential diagnosis.

Methods
We measured resting state MEG of 13 patients with CBS, 10 patients with PSPS, 23 patients with idiopathic Parkinson's disease (IPS) and 23 healthy controls (HC). The activity of 48 cortical areas was estimated via LCMV beamforming and translated into the frequency domain. The aperiodic 1/F – background was subtracted, and the power spectrum's center of mass was calculated on the 4-30Hz interval. Furthermore, we extracted the peak amplitude and the peak frequency for all peaks. Statistical significance was assessed with cluster-based permutation testing and linear mixed modeling.

Results
The center of energy in APS was significantly reduced compared to IPS ($p = 0.0052$) and HC ($p = 0.0019$) with largest effects in fronto-central regions. Peak analysis in this region revealed lower peak frequency in the beta band in APS compared to IPS ($p = 0.0049$) and HC ($p = 0.0156$). No significant differences were found between CBS and PSPS.

Discussion
These observations are reminiscent of findings in Alzheimer's disease, in which spectral changes tend to topographically overlap with atrophic regions. Slowing of oscillations may mirror neurodegeneration. Spectral slowing might be an electrophysiological marker of cortical degeneration and may contribute to distinguish Parkinson syndromes.

IT-25

Practice Related Changes in the Sensorimotor Cortices of Persons with Cerebral Palsy

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Background:
Our MEG research has shown that aberrations in the sensorimotor cortical oscillations of persons with cerebral palsy (CP) are linked with the precision of their lower extremity motor performance. However, it is still unclear how these cortical anomalies might be modulated by practice dependent behavioral improvements.

Methods:
MEG was used to quantify the cortical oscillations serving performance of an isometric knee extension force-matching task for a cohort of persons with CP (N=25) and neurotypical (NT) controls (N=18). We identified the practice-dependent changes in beta (16-22 Hz) and gamma (66-82 Hz) cortical oscillatory activity. Structural equation modeling (SEM) was utilized to probe the multivariate relationships between changes in cortical activity and the post-practice behavioral performance enhancements.

Results:
SEMs indicated that for the NT controls, a greater change in the strength of the sensorimotor (b= -2.263; P=0.024) and occipital (b= -2.031; P=0.042) beta ERD following practice was predictive of faster reaction times. For the persons with CP, a greater change in the strength of the sensorimotor gamma ERS after practice was predictive of a reduction in target overshoot (b= -3.017; P=0.003) and faster target matching (b= -2.964; P=0.003).

Discussion:
For persons with CP, practicing a leg motor action has more of an immediate effect on the execution versus planning of motor actions. Furthermore, those with less of a gamma ERS practice effect exhibited less performance improvements. These results hold major implications for understanding the neurophysiological mechanisms that underlie the clinical improvements seen after physical therapy.

IT-26

With Adequate Viral Suppression, No HIV-Related Changes in Resting State Oscillatory Power Throughout Aging: A Bayesian Analysis

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Background:
HIV infection remains a significant contributor to disease burden, and with the success of antiretroviral therapies, the population of people with HIV (PWH) is aging. A growing literature suggests a relationship between HIV-infection and a profile of age advancement (i.e., accelerated aging). However, despite the known high prevalence of HIV-related brain atrophy, functional deficits, and HIV-associated neurocognitive disorder, HIV-related changes in resting state oscillatory power have not been quantified across adulthood.

Method:
In this study, we utilized resting state MEG to study the oscillatory function of 115 virally-suppressed PWH and 126 uninfected controls age 22-72. All participants were assessed for cognitive impairment and participants completed six minutes of eyes-closed resting state MEG. MEG data were co-registered to participant-specific MRI data and source-imaged. Source-level resting state power and peak frequency were then calculated for canonical frequency bands. We then examined the group-level interactive effects of HIV and chronological age on these metrics. Additionally, we examined effects of HIV-associated neurocognitive disorder. Post-hoc Bayesian analyses were utilized to further explore our effects.

Results:
In examining resting state oscillatory power, independent age-related changes were identified in delta power, beta power, and alpha peak frequency, however, no effects of HIV were identified. Exploring these null results, post-hoc Bayesian analyses showed evidence suggesting many oscillatory metrics were equivalent between PWH and uninfected controls.

Discussion:
In conclusion, in virally suppressed PWH, resting oscillatory power is largely preserved across adulthood. These findings are a critical step towards understanding and treating the aging brain of PWH.

IT-27

Dynamic causal modelling of the neurophysiology of Alzheimer's disease

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Background:
Alzheimer's disease affects neurophysiology by loss of neurones, synapses and neurotransmitters, e.g. acetylcholine. A mechanistic understanding of the human disease will facilitate new treatments. Recent developments in biophysically-informed dynamic causal models enable inferences around laminar and cell-specific disease effects from human non-invasive imaging.1 Based on pre-clinical models and effects of cholinesterase inhibitors, we predicted Alzheimer's disease would affect superficial pyramidal cell gain and extrinsic connectivity in hierarchical cognitive networks.2

Methods:
Magnetoencephalography was recorded during a mismatch negativity (MMN) task from healthy adults (n=15, amyloid-biomarker negative) and people with Alzheimer's disease (n=47, amyloid-biomarker positive) at baseline and 16 months. Sensor data confirmed group differences in MMN amplitude. For each participant, we inverted MMN responses to dynamic causal models. Second-level parametric empirical Bayes tested the effect of group, pTau-181 level and session (baseline vs follow-up) on pyramidal cell gain and extrinsic connectivity.

Results:
Alzheimer's disease reduced the mismatch negativity response. Parametric empirical Bayes confirmed that (1) Alzheimer's disease reduced extrinsic connectivity and superficial pyramidal cell gain; (2) these parameters were conditional on pTau-181; and (3) changed further during follow up.

Discussion:
Dynamic causal models confirmed that reduced superficial pyramidal cell gain and extrinsic connectivity can explain the observed physiological effect of Alzheimer's disease. These effects are opposite to the effects of galantamine.2 This approach to non-invasive magnetoencephalography data may be used for experimental medicine studies of candidate treatments and bridge human disease to preclinical models of drug efficacy. 1. Adams 2021 Brain 2. Moran 2013 JNeuroSci

IT-28

Normative modeling for robust detection of mild traumatic brain injury from MEG recordings

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Despite significant advances in clinical diagnostics, objective biomarkers for identifying mild traumatic brain injury (mTBI) are still lacking. Electrophysiological recordings show potential in detecting pathological cortical oscillations related to injury, but the large heterogeneity both in patient groups and in the healthy population remains a challenge. Normative modeling aims to address this heterogeneity by mapping abnormality as a statistical deviation from reference data. Such outlier detection can readily serve as a nonspecific biomarker, but can by itself not determine the type of abnormality. To address this nonspecificity, we combined normative modeling with machine learning to detect pathological oscillations related to mTBI from resting-state magnetoencephalography (MEG) measurements. A normative dataset (Cam-CAN) comprising 621 healthy participants was used to determine the normal variation in power spectra across the cortex. We employed either the full dataset or an age-matched subset of it as the normative data. To discriminate mTBI patients from healthy control subjects, we trained support vector machine classifiers on the quantitative abnormality maps from 25 mTBI patients and 20 healthy controls not in the reference data. The best performing classifier used the full normative data across the entire age range, and was able to distinguish mTBI patients from controls with an accuracy of 79%. Model inspection revealed theta band activity (4–8 Hz) as a significant indicator of mTBI, consistent with earlier studies. This combination of normative modeling based on a large healthy cohort and classification at the individual level shows potential for identifying patients for further clinical evaluation.

IT-29

Multivariate prediction of mood from MEG features and physiological measures of arousal

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Despite its omnipresence in everyday interactions and its importance for mental health, mood and its neuronal underpinnings are poorly understood. In its simplest operationalization we can describe mood on a single dimension going from "unhappy" to "happy", which can be affected on a minute time scale by experiencing rewards or punishments. Previous work has shown how these mood ratings can be modelled by latent variables representing reward expectation and reward prediction errors (RPE), which show correlations with features of MEG signals: latent expectation was found to be predictive of changes in beta-gamma oscillatory power (25-40 Hz), and RPE explained variance in the evoked response to reward feedback. Building from these results we aim to train a multivariate prediction model to identify features of brain activity and physiology associated with participants' happiness reports during a gambling task. Initial features selection, including MEG evoked responses and oscillatory power as well as physiological measures of arousal (heart rate, electrodermal activity and pupil size), will be guided by analysis of a previous published MEG dataset of 54 adolescent participants. Methods will be pre-registered before testing on a new dataset currently being collected at NIH including two MEG scan sessions from ~30 healthy volunteers (aged 15-26) performing a gambling task with 108 gambling trials and 45 mood reports per session. With this pre-registered analysis we aim to identify predictive neural features of reported mood, validating previous results with a separate dataset, assessing subject test-retest reliability over two sessions and controlling for physiological measures of arousal.

IT-30

The limiting factors for OP-MEG in epilepsy surgery planning: a simulation study

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Background:
When planning for epilepsy surgery, multiple potential sites for resection may be identified through anatomical imaging. The likely seizure onset zone is frequently confirmed using intracranial EEG. Optically pumped magnetometer-based magnetoencephalography (OP-MEG) could replace this invasive recording. Here, we examine the potential limiting factors in simulation.

Methods:
We simulated OP-MEG recordings for 1309 potential lesion sites identified from MRI in the Multi-centre Epilepsy Lesion Detection (MELD) project. This database includes 538 patients with a median average of 2 potential lesion locations per patient. We added errors to both the sensors (e.g. gain and co-registration) and the source model (e.g. lesion extent). To ask whether the simulated epileptogenic lesion could be disambiguated from the other potential sites, we source reconstructed using Multiple Sparse Priors with only the patient's potential lesion locations as priors.

Results:
Knowledge of the candidate lesion zones made the inversion extremely robust to errors in sensor gain, orientation and even location. For sensor position, orientation and gain errors of 5 mm, 10_ and 5%, 98% of the correct sites were identified. The inversion was most significantly impacted by errors in the source model. When the edge of the lesion was simulated as the epileptogenic source but the model prior assumed that only the centre of the lesion was active, performance dropped to 80%.

Discussion:
Flexible OP-MEG helmets could be used in conjunction with anatomical lesion mapping data. The errors due to imprecise gain or array geometry are marginal when compared to sub-optimal source modelling assumptions.

IT-31

Gamma oscillations point to the role of the early visual cortex in atypical motion processing in autism.

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Abnormal neural inhibition may explain a range of sensory processing differences in autism spectrum disorders (ASD). In particular, the impaired ability of people with ASD to discriminate the motion direction of small-size objects and their reduced perceptual suppression of background-like visual motion may stem from impaired surround inhibition within the primary visual cortex (V1) and/or its top-down modulation by higher-tier cortical areas. Here, we aimed to estimate the contribution of surround inhibition to the motion-processing deficit in ASD with magnetoencephalography (MEG). The study included boys with ASD and in typically developing (TD) boys aged 7-15 years. We used MEG to assess a putative index of surround inhibition – the suppression of the visual gamma response (GR) at a high drift rate of a large high-contrast grating. In a separate psychophysical experiment children discriminated direction of large and small high-contrast vertical gratings. The GR suppression was reduced in children with ASD, while their ability to detect direction of motion was compromised only for small stimuli. In TD children, the GR suppression directly correlated with perceptual suppression caused by increasing stimulus size, which suggest the role of top-down modulations of V1 excitability. In ASD, weaker GR suppression was uniquely associated with poor directional sensitivity to the small stimuli. These results favour the hypothesis that poor motion direction sensitivity in ASD is associated with a local inhibitory deficit in V1, rather than with deteriorated top-down modulations of V1 surround inhibition from the higher-tier cortical areas. This study was supported by RSF (project#22-25-00419).

IT-32

Increased excitation-inhibition ratio in children with autism and below-average intelligence.

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Altered excitation-inhibition (E-I) ratio has been implicated in autism spectrum disorders (ASD). However, it is not known whether the direction and degree of changes in the E-I ratio in individuals with ASD correlates with intellectual disability often associated with this developmental disorder. The spectral slope of the aperiodic 1/f activity reflects the E-I balance at the scale of large neuronal populations and may uncover its putative alternations in individuals with ASD with and without intellectual disability. Herein, we recorded magnetoencephalogram at rest in 49 typically developing (TD) boys and in boys with ASD and average (IQ>85, N=30) and below-average (IQ<85, N=19) intelligence, aged 6-15 years. The spectral slopes were estimated in high frequency range, from activity localized using LCMV beamformer approach and individual brain models. The global 1/f slope was calculated by averaging the spectra over all cortical sources. Children with ASD and below-average IQ had flatter slopes than either TD or ASD children with average IQ. The periodic alpha and beta power did not differentiate between the groups. Flattened spectral slope in children with ASD and below-average IQ could not be accounted for by differences in instrumental noise, muscle artifacts or periodic alpha and beta power. The results suggest a shift of the global E-I balance toward hyper-excitation in children with ASD and comorbid intellectual disability. The spectral slope can provide an accessible non-invasive biomarker of a globally altered E-I ratio in ASD. This study was supported by RSF (project # 22-25-00419).

IT-33

Cortical beta burst dynamics are altered in Parkinson's disease but normalized by deep brain stimulation

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Exaggerated subthalamic beta oscillatory activity and increased beta range cortico-subthalamic synchrony have crystallized as the electrophysiological hallmarks of Parkinson's disease. Beta oscillatory activity is not tonic but occurs in 'bursts' of transient amplitude increases. In Parkinson's disease, the characteristics of these bursts are altered especially in basal ganglia. However, beta oscillatory dynamics at the cortical level and how they compare with healthy brain activity is less well studied. We used magnetoencephalography (MEG) to study sensorimotor cortical beta bursting and its modulation by subthalamic deep brain stimulation in Parkinson's disease patients and age-matched healthy controls. We show that the changes in beta bursting amplitude and duration typical of Parkinson's disease can also be observed in the sensorimotor cortex, and that they are modulated by chronic subthalamic deep brain stimulation, which, in turn, is reflected in improved motor function at the behavioural level. In addition to the changes in individual beta bursts, their timing relative to each other was altered in patients compared to controls: bursts were more clustered in untreated Parkinson's disease, occurring in 'bursts of bursts', and re-burst probability was higher for longer compared to shorter bursts. During active deep brain stimulation, the beta bursting in patients resembled healthy controls' data. In summary, both individual bursts' characteristics and burst patterning are affected in Parkinson's disease, and subthalamic deep brain stimulation normalizes some of these changes to resemble healthy controls' beta bursting activity, suggesting a non-invasive biomarker for patient and treatment follow-up.

IT-34

The Oscillatory Dynamics Serving Verbal Working Memory are Altered in Preclinical and Prodromal Alzheimer's Disease

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Background:
In healthy adults, oscillatory dynamics within a predominantly left-lateralized network of brain regions underlie verbal working memory (VWM) performance, but how the preclinical (subjective memory complaint [SMC]) and prodromal (mild cognitive impairment [MCI]) stages of Alzheimer's disease (AD) impact these dynamics is not well characterized. We investigated the effects of SMC and MCI on the oscillations serving specific phases (encoding, maintenance) of VWM.

Methods:
One-hundred-eight adults (50 cognitively healthy [CH], 34 SMC, 24 MCI, 60 female, M age = 61.46) completed a VWM task during MEG. All MEG data underwent standard preprocessing, were transformed into the time-frequency domain, and significant oscillatory responses relative to baseline were imaged using a beamformer. To determine the effect of group (CH, SMC, MCI), ANCOVAs were performed on the resulting whole-brain maps with age as a covariate, and follow-up t-tests were performed. Multiple comparisons were corrected for using a spatial extent threshold (k=500) based on the theory of Gaussian random fields.

Results:
Across groups, decreases in alpha-beta (9-16 Hz) activity were seen in left fronto-temporal regions throughout encoding and maintenance. Significant group differences emerged in the anterior cingulate, inferior frontal, frontal eye field, and superior parietal cortices during encoding (p<.05, corrected). Both SMC and, to a lesser degree, MCI individuals exhibited increases in theta (4-7 Hz) activity within these regions, while these responses were largely absent in CH individuals.

Conclusions:
Adults with preclinical and prodromal AD recruited additional neural resources during VWM performance. Our results support the compensation-related utilization of neural circuits hypothesis.

IT-35

Exploring the robustness of the MEG functional neural network in patients with dementia due to Alzheimer's disease

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Background.
Dementia due to Alzheimer's disease (AD) is associated with various alterations in the functional brain network, whose properties are usually summarised in strongly correlated measures. Given the characteristic progressive neural deterioration induced by AD, determining the robustness of the neural network in these patients could be a key biomarker to help in the disease diagnosis. The purpose of this study was to quantify the alterations that AD continuum elicits in the robustness of the functional neural network by means of novel measures from complex network theory.

Methods.
Magnetoencephalographic (MEG) source-level data from cognitive healthy controls, individuals with mild cognitive impairment (MCI) and patients with dementia due to AD were analysed using leakage-corrected amplitude envelope correlation (AEC). Afterwards, the robustness of the network was estimated using the weighted efficiency measure from complex network theory and under two node attack models (i.e., degree-based node removal and random node removal).

Results.
Weighted efficiency shows that the MEG functional network suffers from a gradual alteration throughout dementia progression for both of the assessed models.

Discussion.
The significant changes on the functional network structure associated with the AD progression are reflected in a loss of network robustness. This finding supports the notion that altered networks in patients with MCI and AD are more sensitive or resilient to network failures than those of cognitive healthy controls.

IT-36

Acute Mild Traumatic Brain Injury (mTBI) disrupts the Coordination of Transient Bursts: A Hidden Markov Model Approach to Magnetoencephalography data

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Introduction
mTBI can cause potentially debilitating long term symptoms, however, the absence of abnormalities in clinical imaging is hindering objective diagnoses. Magnetoencephalography (MEG) has shown great promise in assessing mTBI and may be sensitive to the functional consequences of axonal injury—the putative mechanism underlying mTBI symptoms—by assessing changes in connectivity between brain regions. Recent work has shown that transient bursts in the MEG signal might offer a richer picture of electrophysiology compared to the classical assumption of smoothly varying oscillations. Here, we show that mTBI is related to a reduction in functional connectivity as measured by burst-coincidence between separate brain regions.

Methods
We analysed source-localised resting-state MEG data from subjects with mTBI and individuals with non-head-trauma (acquired within 2 weeks post-injury), and age and sex-matched healthy controls, using a Hidden Markov Model to extract transient bursts. The coincidence of bursts between pairs of atlas regions was used to construct functional connectomes. Recursive random forest feature selection allowed us to systematically extract the most important functional connections when distinguishing subjects with mTBI from healthy participants.

Results
We find a statistically significant reduction in global burst-coincidence in acute mTBI compared to healthy controls. Data-driven selection of those functional connections that best distinguish healthy controls and subjects with mTBI greatly improved differentiation between acute mTBI and non-head-trauma. Our results are numerically consistent with previously published data from mTBI subjects.

Conclusion
Our burst connectivity measure is a promising marker for mTBI and offers a mechanistically plausible measure of axonal integrity.

IT-37 Increased Delta Power in Acute Mild Traumatic Brain Injury (mTBI): A Specific MEG Biomarker?

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Introduction
mTBI can cause debilitating long-term symptoms. However, routine clinical imaging rarely demonstrates abnormalities, hampering objective diagnosis. Magnetoencephalography (MEG) has shown great promise in mTBI—the most reported candidate biomarker being increased resting-state delta-band power. However, most studies collect MEG data a long time post-injury—or only in those who remain symptomatic—not controlling for potential non-specific trauma effects. Here, we address these shortcomings by acquiring MEG data within 14 days of injury and by including a group of controls exposed to non-head-trauma, in patients attending an Accident and Emergency hospital department.

Methods
We measured source localised resting-state delta power in three groups: 27 individuals with mTBI, 9 with non-head-trauma, and 27 healthy controls, age and sex-matched to the mTBI group. Individual, voxel-wise Z-scores were calculated based on the sample of healthy controls and maximum Z-scores were extracted for each subject.

Results
Using a threshold ensuring no false positives in our sample, we found that the maximum Z-score classified 74% of mTBI subjects correctly, mirroring previously reported accuracies in samples of chronic mTBI patients using a similar metric. However, 8 of the 9 non-head-trauma controls were also classified as mTBI.

Conclusion
Excess delta power as measured using MEG appears sensitive to acute mTBI. However, we observe similarly abnormal delta power in non-head-trauma controls. This raises important questions about the specificity and pathophysiology of these changes. While indirect deceleration trauma may have occurred in some non-head-trauma subjects in addition to their primary injury, a non-specific trauma effect cannot be ruled out.

IT-38 Modelling 40 Hz auditory steady-state responses indicates NMDA receptor dysfunction in emerging psychosis

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Background
Schizophrenia is a severe psychiatric disorder associated with large-scale brain network disturbances. Both inhibitory interneurons and excitatory pyramidal cells have been proposed as key players in the aetiology of schizophrenia. However, it is unclear which of these cell types is primarily responsible, and more work is needed to understand the exact nature of their dysfunction. Dynamic causal modelling (DCM) of MEG data offers the possibility to address these questions.

Methods
We analysed MEG data collected during a 40-Hz auditory steady state response (ASSR) paradigm from participants at clinical high-risk for psychosis (CHR-P, n=116), patients with first-episode psychosis (FEP, n=33), controls with nonpsychotic disorders (n=38) and healthy controls (n=49), first reported by Grent-'t-Jong et al (2021, Biol Psych). DCM was used to investigate interneuron and pyramidal cell function, including contributions of NMDA receptors.

Results CHR-P and FEP groups (vs controls) showed reduced 40-Hz power. DCM analyses revealed decreased NMDAR-mediated connectivity between the medial geniculate nucleus and primary auditory cortex in both CHR-P and FEP. We also found reductions in pyramidal cell (but not interneuron) NMDA conductance in both CHR-P and FEP (vs controls).

Discussion
Our results support the hypothesis that pyramidal neuron hypofunction – mediated in part by NMDA receptor dysfunction – is a primary deficit in emerging psychosis. We did not find evidence of interneuron pathology or NMDA receptor dysfunction on interneurons. Consistent with previous findings, we found altered thalamocortical connectivity. These findings highlight the potential of using MEG and computational modelling to probe excitatory/inhibitory circuit change in psychosis.

IT-39

Investigating procedural learning-related brain connectivity processes in children with self-limited focal epilepsy

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Background.
Children with self-limited focal epilepsy (SLFE) often show motor difficulties that have been associated with altered development of functional brain connectivity. Here, we test the hypothesis that procedural learning-related resting-state functional connectivity (rsFC) processes are atypical in SLFE.

Methods.
Magnetoencephalography (MEG) was used to investigate changes in rsFC (2*5 minutes before and after the learning procedure) induced by a behavioural procedural learning session in 10 children with SLFE (6 girls; age: 9,37±1,31 years) compared to 10 matched healthy children (6 girls; age: 9,69±1,31 years). After removing cardiac/ocular artefacts and interictal epileptiform discharges (IEDs) through independent component analyses, a functional connectome was estimated using band-limited power envelope correlation. Unpaired T-tests were then used to compare learning-related changes in rsFC between groups. Node power was regressed out beforehand to exclude possible power-related rsFC changes, and results were controlled for multiple comparisons using maximum statistics.

Results.
Compared to healthy children, those with SLFE showed a significant reduction of learning-related changes in rsFC connections between (i) the right posterior parietal cortex and left lobules 7 and 8 of the cerebellum in the theta band (4-8 Hz) and (ii) the left primary motor and the mesial prefrontal cortices in the alpha band (8-12 Hz).

Discussion.
Our results suggest atypical procedural learning changes in rsFC in SLFE within brain regions that have been associated with (visuo-)motor functions. Hence, these observations, which may be due, among other hypotheses, to frequent IEDs in SLFE, could lead to motor difficulties observed in these children.

IT-40

Neurophysiological consequences of synapse loss in the primary tauopathy of progressive supranuclear palsy

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Synapse loss occurs early in neurodegenerative disease and contributes to cognitive impairment. However, for human disease there has been a lack of formal models to explain how the cortical network physiology underlying cognition is affected by synaptic loss. Biophysical models of brain function can provide a bridge between measured behaviour and neurobiology. Such models can reveal hidden neuronal dynamics supporting neurophysiological observations like electro/magneto-encephalography. Here we extend biophysically informed dynamic causal models by inclusion of synaptic density measures from 11C-[11C]UCB-J positron emission tomography, to explain how regional synapse loss translates into cognitive neurophysiology. Using the primary tauopathy of progressive supranuclear palsy as a demonstrator condition with high clinicopathological correlations, we show that a reduction in synaptic density in inferior frontal cortex affects superficial and granular layer glutamatergic excitation. This superficial and granular excitation is related to individual differences in behaviour, providing a link between synaptic loss, mesoscale inference, and cognitive deficit. A generalised framework of pathology-enriched dynamic causal models is applicable to test the mechanisms of other disorders, with diverse measures of pathology, and the effects of pharmacological interventions.

IT-41 Right P1m predicts social impairment in children with ASD

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Background
In previous magnetoencephalography (MEG) studies, children with Autism spectrum disorder (ASD) have been shown to respond differently to speech stimuli than typically developing (TD) children. Quantitative evaluation of this different response may support early diagnosis and early intervention for ASD. We investigated the relationship between voice-evoked P1m and social impairment in both ASD and TD children.

Methods
We analyzed 49 children with ASD aged 40–92 months and age-matched 26 TD children. We evaluated their social impairment using the Social Responsiveness Scale (SRS) and evaluated their intelligence using the Kaufman Assessment Battery (K-ABC). We performed multiple regression analysis using P1m intensity in right hemisphere and K-ABC Mental Processing scale as the dependent variables, using SRS total T-score as the independent variable.

Results
We identified right P1m intensity as a negative predictor of the SRS total T-score in ASD children, and this relation was not significant in TD children.

Discussion
Right P1m intensity was related to social impairment in ASD children, and not in TD children. This result suggests right P1m intensity can be useful as a predictor of ASD diagnosis and severity.

IT-42 Gamma oscillatory dynamics serving cognitive control are modulated by regular cannabis use in people with HIV

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Background:
Cannabis use and HIV are both associated with deficits in cognitive control and changes in inhibitory and excitatory balances across the cortex. However, less is known regarding the combined effects of HIV and regular cannabis use on the brain circuitry serving higher-order cognition. We hypothesized that cannabis and HIV would interact, such that regular cannabis use among people with HIV (PWH) would induce altered neural interference effects and more normalized spontaneous activity in higher-order cognitive areas compared to nonusers with HIV.

Methods:
Data from 102 participants, including PWH who use cannabis, PWH who do not use cannabis, uninfected cannabis users, and uninfected nonusers were used for analysis. Participants underwent an interview regarding their substance use history and the Eriksen Flanker task during magnetoencephalography (MEG). MEG data were imaged in the time-frequency domain and virtual sensors were extracted using significant peak voxels from ANOVAs of the oscillatory maps depicting the neural interference effect (i.e., incongruent-congruent). ANOVA models were used to assess group-level differences in spontaneous activity.

Results:
We found that nonusing PWH have stronger gamma oscillatory interference effects in the right superior frontal compared to all other groups. Peak voxel time series were extracted from the peak voxel, and we found that cannabis using PWH have more normalized spontaneous gamma activity in the right superior frontal gyrus ($p<0.001$) than PWH who are nonusers.

Conclusions:
Regular cannabis use appears to suppress the impact of HIV on spontaneous and oscillatory gamma in the right superior frontal gyrus.

IT-43

Tau protein spreads through functionally connected neurons in Alzheimer's disease

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Several mechanisms could be behind tau-spread through the brain in Alzheimer's disease (AD): spreading between strongly interacting brain regions (functional connectivity); through the pattern of anatomical connections (structural connectivity); or simple diffusion to spatially adjacent regions. We investigated this by modelling tau-spreading on different networks, and compared the modelled tau-depositions with tau-depositions in several stages of the AD-continuum as measured with in-vivo 18F-flortaucipir PET. We collected eyes-closed, whole-head magnetoencephalography (MEG) recordings from 82 subjects with and without A_-pathology (CSF-A_42 and/or amyloid-PET). Subjects were classed as controls (subjective cognitive decline ((SCD) A_-,n=25), preclinical AD (SCD A_+,n=16), mild cognitive impairment (MCI) due to AD (n=16) or AD dementia (n=25). Tau-propagation was modelled as an epidemic process (susceptible-infected model) on a structural network, a diffusion network, or two functional networks in alpha (8-13Hz) and beta (13-30Hz) bands, derived from the source-reconstructed MEG data. The group-level control network was used as backbone for the model to predict tau spread in the next stages of the AD-continuum; parameters were tuned to produce an optimum correlation to the group-specific tau propagation patterns as measured with 18F-flortaucipir PET. Tau propagation was modelled to start from one seed region in the temporal cortex. The functional networks predicted tau-spread with highest accuracy in the preclinical AD stage (alpha r=0.59; beta r=0.58), followed by the structural network (r=0.45) and simple diffusion (r=0.44). Prediction accuracy declined for the MCI and AD dementia stages. Our results suggest that tau spreads through functional connections, rather than structural connections or simple diffusion.

VT-153

Beyond the early diagnosis of dementia: How we can contribute to its treatment

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Background
Dementia is a progressive disease without any curative pharmacological treatments. Neuroscientists and engineers have been studying biomarkers to diagnose it at the early stage. However, can we justify the early diagnose without any treatments? Although there are no disease-modifying drugs, non-pharmacological treatments (NPTs) often reduce its symptoms and improve quality of life of patients. If MEG-based indices predict or monitor the outcome of NPTs, MEG can then contribute to patients' happiness. In this study, we assessed the relationship between changes of MEG-based indices and effects of NPTs to make the most of NPTs for dementia treatments.

Methods
Nineteen patients with moderate to severe dementia were enrolled in this study. They were admitted in our geriatric health facility to receive NPTs for 3 months. The levels of cognitive impairment and behavioural disturbances, at the beginning and the end of the NPT period, were measured using Mini-Mental Scale Examination Japanese version (MMSE-J) and Dementia Behavior Scale 13 (DBD-13), respectively. To compute MEG-based indices, resting-state neural oscillations were also recorded using MEG at the beginning and the end of the NPTs. The relationship between MEG-based indices and the scores of MMSE-J and DBD-13 were assessed.

Results
MEG-based indices at the beginning of NPT period were relevant to the change in the scores of MMSE-J and DBD-13. Changes in MEG-based indices were also correlated with the change in DBD-13.

Discussion
MEG-based indices monitored the effects of NPTs and predicted their outcome. MEG contributes to improve dementia treatments, as well as its early diagnosis.

VW-127 Transient enhancement of the right temporal delta power in mild cognitive impairment

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Background
Alzheimer's diseases (AD) is a neurodegenerative diseases and a major cause of dementia. MEG is sensitive for oscillatory changes relevant to the neurodegeneration. Previous studies showed that enhanced slow oscillatory activity in the caudal brain at the early stage of AD, followed by rostral slowing, which is called 'Anterior shift'. However, pathological change starts in ventral brain. In this study, we examined the oscillatory changes around ventral regions at the early stage of AD.

Methods
MEG databases in Hokuto and Kumagaya general hospitals were used in the present study: They consist of resting state eye-closed data for 5 min recorded from 134 healthy volunteers (HVs), patients with 29 mild cognitive impairment (MCI) and 41 dementia. Patients with AD was subdivided into two classes according to their Mini–Mental State Examination (MMSE) scores: AD with high MMSE (hAD) and with low MMSE (lAD). Source oscillatory powers were compared using Full Factorial Model (MEG site x participant group) with a covariate of age.

Results
Patients with MCI showed stronger delta oscillatory power than HVs in the right temporal cortex, although hAD and lAD did not. hAD and lAD showed stronger theta power than HVs in the left occipital cortex. The hAD and lAD did not differ significantly.

Discussion
Delta oscillatory power in the right temporal region was enhanced transiently in MCI, but not AD. Although previous studies showed that patients with MCI showed intermediate changes between HVs and patients with AD, present results demonstrated MCI-relevant transient neural changes.

IT-46 Altered phase synchrony and cross-frequency coupling in early cognitive decline

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Background:
Mild cognitive impairment (MCI) often precedes Alzheimer's disease (AD) and may itself be preceded by subjective cognitive decline (SCD). We hypothesized that these forms of early cognitive decline might be accompanied by abnormal neuronal synchronization that could be detected with electrophysiological methods and possibly used to predict progress towards AD.

Methods:
In a first study, we recorded 3-min resting state magnetoencephalographic (MEG) data from 142 subjects with MCI, 85 with SCD, and 116 healthy controls (HC). For 45 MCI patients, a second MEG set was recorded 2 years later. Of these, those (N=23) whose symptoms had worsened were classified as having progressive MCI (pMCI), the others (N=22) with stable MCI (sMCI). We used source reconstruction and estimated phase synchronization (PS) and cross-frequency coupling (CFC) pairwise between 400 cortical parcels.

Results:
We found that global PS in a range from 5 to 20 Hz was significantly reduced in the MCI and SCD cohorts compared to HC, as were 1:2 alpha-beta and 1:3 alpha-gamma CFC. In the analysis of pMCI and sMCI patients, we observed that in both early and late measurements, the alpha peak in PS and CFC was observed at lower frequencies for pMCI then sMCI.

Conclusion:
We found that PS and CFC are altered already early in cognitive decline, with different profiles for patients with pMCI and sMCI. These results indicate that MEG recordings may be used for early diagnosis and prognosis in subjects at risk for AD.

IT-47

Subthalamic Deep Brain Stimulation-Evoked Cortical Responses are Predictive of Optimal Contact Directionality and Movement Outcomes in Parkinson's Disease

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Background
Although there has been substantial progress in the development of therapeutics that alleviate motor symptoms in patients with Parkinson's disease (PD) (e.g., subthalamic deep brain stimulation: STN-DBS), some patients are left without experiencing optimal clinical benefits. One proposed parameter that could aid STN-DBS effectiveness is the directionality of current administered (e.g., segmented vs. ring-shaped contacts). However, the precise neurophysiological mechanisms underlying optimal DBS contact directionality and subsequent clinical outcomes are not well understood.

Methods
In this study, 23 PD patients implanted with STN-DBS completed a monopolar stimulation paradigm of the left STN during magnetoencephalography (MEG) and during standardized movement protocols assessed outside the scanner. MEG data underwent source reconstruction using minimum norm estimation and peak voxel time series data were extracted to interrogate the directional specificity of STN-DBS current administration on accelerometer metrics of fine hand movements using linear mixed effects models.

Results
Our results indicated that DBS-evoked cortical responses in the ipsilateral sensorimotor cortex (SM1) were largest when applying current via optimal contact directionalities (i.e., subject-specific clinically-effective contact direction segment/ring) compared to other non-optimal contact directions tested. Similarly, optimal contact directions yielded smoother movement profiles (i.e., slower single-trial tap acceleration, greater tapping consistency and frequency), which were differentially predicted by SM1 responses in a contact-dependent manner.

Discussion
Taken together, these data suggest that DBS-evoked cortical responses and quantitative assessments of movement may provide novel mechanistic and clinical insight for characterizing the optimal DBS programming strategies necessary for alleviating motor symptoms in PD patients in the future.

IT-48

Stun effect due to subthalamic DBS surgery alters resting-state networks of Parkinson's disease patients

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The implantation of electrodes for deep brain stimulation (DBS) in patients with Parkinson's disease (PD) leads to a temporary improvement in motor symptoms, known as the stun effect. As both DBS and dopaminergic medication alter symptoms and resting-state networks (RSN) of PD patients, but the functional network alteration due to the stun effect are not known, we here investigated whether the stun effect also affects different functional RSN. We recorded 27 PD patients (8 female) in the magnetoencephalograph for 30 minutes while resting two days before and one day after implantation of the DBS electrode. One each recording day the data were acquired once with and once without dopaminergic medication. RSN were determined based on the megPAC approach, i.e., by considering phase-amplitude-coupling between a low (2-30 Hz) frequency phase and a high (80-150 Hz) gamma amplitude (Florin and Baillet, 2015). A jackknife approach was used to test for differences in RSNs due to electrode implantation, separately for both medication states We identified four RSNs across all conditions: motor, visual, fronto-occipital, and frontal. For each of these RSNs, alterations were found due to electrode implantation. These alterations were not restricted to areas spatially close to the DBS trajectory. Interestingly, although the stun effect improved motor symptoms, the pre-operative RSN better corresponded with the networks of age-matched healthy controls. Therefore, the stun effect influences different functional RSN even within areas outside of the DBS trajectory, indicating a brain wide network effect due to the implantation of the DBS electrode.

IT-49

Study of the human cortical hub structure in Mild Cognitive Impairment through multilayer functional connectivity

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Resting-state magnetoencephalography (MEG) is a widely used technique to study functional connectivity (FC) disruption in Mild Cognitive Impairment (MCI). Traditionally, MEG signals are decomposed by frequency and studied independently. However, the interplays between the different frequency bands have rarely been studied. In the present study, we constructed multi-frequency networks to check whether the results obtained using frequency-specific networks are also applicable when assessing the interactions between different frequencies. To this end, we performed eyes-closed resting-state MEG in 105 MCI patients and 248 controls. Cross-frequency brain networks were constructed by calculating the amplitude envelope correlation between all sources in five frequency bands, considering both intra- and inter-band connections, resulting in a single network for each subject. Subsequently, we calculated several centrality measures, and compared both groups accounting for the variability derived from age and education. Node strength and closeness centrality showed a decrease in the connectivity of the regions of interest (ROIs) in the frontal lobe of MCI patients with respect to controls. Eigenvector centrality, on the other side, showed that these frontal ROIs are connected to more important ROIs in MCI patients, while temporoparietal ROIs to less central ROIs with respect to controls. These results are consistent with previous literature, showing that the changes in FC in the brain already described for frequency-specific networks are maintained when considering interactions between frequency bands. Furthermore, these results prove the validity of the methodology we have implemented for the topological analysis of cross-frequency networks, providing a simple procedure to study global brain FC.

IT-50

Does dynamic connectivity help the classification of MCI over static connectivity?

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Background
Using Multi-Kernel Learning (MKL), we previously showed that MEG offers complimentary information above MRI in classifying Mild Cognitive Impairment (MCI). This was based on "static" sensor covariance across several minutes of rest. However, there may be dynamic changes that also differ in MCI. Here we fit Hidden Markov Models (HMMs) to the same data to ask whether dynamic properties improved classification.

Methods
Participants: We used 163 MCI and 144 controls from the BioFIND dataset (https://doi.org/10.48532/007000). Preprocessing: Max-filtered Neuromag data were down-sampled to 500Hz and band-passed 1-48Hz. 3559 cortical sources were estimated using OSL's LCMV beamformer, and reduced to 38 OSL ROIs using PCA. Analyses: The 28 static features were covariances of the ROI timeseries. For dynamic features, we used OSL's time-delay embedded HMM (TDE-HMM) and dual estimation to extract eight states and calculated: 1) 28 temporal properties (fractional occupancy, mean lifetime, mean interval length and number of occurrences for each state), and 2) 56 transition probabilities between states. We ran 1000 permutations of 5-fold cross-validation of Support Vector Machines (SVMs), with MKL to combine SVM decisions across all three types.

Results
Mean classification for static connectivity, temporal properties and transition probabilities alone was 62.0%, 62.6% and 58.6%, respectively. When combining all three, mean accuracy was 63.2%, with an improvement for 85% of permutations.

Discussion
We only found suggestive evidence that dynamic properties of HMM states have additional information above static connectivity for classification of MCI in the BioFIND, but can try other ROIs and models in future.

IT-51 Identification of the theta-to-alpha transition frequency from MEEG data of neurodegenerative patients

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Background:
Common practice in magneto/electro-encephalography (MEEG) signal processing consists in analyzing the data at the different frequency bands; thus, their optimal identification is crucial to reach reliable results. A subject-specific frequency band subdivision is preferable to a standard one. Indeed, for instance, it has been demonstrated a shift towards low frequencies of the power-spectrum profile of Alzheimer's patients. A delicate phase is the identification of the theta-to-alpha transition frequency (TF). The standard method for its identification is that reported by Klimesch et al., 1999, and requires resting-state and task EEG recordings, however, when only resting-state data are available, this is limiting.

Methods:
We propose a novel method for TF identification, which only requires resting-state EEG recordings. Our method identifies two EEG channel groups, characterized by a strong presence of alpha and theta activity, respectively. The two groups play the role of the resting-state and task recordings in Klimesch's method. Our method is implemented in an open-source Python library named transfreq.

Results:
We validated the method on an open-source EEG dataset from both Parkinson's patients and healthy subjects and on an in-house dataset. With the open-source dataset, the absolute value of the difference between the TFs estimated with the two methods (i.e. transfreq and Klimesch's method) was below 1 Hz for 88% of subjects. With the in-house dataset the percentage is 73%.

Discussion:
Transfreq is easy to use and yet very robust, thus it can be easily included in all analysis pipelines.

IT-52 Neural Communication Underlying Episodic Memory in Children: Application of a Pediatric Brain Tumor Survivor Injury Model

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Pediatric brain tumor survivors (PBTS) experience deficits in memory due to effects of tumor and treatment. Neural synchrony disruptions in theta and gamma bands within memory networks may underlie these deficits. This study aimed to determine effects of tumor treatment on neural synchrony in theta and gamma bands between four memory networks: The Medial Temporal (MTN), Posterior Medial (PMN), Anterior Temporal (ATN), and Medial Prefrontal (MPN) networks. 24 PBTS (Mage=13.19) and 23 HC (Mage=12.82) were scanned with T1-weighted MRI and completed the Transverse Patterning (TP) task during magnetoencephalography (CTF 151 channel MEG) to assess episodic visual recall. MEG data was band-pass filtered from 1-150 Hz, epoched, cleaned of artifacts, beamformed using LCMV, and networks were defined using the HCP-MMP1.0 atlas and T1 scans. Weighted phase lag indices (wPLI) were calculated for network connections and compared between groups using Network Based Statistics (NBS) in the theta and gamma frequency bands. TP accuracy and reaction times were assessed for group differences using robust regressions. Pearson's correlations were conducted between wPLI values and task scores with significant PBTS/HC differences. Analysis revealed 6 network connections with increased theta wPLI in PBTS ($p<0.05$) correlated to decreased TP task performance (robust regressions: _= -0.03, Adjusted p= .007, Pearson's correlations: Adjusted R2= 0.179; Rs>|-0.3715|, ps<0.0102, qs<0.0494). Our findings suggest these networks may impact episodic memory function in children, and that theta hyper-synchrony between them may be a pathological process in PBTS.

IT-53 Spatially-resolved cortical slowing predicts cognitive and motor impairments in Parkinson's disease

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Background
In patients with Parkinson's disease (PD), findings of power increases in slow cortical rhythms alongside decreases in faster activity, relative to healthy adults, are well-replicated. This has led to a hypothesis of pathological neural slowing in this patient group. However, the lack of a single continuous model of such slowing has made this hypothesis difficult to verify, and has hindered efforts to understand its significance to the hallmark motor and cognitive impairments of PD. Further, contributions to this effect by aperiodic (i.e., arrhythmic) and periodic (i.e., rhythmic) neural generators has not been explored.

Methods
We use source-imaged magnetoencephalography (MEG) to derive maps of cortical neural slowing from 79 patients with PD relative to a matched group of 65 healthy adults. These maps were modeled alongside motor impairment measured by the Unified Parkinson's Disease Rating Scale-part III and domain-specific cognitive functions quantified using an extensive battery of neuropsychological tests.

Results
We report a spatially-overlapping slowing of multi-spectral neural activity in PD, with contributions from rhythmic and arrhythmic sources. Rhythmic and arrhythmic slowing differentially predict key clinical features of PD, including motor and cognitive functions. These results are also spatially-diverse; slowing of neural activity in the prefrontal, somatomotor, and temporal cortices predict different clinical features.

Discussion
Taken together, these observations are the first evidence for anatomically-specific cortical slowing in PD. This is also the first indication of differential clinical significance of rhythmic and arrhythmic neural slowing, and provide potential new targets for non-invasive patient monitoring and future neurostimulation therapies.

IT-54 Suicide progressing spectrum of Major Depressive Disorder identified by resting-state Magnetoencephalography

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Background
Major depressive disorder patients usually present with varying suicidal severities ranging from non-ideation to ideation and attempt. Reliable indicators of progression to suicide attempt or suicide would be of clear clinical benefit.

Methods
63 depressed patients and 41 healthy controls were enrolled for resting-state magnetoencephalography. Depressed participants consisted of 37 with suicidal ideation but no attempt, 12 with history of suicide attempt, 14 with no suicide ideation or attempt. The latter two groups were defined as extreme groups. A semi-supervised clustering method here extracted the most suicide-related functional features in cortico-striato-thalamo-cortical (CSTC) loops between extreme groups, followed by applying the features to cluster the ideation group. The abnormalities in three CSTC sub-circuits (affective, ventral cognitive, dorsal cognitive) were further studied in the cluster level.

Results
Two clusters were derived from the ideators to judge the higher/ lower risk of each individual. Lower-risk ideators had mild affective and ventral cognitive circuitry anomalies compared to healthy controls. Both higher-risk ideators and attempters presented dysfunction in dorsal cognitive circuit, which involved in working memory and executive function. Furthermore, the suicide progressing spectrum including the extreme groups and ideator clusters were significantly correlated with clinical suicide scores.

Discussion
Depressed patients exhibited transformational abnormalities from the ventral cognitive circuit to the dorsal cognitive circuit as suicidal severity increased, which might increase the vulnerability of suicide and cause patients to develop suicide thoughts into taking actions. These insights of different phases of suicide spectrum and semi-supervised clustering are potentially reliable for suicidal understanding and assessment.

IT-55

Magnetoencephalography resting-state Relative Oscillations correlated with Suicide Attempt in Depression

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Background
In depressed population, appropriate neurophysiologic biomarkers should be implemented for suicide attempt to screen some concealing occasions in clinical. Truly present brain oscillations may have to be questioned because of the existence of aperiodic background signal.

Methods
In resting-state MEG, 33 depressed patients with suicide attempt and 42 depressed patients without suicide ideation or attempt werescanned. 32 brain regions of default mode, salient and central executive network were studied here from source-reconstructed data. Full power spectra were calculated via classic Welch's method. To parameterize neural power spectra, fitting oscillations & one over f (FOOOF) was utilized here to separate relative oscillation power and background signal. Both the full and the relative power in several frequency bands were compared between groups.

Results
All brain regions exhibited the strongest power in alpha band (8-13Hz). Changing trends in full alpha power between groups were found in five regions, but maybe resulted from the disturbance of their significantly different aperiodic intercept. Most importantly, relative alpha power of left angular gyrus in the attempt group was significantly lower than the non-suicide group ($p<0.001$ after correction). Furthermore, relative alpha power of the attempt group was significantly correlated with their clinical suicide scores ($r=0.5153$, $p<0.01$).

Discussion
FOOOF could support the real oscillations and help to detect the suicidal features. The angular gyrus plays a role in brain activities including discourse, problem solving, and planning, whose abnormal oscillations may increase the suicide risk to attempt. Changed relative power represent neurobiological markers of suicidality in depressed patients potentially.

IT-56

Association of Network Neural Synchronization with Information Processing Speed

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Pediatric brain tumor survivors (PBTS) experience significant impairments in information processing speed (IPS) that worsens overtime and impacts future outcomes. IPS underlies higher-order cognitive processes and is mediated by the brain's default mode (DMN) and executive control (ECN) networks. However, it is unclear what role functional connectivity (FC) of the DMN and ECN plays in predicting IPS, and how this association differs between healthy children (HC) and PBTS. Magnetoencephalography (MEG) scanning was conducted using a whole-head 151-channel system (CTF) in 24 HC (12.83±3.08years) and 28 PBTS (13.71±3.02years) during a visual-motor reaction time (RT) task assessing IPS. Data was collected at a sampling rate of 1200Hz or 600Hz and band-pass filtered from 1-150Hz. Signal artifacts and mean RT's >3 standard deviations were removed. MEG data was filtered into canonical frequency bands. The DMN and ECN were defined using the HCP MMP 1.0 atlas on MRI and registered to MEG. Weighted phase-lag index (wPLI) values were computed within each network to index FC, and group differences were assessed using Network Based Statistics. Compared to HC, PBTS displayed slower RT (p=.02, MeanRT:HC=.53ms;PBTS=.65ms), and reduced task-dependent increase in left hemisphere beta (13-29Hz) and right hemisphere high gamma (60-100Hz) oscillations. Across all participants, increased FC of the DMN and ECN predicted faster IPS. Our findings show how network neural synchronization is essential for efficient IPS performance. Further establishing alterations in FC of the DMN and ECN as novel biomarkers of IPS impairments could facilitate early intervention and monitoring of these deficits.

IT-57

DriPP: Driven Point Processes to Model Stimuli Induced Patterns in M/EEG Signals

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The quantitative analysis of M/EEG signals is made possible by the detection of recurring temporal patterns, both in time and in brain space. These patterns can be extracted efficiently using Convolutional Dictionary Learning (CDL) (Dupré La Tour et al., NeurIPS 2018). A natural question is to estimate how their occurrences are modulated by certain cognitive tasks and experimental manipulations. We propose a point process (PP) approach, as the events obtained by CDL make PP amenable to M/EEG studies. We develop a novel statistical PP model - called Driven temporal Point Processes (DriPP) -, where the density of events depends on a set of PP (drivers) corresponding to stimulation events. To model latency effects in neural responses, it is parametrized using truncated Gaussian kernels. To estimate the few parameters of our model, we derive a fast expectation-maximization (EM) algorithm. Simulations reveal that model parameters can actually be identified. Results on public MEG datasets demonstrate that DriPP reveals event-related neural responses - both evoked and induced - by exhibiting known responses such as M100 and P200, and isolates non-task-specific temporal patterns such as blinks or heartbeats. Without any manual tuning or selection, DriPP offers a unified approach to extract waveforms and automatically detect the ones that are modulated by the stimuli. By capturing the surge of activations associated with external events, it provides a direct statistical characterization of when and how each stimulus is responsible for the occurrences of temporal patterns reflecting neural responses. See Allain et al. 2021 (arXiv:2112.06652) for more details.

IT-58

AnyWave: a cross-platform and modular software for visualizing and processing electrophysiological signals.

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AnyWave is a software designed to easily open and view data recorded by EEG or MEG acquisition systems. The application is modular, multi-platform and open source. Colombet B, Woodman M, Badier JM and Bénar CG. "AnyWave: a cross-platform and modular software for visualizing and processing electrophysiological signals." Journal of neuroscience methods 242 (2015): 118-26 gitlab repository: https://gitlab-dynamap.timone.univ-amu.fr/anywave/anywave The main goal is to provide a user-friendly tool for clinicians and a development framework for engineers and researchers allowing them to bring new signal processing or visualization modules using MATLAB or Python programming. The BIDS standard is fully supported, a GUI allows to easily browse BIDS source data and raw data. MRI or CT scans present in the BIDS folder can also be shown using third party software. AnyWave can also convert many MEG/EEG/SEEG data files to the BIDS format. Several C++ open-source plugins are embedded within the installation package. (ICA components extractions, Connectivity measures, basic signal processing). The software can also be run from the command line. This permits to create shell scripts to run batch processing on a large set of data files. Bath processing can also be applied to a whole BIDS dataset. AnyWave responds to a need to deliver state of the art signal processing and visualization techniques. It brings a user-friendly interface to neurophysiologists and allows researchers and engineers to test and develop new algorithms.

IT-59

Functional connectivity predicts MI-based BCI learning

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Despite being a potential tool for rehabilitation and communication, brain-computer interfaces (BCI) control remains a learned skill that presents a large inter-subject variability. Here, we studied the evolution of the functional connectivity during the BCI training. We hypothesized that the training would be accompanied with a decrease of functional integration in areas related to learning process, and that the associated properties would provide information to predict the learning rate. Twenty healthy subjects followed a 4-session motor-imagery-based BCI training over 2 weeks in which magnetoencephalographic signals were recorded. After removing physiological artifacts and performing the source reconstruction, we conducted the connectivity analysis with the _ and _ ranges by computing the imaginary coherence between each pair of ROIs and the relative node strength N by summing the values of the associated row of the connectivity matrix. Connectivity changes revealed a significant across-session declines spatially distributed involving associative regions. Better BCI performance was notably associated with the decrease of relative node strength in areas involved in both mental rotation and working memory (orbital part of the inferior frontal gyrus), in decision making and memory consolidation (cingulate gyrus). We observed, notably in these areas, a significant and positive correlation between connectivity and learning rate ($p < 0.035$), meaningthat the potential to improve performance is higher when the functional disconnection of these regions has not yet started. These results could pave the way to an individualized BCI training based on the use of the task-related functional brain network properties.

IT-60

Independent component analysis extracts reproducible subject-specific MEG responses

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Electromagnetic brain responses contain both reproducible features, i.e., those which are replicable when repeating the experiment, and noise features, i.e., those which are not. Averaging data across subjects is a widely used approach to highlight common response patterns. However, averaging hides individual differences. Here, we describe an algorithm to identify reproducible features for individual subjects at the sensor level. The algorithm first decomposes the data to a linear mixture of temporally independent components. Reproducible features are then classified under the following hypotheses: a signal component is reproducible if 1) it maintains the same temporal pattern over multiple recordings, and 2) it displays it in spatially close areas, as assessed using a variation of the Mahalanobis distance. The algorithm was tested both on simulated and real data from an MEG reproducibility study on picture naming (Ala-Salomäki et al., Neuroimage 227:117651, 2021). Reproducible spatiotemporal components were successfully detected and separated from the simulated data. In the picture naming study, the algorithm identified replicable components whose time evolution and location corresponded with the earlier analysis. Moreover, when the feature selection was added to a decoding pipeline, it yielded improved accuracy. This method shows great promise in extracting neurophysiologically plausible features that are interpretable as independent neural sources. Furthermore, when applied to data from multimodal electromagnetic measures of neural activity -- e.g., MEG and EEG – the present approach may aid the task of data fusion.

IT-61

Decoding across subjects with deep transfer learning

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Decoding external variables (e.g. stimulus category) from internal states (i.e. brain activity) is gaining popularity in neuroscience, with potential applications for brain-computer interfaces and representational similarity analysis (Cichy et al., 2016). As decoding typically fits separate (often linear) models on a per-subject basis (Cooney et al., 2019), we aim to investigate whether deep learning can improve multi-subject decoding. We used a Magnetoencephalography (MEG) dataset, where 15 subjects viewed 118 different images, with 30 repetitions per image (Cichy et al., 2016). We compared a baseline Linear Discriminant Analysis (LDA) classifier with a Wavenet Classifier (WC), our adoption of Wavenet (Oord et al., 2016). All models performed above chance (0.85%), with LDA having the lowest accuracy (20%). Linear and nonlinear versions of WC achieved 44% and 40% accuracy on single-subject data, and 12% and 40% on group data, respectively. Individual subjects might not have enough data to make use of nonlinearity, but at the group level nonlinearity and additional subject embeddings were crucial for good performance. Using permutation feature importance, time-resolved information content is gained from WC, peaking around 140ms post-stimulus. Finetuning the group model on individual subjects separately improves over the linear individual models (47%, not significant). The group model is truly useful in the low data regime. A model trained on 14 subjects generalizes much better with less data to the 15th subject (4% zero-shot accuracy), compared to an individual subject model. Given that there are only 15 subjects the potential of these methods is even higher with bigger datasets.

IT-62

An automated analysis pipeline for resting state MEG data for the assessment of cross-sectional and longitudinal neural functioning

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Magnetoencephalography (MEG) is a powerful clinical and research device for understanding human neurophysiology in typical and diseased states. Recently, we harnessed MEGs potential as a tool for the precise longitudinal evaluation of brain function. We present an analysis pipeline for resting state datasets, for a progressive application of MEG as an innovative brain function monitoring tool, such as in contact sports and the military. We developed an automated, cloud-based, MNE-Python pipeline to rapidly process resting state MEG data. Output analyses returns oscillatory power across 5 canonical bands, for 78 automated-anatomical labelling atlas cortical seeds. Leakage-corrected amplitude envelope correlation (AEC) matrices include connections across intrinsic networks such as the Default Mode (DMN), visuo-motor and salience networks. To demonstrate our pipeline's efficacy, the cortical topography of oscillatory power and network connectivity was compared to published data. The longitudinal stability of the scans was also assessed by measuring 2 participants 2-3 months apart, generating correlation coefficients of power and AEC. In our neurotypical database, cortical oscillatory power maps were consistent with the literature, including frontal midline theta, occipito-parietal alpha, and bilateral somatosensory-motor beta activity. Alpha and beta edges were greatest for intra-network connections in the DMN and visuo-motor networks. Longitudinal scans demonstrated high internal stability against the control datasets via power maps and intrinsic networks, and within subject correlations revealed high stability across all bands, from the lowest (theta r=.71) to greatest (alpha r=.92). For AEC vectors, alpha and beta networks were the most stable and delta the lowest.

IT-63

A software platform for comparison of MEG and stereoEEG findings in epilepsy patients

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Magnetoencephalography (MEG) represents a useful clinical tool for the improvement of surgery outcome in epilepsy as MEG findings have been retrospectively validated on intracranial EEG recordings on large patient cohorts. While the main neurophysiological criteria for pre-surgical evaluation in non-invasive recordings remain seizure onset and interictal epileptiform discharges (IED), computational neuroscience provides access to novel biomarkers such as high frequency oscillations (HFO, > 80 Hz) and spike propagation, widely used in invasive recordings. In this project we built a computational framework for the comparison of MEG and stereoEEG findings in the individual patient. We collected bimodal recordings from patients (N = 5) invited to MEG (Vectorview Neuromag) prior to stereoEEG implantation. We performed standard IED visual detection and data-driven automated irritative zone (IZ) identification (Chirkov et al., 2022) on MEG recordings. We automatically detected HFO (Fedele et al., 2017) and IED propagation patterns (Diamond et al., 2019) on stereoEEG data. We implemented a modular framework to simulate MEG data from stereoEEG signals. First, we mapped stereoEEG activity over the digitized brain (Lin et al., 2021), then we projected distributed sources to sensor space. Non-invasive and invasive analysis agreed in the estimation of the epileptogenic zone in all patients with two left, one right and one bilateral mesial temporal foci, and one anterior cingulate focus. Simulated MEG provided activation patterns resembling recorded MEG data. Therefore, we provide a platform allowing the comparison of multimodal pre-surgical epilepsy analysis together with tools for data simulation and validation of innovative algorithmic approaches.

IT-64

FLUX: A pipeline for MEG analysis

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Magnetoencephalography (MEG) allows for quantifying modulations of human neuronal activity. The technique relies heavily on signal processing and source modelling. To this end, there are several open source toolboxes developed by the community. While these toolboxes are powerful as they provide a wealth of options for analyses, the many options also pose a challenge for reproducible research as well as for researchers new to the field. The FLUX pipeline aims to make the analyses steps and setting explicit for standard analysis done in cognitive neuroscience. It focuses on quantifying and source localization of oscillatory brain activity, but it can also be used for event-related fields and multivariate pattern analysis. Specifically, the pipeline including documented code is defined for MNE Python (a Python toolbox) and FieldTrip (a Matlab toolbox), and a dataset on visuospatial attention is used to illustrate the steps. The scripts are provided as notebooks implemented in Jupyter Notebook and MATLAB Live Editor providing explanations, justifications and graphical outputs for the essential steps. Furthermore, we also provide suggestions for text and parameter settings to be used in registrations and publications to improve replicability and facilitate pre-registrations. The FLUX can be used for education either in self-studies or guided workshops. We expect that the FLUX pipeline will strengthen the field of MEG by providing some standardization on the basic analysis steps and by aligning approaches across toolboxes. Furthermore, we also aim to support new researchers entering the field by providing education and training

IT-65

Direct algebraic identification of current multipoles in three-dimensional space for the magnetoencephalography inverse problem

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Background
In magnetoencephalography (MEG) source identification, current sources are usually modeled as equivalent current dipoles (ECDs). However, actual neural sources have non-negligible spatial extent, which could be accounted for using equivalent current multipoles (ECMs). We extend the previously proposed algebraic method for the multipole source identification of the two-dimensional Poisson equation to the three-dimensional realistic MEG problem.

Methods
By adopting the concentric sphere head model, the radial component of the magnetic field is represented by the current source according to the Biot-Savart law. The multipole expansion of the equation leads to an algebraic relation between the unknown multipole source parameters (location and moment) and the MEG data. Choosing the sectorial harmonic components of the expansion extracts the xy-projection of the source location, resulting in the algebraic equation derived in the conventional two-dimensional method. The z-coordinate can also be estimated by changing the direction of the projection. Once the location is determined, the moment can easily be estimated by solving a linear system. We validated the proposed method by numerical simulations with two distinct current quadrupoles.

Results and Discussion
The proposed method could stably estimate the two quadrupoles, validating the efficacy of the method. In contrast, the results of the ECD model had huge errors because quadrupoles are approximated as two close dipoles with the opposite direction, and thus they cancel each other. Such source distributions are observed in the visual cortex, demonstrating the necessity of the ECM model. Acknowledgements This work was supported by MEXT Q-LEAP Grant Number JPMXS0118067395.

VT-154

Joint Estimation of Sparse Sources and Low-rank Noise for Electromagnetic Brain Imaging

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Electromagnetic brain imaging is the reconstruction of brain activity from non-invasive recordings of magnetic fields and electric potentials. Electroencephalography (EEG) and magnetoencephalography (MEG) are widely used techniques to study the function of the human brain. Efficient reconstruction of the brain activity on the cortex surface from the EEG/MEG measurements is important for neuroscience research and clinical diagnosis. In this work, we consider one of the most realistic assumptions - low rank noise covariance. This is often the case when there are a few active sources of environmental noise or the MEG/EEG sensors are highly correlated. To the best of our knowledge, no existing algorithm has addressed the brain source estimation problem under low-rank noise covariance. We propose a novel robust empirical Bayesian framework which provides us a tractable algorithm for iteratively estimating the noise covariance and brain source activity. In particular, we perform factor analysis of the residual term at each iteration of the Bayesian updates. One key aspect of our proposal is that we do not require any additional baseline measurements to estimate the noise covariance from the sensor data. To demonstrate the effectiveness of the proposed algorithm, we perform exhaustive experiments on both simulated and real datasets. Our algorithm achieves superior performance as compared to several existing benchmark algorithms (extended to the setting of noise with low-rank covariance).

IT-67 Fourier-based waveform analysis dissociates human cortical alpha rhythms

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Neural oscillations have been associated with different brain functions and disorders. Recently, the non-sinusoidal shape of oscillations has gained interest as an indicator of underlying neurophysiology and neurological diseases. However, waveform analysis in the time domain has been limited to dominant neuronal oscillations and by pre-selected waveform features. Here, we contribute a Fourier-series based waveform analysis that allows for a parsimonious and comprehensive analysis of non-sinusoidal waveforms. We applied this novel approach to human cortical alpha oscillations recorded during resting-state and using magnetoencephalography (MEG). Our approach allowed us to dissociate distinct alpha waveforms in occipital, sensory-motor, temporal and parietal cortices. Fourier-based waveform analysis opens a powerful new window for studying neuronal oscillations in health and disease.

IW-121 Stimulus-induced changes in 1/f-like background activity in EEG

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Research into the nature of 1/f-like, non-oscillatory electrophysiological activity in the brain has been growing exponentially in recent years in cognitive neuroscience. The shape of this activity has been linked to the balance between excitatory and inhibitory neural circuits, which is thought to be important for information processing. However, to date, it is not known whether the presentation of a stimulus induces changes in the parameters of 1/f activity that are separable from the emergence of event-related potentials (ERPs). Here, we analyze event-related broadband changes both before and after removing ERPs to demonstrate their confounding effect. Using data from a passive (n=46) and an active (n=23) auditory task, we found that the shape of the pre- and post-event spectra differed significantly after removing the frequency-content of ERPs, and that this difference reduced substantially after accounting for a shift in 1/f activity. This 1/f change manifests as an increase in low and a decrease in high frequencies. Importantly, the magnitude of this rotational shift was related to the attentional demands of the task. The 1/f change is consistent with increased inhibition following the onset of a stimulus, and likely reflects a disruption of ongoing excitatory activity proportional to processing demands. Finally, these findings contradict the central assumption of baseline normalization strategies in time-frequency analyses, that background EEG activity is stationary across time. As such, they have far-reaching consequences that cut across several subfields of neuroscience.

IT-69 Modelling individual variation in brain activity patterns

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In recent years, several studies have reported that it is possible to identify individuals based on functional neuroimaging data (e.g. Finn et al., 2015; da Silva Castanheira et al., 2021). For the most part, these studies have examined correlations between summary statistics (functional connectivity or power spectra) computed from different measurement sessions. However, there are currently no established models of the brain activity patterns that distinguish between individuals. Latent-noise Bayesian reduced rank regression (BRRR) provides a computational method that could advance the understanding of the individual differences in functional brain data (Gillberg et al., 2016). Previously, BRRR has been used to extract latent components from MEG power spectra based on individual and familial features, and the extracted components have been used to successfully identify individuals and siblings (Leppäaho et al., 2019). In the present work, BRRR is applied to Human Connectome Project MEG resting-state data, and latent components are extracted based on individual features using several different measures of functional connectivity. Components extracted from non-leakage-corrected connectivity methods produced higher identification accuracies than those of leakage-corrected methods, and phase-based methods produced higher accuracies than amplitude-based methods. Using 20 latent components and non-leakage-corrected phase methods, it was possible to achieve identification accuracies comparable to accuracies calculated by comparing correlations between connectivity matrices (>90%). BRRR provides a robust method for modelling individual variation of MEG features in resting-state data. It holds promise for examining individual differences in task-related brain activity and in the effects of neurological disorders.

IT-70 Novel Techniques for Noise Estimation in Electromagnetic Brain Source Imaging

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Brain source reconstruction from electro- or magnetoencephalographic (EEG/MEG) data relies on an accurate estimate of what in the data is signal and what is noise. However, in many settings such as resting-state analyses, no baseline data for estimating noise characteristics exists. In this work, we present novel principled techniques that can learn the noise covariance jointly with the distribution of the reconstructed sources within the framework of sparse Bayesian learning (SBL). First, we derive analytic rules to update diagonal noise covariance within SBL algorithms. Second, we propose spatial and temporal cross-validation (CV) schemes, where either subsets of EEG/MEG channels or recorded samples are left out of the source reconstruction, and where the noise variance is selected as the minimizer of the divergence between model and hold-out data. Specifically, we use the Euclidean distance between modeled and empirical time series for spatial data splits, and the log-det Bregman divergence between modeled and observed data covariances for temporal data splits. Finally, we extend our framework to a setting where the noise has full covariance structure.Using Riemannian geometry, we are able to derive an efficient algorithm for updating source variances and full-structure noise covariance along the manifold of positive definite matrices. Extensive simulation studies underline the usefulness and favorable performance of our proposed approaches.

IT-71 Assessing the validity of EEG-based network measures of brain connectivity

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Background: Network measures are increasingly applied to study brain functional connectivity (FC) networks. Electroencephalography (EEG), owing to its excellent temporal resolution, is widely used to estimate FC. However, EEG-based source FC estimation is confounded by 'source leakage' causing spurious connections when using 'non-robust' FC metrics. While this problem can be addressed by 'robust' connectivity metrics, the effect of source leakage on properties of EEG FC networks has not been studied. Methods: We assessed the validity of three commonly used network measures (global efficiency – GE, modularity, and clustering coefficient – CC) by testing against simulated ground-truth networks, generated to have prescribed values of each measure. Activation time courses were generated to reflect the FC pattern in the simulated networks. The resulting time courses were projected to the sensor-space, and projected back to the source-space using the weighted minimum-norm estimate. FC was then estimated using non-robust absolute (COH) as well as robust imaginary (iCOH) coherence. Network measures were calculated and compared to ground-truth networks. Results: Both COH and iCOH were accurately determined the presence of individual connections as well as network properties in simulated sources, but not in sources reconstructed with wMNE, where only GE could be reliably estimated. Reconstructions of modularity and CC showed strong biases. iCOH achieved good performance for noiseless data but underestimated modularity and CC in the presence of noise, whereas COH strongly overestimated modularity and CC regardless of the presence of noise. Conclusion: Robust and non-robust connectivity metrics strongly bias EEG-based reconstructions of network properties, in different ways.

IT-72 Novel techniques for noise estimation in electromagnetic brain source imaging

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Brain source reconstruction from electro- or magnetoencephalographic (EEG/MEG) data relies on an accurate estimate of the signal-to-noise ratio (SNR). However, in many settings such as resting-state analyses, no baseline data for estimating the SNR exists. In this work, we present novel principled techniques that can learn the noise variance _2 jointly with the distribution of the reconstructed sources in the context of sparse Bayesian learning (SBL). First, we derive analytic rules to update _2 within two SBL algorithms (Champagne, Wipf et al., 2010, and low-SNR BSI, Hashemi et al., 2019). Second, we propose spatial and temporal cross-validation (CV) schemes, where either subsets of EEG/MEG channels or recorded samples are left out of the source reconstruction, and where the noise variance is selected as the minimizer of the divergence between model and hold-out data. Specifically, we use the Euclidean distance between modeled and empirical time series for spatial data splits, and the log-det Bregman between modeled and observed data covariances for temporal data splits. Interestingly, all three proposed approaches led to better source reconstruction performance compared to fixing the noise variance to the simulated ground truth. Note that cross-validation approaches are more versatile as they are applicable to any distributed inverse solution, but their long computation times can be prohibitive. In contrast, adaptive noise learning can be evaluated within a single SBL model fit.

IT-73

Towards an Objective Evaluation of EEG/MEG Source Estimation Methods - The Linear Approach

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The spatial resolution of EEG/MEG source estimates poses constraints on the inferences that can be drawn from EEG/MEG source estimation results. Software packages for EEG/MEG data analysis offer a large choice of source estimation methods but few tools for methods evaluation and comparison. Here, we describe a framework and tools for objective and intuitive resolution analysis of EEG/MEG source estimation based on linear systems analysis, and apply those to L2-minimum-norm estimation (L2-MNE) and linearly constrained minimum variance (LCMV) beamformers. We use resolution metrics that define meaningful aspects of source estimation results such as peak localization error (PLE) and spatial deviation (SD). At the core of this framework is the resolution matrix, which describes the potential leakage from and into point sources (point-spread and cross-talk functions, or PSFs and CTFs, respectively). Within this framework we demonstrate how L2-MNE-type as well as LCMV beamforming methods can be evaluated in practice using software tools that have only recently become available for routine use. We performed novel methods comparisons by computing PLE and SD for a larger number of methods as in similar previous studies, including unweighted, depth-weighted and normalized L2-MNE methods (including dSPM, s/eLORETA) and two LCMV beamformers. While some methods can achieve zero PLE for PSFs, their SD as well as both PLE and SD for CTFs cannot be optimized beyond a certain limit. We discuss the significance of these results especially for the estimation of deep sources.

IT-74

Frequency-space reconstruction in MEG-MRI: towards a general implementation

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Our whole-head MEG-MRI scanner prototype uses the same array of sensors for both magnetoencephalography (MEG) and magnetic resonance imaging (MRI). As the signal is read out in an ultra-low, millitesla-range field, the bandwidth of the magnetic resonance is relatively large compared to the frequency of operation. While this removes image artefacts, it also means that Maxwell's equations require that any linear magnetic field gradient is associated with a concomitant magnetic field that affects reconstruction. Traditional Fourier reconstruction would result in severe blurring and distortion. We have implemented an improved image reconstruction framework based on our previously published method that uses a frequency–space formulation: In the first stage, the signal amplitude and phase are estimated on equidistant frequency isocontours by applying the Fourier transform in the frequency-encoding direction. In the second stage, the phase-encoding weightings along these isocontours are combined into a matrix. The three-dimensional image is then reconstructed by solving a matrix equation and interpolating the voxel values in a uniform grid. For each MRI coil, the reconstruction framework can use either an ideal or a measured magnetic field profile or compute the field profile based on the coil geometry. We present the new image reconstruction framework that can be applied in various imaging settings more generally than our initial implementation, along with performance figures related to both image quality and computational efficiency. We further investigate and discuss the best ways to combine the new implementation with our calibration methodology.

IT-75

The MNE-BIDS-Pipeline – Reproducible Large-Scale M/EEG Data Processing

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The Brain Imaging Data Structure (BIDS) is an emerging standard for the organization of neuroimaging data. Its aim is to increase the availability of neuroimaging data resources to simplify replication of research findings, but also to aggregate large datasets in order to harness a new range of scientific questions by augmenting statistical power. MNE-BIDS (Appelhoff et al. 2019) is a Python package that acts as a glue between BIDS datasets and MNE-Python. However, a remaining challenge users have been facing is the construction of reproducible, shareable but also reusable data processing pipelines. To address this problem, we have developed the MNE-BIDS-Pipeline. Inspired by Jas et al.'s (2018) pipeline and building upon MNE-BIDS, it automates data import, preprocessing (e.g., Maxwell and frequency filtering, SSP, ICA, epoching), ERF/ERP construction, time-frequency analysis, and statistical inference via MVPA, both on per-participant and group levels, and for evoked, induced, and resting-state signals. Configuration is done via a simple text file. It has been optimized to efficiently process multiple participants in parallel, allowing it to process the 647 subjects from Cam-CAN in less than 5 hours on one large machine. The pipeline produces quality-control reports. We have processed a number of datasets with the pipeline, including the Cam-CAN, OMEGA, ERP-CORE, a face-processing, and an hMT+ localizer dataset (https://mne.tools/mne-bids-pipeline/examples/examples.html). For all datasets, we could reproduce the original findings reported by the authors, indicating that this tool is relevant for a broad range of M/EEG data.

IT-76

Multi-dynamic network mode modelling in MEG

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Hidden Markov Models (HMMs) have been used successfully in studies of M/EEG and fMRI neuroimaging data, and can predict task conditions, and neurological conditions [Sitnikova et al 2018]. DyNeMo (Dynamic Network Modes) was recently developed to challenge two key assumptions in the HMM by: 1) replacing the short-term, Markovian assumption with a model of long-range dependencies using recurrent neural networks (RNNs), and 2) replacing the assumption of mutually exclusive states with a mixture of dynamic, co-existing modes. However, both HMM and DyNeMo assume that spatio-spectral power and function connectivity (FC) switch with the same dynamics which was shown to bias the estimation of time-varying FC, making it appear more stable over time than it actually is [Pervaiz et al 2022]. Here we propose M-DyNeMo (Multi-Dynamic Network Modes). This separately models the dynamics of power and FC, which are then combined to give a timepoint-by-timepoint description of the data. Inference is the same as in standard DyNeMo, using a Bayesian amortised inference-based approach inspired by Variational Autoencoders. Simulated data shows that M-DyNeMo performs more accurate inference than standard DyNeMo when the ground truth has multiple dynamics. Using amplitude envelope real, resting-state MEG data (6 mins, eyes open) from 55 subjects, M-DyNeMo reveals greater temporal fluctuations in FC than DyNeMo, with larger between-mode variability in the mode-specific FC. In future work, we will investigate if this richer dynamic description provides improved prediction of cognition and behavioural variability.

IT-77

Computational models reveal the distinct neural processes underlying movement preparation, execution and inhibition in MI

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Movement evoked fields (MEFs) within the primary motor cortex (MI) are associated with movement parameters such as force (Slobounov et al. 2004) and complexity (Benecke et al. 1985). MEFs have a protracted development in children (Johnson et al. 2020) and are associated with symptom severity in Parkinson's (Simpson, Khuraibet 1987). During a bimanual response selection/inhibition task in 16 healthy adults (Isabella et al., 2021, unpublished data) we observed consistent polarity reversals of MEFs 0.15s preceding inhibited responses, suggesting they contain information on the coordination of response execution and inhibition within MI. Here we test biophysically principled computational models of these MEFs using Human Neocortical Neurosolver (hnn.brown.edu) to simulate the biophysical generators of MEFs in MI. For executed responses, the Motor Field, MEFI and MEFII were modeled with distal, proximal and distal evoked input, respectively (RMS error=2.26). Furthermore, the readiness field (RF) was modeled by gamma (50-Hz) rhythmic distal bursts from stimulus onset. Similar parameters modeled low-amplitude activity ipsilateral to executed movements, reversing at similar latencies without an RF (RMSE=0.70). Most interestingly, inhibited responses demonstrated an RF modeled by similar rhythmic gamma activity, while inputs reversing the evoked fields had latencies 100-150ms earlier than all other conditions (RMSE=0.82). Our modeling results suggest that response preparation may be characterized by gamma bursting creating the RF, and response inhibition by a preemptive reversal of evoked inputs favouring lemniscal thalamocortical (distal) drive over non-lemniscal or cortico-cortical feedback (proximal) activity. These findings provide important insights into cortical control of motor execution and inhibition.

IT-78

Pseudo-MRIs in pediatric MEG source imaging

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Realistically-shaped head models applied in electromagnetic source imaging are typically constructed from individual MRIs. However, such MRIs are not always available, or they may be of poor quality, hampering the segmentation of tissue types. These problems are particularly prominent in pediatric subjects. If sub-millimeter precision is not crucial, a precisely-warped age-matched MRI template, a pseudo-MRI, can be a viable alternative for the real individual MRI. We utilized MEG and MRI data from three subjects (3–12 years). An easy-to-use Python tool, pseudo-MRI Generator, employing the thin-plate-spline method, was used to warp age-matched pediatric MRI templates. It warps the FreeSurfer-reconstructed template's scalp with digitization points defining subjects' scalp. The warping transform is then applied to all surface, anatomy, and fiducial files of the template MRI. We simulated 148 dipole-patch sources in the original MRI to synthesize 306-channel MEG data for each subject. We then localized the sources using dipole fitting and LCMV beamforming with conductor models derived from the real and pseudo-MRIs By visual inspection, pseudo-MRI head models were properly aligned and appeared comparable to those derived from individual MRIs. For real vs. pseudo-MRI, we computed the mean geometric differences: i) BEM surfaces = < 5 mm, ii) cortical surfaces = < 8 mm, and iii) source space < 7 mm. Similarly, for dipole localization, the mean error was = < 6 mm, and for LCMV = < 8 mm. The simulation results show that the pseudo-MRI could be an alternative to the individual pediatric MRI when the sub-centimeter spatial accuracy is not mandatory.

IT-79 Noninvasive neuromagnetic single trial detection of human spiking activity with ultralow-noise MEG

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Evolution has shaped the human brain as a "single-trial" processor reacting fast and reliably to environmental threats. The noninvasive analysis of its electrical activity commonly draws on electroencephalography/magnetoencephalography (EEG/MEG) with a millisecond time resolution suitable even for short-lived neuronal output spikes associated with synchronized neuronal action potentials. However, due to the instrumental noise of about 2 fT/√Hz in standard MEG, the very small evoked population spikes could so far only be detected after averaging over hundreds of trials. In this work, we investigate neuronal activation following peripheral electro-stimulation of the median nerve. This paradigm is known to elicit a low-frequency response, the N20, superposed with a high-frequency wavelet, the so-called _-burst, which represents a noninvasive signature of synchronized human cortical spiking activity. Using this well-characterized somatosensory response, MEG based on an ultralow-noise superconducting quantum interference device (SQUID), with an order of magnitude improved sensitivity of 0.18 fT/√Hz, is shown to enable the first noninvasive single-trial characterization of human cortical population spikes, revealing amplitudes highly variable between trials and intertrial correlated response latencies.

IT-80 EEGNet: a new platform to share EEG data and advanced analysis pipeline.

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Introduction:
In research, results need to be robust and generalizable to further have an impact on society. However, only a few tools have been created to help reproduce results from research studies. This problematic is at the heart of the open science movement, which promotes collaborative work and data sharing. The idea driving open science initiatives is to make research studies easily reproduceable, notably by facilitating the reusability of existing datasets.

Method:
The EEGNet project aims to provide a platform for sharing and analyzing standardized electroencephalogram (EEG) data. As part of this project, we developed an EEG data analysis tool, based on the Brainstorm software. This user-friendly tool can be used to preprocess, process and perform statistical analysis of EEG data.

Results:
This new tool enables to easily perform complex analyses. More importantly, it allows to created shareable analysis pipeline and standardize EEG data in a shareable format, thereby facilitating the reproducibility of neuroscientific studies. This innovative method will be implemented on the EEGNet platform as an online analysis tool.

Discussion:
Altogether, the analytical tools of the EEGNet platform will facilitate, among other things, the study of states of consciousness (e.g., sleep, waking, coma), and will have the potential to contribute to the early detection of EEG abnormalities in children and adults suffering from psychiatric or neurological disorders.

IT-81 Uncertainty quantification for dipole localization using high-resolution lead fields and Sequential Semi-Analytic Monte Carlo Estimation (SESAME)

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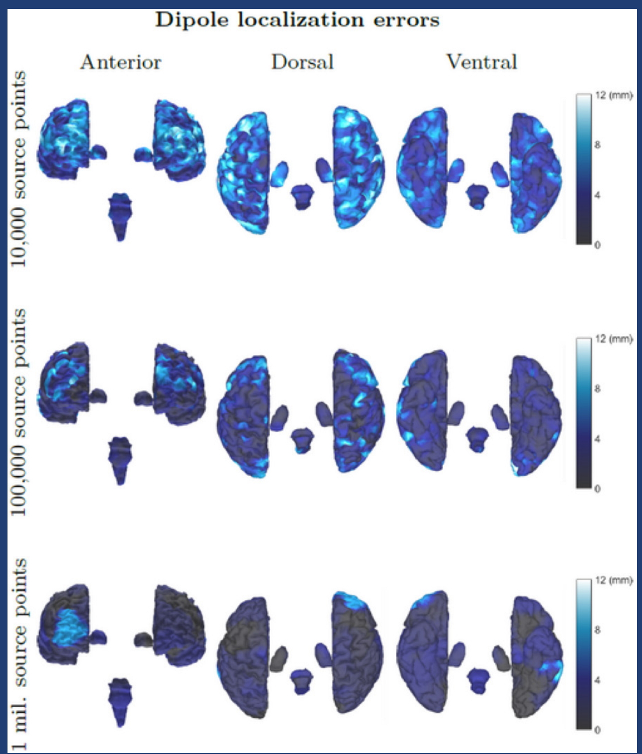
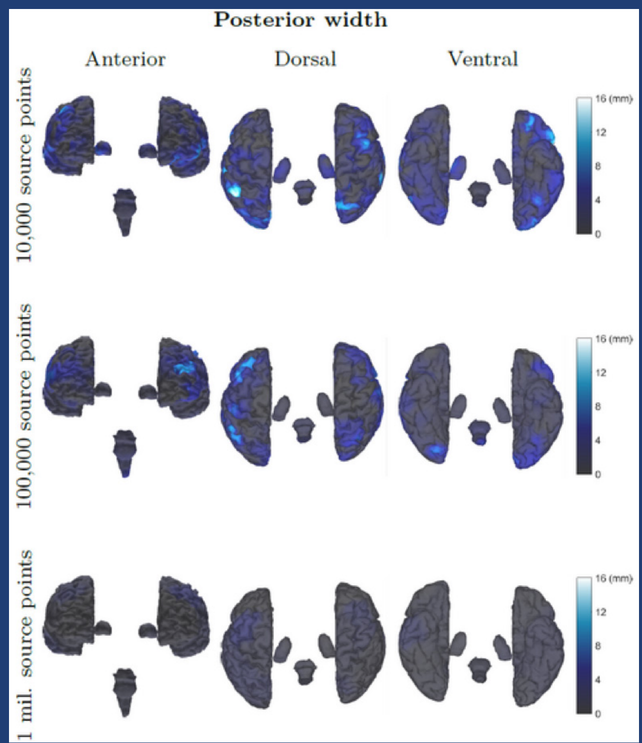
In this study, our goal is to quantify the uncertainty of dipole localization when approached via the recent Sequential Semi-Analytic Monte Carlo Estimation (SESAME) technique using high-density EEG lead field matrices obtained by discretizing a realistic multi-compartment head model by the finite element method (FEM). The SESAME technique has been recently shown to be capable of localizing multiple dipoles in different depths with errors that approach the theoretically and experimentally shown bounds for single dipole localization. Here we first couple SESAME with a FEM-based EEG lead field generator that can discretize a realistic domain and place a dense distribution of dipolar sources in a complex-structured grey matter compartment. This experiment is motivated by the sequential Monte Carlo procedure, which is effective for analyzing a narrow posterior distribution and, thereby, it can potentially benefit from a denser grid size than what is normally seen in EEG source localization. We analyze the dipole localization error distribution spatially for different lead field resolutions extending the number of dipoles in a single lead field up to 1 Million sources. These lead field matrices were obtained using the mesh and lead field generator routine of the Zeffiro Interface toolbox. Our numerical results suggest that uncertainty, measured via the posterior width, and the source localization accuracy can be improved by adding more sources in the lead field model, while the computing times can be maintained appropriately short due to SESAME's approximately linear time dependence on the lead field size.





IT-82 Magnetic fields from a current dipole in a cylinder: testing an analytic calculation against finite element simulations for simple and realistic limb geometries

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Background
Biological currents flowing in the body give rise to electric and magnetic fields which can be detected outside the body. Measurements of these fields allow the originating currents to be inferred using a suitable forward model. The approximately spherical symmetry of the head is advantageous for simplifying the forward models used in magnetoencephalography (MEG). However, when measuring fields from nerve tissue in muscles within limbs, cylindrical symmetry is more relevant.

Method
A suitable mathematical framework has been developed to calculate the magnetic field from an elemental current dipole embedded in a long conducting cylinder. The calculated fields are compared with finite element models run in ANSYS. The finite element simulations can consider more realistic geometries, such as a tapered cylinder, and the effect of including different tissue types in the modelling region. Simulations were therefore run to investigate the error introduced by assuming the dipole-containing limb to be an infinite, homogenous cylinder.

Results
Good agreement was found between the infinite cylinder mathematical model and a long, finite cylinder simulation. Comparing the mathematical model to more realistic geometries and multiple tissues still yielded a maximum error of only around 10 %.

Discussion
The results indicate that the novel analytic expressions exactly predict the magnetic field produced by a dipole embedded in a long conducting cylinder and give reasonable predictions in the case of more realistic geometries. Their integration into inverse modelling will allow application to real data obtained from optical pumped magnetometers (OPMs) arranged around the muscles in a leg.

IT-83

Biobank information management system for M/EEG and MRI data

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Discovering biomarkers from brain imaging data is critically dependent on access to large amounts of curated data. For managing and sharing such data between multiple research sites and for linking imaging data to existing biobanks, we need secure and efficient solutions that fulfill both national and EU-level legal requirements as outlined by the General Data Protection Regulation (GDPR). To this end, we developed a biobank information management system tailored for functional brain imaging data (https://braindata.fi). Following the F.A.I.R. (Findable Accessible Interoperable Reusable) principles for scientific data archiving and discovering, our proposed solution features a searchable metadata database and a separate secure storage system for the actual imaging data. Through the metadata web portal, authenticated users can search through existing datasets, or upload information about their own MEG and EEG datasets through an automated web application implemented in JavaScript and MySQL. For interoperability with existing biobanks, the proposed metadata model extends the Minimum Information About Blobank data Sharing (MIABIS) model, the biobank standard for data sharing. By requiring the uploaded datasets to be compliant with the brain imaging data structure (BIDS) the metadata database can also flexibly store multimodal brain imaging datasets such as functional, structural, and diffusion MRI. To promote discoverability of task data, tasks are mapped to the Cognitive Atlas ontology during the upload procedure. The proposed framework provides an easy-to-use web application for searching, managing and exploiting large collections of brain imaging data to promote research into brain health and disease.

IT-84

Assessing the ability of whole-brain dynamical models to elicit functional connectivity signatures of real M/EEG data

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Introduction: Simulation of electroencephalography (EEG) signals has broad applications in the evaluation of new methods when ground-truth data are required. However, simulating data that closely mimic real EEG signals remains a challenge. The Virtual Brain (TVB, Ritter et al., Brain Connectivity, 2013) is a toolbox that aims to realistically simulate brain activity using neural mass models underlying the EEG signals. In this work, we evaluated whether the EEG-based functional connectivity (FC) among brain sources can be simulated within the TVB framework.

Methods: We performed whole-brain simulations of the scalp-level EEG that mimics real EEG data using the Jansen-Rit model (Jansen and Rit, Biological Cybernetics, 1995) with neural populations modeled in various brain locations defined by the Desikan-Killiany atlas. We then compared various cost functions to fit TVB's model parameters. Furthermore, we investigated whether time-delayed inter-regional interactions leading to nonzero imaginary coherency (Nolte et al., Clinical Neurophysiology, 2004) and time-reversed Granger causality (Haufe et al., Neuroimage, 2013), similar to what is observed in real EEG data, could also be generated within this framework through appropriate choices of the local parameters of regional neural populations and the global parameters driving the interaction among brain regions.

Results and Discussion: We show that spectral FC hallmarks of real EEG can be simulated within the framework of TVB. This provides a basis to simulate neurophysiologically realistic ground-truth data for the verification of EEG-based FC measures. It remains to be demonstrated that the simulated data matches the spatio-spectral properties of real EEG data.

IT-85

An inversion algorithm to distinguish `figure and ground' : parametric identification of a patch source under the background neural currents

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Background: In magnetoencephalography (MEG) applications, distinguishing `figure and ground' of neural currents is often necessary, where `figure' means a focal, connected source on the cortex which is a main target of interest, and `ground' means other neural activities spread over the brain. Examples include identification of an epileptic focus under background neural activities. This paper presents an inversion algorithm to separate them.

Methods: Using a mapping from a cortex to a sphere [1], we represent a focal source by a patch mapped from a circle on the sphere and the background activities by the linear combination of spherical harmonics. Since these representations are determined by parameters with bounded ranges (the center and radius of the circle and the spherical harmonics coefficients), the global optimum that minimizes the misfit of data and the MEG forward solution can be obtained efficiently [2].

Results: Our algorithm was applied to the MEG data of an epileptic patient. Using our method, the shape of an epileptic focus was identified in addition to its center position as obtained by the conventional equivalent current dipole method. Moreover, the focus was stably identified, while the background activities changed temporally.

Discussion: The inversion algorithm to explicitly separate `figure and ground' has been developed based on a combination of heterogeneous source models. As an alternative to using spherical harmonics, employing an imaging approach may also be possible. References: [1] C-H.Im et al., IEEE Trans. Mag., 41, 1984, 2005. [2] Y.D.Sergeyev and D.E.Kvasov, SIAM J. Optimization, 16, 910, 2006.

IT-86

Heterogeneous source model for magnetoencephalography: combination of a parametric and an imaging approach for separation of a focal source and background activities

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Background: The two conventional approaches for the magnetoencephalography inverse problem, the parametric and imaging approaches, have their merits and faults. The former using an equivalent current dipole model identifies the center of a focal source, but it cannot estimate its spatial extent and is affected by the background activities. The latter obtains the spatial distribution of currents but the result for a focal source is blurred or scattered even when using sparse regularization. This paper presents a heterogeneous source model that combines the parametric and imaging approaches to separately obtain a focal source and the background activities.

Methods: For the parametric approach aspect, using a mapping from a cortex to a sphere [1], we introduce a patch source model that represents a focal region in terms of four parameters. The background activities are expressed by the elemental dipoles spread over the cortical surface. Both the optimal patch parameters and the distributed dipole moments are obtained using the maximum likelihood method.

Results: Our algorithm was applied to the magnetoencephalography data of an epileptic patient. The region of an epileptic focus was identified at the front of the left temporal lobe, which coincided with the result using electrocorticography, while the background activities spread over the left occipital lobe were separately obtained.

Discussion: We assumed a single focal source plus distributed background activities. A case of the background activities including another focal patch with a smaller current moment is shown in the paper. [1] C-H.Im et al., IEEE Trans. Mag., 41, 1984, 2005.

IT-87

Comparing equivalent current dipole localization and electric current dipole positions in a three-layer head phantom

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Source localization in magnetoencephalography (MEG) relies on complex data processing chains which desire verification. Physical head phantoms can be used for such verification as they provide ground truth for sources to be localized. Here we introduce a novel realistically shaped physical head phantom with embedded electric current dipoles. The head phantom is based on the geometry of a volunteer and consists of three layers comprising an intracranial volume (sodium chloride solution), skull (gypsum), and scalp (agar hydrogel). The conductivity values of these layers are similar to the standard values used in human head models for electroencephalography (EEG) and MEG. Four electric current dipoles are positioned inside the intracranial volume and are separately activated with sinusoidal waveforms from constant current sources. MEG data were recorded with a 306-channel system and analyzed in the MNE-python toolbox applying an equivalent current dipole (ECD) fit for source localization. The reconstructed ECDs were compared to the digitized dipoles in the head phantom. We found our ECDs within a millimeter vicinity around the physical dipole position with a 98% goodness of fit. These results show both the functionality of our head phantom setup and the source localization pipeline. Influences of conductivity configurations and source interactions can be assessed in this framework. We conclude that our physical head phantom is suitable for metrological verification of models and algorithms used in MEG source localization.

IT-88

Where is the other hippocampus? An investigation into correlated sources.

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Beamformers are a popular approach to the M/EEG inverse problem given their adaptive, data driven nature. Consequently, they are adept at accurate source localisation and interference reduction. However, their mathematical formulation means that sources in the brain which show a high degree of correlation often are incorrectly rejected by the beamformer. Many solutions to mitigate this problem already exist, but in the absence of other information, it is difficult to judge whether enforcing correlated source assumptions is the correct approach. We propose a solution based on the previously-established Empirical Bayesian Beamformer (EBB). The EBB is a Bayesian inversion based on a beamformer-estimated source covariance matrix. Importantly, it returns a model evidence value which can be compared directly against other possible covariance priors (such as minimum norm, for example). By modifying the covariance prior to accommodate correlated sources, we were able to infer whether a correlated or independent source model is appropriate for a given source reconstruction. We show in simulation that comparing the original EBB to the modified, correlated EBB, the latter gives improved model evidence in the presence of distal correlated sources. Conversely, the original performs better when sources are uncorrelated. We then applied candidate correlated and uncorrelated source models of the hippocampus to experimental MEG data (n=22 subjects). Not only does model evidence results suggest that hippocampal activity may be correlated and homologous across hippocampi, but also source-reconstructed theta-band power is significantly increased by incorporating correlated source into the model.

IT-89

A novel method for MEG brain source localization using alternating projection

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We present a novel solution to the MEG source localization problem, which is sequential and iterative, and is based on minimizing the least-squares criterion by the alternating projection (AP) algorithm. This algorithm transforms the multidimensional problem of dipole fitting to an iterative process involving only one-dimensional maximization problems, which are computationally much simpler. Our method has conceptual similarities to the recursive scanning methods (e.g. (T)RAP MUSIC, RAP beamformer), in that they all estimate the source locations iteratively, projecting out at each step the topographies of the previously found dipoles. However, our iterative process is a direct result of the LS optimization, and not an ad-hoc modification to a non-recurrent method. More importantly, the fundamental difference is that our AP method iterates through all sources multiple times until convergence, while the recursive methods stop when the last source is found. Results from simulated and experimental MEG data from a human subject demonstrated robust performance, with consistently superior localization accuracy than popular scanning methods belonging to the beamformer and MUSIC families. Importantly, the proposed solution is more robust to forward model errors resulting from head rotations and translations, with a significant advantage in highly correlated sources. Taken together, our results demonstrated the high performance of the AP method in localization MEG dipole sources. It also revealed the importance of iterating through all sources multiple times until convergence instead of recursively scanning for sources only once in a single sweep.

IT-90

A comparison and validation of ESI methods in vivo

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Background. Electrical source imaging (ESI) is a critical element for EEG data analysis in research and clinical applications. Different ESI methods mainly differ by the quality and quantity of a priori information used in the solution of the inverse problem. Even if pros and cons of each method are relatively well known, there are very few comprehensive comparisons and validations.

Methods. In this study, we compare "in vivo" ten different ESI methods from the MNE-Python package: wMNE, dSPM, sLORETA, eLORETA, LCMV-beamformer, dipole fitting, RAP-MUSIC, irMxNE, gamma map, and Sesame. We use a recently published HD scalp EEG dataset (Mikulan et al., 2020) recorded at Niguarda Hospital (Milan, Italy) from Stereo-EEG implanted patients during Single Pulse Electrical Stimulation. We compare the different ESI methods under multiple choices of input parameters (e.g., regularization, depth) to assess the accuracy of the best reconstruction, as well as the impact of the parameters on the localization performance.

Results. Localization accuracy of focal sources varies considerably among methods: MNE is the least accurate; dipole fitting, Sesame, and irMxNe the most accurate. For some methods(MNE, LCMV), localization accuracy varies considerably with the value of the input parameters whereas for others, the observed variance is small. Overall, we observe a minor impact of the depth weighting parameter.

Discussion. Our findings confirm that EEG is a reliable technique for localization of point sources and suggest that more recent ESI methods could be a valid alternative to traditional dipole fitting in clinical applications

IT-91

NeuroPycon: A python package for efficient multi-processing brain network analysis

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Background. To date, performing all the data processing steps for a complete M/EEG analysis pipeline relies on the use of a multitude of software packages, custom code and specific setting of input parameters. This is not only cumbersome, but may also increase sources of errors and hinders replication of results. Here we describe NeuroPycon (Meunier et al., 2020), an open-source brain data analysis toolkit which provides Python-based template pipelines for advanced multi-processing of M/EEG, fMRI data, with a focus on connectivity and graph theoretical analyses.

Methods. NeuroPycon is based on NiPype framework (Gorgolewski et al., 2011) which facilitates data analyses by wrapping numerous commonly-used neuroimaging softwares into a common python framework. The current implementation contains two complementary packages: * ephypype is mainly based on MNE-python package (https://mne.tools/) and includes pipelines for electrophysiology analysis and a command-line interface for on the fly pipeline creation. * graphpype is based on radatool (https://deim.urv.cat/~sergio.gomez/radatools.php) and is designed to investigate functional connectivity via a wide range of graph-theoretical metrics, including modular partitions.

Results and Discussion. NeuroPycon provides a framework to develop workflows for advanced neuroimaging data analyses. Results visualization is provided through visbrain (http://visbrain.org/), an open-source python software devoted to graphical representation of neuroscientific data. NeuroPycon is available for download via github (https://github.com/neuropycon) and is currently being documented (https://neuropycon.github.io/ephypype/ and https://neuropycon.github.io/graphpype/). Future developments will include fusion of multi-modal data (ex. MEG and fMRI) and an increased compatibility with existing packages of interest such as machine learning tools.

IT-92

Finding the best pipeline to analyse inter-regional functional connectivity

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BACKGROUND: Aggregating statistical dependencies between multivariate time series is important to characterise functional connectivity (FC) between brain regions from source-reconstructed M/EEG data. This study compares the performances of various pipelines that estimate undirected linear FC between regions.
METHODS: To simulate M/EEG-like sensor signals, we proceeded as follows: 1. Ground truth source activity was based on white noise time series filtered in the alpha band. Between one and five pairs of sources interacted with certain time delays. 2. After adding individual 1/f noise, source signals were projected to sensor space. 3. White sensor noise was added. All tested connectivity analysis pipelines calculate one connectivity score for every region combination. To assess the pipelines' ability to detect the true interactions, we calculated the mean reciprocal rank and the area under the precision-recall curve.
RESULTS: The best-performing FC pipeline consists of the following steps: 1. Linearly Constrained Minimum Variance source projection (van Veen, 1997). 2. Principal component analysis within every region. 3. Selection of a fixed number of strongest principal components as basis for further analysis. 4. Calculation of the multivariate interaction coefficient (Ewald 2012) for every region pair. Worst performance was obtained with pipelines estimating FC with the absolute value of coherency.
DISCUSSION: In this study, we tested several connectivity analysis pipelines that are used in the literature. Our simulation clearly shows that many of them do not detect true interactions reliably. To use the winning pipeline of this study could greatly increase the validity of future experimental connectivity studies.

IT-93

Pulse-waveform coupling in a computational brain model

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Over the last decade, pulse-waveform coupling, a.k.a. Dynamical Coupling for Additional dimeNsions (DynaCAN), has proven powerful in solving problems in hybrid MEG-MRI technology. Here, pulse waveforms are carefully designed with temporal features that couple to dynamical aspects of a system. Examples include complicated eddy-current patterns in shielded-room walls and the dynamics of trapped magnetic flux in superconducting components. To study the prospects of the DynaCAN approach in modulating/stimulating neuronal networks in the brain, we apply a computational model.
We train an artificial recurrent neural network (RNN) to perform an audio classification task of word recognition. The model can form synapses in both feedforward and feedback manner between any two neural units. The neural computation converges within hundreds of milliseconds after the audio sample has ended. For modulation, we apply a pulse waveform identically to each unit, so that only the temporal dimension can be used for targeting. This can be seen as representing, e.g., an electromagnetically applied pulse. We apply a computational procedure to find a pulse waveform that helps the network find the right answer in difficult cases. In preliminary findings, a 100-ms pulse waveform applied after the end of an audio input was highly effective: for a set of six audio samples that were wrongly classified in the absence of modulation, a suitable modulating pulse waveform reduced the mean-squared error of classification by 94%. With further findings, we expect the modeling approach to shed light on how MEG can help implement pulse waveforms for the real brain.

IT-94

A pipeline for analysing bursts and non-sinusoidal waveform shapes using Empirical Mode Decomposition.

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Background: Neuronal oscillations contain rich dynamic and non-sinusoidal patterns that represent the signatures of neuronal processes. Yet, these same features can be highly challenging to isolate and analyse using conventional methods. The Empirical Mode Decomposition (Huang et al 1999; EMD) is a time-domain method which separates a signal into oscillatory modes, whilst ensuring physically interpretable phase estimates. We propose an analysis framework built on EMD that allows for of both burst properties and waveform shape.

Methods: Masked EMD is applied to sensor-space Magnetoencephalography (MEG) data to separate it into distinct oscillatory components. Each component is split into individual cycles by detecting jumps in the instantaneous phase. 'Good' cycles have smoothly increasing phase and high amplitude. Oscillatory bursts are continuous 'chains' of good cycles and waveform shape is defined as within-cycle variations in instantaneous frequency. The analysis is implemented with the python EMD toolbox (Quinn et al 2021; http://emd.rtfd.io).

Results: We analyse resting state alpha oscillations and task-evoked beta rebound. In both cases, EMD separates the oscillations into distinct components. The distribution of power across instantaneous frequency and time provides a high-resolution alternative to conventional time-frequency analyses. The burst properties reveal that task-evoked beta occurs in relatively short sequences whilst alpha tends to be more sustained. A wide variability in waveform shape across individual cycles is observed.

Discussion: This approach avoids issues such as band-pass filtering, harmonic interference and long time-windows. It provides a principled framework in which a rich variety of neuronal oscillations can be described.

IT-95

Inter-individual alignment and single-trial classification of MEG data using M-CCA

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Neuroscientific studies often involve some form of group analysis which requires the alignment of recordings across participants. Naive solutions assume that participants' recordings can be aligned anatomically in sensor space. However, this assumption is likely violated due to inter-individual differences in the functional-anatomical organization of human brains. In magnetoencephalography recordings this problem is exacerbated by the susceptibility of MEG to individual cortical folding patterns as well as inter-individual variations of sensor locations over the brain. Multiset canonical correlation analysis (M-CCA) relaxes the assumption of comparable functional-anatomical organization by focusing on function to find a common representation. Here we use M-CCA to find a common representation of MEG activations recorded from different participants (n=15) performing a similar task. Importantly, we derive a method to transform data from a new, previously unseen participant into this common representation. We use a rigorous leave-one-participant-out single trial classification framework to test the information transfer of classifiers across individuals. We compare information transfer between commonly used data combination in sensor space with and without SSS sensor realignment to the M-CCA approach developed here. M-CCA reached nearly 89% of the empirically estimated maximal classification performance compared to only 26.2% for the other two approaches, demonstrating the superiority of M-CCA. Finally, we show that our approach requires only a small number of labeled data from the new participant. We suggest that inter-individual alignment via M-CCA of brain imaging data can become helpful in future endeavors on large open datasets and has potential applications for "warm starting" brain-computer interfaces.

IT-96

Two approaches to tackle the sign ambiguity of beamformed MEG source-reconstructed data

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Background
The beamformer is a well-known technique to reconstruct the magnetoencephalographic signal. This method models the sources as dipoles and applies a spatial filter to extract the contribution of each sensor to the source signal. Because the detected magnetic field does not carry information on the sign of the source dipole, the sign of the reconstructed signal could differ between MEG sessions. This sign ambiguity issue hinders the analysis across sessions (or subjects), and this work compares two approaches to tackle this sign ambiguity.

Methods
We analyse MEG data from 38 healthy subjects, acquired during an n-Back visual task. After standard preprocessing, the data were source reconstructed with a beamformer and parceled in 42 regions. To overcome the sign ambiguity, we first applied a traditional approach that consists in taking the absolute value of all time series. The second method we used is the sign-flipping algorithm; this aims at maximizing the correspondence of the static functional connectivity across subjects. Next, we epoched the data [-0.2, 1.2] s, and each trial was baseline corrected. We extracted the event-related fields (ERFs) for each approach separately, as the mean signal with 95% confidence interval.

Results
Figure 1 reports the ERFs from the two described pipelines in the right visual and left temporal regions.

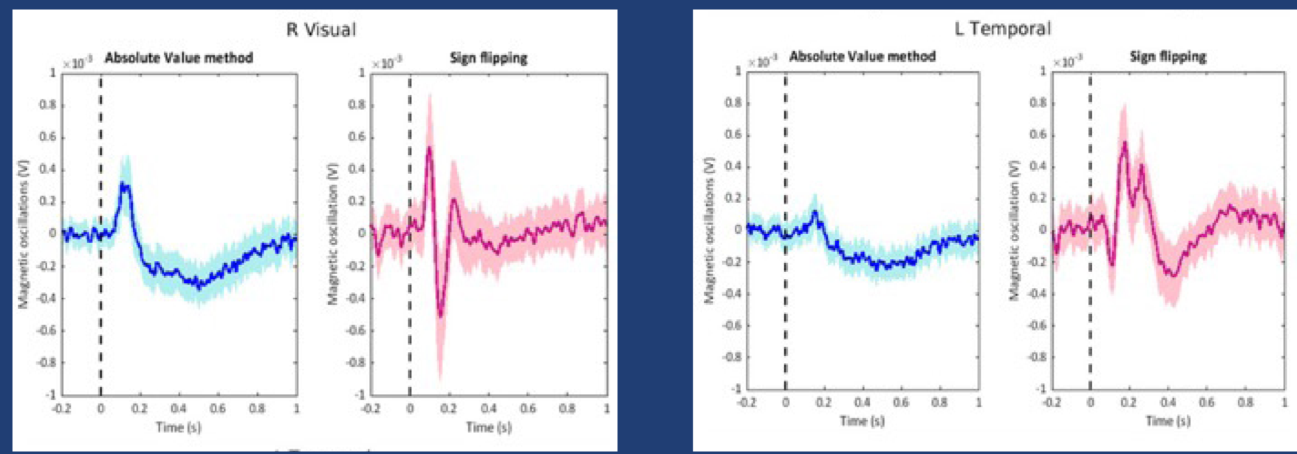

Figure 1 We plot the ERFs of two regions and the related confidence interval (95% CI); the right visual cortex (top) and the left temporal region (bottom). The columns of each region represent the ERFs extracted via absolute value (on the left) and the ERFs extracted via sign flipping (on the right).

Discussion
The sign flipping method reveals the brain's rich temporal dynamics that, instead, seems to be neglected by the traditional absolute value approach. This could explain why traditional MEG analyses have not yet reported ERF waves, like the M300.

IT-97 Towards more robust non-invasive assessment of functional connectivity

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Non-invasive evaluation of functional connectivity, based on source-reconstructed estimates of phase difference based metrics, is notoriously non-robust. This is due to a combination of factors, ranging from a misspecification of seed regions to suboptimal baseline assumptions, and residual signal leakage. In this work, we propose a new analysis scheme of source level phase difference based connectivity, which is aimed at optimising the detection of interacting brain regions. Our approach is based on a beamformer estimation of all-to-all connectivity on a prespecified dipolar grid. A pairwise two-dipole model, to account for reciprocal leakage in the estimation of the localized signals, allows for a usable approximation of the pairwise bias in connectivity due to residual leakage of 'third party' noise. Using sensor-array subsampling, the recreation of multiple connectivity maps using different subsets of sensors allows for the identification of consistent spatially localized peaks in the 6-dimensional connectivity maps, indicative of true brain region interactions. With extensive simulations, we compared different analysis schemes for their detection rate of connected dipoles, as a function of signal-to-noise ratio, phase difference and connection strength. We demonstrate superiority of the proposed analysis scheme, which overall was most sensitive, in comparison single-dipole models, or an approach that discards the zero phase difference component of the connectivity. We conclude that the proposed pipeline might allow for a more robust identification of functional connectivity in experimental data, opening up new possibilities to study brain networks with mechanistically inspired connectivity measures in cognition and in the clinic.

IT-98 Mapping MEG Interictal Activity in Epilepsy Using a Hidden Markov Model

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Background
Epilepsy is a heterogeneous neurological disorder with variable etiology, manifestation, and response to treatment. It is imperative that new models of epileptiform brain activity account for this variability, to identify individual needs and allow clinicians to curate personalized care. Here, we develop such a technique, to detect epileptogenic activity, based upon a hidden Markov model (HMM).

Methods
The HMM was used to create a statistical model of interictal brain activity for 10 paediatric patients. MEG was acquired as part of standard clinical care for patients at the Children's Hospital of Philadelphia. These data are routinely analysed using excess-kurtosis mapping (EKM), however as cases become more complex (multifocal and/or polymorphic), they become harder to interpret with EKM. We assessed the performance of the HMM against EKM for three patient groups, with increasingly complicated presentation.

Results
The difference in localization of epileptogenic foci for the two methods was 7 ± 2mm (mean ± SD over all patients); and 94 ± 13% of EKM temporal markers were matched by the HMM. The HMM localizes epileptogenic areas (in agreement with EKM) and provides significant additional information about the relationship between regions showing abnormal function.

Discussion
A key advantage of the HMM is that model inference is data-driven, meaning states are tuned to the spectral content of each patient's unique brain activity. Model output is also intuitive; users can review results and manually select the HMM epileptiform state, offering advantages over previous methods and allowing broader implementation of MEG epileptiform analysis in surgical planning.

IT-99

Robust Estimation of 1/f Activity Improves Oscillatory Burst Detection

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Neural oscillations often occur as transient "bursts", with variable amplitude and frequency dynamics. Quantifying these effects is important for understanding brain-behaviour relationships, especially in continuous datasets. To robustly measure bursts, rhythmical periods of oscillatory activity must be separated from arrhythmical background 1/f activity, which is ubiquitous in electrophysiological recordings. The Better Oscillation (BOSC) framework achieves this by defining a power threshold above the estimated background 1/f activity, combined with a duration threshold. Here we introduce a modification to this approach, called fBOSC, which uses a spectral parametrisation tool to accurately model background 1/f activity in neural data. Crucially, our fBOSC tool (which is openly available) is robust to power spectra with oscillatory peaks and can also model non-linear spectra. Through a series of simulations, we show that fBOSC more accurately models the 1/f power spectrum compared with existing methods. fBOSC was especially beneficial where power spectra contained a knee below ~0.5-10 Hz, which is typical in neural data. We also found that, unlike other methods, fBOSC was unaffected by oscillatory peaks in the neural power spectrum. Moreover, by robustly modelling background 1/f activity, the sensitivity for detecting oscillatory bursts was standardised across frequencies (e.g. theta- and alpha-bands). Finally, using openly available resting state magnetoencephalography and intracranial electrophysiology datasets, we demonstrate the application of fBOSC for oscillatory burst detection in the theta-band. These simulations and empirical analyses highlight the value of fBOSC in detecting oscillatory bursts, including in datasets that are long and continuous with no distinct experimental trials.

VT-151

Cortical connectivity differences using Network Localized Granger Causality

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Estimating functional cortical connectivity, and how it changes by task or across groups, is critical to understanding how the brain accomplishes tasks, including speech comprehension under difficult listening conditions. Granger causality (GC), as a directional connectivity measure, is a powerful tool for identifying causal interactions underlying neural mechanisms behind successful task completion. While GC analysis is common for functional magnetic resonance imaging (fMRI) data, the low temporal resolution makes it impossible to capture the millisecond-scale interactions underlying dynamic tasks such as noisy speech processing. Magnetoencephalography (MEG) has millisecond resolution, but provides only low-dimensional sensor-level linear mixtures of neural sources, making GC inference challenging. Conventional MEG cortical connectivity methods proceed in two stages: source-localization followed by GC inference for the sources. However, the propagation of spatiotemporal biases in source estimation into the subsequent GC stage results in both false alarms and missing true connections. Instead, we use the network localized Granger causality (NLGC) framework, which requires no intermediate source localization: source dynamics are modeled as latent sparse multivariate autoregressive processes and GC links are extracted based on estimated model parameters. Here, NLGC is employed to identify directional interactions between neural sources in the frontal, temporal, and parietal lobes. Using MEG data from an auditory task with sustained listening to speech degraded by noise, we show that brain network activity changes by age and listening conditions. In particular, with increasing noise, theta band (4-8 Hz) frontal-temporal connectivity changes from bottom-up (temporal_frontal) to top-down (frontal_temporal) in younger participants but not older.

IT-101 GPU-accelerated solutions of bioelectromagnetic forward problems

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A forward model characterises the relationship between source and a measurement in computational form. In EEG and MEG, such models are used in source estimation problems, in TMS they are used for planning and targeting the stimulation. The contribution of the head volume conductor to the forward model is typically solved using BEM or FEM. Here we consider BEM models and the performance benefits of C++ and GPU (Cuda) code over MATLAB. MATLAB is highly efficient in matrix computations but rather slow in other computations, while the GPUs excel in massively parallel problems. We implemented linear Galerkin (LG) BEM solvers in C++ and Cuda languages and benchmarked them against our optimized MATLAB solver [1] in constructing and using an TMS forward model. The test model contained 28000 surface nodes and 12500 cortical dipole triplets. On a standard PC and basic GPU (Nvidia P2000) using C++/Cuda, we built the BEM model and solved full surface potentials of all dipole triplets in three minutes, compared to over 50 minutes in MATLAB. In TMS simulation with a 42-dipole coil model, the performances were comparable, whereas with a 15000-dipole coil the C++/Cuda code was over 50 times faster than MATLAB. In MEG and EEG, the use of basic GPU allows to upgrade from typical 3-shell BEM model to more realistic 4-compartment model without essential increase in computation time. In TMS, the use of C++/Cuda enables real-time performance with practically any coil model. [1] Stenroos and Koponen, NeuroImage 2019

IT-102 New burst detection method reveals task modulation of beta burst waveform shape.

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Modulation of neural activity in the beta frequency band (13-30 Hz) is one of the most established movement-related effects. Recent developments suggest that sensorimotor beta activity is dominated by transient bursts which, only when averaged, suggests the presence of oscillations. Bursts are typically detected using a fixed threshold applied to the beta amplitude envelope, and detected bursts are usually considered as homogenous. Such approaches risk overlooking low amplitude, but potentially meaningful burst events, as well as the diversity of burst waveform shapes which may be informative about the neural circuitry involved in generating them. Here, we present a novel method to detect and characterise burst-like activity in the beta frequency band. We used a visuomotor adaptation task to elicit peri-movement changes in beta activity: the pre-movement beta decrease, and post-movement beta rebound. Bursts were identified in time-frequency space using superlets to preserve accuracy in both time and frequency dimensions. To avoid using a global threshold, an adaptive, iterative method was employed to detect bursts independently within each trial after accounting for the 1/f aperiodic signal. We then extracted and phase-aligned the waveform of each burst, and used PCA to identify a diverse library of burst waveform motifs. The distribution of the waveform motifs varied according to task-epoch, with a clear differentiation between pre-movement and post-movement bursts in waveform shape. Combined with computational modelling, this method has the potential to identify subtle modulations of thalamic and cortical drives to the sensorimotor neural circuits that generate bursts.

IT-103 Evaluating source reconstruction of resting MEG of the human brain: performance, precision, and parcellation

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Background:
Non-invasive functional neuroimaging of the human brain at rest can give crucial insight into the mechanisms that underpin healthy cognition and neurological disorders. Magnetoencephalography (MEG) measures extracranial magnetic fields originating from neuronal activity with very high temporal resolution, but requires source reconstruction to make neuroanatomical inferences from these signals. However, no consensus yet exists on the optimum methodology for source reconstructing resting-state data.
Methods:
Here, we evaluated the performance of six commonly-used source reconstruction algorithms based on minimum-norm and beamforming estimates. In the context of human resting-state MEG, we compared the algorithms using quantitative metrics, including resolution properties of inverse solutions and explained variance in sensor-level data using a cross-validation procedure. Next, we proposed a data-driven approach to reduce the atlas from the Human Connectome Project's multimodal parcellation of the human cortex.
Results:
This procedure produced a reduced cortical atlas with 250 regions, optimized to match the spatial resolution and the rank of MEG data from the current generation of MEG scanners. For both voxel-wise and parcellated source reconstructions, we showed that the eLORETA inverse algorithm had zero localization error, high spatial resolution, and superior performance in predicting sensor-level activity than the other algorithms. However, it should be noted that in low signal-to-noise ratio conditions, the eLORETA solution was biased and therefore the (weighted) LCMV beamformer may be more appropriate.
Discussion:
Our MEG-optimized atlas and comprehensive comparisons of algorithms can serve as a guide for choosing appropriate methodologies in future studies of resting-state MEG.

IT-104 A novel method for EEG artifact removal based on signal subspace partitioning

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Background
Temporal artifact removal methods exist for MEG data, based for example on vector spherical harmonics (tSSS; [1]). Here we present a novel, related method for both MEG and EEG – by making use of newly described scalar spherical harmonics [2] – with improved temporal projection methods.

Methods
Our method first uses scalar (for EEG) or vector (for MEG) spherical harmonics to determine a basis for the spatial components with the largest expected power in clean data. After projecting the data onto this basis, we identify signal components (e.g., extracted by SVD or ICA) that lose a significant portion of their energy in the projection. Such components are considered artifacts that are not brain-related. We then project these components out from the original data with a similar temporal operation used by tSSS. This method requires only a single parameter (the artifact threshold) for use.

Results
Our method efficiently removes some common problematic EEG artifacts. Compared to the related subspace temporal projection that tSSS uses, our method reduces the risk of bias in high-amplitude signals.

Discussion
Our method should work efficiently even in situations where the spatial data model only contains the main spatial features of the signal of interest but not necessarily fine details such as high spatial frequency components or precisely calibrated sensor geometry. In addition, the method does not need a large number of sensors and could therefore be useful for EEG or MEG data with as few as less than 30 sensors.

References [1] 10.1088/0031-9155/51/7/008 [2] 10.1109/TBME.2020.3009053

IT-105

Assessing the performance of a biophysical model with empirical functional connectivity findings

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Recent work suggests that brain rhythms are approximated by a simple but expressive phenomenological model, based on a system of delayed Stuart Landau oscillators (SLO) coupled in the connectome. For a critical range of parameters, such oscillators can generate rhythms which fall into frequency bands often observed in MEG. In short, the brain's structure predicts function to a substantial degree. Here we assess the degree to which our model can explain the spatio-spectral properties of MEG data. We use functional connectivity (FC) to evaluate the quality of our model's performance, comparing simulated networks with empirical ones. We source reconstructed data from 89 participants of the Human Connectome Project using a beamformer. Voxels were parcellated into regions using the AAL atlas. Timeseries were corrected for source leakage via symmetric orthogonalization. We used amplitude envelope correlations to derive whole-brain FC. We simulated data for each region of the AAL atlas. We explored model parameters, such that the Pearson correlation between the simulated and empirical FC was maximised. The SLO generate whole-brain MEG FC within a well-defined range of coupling and delay parameters. This holds for broadband, theta, alpha and beta band signals (rho =0.47, 0.40, 0.45 and 0.53, respectively). This optimal fit is obtained when metastability is highest, overlapping with the range of parameters where the network model also exhibits the best approximation of the MEG frequency spectrum. Our results suggest that transient oscillatory patterns can be explained by intrinsic dynamics shaped by macroscopic anatomical connections.

IT-106

Temporally Adaptive SourcE Reconstruction (TASER)

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The M/EEG inverse problem is mathematically ill-posed. One circumvents this by introducing assumptions about data covariance - commonly assumed to be static in time. Here we introduce TASER which adds a temporal extension to the classic MAP/LCMV reconstruction Equations, with weights now varying in time in a data-driven manner. TASER is facilitated by a new unsupervised inference tool, DyNeMo, which models covariance as a time-varying weighted linear sum of basis set matrices. These matrices can be learnt in the case of a beamformer or fixed a priori for generative approaches (c.f. Multiple Sparse Priors, MSPs (Friston et al., 2008)). Using stochastic inference methods, we model the data with a unidirectional recurrent neural network. These technical advances, modelling the data as a weighted sum rather than with mutually exclusive states, and using more temporal context (i.e. non-Markovian dynamics), makes the technique more applicable to source reconstruction than competing state-space models (Hidden Markov Models). We demonstrate an implementation of dynamic MSPs and beamformers, validating TASER on simulations and previously published MEG head cast data (Barratt et al., 2018). Our results show an improvement upon existing static techniques; we are able to spatially distinguish non-phase locked oscillations arising from the cessation of little and index finger motion. This resolution, on the order of 4mm, is lost when a standard, static inversion scheme is used. Despite never being exposed to the underlying task-structure, we also show that the inference is capable of learning physiologically plausible latent descriptions of the data (i.e. beta bursts).

IT-107

Dynamic Spectral Noise Modelling for Improved OPM Source Reconstruction

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The MEG sensor noise estimate can often be assumed to be stationary, uncorrelated and homogeneous across channels. In the analysis of single trial data, especially with magnetometers (such as OPMs), this noise estimate becomes more important. We explore how source reconstruction stands to benefit from using a linear combination of spectrally-distinct, empirically derived noise covariance matrices (versus using just one). We show how the Multiple Sparse Priors (MSPs, (Friston et al., 2008)) inversion scheme can be extended to adaptively mix relevant noise covariance matrices. We made use of a solenoid (magnetic dipole) phantom inside an array of QuSpin-ZFM 2nd generation sensors and recorded 4 hours of empty room data within our shielded room in London, with and without the phantom energised. We ran a time-delay-embedded Hidden Markov Model (HMM) on the noise to derive distinct spatio-spectral covariance matrices. We found that HMM states were heterogeneous across frequency and space and included vibrational modes of the shielded-room. In all cases, the linear combination of components improved localisation over using just the identity matrix or one time-averaged empirical noise covariance matrix. This effect held even when the number of trials was reduced to a small number, amounting to just a few seconds of data. Our findings suggest that dynamic estimates of noise covariance offer improvements in source reconstruction, especially when the number of trials is small, as will likely be the case in clinical OPM recordings.

IT-108

Transformation to a Common Sensor Space and Riemannian embedding as good as Source Reconstruction for MEG classification of MCI

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Background
If MEG is used for predicting individual traits, does it help to estimate cortical sources first? While source reconstruction can improve coregistration of features across participants, it often requires an additional MRI scan, and no inversion method is perfect. However, linear decoding in sensor-space is systematically biased if classification is based on non-linear features like power spectra. Sabbagh et al. showed that Riemannian embeddings of sensor covariances help address this bias, but the problem of aligning sensor features across participants remains. By examining linear classification of Mild Cognitive Impairment (MCI) versus Controls, we show that applying sensor-alignment before Riemannian embedding performs as well as source localisation on resting-state MEG data.

Methods Participants:
163 MCI and 144 controls with Neuromag data from the BioFIND dataset (https://doi.org/10.48532/007000). Preprocessing: Maxfilter SSS was used to remove noise, and transform data to the default device space. After band-passing 1-87Hz, a LCMV beamformer used to estimate 676 cortical sources (without sensor alignment). Sensor and source data were SVDed to 50 components to match features. Analyses: Classification based on covariance was estimated with 5-fold cross-validation of Support Vector Machines.

Results
Classification for gradiometer covariance of 62.8% increased to 65.0% after aligning head positions. Riemannian embedding increased to 70.2% without, and 71.8% with, alignment, which was better than 69.5% with source reconstruction. For magnetometers, the respective figures were 60.0%, 64.0%, 68.2%, 68.0% and 70.2%.

Discussion
The combination of sensor alignment with Riemannian embedding produced covariance-based classification performance comparable to source reconstruction, yet does not need an MRI.

IT-109

The impact of spectral complexity on estimating source-space connectivity from MEG data

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Background:
Source-space brain functional connectivity is usually estimated, from MEG recordings, through a two-step process: first the neural time-courses are estimated by solving the MEG inverse problem, then connectivity is computed. Thus, when using MNE as inverse method, the regularization parameter set to estimate the time-courses also affects the connectivity estimation. Indeed, such parameter is suboptimal for the latter: a smaller parameter should be preferred. Interestingly, we found that this behaviour is influenced by the spectral properties of the neural time-courses.

Methods: We used MNE as inverse method, and the cross-spectrum to quantify connectivity. We defined the spectral complexity through a proper scalar coefficient, and the optimal parameters for source (__1) and cross-spectrum (__2) estimation as the values minimizing the relative l2-norm of the difference between actual and estimated time-courses/cross-spectra. We simulated several MEG sensor-level data generated from as many pairs of active sources with different spectral complexity and we numerically computed the optimal parameters.

Results:
The spectral complexity influences the value of __2, which decreases for increasing spectral complexity. Such result relies on the dependence of __2 on the signal-to-noise ratio (SNR) of the model that relates the cross-spectrum at source-level with that at sensor-level. Finally, an analytic relation between the SNR of the classical MEG model and the latter one clarifies such relation.

Discussion:
The results can be of great interest in the neuroscientific community as they provide useful information to properly set the regularization parameter when studying functional connectivity allowing a better estimate of the latter.

IT-110

Brain functional connectivity estimation from MEEG data: pitfalls of the standard two-step approach and potentials of a one-step approach

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Background:
Source-space brain functional connectivity quantifies the statistical dependencies that occur between different brain regions. Thanks to its temporal resolution, magnetoencephalography (MEG) is providing a crucial contribution to the investigation of brain connectivity by non-invasively recording time-courses of measurements associated with the magnetic field induced by neural currents. Connectivity is usually estimated in a two-step process: (i) first neural time-courses are estimated by solving the MEG inverse problem by means of an inverse method, being Minimum Norm Estimate (MNE) among the most used; (ii) then connectivity is computed by means of a proper metric. However, this pipeline presents some intrinsic drawbacks: (i) the errors committed during the first step propagate to the connectivity estimate; (ii) MNE promotes smoothness on the solution, which is not desirable as typically few areas are active at any time; (iii) MNE can be computationally unaffordable when dealing with high dimensional brain models.

Methods:
We quantify connectivity through the cross-power spectrum (cps) and we propose a one-step approach for its estimation, which relies on a new linear model that directly relates source-space with sensor-level cps. We propose L1 regularization to solve the inverse problem associated with the newly defined model.

Results:
The proposed approach outperforms the classical two-step approach: (i) it mitigates the errors propagation; (ii) it provides more localized cps estimates, thanks to the sparsity induced by L1 regularization; (iii) it overcomes the computational problems.

Discussion:
The proposed method can provide more accurate and reliable results in the numerous studies involving source-space connectivity.

IT-111 Free noise variance estimation in Magneto/Electro-encephalography

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A common problem in the field of source localisation from Magneto/Electro-Encephalography (MEG) data is represented by the estimation of the amount of noise that afflicts the data, namely the noise variance. Many solutions have been proposed during the last years for algorithms based on regularisation methods but, till now, nothing usable has been developed in the field of Bayesian approaches. We consider the so called Sequential Semi-Analytic Monte Carlo Estimation (SESAME) an algorithm based on Monte Carlo methods focused on the reconstruction of active dipoles in the brain. This algorithm has been developed during the last decade removing the dependence on the input parameters except for the noise variance. Here we present an improved version that removes the dependence also on this specific input parameter, making the algorithm completely autonomous and allowing to both estimate the noise variance or integrating it out, removing the uncertainty on this parameter. For analysing the performance of the algorithm we provide some examples on simulated data, showing how the proposed approach can estimate the noise variance on the data without any additional computational cost.

IT-112 Sensitivity of EEG forward and inverse solutions to conductivity uncertainties

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Background
The variance of head tissue conductivities between patients leads to considerable uncertainty in the results of electroencephalography (EEG) source analysis. In this study, we elaborate upon previous studies by determining the sensitivity of EEG source analysis to tissue conductivity variations with an unprecedented spatial resolution in a highly-realistic state-of-the-art head model.
Methods
EEG forward solutions of dipole sources regularly distributed in the brain compartment were simulated in a detailed six-compartment tetrahedral head model with standard literature tissue conductivities using the finite element method (FEM) multipole approach. Subsequently, a generalized polynomial chaos approach (gPC) was employed to rapidly calculate EEG leadfields for varying tissue conductivities. EEG source analysis of the simulated dipole sources was performed using goal function scans (GFS) based on the EEG leadfields for varying conductivities. Based on the results of 100,000 variations of tissue conductivities, empirical distributions of the source reconstructions were obtained and analyzed.
Results
Our results confirm previous findings that variations of skin and skull conductivities, in general, have the strongest influence on EEG source localizations. However, our results also show how the influence of variations of the different tissue conductivities depends on the characteristics of the source, such as source orientation and depth or thickness of the covering skull.
Discussion
Our results provide important guidance to estimate the uncertainty related to the reconstruction of sources in different brain regions. Furthermore, they allow understanding the specific benefit of individual conductivity estimation for a certain source analysis scenario.

IT-113

An advanced MEG/EEG source-to-parcel collapsing solution for optimal reconstruction accuracy

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Magneto- and electroencephalography (M/EEG) are central non-invasive neuroimaging modalities for probing large-scale human brain dynamics. Source reconstruction of M/EEG data typically creates thousands or tens of thousands of source time series, which can be collapsed into cortical parcels (typically 50_400) in anatomical or functional atlases to reduce redundancy and facilitate inter-subject and cross-modality analyses. Source reconstruction accuracy and signal mixing, however, are variable across brain regions and subjects, and it has largely remained unclear which collapsing methods yield parcel time series that most accurately represents the underlying neuronal sources. We advance here a novel "fidelity-weighted" source-collapsing approach. Source fidelity is a measure of reconstruction accuracy, determined by fixed factors such as individual cortical geometry, head model, and sensor placement, which are captured in the forward and inverse operators. By weighting individual sources with their fidelity, the accuracy for collapsing into a specific parcellation can be greatly improved. Compared to the conventional collapsing by averaging source time series, fidelity-weighted collapsing increased parcel reconstruction accuracy and decreased signal mixing between parcels. Correspondingly, the performance in cortical connectivity detection also increased significantly. These improvements were consistent for different parcellation resolutions and simulated connectivity patterns. We provide a Python toolkit for collapsing M/EEG sources into standardized brain atlas, and to estimate fidelity and source-mixing, which can further inform advanced analyses such as "hyperedge" bundling of spurious connectivity observations. Thus, fidelity-weighted collapsing expands state-of-the-art M/EEG analysis approaches by providing a structured framework for source collapsing into cortical atlases.

IT-114

Spectral Parameterization Resolved in Time (SPRiNT)

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Macroscopic neural dynamics comprise both aperiodic and periodic components. Recent advances in parameterizing neural power spectra offer practical tools for evaluating these features separately. Although neural signals express non-stationarity in relation to ongoing behaviour and perception, current methods for spectral parameterization are constrained to static spectral profiles. We present Spectral Parameterization Resolved in Time (SPRiNT) as a new tool for decomposing neural dynamics into periodic and aperiodic spectral elements in a time-resolved manner. SPRiNT operates on time series and returns a parameterized spectrogram. It derives short-time fast Fourier transforms (FFTs) over sliding time windows, averaging the modulus of FFT coefficients locally in time to produce a temporally smoothed spectrogram. The spectrogram is subsequently parameterized into periodic and aperiodic components using the specparam algorithm. To evaluate algorithm performance, we recovered nonstationary spectral parameters from 10,000 naturalistic time series simulations, varying all dimensions of signal components within realistic parameter bounds. On average, SPRiNT recovered spectral peaks with 70% sensitivity and 73% specificity. Aperiodic exponent and offset parameters were recovered with mean absolute errors (MAEs) of 0.13 and 0.16, respectively. Centre frequency, amplitude, and frequency width of spectral peaks (0-4 per simulation) were recovered with MAEs of 0.46, 0.23, and 0.49, respectively. SPRiNT, validated on simulated and empirical data, is an open-source plug-in library and interoperates with Brainstorm, facilitating its use in a variety of research contexts. SPRiNT addresses growing interests for parameterizing spectrograms derived from multiple signal modalities and advances the quantitation of complex neural dynamics at the natural timescales of behaviour.

IT-115

On the non-uniqueness of the primary and volume current contributions for spherically symmetric conductor models in MEG

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Background In MEG, the current configuration in the case of spherically symmetric conductor can be represented by a triangle with one vertex at the center of the sphere. In this configuration, the tangential portion of the triangle corresponds to the primary current while the radial segments represent the volume currents. Furthermore, Sarvas derived a closed-form solution for the magnetic field that has no reference to the radial/volume portions of the current. Methods We investigate the effects of origin translation on these current components' contributions via the triangle current framework. We prove that the edge contributions do not obey translational symmetry, although the total contribution from the closed loop stays invariant. An equation is derived for the primary and volume current contributions for arbitrary origin choice. Equivalent current dipole fits are also done for shifted origins. Results We show that spatial profile of the goodness of fit (GOF) is not always a good indicator of localization error values. In certain situations, the GOF value remains high (above 0.95) for co-registration and localization errors of more than 2 cm in the plane of the current triangle. However, the GOF value decays rapidly as a function of co-registration errors perpendicular to the triangle plane. Discussion These results demonstrate that assigning a "primary" or "volume" current interpretation to each edge is nontrivial due to their non-unique contributions in different coordinate frames, which should be considered in source localization. In summary, large localization errors may result from poor co-registration despite a high GOF.

IT-116

Dynamic Analysis on Simultaneous iEEG-MEG Data via Hidden Markov Model

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Background Prior to surgical resection of the epileptic focus, intracranial electroencephalography (iEEG) recordings of seizures allows precise evaluations of targeted brain regions. Non-invasive whole-brain Magnetoencephalography (MEG) recordings could help put the iEEG data in the context of overall brain activity, and thus, are readily available for group analysis and interpretation. Methods The simultaneous MEG-iEEG recordings were performed on 11 patients with epilepsy. Pre-processed MEG sensor data was projected to source space. Time delay embedded hidden markov model technique was applied to find recurrent patterns of network activity in a completely data-driven way. To illustrate the intracranial characteristics in the same time, the state-wise correlation spectra were computed for time series of each iEEG contact. Results 5 HMM states were inferred from MEG dataset. State 1 showed a large-scale activation in the frontal area in both hemispheres. State 2 and state 3 corresponded to the left and right temporal activations respectively. State 4 was significant in the parietal part and state 5 were more related to the posterior brain regions. A majority of iEEG electrodes located in the left and right temporal state (state 2 and state3) and also showed an overwhelming correlation with the probability matrix of the two states. Discussion As the placement of electrodes between patients were inconsistent, the dissimilarity of spectra and their modulation by state could help to group the contacts into functional clusters. Our findings is consistent with the clinical condition that most subjects were diagnosed with temporal epilepsy and implanted with temporal electrodes.

IT-117 Unsupervised representation learning of resting-state MEG with Nonlinear ICA

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Resting-state magnetoencephalography (MEG) data shows complex but structured spatiotemporal patterns. However, the electrophysiological basics are unclear and the underlying origins are entangled in MEG data. Here, we developed a method based on the nonlinear independent component analysis (ICA), a generative model trainable with unsupervised learning, to learn representations from resting-state MEG data. After being trained with large data from the Cam-CAN repository, the model has learned to represent and generate patterns of cortical spontaneous activity using latent nonlinear components, which reflect principal cortical patterns with specific spectral modes. When applied to the downstream classification task of audio-visual MEG, the nonlinear ICA model achieves competitive performance with deep neural networks despite limited access to labels. We further validate the generalizability of the model across different datasets by applying it to an independent neurofeedback dataset for decoding the subject's attentional states, providing a real-time feature extraction and decoding mindfulness and thought-inducing tasks with an accuracy of around 70% at the individual level. Our results demonstrate that nonlinear ICA is a valuable addition to existing tools, particularly suited for unsupervised representation learning of spontaneous MEG activity which can then be applied to specific goals or tasks with limited labeled data.

IT-118 Contribution of radially oriented secondary currents in MEG

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The effect of conductivity inhomogeneities on MEG and EEG signals can be expressed using the concept of virtual secondary currents at locations where the conductivity changes. It is well known that radially oriented primary currents do not generate a magnetic field outside a spherically symmetric conductor. However, the contribution of radially oriented secondary currents to the MEG signals is less clear. To address this question, the choice of the reference model for the conductivity plays an important role. If an infinite homogeneous conducting space is taken as the reference model, radial orientation is not well defined, and the effect depends on the relative orientation and location of the secondary currents and the MEG sensors. However, if a spherically symmetric conductor model is chosen as the reference model, some terms in the perturbation analysis can be interpreted as virtual sources with associated volume currents rather isolated virtual source elements in infinite homogeneous space. This provides useful insights into the contribution of conductivity inhomogeneities to the MEG signals. The results are relevant to the interpretation of MEG signals in the presence of fontanels and skull defects.

VT-119 Characterization of mild Traumatic Brain Injuries with Network Microstates of Dominant Functional Connectivity from MEG-based Beamformed Connectivity Analysis

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This study aims to model the MEG resting-state recordings of mild Traumatic Brain Injury (mTBI) patients with time-varying functional connectivity from dominant-coupling of MEG-based source activity. Following our recent study on the dynamic evolution of brain transitions of network microstates, we moved towards the development of a unified frequency-directed approach that takes into account the dynamic content of frequency couplings within (intra-) and between (inter-) typical brain rhythms on a set of normal controls (NC) and mTBI patients. We first beamformed the MEG signals to identify 90 anatomical regions of interest. Then, a dynamic functional connectivity graph (DFCG) was determined using the imaginary part of phase lag value to model the within-frequency rhythm interactions and mutual-information-based phase-to-amplitude cross-frequency coupling for the between-frequency rhythms interaction. The dominant DFCG was determined based on the maximum coupling among all within- and between- frequency couplings. We then applied statistical and topological filtering on each DFCG. At a second level, for every single quasi-static FCG, we estimated the Laplacian transformation and the synchronization level of each node was on the related eigenvalues. The produced 2D matrix was used to model the evolution of the eigenvalues for each group to reveal the network microstates. Our results show that using network microstates obtained from mTBI and NC subjects, we were able to determine one unified DFCG to precisely discriminate subjects from the two groups. In our previous studies, we followed less optimal techniques (separate intra- and inter-frequency couplings on static brain networks at source and sensor level).

VT-120 Characterization of Mild Traumatic Brain Injury using Finite Element Head Modeling and Fused EEG/MEG Source Connectivity Analysis

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This study aims to identify functional connectivity networks of the sources underlying combined EEG and MEG recordings obtained at the resting state from mild Traumatic Brain Injury (mTBI) patients. mTBI is one of the most common brain injuries, but its long-term cognitive, behavioral, and possibly mental effects are difficult to predict based on the typical analysis of neuroelectromagnetic activity from a single modality, i.e., EEG or MEG. Thus, the use of complementary information afforded by combining EEG and MEG recordings can potentially reveal new network connectivity pathways that are otherwise hidden. To strengthen such a synergetic scheme, it is necessary to use realistic head models obtained from individual subjects. Finite element analysis was thus used to solve the forward problem of source identification, and a five-compartment head model (scalp, skull, cerebrospinal fluid, grey and white matter) was built using the T1-weighted MRIs of individual mTBI patients. For source reconstruction, the standardized low-resolution brain electromagnetic tomography (sLORETA) method was used to estimate the underlying brain activity sources of the combined EEG/MEG recordings, which were then projected onto the standardized anatomical brain regions determined by the Desikan-Killiany-Tourville atlas. To assess patient recovery, we analyzed data obtained in two recording sessions, scheduled two weeks and one month after brain injury. Using nodal-degree connectivity maps computed separately for each modality (EEG and MEG) and the maps corresponding to the combined activity (EEG+MEG), we demonstrate the superiority of the combined approach in quantifying the time evolution of brain connectivity networks towards recovery.

VT-121

Clinical MEG Data Curation and Automatic Labeling of Interictal Epileptiform Discharges

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Background:
Important biomarkers to identify epileptogenic zones are interictal epileptiform discharges (IED) measured with magnetoencephalography (MEG), particularly spikes. Manually identifying IED is laborious and time-consuming. Additionally, properly curated MEG data are deficient in the public domain. This study aims to make clinical epilepsy resting-state MEG data publicly available and develop machine learning (ML) algorithms focused on automatic spike detection.

Methods:
Clinical resting-state MEG signal from patients with epilepsy was used. MEG sensor level data pre-processing was done using the MNE-Python package. Individual spike starting and ending time points were manually labeled by an epileptologist. These time points were used to create a binary mask on the MEG signal. A sliding window of dimension 306(channels)x100ms was created. This window was moved every 1ms over the binary mask. Windows with at least one non-zero value were obtained, and the corresponding MEG data was extracted. 2D Convolutional Neural Network with an input dimension of 306x100 was designed. Extracted data and binary masks were used to train the network for spike segmentation.

Results:
535 spikes from 32 patients (18F) were successfully labeled. Average spike duration was 62.09ms. Patient data were split into 60% training, 20% validation, and 20% testing sets to evaluate the algorithm's performance.

Discussion:
We anticipate that an automated algorithm for detecting IED in MEG data will enable us to automate clinical processing. MEG data curation would allow state-of-the-art ML algorithms to uncover new diagnostics and validate clinical practice. We aim to make this data, including labels, publicly available.

VT-122

NeuroImaging Changes Associated with Risk-Weighted Exposure in American Youth Football Players: A Magnetoencephalography (MEG) and MRI Study

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Background:
The objective of this study was to investigate the role cumulative head impact exposure (HIE) has on MEG and MRI measured brain metrics in youth football players.

Materials and Methods:
103 youth football players (all male; mean age = 13.23y) and 22 control participants (all male; mean age = 11.6y) were utilized in this analysis. Football players wore sensor embedded helmets that detected HIE throughout the season. From this data, Risk Weighted Exposure (RWE) was calculated per subject. Diffusion Kurtosis Imaging (DKI), and 8 minutes of eyes-opened resting state MEG data were acquired pre- and post-season for all participants. MEG data underwent standard pre-processing and source localization in Brainstorm. The relative power per frequency band and mean kurtosis (kmean) images were normalized to MNI space. Voxel-wise difference (post-pre) maps were computed for all imaging metrics per subject. Voxel-wise z-scores were computed and thresholded at 2 standard deviations above the mean. A linear regression model was performed on these metrics.

Results:
The number of abnormal voxels in high gamma (60-90Hz) band showed a positive association ($p<0.05$) with RWE (Figure 1). No other bands showed significant associations. Additionally, the number of abnormal voxels for kmean and all frequency bands showed a strong positive association (Figure 2) ($p<0.001$ Bonferroni).

Discussions:
This study found increased high gamma power significantly associated with increased HIE in youth football players, which is concurrent with other TBI studies. However, it is not concordant with the high school group, where delta power was significantly associated with HIE.

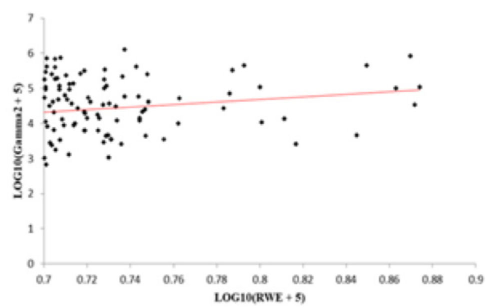

Figure 1. Linear Regression of RWE on High Gamma Response.

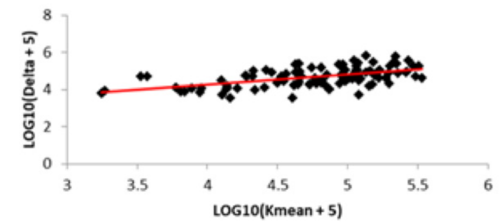

Figure 2. Linear Regression of Kmean on Delta Response.

VT-123

MEG resting state functional connectivity in carriers of spinocerebellar ataxia 1 or 2 reveals network modifications long before the clinical ataxia manifestation

Dunja Duran, Elisa Visani, Laura Canafoglia

IRCCS Fondazione Carlo Besta, Milan, Italy

We analysed 18 patients with spinocerebellar ataxia type 1 or 2 (SCA1 or SCA2) , 23 asymptomatic gene-positive relatives (AsyRs -SCA1 or AsyRs-SCA2) and 14 healthy relatives(HR) . Our aim was to determine if pre-symptomatic subjects could have network modifications, which could be used as a biomarker to distinguish the AsyRs from the HR . Five minutes of resting state MEG data was used. 104 AAL ROIs were defined to extract source time series and calculate the Imaginary Coherence. Connectivity results were successively averaged within six bands([1-4] ,[4-8],[8-12],[13-20],[20-30],[30-45]) and mean connectivity values in addition to the graph topological properties were used to compare the groups. Furthermore, nodal properties of the 104 ROIs were spatially grouped and averaged within 15 broader regions in order to estimate local differences between the groups. We observed significant differences between groups mainly in the alpha band. Interestingly, we found that the network properties of pre-symptomatic patients differ according to the mutation type. More specifically, the normalized clustering coefficient of AsyRs - SCA1 subjects was significantly higher than those observed in AsyRs -SCA2 and both types of affected patients. Regional differences were observed as well, in particular, degree, closeness and eigenvector centrality values differ in AsyRs subjects . Cerebellum regions of AsyRs -SCA2 subjects were more similar to those belonging to the affected patients , while AsyRs -SCA1 did not differ from the HR. Moreover, Left Parietal region of AsyRs , besides having higher centrality values than the affected patients, also correlated with the estimated disease onset.

VT-124

MEG and foramen ovale co-registration in difficult to lateralize temporal lobe epilepsy: benefits and limits of the multimodal evaluation

Dunja Duran, Roberta Di Giacomo, Marco De Curtis

IRCCS Fondazione Carlo Besta, Milan, Italy

Ten percent of pre-surgical patients suffer from temporal epilepsy with unclear lateralisation of epileptogenic foci (DL-TLE) and require additional evaluations (SEEG or foramen ovale electrodes -FOE). We studied seven patients who underwent MEG/ FOE/EEG co-registration with the aim to investigate the amount of mesial activity detectable from MEG data and to determine if a lateralisation index which correctly defines the hemisphere with SOZ (ictal onset activity zone detected with FOE) could be inferred from MEG resting state connectivity. The estimation of the suitable index was performed on 23 patients with well-defined unilateral temporal epilepsy (UTLE) as a control group. The values which correctly defined the affected hemisphere, were successively applied to the DL-TLE patients. Spectral properties as well as spike detections were compared between MEG estimated cortical activity and FOE recordings. For all subjects, cortical sources of spike -free epochs were estimated with dSPM using a deep brain model and averaged within 68 cortical ROIs and the two hippocampi .ciPLV and AEC indexes were calculated for five classical bands(delta, theta, alpha, beta ,gamma). Topological network properties were extracted and differences between affected/non-affected brain hemisphere were evaluated. We observed that interictal mesial activity was only partially detected on MEG data ,with a good spectral correspondence in lower bands. Degree and eigenvector centrality of temporal regions in delta band distinguished the affected from the non affected brain in control UTLE and DL-TLE patients considering the AEC index .Further assessment is needed, to confirm the results.

VT-125 MEG screening for mild cognitive impairment and dementia

Hideyuki Hoshi[1,2], Yoko Hirata[3,4], Momoko Kobayashi[5], Yuki Sakamoto[5], Víctor Rodríguez González[6,7], Carlos Gómez Peña[6,7], Jesús Poza Crespo[6,7,8], Yoshihito Shigihara[2,5]

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Background: Dementia is one of the major health problems among elderly individuals. As a new clinical application of magnetoencephalography (MEG), we are developing a MEG screening method for dementia and mild cognitive impairment (MCI). We have collected over 300 resting-state MEG recordings from healthy controls and patients with dementia and MCI. In order to discriminate different pathological categories (dementia due to Alzheimer's disease, Lewy body dementia, frontotemporal dementia, MCI, and healthy controls, among others), sensor- and source-level MEG data have been analyzed by means of advanced signal processing algorithms. In this talk, preliminary results will be presented. Method: We have recorded resting-state MEG data from 149 healthy controls, 64 patients with dementia, and 41 MCIs. The data acquisition protocol was patient-friendly: each participant undertook only 5 minutes MEG recording with eyes-closed condition. Spectral and entropy-related measures (e.g., relative power in the typical frequency band, mean frequency, Shannon's entropy) are calculated for each data. We also assessed the relationships between these variables, participants' age, cognitive level (MMSE score), and pathological labels. Results: We have corroborated previous findings that spectral-related variables can capture the cognitive decline associated with dementia. We also found that the spatial distribution of the measures reflects pathological differences between subtypes of dementia. Discussion: Resting-state MEG can capture dementia-specific cognitive decline, which may be useful for clinical screening. We discuss the pathological mechanisms which describes the relevance of resting-state MEG to dementia.

VT-126 MEG screening for mild cognitive impairment and dementia

Hideyuki Hoshi[1,2], Yoko Hirata[3,4], Víctor Rodríguez González[5,6], Carlos Gómez Peña[5,6], Jesús Poza Crespo[5,6], Yoshihito Shigihara[2,7]

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Background: Dementia is one of the major health problems among elderly individuals. As a new clinical application of magnetoencephalography (MEG), we are developing a MEG screening method for dementia and mild cognitive impairment (MCI). We have collected over 300 resting-state MEG recordings from healthy controls and patients with dementia and MCI. In order to discriminate different pathological categories (dementia due to Alzheimer's disease, vascular dementia, Lewy body dementia, frontotemporal dementia, MCI, and healthy controls, among others), sensor- and source-level MEG data have been analyzed by means of advanced signal processing algorithms. In this talk, preliminary results will be presented. Method: We have recorded resting-state MEG data from 150 healthy controls, 120 patients with dementia, and 35 MCIs. The data acquisition protocol was patient-friendly: each participant undertook only 5 minutes MEG recording with eyes-closed condition. Spectral and entropy-related measures (e.g., relative power in the typical frequency band, mean frequency, Shannon's entropy) are calculated for each data. We also assessed the relationships between these variables, participants' age, cognitive level (MMSE score), and pathological labels. Results: We have corroborated previous findings that spectral-related variables can capture the cognitive decline associated with dementia. We also found that the spatial distribution of the entropy measures reflects pathological differences between subtypes of dementia. Discussion: Resting-state MEG can capture dementia-specific cognitive decline, which may be useful for clinical screening. We discuss the pathological mechanisms which describes the relevance of resting-state MEG to dementia.

VT-127

Combined EEG/MEG and optimized transcranial direct current stimulation for non-invasive diagnosis and therapy of focal epilepsy

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The goal was to assess the efficacy of targeted (by combined MEEG source analysis) and optimized multi-channel transcranial direct current stimulation (mc-tDCS) as therapy for focal epilepsy in a double blind sham-controlled N-of-1 trial. Targeted and optimized mc-tDCS was applied as alternative therapy in a 19 year-old pharmaco-resistant epilepsy patient. For mc-tDCS optimization we used our recently developed algorithm - Distributed Constrained Maximum Intensity (D-CMI) (Khan et al., 2022) - on a target region which was determined by mean of combined MEEG source analysis of averaged interictal epileptiform discharges (IEDs) using realistic and skull-conductivity calibrated finite-element head modeling. A total amplitude of 4 mA was applied twice for 20 minutes, with a pause of 20 minutes inbetween, for five consecutive days. An Acti-Sham montage (adjacent leads have opposite polarites) was applied with the same regimen as treatment. Between the two stimulation weeks was a washout of 5 weeks. With regard to interictal activity, targeted D-CMI-mc-tDCS led to a highly significant reduction in IED frequency after treatment with median 66% (55.8%± 11.2%, $p < 0.00001$) while Acti-Sham did not ($p > 0.05$). The IED source amplitude was decreased by 76% after treatment with D-CMI- mc-tDCS while it was only reduced by 29% after treatment with Acti-Sham. Side effects entirely pertained to transient sensations. With regard to ictal activity, the patient experienced a seizure with decreased severity during the stimulation week. This proof of principle shows high therapeutic potential for combined MEEG-targeted and optimized mc-tDCS and paves the way for a group study in focal epilepsy.

VT-128

Magnetoencephalography resting-state connectivity patterns in seizure-free and non-seizure-free patients: a comparison with healthy subjects

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[4]Brain Imaging and Neural Dynamic research Group, IRCCS, San Camillo Hospital, Venice, Italy.
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[6]Departement de Genie Electrique, Ecole de Technologie Superieure, Montreal, Canada.
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In a recent Magnetoencephalography (MEG) study, we reported that an epileptic focus, where interictal epileptic discharges (IED) are generated, getting more isolated from the rest of the cortex during resting state, could be considered as a promising predictor of postsurgical outcome (Aydin 2020). Whereas in this first study resting-state connectivity was analyzed using seeds as the focus or its contralateral homologous as a reference, we now aimed to further investigate resting-state MEG in patients, in comparison to corresponding distribution of resting-state connectivity in healthy subjects. We selected 12 patients (7 seizure-free and 5 non-seizure-free patients, 2-years post-surgical follow-up) and 35 healthy controls who underwent MEG data acquisition (Pellegrino 2021). For each patient, we localized the focus using EEG/MEG fusion and a consensus map of IEDs sources (Chowdhury 2018). Next, we selected MEG segments free from any epileptic activity and applied source reconstruction using the wavelet-based Maximum Entropy on the Mean method (Lina 2014). We selected two seed regions, the focus and a contralateral-homologous region (defined manually). Connectivity, amplitude envelope correlation in the alpha band, between the focus or homologous region and the rest of the cortical surface was estimated for all subjects. Each pair of patient's specific seeds (focus /homologous) were also considered to compute connectivity maps from all controls as reference normative data. Our results show that non-seizure-free patients were characterized by significantly increased long-distant connections with the focus. But, seizure-free patients rather showed an increase in long-distant connection with the homologous region, suggesting isolated epileptic networks.

VT-129 Frontal Assessment Battery is sensitive to subtle cognitive decline

Momoko Kobayashi[1], Yuki Sakamoto[1], Hideyuki Hoshi[2], Yoko Hirata[1,3], Kazuyuki Negishi[1], Rika Haraguchi[1], Keisuke Fukasawa[1], Sayuri Ichikawa[1], Yoshihito Shigihara[1,2]

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Background Dementia is a progressive syndrome characterized by chronic cognitive decline, which is assessed by neuropsychological examinations such as Mini-Mental State Examination (MMSE) and Frontal Assessment Battery (FAB). Although the neurophysiological background of MMSE has been extensively studied using neuroimaging techniques such as magnetoencephalography (MEG), fewer studies addressed that of FAB. Therefore, we examined the relationship between FAB and resting-state MEG data. Methods Twenty-seven participants from the outpatient section of the Department of Dementia were enrolled in this study. Their cognitive declines were assessed by FAB and MMSE. Resting-state neural activities were measured using MEG. Median Frequency (MF), Individual Alpha Frequency (IAF), and Shannon Entropy (SE) were used as indices capturing oscillatory characteristics of MEG data. These indices and the source-level of MEG oscillatory powers were assessed with MMSE and FAB scores. Results FAB and MMSE scores were significantly correlated. Three patients showed a decline in FAB, but not in MMSE. The FAB score correlated with MF, IAF, SE, and theta power in the right temporal gyrus. Although the MMSE score too correlated with the three indices, the correlations were weaker than that of FAB. No significant correlation was found between the MMSE score and MEG source power. Discussion Although both FAB and MMSE assess cognitive decline in patients with dementia, they reflect different aspects. FAB is more closely related to the change in neural activity, proceeding clinical symptoms, and is thus, more sensitive than MMSE to the subtle cognitive decline at the early stage of dementia.

IT-119 Prediction of efficacy of rTMS in patients with treatment-resistant depression using the combination approach of electric field and functional connectivity analysis

Yutaro Soejima[1], Masataka Wada[2], Shiori Honda[2], Shuang Liu[1], Mayuko Takano[2], Shinichiro Nakajima[2], Masaki Sekino[1], Yoshihiro Noda[2]

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[2]Department of Neuropsychiatry, Keio University School of Medicine, Tokyo, Japan

Background Globally, repetitive transcranial magnetic stimulation (rTMS) is applied as a therapeutic strategy to treat patients with treatment-resistant depression (TRD). However, the response rate varies with each patient, which is a significant challenge in the application of rTMS. Hence, this study aims to identify objective factors that can predict treatment response to rTMS therapy based on the biophysical characteristics of individual patients. Methods The present study considered the spatial effects of local stimulation by rTMS on the entire brain. Accordingly, we modeled the distribution of the electric field elicited by the rTMS coil in the individual brain and further postulated that functional connectivity measured by resting-state functional magnetic resonance imaging could modify the spreading of the stimulus provoked by the electric field. Subsequently, we identified response predictors using regression analyses, where explanatory and objective variables were stimulus distribution and clinical outcome, respectively. Moreover, to compare our model with other methods, we also performed predictions using only the electric field distribution or the functional connectivity. Results The proposed method exhibited the highest value for the maximum coefficient of determination. Furthermore, the prediction utilizing only functional connectivity proved more precise than that utilizing only the electric field distribution. Discussion These results suggest that the proposed model of spatial spread of the stimulus following rTMS is valid, and that functional connectivity may be more significant than electric field distribution for predicting clinical efficacy of rTMS treatment for TRD.

VT-131

APOE ε4 modulates neural oscillatory activity in precuneus

Pallavi Srivastava, Amy Proskovec, Fang F. Yu, Heidi Rossetti, Jarett Berry, Joseph Maldjian, Elizabeth Davenport

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Background:
Among the genetic risk factors, apolipoprotein E ε4 (APOE4) has been widely studied and known to be a strong predictor of progression to AD. In this study we examined the influence of APOE4 on alpha/theta ratio (ATR) in precuneus, a region known to be involved early in AD.

Methods:
Study participants included 13 APOE4 carriers [APOE4+] (median age 61 years, 9 females, 8 Blacks, 6 healthy, 3 subjective cognitive decline (SCD) and 4 mild cognitive impairment (MCI)) and 38 non-carriers [APOE4-] (median age 64 years, 22 females, 32 Blacks, 15 healthy, 12 SCD, and 11 MCI). All subjects completed resting state MEG along with a T1w brain MRI. MEG data underwent standard preprocessing. Resultant whole-brain maps of spectral activity were filtered into six canonical frequency bands. Relative mean power of each frequency band, and ATR were computed. Generalized linear models (GLM) were computed to assess the association between APOE4 and ATR, after controlling for age, sex, race, and systolic blood pressure (SBP), known to modulate the effect of APOE4.

Results:
Cognitive status was not significantly different between groups (Table1). APOE4+ had significantly lower ATR compared to APOE4- subjects (Table2, Figure1). GLMs revealed significant negative association of APOE4 status with ATR and positive association with SBP (Tables 3-4).

Conclusion:
APOE4 modulates neural oscillatory activity in Precuneus. Allele4 produces neurophysiological dysfunction similar to that seen in AD continuum. Our study shows the potential of MEG metrics as a useful biomarker in detecting early at-risk individuals.

Table 1 Demography

	APOE4+ (n=13)	APOE4- (n=38)	P value
median Age in years	61	64	0.0796
Male	4 (31%)	(42%)	
Female	9 (69%)	(58%)	0.4699
Black	8 (62%)	(84%)	
White	5 (38%)	6 (16%)	0.0862
Healthy subjects	6 (46%)	(39%)	
Subjective cognitive decline (SCD)	3 (23%)	12 (22%)	
Mild cognitive impairment (MCI)	4 (31%)	11 (29%)	0.9204

Table 2 Wilcoxon rank sum: Median alpha/theta ratio

	APOE4+ (n=13)	APOE4- (n=38)	p value
Precuneus_L	1.3975	1.7313	**0.0298***
Precuneus_R	1.3974	1.7832	**0.0390***

Table 3 Generalized Linear Model Outcome: Alpha/theta ratio of Precuneus Left

	β estimate	p value
Age in years	-0.0120	0.2860
Female vs Male	0.1429	0.4160
Black vs white	0.0646	0.7616
Systolic blood pressure	0.0142	**0.0064***
APOE4 carrier vs non-carrier	-0.4348	**0.0338***

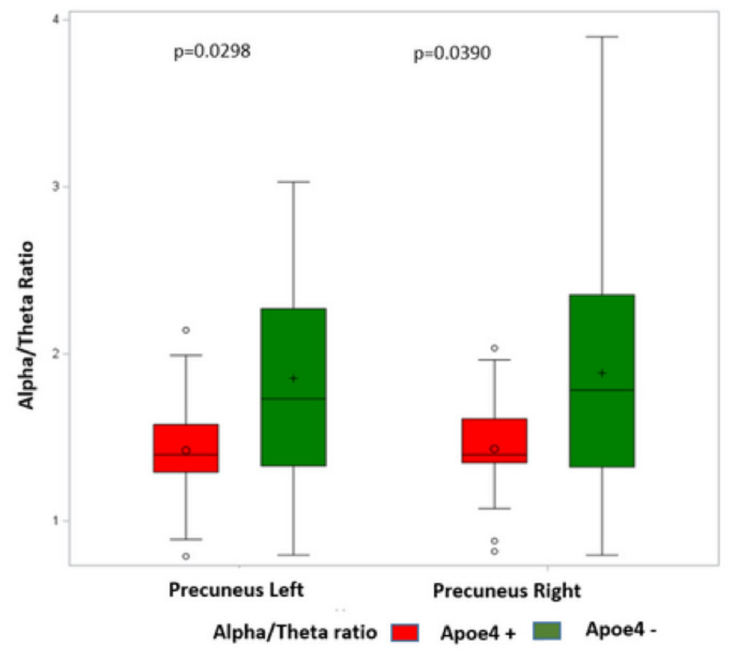

Figure1: Boxplots showing median alpha/theta ratio in Apoe4 carrier (+) and non-carrier (-)

VT-132

Hippocampal alpha/theta ratio- a neuromagnetic biomarker of preclinical and prodromal stages of dementia

Pallavi Srivastava, Amy Proskovec, Heidi Rossetti, Jarett Berry, Joseph Maldjian, Fang F. Yu, Elizabeth Davenport

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Background:
Alpha-theta ratio (ATR) has been associated with cognitive decline and shown to discriminate Alzheimer's disease (AD) from healthy controls (HC). We aimed to 1) determine hippocampal ATR in Subjective Cognitive Decline (SCD) and Mild cognitive impairment (MCI), 2) examine correlations with neurocognitive metrics in a diverse population-based study.

Methods:
Resting MEG was completed on age, sex and race matched 27 HC and 27 SCD (mean age: 63 years, 34 females, 16 Blacks), 22 HC and 22 MCI (mean age: 61 years, 24 females, 14 Blacks), and 22 SCD and 22 MCI (mean age: 62.5 years, 25 females, 15 Blacks). MEG data underwent standard preprocessing. Resultant whole-brain maps of spectral activity were filtered into six canonical frequency bands. Relative mean power of each frequency band, and ATR were computed. Group differences were analyzed using Wilcoxon tests, and Pearson correlation was used to assess neurocognitive relationships.

Results:
MCI vs HC did not show significant differences (Table1, Figure1). SCD had significantly lower ATR in right hippocampus compared to HC (Table2, Figure 2). MCI had significantly higher ATR than SCD (Table3, Figure 3). Theta band was negatively correlated with digit symbol raw score (Table4), MoCA score (Table5) and positively with Trail making part B score (Table6).

Conclusion:
ATR is known to decrease in Alzheimer's Disease. Higher ATR in MCI vs SCD suggests there could be a transient shift to compensate for early cognitive impairment. We show the potential of MEG as a non-invasive biomarker to detect early stages of dementia.

Table 1 Wilcoxon rank sum test: Median alpha/theta ratio			
	HC (n=22)	**MCI (n=22)**	**p value**
Hippocampus_L	1.4002	1.6104	0.0725
Hippocampus_R	1.3833	1.5781	0.1185

Table 2 Wilcoxon rank sum test: Median alpha/theta ratio			
	HC (n=27)	**SCD (n=27)**	**p value**
Hippocampus_L	1.5642	1.1437	0.1236
Hippocampus_R	1.5228	1.1505	**0.0306**

Table 3: Wilcoxon rank sum test: Median alpha/theta ratio			
	SCD (n=22)	**MCI (n=22)**	**p value**
Hippocampus_L	1.1217	1.6104	**0.0026**
Hippocampus_R	1.1195	1.5781	**0.0005**

Figure 1

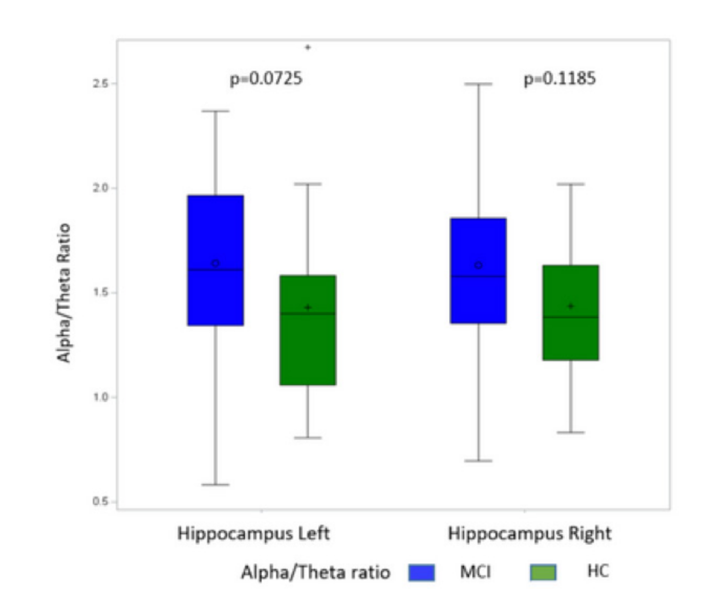

Figure 2

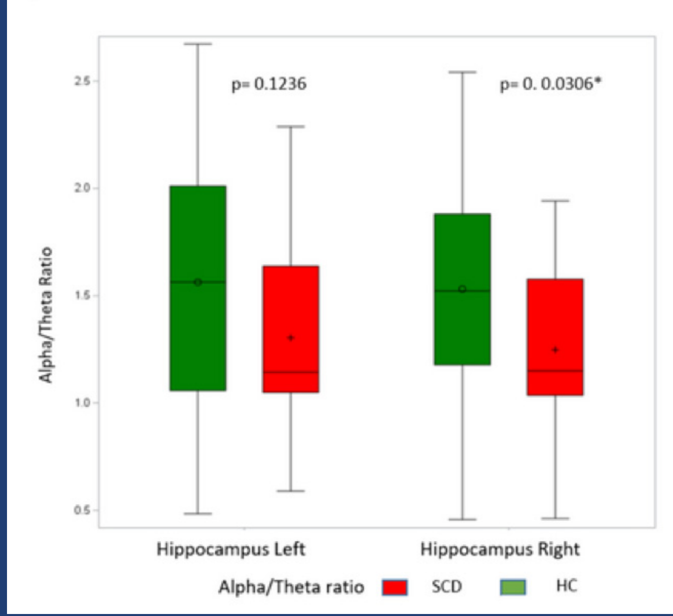

Figure 3

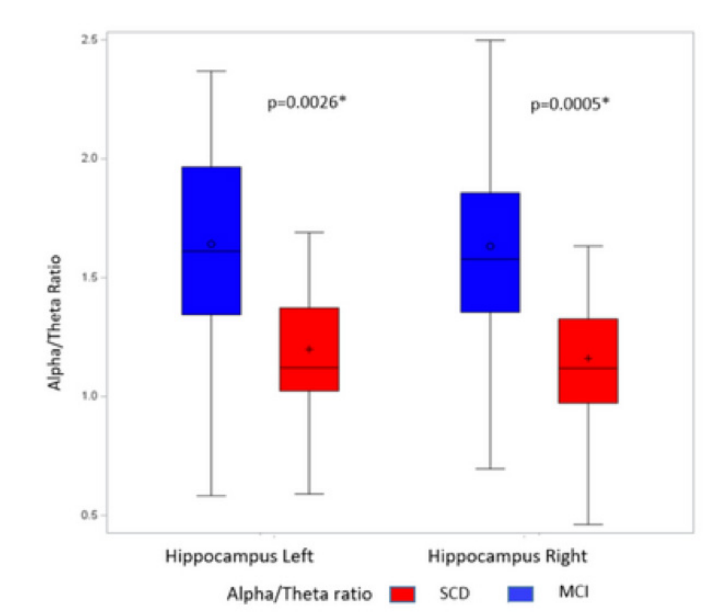

Table 4 Pearson Correlation of Digit symbol raw score with theta in MCI (n=22)		
	r2	**p value**
Hippocampus_L	-0.65461	**0.0009**
Hippocampus_R	-0.56569	**0.0061**

Table 5 Pearson Correlation of MoCA (Montreal Cognitive Assessment) score with theta in MCI (n=22)		
	r2	**p value**
Hippocampus_L	-0.49927	**0.018**
Hippocampus_R	-0.40087	0.0645

Table 6 Pearson Correlation of Trail making part B score with theta in MCI (n=22)		
	r2	**p value**
Hippocampus_L	0.47408	**0.0299**
Hippocampus_R	0.43995	**0.046**

VT-133

Auditory cortical activity influenced by affect

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Affect is difficult to measure because it is an activity that occurs deep within the brain. Since, the limbic system and the thalamus, are connected via the cerebral cortex, we indirectly assessed affect by measuring activity in the auditory cortex using MEG (Magnetoencephalography). There were 14 participants in this study, of whom 11 were male and 3 were female. The mean age is 21.9 years with a standard deviation of 0.74 years. We used IAPS (International Affective Picture System) as a visual stimulus to elicit affect. IAPS has two quantitative indicators of: valence and arousal, and we classified IAPS into three categories; HAHV (High Arousal and High Valence), HALV (High Arousal and Low Valence), and LANV (Low Arousal and Neutral Valence). We measured 20 Hz-ASSR (Auditory Steady State Response) from the auditory cortex when participants were presented with a continuous optimized chirp and three emotionally evocative IAPS in a random visual presentation. The mean amplitudes of the ASSRs when these three categories were presented were compared. The result showed a significant difference in ASSR mean amplitude between HAHV and HALV ($p<0.05$). The results suggested the possibility that affect can be assessed from activity in the auditory cortex.

VT-134

A multiple graph Gaussian embedding method with uncertainty quantification for predicting Alzheimer's disease progression

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Characterizing the subtle changes of MEG functional brain networks associated with the pathological cascade of Alzheimer's disease (AD) may be a key for early prediction of AD progression prior to overt clinical symptoms. We developed a deep learning-based graph Gaussian embedding method for identification and characterization of the early stages of AD using eye-closed resting state MEG data. Specifically, the deep neural network model can learn highly informative MEG brain network node-wise patterns by embedding high-dimensional MEG resting state brain networks into a latent probabilistic space (i.e., multivariate Gaussian distributions). The MEG brain network embedding signatures enable quantitative capturing of subtle and heterogeneous node-wise brain connectivity patterns as well their uncertainty quantification. Moreover, the embedding signatures can be used as input to traditional classifiers for various downstream graph analytic tasks (e.g., AD risk stratification, statistical evaluation of between-group significant changing regions, etc.). Experimental results show that our method could provide a novel quantitative approach to extract node-wise probabilistic Gaussian distribution embeddings that can lead to accurate and informative forecasting of AD progression prediction at diverse preclinical stages. Additionally, statistical evaluation results for the between-group significant brain regions facilitate better understanding of the underlying heterogeneous pathogenesisin AD progression, and may aid to improve the design of precision behavioral interventions. In general, our method motivates a wider adoption of deep learning-based stochastic graph embedding methods to other neuroimaging data. In the future, we will consider extensions to multimodal data (e.g., fMRI, MEG and PET) for more robust inference.

VT-135

Group-level inference of information-based measures for the analyses of cognitive brain networks from neurophysiological data

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We propose a non-parametric permutation-based statistical framework, primarily designed for neurophysiological data (MEG and SEEG), in order to perform group-level inferences on non-negative measures of information encompassing metrics from information-theory, machine-learning or measures of distances. The framework supports both fixed- and random-effect models to adapt to inter-individuals and inter-sessions variability. Using numerical simulations, we compared the accuracy in ground-truth retrieving of both group models, such as test- and cluster-wise corrections for multiple comparisons. We then reproduced and extended existing results using both spatially uniform MEG and non-uniform intracranial neurophysiological data. We showed how the framework can be used to extract stereotypical task- and behavior-related effects across the population covering scales from the local level of brain regions, inter-areal functional connectivity (FC) to measures summarizing network properties. We also present an open-source Python toolbox called Frites that includes the proposed statistical pipeline using information-theoretic metrics such as single-trial functional connectivity estimations for the extraction of cognitive brain networks.

IT-120

Estimating Target Orientations: A Comparison of Beamformer Algorithms and their Performances in Estimating Orientations of Neural Sources

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Background: The efficacy of transcranial electric stimulation (TES) to modulate neuronal activity depends critically on the spatial orientation of the targeted neuronal population. Therefore, correct estimation of the target orientation is of utmost importance. Different beamforming algorithms provide orientation estimates, however, a systematic analysis of their performance is still lacking. Methods: For fixed brain locations, data from sources with randomized orientations is simulated and noise is added (Gaussian or realistic). The orientation is then estimated (1) with EEG and (2) with a combined EEG-MEG approach, in which the tangential component is extracted from the MEG data and the radial component from EEG data. Three different beamformer algorithms are evaluated: Unit-gain (UG), unit-noise-gain (UNG), array-gain (AG). Reliability is tested using bootstrapping. In an additional real data example, the orientations of the visual network areas V5 and the Frontal Eye Field (FEF) are reconstructed with this method. Results: Differences between the beamformers' abilities to estimate the correct orientation are shown: especially the UNG is outperformed by the UG and the AG beamformers. Performance furthermore depends on the ratio of radial and tangential components of the orientation, on regularization parameters and on noise levels. In the real data example, the test-retest-reliability of two measurements was best in the combined estimation approach using UG for both, FEF and V5. Discussion: Choosing the correct beamformer algorithm and combined MEG-EEG data allow a stable reconstruction of source orientation. This study is a first step towards establishing best practice for source orientation estimation.

VT-137 Beamforming of the Seizure Onset Zone: an alternative and useful tool to analyze Magnetoencephalography (MEG) data

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Background:
Magnetoencephalography provides significant information regarding epileptiform activity. Despite the vast array of advanced MEG processing options only a few are approved for clinical use. In this study, we evaluated if Linearly Constrained Minimum Variance (LCMV) beamforming would be an applicable tool for MEG ictal onset source localization.

Methods:
7 epilepsy patients with clinical MEG were included in the study. Equivalent-current dipole (ECD) fitting in MEGIN DANA software was performed as part of standard clinical care. Ictal MEG data were selected and exported to Brainstorm Software with their correspondent T1 weighted Magnetic Resonance Imaging. Preprocessing included notch (60Hz and harmonics) and band-pass (1-100Hz) filters. Noise and data covariance were estimated directly from the recordings. We performed LCMV beamforming for source localization. Spectrum normalized power spectrum density analysis was applied to an individualized time segment and frequency band for each seizure based on visual inspection and time-frequency decomposition maps. Beamformed areas were compared to ECD dipoles, stereoelectroencephalography (SEEG) and surgical outcome data, when available.

Results:
Beamforming was performed in nine seizures, including two that were not able to be modeled with ECD fitting. Four seizures were compared to SEEG, where beamforming source localization was equivalent or more accurate than ECD. In the remaining patients, beamforming matched ECD dipoles.

Discussion: LCMV beamforming source localized the SOZ (seizure onset zone) in two cases where ECD fitting was not possible and was equivalent or more accurate than ECD when compared to SEEG. We contend that beamforming may be useful in identification of the SOZ.

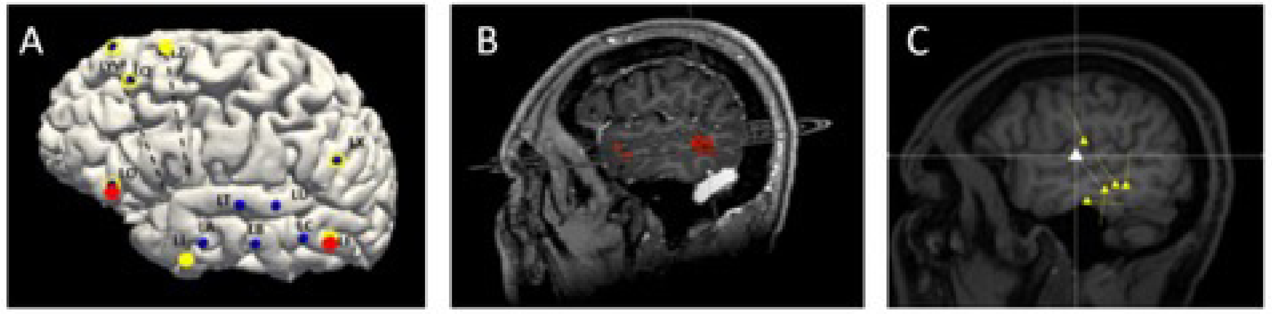

Figure 1. A. 3D (3 Dimensional) image displayed on cortex of one subject evidencing SEEG electrodes implantation map localizing areas of ictal onset (red dots) at the posterior aspect of the medium temporal gyrus (95% of the seizures) and the orbito-frontal cortex (5% of the seizures). **B.** Magnetic Resonance Imaging (MRI) 3D image display localizing the beamformed SOZ to the posterior aspect of the medium temporal gyrus evidenced by the region with maximum power (red) at the selected frequency band. **C.** MRI (sagittal view) evidencing the ictal dipole (white triangle) by Equivalent Current Dipole fitting method. In this case, the first timepoint meeting diagnostic criteria was after the peak of the spike, possibly representing spread.

VT-138 CutFEM forward modeling for EEG-Sourceanalysis

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Introduction
A central step in source-analysis using Electroencephalography (EEG) lies in accurately solving its forward problem, i.e. determining the scalp potential induced by a neural source. Doing so requires an accurate depiction of the volume conduction effects in the human head, represented by a partial differential equation (PDE). Among the options to solve said PDE is the finite element method (FEM) which requires a volumetric discretization, a mesh, of the head domain. When creating the mesh one usually chooses between either hexahedral or tetrahedral elements. Due to their cubic structure, hexahedral meshes are unable to accurately represent the folded and curvy structure of the head while their tetrahedral counterparts, while being more geometrically accurate, are difficult to set up in situations where the head compartments (scalp, skull, gray/white matter,...) are not entirely contained in one another.

Methods
CutFEM belongs to a category of unfitted finite element approaches where the mesh is disentangled from the geometry. Following a description of the method, we will employ it in controlled spherical scenarios as well as a realistic head model where CutFEM is used for a reconstruction of somatosensory evoked potentials.

Results
CutFEM outperforms an existing unfitted FE method with regard to memory consumption and speed and a geometry adapted hexahedral model with regard to accuracy while being able to mesh arbitrarily touching compartments.

Conclusion
CutFEM strikes a balance of numerical accuracy, computational efficiency and ability to model complex geometries that was previously not available in FEM-based EEG forward modeling.

VT-139

Wave catcher - the fast and robust tool for catching cortical traveling waves in the sensor-space data

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Traveling waves (TW) hallmark cortical activity. Linked to synaptic transmission, TWs propagation direction and velocity are informative of cognitive functions and the low level processing mechanisms. To date, most of the TW studies are invasive and use a direct calculation of the TW parameters. TWs identification in non-invasive data is problematic due to inability to separate wave's spatial and temporal dimensions in the measured additive mixture. This can be alleviated by focussing on the time segments where the waves are actually present. To this end we propose a simple, fast and robust test for detecting time intervals with pronounced TW patterns in MEG and EEG sensor-space data. The key idea here is the observation that sensor space representation of the cortical TWs includes scalp-distributed activity with consistent phase shifts between the adjacent measuring sites. This dynamics can be partially captured within the jPCA framework using the difference equation with a skew-symmetric system matrix. Therefore, the extent to which the TW data dynamics is pronounced is measured using the F-ratio of the full and symmetric dynamical model residual variance. The obtained F-values characterize the presence of the TW patterns in a given data segment. In realistically simulated MEG data we distinguished between wave-like and static patterns with AUC-values 0.56, 0.77, 0.81, 0.86 for SNR values 1, 2, 3, 4. We were also able in real MEG data to automatically identify among interictal spikes those with pronounced propagation.

VT-140

The Localized Subtraction Source Model For EEG and MEG forwardmodeling

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One of the basic problems in EEG and MEG source analysis is simulating the sensor measurements that a given neural activity would generate, i.e., the so-called forward problem. The neural activity is typically modeled as a linear combination of mathematical point dipoles. When using a finite element method (FEM) for the forward problem this leads to difficulties, as it is not clear how the singularity of a point dipole can be properly incorporated. Various FEM source models have been proposed, and among these the so-called subtraction source model. The subtraction approach is not only well founded in theory, but also produces accurate results in practice. The major downside of the subtraction source model is that it is computationally prohibitively expensive in practical applications. To overcome this we developed a new source model, called the localized subtraction source model. This source model is designed in such a way that it preserves the mathematical foundation of the subtraction source model, while also leading to sparse right hand sides in the FEM formulation, making it efficiently computable. In my talk, I will present this source model. Furthermore, I will compare it to other state-of-the-art source models with regard to accuracy and computational effort. In multi-layer sphere models the localized subtraction source model will be shown to be as accurate, and in most cases even more accurate, than the other investigated source models, while being largely more efficient than the subtraction source model, and comparable in effort to a Venant source model.

VT-141

New Machine Learning Methods for Nonlinear Interactions in Electrophysiological Data

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Cross-frequency synchronization (CFS) is proposed as a mechanism for integrating spatially and spectrally distributed information in the brain. Recently, we introduced two methods, NID [https://doi.org/10.1016/j.neuroimage.2020.116599] and Harmoni [https://doi.org/10.1016/j.neuroimage.2022.119053], for filling the methodological gap for separating CFS sources and disentangling genuine vs. spurious interactions. NID is a blind source separation (BSS) method for separating cross-frequency coupled (CFC) sources. Its core idea is that oscillations with nonlinear interactions can be mixed in such a way that their mixture has a more non-Gaussian distribution than each of the individual signals. However, NID is not exempted from the well-known problem of spurious interactions due to the non-sinusoidal shape of oscillations. Therefore, very recently we introduced Harmoni -- a novel method that removes components representing harmonics of a non-sinusoidal signal. Harmoni's working principle is based on the presence of CFS between harmonic and the fundamental components of a non-sinusoidal signal. In different realistic EEG simulations, we showed that NID can separate multiple CFC sources even with very low SNRs; and the ROC analyses confirmed that Harmoni can suppress spurious interactions while not affecting the genuine ones. By applying both methods on resting-state EEG data of 81 subjects, NID could extract CFC sources with diverse spatial patterns; and Harmoni could uncover CF couplings that were masked by the strong spurious interactions. In conclusion, NID offers a novel BSS approach based on the statistical properties of CFC sources, and Harmoni can serve as a first steppingstone towards the advancement of methods for refining connectivity patterns in M/EEG.

VT-142

HNN-core: an open-source Pythonic interface to the Human Neocortical Neurosover (HNN) software for cellular and circuit interpretation of human MEG and EEG signals

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HNN-core (https://jonescompneurolab.github.io/hnn-core [https://jonescompneurolab.github.io/hnn-core]) is a Python package containing the non-GUI components of the Human Neocortical Neurosolver (HNN) software. HNN-core offers a Pythonic interface for simulating macroscale human M/EEG signals generated by a biophysically-detailed neocortical model, representing a patch of neocortex under thalamic and corticocortical drive. HNN-core is designed to simulate the time course of primary current dipoles and enables direct comparison, in nAm units, to source-localized M/EEG data, along with layer-specific cell spiking and local field potentials. Tutorials that mimic those available with the HNN-GUI (https://hnn.brown.edu/tutorials [https://hnn.brown.edu/tutorials]) are provided to teach users how to simulate evoked responses and low frequency rhythms in the Pythonic interface. Parameter optimization to match evoked responses is also available, and functions are provided to modify the network synaptic connectivity profiles, a feature not possible in the HNN-GUI. HNN-core is designed to allow the computational and human neuroscience communities to understand and contribute to the development of the HNN software toolkit, following best practices in open-source software. The package is available to install with a single command on PyPI, is unit tested, adheres to modern Python style conventions, and is extensively documented. The Python interface allows easy batch processing and integration with MEG analysis pipelines based on MNE-Python; an example is available for median nerve evoked responses. Efforts are underway to add new features including current source density visualization, sensitivity and uncertainty estimation of learned parameters, and interoperability with existing tools such as NetPyNE, NeuroML and LFPy.

VT-143 Fast parametric curve matching (FPCM) for automatic detection of interictal spikes

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Background Epilepsy is one of the most prevalent neurological disorders, as it affects around 50 million people worldwide, according to the World Health Organization (WHO). Characterized by interictal spikes, produced by synchronous activity of neuronal groups in epileptogenic brain regions (Staley and Dudek, 2006), this disorder may require resection of these regions for the purposes of treatment. Thus, the development of algorithms of automatic spike detection is in a great demands, as they more reliable and less time-consuming than the reviewing of the data performed by human experts. Methods We propose a novel method of fast parametric curve matching (FPCM) for automatic spike detection, which adopts the principles of the standard mimetic approaches, while being threshold-free. This method is adaptive in time domain and allows for qualitative modulation of spike shape properties. Within this method, the spike shape is parametrized by two linear segments and a second-degree polynomial. The coefficients of this structure are obtained as the result of convolution of this morphological model and the data. The process of decision making is defined by logical predicates on signs and ratios of the coefficients. Results The performance based on realistic simulations demonstrate reasonable levels of sensitivity and specificity. Compared to the standard methods, FPCM demonstrated superiority in presence of high-amplitude artifacts. Moreover, we applied this method to real data from patients with epilepsy and obtained consistent results, showing distinguishable patterns and allowing for source localization. Staley, K. J., & Dudek, F. E. (2006). Interictal spikes and epileptogenesis. Epilepsy Currents, 199-202.

VT-144 Imaging and Statistical Testing of Functional Connectivity Between Brain Sources Characterized by Activity with Close-to-Zero Phase Lags

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Background One of the main methodological issues in evaluation of functional connectivity is the spatial leakage (SL) effect which results from volume conduction and leads to false positives in coherence or phase-locking estimates. Several solutions have been already suggested, including the use of imaginary part of coherency or cross-spectrum (Nolte et al., 2004). As these standard metrics are insensitive to zero-phase interactions, they get rid of SL-effects, but may underestimate true physiological interactions, characterized by close-to-zero phase lags. The broad neurophysiological evidence shows that such interactions are crucial for certain integrative processes and, thus, should not be excluded from consideration. Methods The recently proposed method, referred as Phase Shift Invariant Imaging of Coherent Sources (PSIICOS) (Ossadtchi et al., 2018), became the first implementation of the algorithm which reliably detects interactions for all the range of phase-lags by suppressing the power of SL subspace components of cross-spectrum. However, connectivity values obtained via PSIICOS are non-normalized by construction and depend on source power, so that uncoupled sources with high power profiles may become false positives. This limitation motivated us to develop a statistical test based on generation of covariance matrices from Wishart distribution. Results The proposed test showed high performance applied both to simulations and real data. Thus, together with the proposed statistical test PSIICOS can be used as an effective instrument applicable to real EEG- or MEG-data in fundamental research or for clinical purposes.

VT-145

A novel time-delayed correlation method can decompose the frequency mismatch response without using conventional subtraction

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The mismatch response (MMR) is thought to be a neurophysiological measure of auditory novelty detection that could serve as a translational biomarker of various neurological diseases. The MMR is derived by subtracting the event-related potential/field (ERP/ERF) elicited to "deviant" sounds that randomly occur within a train of repetitive "standard" sounds. To avoid several problems associated with this subtraction procedure, we propose a novel method, called weighted-BSST/k, which uses only the deviant response to derive the MMR. We hypothesized this method highlights periodic responses related to the deviance detection, and more sensitive than independent component analysis (ICA). The validity and efficacy of weighted-BSST/k vs. ICA (infomax) were evaluated in 12 healthy adults. The auditory stimuli at a constant rate of 2 Hz were presented. MMRs with the subtraction approach were obtained from bilateral temporal lobes with the subtraction approach at 96–276 ms (MMR time) defined based on spatio-temporal cluster permutation. In the application of the weighted-BSST/k the deviant responses were given a constant weight on the MMR time. The ERF elicited by the weighted deviant responses demonstrated one or a few dominant components representing the MMR with a high signal-to-noise ratio and similar topography to that of the sensor space analysis using conventional subtraction. By contrast, infomax or weighted-infomax revealed many minor or pseudo components as constituents of the MMR. Our new approach may help the use of MMR in basic and clinical research, and it opens a new window into complex event-related brain data.

VT-146

Methods for automatic detection of cardiovascular diseases using magnetocardiography

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Background Magnetocardiography (MCG) potentially offers a fast, noninvasive method for detecting cardiovascular diseases, which has been evaluated in patients with coronary artery disease (CAD), arrhythmia, coronary microvascular disease (CMD), and others. However, the efficacy of MCG is often limited by inconsistent visual interpretation methods. We assess a feature-based approach for developing predictive machine-learning models for disease diagnosis using MCG. Methods Patients with suspected CAD and CMD across four clinical studies underwent ninety-second MCG scans using a 36-channel optically pumped magnetometer (OPM) system. After removing background interference and averaging cardiac cycles, the signal was subject to a range of modeling and analysis techniques, including spatial reconstruction of the cardiac magnetic field and current density, physical single and multiple dipole models, and analysis in the frequency and information theory domains. The resulting set of features encoding the spatio-temporal characteristics of the cardiac magnetic field were coupled with ground-truth patient data from gold-standard clinical endpoints gathered in clinical studies to determine correlations which fueled development and validation of predictive models. Results Predictive models showed competitive or superior performance compared to most standard-of-care clinical diagnostics for detecting obstructive CAD in patients who underwent revascularization (80%/70% sensitivity/specificity, n=124) and detection of CMD in patients confirmed by invasive coronary reactivity testing (90%+ sensitivity/specificity, n=37). Conclusions OPM MCG coupled with predictive machine learning models demonstrate significant potential for detection of cardiovascular diseases. Our method is flexible and may be adapted to a variety of diagnoses and demographics, when supplemented and validated with appropriate clinical data.

VT-147

Basic study of data volume reduction method for MEG analysis

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One of the problems with MEG is that the data volume becomes huge due to long time measurement, and analysis takes a long time. It is expected that analysis can be accelerated by reducing the data volume. One way to reduce the data volume is to use data compression technology, but it is difficult to computation for analysis on compressed data. Therefore, we attempted to reduce the number of bits used to represent fractional values. The common method of representing fractional values in computers is 32-bit floating-point numbers. We considered using 16 bits to represent fractional values. However, since reduces the bit length reduces precision of the representation, we devised two methods to minimize the decline in precision as much as possible. One method uses fixed lengths for the exponent and mantissa parts and limits the range of representation to the range of fractional values that appear in the MEG data. The other method uses a representation method in which the exponent and mantissa parts are variable length, to accuracy within the range of fractional values that appear in the MEG data. We compared the representation accuracy of these two methods. The results suggest that the variable-length exponent and mantissa can represent fractional values with higher precision than the fixed-length method.

VT-148

Physiological evaluation of magnetocardiographic noise: an MEG-MRA study.

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The biomagnetic signals measured by magnetoencephalography (MEG) include not only the magnetic fields generated by the electrical activity of cortical neurons, but also physiological noise caused by biofunctional movements such as heartbeats. Magnetocardiogram (MCG) noise is usually removed using signal processing techniques such as SSP and PCA/ICA (Haumann et al., 2016). However, some aspects of the physiological properties of MCG noise remain unknown. For example, the presence of residual components even when the signal space is restricted to the head by spatial filtering methods such as SSS (Taulu et al., 2005) theoretically suggests the multiple origins for the MCG noise, e.g., cerebrovascular pulsations superimposed on the heart and/or myocardial motion (Jousmäki and Hari, 1996). To clarify this point, we measured the biomagnetic signals using MEG sensors placed near the head, neck and chest of the subjects. Magnetic resonance angiography (MRA) using a 3T MRI was also performed to create various 3D realistic models of the brain, heart and arteriovenous vessels between the head and heart, which were utilised to reconstruct the current density distribution of the MCG noise over the upper body. The results showed that the pulse component was mainly localised in the heart, while in the brain area, the strongest currents were observed in the vertebral artery and middle cerebral artery, indicating an indirect correlation between magnetic field strength and blood flow volume. On the other hand, the DC component was localised around the superior sagittal sinus and may reflect the magnetic moment of venous blood.

VT-149

Continuous Localization of Magnetic Marker Coils Excited by Non-continuous Current for MEG

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Knowing a subject's head position in the system is important to measure the brain activity using a magnetoencephalography (MEG) system. The head position is usually measured using magnetic marker coils attached to the subject's head. So far, we have employed a driver circuit which sequentially applies a burst modulated ac electric current to each coil. The positions of the marker coils have not been measured while brain signal measurements because the marker signals become "noise" when analyzing the brain activity. To realize simultaneous measurements of the burst modulated marker signals and brain activities, we developed a continuous marker coil localization technique for the burst modulated marker signal and a signal analysis algorithm to remove the marker signal from the recorded data. We tested the proposed method using a whole head MEG system and a phantom which emulates equivalent current dipoles (ECDs). Five marker coils were attached to the phantom and excited by the burst modulated current in every 1.6 seconds. The phantom was moved while measurement. The burst modulated marker signals were automatically extracted from the record data. The phantom was successfully localized corresponding to extracted marker signals. We calculated the magnetic field distribution based on the localized marker positions and subtract it from the recorded data. The marker signals were reduced to about 1/10 without any signal distortion like digital filtering. After reducing the marker signals, the ECD signal patterns appeared clearly and the signal sources were successfully localized even when the phantom was moved while recording.

VT-150

Multivariate pattern analysis for MEG: A comparison on spatiotemporal signatures of task-relevant information during the decision-making process.

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Our environment constantly demands different decisions. In perceptual decisions, our choices are determined by external sensory information. In preference-based decisions, our choices rely on the evaluation of endogenous value information. However, the neural representation of task rule for decision-making remains largely unknown. In the present study, we use MEG to identify spatiotemporal signatures of task-relevant information. Thirty-one healthy participants were instructed to perform preference-based or perceptual (contrast discrimination) decisions on a trial-by-trial basis, with the colour of the fixation point indicating the task rule of each trial. Before the main MEG experiment, participants remembered four spatial locations on the screen that are associated with their preferred or non-preferred food items. In the MEG experiment, a pair of Gabor patches appeared in two out of the four locations in each trial, and their contrasts were set by a staircase procedure. For preference-based decisions, participants need to choose the option whose location associated with the more preferred item. For perceptual decisions, participants are instructed to choose the option with the higher contrast. In preference-based decisions, participants were faster and more accurate in choosing between preferred and non-preferred items than between items with similar subjective values. There was no behavioural difference in perceptual decision performance between options associated with different levels of preference. Multivariate pattern analysis (MVPA) on pre-processed MEG data showed a sustained significant decoding of decision task rules before and after stimulus onset. Our findings suggest that the brain actively maintain rule-relevant information before and throughout the decision-making process.

IT-100

Adaptation of ComBat harmonization methods on Voxel-based morphometry measurements from Multi-site gray matter and white matter MRI data

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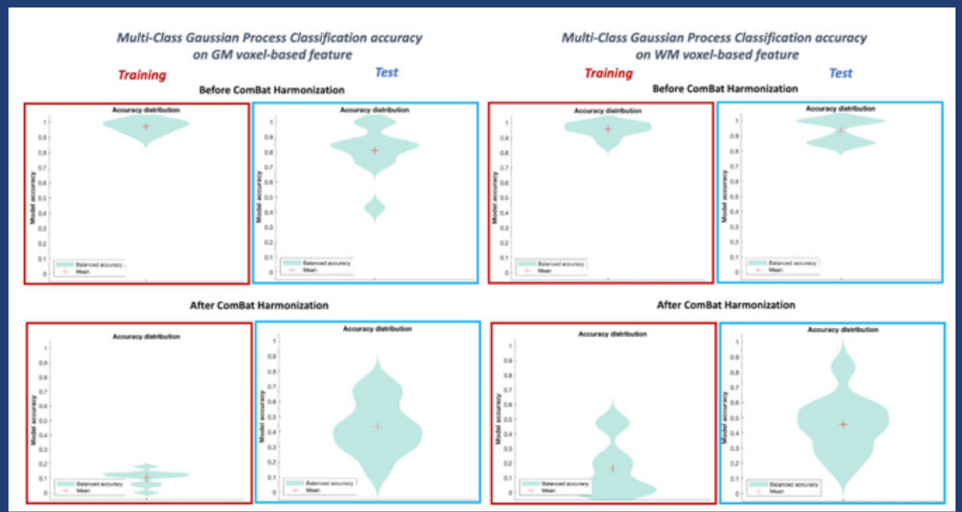
Introduction:
Multi-site magnetic resonance imaging (MRI) data can be biased by undesirable non-biological sources of variability, attributable to differences in scanners and imaging parameters. In this study, we apply ComBat technique, recently adopted to diffusion tensor imaging data, to harmonize voxel-based morphometry (VBM) features across sites and test its performance using artificial intelligence.

Method:
Gray (GM) and white matter (WM) VBM measures were obtained from three-site T1-weighted MRI images of 271 healthy subjects using CAT12. VBM data from each site was divided in training (75%) and test (25%) sets. First, ComBat was applied to GM and WM training datasets while considering age, sex and globally harmonized total intracranial volume contributions. ComBat site-effects correction coefficients assessed on training were applied to the test datasets from the same sites. ComBat efficacy was assessed by comparing the site classification accuracies based on VBM features by applying a Multi-Class Gaussian Process Classification to training and test sets, before and after ComBat harmonization.

Results:
The training accuracy of site classification based on GM and WM features was found to decrease of 90% and 80% respectively, after ComBat harmonization. Test set ComBat application resulted in a 45% site classification accuracy's reduction for GM and 37% for WM features, after ComBat harmonization.

Discussion:
Our findings demonstrate voxel-based ComBat pipeline's effectiveness at removing local site nuisance variability in brain tissue maps. Moreover, ComBat tool has shown flexibility and robustness across voxel-based features, being effective in site effects' correction on unseen independent data from the same sites.



IW-1

Magnetoencephalographic evidence for a functional role of an internal cerebellar clock

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Background The cerebellum has the reputation of being a primitive part of the human brain that mostly is involved in motor coordination and control. In a series of studies, however, colleagues and I have shown that the cerebellum is involved in clocking and creating sensory expectations of the future. In this study, I collected data with the purpose of showing the functional role of this clocking mechanism, expecting theta band (4-7 Hz) and beta band (14-30 Hz) power to correlate with differences in performance. Methods We collected data from 30 healthy participants. Participants were stimulated with sequences of non-painful electrical stimulation that always ended with either an omission or at-threshold-stimulation. Participants then had to indicate with a button press whether they were stimulated or not at the end of each sequence. The stimuli were either presented with regular or irregular time intervals between them. Results In the analysis thus far, we have found that accuracy on the behavioural task can be predicted by the variation in the sequence (the irregular sequences have more variation). We also found cerebellar activation by omissions, which depended on the regularity of the sequences, replicating earlier studies. Outstanding is the correlational analysis between cerebellar activation and performance, which will be ready for the conference. Discussion These results are likely to provide further evidence for the cerebellum functioning as an internal clock and also showcase that the cerebellum determines behaviour and performance in sensory action that requires acting and integrating evidence over precise time-scales.

IW-2

Two-person neuroscience with MEG hyperscanning: Decoding interaction mode from two-brain data

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It can be argued that studying human brains in isolation cannot reveal the neural mechanisms underlying complex real-time social interactions. We therefore used a two-person-neuroscience (2PN) approach in a two-site magnetoencephalographic (MEG) setup developed at Aalto University (Baess et al., 2012; Zhdanov et al., 2015). We aimed to elucidate the neural and behavioral signatures underlying leader–follower coordination and joint improvisation in interacting dyads. Here, we present data from 10 pairs of participants performing a 1D finger-movement mirror game while MEG was simultaneously recorded from both subjects and the related finger kinematics was tracked using accelerometers. We observed that source-level power estimates of rolandic theta were significantly stronger in followers than leaders, while occipital beta was stronger in leaders than in joint improvisers. We then applied multivariate classification on the source-level mean power of the two-brain data (1000-ms moving windows with 500-ms overlap; recursive feature elimination with a logistic regression classifier, 10-fold CV, 20% held-out) separately for six frequency bands. This analysis revealed a set of brain regions and frequency bands whose signals enabled 67–99% accuracy in classifying leader–follower interaction vs. moving in sync without designated leadership. Using all frequency bands simultaneously led to even higher mean accuracy. We conclude that two-brain data can provide insights into the neural correlates of real-time social interaction, beyond those derived from the traditional single-person framework.

IW-3

What is a rhythmic context for the brain? Insights into the mechanisms of temporal predictions.

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Predicting the timing of incoming sensory events is very helpful to optimize information processing in dynamic environments. In the presence of a periodic sensory stimulus, is it well known that temporal predictions can be formed and impact perception: for instance, the detection of a target sound improves if presented on-beat of a preceding periodic signal. However, in more naturalistic environments as speech or music, while being temporally regular, sensory events may also occur with a certain amount of temporal variability. In a series of experiments, we tested how temporal variability of a sensory context affects auditory detection. Participants were asked to detect target sounds embedded in 3 min-long sound sequences where the inter-stimulus-intervals of each sequence were drawn from Gaussian distributions with the same mean (500 ms) but different standard deviations (SD): from 0 ms (periodic) to uniform. At the end of each sequence, we also asked participants to rate their subjective perception of rhythmicity. Behavioral results suggest that auditory detection performance progressively declines with temporal variability, and that temporal predictability effects cease to be observed only for the more variable contexts. Moreover, individual variability could also be explained by the subjective perception of rhythm suggesting that temporal predictions mechanisms rely on internal model of rhythm. Altogether, these findings suggests that temporal prediction mechanisms are robust to temporal variability, and that temporal predictions can be built on sensory stimulation that is not purely periodic nor temporally deterministic. An EEG experiment based on the same experimental design is currently being analyzed.

IW-31

Modulation of M100 amplitude for tones of different frequencies at equal sound pressure level

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Background: In daily life, peoples are exposed to a wide variety of sounds and select the necessary sound information semiautomatically (e.g., linguistic information in environmental sounds). To investigate the selection process of sound information, pure tones in the 200–1000 Hz range were presented.

Methods: Twelve typically development adults with normal hearing subjected in this study. Subjects' brain activity was measured using a 101 ch MEG (Elekta Neuromag, customized). 200 Hz, 300 Hz, 500 Hz, and 1,000 Hz tones were presented. All tones were faded in/out for 10 ms, with a duration of 300 ms and a sound pressure of 70 dB SPL. The dipole estimation was performed for each left and right hemisphere. The maximum value in the 80–120 ms interval of the equivalent current dipole power was the M100 peak amplitude. A two-factor repeated measures analysis of variance was performed for hemisphere (left, right) × frequency (200, 300, 500,1000 Hz).

Results: There was a significant main effect of frequency ($F(3,9) = 5.7$, $p < .05$), reflecting the relative enhancement of the M100 peak amplitude to the 1,000 Hz tone. In uncorrected comparisons, 1,000 Hz M100 peak amplitude was enhanced relative to 300 Hz and 200 Hz, and 500 Hz M100 peak amplitude was enhanced relative to 200 Hz ($p < .05$, respectively).

Discussion: The present study demonstrates that brain activity corresponding to different frequencies occurs even when no task and no attention to the tone. These results suggest that auditory information is selected bottom-up and filtered semiautomatically.

IW-4

MEG, myself, and I: individual identification from neurophysiological brain activity

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Large, openly available datasets and current analytic tools promise the emergence of population neuroscience. The considerable diversity in personality traits and behaviour between individuals is reflected in the statistical variability of neural data collected in such repositories. This variability challenges the sensitivity and specificity of analysis methods. Yet, recent studies with functional magnetic resonance imaging (fMRI) have concluded that patterns of resting-state functional connectivity can both successfully identify individuals within a cohort and predict their individual traits, yielding the notion of a neural fingerprint. Here, we aimed to clarify the neurophysiological foundations of individual differentiation from features of the rich and complex dynamics of magnetoencephalography (MEG) resting-state brain activity in 158 participants. The resulting neurophysiological functional connectomes enabled the identification of individuals with similar identifiability rates to fMRI. We also show that individual identification was equally successful from simpler measures of the spatial distribution of neurophysiological spectral signal power. Our data indicate that identifiability can be achieved from brain recordings as short as 30 seconds, and that it is robust over time: individuals remain identifiable from recordings performed weeks after their baseline reference data was collected. Our results emphasize the value of MEG-based neural fingerprints. We can anticipate a vast range of diverse applications in the personalized, clinical, and basic neuroscience of individual differentiation from large-scale neural electrophysiology, in future longitudinal and cross-section studies.

IW-5

Statistical Learning of Distractor Suppression is Expressed as Altered Neural Excitability in Early Visual Cortex

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Visual attention is highly influenced by past experiences. Attention is implicitly devoted to locations where informative stimuli are more likely. Recent behavioural research has shown that expectations about the spatial location of distractors within a search array are also implicitly learned, and that expected distractors are less interfering. Little is known about the neural mechanism supporting this form of statistical learning. Here we recorded MEG to test whether proactive mechanisms are involved in the statistical learning of distractor locations. Specifically, we used rapid invisible frequency tagging (RIFT) to assess neural excitability in early visual cortex and time-frequency analysis of power to investigate the involvement of alpha-band activity (8-12 Hz). Participants performed a visual search task in which a target was occasionally presented alongside a colour-singleton distractor. Unbeknown to the participants, the distracting stimuli were presented with different probabilities across the two hemifields. The MEG data showed that this distractor probability manipulation produces a change in the RIFT response in early visual cortex, with lower responsiveness to locations associated with higher distractor probabilities. We did not find any evidence of an expectation-driven distractor suppression in the alpha-band activity. These findings indicate that proactive mechanisms of attention are involved in implicit distractor suppression and that these mechanisms are associated with altered neural excitability in early visual cortex. Moreover, our findings indicate that RIFT and alpha-band activity might subtend different and possibly independent attentional mechanisms.

IW-6

The effect of two nights of sleep restriction on emotional attention – a MEG study

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Sleep loss is associated with changes in emotional functioning which extend beyond self-reported mood. The aim of this magnetoencephalography (MEG) study was to test if two nights of sleep restriction altered attention allocation, measured by visual Steady State Response (vSSR), towards Unpleasant or Neutral pictures. Thirty-three healthy, well-sleeping participants were tested twice; after normal sleep and after two nights of sleep restriction (time in bed: 01:00 – 05:00). We used a cued-detection task with an arrow indicating which direction to covertly focus attention (executive control), followed by two simultaneously presented pictures (emotional attention), one Unpleasant and one Neutral, tagged with frequencies (left: 30Hz, right: 40Hz), followed by a response-probe to the left or right. Results showed that covert attention was successfully directed in the arrow direction, especially in visual cortex as indicated by an increase of up to 40% in vSSR power. However, sleep restriction did not alter the attention towards Unpleasant or Neutral pictures (emotional attention). Sleep restriction did also not alter attention allocation towards the arrow direction (executive control). Taken together, using a sleep restriction protocol we could not resolve the reason for the puzzling responses to affective stimuli previously found after total sleep deprivation, as we found neither an increased response towards Unpleasant nor Neutral pictures. It is possible that two nights of sleep restriction have a weaker effect on emotional functioning than one night of total sleep deprivation. The study contributes with novel methodology, assessing the effects of sleep restriction on emotional attention using MEG and vSSR.

IW-7

Valence based emotions altered by emotion judgement task: Observer or Expresser effect.

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Behavioural studies have reported hemifacial bias suggesting one-half of the face to be more expressive. In our previous study, we provided neurological evidence (using MEG) for hemi-facial bias. Previous literature provides evidence that emotion recognition is affected by the judgement task (Observer or Expresser), but how hemi-facial bias interacts with emotion judgement task has gained very little attention. Here, we present results from two MEG studies. In the first study, the participants (N=13) were presented with both positive (+90 & +45 degree) and negative (-90 & -45 degree) faces depicting Happy and Sad emotions for 1000 ms and they had to report the emotion depicted in the stimuli. In the second study, the participants (N=24) were presented with rapid stimulation of emotional faces for 500 ms followed by two other pictures. They were asked to match it with the target face (emotion). To increase the complexity of judgement, the target picture was changed while keeping emotion constant. The data for both the studies was collected at the Northern Ireland Functional Brain Mapping (NIFBM) facility available at Ulster University, UK. We report a strong effect of hemi-facial effect in first study (Observer). The differential amplitude of evoked responses activity from happy and sad emotion emerged only in positive face angles, but not for negative face angles. This effect was not found for expressers (second study). The findings support the behavioral literature focusing on role of judgement task on emotion recognition.

IW-8 Magnetoencephalography correlates of aversive prediction error

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Pain results in an aversive prediction error (PE) that fosters learning and avoidance. While fMRI data support the involvement of periaqueductal grey in encoding aversive PE, the temporal properties of aversive PE are poorly understood. We present preliminary data from an ongoing project that aims to localize the temporal evolution of aversive PEs in healthy controls and subsequently in patients with CRPS. 14 healthy controls performed an instrumental pain avoidance task inside an MEG scanner. The task entailed choosing between 2 options, while learning to avoid the option with high probability of receiving a mechanical pain outcome. Subjects' task behavior were computationally modelled as a function of pain outcome to estimate PEs. Preprocessed MEG signals were source estimated. Time-averaged source maps corresponding to short-latency evoked components following outcome onset were entered into a linear regression model to identify sources that were parametrically modulated by PEs. Short latency evoked fields in response to mechanical pain were identified at 30ms(N1), 50ms(P1) and 85ms(N2) localized over S1. No significant PE-correlated clusters were identified in the 15–40ms and 40–65ms latencies. Significant clusters localized to the left insula, left dorsolateral prefrontal cortex and anterior-mid cingulate were observed in the 65-90ms latency. We show for the first time MEG correlates of mechanical pain aversive PEs. The time course of the PE overlapped with the early N2 component. The involvement of multiple brain foci in the early stages of pain processing could provide insights into cue-pain associative learning impairments in pain patients.

IW-9 Changes in anterior cingulate and medial prefrontal oscillations are associated with altered signatures of Bayesian predictive coding in trait anxiety

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BACKGROUND. Misestimation of uncertainty is a central feature of learning difficulties in anxiety. In Bayesian predictive coding (PC), precision or uncertainty weights on prediction errors shape the relative influence of prior beliefs and sensory evidence on belief updating. Rhythm-based accounts of Bayesian PC further suggest that precision-weighted prediction errors (pwPEs) are encoded in gamma oscillations (>30 Hz), while predictions are represented in 8–30 Hz oscillations. In this framework, states of anxiety have been shown to bias uncertainty estimates during decision making in a volatile environment, impairing belief updating and learning. METHODS. We used magnetoencephalography to investigate how subclinical trait anxiety modulates the source-level spectral correlates of pwPEs during reward-based learning. Two groups of high and low trait anxiety (HTA, LTA; N = 39) participants performed a probabilistic reward-based learning task with changing stimulus-reward contingencies. We modelled behaviour using a hierarchical Bayesian learning model, quantifying the parametric effects of trial-wise estimates of pwPEs on the source-level time-frequency responses using convolution modelling and LCMV beamforming. RESULTS. We show that misestimation of different types of uncertainty can promote learning in HTA despite an initial adaptation deficit. These changes are driven by inflated estimates of environmental volatility, increasing the degree to which new outcomes update beliefs. Convolution modelling reveals that HTA enhances gamma responses and decreases alpha/beta activity associated with pwPEs about stimulus outcomes relative to LTA. These effects are observed in the orbitofrontal cortex, anterior cingulate cortex and prefrontal cortex. Discussion. We discuss our results in the context of precision psychiatry.

IW-10

Spatial attention tunes temporal processing in early visual cortex

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The perception of dynamic visual stimuli relies on two apparently conflicting perceptual mechanisms: rapid visual input must sometimes be integrated into unitary percepts but at other times must be segregated or parsed into separate objects or events. Though they have opposite effects on our perceptual experience, the deployment of spatial attention benefits both of these operations. Little is known about the neural mechanisms underlying this impact of spatial attention on temporal perception. Here we use magnetoencephalography (MEG) to demonstrate that the deployment of spatial attention for the purpose of segregating or integrating visual stimuli impacts pre-stimulus oscillatory activity in retinotopic visual brain areas where the attended location is represented. Alpha-band oscillations contralateral to an attended location therefore speed up when stimuli appearing at this location will need to be segregated, but slow down in expectation of the need for integration, consistent with the idea that alpha frequency is linked to perceptual sampling rates. These results demonstrate a novel interaction between temporal visual processing and the allocation of attention in space.

IW-11

Coupling of pupil-and neuronal population dynamics reveals diverse influences of arousal on cortical processing

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Fluctuations in arousal, controlled by subcortical neuromodulatory systems, continuously shape cortical state, with profound consequences for information processing. Yet, how arousal signals influence cortical population activity in detail has so far only been characterized for a few selected brain regions. Traditional accounts conceptualize arousal as a homogeneous modulator of neural population activity across the cerebral cortex. Recent insights, however, point to a higher specificity of arousal effects on different components of neural activity and across cortical regions. Here, we provide a comprehensive account of the relationships between fluctuations in arousal and neuronal population activity across the human brain. Exploiting the established link between pupil size and central arousal systems, we performed concurrent magnetoencephalographic (MEG) and pupillographic recordings in a large number of participants, pooled across three laboratories. We found a cascade of effects relative to the peak timing of spontaneous pupil dilations: Decreases in low-frequency (2–8 Hz) activity in temporal and lateral frontal cortex, followed by increased high-frequency (>64 Hz) activity in mid-frontal regions, followed by monotonic and inverted U relationships with intermediate frequency-range activity (8–32 Hz) in occipito-parietal regions. Pupil-linked arousal also coincided with widespread changes in the structure of the aperiodic component of cortical population activity, indicative of changes in the excitation-inhibition balance in underlying microcircuits. Our results provide a novel basis for studying the arousal modulation of cognitive computations in cortical circuits.

IW-12

Phase of neuronal oscillations correlates with temporal integration

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Interaction with the environment relies on integration of incoming signals. The neuronal processes underlying these integration processes are not fully understood. In the present study, we investigated the role of the phase of neuronal oscillations for visual integration. We recorded neuronal activity from 25 participants using MEG (MEGIN Oy, Finland) while subjects performed a visual temporal integration task. In this task, two stimuli are presented with a variable interstimulus interval (ISI). Each stimulus consisted of annuli located on a 4x4 grid. If both stimuli were combined, one position on the grid remained empty. Participants' task was to locate the empty position. This task could only be solved if both stimuli were temporally integrated (Wutz et al., 2016). In a pre-experiment we determined individual ISI for which participants could locate the empty position in 50%. Next, MEG data were projected on source-level. We contrasted neuronal activity of trials with successful integration vs. no integration (i.e., correct vs. incorrect trials). To estimate differences in phases of neuronal oscillations, we used the phase opposition sum (POS, VanRullen, 2016), which computes differences in intertrial phase coherence across trials and between conditions. We found POS values in the alpha/beta-band in parieto-occipital regions to be significantly different from surrogate data. The results indicate that the phase of neuronal oscillations was different between trials with successful integration compared to trials in which integration of the two stimuli was not successful. The results indicate that the phase of neuronal oscillation plays a role for visual temporal integration.

IW-13

Oscillatory correlates of behavioural control over internal and external errors

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Agents can optimise behaviour by monitoring the outcome of their actions. When an action produces an undesirable outcome, the agent can adjust their behaviour ('behavioural control'). However, undesirable outcomes can be result from two distinct sources, which require different sources of control: Firstly, an 'internal' error such as a mis-perception, which requires continuing with the current strategy, but increasing effort (e.g., slowing down); Secondly, an 'external' error arising from a change in the environment, which requires a new strategy (e.g., updating a cognitive map). Typically, agents must deal with both noisy perceptual input and changing environments at the same time. What neural signals are associated with control of internal and external errors? And, when feedback is given to indicate an undesirable outcome, how is the brain response different if that outcome is attributed to an internal or external error? I will present behavioural and EEG data from a novel task where participants have to perform a difficult orientation judgement in a pair of lateralised targets, one of which is associated with a reward at any given time. Thus, reward omission can arise both from mis-judging an orientation, or from selecting the wrong target. Preliminary EEG analysis suggests that posterior alpha power – a correlate of visual attention – likely relates to control of internal errors, being higher on correct than error trials. In contast, motor beta likely relates to external errors, being higher on and preceding side-switches and on trials was faster reaction times. These findings illuminate distinct sources of behavioural control.

IW-14

Altered functional connectivity serving cognitive flexibility in regular cannabis users

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Background: Cannabis is known to impact higher-order cognitive processes such as attention and executive function. However, little is known regarding the neural oscillatory dynamics serving cognitive flexibility, a component of executive function, in cannabis users. Methods: We recruited 25 participants who had used cannabis at least two times per week for the past three years and 30 demographically matched nonuser controls. Participants completed neuropsychological testing, an interview regarding their current and past substance use, a urinalysis to confirm self-reported substance use, and a task-switch cognitive paradigm during magnetoencephalography (MEG). Time-frequency windows of interest were identified using a data-driven approach, spectrally specific neural activity was imaged using a beamformer, and whole-brain neural switch cost maps were computed by subtracting the switch condition from the no-switch condition per participant. Using the peak voxels in these neural switch cost maps as seeds, connectivity was computed using voxel-wise coherence. Results: Cannabis users exhibited altered functional connectivity between visual cortices and regions in the frontoparietal network in theta, alpha, and gamma frequency ranges (all ps < 0.05, corrected). Additionally, by integrating the neuropsychological data, we found a significant group-by-attention performance interaction ($p = 0.017$) predicting alpha functional connectivity between the right visual cortex and right middle temporal gyrus, suggesting differential patterns of functional connectivity associated with attention performance in cannabis users compared to nonusers. Discussion: These results indicate modified multispectral functional connectivity between visual cortices and brain structures underlying executive function in cannabis users.

IW-15

Dynamic variation of individual alpha peak frequency is linked with interoceptive sensitivity and approach motivation

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Alpha oscillations show individual stability in frequency (individual alpha peak frequency, IAPF), which, however, is modulated due to cognitive demands. IAPF has been linked also with variance in perceptual sampling and integration. IAPF may thus influence how the brain reacts to external (or internal) information flow. Previous studies have linked IAPF mainly with cognitive functions, but it may also underlie our tendency to respond to 'social demands', mediated via exteroceptive and interoceptive sensations. We studied the relationship between MEG determined IAPF and the approach-avoidance motivation, as estimated by BIS/BAS scale, in 50 adults. We determined IAPF during exteroceptive vs. interoceptive tasks and further examined its link with interoceptive sensitivity (IS). We used 48x20s blocks with sounds either in synchrony (half of the blocks) or asynchrony with the individually determined heartbeat. The sounds in each block were either all the same (half of the blocks) or with single deviant. The MEG tasks were SOUND discrimination (deviant/no deviant, 24 blocks), HEARTbeat discrimination (heart-sound synch/not synch, 24 blocks), and REST (eyes closed/open). Higher behavioural approach was associated with larger IAPF difference in SOUND vs. REST (EC). Moreover, better performance in the HEART task (IS) was associated with larger IAPF difference in SOUND vs. HEART. Thus, stronger task-related reactivity of IAPF may link with higher approach motivation and flexible engagement in processing external vs. internal information. In general, the dynamics of IAPF may be relevant for understanding the individual differences not only in cognitive functions but also in psychological experience.

IW-16

Neural oscillatory dynamics underlying attentional reorienting during development

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Background: Flexible allocation of attention undergoes a protracted developmental course with changes occurring into adolescence, which may be due to the maturation of networks of regions underlying the coordination of adaptive attention re-orienting. The current study examined the neural oscillatory dynamics underlying attention reorienting in a large developmental sample. Methods: We used magnetoencephalography (MEG) to examine neural oscillatory activity during a Posner cuing task in 80 healthy youth (6–14 years-old). In the valid condition, the cue and target appeared in the same location, while in the invalid condition the cue and target appeared in opposite hemifields. All MEG data were converted to the time-frequency domain and imaged using a beamformer. Peak activity from beamformer images was correlated with age, accuracy, and reaction time. Results: Behaviorally, the ability to reorient attention improved with age (validity effect RT, $p = .02$). Oscillations within the alpha-beta and theta bands during attention reorienting (invalid > valid) were stronger in key regions of the dorsal and ventral attention networks (e.g., right precuneus, right middle frontal gyrus and orbitofrontal cortex, and left lingual gyrus). Stronger oscillatory activity in the alpha-beta band within the left lingual gyrus correlated with improved accuracy ($p = .04$). Discussion: Findings suggest age-related improvements in behavior, with increased oscillatory activity during flexible allocation of attention in brain regions within the dorsal and ventral attention networks. Associations with task performance were specific to alpha-beta oscillatory activity within the lingual gyrus, a region that has been implicated in top-down visual reorienting processes.

IW-17

Attention directed to proprioceptive stimulation alters its cortical processing in the primary sensorimotor cortex

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Background. Movement-evoked fields to passive movements and corticokinematic coherence (CKC) between limb kinematics and magnetoencephalographic (MEG) signals can both be used to quantify the degree of cortical processing of proprioceptive afference. We examined whether processing of proprioceptive afference in the primary sensorimotor cortex is modulated by attention directed to the proprioceptive stimulation of the right index finger using a pneumatic-movement actuator to evoke continuous 3-Hz movement for 12-min. Methods. Twenty healthy volunteers (mean ± SD age 27.8 ± 5 years; 10 females). were measured using whole-scalp MEG. The participant attended either to a visual (detected change of fixation cross colour) or movement (detected missing movements) events. The attentional task alternated every 3-min. Coherence was computed between index-finger acceleration and magnetoencephalographic signals, and sustained-movement-evoked fields were averaged with respect to the movement onsets every 333 ms. Results. Attention to the proprioceptive stimulation supressed the sensorimotor beta power (by ~12%), enhanced movement-evoked field amplitude (by ~16%) and reduced corticokinematic coherence strength (by ~9%) with respect to the visual task. Coherence peaked at the primary sensorimotor cortex contralateral to the proprioceptive stimulation. Discussion. Our results indicated that early processing of proprioceptive afference in the primary sensorimotor cortex is modulated by inter-modal directed attention in healthy individuals. Therefore, possible attentional effects on corticokinematic coherence and movement-evoked fields should be considered when using them to study cortical proprioception in conditions introducing attentional variation.

IW-18

Individual MEG resting state criticality parameter predicts bistable percept stability

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Background One bistable perception paradigm, used to understand conscious perception, is the structure-from-motion (SfM) task, which presents 2D objects that are perceived as moving 3D objects. Previous research related cortical alpha (around 10Hz) and gamma (>40Hz) rhythms to bistable percept switches. Conscious experience is a highly individual case; however, studies investigate consciousness typically at the level of groups. Yet, it seems essential to study individual differences in neural activity and how they relate to conscious experience. Methods We collected MEG resting-state data from 22 volunteers, who later performed a bistable SfM task, in which they indicated whether a dot cloud moved left- or rightwards. We analyzed source-space MEG data filtered in different frequency bands (alpha, gamma, and broadband). As indicators of self-organized criticality, we extracted avalanche numbers and computed the slope of avalanche distributions in each subject. We also computed resting-state alpha band power, adjusted for aperiodic activity. We correlated the slope in different frequency bands and alpha power to percept stability (average percept duration in seconds). Results Using non-parametric correlations, we found a relationship between the criticality parameter slope in the alpha band and percept duration such that longer percept duration correlated with smaller slopes (closer to -1.5). Neither slopes estimated from gamma, or the broadband signal nor alpha power was correlated to behavior. Discussion In this exploratory study, we found that an alpha band measure of criticality, which can be a global measure of excitability, was related to individual percept stability in a bistable paradigm.

IW-19

Dissociating Neural Bases for Predictive Processes in Language Comprehension Using MEG

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Neurocognitive research on language comprehension revealed that language comprehenders continuously generate a prediction about upcoming input. The generation of prediction is reflected by the EEG component N400 (Kutas and Federmeier, 2011) and/or the MEG component M350 (Dikker and Pylkkanen, 2013; Maess et al., 2016). Nevertheless, it is still debated about the nature of such neural reflections (Niewland et al., 2019). In this research, we investigate the nature of neural reflections of predictive processes in language comprehension using MEG. Twenty-nine native Japanese speakers participated in the experiment measuring neuromagnetic activities while they silently read 216 short Japanese sentences projected on the screen word-by-word. Japanese is one of the languages that employ a classifier system in counting elements; "three cars", for instance, must be expressed as "san-dai-no kuruma (lit. three bodies of car)" instead of "#mit-tsu-no kuruma (lit. three pieces of car). The preceding classifier "-dai" yields a strong forward prediction for the up-coming noun. MEG data were recorded using a whole-head 306 channel Electa-Neuromag MEG system. Recorded data were analyzed by SPM12 M/EEG software package. Preliminary analysis of 13 participants indicated that neural activities in the left middle temporal gyrus (MTG) is modulated by the degree of naturalness of the sentence. Whereas the right MTG and bilateral occipital gyrus showed stronger activation at the position of less-predicted nouns in the 400-600ms time window. We will report the result of analysis of 29 participants and discuss its implications on the neural bases of predictive processing.

IW-20

Spatiotemporal Oscillatory Dynamics of Visual Selective Attention during a Simon Task

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Background: The Simon task is a test of visual selective attention that has been widely used to probe conflict monitoring, interference resolution, and cognitive control. However, to date, few studies have focused on the selective attention component of this task and imaged the underlying oscillatory dynamics serving task performance. We investigate the network level dynamics serving successful performance by leveraging the excellent spatial and temporal precision of magnetoencephalography (MEG). Methods: MEG data were collected from thirty-three healthy adults (ages 27-44) during a number-based Simon task and were preprocessed and transformed into the time-frequency domain. Significant time-frequency windows were identified using a data-driven approach across conditions and these were imaged by condition using a beamformer. Voxel-wise paired t-tests were used to identify brain regions exhibiting differences in oscillatory activity between conditions. Results: Across both congruent and Simon conditions, we observed robust decreases in alpha (8-12 Hz) activity in the bilateral occipital cortices and cuneus, and increases in theta (3-6 Hz) activity in the bilateral frontal eye fields, right insula, and left premotor cortex. Paired t-tests between conditions revealed stronger alpha desynchronization in the Congruent relative to the Simon condition in the insula, and stronger theta synchronization in the middle temporal gyrus. Discussion: These findings suggest that region and spectrally-specific oscillatory dynamics contribute to visual selective attention processes in the Simon task, and that such processes are transient and fully completed shortly after the behavioral response in most trials.

IW-21

Effects of Chronic Cannabis Use on the Neural Dynamics Underlying Attentional Reorientation

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Background: Cannabis is the most widely used illicit drug in the United States and is often associated with changes in attention function, which may ultimately impact numerous other cognitive faculties (e.g., memory, executive function). Importantly, despite the increasing rates of cannabis use and widespread legalization in the United States, the neural mechanisms underlying attentional dysfunction in chronic users are poorly understood. Methods: We used magnetoencephalography (MEG) and a modified Posner cueing task in 21 chronic cannabis users and 32 demographically-matched non-user controls. MEG data were imaged in the time-frequency domain using a beamformer and peak voxel time series were extracted to quantify the oscillatory dynamics underlying use-related aberrations in attentional reorienting, as well as the impact of spontaneous neural activity immediately preceding stimulus onset. Results: Behavioral performance on the task (e.g., reaction time) was similar between chronic cannabis users and non-user controls. However, the neural data indicated robust theta-band oscillatory across a distributed network during attentional reorienting, with activity in the bilateral inferior frontal gyri being markedly stronger in users relative to controls. Additionally, we observed significantly reduced spontaneous theta activity across this distributed network during the pre-stimulus baseline in cannabis users relative to controls. Conclusions: Despite similar performance on the task, we observed specific alterations in the neural dynamics serving attentional reorienting in chronic cannabis users compared to controls. These data suggest that chronic cannabis users may employ compensatory processing in the prefrontal cortices to efficiently reorient their attention relative to non-user controls.

IW-22

Causal role for medial prefrontal cortex in reality monitoring

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Background:Reality monitoring (RM) is distinguishing self-generated from externally-derived information. RM impairments are particularly relevant for patients with schizophrenia (SZ), and contribute to psychotic symptoms of hallucinations (indicating the break with reality). We have shown using functional MRI and magnetoencephalography imaging (MEGI) that the medial prefrontal cortex (mPFC) plays a critical role in RM in healthy controls (HC), emphasizing the critical need to investigate whether mPFC can causally impact RM. Unfortunately, mPFC is hypoactive during RM in SZ. Here, we examine whether increasing mPFC activity with high-frequency 10Hz repetitive transcranial magnetic stimulation (rTMS), causally enhances RM in SZ. Methods:We conducted a randomized controlled trial in which HC and SZ are assigned to either active 10Hz rTMS to increase mPFC activity or to a sham/control condition. Using MEGI RM tasks from pre-to-post rTMS, we examine how active rTMS modulation of mPFC activity causally induces neural and behavioral plasticity in the RM network in HC and SZ compared to the control condition, for future novel therapeutics in SZ. Results: Active 10Hz of rTMS, HC (N=10) showed significantly improved RM performance, compared to the control. After 10Hz rTMS targeting mPFC vs. baseline, HC and SZ (N=10) showed enhanced mPFC activity (i.e., greater beta power reductions) during encoding of information, which induced concomitant improvements in memory retrieval accuracy in HC and SZ. Discussion:Results show for the first time that the mPFC represents a higher-order neural structure that causally mediates RM, whose activation can be increased by rTMS even in chronically-ill SZ.

IW-23

Anticipatory Beta-Burst Probability Distributions in a Visual Attention Network during an Antisaccade Task

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Background: Antisaccade tasks require the participant to inhibit a reflexive “prosaccade” towards a peripheral stimulus, and instead make a deliberate “antisaccade” in the opposite direction. Impairments on this task likely reflect impaired top-down inhibitory control of attention, which are found in Attention-Deficit/Hyperactivity Disorder (ADHD) and Specific Learning Difficulties (SpLDs). We investigated “beta-burst” probability distributions in a visual attention network during the anticipatory period preceding a prosaccade/antisaccade target, and effects of gaze-control training (RECOGNeyes) on these distributions. Methods: Before and after two weeks of RECOGNeyes training, 35 volunteers with a SpLD/ADHD completed an antisaccade task, whilst magnetoencephalography (MEG) and autonomic measures (pupillometry and heartrate) were recorded. Antisaccade blocks alternated with prosaccade blocks (6 trials/block). An alerting cue was presented 800ms before each target stimulus. Results: Antisaccade reaction times (RT) improved after RECOGNeyes training. Over the cue-target period, MEG beta-burst probability reduced then increased. On Day 2 and antisaccade trials, a further “anticipatory” reduction occurred 100ms before the target. Greater pupil dilation and cardiac deceleration rates correlated with faster RTs. Discussion: Increased beta-bursts in the anticipatory period prior to the target could reflect preparation of internal inhibitory control processes. The “anticipatory” reduction in beta-bursts on Day 2 and antisaccade trials is a potential marker for top-down anticipatory control for making the upcoming required attentional shift, and may relate to timings of autonomic alerting and orienting processes. Our findings warrant further investigation using a multi-modal approach and could inform the development of new therapeutic interventions for ADHD and SpLDs.

IW-24

Neural correlates of predictive coding in continuous speaking and listening

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The underlying neural substrates of speech production and perception are partially shared, but they are also supported by distinct neural networks. Here we used magnetoencephalography (MEG) in order to examine the underlying neural substrates and their frequency-specific communication channels driving natural speech production and perception. Participants (n=30) answered seven given questions (60 seconds each; condition #1) as well as listened to audio-recordings of their own voice from previous sessions (condition #2) while MEG data was recorded (CTF Systems). Amplitude envelope was extracted from the continuous speech signal. Individual MRIs were used to estimate source models per participant. Cortical areas were divided into 230 anatomical parcels. For each parcel, the first three SVD components were extracted. We then estimated mutual information (MI) between the speech envelope and all three time series. Next, using a blockwise approach, we estimated the connectivity between the left STG (LSTG) and other parcels using a multivariate nonparametric Granger causality approach (mCG). Our speech-brain coupling results separated the temporal areas following the speech envelope (in the theta range) from frontal and motor areas preceding the speech envelope (in the delta range). Moreover, our connectivity results indicate that the feedback signals, connecting higher areas such as motor to STG, represent predictions and are communicated via slow rhythms (below 40 Hz) whereas feedforward signals (reverse direction) represent prediction errors and are communicated via faster rhythms (above 40Hz). Our findings bring novel insights into how multiple brain areas interact to produce or perceive speech through different frequency bands.

IW-25

The human brain compresses binary sound sequences using a language of thought

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When perceiving sequences of events, the human brain grasps the present regularities to encode them in memory and predict future events. In this study, we consider binary sequences of sounds that exhibit various levels of sequence knowledge, ranging from transitional probabilities to chunks and nested structures. We assume that, to compress these sequences in memory, we adopt a mental description expressed in terms of an algorithmic-like language: a language of thought. To test this hypothesis, we recorded participants' brain activity with MEG and with fMRI while they were listening to these sequences. Results conform with our predictions. In addition to the processing of statistical properties, the observed brain responses are modulated by sequence complexity, i.e. the minimal description length provided by the formal language. When participants were discovering the sequence structure, brain activity increased with sequence complexity. Conversely, when deviant sounds were introduced to probe neural expectations, novelty responses were reduced as sequences became more complex. These results suggest that the language of thought we use to encode these sequences involves repetitions with variations and allows for recursive composition into nested structures.

IW-26

Recruitment of mentalizing system in verbal communication – Magnetoencephalographic hyperscanning study

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Language, i.e., verbal communication is important communication tool for human beings. In verbal communication, a person not only recognizes other's words but also predicts the other's behavior to plan the next utterance. The mentalizing system, which enables to infer the mental state of others, should be essential for communication, but its involvement remains largely unexplored. The purpose of this work was to clarify the neural processes of the mentalizing system by our magnetoencephalographic hyperscanning system. Ten pairs, 20 adults participated in this study. Each participant, facing the partner virtually, uttered alternatively in natural or patterned condition. In natural condition, each participant uttered a word associating to partner's utterance. In patterned condition, each participant uttered consecutive Japanese syllabary. Magnetoencepalograms of paired participants were recorded simultaneously and amplitudes of the spontaneous brain rhythm were analyzed. The target time windows were set before (think state) and after (wait state) each utterance. 3-way RM ANOVA, condition (natural/patterned) x brain region (62) x state (think/wait), revealed significant interaction (p_0.05) in the amplitude of alpha-band (8-12 Hz) rhythm. Also, 2-way RM ANOVA of condition and brain region were significant for each state (p_0.05). Post-hoc t-test showed the amplitude of alpha-band rhythm was significantly lower for natural condition in 19 brain regions (think state) and 39 brain regions (wait state) relating to mentalizing system. Our results suggest mentalizing system plays important role in verbal communication and is more recruited after each utterance (wait state) rather than before utterance (think state).

IW-27

Neuromotor control of speech: Results from a MEG-compatible speech tracking system

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Background. Functional neuroimaging and articulography and are two major tools for studying the neurobiology of speech production. Until now, however, it has generally not been feasible to use both in the same experimental setup because of technical incompatibilities between the two methodologies. Here we describe results from a novel articulography system dubbed Magneto-articulography for the Assessment of Speech Kinematics, used for the first time to obtain kinematic profiles of oro-facial movements during speech together with concurrent magnetoencephalographic (MEG) measurements of neuromotor brain activity. Methods. MASK was used to characterise speech kinematics in six healthy adults, and the results were compared to measurements from a separate participant with a conventional Electromagnetic Articulography (EMA) system. Analyses targeted the gestural landmarks of reiterated utterances /ipa/ and /api/ and time-registered beta-band MEG activity. Results. The results demonstrate that MASK reliably characterises key kinematic and movement coordination parameters of speech motor control; and that these parameters are reflected in neural beta-band responses generated in para-central and precentral motor regions of the brain. Discussion. This new capability for measuring and characterising speech movement parameters, and the brain activities that control them, within the same experimental setup, paves the way for innovative cross-disciplinary studies of neuromotor control of human speech production, speech development, and speech motor disorders.

IW-28

Functional hyperconnectivity during verb generation in magnetoencephalography persists to age 8-12 years for children born extremely preterm

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Children born extremely preterm (EPT) are at risk for language difficulties, but outcomes are heterogenous. We previously reported functional hyperconnectivity in EPT at 4-6 years that positively correlated with language skills. Here, we use multimodal neuroimaging to investigate brain markers of resiliency, relating connectivity to language at 8-12 years for EPT and term children (TC). In this preliminary report of a longitudinal study of language in EPT, we analyze functional connectivity (weighted phase lag index, wPLI) in 16 EPT and 18 TC using fMRI-constrained magnetoencephalography (MEG) during verb generation. fMRI is obtained at 3T (Philips Ingenia). MEG is recorded at 1200Hz (275-channel CTF). Verbs-Noise contrasts are generated for fMRI. Activation maps are parcellated into 200 random units. Parcels with >10% activation serve as nodes for MEG analyses. Linearly constrained minimum variance beamforming estimates activity at each node. wPLI is calculated from trial-wise frequency representations and compared between groups using cluster-based permutation testing, then correlated with Core Language scores from the Clinical Evaluation of Language Fundamentals. There are no significant group differences in age, sex, or language representation on fMRI. EPT score lower than TC on Core Language (unlike at 4-6 years). EPT exhibit functional hyperconnectivity versus TC at 59.5-70Hz, not correlated with language skills. However, there is a significant cluster of correlations between wPLI and language performance at 2-8.5Hz (rho 0.34-0.44). Functional hyperconnectivity persists in EPT to 8-12 years. Low-frequency connectivity relates to language performance. Ongoing work will determine the trajectory of this hyperconnectivity and role in language development.

IW-29

What is a rhythmic context for the brain?

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The ability to make predictions on the timing of upcoming sensory events is a major adaptative brain function that helps to optimize information processing in dynamic environments. In the presence of a periodic sensory stimulus, is it well known that temporal predictions can be formed and impact perception: for instance, the detection of a target sound improves if presented on-beat of a preceding periodic signal. However, in more naturalistic environments as speech or music, while being temporally regular, sensory events may also occur with a certain amount of temporal variability. Here we tested how the temporal variability of a sensory context affects perception. Specifically, we asked how rhythmic the sensory context needs to be in order to observe temporal prediction effects on auditory detection. Participants were asked to detect target sounds that where embedded in 6 min-long sound sequences. The inter-stimulus-intervals of each sequence were drawn from Gaussian distributions. The distributions had the same mean (500 ms) but different standard deviations (SD): from 0 ms (periodic) to 150 ms SD. Preliminary results suggest that auditory detection performance progressively declines (as measured by a lower d-prime and longer reaction times) with the temporal variability of a context, and that temporal predictability effects cease to be observed only for the more variable contexts (> 100 ms SD). Therefore, this work suggests that temporal prediction mechanisms are robust to temporal variability, and that temporal predictions can be built on sensory stimulation that is not purely periodic nor temporally deterministic.

IW-119

Neural Speech Decoding from Segregated Brain Regions' Neuromagnetic Signature

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Neural speech decoding attempts to decode speech information directly from brain activity and has the potential to restore communication for patients with locked-in syndrome. Recent studies with Magnetoencephalography (MEG) have shown promising results in neural speech decoding. However, the spatial dynamics in MEG-speech decoding has rarely been investigated. Here, we evaluated the contribution of each brain regions (left- and right- frontal, temporal, parietal, and occipital lobes) in speech decoding. MEG recordings from 7 healthy volunteers were collected while they performed 100 trials of imagined and overt speech of 5 different phrases. Linear discriminant analysis (LDA) was then used to classify the MEG signals corresponding to these 5 phrases during both imagination and production for each region separately. Decoding accuracy for each individual region was significantly above chance level for both imagined and spoken speech decoding (1-tail t-test; $p < 0.05$). Furthermore, decoding performance with sensors from left and right temporal lobes combined was on par with whole-brain performance (1-tail t-test; $p = 0.28$ for overt speech, $p = 0.47$ for imagined speech). No significant difference in decoding performance was found between left and right hemisphere sensors (2-tail t-test; $p = 0.28$). Our results suggest that MEG sensors close to the temporal lobes contributed the most to our neural speech decoding results. Thinking ahead, optically pumped magnetometer (OPM) based wearable MEG-speech-BCI designs could potentially benefit by using a sparse number of sensors focused on the temporal lobe(s), thereby effectively reducing the computation and cost of the MEG-based speech-brain computer interface.

IW-32

I can't believe it's not German: Characterizing context-dependent neural activity with pseudo-speech.

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Many recent studies have used naturally spoken sentences to characterize speech-evoked neural activity. The increased ecological validity of natural speech comes with the difficulty of disentangling multiple correlated features. We previously found that the magnitude of speech-evoked activity in delta and theta bands is modulated by the predictability of individual phonemes in context (Donhauser & Baillet, 2020). However, in natural speech, multiple levels of context are available simultaneously. Apart from lexical-level or sentence context, there is predictability from sub-lexical regularities: phonotactic rules that describe the legitimate combination of phonemes. Here we aim to dissociate the effect of sub-lexical and higher-level context on continuous neural responses. We created a corpus of running pseudo-speech that follows the phonological characteristics of German. A language's phonology is characterized by its specific phoneme inventory, rules of syllable composition, and intonation patterns. Real sentences were modified by a phoneme shuffling procedure to create pseudo-sentences that are composed of legal German syllables but have no lexical content. Both real and pseudo-sentences were pronounced with matching intonation using a text-to-speech engine. German speakers listen to sentences of both types while detecting target words. We analyze the simultaneously recorded neurophysiological activity using TRF regression models including different levels of context. Neural responses in the theta band should reflect sensitivity to sub-lexical but not higher-level context. Delta band responses should be sensitive to higher-level context, but in its absence track slow amplitude and intonational contours. This pattern would be direct evidence for the informational separation of these two time scales.

IW-33

Auditory working memory maintenance during a dichotic speech shadowing task

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The ability to maintain relevant auditory information in working memory (WM) during a conversation in a lively environment is crucial for human communication. Established work theorizes that both for verbal and non-verbal auditory WM items, this process relies on subvocal "rehearsal" within a phonological loop, governed by a left inferior-frontal-parieto-temporal brain network. How this loop manages auditory verbal processing in parallel with WM maintenance is still unknown. Here, we employed a dichotic-listening/articulatory-suppression task to interfere with WM maintenance of parametrically varied ripple sounds during MEG recordings. Dichotic syllables /ba/ and /da/ were presented during the retention period of a delayed match-to-sample task. Participants were asked to either repeat both /ba/ and /da/ (Speech Shadowing, SS) or only /ba/ sounds (Selective Speech Shadowing, SSS) when presented to one ear and ignore syllables presented to the other ear. Vocal responses were recorded using an MEG-compatible microphone. Increased attentional demands during the SSS task were reflected by the slowing of behavioral reaction times to WM probes, as compared to the SS task, and by the strengthening of MEG functional connectivity between inferior frontal, supramarginal, and auditory cortices. The content of auditory WM was classified at above chance level from both MEG functional connectivity and collective spatiotemporal activation patterns of left frontoparietal-temporal regions, as analyzed during a silent period in-between the interfering stimuli. Our working hypothesis is that brain regions involved in articulatory-motor processing and auditory perception can maintain information even when active WM rehearsal is suppressed by competing speech and listening tasks.

IW-34

Alpha power during language comprehension task predicts outcome performance

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Alpha power attenuation during cognitive task performing has been suggested to reflect a process of release of inhibition, increase of excitability, and thereby, benefit the improvement of performance. We hypothesized that changes in individual alpha power during the execution of a complex language comprehension task may correlate with the individual performance in that task. Thus, we tested this by using the magnetoencephalography (MEG) recording from thirty native (L1) German speakers during a 4-day German sentence comprehension task. The sentence complexity was manipulated by whether it is single or double relative clause center-embedding (i.e., single and double conditions). We first estimated the individual frequency with the highest power in the low frequency range (7-30Hz) from the resting-state recordings in sensor space. Then, we examined the power attenuation (single vs. double) of this individual frequency during comprehension of sentences in source space. Results showed that neither the frequency nor the power of the spontaneous oscillatory activity at rest were associated with the individual performance. However, during the execution of a sentence processing task, the individual alpha power attenuation did correlate with individual language comprehension performance. This effect was observed for source activity in the left temporal regions known to be associated with language processing. We conclude that in-task attenuation of individual alpha power is related to the essential mechanism of the underlying language processes, rather than merely to general phenomena like attention or vigilance.

IW-35

Neural tracking of speech does not unequivocally reflect intelligibility

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During listening, brain activity tracks the rhythmic structures of speech signals. Here, we directly dissociated the contribution of neural tracking in the processing of speech acoustic cues from those related to linguistic processing. To address this question, we examined the neural changes associated with the comprehension of Noise-Vocoded (NV) speech using magnetoencephalography (MEG). Participants listened to NV sentences in a 3-phase training paradigm: (1) pre-training, where NV stimuli were barely comprehended, (2) training with exposure of the original clear version of speech stimulus, and (3) post-training, where the same stimuli gained intelligibility from the training phase. Using this paradigm, we tested if the neural responses of a speech signal was modulated by its intelligibility without changing its acoustic structure. To test the influence of spectral degradation on neural tracking independently of training, participants were listening to two types of NV sentences (4-band and 2-band NV speech), but were only trained to understand 4-band NV speech. Significant changes in neural tracking were observed in the delta range in relation to the acoustic degradation of speech. However, we failed to find a direct effect of intelligibility on the neural tracking of speech in both theta and delta ranges. This suggests that acoustics greatly influence the neural tracking response of speech signals, and caution shall be made when choosing the control signals for speech-brain tracking analyses, considering that a slight change in acoustic parameters can have strong effects on the neural tracking response.

IW-36

An oscillatory multiplexing mechanism for foveal and parafoveal word processing during reading

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Background: During natural reading, our eyes move from word to word 3-4 times per second. We investigated how this fast visual processing is coordinated in the visual hierarchy. Procedures: A pair of words are presented simultaneously on the screen with a 0.8° visual angle in between. Words are selected from four categories and written in four colours (e.g. lion in red and apple in blue). Participants (n=35) read these two words silently while brain activity and eye movements are recorded simultaneously with MEG and an eye tracker. Analysis: Pre-processing is done following the FLUX pipeline (http://www.neuosc.com/flux). Epochs are aligned with the gaze onset of the second words. Multivariate pattern classification is applied to decode the colour and category of the first (foveal) and second (parafoveal) words. A searchlight beam-forming approach is used to identify the brain regions contributing to the classification. Preliminary results: Both colour and category of the first word can be decoded foveally. However, only the colour but not the category of the second (parafoveal) word can be decoded before gazing at it. Furthermore, colour information from the first and second word are encoded at different alpha phases, which prevents potential interference of the colour between fovea and parafovea. Conclusion: We propose a multiplexing mechanism in which the high-level feature (category) from foveal is processed in the late visual hierarchy, while the low-level feature (colour) from parafovea is processed in the early visual hierarchy. Alpha oscillations serve to organize the temporal coordination for this multiplexing mechanism.

IW-37 Decoding semantics in E/MEG source space: from trial to task

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While there is some agreement on the identity of the brain regions that constitute the semantic network, the role of individual regions and their spatiotemporal brain dynamics are still poorly understood. We recorded brain activity during one visual lexical decision (LD) and three semantic decision (SD) tasks; importantly, each word presented belonged to one of five semantic categories. Using source space decoding, we investigated what type of information is present in different ROIs (Anterior and Posterior Temporal Lobe, left Inferior Frontal Gyrus, Primary Visual Areas, and Angular Gyrus), at different time points, for different tasks and stimulus categories. While task effects for both decoding general (LD vs SD) and specific (SD vs SD) classification were present across all our ROIs starting from 50-100 ms, single-word semantic category was decodable just in a subset of mainly temporal areas incl. ATL, between about 200-600 ms post stimulus. Decoding accuracy was higher in SD compared to LD task. We found differences between two distinct approaches to brain decoding, i.e., between decoding per ROI vs across ROIs with backprojection of the classifier weights: When the effect of interest is distributed across regions, then the across-ROI approach appears to be more informative, while if the effect is only present in a few ROIs, then per-ROI decoding seems to be more sensitive. Our results complement previous finding from evoked responses and functional connectivity analyses that showed early task modulation in the semantic brain network, and they further characterize bilateral ATL's central role in this network.

IW-38 Spatiospectral cortical patterns in naturalistic continuous reading

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Background The majority of neuroimaging studies on reading have used very tightly controlled experimental settings and short text stimuli. In order to gain a more comprehensive view of the neural correlates of reading, the present experiment combined naturalistic reading of long text passages with the high temporal and spatial resolution of MEG. Methods Thirteen participants performed a naturalistic reading task by freely reading texts that extended across three pages while their cortical activity was recorded with MEG. Ocular activity was monitored with eye-tracking and EOG. As a control task, the participants searched texts for flipped letters with reading-like eye movements. Differences in cortical activity between the two tasks were analysed by estimating and contrasting the spatial distribution of signal power in six frequency bands between 1 and 90 Hz with Dynamic Imaging of Coherent Sources. Results Statistically significant differences in signal power were observed especially in the right hemisphere: in the 8-13 and 15-25 Hz bands, large clusters of power differences were detected in the occipital and parietal cortices (lateral and medial) and in the temporal cortex. Additional smaller clusters in the right hemisphere were also seen in frequency bands between 1 and 47 Hz. In the left hemisphere, solitary clusters were found in the 1-4, 8-13, 15-25 and 31-47 Hz bands. Discussion The results indicate that natural reading of realistic connected text is characterised by activation of an extended right-lateralized attentional network, as well as areas involved in linguistic processing and eye movement control.

IW-39 Steady-state responses to concurrent melodies: source distribution, top-down, and bottom-up attention

Humans can direct attentional resources to a single sound occurring simultaneously among others to extract the most behaviourally relevant information present. To investigate this cognitive phenomenon in a precise manner, we used frequency-tagging to separate neural auditory steady-state responses (ASSRs) that can be traced back to each auditory stimulus, from the neural mix elicited by multiple simultaneous sounds. Using a mixture of 2 frequency-tagged melody streams, we instructed participants to selectively attend to one stream or the other while following the development of the pitch contour. Bottom-up attention towards either stream was also manipulated with salient changes in pitch. Distributed source analyses of magnetoencephalography measurements showed that the effect of ASSR enhancement from top-down driven attention was strongest at the left frontal cortex, while that of bottom-up driven attention was dominant at the right temporal cortex. Furthermore, the degree of ASSR suppression from simultaneous stimuli varied across cortical lobes and hemisphere. The ASSR source distribution changes from temporal-dominance during single-stream perception, to proportionally more activity in the frontal and centro-parietal cortical regions when listening to simultaneous streams. These findings are a step forward to studying cognition in more complex and naturalistic soundscapes using frequency-tagging.

IW-40 Individualized epidemic models based on MEG brain networks characterize seizure propagation and the effects of epilepsy surgery

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Background Epilepsy surgery is the treatment of choice for drug-resistant epilepsy patients, but only 2/3 of the patients are seizure-free (SF) after surgery. Simulation of seizure dynamics and epilepsy surgery on brain networks, via computational models, may help us improve outcome rates1 or reduce side-effects by finding resection strategies individually targeted for each patient2,3. Methods We modelled seizure propagation as an epidemic spreading process2,3 on the patient's brain network, reconstructed from resting-state MEG recordings using the Amplitude Envelope Correlation, AEC. By not correcting for volume conduction, the AEC retains information of structural connectivity2. The model was fitted for each patient to reproduce SEEG ictal recordings, and the likelihood C(R) of each ROI of generating seizures was estimated. Results The model reproduced the SEEG seizure-propagation patterns2, with a better fit for SF than non-SF patients (C(RA)SF-C(RA)NSF=0.19,p=0.097), when considering the resected area (RA) as the seed. RA-ROIs were significantly more likely to start seizures (C(RA)-C(NRA)=0.074, p=0.021), but did not overlap with the optimal seed regions. Discussion Spreading models fitted with patient-specific MEG networks describe the main aspects of seizure propagation and can be used to generate an hypothesis about the seizure onset zone. Combined with virtual resection algorithms, smaller or alternative resection strategies, targeted for each patient, can be determined with the goal to improve surgery outcome.

References [1] N. Sinha et.al. Brain 140.2-(2017). [2] A.P. Millán, et.al. Scientific Reports 12.1-(2022). [3] I.A. Nissen et.al. Scientific Reports. 11.1-(2021).

IW-41

Decoding and cross-decoding languages

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Is language selection decodable from neural activity in proficient bilinguals? Previous research did not yield a conclusive answer to this issue by employing different neuroimaging method. Interestingly, classical direct brain stimulation studies detected different brain regions related to language production in separate languages for bilingual speakers. In the present MEG study, we addressed this question in a group of proficient Spanish-Basque bilinguals. Participants (N=45) were involved in two tasks. In a picture naming tasks they were asked to name a picture either in Basque or in Spanish in separate mini blocks. Pictures printed in black ink were asked to be named only if the ink turned to green after one second (10% of the trials). Similarly, in a reading aloud task printed words should be read overtly only if their ink turned to green. Decoding analysis were performed separately for the two tasks focusing on the Spanish-Basque contrast. A moderate higher-than-chance accuracy (~55%) starting ~100 ms was observed for both tasks. Temporal generalization analyses for the picture naming task showed a sustained effect, while for the reading task two stages of processing (at ~100 ms and starting ~300 ms) were evident. Cross-task decoding analysis highlighted robust generalization effects from the picture naming to the reading in the later time interval. The present findings support the possibility of exploring the trial-by-trail variability in the MEG activity for dissociating language selection across time in the bilingual brain. Critically, cross-decoding provide novel evidence on the shared language representations between naming and reading.

IW-42

Neurophysiological correlates of age-related changes in lexical-semantic processing

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Understanding normal age-related neurophysiological changes in lexical-semantic processing is important, as an abnormal weakening of the so called N400 effect in lexical-semantic priming has been associated with dementia development. Here, we used magnetoencephalography (MEG) in a semantic priming task tapping into the N400 effect in healthy participants. 49 Finnish-speaking adults, divided into young (22–32 years) and old (62–69 years) age groups, were measured while they evaluated whether word-pairs were semantically related (e.g., banana-orange) or unrelated (e.g., banana-police). MEG measurements were repeated one week later. For source reconstruction, we applied cortically constrained minimum-norm estimates. A significant N400 effect was observed in both age groups ($p<0.05$, assessed with within-group spatiotemporal cluster-based permutation testing), originating mainly from left superior temporal, middle temporal, and middle frontal areas. A difference in the N400 contrast between age groups was observed in the left middle temporal cortex at 250–500ms during the second measurement day ($p<0.01$). The peak latency of the sensory N400 response measured over the left temporal cortex in the unrelated condition was shorter (~340ms) for young subjects (~400ms) during both measurement days ($p<0.01$, between-group t-test). Despite the slower brain responses, old subjects had significantly faster behavioral reaction times ($p<0.001$) while they made a comparable number of errors. Taken together, the results indicate significant age-related changes in neural processes underlying semantic word associations that do not translate into reduced behavioral performance. Neurophysiological recordings may reveal changes in lexical-semantic processing earlier than behavioral measures, and thus aid in early detection of age-related cognitive decline.

IW-43

Saccades are locked to the phase of alpha oscillations during natural reading

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The aim of this study is to uncover if mechanisms of covert spatial attention support natural reading in which the eyes scan a sentence. It is debated if upcoming words are processed at the lexical level before saccade to the word; a process referred to as lexical parafoveal processing. The eye-movement literature has found no robust evidence for it. This points to a serial processing model where words are processed one-at-a-time rather than a parallel processing model where multiple words are simultaneously processed. Here we address this question by combining eye-tracking, MEG and 'rapid frequency tagging' (RFT) in a natural reading task. Full sentence was presented in which target words of either low or high word frequency were frequency tagged (flickered) at 60Hz. The RTF is non-perceivable but produces a strong signal from visual cortex. We measured the cortical coherence in responses to RFT during pre-target fixation, which reflects parafoveal processing of the target. We found no evidence for fixation difference on words preceding targets. Importantly, RFT-coherence during pre-target fixation was both stronger and earlier when preceding low as compared to high frequency targets. The RFT-coherence difference was negatively correlated with reading speed of the full sentence and predicted a reduction in target fixation. In conclusion, our findings provide novel evidence for parafoveal lexical processing supporting a parallel processing model. Importantly parafoveal processing predicted reading speed. In addition, our approach demonstrates that RFT is a powerful tool to study parafoveal processing as it sheds new light on natural reading.

VW-126

A multilayer network approach in modeling the inter- and intra- modal interactions underlying statistical learning of multisensory stimulation streams in musicians and non-musicians: an MEG study.

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Recent advancements in the field of complex network science led to the modelling of multilayer representations. These hypernetwork representations provide the ground to understand brain's hierarchical functioning and link the multilayered brain functionality to cognitive hierarchy. Here we present a multilayer network approach to model (a) the inter- and intra-modal interactions underlying multisensory integration, and (b) to model how domain-specific expertise re-organizes the characteristics of the corresponding hypernetwork. To this aim, we employed a multifeatured statistical learning paradigm implemented via magnetoencephalographic (MEG) measurements. The paradigm allowed us to assess the differential contribution of long-range cortical networks involved in multi- vs. uni-sensory statistical learning. Expertise related neuroplastic effects were modeled via a comparison of a group of musicians and a group of non-musicians. Activity time-series for the 360 sources included in the HCP atlas were estimated via single trial source analyses, using individual BEMs. Phase Transfer Entropy was used to estimate significant connectivity networks. Edge-to edge correlation between the different networks was used to estimate hyperedges and inter-network interactions. Statistically significant hypernetworks for musicians and non-musicians were compared using a general linear model approach. Results showed that both expertise and behavioral results were related with a compartmentalization of the supramodal statistical learning processes and a reduced inter-network connectivity. Current results provide new indices regarding the functionality of cortical regions commonly thought as multisensory, regarding approach's validity and as well as regarding the link between the hierarchical architecture of brain and cognitive functionality in the framework of multisensory integration.

IW-46

Decoding Neural Representation of Words in Language Production from Magnetic Signals Measured by a Superconducting Self-Shield MEG

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From neural signals measured by EEG and MEG, previous studies successfully decoded words or phrases when the participants comprehended visually or auditorily presented words (Chan et al., 2011; Dash, Ferrari, and Wang, 2020). Such results indicate that information about individual words are represented as neural activities in the course of language comprehension. However, relatively less research was conducted about the neural representation of words in language production. In this study, we decoded words from signals recorded by a superconducting self-shield MEG (Ohta et al., 2004) when the participants orally named visually presented images of familiar objects. Five native Japanese speakers are asked to (i) see the images of six objects, (ii) imagine the action related to the objects, (iii) silently name the objects, and (iv) orally pronounce the objects' names. MEG signals were recorded from 64 channels of SQUID sensors during these tasks. The classification analysis of magnetic signals using the support vector machine resulted in significantly higher accuracy above the chance level (permutation test, $p<.05$) in (i) and (iv) but not in (ii) and (iii). The result indicates that words are represented neurally in the course of language production but representations vary during the time course. In addition, it shows that the higher S/N rate of superconducting self-shield MEG (Hornberger et al., 2017) is effective in research on higher-ordered cognitive functions such as language production that involve rapid changes of neural representations.

IW-47

Electrophysiological variability in MEG evoked responses during auditory word processing

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Background: Processing of spoken words results in wide-spread neural activity throughout auditory pathways. Event-related potentials (ERPs) or fields (ERFs) are commonly used to capture word comprehension processes and their relation to behavioral parameters. Studies assessing variability of ERPs/ERFs focus on peak amplitude and latency, disregarding spatiotemporal dynamics. Here we assess the variability of event-related measures across a large number of participants, also taking into account the ERP waveform shape. Methods: We leverage a large open MEG dataset (91 participants, Schoffelen et al., 2019). Participants listened to Dutch words. Generalized eigenvalue decomposition was used to extract spatio-temporal ERP components relative to word onset. As a sanity check for our component extraction procedure, lexical frequency effects were examined. Then, we investigated time courses and spatial location of extracted components across participants via hierarchical clustering using the whole ERP waveform. Across hemispheres, the number of word-responsive components as well as signal-to-noise ratio was assessed. Results: At the group level, early and late clusters of lexical frequency effects show that our pipeline extracted components with preserved sensitivity. On an individual level, we identify (at least) two robust word-sensitive components per hemisphere on average, with differential temporal dynamics. We find high variability across participants with respect to signal-to-noise ratio. Discussion: Investigation of variability across participants will help understand limitations of MEG recordings during lexical processing. Next steps take into account individual-specific cortical folding and investigate whether concurrent EEG is beneficial for investigation of lexical processing for certain subgroups.

IW-48

Neural differences in developmental dyslexia as a function of phonological skills: Evidence from auditory MEG data

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The majority of dyslexic readers have a phonological processing and a verbal memory deficit, leading to underspecified phonological representations (Phonological Representation Hypothesis of Dyslexia). Despite this, their processing of everyday speech is largely unaffected. It remains unclear how dyslexic readers organize linguistic information to compensate for a phonological deficit. This work investigates the relationship between individuals' phonological skills and their neural responses to auditory words at the phonological and at the lexical levels. Phonological neighbourhood size was used as a proxy of phonological encoding, and written word frequency (token) as a proxy of whole word encoding. 14 individuals diagnosed with dyslexia and 17 without a history of reading difficulties heard single Spanish words and occasionally had to indicate whether the word was animate while MEG data was recorded. The effects of phonological neighbourhood and word frequency were extracted as event-related regression coefficients (Hauk et al., 2009) and correlated with participants' behavioural phonological scores. Significant effects at the MEG sensor level were source localized using beamforming. In line with the Phonological Representation Hypothesis, we found weaker neural responses to phonological neighbourhood for individuals with lower phonological skills in the left and right hemispheres. This effect was strongest in the left inferior frontal gyrus. Importantly, phonological skills were also correlated with participants' sensitivity to word frequency. The peak of this effect was in the right superior temporal region. This suggests that phonological processing and the organization of higher-level linguistic information are linked. Implications for theories of developmental dyslexia will be discussed.

IW-49 Temporal dynamics of motor and language areas suggest a compensatory role of the motor cortex in second language processing

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The involvement of the motor cortex in language understanding has been intensively discussed in the framework of embodied cognition. Although some studies have provided evidence for the involvement of the motor cortex in different receptive language tasks, the role that it plays in language perception and understanding is still unclear. In the present study, we explored the degree of involvement of language and motor areas in a visually presented sentence comprehension task, modulated by language proficiency (L1: native language, L2: second language) and linguistic abstractness (literal, metaphorical, and abstract). Magnetoencephalography data were recorded from 26 late Chinese learners of English. A cluster-based permutation F-test was performed on the amplitude of the source waveform for each motor and language region of interest (ROI). Results showed a significant effect of language proficiency in both language and motor ROIs, manifested as overall greater involvement of language ROIs (short insular gyri and planum polare of the superior temporal gyrus) in the L1 than the L2 during 300-500 ms, and overall greater involvement of motor ROI (central sulcus) in the L2 than the L1 during 600-800 ms. We interpreted the greater degree of motor cortex involvement in the L2 as a higher demand for cognitive resources to compensate for the inadequate engagement of the language network. In general, our results indicate a compensatory role of the motor cortex in L2 understanding. KEYWORDS motor cortex involvement, magnetoencephalography, native language, second language, language proficiency, abstractness

IW-50 Computational modeling of MEG evoked responses during visual word recognition using a convolutional neural network

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Neuroimaging studies have provided a wealth of information about when and where changes in brain activity might be expected during reading. We sought to better understand the brain processes that give rise to this activity and evaluated the suitability of a convolutional neural network as a model of the macro-scale computations performed by the brain during visual word recognition. The model was a VGG11 network trained to recognize images of rendered text. It was compared to MEG evoked responses to written words, pseudowords, consonant strings, letter-like symbol strings, and noise embedded words. The same stimuli were presented unmodified to both the model and human volunteers. Guided equivalent-current-dipole (ECD) modeling was used to isolate three evoked components commonly observed during reading. The amplitude of these components was compared to the mean activity in each layer of the model. In contrast to traditional models of reading, our model directly operates on the pixel values of a stimulus image, allowing for a simulation of the early (< 200 ms) responses that are associated with the detection and segmentation of letter shapes. Furthermore, the scale afforded by the deep learning architecture allows the model to have a large vocabulary of 10k Finnish words, facilitating/enabling a simulation of the N400m response to word-like versus non-word-like letter strings. We conclude that the deep learning techniques that revolutionized models of object recognition can also create powerful computational models of reading, which will greatly facilitate testing and refining theories on language processing in the brain.

IW-51 Dynamic brain connectivity supports semantic processing during object recognition

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Visual perception requires the rapid transformation of sensory signals into meaningful, object-specific representations. However, the role of inter-regional feedback and recurrent connectivity along the ventral visual pathway during object recognition remains unclear. To address this, we analysed both fMRI and MEG recordings of participants performing a basic-level naming task for common objects. The semantic similarity between objects was measured using property norming data and representational similarity analysis (RSA) was used to test for semantic representations, alongside visual information modelled incrementally through layers of a biologically-inspired artificial neural network. Crucially, we also employed representational connectivity analysis (RCA) to investigate when and where connectivity patterns related to visual and semantic properties emerge and how they evolve over time. RSA of the fMRI data revealed that activity patterns in bilateral posterior ventral temporal cortex and ventral and medial anterior temporal regions were uniquely related to semantic feature knowledge. Further, applying a searchlight analysis to source localised MEG signals, we found semantic knowledge related to neural activity patterns from 160 ms, first in posterior ventral temporal cortex before engaging a posterior and anterior temporal network after 240 ms. Finally, RCA showed that both visual and semantic features were linked to feedforward processing, whereas only semantic and higher-level visual properties captured feedback relationships, between 200-400 ms. Together, these results indicate that accessing the meaning of visual objects requires the dynamic interplay of both feedforward and feedback activity supported by posterior and anterior aspects of the ventral visual pathway.

IW-52 Investigating the neurocorrelates of human communication using music and MEG hyperscanning

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[Introduction] The cognitive ability to communicate through sound is essential to daily life. However, the neurocorrelates underpinning inter-active human communication remain unclarified. Improvisational music, which has parallels to speech, can be used as a medium for auditory communication and has precedence in neuroimaging experimentation. In the present study, we used improvisational music and magnetoencephalographic (MEG) hyperscanning to explore the neurocorrelates of auditory communication which are associated with its creative nature and influenced by the social roles of the communicators involved. [Methods] Ten right-handed pairs of classically trained adult musicians were alternately assigned the roles of Leader and Follower, and performed musical communication under two performance conditions in which the Follower responded phrases played by the Leader by either copying the rhythm or freely improvising. Differences in theta (5-7 Hz), alpha (8-13 Hz), and beta (15-29 Hz) cortical activity envelopes during mental imagery of the musical communication were analyzed according to social role (Leader/Follower) and playing condition (Copy/Improvise). [Results] Improvisational cognition was differentiated by theta activity in contralateral motor areas, whereas social role was differentiated by pronounced occipital alpha and beta synchronization suggestive of working memory retention engagement in Followers but not Leaders. [Discussion] The results corroborate ideas in musical neuroscience regarding the drivers of brain activity during improvisational cognition. Moreover, the results offer compelling evidence that the cognitive strategies of interlocutors during communication exchanges differ in accordance with their social role/hierarchy, thereby indicating the need to control for social role/hierarchy in social neuroscience research.

IW-53

Does motor imagery lead to sensory attenuation?

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Introduction Typically, self-generated sounds elicit smaller cortical responses compared to externally generated sounds. This phenomenon is known as sensory attenuation. Although there are many similarities between imagined and executed movements at the neural level, only few studies investigated if imagined actions modulate subsequent auditory perception(Kilteni et al., 2018). In this study, we used MEG to investigate sensory attenuation following imagined movements. Methods We recruited twenty healthy right-handed volunteers. MEG data was recorded during three different conditions. Passive: the auditory stimulus was presented with random inter-stimulus intervals. Active: the participants received the auditory stimulus immediately after each button press. Motor imagery: The participants were asked to imagine the button press action after receiving a visual cue. The auditory stimulus was presented shortly after the visual cue. Results We observed significantly reduced M100 amplitude for active compared to passive condition. However, no attenuation was observed in motor imagery condition. Still, in this condition, significant modulation of beta oscillations over the motor area contralateral to the side of the imagined button press indicated successful motor imagery. Beta modulation was confined to motor cortex and absent in auditory areas in contrast to the active condition. Discussion Our finding of a significant correlation between the neuronal activities in motor and auditory areas indicate functional interactions between the areas in the active condition(Abbasi & Gross, 2019). However, lack of M100 attenuation and beta modulation in motor imagery condition indicate that the brain's internal model does not predict the sensory consequences of the imagined movement.

IW-54

The role of beta oscillations in motor adaptation and action-inhibition

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Background: Influential theories on the role of beta oscillations have struggled to find a unitary interpretation. Currently, two main views focus on the inhibitory function of beta and the role of this rhythm in somatosensory integration. To explore if these interpretations refer to separate processes in the sensorimotor system, we observed beta dynamics during action-inhibition and learning. Methods: We recruited 17 healthy participants who performed a joystick reaching paradigm in both an action-inhibition and motor adaptation task in the MEG. The two tasks differed in the overall goal of the motor performance (motor control vs learning) while the kinematic features were held constant. An LCMV beamformer was used for extracting virtual sensors from a set of ROIs (M1,IFG,pre-SMA). Virtual sensors time series were decomposed into their time-frequency representation in the beta (15-30Hz) range. Results: Beta rebound in M1 was reduced in trials in which a task-related error was present. In the action-inhibition task, this effect was observable comparing successful vs unsuccessful stops, with the latter showing less beta rebound power. A comparable modulation was present in the motor adaptation task, in which trials that showed a large angular error presented a reduced rebound compared to trials with small angular error. Discussion: We found that beta rebound modulations serve as a ubiquitous error monitoring process, independent of the task performed. This supports the notion that beta rebound has a role in the processing of movement outcomes.

IW-55

The effect of GABAergic modulation on movement-related beta oscillations

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Background: Previous Pharmaco-MEG studies suggest that beta oscillations are linked to the levels of GABAergic inhibition in the brain. Beta dynamics vary depending on the kind of drugs administered (receptor agonist; reuptake blocker) and on the current state of the system (active vs resting). Uncovering these dynamics could help us understand the mechanism behind beta generation and its functional role in the sensorimotor system. In this study, we investigated the dependence of task-dependent beta oscillations on the excitatory-inhibitory balance using MEG. We pharmacologically manipulated the GABA system using gaboxadol, an extra-synaptic GABA-A agonist. Methods: We recruited 9 healthy participants who performed a finger abduction task in the MEG. Participants had two experimental sessions, one in which they received gaboxadol (15mg) and another in which they received a placebo and were tested before and 25 minutes after drug administration. Virtual sensor time series from primary motor cortex were decomposed into their time-frequency representation in the beta (15-30 Hz) range. Furthermore, the SPRiNT toolbox was used to parametrise power spectra into periodic (oscillatory) and aperiodic components. Results: A repeated-measures ANOVA showed an interaction between drug and session with increasing beta power following gaboxadol administration. Notably, this effect was present only for beta rebound. Analysis of parametrised spectra in the beta rebound time window showed an increase in periodic beta power as well as aperiodic offset. Discussion: Gaboxadol administration resulted in increased beta rebound. However, this increase was not exclusively ascribed to rhythmic components per se but also included changes in aperiodic activity.

IW-56

Age-Related Trends in Neuromagnetic Transient Beta Burst Characteristics During a Sensorimotor Task and Rest

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Background:There is a recent trend in describing human neurophysiological recordings as a series of transient bursts of neural activity rather than averaged sustained oscillations as transient burst characteristics may be more directly correlated with the neurological generators of brain activity. Methods: In this work, we detect and characterize transient beta bursts in MEG recordings acquired at the Cambridge Centre for Ageing and Neuroscience of roughly 600 participants with a nearly uniform age distribution between 18 and 88 years old. The participants were recorded during wakeful resting and while they performed a unilateral button press task. Our investigation focuses on age-related changes in transient beta burst characteristics over the contralateral primary sensorimotor cortex. Results: We find that transient burst rate (i.e. the number of beta bursts occurring per unit time) is the predominant factor driving previously discovered age-related changes in the amplitude of beta suppression and post-movement beta rebound associated with the button press task. We additionally find that burst rate increases with age during the pre-stimulus interval but not during the rest interval. Discussion: These findings suggest that fundamental changes in beta bursts occur when switching from resting to a pre-task state and that this effect is more substantial in younger participants. Furthermore, we will present age-related changes in the temporal dynamics of the transient beta bursts over ipsilateral motor cortex. This work is as an important step in characterizing transient bursts in neuromagnetic signals in the temporal domain, towards a better understanding of the healthy aging human brain.

IW-57

M/EEG networks integration to elicit patterns of motor imagery-based BCI training

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Despite its clinical application, voluntarily modulating brain activity appears to be a learned skill that affects the usability of brain-computer interfaces (BCIs) systems. The involved learning process induces a brain network reorganization that remains poorly understood. We hypothesized that integrating information from electroencephalography (EEG) and magnetoencephalography (MEG) data, provides a better description of the network changes occurring during the BCI training. We performed experiments on a group of 20 naive healthy subjects during a BCI training consisting of four sessions over two weeks in which both EEG and MEG signals were recorded. The task consisted in controlling the vertical position of a moving cursor through the _/_ modulation to reach a target displayed on a screen. We adopted a multilayer approach to integrate brain network properties from EEG and MEG data. Regardless the chosen modality, a progressive increase in the integration of somatosensory areas in the _ band was paralleled by a decrease of the integration of visual processing and working memory areas in the _ band. Only brain network properties in multilayer network correlated with future BCI scores in the _2 band (p < 0.01): positively in somatosensory and decision-making related areas (gyrus rectus & subcentral gyrus) and negatively in associative areas (superior occipital gyrus). Our results constitute the first proof of a learning process from the integration of M/EEG networks properties. Integrating multimodal brain network properties could be considered as a potential marker of BCI learning.

IW-58

Magnetoencephalographic spectral fingerprints differentiate evidence accumulation from saccadic motor preparation in perceptual decision-making.

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Neurophysiological studies on primates provided evidence for an intentional model of perceptual decision-making, establishing that decisions and actions are implemented in the same areas. Although much progress has been made, the neural underpinnings of decision mechanism remain unclear. Here, by exploiting MEG recordings, we describe a human homologue of the decision variable, disentangling the spectral contribution of evidence accumulation and motor preparation. We acquired MEG data from sixteen subjects performing a continuous version of the Random Dot Motion task in which participants indicated the direction of coherent motion through a saccadic movement. Behavioral differences was assessed by a 3x2 ANOVA. To investigate neural modulation a sensor-level and source-level time-frequency (TF) analysis were performed; the contrast between drift rate modulations over time was assessed by a cluster-based permutation test. Behavioral results confirmed a main effect of evidence on both indices of performance, TF analysis showed a significant alpha power ERD and a beta power ERD/ERS over the posterior sensors; these modulations localized in a region of the parietal cortex overlapping with oculomotor decision area. Importantly, the alpha ERD drift rate significantly differs between difficulty levels (p= 2*10-4), showing a significant correlation with the difference in the behavioral performance (RT: p=0.024, accuracy: p=0.015). Conversely, no significant variation as a function of the difficulty was found in the beta modulation. Overall, our results support the foundational neurophysiological findings of the intentional account of decision-making, additionally showing a spectral dissociation between mechanisms of evidence accumulation and motor preparation within the same areas.

IW-120

Theta/Gamma Phase-Amplitude Coupling Predicts Rapid Consolidation of Human Skill Learning

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Early learning of a new skill is supported by rapid consolidation that develops during rest intervals interspersed with practice. Here, we investigated the contribution of Theta/Gamma Phase-Amplitude Coupling (_/_ PAC) — proposed to support sequential memory processing in animal models — to rapid consolidation in healthy humans. We collected MEG recordings from 27 healthy volunteers practicing a novel sequence learning skill (repeated typing of 4-1-3-2-4) with their non-dominant left hand over 36 trials of practice (10 s each) interspersed with rest (10 s each). We then computed single-trial _ (4-7 Hz) / _ (30-140 Hz) PAC at 1-Hz resolution for each brain region during these rest intervals. Participants reached 95% of peak performance (correct keypresses/s) within the first 11 trials (early learning). Performance remained stable from trials 11 to 36 (late learning). _/_ PAC was stronger during early than during late learning (one-sample paired t-test, $p < 0.05$) in a frontal region encompassing the right motor cortex (RM1, contralateral to the practice hand). A region of interest analysis showed that _/_ PAC over RM1 predicted rapid consolidation during early (r=0.67) but not during late (r=-0.06) learning. Further, _/_ PAC correlated more strongly with learning speed during early (r=-0.71) than during late (r=-0.23) learning. We conclude that _/_ PAC predicts rapid skill memory consolidation in humans and is a marker of learning progression. Understanding the dynamics of _/_ PAC in the context of neurorehabilitation after stroke could contribute to the design of more clinically effective treatments.

IW-60

Waves and bursts: Examining the nature of neurophysiological activity preceding movement in a complex motor task

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BACKGROUND: Recent studies suggest traditionally defined neurophysiological activity may be non-oscillatory in nature, instead displaying burst-like activity when examining non-trial-averaged data. Previous studies have demonstrated burst-like behavior in the beta frequency range preceding movement onset, where the number of events in this window relates with behavior on the task. The current study further examines this activity and its prediction of behavior during a complex motor task. METHODS: Adults (N=78) completed a complex motor task during MEG, pressing a pseudorandomized, cued sequence of buttons on a button pad. Single-trial time-series were extracted from the contralateral motor peak. Burst metrics were extracted and subjected to mixed effects modeling to determine their predictive power of behavioral metrics (reaction time, movement duration). RESULTS: We found beta events throughout the planning period preceding movement, with an average of 5.6 event peaks per trial. These events had a long average duration of 721.7ms. When examining the predictive power of the characteristics of these events on behavior, peak power ($p<.001$), duration ($p<.001$), and number of events ($p=.008$) significantly predicted reaction times; peak power ($p=.001$) and duration ($p<.001$) significantly predicted movement duration. Greater power, longer duration planning responses led to both faster reaction times and shorter movement duration. A greater number of events was associated with longer reaction times. DISCUSSION: These results indicate that the specificity of single trial data lend well to the individual prediction of behavior, regardless of the nature of the activity. Further, the long duration of these threshold-free activity peaks suggest some oscillatory-like behavior.

IW-61

Beta-band dynamics during motor learning

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Background: OPMs offer a new generation of magnetoencephalography (MEG) instrumentation with better data quality, lifespan-compliance, and a route to more naturalistic neuroscientific experimentation with subjects free to move during a scan. In this work, we aimed, for the first time, to assess brain oscillatory dynamics whilst a subject learnt to play a musical instrument. Methods: Three participants were scanned 5 times on consecutive days. The task involved repeatedly playing a sequence of 5 chords on a ukulele. A visual representation of the chords was displayed on a screen and the participant had to complete the sequence in a specified time. This task involved significant head movement, as the participant looked at chord patterns on the screen, and then to their fingers to form the chords. Nevertheless, we were able to collect high fidelity data. Results: Modulation of beta-band (13-30 Hz) neural oscillations was localized to primary motor cortex. We measured the expected response, which involves a drop in beta amplitude during the task followed by an increase above baseline (the beta rebound) on task cessation, in all three participants. Moreover, we observed that the amplitude of the beta rebound, in two of the three subjects, was significantly modulated by the way in which the chords were played, with poorly played chords eliciting a smaller rebound. Discussion: This study demonstrates the flexibility of OPM-MEG to enable new types of motor learning and confirms the fact that high quality MEG data can be acquired even in the presence of large head movement.

IW-62

Testosterone Levels Mediate Beta Oscillatory Dynamics Serving Motor Control in Developing Youth

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Introduction: Recent investigations have studied the developmental trajectory of motor-related oscillatory responses in attempts to delineate maturational improvements that take place from childhood to young adulthood. While these studies included youth during the pubertal transition period, none have probed the unique effects of testosterone levels during this stage on developmental neural changes. Methods: We collected salivary testosterone samples and recorded magnetoencephalography during a complex finger-tapping task in a sample of 54 youth aged 9 – 15 years old. The resulting data were transformed into the time-frequency domain and the windows of interest within the beta range were determined using a data-driven approach and imaged using a beamformer. The relationships between testosterone, age, task behavior, and beta oscillatory (15 – 40 Hz) dynamics were examined using structural equation modeling. Results: We found strong developmental effects of testosterone on both reaction time and movement-related beta activity. However, we also found that these relationships mediated the effect of age on movement duration. Our primary results suggested that testosterone levels mediate the developmental trajectory of beta oscillatory dynamics serving motor control and thereby performance. Discussion: These are the first data to use testosterone levels as a proxy for pubertal developmental in the context of motor control development. Our findings reveal that testosterone affects beta oscillatory dynamics, controlling for age, in the primary motor cortex and distinct measures of motor performance.

IW-63

Modulation of movement-related beta activity after spinal cord injury

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Spinal cord injuries (SCI) cause plastic changes in the motor cortex as a result of deafferentation (Lopez-Larraz et al. 2015). Little is known about the timing of these changes with respect to the injury. Here we evaluated the evolution of event-related desynchronization (ERD) and synchronization (ERS) during motor task in subacute SCI patients. In healthy adults, such measures are stable across measurements, irrespective of attention (Illman et al. 2022), rate and force of movement (Fry et al. 2016). Modulation of movement-related beta activity (14-21 Hz) to 2-sec hand squeezing was recorded with magnetoencephalography (MEG) in seven patients with subacute, incomplete SCI. Patients underwent 3-4 MEG recordings within the first year after SCI (at days of 51±16, 108±15, 150±17, and 371±8 post-injury). Four of the seven patients received active paired associative stimulation (PAS; Shulga et al. 2021) and three received sham treatment for 12 weeks starting 63±16 days after the injury. Longitudinal recordings are ongoing. The modulation of beta suppression (ERD) and rebound (ERS) were analyzed as time-frequency representations. The SCI patients, irrespective of the PAS status, showed statistically significant variability over time in both hemispheres in ERS ($p < 0.01$) and ERD power ($p < 0.05$; highest vs. lowest values over time). In contrast to healthy subjects, beta modulation was thus highly unstable in subacute, incomplete SCI patients during the first year after SCI, suggestive of on-going cortical reorganization and neuroplasticity. Significance of PAS cannot yet be reliably valued taken the small group size.

IW-64

An in silico study on the superiority of magnetomyographic over electromyographic data for motor unit decomposition

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Background: Studying motor units (MUs) is essential for understanding motor control, neuromuscular disorders, and driving human-machine interfaces. Individual MU firings are currently estimated in vivo by decomposing electromyographic (EMG) signals. Due to our body's electric properties, the separability of the individual MU sources is limited. Unlike electrical signals, magnetic fields pass through biological tissues without distortion. This and the emerging technology of quantum sensors make magnetomyography (MMG) a highly promising methodology. However, the full potential of MMG for providing novel insights on neuromuscular physiology has yet to be explored. Methods: In this work, we investigate the potential of non-invasive MMG-based MU decomposition by performing OPM measurements during voluntary isometric contractions. For obtaining upper bound accuracy estimates for EMG-based and MMG-based MMG MU decomposition, we perform in silico trails closely integrating a model of EMG and MMG into state-of-the-art MU decomposition methods. Results: The first OPM measurements of isometric voluntary contractions demonstrate the feasibility of measuring MMG for decoding the neural drive to a muscle. Our in silico trials demonstrate the superiority of MMG over EMG for robustly predicting the discharge patterns of MUs. Decomposing MMG instead of EMG increases the number of separable MUs by 84%. Notably, MMG exhibits a less pronounced bias for detecting superficial MUs and its decomposition is less affected by subcutaneous fat. Discussion: The presented work provides new insights on methods for studying the neuromuscular system in vivo and hence, guidance for revolutionizing biomedical applications.

IW-65

Towards automated and fast mapping of the motor cortex: a conventional and multi-locus TMS study

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Fine-tuned limb movements require a synergistic engagement of multiple brain regions. For instance, the motor cortices simultaneously drive action potentials to activate hand and forearm muscles. Delineating the muscles' cortical representation is crucial for understanding the cortico-motor function and enabling pre-surgical evaluation of eloquent brain regions. Transcranial magnetic stimulation (TMS) is a well-established tool for non-invasive motor mapping. In a previous study, we measured the overlap in cortical representation and the coactivation of hand and forearm muscles with a commercial figure-of-eight TMS coil. This study showed a high cortical representation overlap between the forearm and intrinsic hand muscles, bigger than only between the hand muscles. However, conventional TMS requires the manual placement of the stimulation coil over each target for mapping the motor representation, a slow and prone-to-error process. Here, we developed a multi-coil TMS system to electronically control the stimulus location and orientation on the cortical surface. Then, we mapped an intrinsic hand muscle representation on a healthy volunteer with fine spatial definition (~1 mm) without manually moving the transducer. The multi-coil system enabled a fast and precise motor mapping and can be combined with closed-loop algorithms to perform automated mappings based on structural and functional connectivity. These algorithms can account for the coactivation of synergistic muscle groups to define highly relevant cortical areas in pre-surgical evaluations and rehabilitation applications, improving diagnostics and treatments for better patient prognostics. We thank Maria Nazarova and Pavel Novikov for their contributions on computing the cortical representation overlaps.

IW-66

The impact of three different surface electrode protocols on the amplitude of motor evoked potentials

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Background: The peak-to-peak amplitude of motor evoked potentials (MEPP-P) by transcranial magnetic stimulation (TMS) is a parameter widely used to assess the properties of the corticospinal tract and to set the stimulation intensity applied in repetitive TMS. However, as different surface electrode montages have been adopted to record the electromyographic (sEMG) signal in clinical and basic studies, possibly leading to divergences in comparing repetitive TMS treatment outcomes. Therefore, this study aimed to evaluate the effect of three different sEMG electrode montages on the MEPP-P. Methods: Eight healthy right-handed subjects (6 women) participated in the study approved by the local ethical committee. Surface EMG signals were recorded from both upper limbs' biceps brachii (BB) muscles. The three sEMG electrode montages (E1-E2 differential) were placed according to the following protocols: Protocol 1. Innervation zone [E1]–[E2; epicondylus lateralis]; montage; Protocol 2. Muscle belly [E1]–[E2; epicondylus medialis]; Protocol 3. E1-E2 over the muscle belly, but with an inter-electrode distance between 40–90% of the total muscle length. Thirty single TMS pulses were applied on the BB hotspot with a figure-of-eight coil at 120% of the resting motor threshold (rMT). Results: The rMTs were significantly higher ($p < 0.05$) for Protocol 3 than for the other two protocols, and Protocol 2 was the lowest. Protocol 2 also provided MEPP-P about 2.0 to 4.0 times greater ($p < 0.05$) than Protocols 1 and 3. Discussion: Our results suggest that careful consideration should be taken when comparing TMS studies using distinct electrode placements for MEP recordings.

IW-67

Cortical Theta-Gamma Coupling Governs the Adaptive Control of Motor Commands

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Background: Motor control requires the adaptive updating of internal models to successfully target desired outcomes. This adaptive control can be proactive, such that imminent actions and corresponding sensorimotor programs are anticipated prior to movement, or reactive, such that online error correction is necessary to adjust to sudden changes. While substantial evidence implicates a distributed cortical network serving adaptive control when behavioral changes are required (e.g., response inhibition), the neural dynamics serving such control when the target motor commands are to remain intact are poorly understood. Methods: We developed a novel proactive-reactive cued finger tapping paradigm that was performed during magnetoencephalography (MEG) by 25 healthy adults. Importantly, to ensure condition-wise differences in adaptive cueing were not attributable to changes in movement kinematics, motor selection, and planning processes were held constant despite changes in task demands. All MEG data were imaged in the time-frequency domain using a beamformer to evaluate the effect of proactive and reactive cues on movement-related oscillations and subsequent performance. Results: Our results indicated spectrally-specific increases in low (i.e., theta) and high (i.e., gamma) frequency oscillations during motor execution as a function of adaptive cueing. Additionally, we observed robust cross-frequency coupling of theta and gamma oscillatory power in the contralateral motor cortex and further, the strength of this theta-gamma coupling during motor execution was differentially predictive of behavioral improvements and decrements during reactive and proactive trials, respectively. Discussion: These data indicate that functional oscillatory coupling may govern the adaptive control of movement in the healthy brain.

IW-68

Peripheral Somatosensory Entrainment Modulates the Cross-Frequency Coupling of Movement-related Theta-Gamma Oscillations

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Background:The control of voluntary movement requires a reciprocal volley between somatosensory and motor systems from the cortex to the periphery, with somatosensory feedback essential for the online updating of motor commands to reach desired behavioral outcomes. However, this dynamic interplay amongst sensorimotor brain systems serving motor control remains poorly understood. Methods:We designed a novel somatosensory entrainment-movement task, which 25 adults completed during magnetoencephalography (MEG). Specifically, subthreshold electrical stimulation (ES) was applied to the right median nerve at a sensorimotor-relevant frequency (15 Hz), while participants completed a quasi-paced finger tapping paradigm with their right index finger. MEG data was transformed into the time-frequency domain and imaged using a beamformer to evaluate the effect of continuous somatosensory feedback (i.e., entrainment) on movement-related oscillations and motor performance at the single trial level. Results:Our results indicated frequency-specific reductions in movement-related oscillatory power (i.e., theta, gamma) in the contralateral motor cortex during motor execution. Additionally, we observed robust cross-frequency coupling within the motor cortex and further, stronger theta-gamma coupling was predictive of faster reaction times, irrespective of stimulation protocol (i.e., stim vs. no stim). Finally, in the presence of ES, cross-frequency coupling of movement-related oscillations was reduced, and the stronger the entrained neuronal populations (i.e., increased oscillatory power) were prior to movement onset, the weaker the inherent theta-gamma coupling became in the motor cortex. Discussion:This novel exogenous manipulation paradigm provides key insight on how the somatosensory system modulates the motor cortical oscillations required for volitional movement in the normative sensorimotor system.

IW-69

Effects of Regular Cannabis Use on the Neural Dynamics Serving Complex Motor Control

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Background:
Cannabis is the most widely used illicit drug in the United States. Regular use has been linked to deficits in attention and memory. However, the effects of regular cannabis use on motor control are less understood.

Methods:
A sample of 18 cannabis users and 23 nonuser controls performed a complex finger movement task using the right hand during magnetoencephalography (MEG). Time-frequency windows during motor planning and execution phases were imaged using a beamformer and whole brain functional connectivity was computed using the dynamic imaging of coherent sources approach, with the left primary motor cortex (M1) as the seed. Maps were examined for condition (complex vs. simple), time window (planning vs. execution), and group effects.

Results:
Whole-brain analysis revealed a group-by-window interaction such that users exhibited stronger beta (16-24 Hz) desynchronization in the left superior parietal during motor execution relative to nonusers. In addition, there was a group-by-condition interaction in cortico-cortical connectivity from the left M1 to the right cerebellum and bilateral parietal cortices during motor planning and the right postcentral gyrus during motor execution. In all cases, this group-by-condition interaction indicated that users had stronger cortico-cortical connectivity between the left M1 and these regions during complex relative to simple trials.

Conclusions:
We observed specific differences in the neural dynamics serving motor control in regular cannabis users compared to nonusers. These data suggest that regular cannabis users may employ compensatory processing in the parietal cortex in conjunction with stronger connectivity to adequately perform a complex motor task relative to nonusers.

IW-70

Beta Oscillations in the Subthalamic Nucleus uncouple from Motor Cortex during Changes of Movement Direction

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Background:
Neural oscillations in the beta and gamma frequency ranges have been implicated in movement preparation, initiation, and inhibition. An increase in beta power after movement cancellation, the post-movement-beta rebound (PMBR), has been observed in both subthalamic nucleus (STN) and cortex. Its role is still being debated. To date, studies examining the inhibition of behaviour have largely relied on ballistic movements. Here we aimed to uncover how changing and stopping of a continuous movement is represented in the brain.

Methods:
We simultaneously recorded magnetoencephalography (MEG) and STN local field potentials (LFPs) from 12 Parkinson's disease (PD) patients who underwent surgery for deep brain stimulation the day before measurement. Patients were required to turn a wheel with their index finger. Visual cues prompted them to start turning, change direction (reversals) and stop turning.

Results:
We observed sustained movement-related beta desynchronization at movement start and a prominent PMBR after movement termination in both STN and motor cortex. We hypothesised that reversals might contain both of these aspects, yet the oscillatory activity accompanying them was distinctly different. During reversals we observed transient decreases and increases in beta power in LFP channels. Motor cortical beta power suppression was stronger and more sustained. Crucially, cortical beta power did not increase at reversal.

Discussion:
While the PMBR appears to be a global feature of complete stopping, the STN seems to reflect the deceleration required for reversals without this activity propagating to cortex.

IW-71 Adaptive neural network classifier for decoding finger movements

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While non-invasive Brain-to-Computer interface can accurately classify the lateralization of hand moments, the distinction of fingers activation in the same hand is limited by their local and overlapping representation in the motor cortex. In particular, the low signal-to-noise ratio restrains the opportunity to identify meaningful patterns in a supervised fashion. Here we combined Magnetoencephalography (MEG) recordings with advanced decoding strategy to classify finger movements at single trial level. We recorded eight subjects performing a serial reaction time task, where they pressed four buttons with left and right index and middle fingers. We evaluated the classification performance of hand and finger movements with increasingly complex approaches: supervised common spatial patterns and support vector machine (CSP + SVM); unsupervised linear finite convolutional neural network (LF-CNN) and linear finite recursive neural network LF-RNN; available deep learning algorithms as EEGNet, FBCSP-ShallowNet, Deep 4. The right vs left fingers classification performance was accurate above 90% for all methods. However, the classification of the single finger provided the following accuracy: CSP+SVM : – 0.68 ± 7%, LF-CNN : 71 ± 10%, LF-RNN : 76 ± 5%, EEGNet : 72 ± 7%, FBCSP-ShallowNet : 66 ± 9%, Deep4 : 69 ± 8%. CNN methods allowed the inspection of spatial and spectral patterns, which reflected activity in the motor cortex in the theta and alpha ranges. Thus, we have shown that the use of CNN in decoding MEG single trials with low signal to noise ratio is a promising approach that, in turn, could be extended to a manifold of problems in clinical and cognitive neuroscience.

IW-72 A proposed Interdisciplinary Approach to Advance Magnetomyography Techniques for Magnetic Field Recordings of Skeletal Muscles

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Recording and evaluating the electrical activity produced by skeletal muscles is an important medical diagnostic tool, which enables detailed studies of the neuromuscular system, and empowers many applications.However, existing measurement techniques face fundamental physical constraints and a radical new approach will be required to advance our capabilities. Our workexamines the potential of quantum magnetometry with nitrogen vacancy (NV) centres to initiate a fundamental paradigm shift in skeletal muscle studies. Our interdisciplinary approach will combine expertise in simulation technology, quantum physics and ethics to develop this project from proof of concept measurements through to device prototype testing.

IW-73

MEG source imaging of resting state oscillatory patterns in healthy subjects and validation with the intracranial EEG atlas of the healthy brain

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Due to the ill-posed nature of the EEG-MEG source imaging (EMSI) problem, the accuracy of EEG-MEG estimated sources requires careful validation. This project aims to determine the limits of resting-state MEG (rsMEG) source analysis by validating it quantitatively with the intracranial EEG (iEEG) atlas of the healthy brain (Frauscher2018). We considered rsMEG data acquired on 40 healthy participants, each lasting 60-seconds with eyes-closed, (Pellegrino2021). We adapted the wavelet-based Maximum Entropy on the Mean (wMEM) method (Lina2012), taking advantage of discrete wavelet representation of MEG signals to localize resting state oscillations. To quantitatively compare the MEG derived results with the iEEG atlas, an iEEG forward model was applied to MEG source maps to estimate electrical potentials at virtual iEEG electrodes, ViEEG (Grova2016), for all actual iEEG electrode positions in the atlas. Power spectra were calculated and compared for 38 anatomical regions of interest (ROIs) specified in the iEEG atlas. For each ROI, we also calculated the percentage difference of channels exhibiting a peak in VIEEG compared to iEEG for each spectral band. The MEG estimated power spectra are better retrieved in lateral regions compared to medial regions in most spectral bands, and are especially poorly retrieved in deeper regions such as the hippocampus and amygdala. Further analysis shows an overestimation of channels exhibiting spectral peaks in the alpha band in all ROIs compared to other spectral bands. The large prevalence of alpha oscillations could be generated by remaining spatial leakage associated with EMSI and high-amplitude alpha oscillations in resting-state eyes-closed condition.

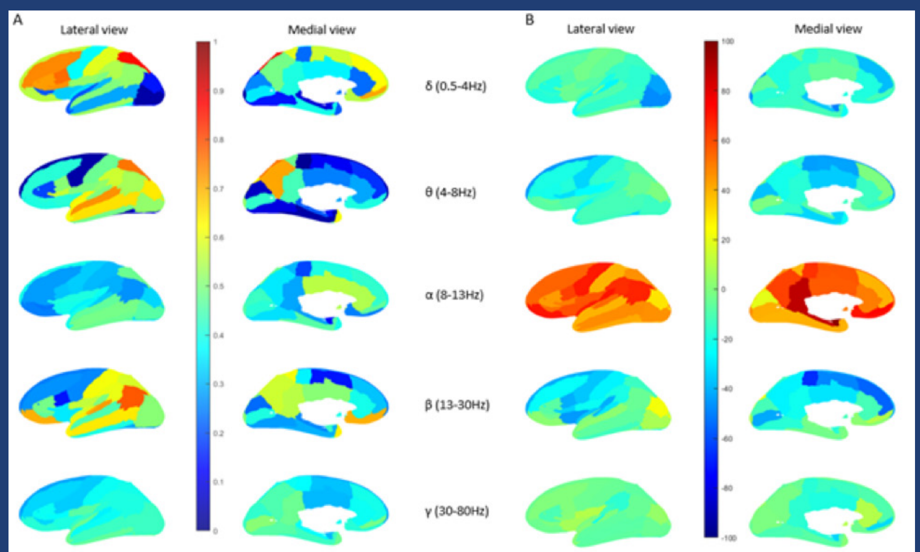

Figure: Estimation of spectral characteristics by MEG derived V_{iEEG} and comparison with ground truth iEEG atlas for 38 regions of interest (ROI) specified in MICCAI atlas. **(A)** Average probability of V_{iEEG} to estimate power spectral density (PSD) compared to iEEG for each spectral band. For each ROI, the probability is calculated as $\left(1 - \frac{|median\ PSD_{iEEG} - median\ PSD_{ViEEG}|}{Standard\ Deviation_{ViEEG}}\right)$ at each frequency (0.5-80 Hz with 0.5 Hz step), where PSD_{iEEG} is calculated for all channels in a specific ROI, N_{ROI}, and PSD_{ViEEG} is calculated for total N_{ROI} x 40 channels, each of the 40 subjects contributing one virtual iEEG channel per intracerebral atlas channel.; **(B)** Percentage difference of estimation of number of channels exhibiting spectral peaks by V_{iEEG} compared to iEEG in each spectral band for each ROI. Median value of percentage difference over 40 subjects is plotted as color map ranging from underestimation (cooler color) to overestimation (warmer color).

IW-74

Synchronization in the connectome: Metastable oscillatory modes emerge from interactions in the brain spacetime network

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A rich repertoire of oscillatory signals is detected from human brains with electro- and magnetoencephalography (EEG/MEG). However, the principles underwriting coherent oscillations and their link with neural activity remain under debate. Here, we revisit the mechanistic theory that transient brain rhythms are a signature of metastable synchronization, occurring at reduced collective frequencies due to delays between brain areas. We consider a system of N=90 damped oscillators – approximating the short-lived gamma-frequency oscillations generated by neuronal feedback-inhibition in local field potentials – coupled according to the map of diffusion tracts between brain areas. Varying only the global coupling strength and conduction speed, we identify a critical regime where spatially and spectrally resolved metastable oscillatory modes (MOMs) emerge at sub-gamma frequencies, approximating the MEG power spectra from 89 healthy individuals at rest. Further, we demonstrate that the frequency, duration, and scale of MOMs - and the resulting frequency-specific envelope functional connectivity – can be controlled by global model parameters, while the connectome structure remains unchanged. Grounded in the physics of delay-coupled oscillators, these numerical analyses demonstrate the role of delayed interactions in the connectome in structuring oscillatory brain activity in space and time.

IW-75

The power bias has a limited impact on MEG envelope functional connectivity

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Electrophysiological measures of functional connectivity (FC) can be biased by variations in signal-to-noise ratio (SNR). Functional networks similar to those of fMRI emerge from MEG envelope FC at rest within _ (8–12 Hz) and _ (12–30 Hz) frequency bands where MEG signal power is maximal. This raises the question, are these MEG networks merely an artefact of the power bias? We investigated this question using a new power bias correction consisting in a SNR-dependent renormalization of MEG envelope FC. The renormalization factor was derived analytically by modeling the signals as a mixture of neural and noise contributions and extracting the neural envelope connectivity as a function of SNR and measured connectivity. This model was validated using simulations and then applied on a functional connectome based on a dense brain parcellation and pairwise estimation of band-limited (1–45 Hz, 1 Hz-wide bands) source envelope correlation with geometric spatial leakage correction. The data comprised resting-state recordings (5 minutes, eyes open) of 25 right-handed healthy adult subjects (13 females, age: 19–36 years) acquired with a whole-scalp MEG system (Vectorview, MEGIN). The impact of power-bias correction on the resulting FC spectra was estimated using a relative error index. Results showed that, at the SNRs exhibited by MEG resting-state signals (4.221±1.645), power-bias correction does not modify connectivity spectra substantially (1.58±0.75%). This confirms that functional networks are indeed driven by spontaneous interactions among electrophysiological brain rhythms. In practice, this also indicates that power-bias correction is not fundamental to MEG FC estimation.

IW-76

Hidden Markov Modelling in volunteer propofol anaesthesia

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Background:Propofol is the most common intravenous anaesthetic. However, its mechanisms of action remain incompletely understood. A strong clinical need exists for individualised, brain-based biomarkers. Hidden Markov Modelling (HMM) has emerged as a promising way to identify dynamic, subject-specific states in electrophysiological data. Methods:We applied the Time-Delay-Embedded HMM (HMM-MAR toolbox) to 32-channel electroencephalogram data collected from 16 healthy volunteers (8 female, 28.6±7 years) undergoing an ultra-slow 48-minute induction to 4µg/ml propofol effect-site concentration. Data were cleaned using independent component analysis, down-sampled to 100Hz, and bandpass-filtered 0.5-45Hz. N=16 states were estimated based on the elbow criterion in free-energy (N=4-28 states showed similar results). Data were time-embedded with ±50ms lags and HMM was run on the top 17 principal components in the embedded space (90% variance explained). State-specific spectral information was extracted using multi-tapering. The state switching rates for first and last third of induction were computed. Sliding-window fractional occupancies (3min window) were correlated with drug concentration to highlight dose-specific states. Results / Discussion:State switching was significantly reduced in late compared to early induction (Wilcoxon P=0.0056). Seven states showed significant association with propofol dose (Spearman _ with P<0.05, FDR-corrected), including a wakefulness-specific State 9 with high occipital alpha, loss-of-responsiveness-specific State 1 with high temporal beta, and several anaesthesia-specific states with high delta power. We provide evidence that HMMs may identify time-resolved, dose-dependent, clinically relevant states in anaesthetic brain activity. Ongoing work is clarifying their functional roles.

IW-77 Hemispheric Asymmetry of Caudate Nucleus, Globus Pallidus and Thalamus is Associated with Lateralized Alpha Power Modulation

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Introduction. There is increasing evidence that subcortical structures may contribute to high-level cognitive functions, such as spatial attention, working memory, and cognitive control. However, the relationship between subcortical structures and oscillatory cortical dynamics in relation to behaviour remains unclear. Method. We addressed whether volumetric hemispheric asymmetries in subcortical structures relate to oscillatory modulations of spatial attention under varying conditions of perceptual challenge. Two faces were presented in respectively the left and right hemifield in a cued spatial attention task. Participants were asked to indicate a change of eyes of the face in the cued direction. The 'loads' of targets and distractors were manipulated using noise masks. To relate structure to function, we calculated hemispheric lateralization modulation (HLM) of alpha oscillation as well as hemispheric lateralized volumes (LV) for subcortical nuclei. A generalized linear regression model was applied to relate HLM of alpha power to the LVs of subcortical nuclei. Results. Using a data driven model selection approach, we found that the best model explaining the variability of HLM includes Globus Pallidus, Caudate Nucleus and Thalamus as regressors; however, these regions related differently to the load manipulations of targets and distractors. Discussion. Our findings point to a link between the basal ganglia nuclei and measures of alpha oscillations in relation to spatial attention. Also, they demonstrate differentiated contributions of the different subcortical structures depending on target or distractor load, thus informing theories of how subcortical structures relate to oscillatory dynamics in challenging attentional settings.

IW-78 Mixtures of dynamic functional brain network modes in MEG data

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Background It is now widely accepted that network activity in the brain changes with time. Time-varying approaches used to model brain networks often assume a mutual exclusivity over time, e.g. clustering methods or the Hidden Markov Model (HMM) [Baker, et al. Elife 3, e01867 (2014)]. Whilst a useful constraint, this assumption may compromise the ability of the approach to describe the data effectively. Here, we propose a new model for neuroimaging data called DyNeMo (Dynamic Network Modes). Methods DyNeMo consists of a generative model that describes functional brain networks as a time-varying linear mixture of spatially distributed 'modes' and a Bayesian inference scheme that is scalable to large datasets. A recurrent neural network is used in DyNeMo to model latent dynamics. This facilitates a longer memory compared to an HMM. We train DyNeMo on resting-state MEG data (eyes open) consisting of 55 subjects. Results We demonstrated DyNeMo's ability to learn a linear mixture of modes and long-range temporal dependencies in mixing coefficients using simulated data. When trained on real MEG data, DyNeMo revealed modes with plausible functional brain network structure and with fast dynamics at similar time scales to the HMM. We show that DyNeMo provides an alternative description to the HMM that remaps states as modes. Discussion The results suggest that the assumption of mutual exclusivity in the HMM is not unreasonable in practice, and that both the HMM and DyNeMo are valid, complementary descriptions. Overall, DyNeMo is a powerful new alternative approach for studying brain network dynamics.

IW-79

Investigation of transcranial ultrasound-induced neuroplasticity of the human motor cortex by magnetoencephalography

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Introduction: Low intensity transcranial focused ultrasound stimulation (TUS) is an emerging technology for non-invasive brain stimulation (NIBS) that can penetrate deep brain structures with more focal stimulation than currently used forms of NIBS. Theta-burst TUS induces sustained increases in motor cortex excitability for at least 30-60 minutes after stimulation. tbTUS shows promise for the non-invasive treatment of brain disorders; however, its mechanism of action is unknown. Objectives: To elucidate the effects of tbTUS on oscillatory brain responses and network connectivity using transcranial magnetic stimulation (TMS) and magnetoencephalography (MEG). Methods: TMS and tbTUS were delivered to the left motor cortex of 15 healthy participants. Before and after each tbTUS intervention, we obtained motor-evoked potentials (MEPs), short-interval intracortical inhibition (SICI), and intracortical facilitation (ICF). MEG recordings of oscillatory brain activity during a resting state and motor task were also collected. Results: TMS demonstrated sustained increased MEP amplitude and decreased SICI following tbTUS, with an absence of changes in ICF. MEG analysis revealed TUS-mediated decreases in alpha power within bilateral supplementary motor cortices and decreases in beta power within the right basal ganglia and parietal region. Coherence analysis revealed increased local connectivity in motor centres overlapping with those identified on spectral power analysis. Conclusions: Our findings provide insights into the neurophysiologic basis of TUS-mediated neuroplasticity and provide a possible explanation for sustained increases in motor network excitability with tbTUS. Future studies will characterize the durability of TUS-mediated neuroplasticity and its clinical applications, such as in traumatic brain injury and stroke rehabilitation.

IW-80

The impact of mild-to-severe hearing loss on somatosensory gating in children

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Sensory gating is a neurophysiological phenomenon whereby the response to a second stimulus in a pair of identical stimuli is attenuated. It is thought to reflect the process by which the brain filters out redundant information to preserve neural resources for behaviorally-relevant stimuli. Children with hearing loss (CHL) have shown altered sensory responsivity in modalities outside of the auditory domain relative to children with normal hearing (CNH), but the cascading neural and behavioral effects have not been investigated with regards to gating. To this end, a matched cohort of CHL and CNH were presented with a paired-pulse median nerve stimulation during magnetoencephalography. Stimulus-related neural activity was imaged and peak virtual timeseries were extracted. A repeated-measures ANOVA showed significant main effects of stimulation and group, as well as a significant group-by-stimulation interaction. Follow-up testing showed that CHL had larger responses to stimulation overall, as well as greater gating from the first to the second stimulation. However, follow-on analyses of the gating ratio (controlling for differences in overall response power) were not significant between groups, suggesting that CHL were able to compensate for their enhanced responsivity to gate as effectively as CNH. We then investigated how gating ratio correlated with behavioral outcomes between groups. We found that smaller gating ratios (indicative of more effective gating) were correlated with better classroom behavior and language ability in CHL only. In sum, CHL showed enhancement of somatosensory-related neural responses relative to CNH, and individual variability in somatosensory gating in CHL was related to behavioral outcomes.

IW-81

Alpha-band oscillatory activity is modulated by the phase of respiration during spontaneous and volitionally controlled breathing

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Breathing is a cyclic bodily rhythm consisting of active inspiration and passive expiration. Although mainly in autonomic control, breathing can also be volitionally controlled during e.g. speaking. Recent animal and human studies have provided evidence regarding respiration-brain coupling, but less is known how phases of respiration, i.e. inspiration and expiration, modulate neural activity. We investigated whether alpha-band oscillatory activity is modulated by the phases of respiration and whether this modulation differs between spontaneous and volitionally controlled breathing. Magnetoencephalography (MEG) and respiration data were recorded from 40 participants. MEG recordings consisted of three conditions: 1) spontaneous breathing with eyes closed, 2) spontaneous breathing with eyes open and 3) deep breathing with eyes open. At the sensor-level, time-frequency representations (TFRs) were calculated for a time window from 0 to 4000 ms and with a baseline from -500 to 0 ms with respect to the onsets of inspiration and expiration. Moreover, source reconstruction using beamforming was applied to investigate the spatial distribution of neural activity during different phases of respiration. Visual inspection of the sensor-level TFRs showed that alpha activity decreased during inspiration and increased during expiration in all breathing conditions. Preliminary source-level cluster-based permutation test results indicated that alpha activity increased during expiration in comparison with the baseline time window in sensorimotor and parietal areas across all breathing conditions. Results regarding inspiration were not statistically significant. In conclusion, these findings suggest that expiration modulates neural activity during both spontaneous and volitionally controlled breathing.

IW-82

Distinct changes in oscillatory brain dynamics during Samatha and Vipassana meditation: an MEG study

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Background. Different meditation practices involve distinct attentional processes. While Samatha is a form of focused-attention meditation (FAM), Vipassana refers to open-monitoring meditation (OMM). Despite a flourishing body of research investigating the neural correlates of meditation, the underlying neural mechanisms that mediate the distinct processes associated with different forms of meditation are still poorly understood. Methods. We set out to characterize the properties of brain signals recorded in expert Buddhist monks with magnetoencephalography (MEG) during resting state (RS), FAM and OMM in a group of ten expert meditators. The raw MEG data were analyzed using the open source python package NeuroPycon (https://github.com/neuropycon). We reconstructed the neural activity using a Minimum Norm Estimate algorithm and computed source spectral power in five different frequency bands. We also computed long-range temporal correlation (LRTC) on neural oscillations using Detrended Fluctuation Analysis (DFA). Results and Discussion. The results reveal unique patterns of oscillatory activity specific to FAM and to OMM. The source spectral power analysis shows that compared to RS, FAM exhibits a prominent decrease in beta-band power in occipital and temporal regions, while in OMM, theta-band power decreases were observed in occipital, temporal and frontal regions. The LRTC analysis revealed an increase in the scaling exponent that was particularly prominent in OMM (compared to RS) in the beta-band. Although preliminary, these findings shed light onto the mechanisms involved in the behavioral and attentional capacities associated with these two meditation techniques.

IW-83

Small-Worldness as a Potential Biomarker for School-Readiness: A Graph Theory Analysis of MEG Data

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Small-worldness is a graph theoretical characteristic of functional brain networks that is known to index brain maturation in band-limited electrophysiological resting state networks (Khan, 2018; Boersma, 2011). However, little is known about the relationship between small-worldness in functional brain networks and behavioral indices of maturation, such as the acquisition of literacy. MEG data was collected on 48 pre-literate five-year-old children performing a visual target-detection task. Subjects additionally completed a battery of literacy measures before and after completing a two-week literacy intervention program. We perform an exploratory graph theory analysis of the MEG data. We describe distributions of path length, clustering coefficient, and small worldness in theta (4-7 Hz), alpha (8-12 Hz), beta (13-30 Hz), and low gamma (31-55 Hz) bands for task-evoked networks in source space. For each band, we report linear regression coefficients exploring potential associations between path length, clustering coefficient, and small-worldness with behavioral response to literacy intervention. Characteristics of task-evoked networks range from random to small-world with higher proportions of small-world networks occurring in the lower frequency bands. Minimal support for an association between small-worldness and behavioral measures appears only in the beta band among subjects with connected beta networks.

IW-84

The role of beta-band oscillations in interhemispheric interaction

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Synchronization in beta/gamma and slow alpha/theta oscillations is thought to underlie the integration and storing of information in visual working memory (VWM), but the specific mechanistic role in WM maintenance has remained unclear. In behavioral studies, VWM capacity in delayed match-to-sample (DMS) tasks is 2-4. Intriguingly, these studies suggest that memory capacity increases when stimuli are presented in both hemifields compared to a single hemifield. Here we set out to investigate whether increased memory capacity for bilateral stimuli is predicted by increased interhemispheric beta- or gamma band synchronization. To test this, we will record high-density electroencephalography (EEG, 256 sensors) and magnetoencephalography (MEG) of 20 subjects during a DMS task, where stimuli are presented either in one unilateral hemifield or across both visual hemifields. We then identify oscillatory networks across frequencies from source reconstructed MEG/ EEG data. Pilot data indicates (1) higher behavioral efficiency and (2) increased beta-band power and strengthened interhemispheric phase synchrony in posterior sites for bilateral stimulation. Taken together, this study will lead to a better understanding how visual information is integrated across hemifields to support VWM.

IW-85

Robust resting-state oscillatory fingerprints of GABA-ergic and non-GABA-ergic sedation.

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We compared resting-state oscillatory activity/connectivity changes with two sedative drugs (Propofol (pro) a GABA-ergic and dexmedetomidine (dex)- an _2- adrenergic agonist). A machine classifier was trained and then applied on separately collected propofol sedation data to assess robustness of drug-specific oscillatory fingerprints. Methods Experiment 1: Resting-state MEG (CTF 275, eyes-open, 15 minutes) recordings in 16 participants during mild sedation with either propofol, dexmedetomidine or saline (single-blind crossover design). Experiment 2: Resting-state MEG in 15 different participants during mild propofol sedation. Source analysis used linearly constrained minimum-variance (6mm isotropic, Fieldtrip) beamforming, separately for delta (1–4 Hz), theta (4-8 Hz), alpha (8–13 Hz), beta (13-30 Hz) and gamma (40–60, 60–80 and 80–100 Hz) bands. Functional connectivity (fc) was computed between nodes of the 90 AAL atlas regions using amplitude envelope correlation. Voxelwise activity was also estimated using the temporal coefficient of variation of the Hilbert amplitude envelope. Activation maps for each frequency-band were used to assess voxelwise drug-effects and then taken forward to train a Matlab Support Vector Machine (SVM) classifier. Dex decreased fc in the delta/ theta bands. Dex produced source activity changes in delta and theta bands, while propofol caused alpha band changes. Using SVM, a classifier trained on the Pro/Dex dataset in Experiment 1, could correctly identify (80%) those participants in Experiment 2, as having been administered propofol, rather than dex. These results demonstrate that source-localised resting-state MEG provides a robust and repeatable window onto drug-specific target engagement, suggesting sensitive mechanistic specificity.

IW-86

Resting state MEG signals reflect executive dysfunction in early cognitive impairment

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Background Dementia is a syndrome characterised by cognitive impairment due to various brain diseases. Cognition is multi-dimensional, which includes learning/memory and executive function. They are primally evaluated using batteries of neuropsychological assessments: Mini-Mental State Examination (MMSE) and Frontal Assessment Battery (FAB), among other. The former evaluates global function mainly in learning/memory dimension, whereas the latter focuses on executive function. Although they are widely used, they have innate limitations, such as skill dependence, subjectivity, ceiling, and practice effects. In our hospital, magnetoencephalography (MEG) can compensate these limitations, providing objective potential biomarkers sensitive to severity of dementia. Here we show that the MEG biomarkers reflect different dimensions of cognition. Methods MMSE/FAB scores and resting-state MEG data were acquired from 207 patients in Kumagaya general hospital. As MEG biomarkers, Median Frequency (MF), Individual Alpha Frequency (IAF), and Shannon's Spectral Entropy (SSE) were computed. Linear mixed effect model was used to assess the directional relationships between MMSE/FAB and MF/IAF/SSE. Results The regression analysis demonstrated that MF was predicted by both MMSE and FAB scores, while IAF and SSE were predicted only by MMSE and FAB scores, respectively. Discussion Our results showed that a combination of MEG biomarkers can be used to capture different dimensions of cognitive status. MEG is an objective tool, free from ceiling and practice effects, which can be used repeatedly. MEG would support clinicians to monitor patients' cognitive status and contribute to provide better treatments.

IW-87

Exploiting brain critical dynamics to inform Brain-Computer Interfaces

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Background Brain-Computer Interfaces (BCIs) are suboptimal in 30% of users. The dynamical processes underlying BCI training are only partly understood, especially the scale-free perturbations, "Neuronal avalanches", spreading and reconfiguring across the whole brain [1]. We hypothesize that the sequence of regions recruited by avalanches conveys the processes underlying BCI performance. Methods We used MEG data from a motor imagery-based BCI training session (20 subjects, aged 27.5 ± 4.0 years, 12 men [2]. For each condition, we estimated the avalanche transition matrix (ATM), containing the probability that region j would be active at time t+1, given region i was active at time t [3]. We obtained the edge-wise difference between the ATMs of the two experimental conditions in each subject, validated them via permutation analysis, and checked which regions discriminated the most between the two tasks. Then, we correlated the difference of the probabilities associated with the edges to BCI performance. Results All the significantly different edges cluster upon the premotor areas, involved during the MI task, and the cunei, involved during visual processing. In particular, the differences in the probabilities associated with edges incident upon areas such as the right paracentral lobule and the caudal middle frontal bilaterally directly correlate with the BCI scores (r=0.80 p=3x10-5; r=0.66 p=1.9x10-3; r=0.48 p=0.035, respectively). Discussion Our results suggest that avalanches capture functionally-relevant processes of interest for alternative BCI designing. 1 P. Sorrentino et al.," Sci Rep, Feb. 2021. 2 M.-C. Corsi et al. " NeuroImage, Apr. 2020. 3 P. Sorrentino et al., eLife, Jul. 2021.

IW-88

MEG Cortical Microstates: Spatiotemporal characteristics, dynamic functional connectivity, and stimulus evoked responses

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EEG microstate analysis is a useful approach for studying brain states - nicknamed `atoms of thought' - and their fast transitions in healthy cognition and disease. A key limitation of conventional microstate analysis is that it must be performed at the sensor level, and therefore gives limited anatomical insight into the cortical mechanisms underpinning these states. In this study, we generalise the microstate methodology to be applicable to source-reconstructed electrophysiological data. Using simulations of a neural-mass network model, we first established the validity and robustness of the proposed method. Using MEG resting-state data, we uncovered ten microstates with distinct spatial distributions of cortical activation. Multivariate pattern analysis demonstrated that source-level MEG microstates were associated with distinct functional connectivity patterns. Using a passive auditory paradigm, we further demonstrated that the occurrence probability of MEG microstates were altered by evoked auditory responses, exhibiting a hyperactivity of the microstate including the auditory cortex. Our results support the use of MEG source-level microstates as a data-driven method for investigating brain dynamic activity and connectivity at the millisecond scale. In addition, we have developed a Matlab toolbox for EEG/MEG sensor/source space microstate analysis to facilitate future studies into brain microstate dynamics.

IW-89

Resting State Functional Brain Networks Are Activated In Cycles

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Introduction The resting brain rapidly alternates between several stereotypical and recurrent oscillatory states, each of which subserve highly specialized cognitive functions. It is unclear whether the evolution of these patterns over longer time scales is intrinsically structured, or whether they instead arise and quiesce randomly, without any overarching organization.   Methods We used a Hidden Markov-Modelling to infer resting state network activation patterns across three large MEG datasets: MEGUK (N=55), Cam-CAN (N=600), and HCP (N=79). We used a new method to study the long-term organizational structure of state switching, which is based on the contrast of a state's probability to be active shortly before, or shortly after another state.   Results Using our new method, we found that all HMM states are interconnected by an overarching cyclical architecture. The strength of the cyclical structure was found to be significantly higher for the observed data compared to null data simulated from the HMM's transition probability matrix (). This pattern was present in all 3 datasets, and moreover, cycle period correlated negatively with age () and was predictive of fMRI dynamics (). Conclusion We show for the first time that functional brain networks in resting state MEG are activated in cycles. The presence and order of these cycles are robust across three large datasets and are correlated to age and predictive of fMRI dynamics.

IW-90

Richer than we thought: Rich-club network development is frequency- and sex-dependent

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A set of highly connected brain regions called the "rich-club" play a vital role in integrating information across the functional connectome and support a wide range of cognitive functions. Existing literature has identified changes in rich-club organization across the lifespan using functional magnetic resonance imaging (fMRI), however few studies have examined sex-specific developmental trajectories. We are the first to use resting-state magnetoencephalography (MEG) to examine the frequency- and sex-dependent development of the rich-club in a large single-site sample (N=383) encompassing a wide age span (4–39years), some of whom underwent multiple scanning sessions (479 total data points). Findings in the theta frequency band (4-7Hz) were concordant with prior fMRI studies which reported primarily linear changes with age and sex differences in the rich-club network in children and adolescents, and adults. We observed a strong dissociation between males and females across alpha (8-14Hz), beta (15-29Hz), low gamma (30-55Hz) and high gamma (65-80Hz) frequencies. While males showed either increased or no change in rich-club organization with age in these bands, females showed a very similar non-linear trajectory in these four frequencies, which increased through early childhood, followed by decreases during adolescence and early adulthood. Our findings highlight the importance of neurophysiological modalities in capturing interactions between age and sex in rich-club organization that only emerge in the faster oscillatory frequency bands. We demonstrate that oscillatory dynamics are key considerations in understanding sex-differences and developmental trajectories of the brain's network organization that underlies cognitive functions and resilience.

IW-91

Critical-like bistable dynamics in the resting-state human brain

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Brain activity exhibits scale-free avalanche dynamics and power-law long-range temporal correlations (LRTCs) across the nervous system. This has been thought to reflect "brain criticality", i.e., brains operating near a critical phase transition between disorder and excessive order. Neuronal activity is, however, metabolically costly and may be constrained by activity-limiting mechanisms and resource depletion, which could make the phase transition discontinuous and bistable. Observations of bistability in awake human brain activity have nonetheless remained scarce and its functional significance unclear. First, using computational modelling where bistable synchronization dynamics emerged through local positive feedback, we found bistability to occur exclusively in a regime of critical-like dynamics. We then assessed bistability in vivo with resting-state magnetoencephalography and stereo-encephalography. Bistability was a robust characteristic of cortical oscillations throughout frequency bands from _ (3–7 Hz) to high-_ (100–225 Hz). As predicted by modelling, bistability and LRTCs were positively correlated. Importantly, while moderate levels of bistability were positively correlated with executive functioning, excessive bistability was associated with epileptic pathophysiology and predictive of local epileptogenicity. Critical bistability is thus a salient feature of spontaneous human brain dynamics in awake resting-state and is both functionally and clinically significant. These findings expand the framework of brain criticality and show that critical-like neuronal dynamics in vivo involves both continuous and discontinuous phase transitions in a frequency-, neuroanatomy-, and state-dependent manner.

IW-92

Travelling beta burst activity in the human sensorimotor cortex

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Beta oscillations in the human sensorimotor cortex are hallmark signatures of healthy and pathological movement. In single trials, beta oscillations include bursts of intermittent, transient periods of high-power activity. These burst events have been linked to a range of sensory and motor processes, but their precise spatial, spectral, and temporal structure remains unclear. Specifically, a role for beta burst activity in information coding and communication suggests spatiotemporal patterns, or travelling wave activity, along specific anatomical gradients. We here show in human magnetoencephalography recordings that burst activity in the sensorimotor cortex occurs in planar spatiotemporal wave-like patterns that dominate along two axes either parallel or perpendicular to the central sulcus. Moreover, we find that the two propagation directions are characterised by distinct anatomical and physiological features. Finally, our results suggest that sensorimotor beta bursts occurring before and after a movement share the same generator but can be distinguished by their anatomical, spectral and spatiotemporal characteristics, indicating distinct functional roles.

IW-93

Interindividual variability in multimodal connectome

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Individuals are different in behavioural responses and cognitive abilities. Neural underpinnings of individual differences are largely unknown. Here, by using multimodal imaging data including diffusion MRI, functional MRI and MEG, we show the consistency of interindividual variation in connectivity across modalities. We calculated structural connectome from probability of connections estimated from tractography, functional connectome based on correlation of BOLD time series and envelope amplitude correlation of alpha and beta oscillations from MEG signals projected on cortical surface. We demonstrated that regional differences in individual variability of structural and functional connectomes is characterized by higher variability in association cortices and lower variability in sensory and visual cortices. This pattern is consistent across all modalities at varying degrees as shown by significant alignment between functional and structural connectome variabilities at several clusters of brain regions. Variability in connectivity was associated with cortical myelin content and microstructural properties of connections. Our findings contribute to understanding of individual differences in functional and structural organization of brain and facilitate fingerprinting applications.

IW-94

Rapid-invisible frequency-tagging for brain-computer interfaces

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Brain-computer interfaces (BCI) based on steady-state visual evoked potentials (SSVEP) are among the most commonly used BCI systems. They require participants to covertly attend visual objects flickering at specific frequencies. The direction of attention can then be decoded in real-time by analysing the power of neuronal responses at the flicker frequency. While steady-state BCIs are typically applied at slower frequencies (<30 Hz), we here explore the application of faster frequencies (>50 Hz), which are invisible to participants and at the same time, increase the temporal resolution at which SSVEPs can be resolved. To implement this novel rapid invisible frequency-tagging technique, we utilized a state-of-the-art projector with refresh rates of up to 1440 Hz. We modulated the luminance of visual objects at 56 and 60 Hz, which produced a strong neuronal response measurable with magnetoencephalography (MEG). The direction of covert attention, decoded from frequency-tagging responses, was used to control a real-time PONG game. Our results show that eight out of nine participants were able to play the game, with accuracies exceeding 60%. Importantly, only actively using seven sensors for the BCI, participants were able to modulate the power of frequency-tagging responses within a 1-second-interval. By not producing visible flicker, our BCI is less distracting and causes less fatigue than existing systems, allowing for longer application while providing higher communication rates. It opens new avenues for fundamental research and practical applications. In combination with novel optically pumped magnetometers, it could facilitate the development of high-speed and high-mobility next generation BCI systems.

IW-95

Feature selection in Guided Search is associated with modulated neuronal excitability to target and distractor features in early visual regions

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In visual search for a known target in a display (or a world) containing distractor items, attention is guided toward items having target features and away from items having distractor features. We used Rapid Invisible Frequency Tagging (RIFT) to understand the neuronal mechanisms underlying feature guidance in an MEG study. We hypothesized the RFT responses to target features to be enhanced and responses to distractor features to be reduced when their respective roles were known to the participants. Participants (N=32) were instructed to indicate the presence or absence of a blue or yellow target "T" presented among blue and yellow "L" distractors. The colours were tagged at 60 and 67 Hz, respectively, making the flicker unperceivable. In the guided search condition, participants were informed about the target colour, whereas in the unguided search condition, the colour of the T was randomized and not known to the participant. The RFT response to the Target-colour was significantly stronger than the response to the Distractor-colour, in the guided but not the unguided search condition. Moreover, we find the response to the guided Target-colour to be significantly enhanced compared to the unguided Target-colour while the response to the guided Distractor-colour was reduced compared to the unguided Distractor-colour. These results provide evidence that attentional selection in Guided Search is implemented by both a boosting of neuronal responses to target features in early visual regions as well as a decrease in the excitability associated with distractor features.

IW-96

Tracking the temporal dynamics of semantic processing during object recognition

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BACKGROUND: Humans' ability to understand the world and communicate with each other is tied to mental representations of concepts. Understanding more about these representations and how they are accessed is key to developing a model of language in the brain. METHODS: We combine magnetoencephalography and machine learning to investigate how these concepts are represented and accessed in the brain over time. We use a picture viewing task and contrast two modelling approaches to map the dynamic brain response patterns to semantics. We compare the traditional sliding window of fixed length and a novel cumulative modelling approach. RESULTS: Temporal cross-decoding indicates information generalization across nearby time windows between 200 and 750 ms after stimulus onset. With the cumulative modelling approach, we show that during this time period the brain gradually accumulates semantic information and eventually reaches a plateau. The timing of this plateau point varies across individuals indicating differences in the temporal domain of semantic processing. Representational similarity analysis shows temporal patterns in accordance with the decoding results and suggests that occipital areas are most relevant to semantic processing of pictures. DISCUSSION: We present here a new perspective on the temporal dynamics of semantic processing. With the cumulative modelling approach, we track the processing of information and show that the brain accumulates semantic information during object recognition. This work reveals a new dimension of individual variability in language processing and opens new avenues for language research.

IW-97

The primary auditory cortex contributes to unisensory tactile frequency discrimination

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Background: Recent studies have shown that tactile-auditory multisensory stimulation optimizes perception. However, how these senses interact with each other to improve sensory integration remains unclear. Here, using iEEG and EEG recordings in humans, we investigate whether the auditory system contributes to the discrimination of sounds (pitch) delivered via the tactile modality only (vibrotactile speakers). Methods: During iEEG recordings, we presented an oddball paradigm through vibrotactile stimulation gloves to two patients with intractable epilepsy. We also used the same paradigm with 20 healthy participants during EEG recordings. The paradigm consisted of a random presentation of deviant stimuli (225, 250, 500, 800 and 1000Hz) during a sequence of standard sounds (200Hz). To control for auditory perception, participants were asked to listen to a continuous white noise while wearing earplugs. Results: iEEG data first revealed that primary auditory cortex (A1) is activated (gamma increase relative to baseline) during tactile perception, and, more importantly, its activity is modulated with deviance detection. EEG data in healthy participants confirmed these results: a right lateralized response in somatosensory and auditory regions was observed in response to standard stimuli. For detection of deviance, an early positive response around 200ms was observed with generators in the right auditory cortex. A positive wave was then observed around 450ms with generators in the dorsal stream. Discussion: These findings suggest that pitch discrimination without auditory perception is supported by an interplay between somatosensory and auditory systems. These results provide a better understanding of multisensory interaction during tactile unisensory perception.

VW-161

M170 was enhanced by animal avatar faces but not modulated by communication

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During covid-19 epidemic, distant communication has been developed. Communication by using avatar faces that can capture facial expressions in real time are becoming popular. Our latest results showed that transient brain response M170, which is sensitive to facial stimuli, could be not only evoked by animal avatar faces but larger than human faces, suggesting that avatar faces are easier to communicate with. The purpose of this study was to examine whether the amplitude of the M170 can be modulated by avatar communications. Nine participants watched five different facial expressions of cat and dog avatar faces (made of FaceRig©, Holotech Studios SRL, Romania) and human faces in two (before and after) sessions. Between sessions, each participant communicated with an actress using only cat or dog avatar for 8 min. During the before and after sessions, transient responses of magnetoencephalogram were recorded and averaged over 100 times for each condition (cat, dog avatar and human). The source amplitude of M170 were estimated in the fusiform gyrus by minimum norm estimation method, and the source amplitudes were compared between before and after sessions. Result showed there is no main effect between sessions of both the communicated and uncommunicated animal avatars in M170 amplitude. It is possible that avatar communication does not influence M170 but other time window. Number of the participants and method of measuring M170 may also influence the result. More suitable method to examine the effect of avatar communication reminds to be discussed.

VW-160

Auditory evoked magnetic fields in the processing of discriminate between meaningful and meaningless words

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Background
From our previous study, we found a clear correlation between the auditory evoked magnetic fields (AEF) M100 and the syllables when the subjects could understand the speech as meaningful words. Therefore, we will investigate further about the difference in AEF related to meaningless words when the subjects discriminate between meaningful and meaningless words.

Methods
To investigate this, we captured the neuromagnetic signals emitted by the brains of subjects when listening synthetic words. The basic idea is to make meaningless words by replacing phonemes of meaningful words. In this experiment all eight subjects were right-handed native Japanese speakers. Subjects were instructed to press one of two keys (Yes / No) depending on meaningful words or meaningless words. We used 400 channels SQUID gradiometer, PQ1400RM made by Yokogawa Electric Corporation.

Results
We focus here on the processing of discriminate between meaningful and meaningless words. The AEF M100 component was most significantly observed when the subject listened to the syllable that could discriminate as meaningless words. In other words, the AEF M100 component was most significantly observed about 100 ms after the syllable that could discriminate as meaningless words. Note that all subjects exhibited the same trend.

Discussion
We investigated about the AEF in the processing of discriminate between meaningful and meaningless words related to synthetic words. We find a clear correlation between the AEF M100 and the syllable that could discriminate as meaningless words. Acknowledgment: This work was supported by JSPS KAKENHI Grant Number 18K11379.

IW-100

Pre-stimulus oscillation phase predicts visual perception

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Perception of and attention to visual stimuli has been proposed to fluctuate rhythmically. In line, correlation between pre-stimulus alpha and theta phase with stimulus detection and attention has been reported in frontal and posterior brain areas. However, the results are inconclusive as no prior studies have tested whether fluctuation in perception and attention are present concurrently. Moreover, the cortical sources underlying these putative phase-behavior relationships have remained scarcely addressed. We used three visual threshold stimulus detection tasks together with magnetoencephalography (MEG) and individual-cortical-anatomy based source modeling to (1) test the hypothesis of pre-stimulus oscillations biasing stimulus detection and attention in separate frequencies and, importantly, (2) to identify the underlying cortical sources. Phase Opposition Sum (POS) was used to quantify phase-behavior coupling. We found that the pre-stimulus phase in alpha and theta frequency bands was significantly predictive of visual detection performance in all three tasks. The phase-behavior correlation of theta oscillations was stronger in the task condition with a pre-stimulus attention cue, implying a functional role for theta in top-down attentional processes. Source modeling showed that the phase-behavior correlations arose predominantly in the fronto-parietal and cingulo-opercular control systems and in the hierarchy of task-relevant processing systems, i.e., the dorsal attention system and visual system. These findings thus extend prior art by revealing that the pre-stimulus phase effects arise in the co-operation of brain systems achieving control and processing functions. Moreover, these findings corroborate the predictive nature of pre-stimulus phase in visual threshold stimulus detection in a comparable set of experimental paradigms.

IW-101

Preliminary study of intra-modal and inter-modal sensor correlation using concurrent MEG and EEG from an auditory task

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Combined multimodal imaging approaches, using functional magnetic resonance imaging (fMRI), magnetoencephalography (MEG), and electroencephalography (EEG), have contributed to a comprehensive understanding of the human brain network, by comparing source level results obtained from respective unimodal measurements. Although advanced source reconstruction methods have been developed for both MEG and EEG, sensor-level analyses are still frequently preferred for practical purpose. In this preliminary study, we investigated sensor-level functional connectivity using simultaneously recorded MEG and EEG data during an eyes open resting condition and an auditory task condition from a healthy subject group. MEG signals were recorded from a whole-head MEG system with 152 first order axial gradiometers, and EEG signals were recorded from 19 scalp electrodes placed according to the standard international 10-20 system. Both intra-modal and inter-modal sensor correlations were computed using the Gaussian copula mutual information estimator and tested for statistical significance. Mutual information based graph theory was used to study brain network connectivity in different task conditions. We also explored the effect of EEG reference on the sensor-level connectivity patterns, by comparing the results for four reference methods: the cephalic reference, average earlobe reference, global average reference, and a reference electrode standardization technique (REST).

IW-102

Neuromodulation in people with tinnitus: A concurrent transcranial direct current stimulation – magnetoencephalography study

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Background Transcranial Direct Current Stimulation (tDCS) is a technique involving low-intensity electric current delivered to the brain via scalp electrodes. It is a potential treatment option for tinnitus. Magnetoencephalography (MEG) was used to investigate differences in oscillatory power and measure changes in brain-wide functional connectivity of people with tinnitus, before, during, and after tDCS. Methods 40 participants with tinnitus were randomly assigned to received either real or sham tDCS. Resting state MEG recordings were collected for 10 minutes before, 20 minutes during, and 10 minutes after intervention. Preliminary analyses were conducted to detect global differences in oscillatory power and functional connectivity between and within frequency bands across pre-intervention and post-intervention timepoints. Results First-pass omnibus test results on a subset of participants (N=19) indicated no statistically significant main effect of time (before vs after intervention): _: p = .632; _: p = .221; _: p = 0.41; _: p =.421; or condition (active vs sham) _: p = .967; _: F p = .300; _: p = .564; _: p = .577; on functional connectivity across the brain. No significant interactions between time and condition were observed: _: p = .505; _: p = .263; _: p = .210; _: p = .193 Conclusion This study was the first to combine tDCS with MEG in the tinnitus population. It is currently ongoing and further analyses will include MEG data collected during intervention, as well as comparisons of oscillatory power and connectivity between brain regions.

IW-103

Do alpha oscillations causally influence perception?

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The role of alpha oscillations for perception has been investigated in several studies. Many of these studies used near-threshold detection tasks in which subjects had to report whether they perceived a weak stimulus. These studies have shown that the power of prestimulus alpha oscillations negatively correlates with detection rates: in trials with low power, the weak stimulus could be better detected than in trials with high power. While the correlative relationship has been demonstrated frequently, evidence for a causal role of alpha oscillations for perception is rare. In this study, we used real-time MEG and an established near-threshold visual detection task (van Dijk et al., 2008) to investigate the putative causal role of alpha power for perception. We recorded ongoing neuronal activity from 20 subjects with a 306-channel MEG (MEGIN Oy, Finland). We computed real-time alpha power in parieto-occipital sensors while subjects were sitting in the MEG. If alpha power was higher/lower than individually determined upper/lower thresholds, we presented the near-threshold stimulus. Since previous studies reported a negative correlation between alpha power and detectability of the stimulus, we hypothesized that subjects are able to detect the stimulus in states of low alpha power, while they miss the stimulus in states of high alpha power. In contrast to our hypothesis, we found that subjects' detection rates did not significantly differ between trials with high and low alpha power. This negative finding argues against a causal role of alpha power for perception.

IW-104

Expectation Suppression in the visual and auditory domain: a MEG study

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Expectation suppression is a reduction in neural responses to expected stimuli. This expectation could be linked to either content (what) or timing (when) of a stimulus. Previous studies have generalized the suppression effects across sensory modalities by default, without explicitly testing parallel paradigms in different sensory domains. Here, we present results from two MEG studies comparing the effect of what and when on expectation suppression in the visual and the auditory domain. In a visual experiment, participants were presented with five Gabors (four entrainers and a target). The orientation of target Gabor could be either predictable or not (what factor) and the timing between the Gabors could be predictable or not (when factor). Similarly, in an auditory experiment, four entrainer tones could either predict the pitch (what) of the target tone or not, and the timing between tones was also modulated (when). Participants' task focused on the feature of target that was orthogonal to the predicted what feature. Expectation suppression in the visual domain was mainly driven by the what factor with evoked responses to predictable stimuli gradually reducing across entrainers. Temporal uncertainty enhanced this suppression carried out by the what factor. Conversely, expectation suppression in the auditory domain was sensitive to both what and when factor. Temporal predictions critically enhanced the suppression carried out by what factor. In two experiments we observed expectation suppression in both visual and auditory perception. However, the two sensory modalities show qualitatively different expectation suppression effects interacting with temporal predictability.

VW-162

Neural engagement with videos is maximized during scenes featuring full body movements

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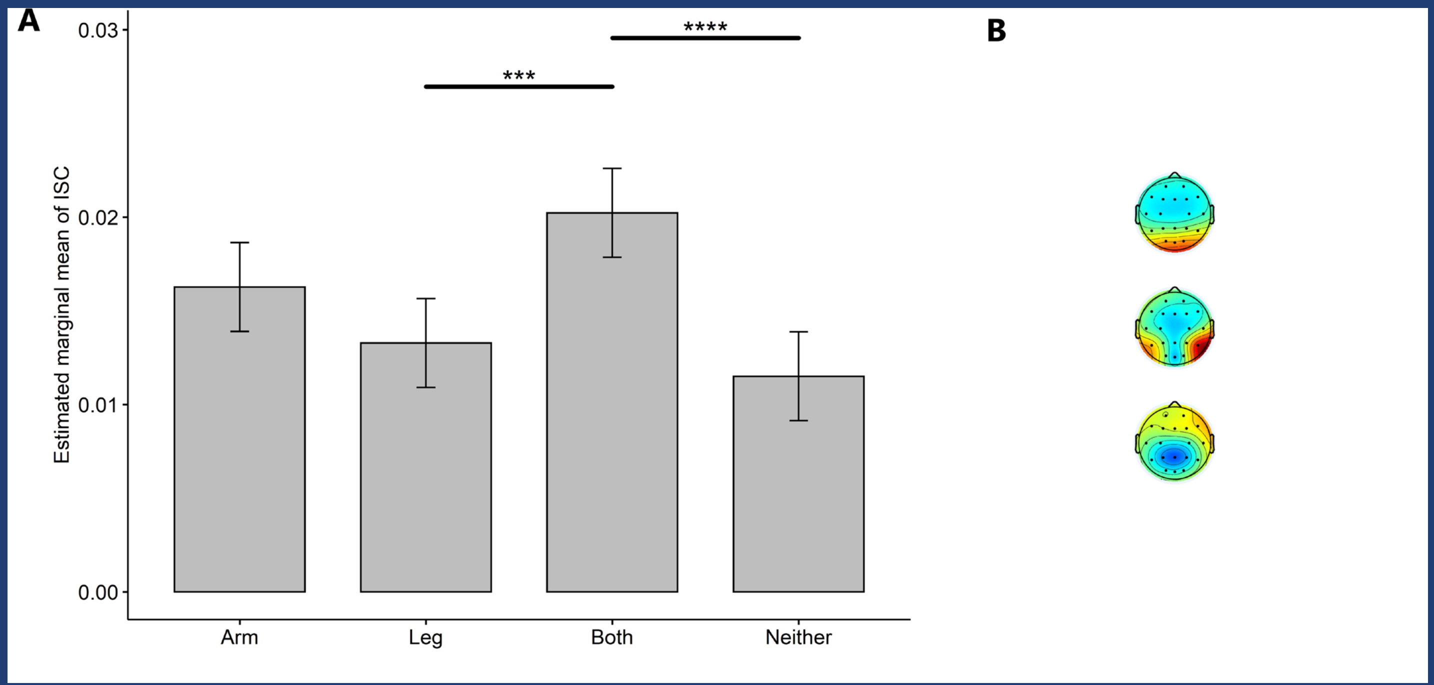
During watching a movie, the audience is believed to exhibit maximal engagement during action scenes that usually contain a great amount of body movements. However, the neurophysiological mechanisms underlying the engagement with others' movements are not clear. We hypothesized that individuals' neural engagement with videos is higher during scenes featuring full body movements, i.e., simultaneous arm- and leg-related movements. To test our hypotheses, we recorded EEG data from 39 healthy participants, including young adults and children (age range 4-26 years, mean=14.4), while watching naturalistic videos featuring human movements. The videos were automatically annotated as arm- or leg-related using a machine learning algorithm. "Neural engagement" was quantified by the inter-subject correlation (ISC) of EEG responses evoked by the videos, which corresponds to the sum of the three strongest correlated components across participants (Figure 1B). An ANCOVA, with participants' age as a covariate ($p<.0001$), showed that the effect of stimulus movement on ISC was statistically significant ($p<0.0001$; Figure 1A). Post-hoc analysis showed that ISC was significantly higher during scenes featuring both arm and leg movements compared to those featuring only leg movements ($p=.0004$) and those featuring neither arm nor leg movements ($p<.0001$). Our findings suggest that neural engagement of viewers during movie scenes is maximized by the richness of movement content, and further highlight the importance of feature extraction in studies implementing naturalistic stimuli. This study was supported by RSF project 20-68-47038. This study used the HSE Automated system of non-invasive brain stimulation for synchronous registration of brain activity and eye movements.



IW-106

The impact of eye closure on anticipatory alpha activity in a tactile discrimination task

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Background: Since their discovery, alpha oscillations (8–14 Hz) have been noted to increase in power over posterior areas when awake participants close their eyes. Recent work, especially in the context of (spatial) attention, suggests that alpha activity reflects a mechanism of functional inhibition. However, it remains unclear how eye closure impacts the anticipatory alpha modulation observed in attention paradigms, and how this affects behavior. Methods: We recorded magnetoencephalography (MEG) in 33 human participants performing a tactile discrimination task under conditions with their eyes open versus eyes closed. Results: We replicated the hallmarks of previous somatosensory spatial attention studies: alpha lateralization across the somatosensory cortices as well as alpha increase over posterior (visual) regions. Furthermore, we found that eye closure leads to (1) reduced task performance; (2) widespread increase in alpha power; and (3) reduced anticipatory visual alpha modulation (4) with no effect on somatosensory alpha lateralization. Regardless of whether participants had their eyes open or closed, increased visual alpha power and somatosensory alpha lateralization improved their performance. Discussion: We provide evidence that eye closure does not alter the impact of (anticipatory) alpha modulations on behavioral performance. We propose there is an optimal visual alpha level for somatosensory task performance, which can be achieved through a combination of eye closure and top-down anticipatory attention.

VM-156

Auditory cortical responses to natural sounds in post-stroke aphasia

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Knowledge on cortical-level functional changes in aphasia could help to design neurophysiologically based rehabilitation approaches. Humans are remarkably good at perceiving relevant sounds even in noise, relying on both bottom-up and top-down analysis. For degraded speech signal processing, prior word-form representations appear influential (Norris et al. 2008). We studied, with MEG, cortical processing of speech and environmental sounds presented in isolation and in noise (+18 dB SNR) in Finnish-speaking adults with a left-hemispheric ischemic (N=10) or hemorrhagic (N=5) stroke and in healthy age-matched controls (N=25). All patients had demonstrable behavioral problems in speech processing. The speech sounds were consonant-initial, common Finnish nouns, and the environmental sounds comprised, e.g., well-recognizable animal cries and traffic sounds. In healthy subjects, the background noise influenced MEG responses in supratemporal auditory cortices bilaterally: the N400m responses to speech sounds were significantly prolonged ($p < 0.001$) in the presence of noise, in accordance with earlier results (Renvall et al. 2012). No similar effect was observed in chronic aphasic patients with ischemic stroke ($p = 0.311$), while the responses in patients with hemorrhagic stroke showed an effect similar to controls. Chronic aphasic patients with left-hemispheric ischemic stroke seem to be unable to boost their single-word processing in noise, contrary to healthy controls and patients with hemorrhagic stroke. Thus, different kinds of tissue damage may suggest lesion-specific functional changes in the bilateral language network.
References: Norris & McQueen, Psychol Rev, 2008; Renvall, H. et al. Cerebral Cortex, 2012.

IW-108

Is visual gamma enhanced by image anisotropy?

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Gamma oscillations can be reliably generated in visual cortex for most subjects by presentation of simple, oriented stimuli such as gratings but are often weak or absent in response to more naturalistic stimuli. It has been proposed that gamma is responsive to variance in stimulus energy across orientations (Hermes et al., 2019, eLife) and therefore the weak gamma response to natural images may be due to those images tending to have low anisotropy. To test this hypothesis, we rank ordered a large set of natural images based on a measure of image anisotropy and presented ten subjects with the images with the highest and lowest anisotropy. Data were acquired during stimulus presentation using a 275-channel CTF MEG system and the gamma response (40-150 Hz) was extracted from visual cortex using beamforming. Consistent with the orientation variance hypothesis, we found a trend for narrowband gamma (40-70Hz) to be enhanced for high vs low anisotropy images although this did not reach statistical significance, possibly because the stimuli produced weak gamma responses. The high frequency (<70Hz) gamma 'spike' at stimulus onset showed the reverse pattern, being stronger to low vs high anisotropy images. Our data suggests that the visual gamma response to natural images may indeed be influenced by image anisotropy, but that testing with a much larger sample of subjects or using methods that can measure gamma with greater SNR (such as ECoG) will be necessary to confirm this.

IW-109 Bidirectional Cortical Maps for Somatosensory Perception

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Somatosensory perception involves complex co-operation among multiple brain areas. Although its exact mechanism is unclear, emerging evidence has indicated that somatosensory perception is largely affected by specific neuronal activation of many cortical regions beyond the S1. The present study combines direct cortical stimulation (DCS) mapping data for eliciting somatosensory perceptual experiences and high-gamma band (50 to 150 Hz, HG) mapping data during somatosensory tasks. We constructed normalized cortical maps of the elicited somatosensation by DCS on ECoG electrodes from 51 patients with intractable epilepsy. Additionally, we generated four-dimensional (4-D) maps of ECoG HG activities during various sensorimotor tasks from 20 (for movement tasks) and 30 (for tactile tasks) epilepsy patients. Our results showed that artificial somatosensory perception is elicited not only from conventional somatosensory-related cortical regions such as the S1 and S2, but also from widespread network including superior/inferior parietal lobules, and premotor cortex. Furthermore, the distributions of electrode sites elicited somatosensation showed distinct spatial differences depending on the quality of somatosensation. The DCS on the dorsal part of PPC generally induced movement-related somatosensation, whereas that on the ventral part of fronto-parietal area exclusively elicited tactile sensation. Furthermore, the 4-D HG mapping results show considerable similarity in spatial distribution between HG and DCS maps. These findings suggest that macroscopic neural processing for somatosensation has distinct pathways depending on their perceptual functions. Additionally, the results provide evidence for the “perception and action” related neural streams of somatosensory system.

IW-110 Neurophysiological correlates of somatosensory tinnitus modulation

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Background Tinnitus is the subjective perception of a sound without a physical sound source (Lockwood et al., 2002). It is known that neuronal activity in auditory and non-auditory brain areas contribute to its generation. Rather recent research has highlighted somatosensory processes associated with tinnitus (Shore et al., 2016). We here investigate if differences in tinnitus perception mediated by the somatosensory system are reflected in auditory brain oscillations. Methods We asked 24 chronic tinnitus patients to perform relaxing and straining exercises with their jaw (blocked design, randomized order). After each condition participants concentrated on their tinnitus for 3 minutes, while brain activity was measured with Magnetoencephalography. Every minute, they rated loudness and unpleasantness of their tinnitus on a visual analogue scale. Brain activity was contrasted for the strained versus relaxed state on sensor and source level with a focus on gamma activity. Results Participants experienced their tinnitus louder and more unpleasant in the strained compared to the relaxed condition (both $p<.05$). Furthermore, we found a significant positive cluster in the gamma frequency band on sensor level for the strained versus relaxed condition (32-46 Hz, cluster $p<.05$). According to source analysis, the gamma power increase showed up mainly in right secondary auditory cortex.   Discussion Our results suggest that the somatosensory system modulates tinnitus by modulating auditory gamma power. This underlines the crucial role of the somatosensory system in generating and maintaining tinnitus. Beyond, our results indicate that the level of auditory gamma power is associated with phantom sound perception.

IW-111

Dynamic whole brain network activity explains trial-to-trial somatosensory perceptual variability

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The relationship between whole brain spontaneous neural networks and behavioural variability is poorly understood. Previous research was limited in the number of brain regions investigated and focussed on specific spectral components. To provide a network view we recorded MEG data from 30 participants and used a tactile discrimination task (Baumgarten et al., 2015) to investigate the whole-brain network-behavior relationship. Two electric pulses were applied at the index-finger and participants responded whether they perceived one or two pulses. The time between the two pulses was adjusted with a staircase for each participant to have a hit rate of 50%. The inter-trial interval was randomised between 8 and 10 seconds. Cleaned MEG inter-trial sensor data were projected with an LCMV beamformer on individual cortical surfaces. These data were reduced to the mindboggle atlas via PCA. A time-delay embedded hidden Markov model (Vidaurre et al., 2018) was fit to obtain time resolved networks. Each network had a unique spatio-spectral and temporal fingerprint. Behavioural variability in detecting the stimuli as one or two pulses could be explained by significantly altered transition probabilities between different networks on a trial-by-trial basis. Additionally, on a spectral level increased transitions between networks forming in the alpha and beta band were beneficial for behavioural performance. Moreover, the percept of 2 pulses was preceded by more switches and energetically efficient transitions between networks. By leveraging a data-driven pipeline we provide novel insights into the spatial, spectral and temporal dynamics of whole-brain networks and their relationship to behavioural variability.

IW-112

tACS at the alpha frequency affects several alpha components in different manners

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While transcranial alternating current stimulation (tACS) has been used to investigate the causal roles of oscillatory neural activities in perception and cognition, there are large individual differences in tACS effects. The effect of tACS targeting the occipital alpha oscillations also varies largely across subjects. This variance might partly originate from the fact that there are multiple alpha components, and tACS affects each component differently. Here, we investigated the mechanisms behind individual differences in tACS effects by evaluating the aftereffect of tACS on multiple alpha components whose peak frequency and spatial patterns are different. Eighteen participants received 20-min of tACS or sham stimulation on separate days. Ten-min of MEG data were collected before and after the stimulation and spectral analysis was performed with a high-frequency resolution of 0.1 Hz to disentangle different alpha components whose peaks are close in frequency. As a result, three alpha components were observed, in the ascending order of frequency: temporal, occipital, and parietal. Comparison of each component between before and after tACS periods revealed decreased power of the temporal component, and increased power of the occipital component by tACS. The parietal component was not modulated by tACS. Post-hoc analysis showed that the frequencies of occipital/temporal components were slightly faster/slower than the stimulus frequency. Thus, our results indicate that the aftereffect of tACS depends on the relationship of frequencies between tACS and intrinsic alpha components. This relationship can be explained by the long-term potentiation and depression by spike-timing-dependent plasticity (Vossen et al., 2015).

IW-113

Investigating the Relationship Between Layer-Specific Cortical Myelination and MEG-measured Visual Oscillatory Dynamics

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Background: Cortical myelin is considered to be a proxy of neuronal density, possibly underpinning individual variability in neuronal/synaptic dynamics. For example, it has been shown to correlate positively with auditory ERFs. Cortical oscillations at different frequencies are also known to have layer-specific generative mechanisms. Here, therefore, we investigated the relationship between visual oscillatory responses and layer-specific myelination of V1. Methods: Using MEG (CTF-275), a visual-grating paradigm was used to induce gamma oscillations in V1 and, after beamforming (LCMV-Fieldtrip), the peak gamma amplitude and frequency was extracted for each participant. An exploratory analysis of the amplitude spectrum, at the same peak location, was also performed for the baseline and stimulus time-periods. Using quantitative R1 (1/T1) maps acquired at 7T (Siemens Magnetom, 0.65mm isotropic, MP2RAGE/SA2RAGE sequences), depth-specific myelin estimates were derived for each participant on the cortical surface at 7 different layers. Results: No significant correlations were found between peak gamma amplitude or frequency and R1 estimates in V1. However, the results of the whole spectra analysis indicated a relationship between superficial myelin and visual gamma power (~40Hz). In the baseline, the strongest correlations were observed between lower beta frequencies (~15-20Hz) and myelin in deeper cortical layers. Discussion: Several factors may have affected our ability to detect a relationship between peak gamma amplitude/frequency and cortical myelination. However, the results of the whole spectra analysis, which accord with animal models of the depth-specificity of specific frequencies, warrant further investigation. The results also pose intriguing questions regarding the significance of 40Hz activity.

IW-114

Neurofunctional differences when processing subsecond and suprasecond auditory time intervals.

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Background: The perception of subsecond time intervals is thought to be supported by automatic sensory circuits. In contrast, it has been proposed that suprasecond intervals are processed by high-order cortical network such as the central executive network. In the present study, we investigate whether distinct or common neural resources support the perception of sub and supra second time interval. Methods: We used electroencephalography (EEG) and an auditory oddball paradigm on time intervals in twenty participants. For each trial, one deviant inter-sound-onset-interval was randomly presented through the standard intervals (800ms for the subsecond condition, and 1600ms for the suprasecond condition). These deviant intervals were either shorter or longer than the standard interval (delayed). Auditory evoked potentials were studied for each condition at both the sensor and source level. Results: A positive frontocentral peak at 190ms after stimulus onset, with generators in the right primary auditory cortex, was associated with the detection of subsecond deviants. For the suprasecond condition, a biphasic response was associated with deviance detection. A negative peak at 170ms with generators in the right inferior frontal gyrus and right precentral gyrus followed by a frontocentral positivity at 350ms with generators in the dorsal pathway including the premotor cortex and the supplementary motor area is observed. Activity in this fronto-parietal network for detection of delayed deviants might represent top down and prediction error mechanisms. Conclusion: These results suggest that distinct neural mechanisms support the perception of sub and supra second time intervals in the human brain.

IW-115

Effective connectivity of the ventral occipito-temporal cortex during face perception, recognition and repetition: An M+EEG study

Extensive neuroimaging studies of face processing suggest a core network consisting of the occipital face area (OFA) for detecting facial features and the fusiform face area (FFA) for holistic face identities. Functional interactions within these regions were initially described as a feed-forward network with information flow from early visual cortex (EVC) to the OFA, and then to FFA. However, findings of normal responses to faces in the FFA of patients with OFA lesions challenge this hierarchy. Both areas, along with EVC, also show decreased neural responses due to repetition of faces, which may modulate either local connections within each region or connections between regions. In the proposed study, we address this debate by investigating effective connectivity of the core face-sensitive network during face processing. We use a publicly available M/EEG dataset of 16 healthy participants with 150 trials each of famous, unfamous and scrambled faces presented in a pseudo-random order, showing a robust M/N170 effect observed for faces versus scrambled images. We apply dynamic causal modelling with Parametric Empirical Bayes to source activity estimated by simultaneous inversion from EEG and MEG sensors. We use family-wise Bayesian model comparison to test whether connectivity between EVC, OFA and FFA is modulated by perception, familiarity and repetition of faces. Our findings help elucidate the computations performed by neural circuits in face-selective regions during perception and recognition of repeated faces. This complements previous work applying DCM to fMRI data on similar paradigms and informs future work on fusing network models of M/EEG and fMRI.

IW-116

Alpha-echoes as travelling waves detected by MEG

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Growing evidence suggests that travelling waves are functionally relevant for cognitive operations in the brain. Several electroencephalography (EEG) studies suggest that perceptual alpha-echo, representing the brain response to a random visual flicker, propagates as travelling wave across the cortical surface. In this study, we used magnetoencephalography (MEG) to explore the spatial propagation dynamics of the alpha-echo. To this end, we presented participants with grating stimuli while modulating luminance of the stimuli by random noise and simultaneously acquiring MEG. At the group-level, we observed a spatial decay of the amplitude of alpha-echo ($p < 0.001$). The amplitude decreased radially from the parietal sensor, where the alpha-echo showed the largest amplitude. The propagation latencies, relatively to the same parietal sensor, consistently increased with the distance ($p < 0.001$). Importantly, the propagation speed derived from these latencies was around 10 m/s, which is within the range reported for neuronal systems, 0.1-10 m/s. Interestingly, propagation of the alpha-echoes was predominantly central to lateral, while EEG studies reported mainly parietal to frontal propagation. Moreover, propagation speed of the alpha-echoes was higher compared to that in EEG studies; around 10 m/s compared to 2 m/s. We believe that a complementary simulation study could provide insight into the discrepancy between MEG and EEG results.

IW-117 Neural synchrony and signal transmission in top-down control of low-level processing of visual events

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Endogenous attention facilitates processing of visual stimuli through influencing the alpha / theta oscillatory phase and local oscillation amplitudes in sensory brain areas. However, less is known of the mechanisms that implement attentional top-down control between fronto-parietal and visual regions. Large-scale alpha-band network synchronisation has been proposed to a be putative mechanisms for top-down control, but data to support this hypothesis is correlative and inconclusive. In contrast, gamma-band synchronization has been proposed as mediating bottom-up sensory information. We are collecting MEG-EEG and TMS data together with visuospatial attention task to obtain mechanistic and causal evidence for the significance of large-scale synchronization networks in top-down control of endogenous attention and whether they implement the transfer of information between fronto-parietal regions with the visual system and thereby modulate bottom-up sensory processing. We furthermore aim at disentangling visuo-spatial attentional from top-down control networks. Our preliminary results show synchronization of brain oscillations between prefrontal, parietal and visual areas is correlated with endogenous attention, whereas higher frequencies (e.g., gamma) underlie bottom-up processes. We will be presenting large-scale synchronization networks and the key hubs and connections mediating attention control on an initial cohort of 10 participants. These network data will be used for planning MEG-informed TMS interventions

VW-119 Creativity is in the eye of the beholder: unconstrained pareidolia in fractal patterns

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Creativity is a highly coveted and multifaceted skill. Empirical research typically probes creativity by estimating the potential for problem solving and novel idea generation, a process known as "divergent thinking". Here, by contrast, we explore creativity through the lens of perceptual abilities by asking whether creative individuals are better at perceiving recognizable forms in ambiguous stimuli, a phenomenon known as pareidolia. We designed a visual perception task in which 50 participants, with various levels of creativity, were presented with ambiguous stimuli and asked to identify as many recognizable forms as possible. The stimuli consisted of cloud-like images with various levels of complexity, which we controlled by manipulating fractal dimension (FD). Furthermore, MEG data were collected while participants performed the same pareidolia task. We found that pareidolic perceptions arise more often and more rapidly in individuals that are more creative. Furthermore, the emergence of pareidolia in high-creatives happened more constantly across the span of FD values, suggesting a wider repertoire for perceptual abilities in creative individuals. MEG data revealed that pareidolia is characterized by increase in theta and decrease in alpha power in frontal areas, and widespread decrease in differential entropy. Our behavioral findings suggest that pareidolia may be used as a perceptual proxy of idea generation abilities, a prerequisite for creative behavior. Moreover, our MEG results constitute a first step toward the identification of the neural markers of unconstrained pareidolia. These findings expand our understanding of the perception-creation link and open new paths in studying creative behavior in humans.

VW-120

Beta oscillations in human MEG synchronize after negative rather than positive outcomes following exploratory decisions under a probabilistic gambling task

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Post-feedback frontal beta-band oscillations are commonly considered a mechanism that is triggered by positive outcomes and promotes strengthening of the action plan that has led to the reward. However, an action rewarded is not always a truly optimal choice. In probabilistic gambling tasks, after the optimal strategy has been learned by participants, they still occasionally commit exploratory choices, which are disadvantageous on average – but still may be positively rewarded on some trials. We asked whether positive feedback for deliberately explorative choices was followed by beta-band synchronization. Alternatively, a negative outcome, which matches the prediction of the acquired utility model, might induce beta synchronization, thus strengthening the probabilistically optimal action strategy. To answer this question, we recorded MEG, while forty volunteers performed a probabilistic two-alternative gambling task, during which they were asked to make choices between two alternatives. One alternative incurred wins more often than losses, while the other one incurred losses more often than wins. We found that the commonly observed pattern of beta synchronization in response to the feedback was paradoxically inversed for deliberate exploratory choices: frontal beta power was increased after the negative feedback but not after the positive feedback. We hypothesize that since exploratory choices are tentative quests for information committed by participants in violation of the learned utility model, the negative feedback for such choices actually works to strengthen the utility model and to re-establish its advantage over a competitor - the explorative decision. Supported by Russian Science Foundation grant #20-18-00252.

VW-121

Embodied mindfulness: Brain - body interaction in meditators

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The aim of this project is to study the visceral mechanisms of attentional control and emotional regulation in meditation by developing a physiological model of the embodied mind. We study the interaction between brain dynamics and cardiac, respiratory and intestinal function from the MEG signals (Elekta system), electrocardiogram (EKG), electrogastrogram (EEG) and a device compatible with MEG system to measure bi-nasal measure of air pressure. We scanned 50 participants with different levels of meditation experience and were asked to fill a set of questionnaires to characterize their life style, with the goal of correlating expertness and customs with biological parameters. Experts and meditators show a different pattern of the cardiac cycle, as measured with the heart rate variability, as well as differences in the main oscillation of the gastric rhythms. Our results at brain level show, in resting state, an increase of alpha oscillation in occipital areas in meditators when compared with novices, that correlates with years of experience. Also meditator shown an enhanced functional connectivity (PLV) in links coupling occipital, insular and pre-frontal areas in both alpha and gamma spectral band. Our results support the hypothesis of the increase of alpha as a control of internal interferences, a reinforced mechanisms with the meditation practice.

VW-122

Slow-paced expiration reduced sensitivity to emotion perception

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Background. Respiratory patterns are tightly linked to emotion. Despite the evolutionary advantage of preparing an organism to cope with emotional events evoking rapid or impaired breathing, over-activation of this pathway could be detrimental. Given that the act of slow breathing is conceptually thought to be able to regulate emotional processing, this study tested the hypothesis that slow breathing may modify the temporal regime imposed by breathing cycles and in turn, modulates brain activity and eventually affects sensitivity to incoming emotional stimuli. Methods. Twenty participants were instructed to breathe at a slow (0.125 Hz) or a normal pace (0.25 Hz) while concurrently detecting the presence of fearful expressions which were delivered at the stage of ongoing inhalation or exhalation. Respiratory and magnetoencephalography (MEG) activities were simultaneously recorded. Results. Behaviorally, perceptual sensitivity to fearful expression detection was reduced at the stage of ongoing exhalation relative to inhalation during slow-paced breathing but not during normal-paced breathing. MEG results showed that these behavioral outcomes reflected the modulation of post-stimulus alpha power activity. Such modulation was driven by different breathing paces, as they could differentially adjust prestimulus theta phase and exert the influence via theta phase-alpha power coupling. Conclusions. The overall results suggest that brain rhythms, coupled to voluntarily-controlled respiratory rhythms, may provide a configuration of temporally organizing activity that links breathing behavior to brain state and ultimately prepare for upcoming emotional events.

VW-123

What makes the sex detectable from EEG and what does that mean for deep learning-based disease detectors?

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Background Deep learning is increasingly being used to detect diseases from M/EEG but remains difficult to interpret and can inadvertently exploit undesired features, including non-neural artifacts. Deep learning has been demonstrated to accurately detect the sex from EEG (>80%). For diseases with unequal prevalence in males and females, sex becomes a critical confounder in deep learning-based classifiers. Our work addresses three topics: What does a neural network look for when it detects the sex from EEG? Where do sex differences originate from? And how can we identify and reduce sex biases in disease detectors? Methods We designed a shallow neural network with the intention that findings therefrom generalize to commonly deeper neural networks. We trained the network to detect the sex on random EEG segments (1140 patients, TUH-EEG-Corpus). To interpret the neural network and the learned distinctive patterns in the data, we estimated the relevance of all EEG data points and created saliency maps. To narrow down the suspected sources of sex differences in the EEG, we quantified the impact of removing artifacts and filtering traditional frequency bands. Results Instead of brain waves, the networks initially focused on electrocardiac artifacts. After filtering these artifacts, the sex remained detectable. EEG topographies were critical to detect the sex, but waveforms and frequencies were not. We were able to determine the sex even from data with shuffled time-domain. Discussion Non-neural artifacts introduce sex biases in automated disease classifiers. Different performance for one sex for male- or female-only trained models indicates such biases.

VW-124

The Right Hemisphere Is Responsible for the Greatest Differences in Human Brain Response to High-Arousing Emotional versus Neutral Stimuli: A MEG Study

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Studies investigating human brain response to emotional stimuli—particularly high-arousing versus neutral stimuli—have obtained inconsistent results. The present study was the first to combine magnetoencephalography (MEG) with the bootstrapping method to examine the whole brain and identify the cortical regions involved in this differential response. Seventeen healthy participants (11 females, aged 19 to 33 years; mean age, 26.9 years) were presented with high-arousing emotional (pleasant and unpleasant) and neutral pictures, and their brain responses were measured using MEG. When random resampling bootstrapping was performed for each participant, the greatest differences between high-arousing emotional and neutral stimuli during M300 (270–320 ms) were found to occur in the right temporoparietal region. This finding was observed in response to both pleasant and unpleasant stimuli. The results, which may be more robust than previous studies because of bootstrapping and examination of the whole brain, reinforce the essential role of the right hemisphere in emotion processing.

VW-125

Neural rhythmic representation of intergroup bias: comparing political right and left

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It is widely debated whether the two political wings, right and left, are symmetrically polarized or differ fundamentally and asymmetrically. Several neuroimaging and electrophysiological studies have examined this question but neural rhythmical activity has been largely overlooked. Framed in the political turbulence of Israel, our study has utilized magnetoencephalography (MEG) to investigate neural oscillations representing intergroup bias and the possible neural differences between political wings. We sampled 79 Israeli adults who underwent the Implicit Association Test (IAT) during MEG recording. The only rhythm associated with intergroup bias in earlier studies has been the alpha rhythm and our findings confirmed that. Further, this effect appeared in the rightist group but not in the leftist and was significantly different between the two groups at the neural level. This study has implications for the neuroscience of political ideology.

IW-44

Ideological values parametrically modulate empathy neural response to vicarious suffering

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Magnetoencephalography (MEG) has not been applied thus far to investigate political psychology. In the current study, we exploited MEG spatiotemporal resolution to test whether empathy neural response to vicarious suffering is stronger among political leftists (i.e., liberals) as compared to political rightists (i.e., conservatives). The literature in political psychology tends to point to this ideological asymmetry, however, it leans on self-reports, which is often limited by subjective bias and conformity to social norms. Here, we aimed to test this asymmetry by investigating the neural empathy response and by exploring insights from the neural findings. We recorded oscillatory neural activity in fifty-five participants while they completed a well-validated neuroimaging paradigm for empathy to vicarious suffering. The findings revealed a typical rhythmic empathy response (i.e., in the alpha-band) in a typical neural substrate for cognitive empathy (i.e., the temporal-parietal junction). This empathy neural response was significantly stronger in the leftist than in the rightist group. In addition to this dichotomous division, the neural response was parametrically modulated by political inclination and driven by right-wing ideological values. This is the first study to reveal an asymmetry in the neural empathy response as a function of political ideology. The findings reported in this study further consolidate the self-reported literature in this research area of political psychology, and further suggest that ideological values can parametrically modulate empathy neural response to vicarious suffering. This study opens new vistas for addressing questions in political psychology by using MEG.

VW-128

MEG Language Mapping Using an Automatic Algorithm for Equivalent Current Dipole and DICS Beamformer in Patient Undergoing Epilepsy Surgery

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Magnetoencephalography (MEG) is still underutilized in presurgical language mapping (PLM) in epilepsy centers, though its efficiency and accuracy have been demonstrated1. The main reason for this is that the single equivalent current dipole (sECD) method used involves subjective judgements. To address this technical issue, we developed a completely automated, objective, algorithm for PLM, using sECD that removes all subjective judgements on the part of the user (Figure 1). We then compared performance of this sECD algorithm with the dynamic imaging of coherent sources (DICS)2 beamformer for PLM in 20 patients with epilepsy (18.0 ± 13.9 years; 8 males; 3 sedated; 18 right-handed) using a word recognition task2 in two repeated sessions. Our results revealed that the sECD algorithm provided a significant concordance between the language laterality index (LI) of the two sessions across all subjects (correlation = 0.9; P < 0.00001). Conversely, DICS beamformer in four frequency bands provided a much lower, non-significant concordance (correlation < 0.44; P > 0.06). In addition, the DICS beamformer provided a biased result toward symmetric language representation (LI ≈ 0) unlike sECD, that provided a more reasonable language lateralization and localization which agreed with previous studies showing right and bilateral language representation in 25-30% of epilepsy patients4 (see Table 1 and Figure 2). Comparisons of the developed sECD algorithm with other MEG analysis methods are forthcoming.

References: 1Papanicolaou et al., J. Neurosurgery 2004;100.5:867–876. 2Gross et al., PNAS 2001;98.2:694–699. 3Youssofzadeh and Babajani-Feremi, NeuroImage 2019;201:116029. 4Gaillard et al., Neurology 2007; 69:1761–1771.

Table 1. Results of presurgical receptive language mapping in 20 patients with epilepsy during a word recognition task using two approaches: (1) the developed algorithm in this study based on the single equivalent current dipole (sECD) method; (2) the dynamic imaging of coherent sources (DICS) beamformer in the alpha (8-12 Hz), low beta (12-20 Hz), high beta (20-30 Hz), and low gamma (30-50 Hz) frequency bands. Patients performed two repeated sessions of the word recognition task. In DICS beamformer, suppression and augmentation of source power compared to a baseline were considered for the alpha/betta and gamma bands, respectively.

	sECD	DICS Beamformer			
		Alpha	low Beta	high Beta	low Gamma
Laterality Index (LI) across all subjects and Sessions [Mean ± STD]	0.31 ± 0.65	0.09 ± 0.56	0.02 ± 0.6	0.06 ± 0.71	-0.03 ± 0.85
% of Sessions w Left Laterality	72%	38%	31%	47%	44%
% of Sessions w Right Laterality	23%	23%	31%	31%	44%
% of Sessions w Bilateral Representation	5%	38%	38%	22%	12%
% Same Laterality b/w Session1 & Session2	79%	42%	53%	33%	56%
Correlation of LI b/w Session1 & Session2	0.90	0.37	0.44	0.16	0.27
P-value of Correlation of LI b/w Session1 & Session2	< 0.00001	0.121	0.061	0.517	0.303

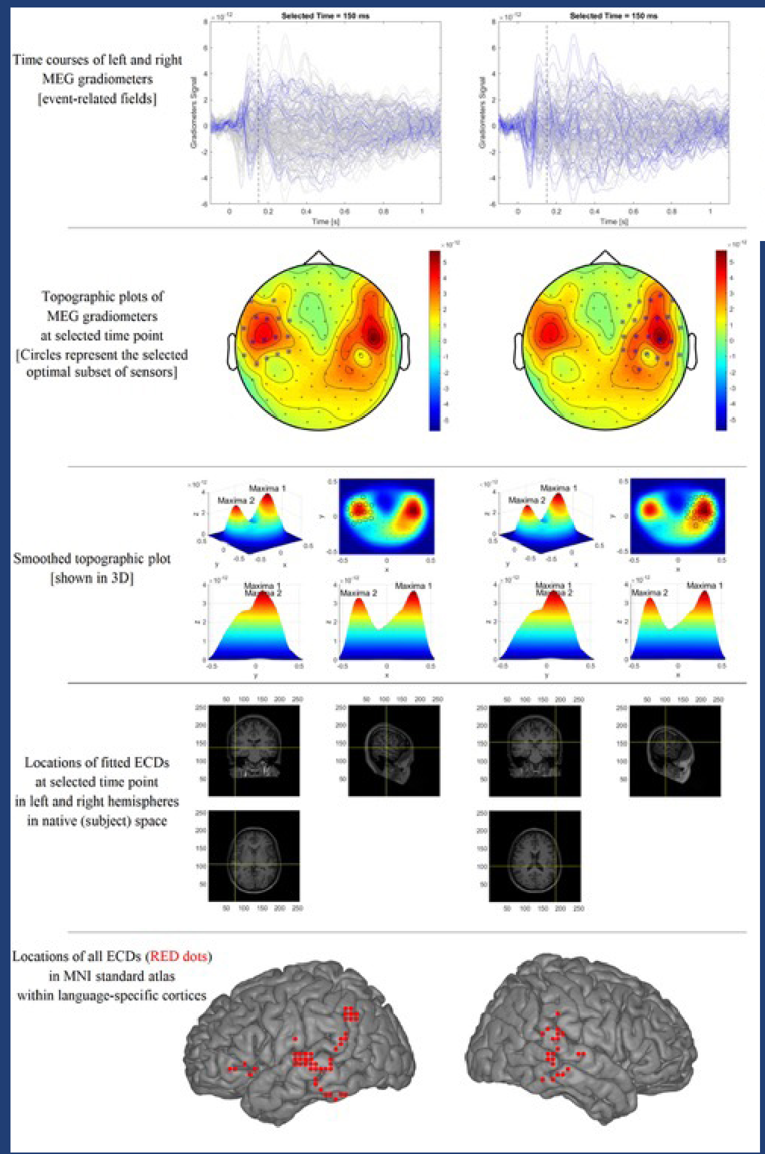

Figure 1. The implemented automatic algorithm for language mapping using single equivalent current dipole (sECD). The algorithm selects an optimal subset of MEG sensors corresponding to each of up to five local maxima in the smoothed field patters of gradiometers at a given latency (typically every 1 ms). Then the source location (in native space) corresponding to each of the local maxima is calculated using the sECD model, and the location is transferred to the standard the Montreal Neurological Institute (MNI atlas). For a selected time-window of interest (150 to 600 ms for the task used in this study), all dipoles surviving specific criteria (e.g., residual variance < 20%) within the left and right language ROIs (specified based on the Brainnetome standard atlas) are used for language mapping and ultimately calculating the language laterality (LI).

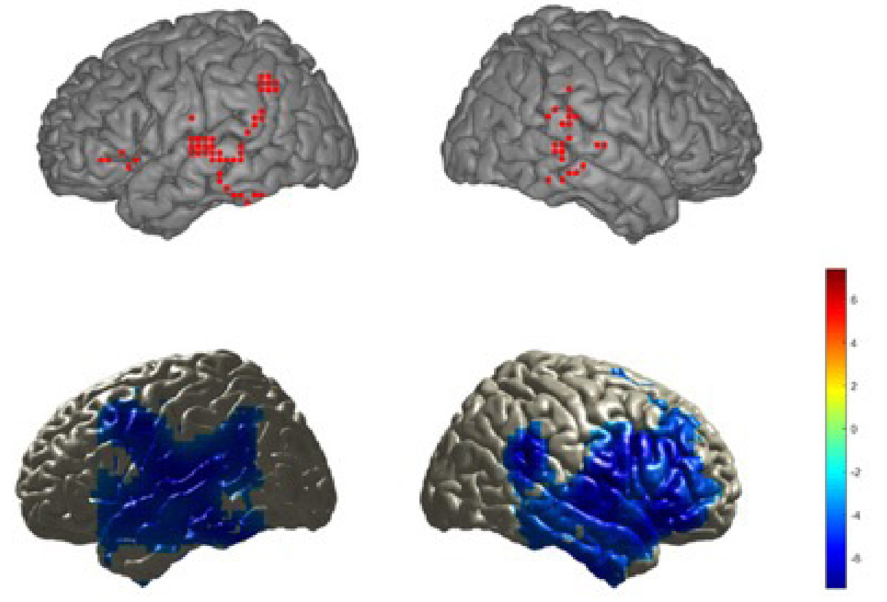

Figure 2. Results of language mapping using the implemented automatic algorithm based on the single equivalent current dipole in this study (top) and suppression of source power in the beta band based on dynamic imaging of coherent sources (DICS) beamformer (bottom) in a representative patient.

VW-129

Magnetic Source Imaging and beta decrease: towards approaches to determine language laterality

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Background:
Few studies reported successful language laterality index (LI) calculations based on imaging decreased beta activity using distinct beamforming and dynamic Statistical Parameter Mapping (dSPM) Minimum Norm Imaging (MNI) approaches. We aimed to evaluate the performance of these approaches for determining language laterality relative to standard clinical methods.

Methods:
Sixty patients with epilepsy performed an auditory word-recognition task for mapping of receptive language function during clinical presurgical magnetoencephalography evaluation. All MEG data underwent standard preprocessing, and artifact-free trials were transformed into the time-frequency domain. Significant beta responses relative to baseline at the MEG sensor level were imaged using a linearly constrained minimum variance (LCVM) beamformer and dSPM MNI. We also performed equivalent-current dipole (ECD) fitting of language evoked fields. LI was calculated based on above half-maximum threshold sum of the beta decrease within language-related regions of interest; then compared to ECD fitting and to reports of fMRI and WADA tests, when available.

Results:
Beamforming and MNI successfully source localized language areas, including in non-diagnostic scans by ECD fitting. Decreased beta activity was observed in language-related areas. However, LI calculations had a concordance < 50% compared to ECD fitting and fMRI/WADA. Additionally, left-hemispheric dominance percentage was lower than that reported in prior studies.

Discussion:
Agreeing with literature we observed decreased beta oscillations during language processing in language-related areas using beamforming and MNI. Nevertheless, we failed in lateralizing language. We suggest that our negative results are due to inadequate methodology for laterality index calculation and limitation of the language paradigm.

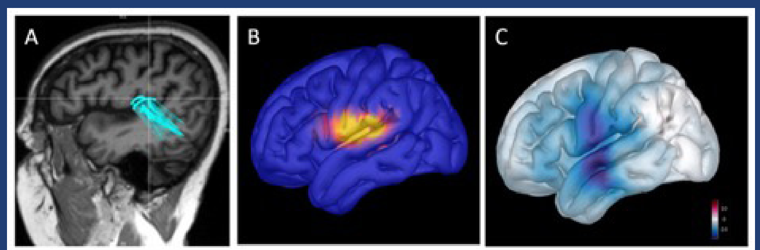

Figure 1. A. Magnetic Resonance Imaging (sagittal view) of one subject evidencing dipoles from language evoked response (LER) meeting diagnostic criteria (blue) only to the left hemisphere (subcentral gyrus, transverse gyrus, and superior temporal gyrus) by Equivalent Current Dipole fitting method. **B.** 3D (3 Dimensional) image displayed on cortex of the same subject during LER: beamforming power increase (yellow) on the left hemisphere (subcentral gyrus, transverse gurus, superior temporal gyrus, insula, and part of supra marginal gyrus). **C.** Beamforming beta decrease (blue) on subcentral gyrus, transverse gyrus, superior temporal gyrus, and insula also extending to pre and post central.

VW-130

Rapid acquisition of word meaning involves immediate plastic changes in neocortical speech-related areas: MEG study

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Neurocognitive mechanisms of rapid acquisition of word meaning remain debatable, and the available experimental evidence remains controversial – with evidence both for and against rapid cortical plasticity. We hypothesized that an operant learning procedure, which involves active participation of a subject in the process of learning, will promote immediate neocortical effects of rapid word meaning acquisition. We recorded magnetoencephalogram in adult subjects involved in an auditory-motor learning procedure. Participants were required to discover meaning of novel action words from their association with specific actions by way of “trial-and-error” learning. We analyzed event-related fields and beta-oscillations in passive experimental blocks before and immediately after learning, as well as in active blocks in the course of learning. We found that emerging activation in perisylvian speech-related areas could be detected both during the advanced stages of leaning and immediately following learning. This learning-related activity was found predominantly in the left hemisphere, and it involved a network of cortical areas linked to auditory speech processing – such as superior temporal sulcus, inferior frontal sulcus,intraparietal sulcus,anterior temporal lobe.The effects of semantic learning were dissociable from the effects of familiarization caused by stimulus repetition. Thus, our results evidence that rapid word meaning acquisition can immediately recruit neocortical speech-related areas.Supported by RFBR grant 17-29-02168.

VW-131 Synchronization of beta oscillations reflects meaning acquisition of novel words: MEG study

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How the brain learns new words is one of hot yet unresolved questions in neurolinguistics and neurobiology. To examine the process of meaning acquisition of novel word-forms, we measured magnetoencephalographic signal during an operant conditioning task during which participants performed a trial-and-error search for meaning of eight pseudowords that referred to body part movements. We compared power of beta oscillations (15–30 Hz) in three conditions: (1) at the start of learning process, (2) after reaching the learning criterion, and (3) in the end of experiment. We observed a progressive increase in beta synchronization in correct trials throughout the learning sessions. Statistically significant increase in beta synchronization was found in three clusters: frontal (appearing at ~800 ms after word-form onset), occipito-temporo-parietal (at ~200 ms after the motor response) and central (~500 ms post-response). The post-response increase in beta power at central sensors likely reflects post-movement beta rebound. Its modulation by the extent to which the association between the wordform and the movement was memorized is in line with recent observations that higher post-movement beta rebound indicates greater confidence in performed movements (Tan, Wade, Brown, 2016) and promotesa reinforcement of the current motor state (Engel & Fries, 2010). We tentatively suggest that the beta increase in frontal and occipito-temporo-parietal sensors may reflect a similar learning-related mechanism in non-motor domain.Supported by RFBR grant 17-29-02168.

VW-132 Lateralized processing of periodicity and formant structure of vowels in the auditory cortex of children and adults

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Background. The spectral formant structure ('vowelness') and periodicity (pitch) are the major properties that determine the identity of the vowel and the characteristics of the speaker. The development of hemispheric asymmetry in the processing of these vowel properties is still a matter of debate. Method. To address this problem, we independently manipulated the periodicity and formant structure of vowels while measuring auditory cortex responses using MEG in adults and children. We focused on the negative sustained field, which reflects the activity of auditory cortex neurons responding in a non-stimulus-locked manner. Subjects passively listened to a series of 800 ms-long spectrally complex sounds characterized by periodicity (periodic non-vowels), formant constancy (non-periodic vowels), or none of them (control sound). Results. When compared to the control stimulus, both periodicity and 'vowelness' led to an early (<100 ms) and prolonged (400 ms or more) increase in negative current (negative differential response). In adults, these differential responses to periodicity and 'vowelness' were lateralized to the right and left hemispheres respectively. No hemispheric lateralization for 'vowelness' was observed in children. Conclusions. The processing of vowels is associated with an augmented sustained neural response, whose lateralization differs for the two basic vowels' properties and depends on age. The rightward lateralization for periodicity is present in both adults and children, while the leftward lateralization for formant structure increases from childhood to adulthood. The sustained negative response may reflect an increased synaptic gain in the superficial cortical layers, caused by feedback associated with the processing of meaningful sound features.

VW-133

Cortical Entrainment to the Speech Envelope and Intonational Phrase Boundaries

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Background Magneto- and electroencephalographic (M/EEG) studies have demonstrated the cortical entrainment to syllabic rhythm of speech and linguistic structures of phrases. The present study aimed to extend the understand of cortical entrainment in speech comprehension and evaluate the extend to which the prosodic boundary can influence MEG activities in naturalistic language comprehension. Methods Eleven adults who are native speakers of Mandarin Chinese participated in a speech comprehension task, in which they would hear normal speeches or noise-vocoded speeches which were vocoded with 16 channels or 4 channels. Speech materials and annotations of intonational phrase boundaries (IPBs) were based on a large-scale Chinese corpus (Sinica COSPRO corpus). Results The signal from each MEG sensor was modeled as temporal response functions (TRFs) convolved with two acoustic features (speech envelopes, envelop onsets), and IPBs. In the hearing of normal speeches, TRFs of acoustic features showed two major peaks near 70 ms and 170 ms, and the TRF of IPBs yielded a peak near 200 ms. On the other hand, TRFs of acoustic features showed smaller peaks near 70 ms and 170 ms in the hearing of 16-channel vocoded speeches, and it only showed one peak near 70 ms in the hearing of 4-channel vocoded speeches. There was no IPBs effect on MEG in the hearing of vocoded speeches. Discussion The results demonstrated that the MEG signals were correlated with speech envelopes, envelop onsets and prosodic boundary. Finally, these effects were modulated by the intelligibility of the sensory input.

VW-134

The development of hemispheric lateralization to speech in infants

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Background While the left hemisphere lateralization for speech is well documented in adults, the origin of this functional asymmetry is unclear. There is conflicting evidence of whether left lateralization in infants is specific to speech or observed for all sounds. This study compared hemispheric lateralization of salient, ecologically relevant speech to a non-speech but spectro-temporally complex control stimulus in awake infants. We predicted that the differentiation of the two stimuli requires experience with sound and would increase with age, with an initial left dominance for both. Methods MEG responses were recorded longitudinally at 3 (n=27), 6 (n=19), and 11 (n=14) months to an English bi-syllabic word and an amplitude-modulated complex tone with an Elekta Neuromag 306-channel MEG system. The raw data were filtered using the temporally extended signal space separation method to remove artifacts originating outside the head and a movement compensation algorithm was applied to correct for head movement. Following automatic cardiac artifact suppression with signal space projection, data were then epoched and a Laterality Index was calculated from late-field (350-650 ms) MEG responses recorded in each condition to assess lateralization. Results MEG data with good signal-to-noise ratios were recorded in infants as young as 3 months in both conditions. However, preliminary analysis of the late-field laterality index shows variability across infants, with no clear trajectory in the first year of life. Conclusion Late-field MEG responses offer a robust method of investigating how functional specialization develops in infancy. Preliminary results highlight the importance of considering individual variability across infants.

VW-135

Immediate prior experience enhances cortical processing of high-level linguistic structure

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Background: Neural activity has been shown to track hierarchical linguistic units in connected speech and these responses can be directly modulated by changes in speech intelligibility caused by spectral degradation. Methods: In the current study, we manipulate prior knowledge to increase the intelligibility of physically identical speech sentences and test the hypothesis that the tracking responses can be enhanced by this intelligibility improvement. Cortical magnetoencephalography (MEG) responses to intelligible speech followed by either the same (matched) or different (unmatched) unintelligible speech were measured in twenty three normal hearing participants. Results: Driven by prior knowledge, cortical coherence to "abstract" linguistic units with no accompanying acoustic cues (phrases and sentences) was enhanced relative to the unmatched condition, and was lateralized to the left hemisphere. In contrast, cortical responses coherent to word units, aligned with acoustic onsets, were bilateral and insensitive to contextual information changes. No such coherence changes were observed when prior experience was not available (unintelligible speech before intelligible speech). Discussion: This dissociation suggests that cerebral responses to linguistic information are directly affected by intelligibility, which in turn are powerfully shaped by physical cues in speech. These results provide an objective and sensitive neural index of speech intelligibility, and explain why previous studies have reported no effect of prior knowledge on cortical entrainment.

VW-136

Evaluation of differences of melody-contour perception between musicians and non-musicians by mismatch fields

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We measured mismatch fields (MMFs) for changes of melody contour in both musicians and non-musicians and evaluated interhemispheric differences. Sequences of 5 tones with melody contours of rising-falling shape were used as stimuli. A standard and five types of deviant stimuli were generated by changing the pitch of the third tone. A 306-ch whole-head MEG system was used to record MMFs induced by the deviant stimuli. As results, in the non-musician, a larger MMF was observed as the difference of pitch of the third tone increased. In contrast, in the musician, a larger MMFs appeared for the change of the melody contour, a shape of pitch change of the entire sequence, than for the pitch change of the third tone. Additionally, the latency of the MMF was shortened in the musician compared to that in the non-musician. In terms of the hemispheric difference, MMF latency in the left hemisphere was smaller than that in the right hemisphere, regardless of the musical experience. Further, MMF for the melody-contour change showed the left-hemispheric dominance in the musicians, suggesting that the left hemisphere plays a more important role in the processing of the melody contour. The results obtained indicated that musical experience increased the ability to capture a tone sequence as a group and consequently improved discrimination of the melody contour. Further, the musical experience increased processing speed and the left hemisphere dominance in melody perception.

VW-137

Grammar-based cortical tracking of speech in noise is immature in school-aged children

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Children have more difficulty perceiving speech in noise than adults. Whether these difficulties relate to immature processing of prosodic or linguistic elements of the attended speech is still unclear. To address the impact of noise on linguistic processing per se, we assessed how acoustic noise impacts the cortical tracking of intelligible speech devoid of prosody in school-aged children and adults. Twenty adults and twenty children (7-9 years) listened to synthesized French monosyllabic words presented at 2.5 Hz, either randomly or in 4-word hierarchical structures wherein 2 words formed a phrase and 2 phrases formed a sentence, with or without babble noise. Neuromagnetic responses to words, phrases and sentences were identified and source-localized. Children and adults displayed significant cortical tracking of words in all conditions, and of phrases and sentences only when words formed meaningful sentences. In children compared with adults, cortical tracking of linguistic structures was lower for all structures in conditions without noise, and similarly impacted by the addition of babble noise for phrase and sentence structures. Critically, when there was noise, adults increased the cortical tracking of monosyllabic words in the inferior frontal gyri but children did not. This study reveals an immature grammar-based cortical tracking of speech linguistic structures in school-aged children. Furthermore, it suggests that children fail to enhance their cortical tracking of monosyllabic words in a multi-talker background. This failure could contribute to their notoriously lower behavioral ability to understand speech in noise.

VW-138

Learning of pseudoword-movement association is accompanied by enhanced beta synchronization

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Action-related words (such as verbs related to body parts movements) have often been used in experimental studies of embodied semantics. Yet, the process of how a novel word acquires association to a motor program remains largely unknown. To examine this process, we measured magnetoencephalographic signal while the participants (n=22) performed the trial-and-error search for the meaning of acoustically presented pseudowords by moving their extremities. We compared the power of beta oscillations (15–25 Hz) in three conditions: (1) at the start of learning, (2) at the advanced stage of learning, and (3) during self-paced movements without any task. We discovered that correct movements at the advanced stage of learning triggered a significantly enhanced post-movement beta rebound in the sensorimotor cortex, compared to the other two conditions. This finding parallels the reports of the increased beta rebound in the course of motor skill acquisition (Tan, Jenkinson, and Brown, 2014), but, given the negligible motor learning in our task, we assume it rather reflects formation of semantic associations between pseudowords and corresponding movements. Moreover, at the advanced stage of learning, there was also a significant peri-movement beta power enhancement in non-sensorimotor cortical areas implicated in performance monitoring (e.g., dorsolateral and medial frontal cortex), memory formation (e.g., posterior cingulate and medial temporal cortices), and in the language-related area at the left frontal lobe. We propose that this widespread beta synchronization serves to establish and reinforce the cross-structure interaction involved in binding the preceding movement to the presented pseudoword. Supported by RFBR grant 17-29-02168.

VW-139

Optimizing network-based language mapping in children and adolescents using MEG and rTMS

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INTRODUCTION:
We compare MEG connectivity and centrality-based language maps to language rTMS findings.

METHODS:
26 subjects, ages 5-19, completed MEG (stories) and navigated rTMS (naming). MEG was collected on a 275-channel whole-head system (CTF, Coquitlam, BC), at 1200Hz, and analyzed using FieldTrip routines. Continuous recordings were filtered from 0.1-100Hz, and power line noise supressed. Artifacts were removed via ICA. Data were epoched from 0-2000ms, from sentence onset, and sources estimated via an LCMV beamformer. Connectivity (coherence, imaginary coherence, PLV, wPLI), and centrality (eigencentrality, betweenness) were computed within canonical frequency bands. Picture naming is widely used in rTMS. We studied 33 sites (standardized) per hemisphere, regularly distributed over the lateral cortex. Each site was assessed 3 times. Pulses were initiated 300ms after picture onset, delivered at 5Hz for 1 second. Sessions were reviewed by two independent raters. Sites were deemed critical for language if both raters identified errors (no response, phonologic, or semantic). MEG and rTMS results were assessed in a common anatomical framework and compared using ROC analyses. Combinations yielding maximal AUC were identified; Youden's J-statistic identified optimal centrality threshold for the preferred schemes.

RESULTS:
rTMS revealed predominantly left lateralized critical language sites across participants. ROC analyses revealed eigencentrality on coherence and PLV in the beta band were in maximal agreement with rTMS. Retaining the top 65% of nodes yielded the optimal balance between sensitivity and specificity.

CONCLUSION:
Sites showing high eigencentrality within the beta band are useful for mapping critical cortical language sites.

VW-140

Region specificity of cortical lateralization for the processing of abstract and concrete verbs: evidence from an auditory magnetic mismatch negativity study

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Neuroimaging studies show that abstract and concrete semantics processing is supported by partially overlapping multimodal and amodal neural networks. The fMRI studies suggest that these networks' activity differs in lateralization patterns: more left-lateralized for abstract, and more bilateral for concrete semantics. To address the rapid automatic processing of spoken verb meaning and its region-specific lateralization, we used magnetic mismatch negativity (MMN), an early lexically-semantically sensitive brain response. We developed an MMN paradigm using concrete (hand-related) and abstract verbs, matched in temporal, acoustic, and psycholinguistic features. Neuromagnetic responses of thirty healthy participants (18 females, mean age 20.4 years) were recorded using a 306-channel VectorView MEG set-up. We conducted beamformer source analysis in pre-defined bilateral ROIs: hand primary motor area (BA4), and anterior Broca's area (BA45). The primary auditory cortex (BA41) responses were a baseline for ROI-specific lateralization comparison. While in BA41 all responses were left-lateralized, in the BA4 hand area the concrete verb produced more right-lateralized response than the abstract, and in BA45 the abstract verb produced more left-lateralized response than the concrete (Fig.1). These findings suggest the enhanced involvement of the language-specific left hemisphere in abstract semantics processing. Stronger right-hemispheric activation for the concrete verb is likely underpinned by the more distributed, bilateral referent-based semantic representations. These results also confirm differential sensorimotor system involvement in abstract and concrete semantics processing at the neural level.

Acknowledgments
Supported by RSF project 20-68-47038. This study used HSE Automated system of non-invasive brain stimulation for synchronous registration of brain activity and eye movements.

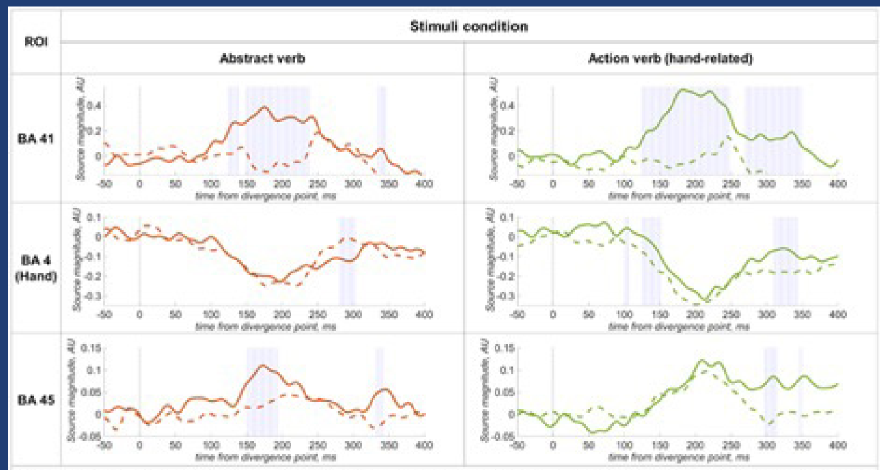

Figure 1. Magnetic source time courses of the mMMN responses on the word stimuli (action, abstract) within specific ROIs (primary auditory cortex, primary motor hand area, anterior Broca's area). The solid curves correspond to the left-hemispheric mMMN responses, the dashed curves correspond to the right-hemispheric mMMN responses. The shadowed areas correspond to the time points with the significant between-hemispheric response differences (paired permutation t-test, p <. 05).

VW-141

Overt speech decoding from MEG data decontaminated from articulation artifacts: feasibility and uses

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Speech is the inherently human trait that continues to puzzle neurocognitive researchers and attracts a great deal of attention from the scientific community. The temporal scale of speech production and comprehension requires the use of neuroimaging methods with an appropriate temporal resolution, such as MEG and EEG. However, speech production is accompanied by significant muscular activity that contaminates non-invasively collected electrophysiological data and precludes efficient exploration of the speech production's neural substrate for research and medical purposes. Here we used the task of MEG-based overt speech decoding to assess the amount of information about cortical processes associated with speech production present in MEG data before and after the removal of independent components manifesting speech-related muscular activity. We find that indeed raw MEG data appear to be highly contaminated with articulation-related muscular activity and which yields high-quality decoding of internal speech representation timeseries. At the same time, the use of MEG data cleaned from the articulation-related artifacts affords acceptable but significantly lower decoding accuracy. Exploration of the interpretable convolutional decoder weights confirms that decoding on the basis of decontaminated MEG data relies on physiologically plausible speech production areas. We conclude that after the appropriate decontamination, MEG data recorded concurrently with overt speech can be potentially used for exploring rapid speech production processes ecologically and non-invasively and for identifying speech-related eloquent cortex in candidates for neurosurgery.

VW-142

Functional cortical localization of the finger using corticokinematic coherence with deep learning-assisted capture motion system

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Background: Corticokinematic coherence (CKC) between magnetoencephalographic (MEG) signals and movement signals through an accelerometer (ACC) is useful approach for functional localization of the primary sensorimotor cortex (SM1) of the finger. However, the cables with ACC device sometimes disturb the smooth movements of the finger. Here, we demonstrated the novel technique for CKC using deep learning-assisted capture motion with videography, in comparison to the CKC with ACC. Methods: Eleven healthy volunteers performed rhythmical up-to-down movements of the right index finger in the whole-head MEG system. Movements of the finger were monitored with ACC. Movements of the finger were also recorded with video-camera and examined off-line with deep learning-assisted capture motion system using DeepLabCut. Coherence spectra and cross-correlograms were analyzed between MEG signals and movement signals with capture motion and ACC. Results: The coherence spectra for the right finger CKC showed peaks over the contralateral hemisphere at 1.8–7.3 Hz and 1.8–7.5 Hz with capture motion and ACC, respectively, corresponding to the frequencies of movements of the finger (1.8–4.0 Hz) and its harmonic in all subjects. Cortical sources for finger CKC with capture motion were located around the hand knob in the central sulcus, suggesting the SM1 of the finger regions. Discussion: CKC based on deep learning-assisted capture motion may be a novel and useful approach for the functional localization of the finger SM1.

VW-143

Information Transfer Reveals Communication between Motor Cortex and Cerebellum

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Symbolic transfer entropy (STE) reveals not only the magnitude and direction of information transfer, but also its latency. This is accomplished by evaluating STE as a function of phase space advance. Statistical reliability is ensured by subtraction of surrogate data (phase-scrambled sources) results. STE analysis was applied to two MEG datasets with a right dominant subject performing self-paced finger movements (button press) using either the right or left index finger. Data were acquired using a CTF-275 channel MEG sampled at 4.8 kHz. The right and left M1 coordinates were determined for time-locked motor activity by LCMV beamformer imaging. Two additional locations were selected in the right and left lateral fissure of the cerebellum from the subject's MRI. An LCMV beamformer was used to estimate the source time-series for each of the four sources in a 60-200 Hz bandpass. For right button press, we observed peak transfer from left M1 to right cerebellum of 44.4 mbits at a latency of 6.9 ms. Transfer from right cerebellum to left M1 had a maximum of 44.0 mbits at 8.1 ms. For the left button press, information transfer from right M1 to left cerebellum had a maximum of 54.5 mbits at 10.4 ms, and from left cerebellum to right M1 was 55.3 at 11.0 ms. The STE peak magnitudes were significantly smaller for ipsilateral transfers between M1 and cerebellum. The maxima were also much broader (~6 to 12 ms) for the non-dominant (left) button press.

VW-144

Cortical alpha/beta oscillations in voluntary prolonged eye fixations

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Background. The neural underpinning of the intentionally prolonged gaze fixation that is used in gaze-controlled interfaces remains unknown. Here, we compared cortical alpha/beta-band oscillations induced by two different types of fixations where the eye dwells for more than 500 msec: (a) intentional fixations committed to control the computer and to make moves in the game; (b) spontaneous fixations occurring during a visual search. Methods. We collected MEG data from 29 healthy participants when they freely played a gaze-controlled game EyeLines (Shishkin et al., 2016). Distributed source modeling of fixation-related alpha/beta (de-)synchronization was performed after generalized eigendecomposition of covariance matrices. A cross-validation scheme was used to obtain robust spatial filters. The significance of the effects was assessed with cluster-based permutation statistics on time-frequency maps. Results. Intentional fixations as compared to spontaneous ones were accompanied by the relative alpha (10-15 Hz) power increase that evolved 400 msec before a fixation onset and was sustained for 650 msec. The cortical sources of this differential alpha synchronization were predominantly localized in precentral areas and were consistent with the location of the frontal and supplementary eye fields. Discussion. Increased alpha/beta synchronization preceding intentional gaze dwelling suggests the role of active inhibition of the cortical oculomotor circuit responsible for natural saccadic behavior. The results may provide new insight into the neural mechanisms that explain the flexibility of visually guided behavior.
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VW-145 Novel Use of a Simulated Driving Task to Probe Motor and Cognitive function.

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MEG is particularly well-suited to the study of human motor cortex oscillatory rhythms and their role in motor control. However, the majority of motor tasks studied to date tend to lack the complexity and ecological relevance of everyday tasks. In this study, we describe a new approach to study motor and cognitive function using an MEG compatible driving simulator. We scanned 23 healthy individuals age 16-23 years (mean age = 19.5, SD = 2.5; 18 males and 5 females) who completed a custom-built driving scenario (Diagnostic Driving Inc.) consisting of n=20 rest and active driving trials involving accelerating and braking in response to traffic light cues at intersections. A MEG-compatible steering wheel and gas/brake pedals were used to record behavioral responses (Current Designs Inc.). Neuromagnetic data was recorded with a 275-channel CTF MEG, and a volumetric MRI scan was used for MEG source localization. Differential beamformer methods were used to localize beta-, gamma-, and frontal theta-band responses. Of the 23 participants, three were removed due to excess head motion (> 1.0cm/trial). Non-parametric group analysis revealed significant regions of pedal-use related B-ERD activity, (localized to the left pre-central foot area, as well as bilateral superior parietal lobe: $p<0.01$ corrected), movement related gamma-band synchrony (MRGS) (localized to the medial precentral gyrus: $p<0.01$ corrected), and frontal midline theta band activity (specifically bilateral superior frontal gyrus: $p<0.01$ corrected) likely reflecting increased cognitive control over behaviour. This paradigm can be utilized to probe more ecological motor and cognitive functions from different developmental and clinical populations.

VW-163 Local and large-scale neural dynamics in conscious visual perception

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Identifying the fundamental nature of visual awareness remains a challenge for modern cognitive neuroscience, and a source of ongoing debate. When presented at perceptual threshold, identical sensory information may become conscious, or remain undetected. These observations have given rise to two largely contradictory theoretical accounts; the first one assumes that consciousness is an 'all-or-none' phenomenon, whereby visual experience is either present or absent. The second theory posits that phenomenal experience evolves gradually, by transitioning through unique levels of subjective awareness that can be accessed independently of each other.

Using source reconstructed MEG data, we aimed to distil the unique local and network dynamics that predicate the transition from subliminal to conscious processing, while controlling for attentional- and response-related effects. Participants (N = 20) had to respond to visual stimuli, individually calibrated at a constant contrast yielding ~50% detection rate. We found that early evoked activity (~150 ms) and theta oscillations dissociated consciously from unconsciously detected stimuli; nevertheless, distinguishing between two visual targets was associated with activity peaking at ~300 ms, predominantly in areas of the fronto-parietal network. Additionally, detected targets were also associated with an increase in delta/theta, and alpha-band inter-areal synchronization.

These findings support the notion that synchronization between visual areas and the fronto-parietal network is a prerequisite for conscious perception. While early activity appears to be sufficient for a mere perceptual experience to form, accessing the contents of that experience requires additional processing steps, offering support to the notion that conscious perception is a graded phenomenon.

VW-146

Heritability of local network properties in resting-state MEG

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Graph analysis of resting-state magnetoencephalography (rs-MEG) can quantify brain network characteristics related to healthy behavior and cognition1. Neurological disorders are associated with alterations in network properties of individual brain regions2. Likewise, these properties may be influenced by genetic factors. Previous studies have examined heritability of rs-MEG amplitude synchrony3. To the best of our knowledge, our study is the first to investigate heritability of local graph measures based on rs-MEG amplitude and phase synchrony.

This study included 89 subjects (17 monozygotic, 12 dizygotic twin pairs) from the Human Connectome Project4. Connectivity between regions of the Brainnetome atlas was estimated with the debiased weighted phase lag index (dwPLI) and leakage-corrected amplitude envelope correlation (lcAEC)5. Strength (S), eigenvector centrality (EVC), clustering coefficient (CC), and nodal efficiency (NE) were computed, and heritability was evaluated with the APACE toolbox, adjusting for age, sex, and their interactions.

S, CC, and NE for lcAEC were significantly heritable (p < 0.05, FWE-corrected) with a right frontotemporal distribution in alpha and low beta (Figure 1) and for a few regions in delta, theta, and high beta. The three measures for dwPLI were significantly heritable for a few regions in alpha and high beta (Figure 2). Our results indicate that local network characteristics are more heritable for amplitude than phase synchrony, localized to specific brain regions in alpha and beta.

1Douw et al., PLoS One, 2014;9.2:e88202.
2Pourmotabbed et al., Hum Brain Mapp, 2020;41.11:2964-2979.
3Colclough et al., Elife, 2017;6.
4Larson-Prior et al., Neuroimage, 2013;80:190-201.
5Pourmotabbed et al., Hum Brain Mapp, 2022;43.4:1342-1357.

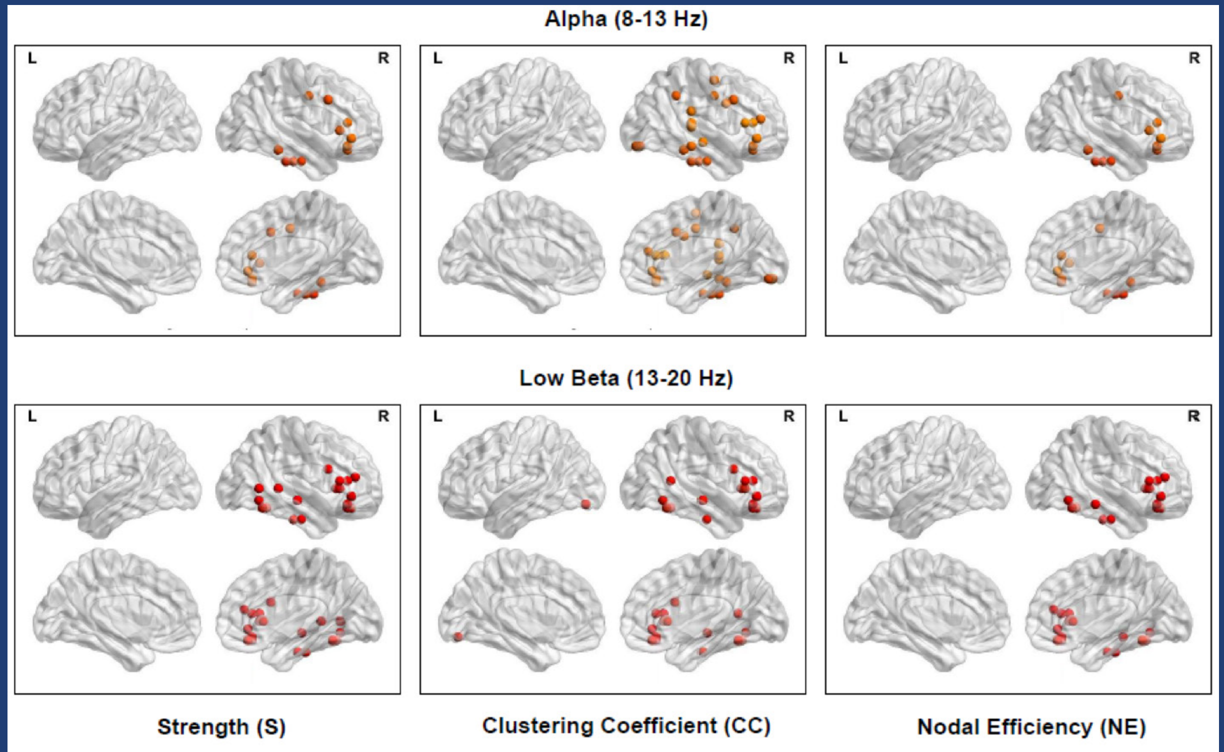

Figure 1. Brain regions whose local graph measures were significantly heritable ($p < 0.05$, FWE-corrected) in alpha and low beta for the leakage-corrected amplitude envelope correlation (lcAEC). Darker red indicates a higher heritability (h^2), which ranges from 0 to 1 and corresponds to the proportion of the phenotypic variance explained by genetic factors.

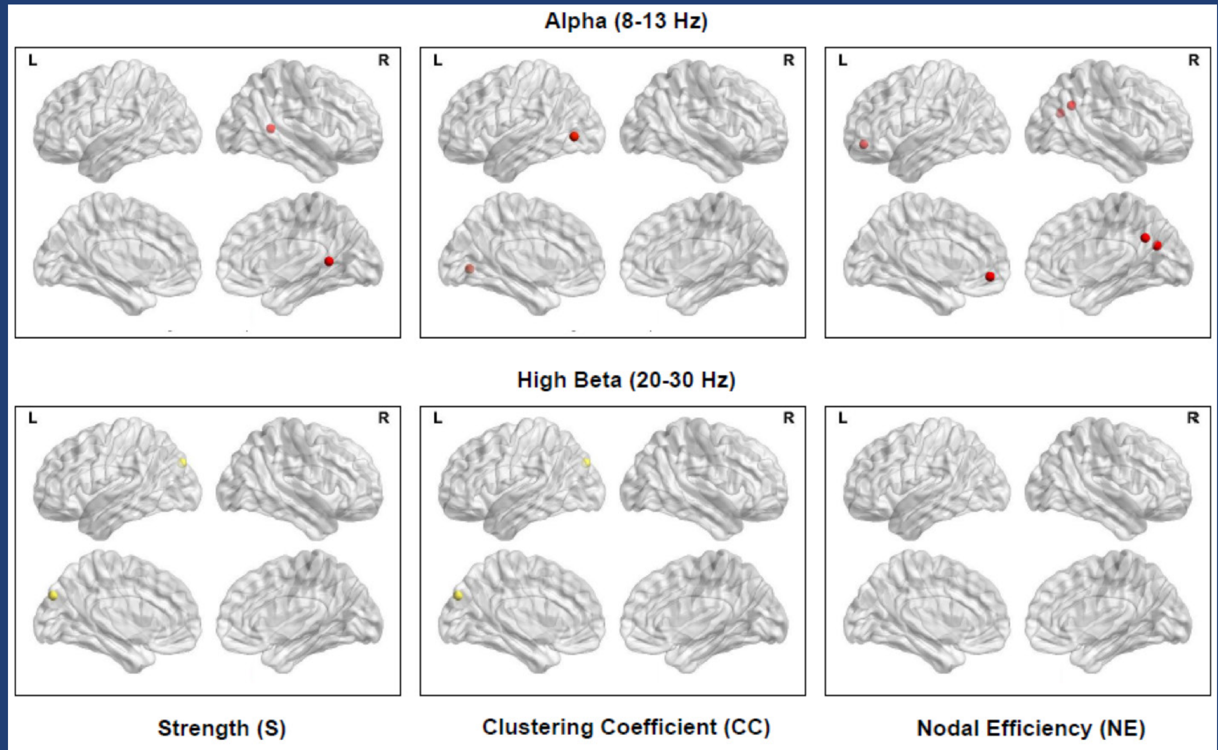

Figure 2. Brain regions whose local graph measures were significantly heritable ($p < 0.05$, FWE-corrected) in alpha and high beta for the debiased weighted phase lag index (dwPLI). Darker red indicates a higher heritability (h^2), which ranges from 0 to 1 and corresponds to the proportion of the phenotypic variance explained by genetic factors.

VW-147 Long term meditation practice leads to changes in insula aperiodic activity and connectivity in the gamma band.

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Background Meditation has been shown to improve cognitive and emotional processing and reduce anxiety and depression. Contrasting experienced with inexperienced meditators may lead to greater understanding of the location and form of functional changes. Methods Eleven long-term meditators (LTMs, >5 years experience) and 11 meditation-naïve control participants underwent MEG recording during 5 minutes eyes open rest (baseline) and 20 minutes eyes-open open-monitoring mindfulness meditation. Time series estimates for each region in the Destrieux atlas were generated using dSPM. Power spectra were calculated for each participant, atlas region and time period, and parameterized using the FOOOF algorithm. The resulting fit parameters were contrasted between groups using an FDR procedure. Connectivity between regions for different frequency bands was calculated using amplitude envelope correlations. Results During meditation LTMs had significantly larger aperiodic exponents in left frontomarginal sulcus, left anterior insula, and left frontal inferior sulcus, and significantly lower frequency alpha peak in left postcentral sulcus. LTMs had significantly lower connectivity in gamma (30-80Hz and 80-120Hz) compared to controls during meditation, with largest difference in connections involving left hemisphere insula, Heschel's gyrus and subcentral gyrus. LTMs also had significantly higher connectivity in alpha (8-13Hz) during rest, with largest difference in connections involving left insula and precentral gyrus. Discussion The increase in aperiodic exponent in LTMs during meditation may reflect a shift in the balance between excitatory and inhibitory currents in regions associated with socio-emotional, attention and salience processing. The reduced connectivity in gamma corresponds to changes in networks related to emotional response and cognition.

VW-148 Neural oscillations associated with adaptation to left-right reversed audition

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Humans can adapt to unusual sensory spaces both perceptually and behaviorally. To reveal this mechanism from an auditory aspect, we have developed a wearable system that achieves left-right reversed audition space and detected perceptual and behavioral adaptation to the reversed audition, as reported in the past BIOMAG conferences. However, neural oscillations associated with the adaptation are not fully understood. Therefore, we reanalysed magnetoencephalographic data measured every week during either four- or five-week exposure to left-right reversed audition. The data was measured under the audiovisual matching task with respect to left and right of audiovisual stimuli; participants were instructed to discriminate spatially congruent and incongruent combinations of a tone delivered to either ear and a white square cue displayed in either visual hemifield. Correlated with reduction of a feeling of strangeness for the reversed audition, gamma power coupled with beta phase in the auditory cortex gradually decreased from pre-exposure period for incongruent stimuli, while it appeared and gradually increased for congruent stimuli. No notable oscillatory activity was found for changes in behavioral priority of stimulus congruency that occurred at the fourth or fifth week after perceptual adaptation. These findings suggest that structured neural oscillations correlated with perceptual adaptation are presumably involved in error processing of audiovisual information, where errors are calculated based on the optimization progress. After the optimization, the new rule of audiovisual spatial integration is established in the auditory cortex, which enables us to behaviorally interact with the unusual auditory space.

VW-149

Brain activation related to apparent motion illusion

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The purpose of this study was to clarify the brain regions related to cognitive processing of apparent motion illusion using magnetoencephalography (MEG). Each participant was measured MEG during observation of both conditions of optimal-illusion and no-illusion. Concentrating to early stages of visual information processing, we focused to the primary visual cortex, for analysis. The source waveforms were estimated by minimum norm least-squares method in each brain area, and activation amount of the waveform current at some occipital sites were used for statistical analysis. Since our previous studies have shown that brain activation related to motion perception has occurred within 100ms after stimulus presentation, our interest of the time course was set to 0-200ms after stimulation. The results showed that current amplitudes of the superior and inferior occipital gyri during motion illusion at the right hemispheric area were greater than those during no-illusion, suggesting hemispheric asymmetry. This result was consistent with our previous studies. At the superior and middle occipital areas, the amplitude of no-illusion condition was significantly larger than that of motion-illusion, suggesting that different activation involved in two conditions may be occurred in these areas. We would be better to seek the processing network of motion perception beyond the primary areas within 200ms for other brain sites over 200ms.

VW-150

Emotional pictures modulate annoyance of tinnitus-like sounds via alpha/beta band visual-auditory network

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To inform understanding of the role of emotion/stress in tinnitus, we tested whether the annoyance-ratings of tinnitus-like sounds changed with mood induction through negative/stressing vs. positive/calming pictures. Affirming this behaviorally, we looked into the brain processes underlying this emotion effect focusing on oscillatory power changes. A DICS beamformer analysis showed increased alpha (9-13 Hz) and beta (14-21 Hz) power in primary and secondary visual and auditory areas as well as parietal association areas in the RH during tones in the negative condition (when mood inducing pictures are not present anymore). A subsequent time-frequency beamforming analysis in regions showing these power differences found temporal peaks of such differences, closely following one another in sequence from occipital over parietal to auditory areas. Finally, statistical analyses with linear mixed models using forward selection to optimize models explaining power-in-regions as well as annoyance rating outcomes confirmed this "back-to-front" traveling of the emotion effect, with alpha driving beta, and beta in supramarginal gyrus being most predictive of rating outcome. On top of confirming the impact of stress on perception tolerance and showing how emotions influence tone processing in the brain, these results shed new light on brain processes integrating information from different modalities and on the respective roles of alpha and beta power.

VW-151 MEG study of visceral stimulation during various sleep stages in humans

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Traditionally the cognitive science paradigms consider the influence of the external environment on the cortical processing. However, recent studies reevaluate this view and emphasize the input from internal organs (e. g. gastrointestinal tract). Their independent oscillatory electrical activity is supposed to maintain the exchange between the brain and viscera. The visceral sleep theory (Pigarev, 2013) suggests that during specific sleep portions the signals arriving from internal organs are prioritized in terms of cortical processing as compared to the exteroceptive information. Our study provides evidence of sleep-stage dependent differentiation of cortical processing in response to intestine stimulation with an autonomous electrical stimulator pill, which occurred every 3 seconds at 50Hz rate. The MEG data was collected from three healthy participants during several hours of sleep. The sleep staging was performed automatically using YASA Toolbox (Vallat and Walker, 2021). The analysis of MEG data demonstrated that within the deeper sleep stages the evoked response at ~500 milliseconds after the stimulation became more pronounced. This activity appears to be reliably localized to insula - presumably one of the crucial structures receiving visceral signals due to its viscerotropic organization, and what is more intriguing to the occipital cortex, typically involved in analysis of visual information during wakefulness. At the same time, in one participant we observed the induced response in the theta band ~2 seconds after stimulation in fast sleep. The obtained results may have implications both for the development of the theoretical definition of sleep as well as for novel clinical in-sleep therapeutic approaches.

VW-152 Impaired inhibition in the visual cortex in premenstrual dysphoric disorder: MEG and psychophysical study

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Premenstrual dysphoric disorder (PMDD) is a severe mood disorder associated with abnormal sensitivity to neurosteroids, which can affect the neuronal excitation/inhibition (E/I) balance and exacerbate mood symptoms during the luteal phase of menstrual cycle (MC). In the visual cortex, the altered E/I balance can affect electromagnetic gamma oscillations and basic perceptual functions. Here we tested if the E/I balance in the visual cortex is altered in women with PMDD. Magnetoencephalography (MEG) and psychophysical experiments were performed in twenty PMDD and 27 control women during the follicular (asymptomatic) and luteal (symptomatic) phases of MC. During MEG, the participants viewed large high-contrast static or drifting (1.2o/s;3.6o/s;6.0o/s) circular gratings. Visual gamma response (GR) suppression at high drift rates was used as a measure of effectiveness of neural inhibition in the primary visual cortex. During psychophysical task, subjects discriminated direction of motion of large (12°) and small (1°) high-contrast vertical gratings. Performance deterioration in case of the 'large' as compared to 'small' grating (spatial suppression) was considered as a measure of surround inhibition strength. GR suppression was lower in PMDD than in control participants. Moreover, GR suppression in PMDD decreased from follicular to luteal phase. The reduction of neural inhibition in PMDD from follicular to luteal phase was further supported by results of the psychophysical experiment. E/I ratio is elevated in the visual cortex in women with PMDD, especially during the luteal phase of MC. Our study provides neurophysiological evidence for the role of E/I imbalance in PMDD.

VW-153

MEG visual gamma oscillations predict sensory perception in women: a replication study

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Introduction: Magnetoencephalographic (MEG) visual gamma oscillations arise from the interplay between excitatory (E) and inhibitory (I) neurons, making gamma a promising candidate biomarker for E-I balance. Our recent findings suggest that regulation of the E-I balance in the visual cortex is reflected in attenuation of oscillatory gamma response (GR) during strong sensory stimulation. In particular, we found that hypersensitivity to sensory stimuli in adult males was associated with reduced GR attenuation as the motion velocity of a high-contrast visual grating is increased. Here, we aimed to replicate these findings in neuro-typical females. Methods: 27 females were presented with large static or moving ('slow', 'medium', 'fast') high-contrast circular gratings. To estimate the GR attenuation with transition from 'slow' to 'fast' visual motion velocities, we computed the gamma suppression slope (GSS). Sensory sensitivity in everyday life was assessed with the Adolescent/Adult Sensory Profile questionnaire. Results: A lower GR suppression (higher GSS) was associated with an elevated sensory sensitivity in general (Spearman R(27)=0.40;p=0.038) and in the visual domain (Spearman R(27)=.42;p=.028). Changes in the GR from static to moving stimuli did not correlated with the sensitivity scales. Discussion: These results on the link between GSS and sensory sensitivity in females replicate the previous findings in males. As hypersensitivity is thought to reflect elevated visual cortex excitability, the GSS may provide useful information about E-I balance regulation in the visual cortex and be a potentially useful index in those neuropsychiatric disorders that are characterized by an E-I imbalance.

VW-154

Reproducibility of evoked fields to proprioceptive stimulation of the ankle joint

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Background. Proprioceptive afference to the cortex can be investigated with evoked fields to intermittent passive movements using MEG. Whether these measures are reproducible within and between sessions, a prerequisite for examining longitudinal modulations of ankle proprioception in the human cortex, is unclear. Methods. Fifteen healthy volunteers (36.6 ± 6 yrs, 7 females, 14 right-legged) participated in two MEG sessions where their dominant ankle joint was moved every 3 ± 0.25 s using a pneumatic-movement actuator. Within-session measures (n=12) were collected 1.5 h apart for 12 participants, and between-days measures 8 ± 3 days apart for 15 participants. Ankle kinematics were recorded with a 3-axis accelerometer. The evoked fields were averaged across 153 ± 10 stimuli, and peak response was selected among 20 Rolandic MEG gradiometer pairs (vectorsum) contralateral to the stimulus. Spearman correlation and intra-class correlation coefficient (ICC) were computed between the sessions. Results. All sessions resulted in significant evoked fields peaking in the gradiometers over the primary sensorimotor cortex. Within-session amplitude (session-1: 57.19 ± 19.33 fT/cm, session-2: 56.55 ± 21.77 fT/cm) showed high correlation (_ = 0.81, p= 0.002) and excellent (> 0.75) ICC (0.96). Similarly, between-days amplitude (Day-1: 67.56 ± 24.93 fT/cm, Day-2: 65.63 ± 24.91 fT/cm) showed high correlation (_ = 0.9, p< 0.001) and excellent ICC (0.87). Discussion. Evoked fields to proprioceptive stimulation of the ankle joint proved to be highly reproducible when using precise pneumatic-movement actuators in MEG. Therefore, this method can be used to quantify the changes over time in cortical proprioceptive processing arising from lower limb movements.

VW-155

Evaluation of fundamental perception characteristics of cartilage-conduction hearing using physiological and psychological measurements

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In bone-conduction (BC), a transducer needs to be clamped strongly against the mastoid process of the skull and this has severely caused pain and discomfort on users. To solve such defects of BC, cartilage-conduction (CC) has been proposed and applied to devices such as hearing aids and smartphones. CC uses the ear cartilage tissue as the main sound transmission medium, together with skins and bones, by bringing a transducer into contact with the pinna. However, CC has limited number of studies and the effects from nonlinearity and deformation of the cartilage tissues is unclear. In this study, the fundamental perceptual characteristics of CC hearing were evaluated using psychophysical and neurophysiological measurements in humans and compared with air conduction (AC) and conventional BC hearings. Three psychophysical experimental sessions were conducted using a transformed up-and-down procedure in estimating hearing thresholds, temporal-modulation-transfer function tracing for assessing temporal-resolution, and frequency-difference limens. All sessions were conducted in three stimulus conditions; AC, conventional BC, and CC. Also, mismatch fields (MMFs) were recorded for changes of stimulus duration and frequency. As results, CC showed lower hearing thresholds than conventional BC, however, slightly poorer temporal and frequency resolutions than AC and conventional BC. Because the pinna is much lighter than the skull, CC is assumed to require lower energy than BC in transmitting vibrations. On the other hand, BC appeared to have better resolution than CC and these findings may have reflected certain deterioration of sound components traveling through the ear cartilage tissues in CC.

VW-157

Assessing Whole Cortex Relationships between Cortical Thickness and Gamma Synchrony using PLV and ciPLV

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Background Gamma synchrony (GS) is a fundamental property of the cerebral cortex strongly depending on the interplay between parvalbumin-positive interneurons and pyramidal neurons. Recent evidence suggests that GS sustained by rhythmic auditory gamma stimulation involves the entire cortical mantle (Farahani et al., 2021; Pellegrino et al., 2019; Tada et al., 2021). However, evidence on structure-function-relationship is limited to A1 (Edgar et al., 2014; Hirano et al., 2020; Kim et al., 2019). Here, we assess whether cortical thickness (CT) is related to propagation of GS throughout the cortex. Methods 52 healthy subjects (40 female, mean age=29.25 ± 7.43) underwent MEG while being exposed to 180 1-sec sequences of a 40 Hz amplitude-modulated tone interleaved with 1-sec of silence. T1-weighted images were acquired on a 1.5 T Achieva Philips scanner. PLV and ciPLV (seeds: bilateral A1) were calculated in source space and correlated with CT (Spearman's rho). Results There were significant positive correlations between CT and PLV in bilateral perisylvian areas for respective A1 seeds and contralateral spreads to parietal, frontal and occipital areas. For ciPLV there were correlations in the bilateral frontal, temporal, parietal and occipital lobes featuring a pattern different from PLV. Discussion While PLV captures instantaneous connectivity, but is biased by volume conduction, ciPLV captures synchronous relationships for lag ≠ 0 and is less prone to volume conduction. Our results suggest that the interplay between PLV and ciPLV have the potential to disentangle instantaneous vs. lagged relationships between cortical thickness and GS, revealing complex relationships beyond the primary sensory areas.

VW-158

Brain asymmetry in dichotic listening task

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Auditory processing disorder is a disorder in which a person complains of difficulty in hearing despite normal hearing. Behavioral tests have been performed for this disease, and further objective measures are needed. In this study, we measured the brain activity under the active and the passive conditions in the dichotic listening task using the magnetoencephalography. Twenty-seven Japanese adults with normal hearing participated in this study. In the dichotic listening task, different words are presented simultaneously to the left and right ears, and the perceived words are written down on paper. The presented words were frequency-tagged by modulating them at different frequencies. Such frequency tagging allowed to selectively quantify the response of the left and right auditory cortex to left and right ear stimuli. As a result, the ASSR amplitude was dominant in the left auditory cortex under the active condition, suggesting an influence of the language area of the cortex. On the other hand, the left hemisphere was not dominant under the passive condition. In addition, the accuracy was dominant in the right ear, and tended to correlate with the ASSR amplitude. These results suggested a contralateral dominance effect on the language area located in the left hemisphere.

VW-159

Neural dynamic underlying global precedence in visual perception representation

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Background: Fast and efficient processing of global information (compare with local information) in a complex visual environment is an advantage of the human visual system, and also a fundamental difference between human vision and computer vision. However, the neural dynamics of this global precedence effect (GPE) is still unclear. As previous study using the high-density behavioral sampling revealed that the behavioral alpha oscillation directly related with GPE, this project use MEG to investigate the relationship between neural alpha oscillations and GPE in behavior performance. Methods: The study recorded MEG signal when subject saw a compound visual stimulus (Navon Letter like) which latter they need partially report the global feature or local feature of this visual pattern. Resutls: By analysis the MEG data, we reveal that people show more alpha inhibition when they need report the global feature of the visual pattern, and this alpha inhibition is significant correlated with their GPE performance. Further more, when use the IEM model to decode how people represent the global feature or local feature, we found that the temporal dynamic of decoding performance for global feature representation show alpha oscillation, and this alpha oscillation of global feature representation also significant correlated with behavior GPE performance. Discussion: In summary, this study not only provides behavior and neural evidence advocating the hypothesis that neuronal alpha oscillations activity is related with global precedence, but also provide evidence support that alpha oscillation also important for the global feature representation.

AWARDS

Early Career Researcher Award

11 finalists who have been selected to present a 10-minute presentation during the Early Career Researchers Award Presentations on Tuesday 30 August between 08.45 – 10.45 in the C Block Lecture Theatre. These will be judged by the Awards Committee, with three prize winners being announced at the main social event and again at the Town Hall session. The finalists are:

- Noor Al Dahhan, Postdoctoral Research Fellow, The Hospital for Sick Children (SickKids)
- Irene Harmsen, MD/PhD Candidate, University of Toronto
- Niall Holmes, Research Fellow, University of Nottingham
- Joonas Livanainen, Postdoctoral Appointee, Sandia National Laboratories
- Mainak Jas, Research fellow, Massachusetts General Hospital
- Lari Koponen, Research Fellow, University of Birmingham
- Victor Hugo Souza, Research Fellow, Aalto University
- Rachel Spooner, Postdoctoral Researcher, Heinrich-Heine University Düsseldorf
- Tim Tierney, Senior Research Fellow, University College London
- Alex Wiesman, Postdoctoral Fellow, Montreal Neurological Institute and Hospital
- Koos Zevenhoven, Research Group Leader, Aalto University

James Zimmerman Prize

We are delighted to confirm that Dr. Jiri Vrba has received the James Zimmerman Prize, which is awarded on the basis of significant contributions to novel SQUID-based or new generation sensor developments and their applications in the field of biomagnetism. Dr. Vrba is one of the pioneers of MEG technology and has made outstanding and lasting contributions to many aspects of MEG hardware, software and experimental research throughout his career. Dr. Vrba's career has spanned the gamut of MEG methods development, from SQUID optimisation to the development of whole-head systems, noise cancellation systems and source estimation.

Mid-career award

We are delighted to confirm that Dr. Stephanie Jones has received the Mid-Career Award for her transformative contributions to the field of biomagnetism research. Dr. Jones' work on the mechanisms of beta "oscillations" and biologically-principled mathematical and computational models will significantly influence biomagnetism research for years to come. Her research is fundamentally cross-disciplinary and provides a link between cellular network circuitry models of brain activity and whole-head MEG signals.

Data Analysis Competitions

This year we ran three data analysis competitions.

1. The Dementia Screening Challenge organized by Yoshihito Shigihara and Hideyuki Hoshi at Hokuto Hospital Japan and sponsored by RICOH.

2. The Ketamine in depression competition run by Jessica Gilbert at NIMH, Bethesda, USA.

3. The Epilepsy Challenge organised by Jean-Michel Badier and Christian Bénar at the Institut de Neurosciences des Systèmes, Marseille, France.

There was a fantastic response with entries from multiple international teams. The competition organisers and selected winning teams will be presenting and discussing their work from 17.00-18.00 on Monday 29th August in the C Block Lecture Theatre.

SOCIAL PROGRAMME

There are a number of social activities for you to join during your time at Biomag2022.

Sunday 28 August: 17.00 – 18.30: Opening ceremony and reception

This is included in your registration fee. No ticket is required to attend.

We will be providing 2 drinks per person and a light buffet.

This will take place in the Great Hall (R6 on the **Edgbaston campus map**)

Tuesday 30 August: 19.00 – 23.00: Band night hosted by Aston University

There will be two bands performing:

- Jazz Jamsession with Peter and Simon
- The Quasi-Rhythmic-Oscillators

Pizza will be provided, along with a bar will be open to purchase drinks.

There is no cost but if you would like to attend but have not contacted **academic.conferences@contacts.bham.ac.uk** please speak to the team at the registrations desk.

This will take place in the The Lounge, Aston University Students Union, 8 Coleshill Street, Birmingham, B4 7BX. Directions can be found on the website, and at the registrations desk.

Wednesday 31 August: 19.00 – 23.00: Main conference social event

Tickets are required to join this event. If you haven't purchased one but would like to attend, please check with the team at the registrations desk to see if there are any available.

Tickets include a street food feat and complimentary drinks. A bar will also be open to purchase additional drinks.

This will take place at the Custard Factory, Gibb Street, Digbeth, B9 4AA.

Please note that there will be coaches taking attendees to the venue from the University of Birmingham and returning to the campus. Further details will be provided during the event.

We have also listed local restaurants and activities on the website. (link to **https://biomag2020.org/**)

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You can find them in the Green Heart Marquee, along with a presence on the virtual event platform

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