Welcome to MEG-UKI 2025

Hosted by University College London

16th to 18th July 2025

Mary Ward House, 5 – 7 Tavistock Place, London, WC1H 9SN, United Kingdom

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Sessions Overview

Day 1 – Naturalistic Neuroscience – 16th July 2025

Naturalistic Neuroscience 1 (10:40 – 13:00)

Speakers: Dominik Bach; Hyojin Park; Joseph Gibson; Stephanie Mellor; Matias Ison

Naturalistic Neuroscience 2 (14:00 – 16:50)

Speakers: Victoria St.Clair & Giulia Serino; James Dowsett; Katharine Lee; Christine Embury; Christoph Daube; Jamie Ward

Day 2 – 17th July 2025

Dementia Research (10:00 – 11:15)

Speakers: Yoshihito Shigihara; Mats van Es; Aygun Badalova; Atheer Al-Manea

Dynamics (11:45 – 12:30)

Speakers: Andrew Quinn; Ayelet Landau; Francesco Mantegna

Posters (12:30 – 13:00)

Speakers: 1) Jiawei Liang
2) Vasiles Balabanis
3) Ryan M.C. Law
4) Ryan Beveridge
5) Petroc Sumner
6) Jan Schalla
7) Alicia Rybicki
8) Jason da Silva Castanheira
9) Zahra Eshagh Nimvari

Cognitive Neuroscience (14:30 – 15:45)

Speakers: Jiaqi Li; Heather Statham; Klaus Kessler; Daniel Griffiths-King

Oscillations and rhythmic MEG (16:15 – 17:45)

Speakers: Eleonora Marcantoni; Tara Ghafari; Oscar Ferrante; Dorottya Hetenyi; Zimo Huang

Day 3 – 18th July 2025

Methods for MEG (10:00 – 11:00)

Speakers: Krish Singh; Rasha Hyder; Lainya Knopik; Fabrice Guibert

Deep Learning (11:30 – 12:00)

Speakers: Rukuang Huang; Sungjun Cho

Posters (12:00 – 12:30)

Speakers: 1) Rebecca Taylor
2) Harry Cook
3) Alireza Karami
4) Arnab Rakshit
5) Alexander Zhigalov
6) Thomas Pirenne
7) Xin Wang
8) Emily Todd

Clinical Neuroscience (14:00 – 15:30)

Speakers: Hsi (Tiana) Wei; Olivier Burta; Oliver Kohl; Ingrid Martin; Svenja Knappe

Day 1 – Naturalistic Neuroscience – 16th July 2025

Overview

Time	Speaker(s)	Title
09:00 – 10:30		Coffee and Registration
10:30 – 10:40	Martina Callaghan	Opening remarks on naturalistic imaging
10:40 – 11:30	Dominik Bach	Critical Intelligence: Towards understanding the neural mechanisms of naturalistic adaptive behaviour
11:30 – 12:00		Tea break
12:00 – 12:15	Hyojin Park	Seeing Speech in a New Light: An MEG Study on Augmenting Speech Performance using Rapid Invisible Frequency Tagging (RIFT)
12:15 – 12:30	Joseph Gibson	Measurement of brain activity during naturalistic tasks
12:30 – 12:45	Stephanie Mellor	Auditory evoked responses during ambulatory movement in OP-MEG
12:45 – 13:00	Matias Ison	Neural Dynamics of Free Viewing: Insights from concurrent M/EEG/OPM-MEG and Eye Tracking
13:00 – 14:00		Lunch
14:00 – 14:30	Victoria St.Clair & Giulia Serino	Catching the young mind in motion: Wearable fNIRS in naturalistic settings
14:30 – 14:45	James Dowsett	Decoding real world scenes with mobile EEG and LCD flicker glasses
14:45 – 15:00	Katharine Lee	Dynamic functional connectivity during sleep in term and preterm infants
15:00 – 15:15	Christine Embury	Spike detection in a variety of presentations of epilepsy in children using OPM-MEG
15:15 – 15:45		Tea break
15:45 – 16:00	Christoph Daube	Integrative modeling of beta power responses to speech
16:00 – 16:50	Jamie Ward	Studying the Social Brain using Wearables and Theatre
17:00 – 18:00		Welcome drinks

Full details

Coffee and Registration

09:00 – 10:30
Ground Floor

Opening remarks on naturalistic imaging

10:30 – 10:40
Mary Ward Hall

Naturalistic Neuroscience 1

Chair: Nicholas Alexander

10:40 – 11:30 (Keynote)

Critical Intelligence: Towards understanding the neural mechanisms of naturalistic adaptive behaviour

Dominik Bach
University of Bonn

Abstract: All animals including humans have to cope with immediate threat to survive and reproduce. Ample evidence shows that non-human animals behave in sophisticated and apparently goal-directed ways. Rapid decisions between these actions, without much leeway for cognitive or motor errors, poses a formidable computational problem. In my talk, I will give an overview of our research that aims to elucidate the neural mechanisms of these decisions. First, our virtual reality (VR) platform allows simulating immediate threat situations in a safe manner. Second, results from a series of behavioural experiments suggest that human behaviour under threat, while following a standard motor sequence, is flexibly adapted and exhibits many characteristics of reflective planning. Third, we developed a VR head mounted display (HMD) that can be used together with optically pumped magnotmeters. Our data suggest that this HMD allows recording meaningful MEG signals across the entire brain. Together, our results pave the way towards an investigation of naturalistic threat-related decisions with MEG.

Tea break

11:30 – 12:00
Ground Floor

12:00 – 12:15 (Short talk)

Seeing Speech in a New Light: An MEG Study on Augmenting Speech Performance using Rapid Invisible Frequency Tagging (RIFT)

Hyojin Park
University of Birmingham

Co-authors: Yali Pan, Ana Pesquita, Ole Jensen, Katrien Segaert, Hyojin Park
Abstract: In challenging listening environments, visual cues such as lip movements can enhance speech comprehension. Here, we hypothesise that the external modulation of visual speech signals using non-invasive rhythmic stimulation can harnessed to improve speech understanding. We directly tested the hypothesis using a novel paradigm using Rapid Invisible Frequency Tagging (RIFT). RIFT is a technique that modulates visual stimuli at specific frequencies below the threshold of conscious perception to influence neural processing. We manipulated visual speech signals - using RIFT - to influence the integration of visual and auditory information, and measured brain responses using magnetoencephalography (MEG) alongside speech comprehension performance. 40 participants viewed naturalistic speech videos under dichotic listening conditions. One ear was presented with speech that matched the visual speech information (task relevant) while the other was presented with speech that did not (task irrelevant). Both streams of auditory speech were tagged at 40Hz. The visual flicker (55Hz) was implemented on the area whereby participants derive visual speech information: the speaker's mouth and was modulated by either task relevant or irrelevant speech amplitude envelopes. When modulated by relevant speech information, RIFT significantly enhanced performance in behavioural measures of speech comprehension. The MEG results showed significant effects of auditory and visual tagging in their respective sensory cortices across all experimental conditions. The visual tagging response was significantly stronger when the amplitude was modulated by relevant speech. This stronger tagging response predicted speech comprehension performance. These results suggest that modulating visual input with relevant auditory speech rhythms can facilitate the excitability of visual cortex perhaps leading to enhanced crossmodal integration. Non-invasive sensory stimulation through RIFT may therefore serve as a promising tool for improving speech intelligibility in complex listening environments with multiple competing speakers, particularly for populations such as older adults, individuals with hearing impairments, or those with auditory processing disorders.

12:15 – 12:30 (Short talk)

Measurement of brain activity during naturalistic tasks

Joseph Gibson
University of Nottingham

Co-authors: Joseph Gibson1, Ryan M. Hill1,2, Niall Holmes1,2, Lukas Rier1,2, Jessikah Fildes1, Matias Ison3, Alan Kirby, Vishal Shah4, Elena Boto2,1, Richard Bowtell1,2, Matthew J. Brookes1,2 1Sir Peter Mansfield Imaging Centre, School of Physics and Astronomy, University of Nottingham, Nottingham, United Kingdom 2Cerca Magnetics Limited, 7-8 Castlebridge Office Village, Kirtley Drive, Nottingham, United Kingdom 3School of Psychology, University of Nottingham, Nottingham, United Kingdom 4QuSpin Inc. 331 South 104th Street, Suite 130, Louisville, Colorado, USA
Abstract: Background: Functional neuroimaging seeks to characterise how neural activity underpins cognition. Most modalities require participants to remain still in enclosed spaces, preventing the implementation of naturalistic tasks that accurately depict real-world environments [1]. Here, we exploited a wearable OPM-MEG system to assess motor network dynamics whilst subjects learnt to play a musical instrument; a complex, naturalistic motor learning task that elicits rich brain activity [2]. Methods: 22 participants were scanned twice using a 192-channel OPM-MEG system [3] while playing 'Twinkle Twinkle Little Star' on the violin. Before the first scan, they viewed a video of an expert playing the tune; between scans, they received a 25-minute violin lesson from the same expert. Participants played the tune 30 times in both runs. An IR tracking system (Optitrack, NaturalPoint Inc., Corvallis) was used to monitor participant movement and allowed participants to self-pace the trials. Audio data of each trial were also recorded. OPM-optimised Spatiotemporal Signal Space Separation (tSSS) [4] was used to reduce the effects of motion artefacts. MEG data were source-localised using an LCMV beamformer and beta-band (13-30Hz) dynamics were examined. Results: Large head movements (max (140±100)mm translation / (47±50)° rotation) were observed during the task, however tSSS reduced movement related artefacts (from ~0.9nT to ~0.4pT, shielding factor 2250). The expected movement related beta decrease (MRBD) was observed in all participants during playing of the tune and, compared to rest, localised to the sensorimotor regions. We observed a trend for a greater MRBD (p=0.067) following the lesson compared to before the lesson, in the right dorsolateral motor region. Discussion: We successfully collected a rich naturalistic dataset with 22 participants comprising MEG, audio and motion tracking data. We have shown that despite the presence of large motion we are able to reliably measure high-fidelity MEG data, and we have seen preliminary evidence of differences in motor dynamics following the lesson with an expert. Future analyses will combine measures of trial rating to investigate if brain activity changes with success and explore functional connectivity measures. References: [1] Maselli et al. 2023, 10.1016/j.plrev.2023.07.006 [2] Gelding et al. 2019, 10.1038/s41598-019-53260-9 [3] Schofield et al. 2024, 10.1162/imag_a_00283 [4] Holmes et al. 2024, 10.1109/TBME.2024.3465654

12:30 – 12:45 (Short talk)

Auditory evoked responses during ambulatory movement in OP-MEG

Stephanie Mellor
University of Zurich; ETH Zurich; University College London

Co-authors: Tim M. Tierney, James Osborne, Meaghan E. Spedden, Robert A. Seymour, Nicholas A. Alexander, Cody Doyle, David Bobela, George C. O'Neill, Katarzyna Rudzka, Sahitya Puvvada, Maike Schmidt, Vishal Shah, Gareth R. Barnes
Abstract: The latest generation of Optically Pumped Magnetometer (OPM)-based Magnetoencephalography (OP-MEG) systems are increasingly portable and lightweight, making the system easier to wear while undertaking large, whole-body translational and rotational movements. This comes at the expense of added interference due to this movement, and necessitates careful consideration of how non-stationary environmental interference will be addressed. To demonstrate the potential of such setups, we recorded OP-MEG from three participants during auditory stimulation, while the participants walked around a magnetically shielded room, moving across an area of at least 1.7 m2 and rotating by at least 180-degrees. All sensor-specific electronics were housed within a wearable backpack, minimising movement restrictions which would otherwise be imposed by sensor cabling. In this experiment, the maximum peak-to-peak range of the observed magnetic field recorded on a single channel was 25.2 nT, considerably beyond the approximately 4 nT range of many previous OP-MEG systems. We show that adaptive multipole modelling (AMM) with the temporal extension can be used to separate the interference and neuromagnetic signals, despite the large degree of movement and close proximity of the sensor electronics. We observed significant auditory evoked responses at the sensor-level, without the need for source localisation approaches for interference suppression. These findings demonstrate the capability of OP-MEG for conducting naturalistic experiments involving movement.

12:45 – 13:00 (Short talk)

Neural Dynamics of Free Viewing: Insights from concurrent M/EEG/OPM-MEG and Eye Tracking

Matias Ison
University of Nottingham

Co-authors: Matias J. Ison, Joaquin Gonzalez, Damian Care, Aditi Jain, Ryan Hill, Joseph Gibson, Paul McGraw, Matthew J. Brookes & Juan E. Kamienkowski
Abstract: Eye movements are fundamental to a range of daily activities, from reading to driving. Although behavioural

patterns of eye movements during real-world tasks are well-characterised, the neural mechanisms supporting these processes remain elusive, partly due to the substantial artifacts they introduce in M-EEG recordings, often eclipsing neural signals. We present a set of experiments combining eye tracking with EEG, MEG and OPM-MEG recordings in various naturalistic tasks involving eye movements. Participants completed a hybrid visual and memory search task (EEG: N=42; MEG: N=21), in which they searched for one of several items held in memory, and a simulated driving task (OPM-MEG: N=10) using an optically pumped magnetometer system. In the EEG study, we demonstrate how deconvolution methods applied to fixation-related potentials (FRPs) can effectively disentangle temporally overlapping neural events, revealing distinct components related to target detection, task progression, and memory load. MEG source reconstruction of fixation-related activity allowed us to identify a visually evoked lambda response originating in primary visual cortex (V1). Target-related activity was observed in a distributed P3m component and further confirmed with a functional connectivity analysis. Time-frequency analyses revealed neural signatures of memory encoding, retention, and visual search. Applying similar strategies to the driving task enabled to characterization of fixation-aligned visual and attentional processing in dynamic, realistic environments. Altogether, these findings allow us to understand how the neural mechanisms underlying the interaction of memory, attention and visual processing emerge in complex dynamic tasks involving eye movements, offering insights toward more ecologically valid models of cognition.

Lunch

13:00 – 14:00
Ground Floor

Naturalistic Neuroscience 2

Chair: Alberto Mariola

14:00 – 14:30 (Long talk)

Catching the young mind in motion: Wearable fNIRS in naturalistic settings

Victoria St.Clair & Giulia Serino
Birkbeck

Abstract: Young children develop in complex, stimulus-rich environments. Understanding the developing brain in childhood requires conducting naturalistic studies in real-world environments. In this talk, we will discuss various approaches to extending neuroscientific research beyond controlled laboratory settings. Specifically, we will present several naturalistic functional near-infrared spectroscopy (fNIRS) studies conducted at Birkbeck's ToddlerLab. We will describe a set of hyperscanning studies, in which we use wearable fNIRS with multiple participants simultaneously, to investigate the neural correlates of collaborative problem-solving between preschoolers. We will review the optimisation of our analytical pipelines to reduce the influence of physiological noise in naturalistic signal measurement. We will also discuss how techniques such as diffuse optical tomography (DOT) and virtual reality can be used to simulate everyday experiences within controlled lab environments, particularly in studies involving neurodivergent children. Finally, using attention as a case study, we will present new approaches for exploring naturalistic parent–infant interactions with fNIRS technologies. We will reflect on the lessons learned and the challenges encountered when working with different age groups, populations, and experimental settings.

14:30 – 14:45 (Short talk)

Decoding real world scenes with mobile EEG and LCD flicker glasses

James Dowsett
University of Stirling

Co-authors: James Dowsett, Inés Martín Muñoz, Paul Taylor

Abstract: We are developing a new method for generating Steady State Visually Evoked Potentials (SSVEPs) of real-world environments in mobile EEG/MEG with LCD flicker glasses (Dowsett et. al. Journal of Neuroscience Methods, 2020). LCD glasses go dark, like sunglasses, when voltage is applied across the glass. The timing can be accurately controlled, allowing the glasses to flicker at any frequency. We previously demonstrated robust SSVEP responses from single channel EEG whilst participants were walking, overcoming the problems of motion artefacts without requiring high numbers of sensors. Using this method, we can apply a high frequency visual flicker to whatever the participant is looking at in the real-world; unlike traditional SSVEP paradigms which are limited to pictures on

screens. In the current study we applied this method to decoding real-world environments. Specifically, when participants stood in 6 unique locations and fixated on a point in the distance, while the glasses flickered at 10 Hz, a unique SSVEP waveform shape was generated. We found that SSVEP responses from real world scenes are surprisingly complex and have distinct shapes: they differ markedly across scenes and participants but are consistent within individuals, even across sessions. This unique SSVEP could be reproduced at a later time and also on a separate day, even if various aspects of the visual scene had changed such as overall luminance or cloud cover. The SSVEPs were significantly unique and consistent that the correct scene could be identified with over 90% accuracy. This decoding works with a single electrode, with any of the electrodes tested, and even with a few second's of data. The decoding was successful with both 10 Hz, 1 Hz and 40 Hz visual flicker; 40 Hz is particularly promising for future research in naturalistic neuroscience as the visual flicker at this frequency is barely noticeable and would not interfere with normal daily activities. We band-pass filtered the SSVEP at various harmonics to investigate the contribution of different frequency bands to decoding accuracy; for all flicker frequencies tested the SSVEP contained information at harmonics of the flicker frequency, and in all cases the gamma band (40 Hz) contained the maximal amount of information about the visual scene. We propose that this is a highly promising method for naturalistic EEG and MEG.

14:45 – 15:00 (Short talk)

Dynamic functional connectivity during sleep in term and preterm infants

Katharine Lee

University of Cambridge

Co-authors: K. Lee, B. Blanco, R. Cooper, A. Edwards, J. Hebden, K. Pammenter, J. Uchitel, T. Austin

Abstract: Preterm birth has been associated with cognitive, social, and sleep difficulties later in life, outcomes that may be exacerbated by affected sleep (Gao, 2017, Stangenes, 2017). However, the relationship between sleep states, gestational age (GA), and functional brain development remains poorly understood. Studying the role of protected sleep in the NICU may reveal neuroprotective benefits and improve long-term clinical outcomes. High-Density Diffuse Optical Tomography (HD-DOT), a functional near-infrared spectroscopy (fNIRS) technology, has been used to investigate static resting-state functional connectivity (FC) during active sleep (AS) and quiet sleep (QS) states in term-aged infants (Uchitel, 2023). Dynamic FC analysis investigates time-varying patterns in brain activity to shed light on the non-stationary nature of resting state brain functionality. One method proposed for this objective identifies recurring co-activation patterns (CAPs) using clustering algorithms which capture instantaneous brain configurations (Liu, 2018). This study examines dynamic FC in term and preterm infants during sleep to better understand the functional relationship between sleep states and early brain connectivity. HD-DOT data were acquired from sleeping newborns at the Rosie Hospital, Cambridge UK (term cohort: n = 44, GA = 40+0 weeks (median), 38+1 - 42+1 weeks (range); preterm cohort: n = 26, GA = 35+0 weeks (median), 29+1 - 36+6 weeks (range)). Sleep state was labelled as AS/QS using synchronized video or electroencephalography. Frames were sorted by seed activity for three regions of interest (ROI), frontal, central, and parietal regions, and the top 15% frames were selected for k-means clustering. This threshold was chosen because the average of the top 15% of seed-selected frames strongly correlated with the seed-based correlation maps from the static analysis, validating the CAP procedure (see Figure 1). The clustered frames were averaged to create the CAP maps. Dynamic FC was compared across sleep states by calculating CAP consistency, in-participant fraction, dwell time, and transition likelihood for the term cohort. Additionally, regional bilateral activation was compared across sleep states within each CAP using a two proportion Z-test. The post-clustering analysis has been performed for the term cohort and will be applied to the preterm cohort for comparison.

15:00 – 15:15 (Short talk)

Spike detection in a variety of presentations of epilepsy in children using OPM-MEG

Christine Embury

Young Epilepsy

Co-authors: Christine M Embury, Zelekha Seedat, Kelly St. Pier, Caroline Scott, Friederike Moeller, Krishna Das, Tim Tierney, Gareth Barnes, Matthew Walker, Umesh Vivekananda, J. Helen Cross

Abstract: Epilepsy impacts more than 100k children in the UK alone. Curative treatments in focal lesional epilepsies are largely dependent on precision mapping of epileptogenic activity coupled with structural imaging to determine surgical targets. Previous studies demonstrate the improved mapping of epileptic activity in magnetoencephalography (MEG) relative to electroencephalography (EEG), but these benefits are likely not realised in those ill-suited for the static, one-size-fits-all set-up of traditional cryogenic MEG. The next generation of the technique, optically-pumped magnetometer (OPM)-MEG promises adaptability and improvement in signal detection by bringing the sensors close to the scalp and arranging them flexibly to better fit all head sizes and shapes, particularly advantageous in children. To examine the capabilities of OPM-MEG in detecting epileptic activity in children with epilepsy, we scanned 12 children, six with focal and six with generalised, for 15 minutes to 1 hour while resting or performing tasks. Our OPM-MEG array consisted of 64 QuSpin dual axis sensors (128 channels) housed in child-sized helmets within a light MuRoom coupled with static active shielding (Cerca Magnetics Ltd., Nottingham, England, UK). Data were

pre-processed in BESA Research (version 7.1, BESA GmbH, Gräfelfing, Germany) to reduce the influence of cardiac activity. Spikes were marked by experienced clinical scientists. Spike counts were determined per data file and compiled for each participant ranging from 3 detected spikes to more than 70 in the time they were able to complete in the scanner (up to an hour). For those with focal presentations, equivalent current dipoles were mapped on the half-rise of spikes to determine the ability to precisely delineate epileptic foci from interictal activity detected. Overall, we demonstrate the ability of the technique to detect epileptiform activity in children with focal and generalised epilepsies, and with concordance with clinical presentation. This investigation lays the groundwork for a wider use case for the technique, combining the adaptable set-up and increased tolerability with increased sensitivity and precision of the equipment over available clinical tools. OPM-MEG demonstrates an advantageous potential leap for diagnostic capabilities as well as presurgical workup in paediatric epilepsy.

Tea break

15:15 – 15:45
Ground Floor

15:45 – 16:00 (Short talk)

Integrative modeling of beta power responses to speech

Christoph Daube
University of Glasgow

Co-authors: Joachim Gross, Robin A. A. Ince

Abstract: Recently, sensory neuroscience has embraced "naturalistic" experimental conditions in which brain activity is recorded during movie watching, natural scene observation or audiobook listening. In combination with modern video-, image- or audio-processing models, this has yielded unprecedentedly predictive stimulus-computable models of brain activity whose validity is hoped to exceed that of models developed from simplistic artificial stimuli. However, the field is now facing a new set of challenges: With stimulus material full of uncontrolled correlations, it remains unclear what features actually cause response variance. The interpretability is further obscured by the complexity of competitive stimulus processing models. Moreover, linear "encoding models" that relate model representations to brain responses are overly flexible, leaving high degrees of freedom such that many different extracted feature spaces predict response variance to the same degree. It becomes difficult to adjudicate between algorithmically diverse hypotheses. Here, we address these challenges with an approach that aims to generalise the performance of a linear encoding model predicting understudied power time courses as recorded with MEG in response to speech listening. Specifically, we find that such encoding models, trained on passive audiobook listening data, fail to generalise to simple and interpretable but out-of-distribution controlled conditions known from the literature. We diagnose this problem to stem from the largely unconstrained and nonlinear phase responses of the encoding models and devise a regularisation penalty to tackle this. While this effectively reduces the degrees of freedom of the encoding models, some of them achieve competitive performance not only on the passive audiobook listening data, but also on the controlled experiment. However, other models, even when constrained, still fail to generalise to the controlled experiment. This highlights how the consideration of a simplistic but controlled experiment points out dispensable model degrees of freedom and affords an improved and interpretable capacity to adjudicate between models that are equiperformant in the naturalistic condition. Taken together, we subscribe to an integrative perspective on sensory neurosciences that attempts to bridge rich naturalistic datasets to controlled experiments, and specifically considers evidence readily available from existing literature.

16:00 – 16:50 (Keynote)

Studying the Social Brain using Wearables and Theatre

Jamie Ward
Goldsmiths

Abstract: Measuring detailed information on how people move, see, and think during realistic social situations can be a powerful method in studying social behaviour and cognition. However, measurement-driven research can be limited by the available technology, with bulky equipment and rigid constraints often confining such work to the laboratory, thus limiting the ecological validity of any findings. In this talk, I will discuss some of the studies on live performance I've been involved with, using techniques like wearable EEG hyperscanning, eye-tracking, and motion capture. The work aims to explore the use of live performance and theatre as a laboratory for real-world neuroscience, while developing new measurement techniques using wearable sensors.

Welcome drinks

17:00 – 18:00
Ground Floor

Day 2 – 17th July 2025

Overview

Time	Speaker(s)	Title
09:00 – 09:20		Coffee and Registration
09:20 – 09:50		Coffee Break; Business meeting
09:50 – 10:00	Yulia Bezsudnova, Gareth Barnes	Opening remarks
10:00 – 10:30	Yoshihito Shigihara	Clinical Utility of MEG in Dementia Care: Insights from Outpatient Experience
10:30 – 10:45	Mats van Es	MEG network dynamics offer enhanced sensitivity for detecting amyloid pathology and disease progression in Alzheimer's disease
10:45 – 11:00	Aygun Badalova	Practice-induced reductions in Gamma power in Response to Proper Name Anomia Therapy in people with dementia: An MEG Study
11:00 – 11:15	Atheer Al-Manea	Electrophysiological correlates of the Last-In-First-Out hypothesis of age-related white matter decline.
11:15 – 11:45		Tea break
11:45 – 12:00	Andrew Quinn	Distinct spectral profiles of ageing and neurodegeneration
12:00 – 12:15	Ayelet Landau	Universal rhythmic architecture uncovers distinct modes of neural dynamics
12:15 – 12:30	Francesco Mantegna	The temporal dynamics of speech motor control during imagined speech
12:30 – 13:00	1) Jiawei Liang 2) Vasiles Balabanis 3) Ryan M.C. Law 4) Ryan Beveridge 5) Petroc Sumner 6) Jan Schalla 7) Alicia Rybicki 8) Jason da Silva Castanheira 9) Zahra Eshagh Nimvari	Flash Talks session 1 1) Optically Pumped Magnetometers are Better than SQUID Magnetometers in Multivariate Pattern Analysis on Visual Processing 2) MEG functional connectome fingerprints: robustness of MEG sub-networks using meta-heuristic optimization 3) Meaning construction in the anterior temporal lobe: a MEG/EEG study 4) Mind to Motion: An MEG-Driven Real-Time Exoskeleton for Stroke Rehabilitation 5) Sensory sensitivity and visual discomfort are not associated with altered gamma oscillations; a test of the excitation-inhibition hypothesis 6) Quantification of head movement in Parkinson's disease patients with head casts 7) Dopaminergic Modulation of Incentive Salience in Naturalistic Visual Search 8) Recommendations for Quantifying Rhythmic and Arrhythmic Components of Brain Activity 9) Interrogation of sensorimotor networks in ALS and MS using effective neural signal connectivity analysis
13:00 – 14:30		Lunch and poster session 1
14:30 – 15:00	Jiaqi Li	Working Memory Reactivation Across Embedded Language Structures

Time	Speaker(s)	Title
15:00 – 15:15	Heather Statham	Automatic and Selective Inhibition in the Brain: A MEG and Selective Stop Task Study
15:15 – 15:30	Klaus Kessler	A Distinct Neural Oscillatory Basis for Perspective-Taking in Autism
15:30 – 15:45	Daniel Griffiths-King	MEG signatures of BOLD: Characterising between subject-variability in contralateral and ipsilateral motor responses to unilateral finger abductions
15:45 – 16:15		Tea break
16:15 – 16:45	Eleonora Marcantoni	Multi-sensory rhythmic stimulation of hippocampal theta to modulate episodic memory in humans
16:45 – 17:00	Tara Ghafari	Subcortical Contributions to Oscillatory and Behavioural Asymmetries: Insights from the Hemispheric Laterality of Basal Ganglia and Thalamus
17:00 – 17:15	Oscar Ferrante	Neuronal correlates of predictive distractor suppression
17:15 – 17:30	Dorottya Hetenyi	Pre-stimulus shape predictions fluctuate at alpha rhythms and bias subsequent perception
17:30 – 17:45	Zimo Huang	Human Hippocampal Theta-Gamma Coupling Coordinates Sequential Planning During Navigation
19:00 – 22:00		Social evening with drinks and buffet

Full details

Coffee and Registration

09:00 – 09:20
Ground Floor

Coffee Break; Business meeting

09:20 – 09:50
Ground Floor; Dickins Library

Opening remarks

09:50 – 10:00
Mary Ward Hall

Dementia Research

Chair: Gareth Barnes

10:00 – 10:30 (Long talk)

Clinical Utility of MEG in Dementia Care: Insights from Outpatient Experience

Yoshihito Shigihara

Hokuto Hospital

Co-authors: Hideyuki Hoshi, Momoko Kobayashi, Keisuke Fukasawa, Keita Shibamiya, Sayuri Ichikawa, Yoko Hirata
Abstract: Dementia is a functionally defined condition in which various brain diseases lead to cognitive impairments that interfere with daily living. The severity of these impairments does not always correspond directly to the severity of the underlying disease, as multiple factors—such as lifestyle—modulate this relationship. Clinically, we often observe that patients show cognitive improvements after receiving well-being advice from clinicians, even when the causative disease is progressive. This highlights the need for effective tools to monitor treatment outcomes. While neuropsychological assessments are valuable, they have inherent limitations, such as learning and ceiling effects. Magnetoencephalography (MEG) offers complementary insights by capturing brain activity associated with cognitive states, particularly during the rest. Resting-state MEG provides rich information that can be used to infer both functional and pathological brain changes. Since 2019, we have routinely used MEG in our outpatient department for the assessment and treatment of dementia, accumulating experience with over 500 patients reporting subjective and/or objective cognitive impairments. Our findings include: 1. Different spectral parameters of MEG data are associated with distinct aspects of cognitive function. 2. These parameters also correlate with cerebral blood flow (assessed via ultrasonography) and pathological changes (measured using single-photon emission computed tomography). 3. Nonpharmacological treatments improve patients' cognitive states, and these improvements are reflected in changes in MEG-recorded brain activity. 4. Clinical staff's subjective impressions of cognitive improvement align more closely with changes in MEG data than with neuropsychological test scores. 5. MEG can predict cognitive improvement following nonpharmacological interventions. In this presentation, we summarise these findings and discuss the future role of MEG in clinical practice, with the goal of enhancing patient well-being. We propose that 'MEG' stands for 'Make Everyone Good', reflecting its potential to support a more holistic and human-centred approach to dementia care.

10:30 – 10:45 (Short talk)

MEG network dynamics offer enhanced sensitivity for detecting amyloid pathology and disease progression in Alzheimer’s disease

Mats van Es

University of Oxford

Co-authors: Mats W.J. van Es, Andrew J. Quinn, Jemma Pitt, Tony Thayanandan, Marlou N Perquin, Alexandra Krugliak, Ece Kocagoncu, Juliette Lanskey, Chetan Gohil, Vanessa Raymont, James B. Rowe, Anna C. Nobre, Mark W. Woolrich
Abstract: Current diagnosis and monitoring of Alzheimer’s Disease (AD) focus on Amyloid-beta, Tau aggregates, and atrophy. To advance treatments, new biomarkers are needed that are sensitive, reliable, and predictive of disease progression. We evaluated MEG spectral density in early symptomatic AD. We used data from the New Therapeutics in Alzheimer’s Disease (NTAD) study [Lanskey et al., 2022]: participants aged 50-85 with mild cognitive impairment or early AD (n=67, biomarker positive) and normal cognition (n=34, biomarker negative). Independent Cam-CAN data (N=612) were used to model confounds, including age, sex, and scanner effects. We examined spectral activity during resting wakefulness. First, we assessed static spectral power to replicate previous findings. Next, we applied Hidden-Markov Modelling (HMM) [Vidaurre et al., 2018] with 10 states to investigate brain network dynamics as a potentially more sensitive biomarker. We assessed cross-sectional differences (amyloid groups) and longitudinal changes (baseline to annual follow-up in amyloid-positive participants), and evaluated two-week test-retest reliability using intraclass correlation coefficient (ICC). We replicated previous findings of oscillatory slowing in AD: increased delta/theta and decreased alpha/beta power. These effects were robust at the group level but small to moderate in size (Cohen’s f2 < 0.35). Similar trends appeared in brain network spectra, with sensitivity varying by network and frequency band. Effect sizes exceeded those of static spectra in 6/10 states, and were strongest in a parietal alpha network (Cohen’s f2 > 0.7) in the alpha/beta band. Excluding one network, power in all networks was reliable (ICC > 0.8) and more reliable than static features. Longitudinally, the most pronounced changes occurred in a distinct network and frequency band compared to cross-sectional differences: patients showed reduced high gamma power (44-120 Hz) in a frontal network (Cohen’s f2 > 1.0), an effect only hinted at in static spectra. These results indicate that brain network dynamics are sensitive to amyloid status and disease progression, and that network spectra are more sensitive and reliable than static spectra. This suggests promise as a biomarker tool. Future analyses will examine correlations with cognitive scores and other biomarkers.

10:45 – 11:00 (Short talk)

Practice-induced reductions in Gamma power in Response to Proper Name Anomia Therapy in people with dementia: An MEG Study

Aygun Badalova

University College London

Co-authors: Aygun Badalova 1,3 Tae Twomey 1,3, Vladimir Litvak 4 George O’Neill 4 Alex Leff 1,2,3
Abstract: Objective Proper name anomia is a common language deficit observed in people with dementia (PWD),

impacting their ability to recall and retrieve the names of familiar people. This study investigates the neural changes associated with a 6-week, app-based, proper-name anomia therapy in PWD using MEG and whether this learning-based therapy leads to changes in gamma-band oscillatory activity within the left superior temporal gyrus (STG).The left STG was chosen for its key role in language processing and name retrieval. Methods 26 PWD with proper name anomia were recruited. Following baseline assessment, patients underwent a structured 6-week proper-name anomia therapy program using a novel app called Gotcha! Participants were trained to name 6-10 faces (usually their relatives and close friends), using confrontation naming and audio cueing methods. MEG recordings were obtained at two time points: pre- and post-therapy while PWD were presented with pictures of the trained familiar or untrained, but famous faces, which they named aloud. MEG data were analysed in SPM, we measured source localised gamma-band (30-80 Hz) power 0-3400 ms after the onset of a face We ran a 2x2 factorial analysis on our source images (famous v familiar; pre- v post-therapy) using a repeated-measures ANOVA to look for changes in power across conditions. The behavioural data was analysed using a repeated-measures ANOVA with the outcome being correctly named faces while free-naming. Results Behavioural data analysis revealed that the Gotcha! therapy app is effective with a significant effect at the group level of training > baseline, $F(1,36)=55.47$, $p=0.01$. For the MEG analysis, we identified a large cluster of 1205 voxels situated in the left superior temporal gyrus (MNI: -54 10 -6, $F=11.92$, $p=0.016$ peak level FWE-corrected over the left STG) where gamma reduction was associated with training (pre-post) of familiar faces, but not (untrained) famous faces. This is the first study to demonstrate that this region also supports re-learning for familiar face-name associations in PWD. Discussion App-based proper name anomia retraining appears to be an effective therapy for PWD. Initial MEG findings suggest that therapy effects are manifest in areas associated with face-naming.

11:00 – 11:15 (Short talk)

Electrophysiological correlates of the Last-In-First-Out hypothesis of age-related white matter decline.

Atheer Al-Manea
University of Birmingham

Co-authors: Magda Chechlacz & Andrew J Quinn

Abstract: The Last-In-First-Out (LIFO) hypothesis proposes that phylogenetically newer, later-myelinating brain regions are more vulnerable to age-related degeneration than evolutionarily older structures. However, the electrophysiological correlates of this structural aging pattern remain poorly understood. We will test whether peak alpha frequency and power decline are more impacted by variability in anterior or posterior tracts of the corpus callosum. The alpha rhythm is spatially localized closer to the posterior tracts whereas the LIFO hypothesis suggests that the anterior tracts are more susceptible to age related deterioration. We combined high-resolution diffusion MRI tractography, SIFT2 streamline weighting, and volumetric analyses in 542 adults (18–88 y) from the Cam-CAN ageing cohort, using the multimodal micapipe (v0.2.3) pipeline, to chart age-related white matter decline across three corpus callosum (CC) segments: Forceps Minor (FMI), mid-body (CC_MID), and Forceps Major (FMA). Segmentation of these anterior, middle, and posterior callosal bundles revealed a pronounced anterior-to-posterior gradient of deterioration. The Forceps Minor exhibited the most substantial decline in both volume and weighted fractional anisotropy (FA), while mid-body demonstrated intermediate vulnerability, and Forceps Major showed relative preservation. Standard diffusion tensor-imaging (DTI) metrics (mean FA) failed to detect subtle mid-body and posterior declines whereas SIFT2-weighted FA revealed robust negative age slopes. Volumes declined steeply in all segments, and quadratic models further revealed accelerated deterioration in later decades. This replicated the pattern of structural connectivity suggested by the LIFO hypothesis. A GLM-Spectrum analysis predicting individual variability in the resting state power spectrum shows the strongest effects with the anterior corpus callosum compared to the middle, or posterior tracts. This structure-function dissociation refines the LIFO model by integrating advanced tractography and electrophysiological metrics to capture divergent aging trajectories in the human brain’s structure and function.

Tea break

11:15 – 11:45
Ground Floor

Dynamics

Chair: Tim Tierney

11:45 – 12:00 (Short talk)

Distinct spectral profiles of ageing and neurodegeneration

Andrew Quinn
University of Birmingham

Co-authors: Andrew J. Quinn, Mats W.J. van Es, Jemma Pitt, Tony Thayanandan, Marlou N Perquin, Alexandra Krugliak, Ece Kocagoncu, Juliette Lanskey, Chetan Gohil, Vanessa Raymont, James B. Rowe, Anna C. Nobre, Mark W. Woolrich

Abstract: Non-invasive recordings of brain electrophysiology offer insight into age-related decline and disease related degeneration of neuronal function. These changes are reflected by alterations in the power spectrum of EEG and MEG recordings. Statistically rigorous analysis methodologies are needed to translate these findings into clinically meaningful metrics that address the global challenge of maintaining brain health in ageing populations. We us the CamCAN dataset to identify a full-frequency profile of the ageing effect on resting state electrophysiology and establish a basis for effect size calculation on the spectrum. Specific oscillations within this profile have different effect sizes indicating that sample size planning for ageing effects must consider the specific features of interest. The frequency profile of ageing is strongly robust to a range of common covariates and partially robust to modelling of grey matter volume. We establish that a well powered sample may become underpowered when analyses look to establish the age effect that is linearly separable from an age-relevant covariate such as grey matter volume. These results help to consolidate a variable literature of age effects on resting state brain electrophysiology and provide a pathway towards formal comparison and assessment of candidate markers for brain health in ageing. These results are used as the basis to explore the distinction between Alzheimer's Disease (AD) and healthy ageing, and specifically whether neurodegeneration can be considered a form of accelerated brain ageing. We used data from the New Therapeutics in Alzheimer's Disease (NTAD) study to compute full-frequency profiles of ageing and of presence of Alzheimer's pathology. The results show distinct spectral profiles for each predictor indicating that although age is a strong risk factor for neurodegeneration it has a separate impact on neuronal function. Crucially, the full spectral profiles showed a distinction between ageing and neurodegeneration, they can have highly correlated spatial effects at individual frequencies. Specifically, both ageing and the presence of AD lead to a decrease in posterior spectral power in the high alpha range, whereas they have distinct effects in the beta range. This result suggests that both high sensitivity for AD pathology and separability close covariates must both be optimised when searching for clinical markers.

12:00 – 12:15 (Short talk)

Universal rhythmic architecture uncovers distinct modes of neural dynamics

Ayelet Landau
University College London

Co-authors: Golan Karvat, Maité Crespo-García, Gal Vishne, Michael C Anderson

Abstract: A prominent idea in neuroscience, for over a century, has been that brain activity comprises electrical field potentials that oscillate in different frequency bands. This notion, however, has been critiqued on various grounds. Most recently, evidence suggests that brain oscillations may sometimes appear as transient bursts rather than continuous rhythms. Here, we explore the hypothesis that rhythmicity—whether sustained or bursty—represents an additional organizing principle or dimension of brain function. We analysed neurophysiological spectra of 859 participants covering diverse species, recording methods, ages (18-88), brain regions, and cognitive states in both healthy and disease, using a new rhythmicity measure. Through computer simulations and brain stimulation, we identified a universal spectral architecture comprising two categories: high-rhythmicity bands linked to continuous oscillations and new low-rhythmicity bands characterized by brief bursts. Beyond characterizing this architecture I will discuss its functional consequences and examine whether the two categories of activity relate to two different modes of information processing. Namely, sustained bands reflecting maintenance of ongoing activity, and transient bands indicating responses to changes.

12:15 – 12:30 (Short talk)

The temporal dynamics of speech motor control during imagined speech

Francesco Mantegna
University of Oxford

Co-authors: Joan Orpella, David Poeppel

Abstract: Speech production constitutes a fundamental activity inherent in our interactions and communication with others. The apparent ease we experience during speech production conceals the inherent complexity of its underlying machinery. The subjective feeling that speech production is seamless derives from extensive prior experience, which we constantly deploy to make predictions and apply corrections as we speak. One convenient way to study these feedforward and feedback control mechanisms is through imagined speech—that is, the internal generation of speech in the absence of motor articulation and its sensory consequences. When speech is conjured up internally, control

mechanisms are not overshadowed by brain activity associated with motor execution and sensory feedback, making them more easily identifiable in the brain signal. During my PhD, I conducted three magnetoencephalography (MEG) studies investigating the temporal dynamics of speech motor control during imagined speech. The first study (1) explores how the decodability of sensory and motor transient neural representations associated with imagined speech varies depending on speech content (e.g., consonants vs. vowels). The second study (2) reveals a dynamic shift in the hemispheric lateralization of functional connectivity between motor and auditory areas, suggesting that feedforward control exhibits left lateralization prior to imagined speech production, while feedback control exhibits right lateralization afterward. The third study (3) demonstrates a spatiotemporal segregation of frequency-specific power modulations in the alpha and beta frequency bands in motor and auditory areas, respectively. Additional analyses confirmed that these two frequencies are not harmonics but rather spectrally distinct: a somatomotor 'mu' rhythm and an auditory 'tau' rhythm. This segregation indicates distinct coding schemes that necessitate sensorimotor coordination during imagined speech. Collectively, these studies contribute to advancing our understanding of speech motor control, offering a more precise temporal characterization of both covert and overt speech production subprocesses and thereby shedding new light on its neural architecture. Moreover, they lay the foundation for a non-invasive brain-computer interface, a topic that I am currently investigating in my postdoc.

Posters

Chair: Tim Tierney

12:30 – 13:00 (Flash talks)

Flash Talks session 1

1) Optically Pumped Magnetometers are Better than SQUID Magnetometers in Multivariate Pattern Analysis on Visual Processing
2) MEG functional connectome fingerprints: robustness of MEG sub-networks using meta-heuristic optimization
3) Meaning construction in the anterior temporal lobe: a MEG/EEG study
4) Mind to Motion: An MEG-Driven Real-Time Exoskeleton for Stroke Rehabilitation
5) Sensory sensitivity and visual discomfort are not associated with altered gamma oscillations; a test of the excitation-inhibition hypothesis
6) Quantification of head movement in Parkinson's disease patients with head casts
7) Dopaminergic Modulation of Incentive Salience in Naturalistic Visual Search
8) Recommendations for Quantifying Rhythmic and Arrhythmic Components of Brain Activity
9) Interrogation of sensorimotor networks in ALS and MS using effective neural signal connectivity analysis

1) Jiawei Liang
2) Vasiles Balabanis
3) Ryan M.C. Law
4) Ryan Beveridge
5) Petroc Sumner
6) Jan Schalla
7) Alicia Rybicki
8) Jason da Silva Castanheira
9) Zahra Eshagh Nimvari

Mary Ward Hall

Lunch and poster session 1

13:00 – 14:30
Ground Floor

Cognitive Neuroscience

Chair: Dorottya Hetenyi

14:30 – 15:00 (Long talk)

Working Memory Reactivation Across Embedded Language Structures

Jiaqi Li
University of Oxford

Co-authors: Jiaqi Li, Yali Pan, Hyojin Park, Peter Hagoort, Huan Luo, Ole Jensen
Abstract: Recursiveness, involving hierarchical embedding of clauses, is a key feature of human language that depends on working memory (WM). During speech comprehension, listeners must maintain previously processed words or phrases for later unification. However, the neural mechanisms underlying how WM supports the processing of complex recursive structures remain unclear. We constructed English sentences with embedded language structures (e.g. The dog, who chases the cat, jumps over the mud.) and recorded magnetoencephalography (MEG) signals while English native speakers listened to these sentences. Neural decoding results demonstrate that during speech comprehension, previously encoded information (e.g. the dog) is maintained in an activity-silent state until syntactic cues (e.g. jumps over) trigger unification. In our study, the verb (e.g. jumps over) reactivated the subject constituent that preceded the embedded clause (e.g. the dog) after 600 ms of the verb's onset. Furthermore, source-level searchlight analysis reveals that the memory reactivation first occurs in the prefrontal cortex followed by reactivation in the temporal cortex. Further analysis revealed that the syntactic structure of the embedded clause specifically modulated the memory performance related to unification and the strength of memory reactivation. This study provides crucial insights into the temporal and spatial dynamics of WM functions required for unification operations across embedded structures. By bridging the gap between the domains of WM and language comprehension, this work offers a novel perspective with potential implications for refining computational models of both WM and language processing.

15:00 – 15:15 (Short talk)

Automatic and Selective Inhibition in the Brain: A MEG and Selective Stop Task Study

Heather Statham
Cardiff University

Co-authors: Dr Aline Bompas, Professor Krish Singh, Philip Schmid
Abstract: The stop-signal reaction time (SSRT) is widely used to quantify action inhibition in manual and saccadic tasks. However, it is criticized for its limited reliability (Hedge et al., 2018, Behaviour Research Methods) and its dependency on visual and motor delays (https://mathpsych.org/presentation/1061). Still, many neurophysiological studies rely on SSRT to identify neural markers of inhibition such as increased beta-band oscillations, and P300 and N100 event-related potential (ERP) components. The selective stopping task offers more informative indices by having participants give speeded responses to lateralized dots on go trials, but withhold responses when a stop signal appears, or still respond when an ignore signal appears. The time at which reaction time distributions diverge between go trials and signal-present trials reflects the minimum estimate of visual and motor delays, termed visuomotor deadtime (VMDT). The time at which stop and ignore distributions diverge, denoted Ts, marks the earliest time that top-down, instruction-relevant signals can influence action. Additionally, peak latencies of partial response electromyography (prEMG) can be used to index the timing of inhibition as they reflect when an initiated muscle response has been interrupted before a full response can be recorded (Raud et al., 2022, eLife). We will outline the study and analysis plan of a manual selective stopping task in MEG. Our aim is to isolate the neural mechanisms of automatic (task-unrelated) and selective (task-related) inhibition. For each process, we will identify 1) trials where this process has most likely occurred, and 2) comparable control trials where it hasn't. To do so, we will use trial types (go, ignore and stop) and their behavioural outcomes (no responses and response times in relation to key behavioural landmarks: VMDT, Ts and prEMG peak latencies). We will compare the oscillatory power across trials to identify when (in a trial) and where (in the brain) differences occur. Specifically, a marker for selective inhibition should distinguish 1) successful stop trials with a prEMG after Ts, and 2) successful ignore trials with a response time longer than Ts. For this marker to provide a credible mechanism for selective inhibition, it would need to be frontocentral and start before Ts. Similarly, a marker of automatic inhibition should distinguish activity in the motor cortices between go and signal-present trials with response times between VMDT and Ts.

15:15 – 15:30 (Short talk)

A Distinct Neural Oscillatory Basis for Perspective-Taking in Autism

Klaus Kessler
University College Dublin

Co-authors: Klaus Kessler, Robert Seymour, Gina Rippon, Hongfang Wang
Abstract: Understanding that others may see the world differently from ourselves is a vital developmental milestone, closely tied to visuospatial perspective taking—specifically, the ability to mentally adopt another person's visual perspective (level-2 perspective taking). Given that many autistic individuals experience challenges with this type of mental transformation and often face social difficulties later in life, this study explored differences in visual perspective-taking abilities between autistic and non-autistic adolescents. Perspective-taking is a complex cognitive skill central to social understanding. It typically involves an an embodied mental transformation whereby people mentally rotate themselves away from their physical location into the other's orientation. This mental shift is known to engage theta-band (3–7 Hz) brain oscillations within a fronto-parietal network, including the temporoparietal junction—a pattern established in prior research (e.g., Seymour et al., 2018; Wang et al., 2016; Gooding-Williams et al., 2025). Previous studies suggest that individuals with autism spectrum disorder (ASD) often struggle with such embodied strategies. To examine the neurophysiological mechanisms underlying these differences, we used (cryogenic) magnetoencephalography alongside a validated perspective-taking task in 18 autistic and 17 age-matched non-autistic adolescents. Results showed that as the angular disparity between the participant's and the avatar's viewpoint increased, autistic participants exhibited significantly slower reaction times. This behavioural effect was mirrored by a reduction in theta power across a broad network of regions typically active during social cognitive tasks. Interestingly, autistic adolescents also showed greater decreases in alpha power within the visual cortex, regardless of task condition. These findings—reduced theta activity, increased alpha suppression, and steeper increases in response time with angular disparity—suggest that autistic individuals may rely on alternative cognitive strategies, such as mentally rotating objects, rather than simulating another's perspective through embodied transformation. Notably, when participants were asked to simply track rather than adopt another's perspective, no group differences emerged in behaviour or neural oscillations. This indicates that the observed differences are specific to high-level, embodied perspective-taking rather than to simpler social attention processes.

15:30 – 15:45 (Short talk)

MEG signatures of BOLD: Characterising between subject-variability in contralateral and ipsilateral motor responses to unilateral finger abductions

Daniel Griffiths-King
Aston University

Co-authors: Daniel Griffiths-King, Sian Worthen, Caroline Witton, Paul Furlong, Michael Hall and Stephen Mayhew
Abstract: Human behaviour relies on collaborative and antagonistic brain activity. In unilateral sensorimotor tasks, fMRI reveals positive and negative BOLD responses (PBR/NBR) in the contralateral and ipsilateral sensory cortices respectively (Nelson & Mayhew, 2024), but their neural basis remains poorly understood. We used MEG to examine broadband oscillatory responses during unilateral motor tasks, to identify contralateral and ipsilateral signatures that might underlie PBR and NBR. Most previous studies focus on the positive motor BOLD component (e.g. Stevenson et al., 2011), overlooking potential ipsilateral contributions. We analysed a subset of the MEGUK dataset (35 adults recruited from Aston University). Participants performed right-hand finger abductions following visual grating offset (1.5–2s duration; 8s inter-trial interval). MEG & EMG data were processed with MNE-Python (v1.8.0) using the MNE-BIDs pipeline. Source activity was reconstructed in the primary motor cortex (M1) via LCMV beamforming, using Freesurfer-derived anatomical models. Analyses targeted three time–frequency windows: (i) beta (15–30 Hz) ERD (event-related desynchronisation; –500–500 ms), (ii) PMBR (post-movement beta rebound; 1000–2000 ms), and (iii) gamma (60–90 Hz) ERS (event-related synchronisation; –500–500 ms), all time-locked to EMG peak onset. Peak source activity was localised within contralateral & ipsilateral precentral gyri, defining M1 regions of interest (ROIs) resulting in 6 virtual electrode (VE) locations per participant. Group-level TFRs (via DPSS multitapers) showed bilateral ERD & PMBR, but with stronger contralateral dominance. PMBR VE time series showed similar peak amplitude & latency across hemispheres. However, individual TFRs revealed variability, including absent contralateral ERD, or even reversed lateralisation of PMBR/ERD. While intra-individual MEG response consistency is well-characterised (e.g. Espenhahn et al., 2017), variability across individuals—especially in ipsilateral responses—remains underexplored. ECoG recordings show fMRI visual cortex NBR is associated with an absence of high frequency band responses (Fracasso et al, 2022) whilst rodent optical imaging spectroscopy studies indicate gamma-band power reductions related to negative hemodynamic responses (Boorman et al, 2015). However, we found no definitive differences in oscillatory activity, including motor-gamma, within ipsilateral hemisphere suggestive of mechanisms which may underpin NBR.

Tea break

15:45 – 16:15
Ground Floor

Oscillations and rhythmic MEG

Chair: Jason da Silva Castanheira

16:15 – 16:45 (Long talk)

Multi-sensory rhythmic stimulation of hippocampal theta to modulate episodic memory in humans

Eleonora Marcantoni
University of Glasgow

Co-authors: Eleonora Marcantoni , Danying Wang, Robin Ince, Dan Bush, Lauri Parkkonen, Satu Palva, Simon Hanslmayr

Abstract: Hippocampal theta oscillations play a critical role in binding multisensory information into coherent episodic memories. Recent evidence suggests that externally entraining these oscillations via 4-Hz audio-visual Rhythmic Sensory Stimulation (RSS) can significantly enhance memory performance in associative memory tasks. However, the current “one-size-fits-all” stimulation approach overlooks individual differences in neural dynamics, potentially contributing to the variability observed in behavioral outcomes. To address this limitation, we developed a pipeline to estimate the individual's hippocampal theta frequency during a memory task and adapt the stimulation frequency in real time. The pipeline comprises several key steps. First, hippocampal signals are extracted from MEG recordings using an LCMV beamformer. Next, Generalized Eigenvalue Decomposition (GED) is applied to isolate theta-band activity from the broadband signal. Finally, the Cyclic Homogeneous Oscillation (CHO) detection method is used to verify the presence of oscillations and identify their central frequency. This frequency is then used to dynamically adjust the flickering rate of the sensory stimuli during the task. As a proof of concept, we first validated the use of GED and CHO on rodent LFP data by attempting to replicate the well-established correlation between running speed and hippocampal theta frequency. The results confirmed the feasibility of this approach, with the pipeline successfully reproducing the expected relationship ($R = 0.27$, $p < .001$, Î·Â² = 0.315). Subsequently, we applied the full pipeline offline to a human MEG dataset collected during an associative memory task involving 4-Hz RSS. Our aim was to evaluate whether the pipeline could detect stimulation-induced changes in hippocampal theta frequency. As hypothesized, the estimated frequencies during stimulation were significantly closer to 4 Hz compared to pre- and post-stimulation windows (main effect of time: $F(6,120) = 24.99$, $p < .001$, Î·Â² = 0.315). Currently, we are validating the pipeline using a simultaneous MEG-iEEG dataset, allowing us to compare the frequencies estimated from MEG with ground-truth hippocampal activity recorded via iEEG. This step will offer critical insights into the accuracy and reliability of the approach. Preliminary results indicate that real-time detection and tracking of individual theta frequencies is feasible, supporting the potential to test personalised RSS in memory enhancement.

16:45 – 17:00 (Short talk)

Subcortical Contributions to Oscillatory and Behavioural Asymmetries: Insights from the Hemispheric Laterality of Basal Ganglia and Thalamus

Tara Ghafari
University of Oxford

Co-authors: Tara Ghafari, Mohammad Ebrahim Katebi, Mohammad Hossein Ghafari, Aliza Finch, Ole Jensen

Abstract: Healthy individuals exhibit a subtle leftward attentional bias known as pseudoneglect, typically attributed to right-hemisphere dominance for attention. While cortical contributions are well-established, the role of subcortical structures remains less clear. In this study, we explored how naturally occurring volumetric asymmetries in subcortical regions relate to both behavioural and neurophysiological markers in healthy adults. In a behavioural experiment with 44 participants, we assessed spatial bias using a computerised landmark task and eye-tracking, quantifying the point of subjective equality (PSE). Structural T1-weighted MRI data were processed using FSL FIRST to calculate lateralised volumes (LVs) of seven subcortical structures. General linear model analyses revealed that individual differences in PSE were significantly predicted by the lateralised volume of the putamen, suggesting a subcortical origin for individual variation in attentional bias. Complementing this, we analysed resting-state MEG data from a larger cohort (n = 590, Cam-CAN dataset), correlating frequency-specific hemispheric power asymmetries with subcortical volume asymmetries. We found significant associations between the lateralisation of oscillatory power and subcortical volumes. Notably, the putamen showed correlations with lateralised power in the beta band, the thalamus was significantly correlated with alpha laterality and the hippocampus with laterality in the delta/theta bands. Together, these findings provide converging evidence that subcortical volumetric asymmetries not only shape behavioural hemifield biases in spatial attention but also influence the lateralisation of neocortical oscillatory activity. This work highlights the importance of subcortical structures in supporting attentional processes in the healthy brain and lays the groundwork for future research into their role in neurodegenerative disorders.

17:00 – 17:15 (Short talk)

Neuronal correlates of predictive distractor suppression

Oscar Ferrante
University of Birmingham

Co-authors: Ole Jensen, Clayton Hickey
Abstract: Visual attention is influenced by the statistical regularities of our environment, with spatially predictable distractors being actively suppressed. Yet, the neural mechanisms underlying this suppression remain poorly understood. In this talk, I will show how we have used magnetoencephalography (MEG), rapid invisible frequency tagging (RIFT), and multivariate decoding analysis to provide new insight on the processing of predicted distractor locations in the human brain. Using a statistical learning visual search task where a colour-singleton distractor appeared more frequently on one side of the visual field, we found that early visual cortex exhibited reduced neural excitability in the pre-search interval at retinotopic sites corresponding to higher distractor probabilities. During this period, a temporo-occipital network encoded these distractor locations, supporting the hypothesis that proactive suppression directs visual attention away from predictable distractors. Notably, the neural activity associated with pre-search distractor processing extended into the post-search period during late attentional stages (around 200 ms), suggesting a mechanistic link between proactive and reactive distractor suppression. These findings offer critical insights into the neuronal correlates of predictive distractor suppression and provide a deeper understanding of the cognitive mechanisms underlying selective attention.

17:15 – 17:30 (Short talk)

Pre-stimulus shape predictions fluctuate at alpha rhythms and bias subsequent perception

Dorottya Hetenyi
University College London

Co-authors: Dorottya Hetenyi & Peter Kok
Abstract: Predictions about future events significantly influence how we process sensory signals. In previous work, we demonstrated that predicted shape representations exhibit oscillatory activity in the alpha band (10–11 Hz) during pre-stimulus intervals. In that study, participants performed a task that was orthogonal to the shape predictions. Here, we extended these findings by having participants perform a shape identification task that directly relied on the shape predictions, allowing us to link the neural correlates of prediction to subjective perception. We used magnetoencephalography (MEG) combined with multivariate decoding to examine the content and frequency characteristics of perceptual predictions and relate them to behaviour. The shape identification task involved auditory cues predicting which shape was likely to appear. To make the identification of the shapes challenging, they were embedded in white noise. First, we found that valid prediction cues improved both identification accuracy and reaction times. Signal detection theory analyses revealed that participants were significantly biased toward reporting the predicted shape (i.e., reduced criterion), without a change in sensitivity (i.e., similar d-prime). We replicated our previous finding that predicted shape representations fluctuate in the alpha band (10–11 Hz). Logistic regression analyses further revealed that this shape-specific alpha power predicted perceptual biases induced by the predictions. That is, when shape-specific alpha power was high, participants were more likely to perceive the predicted shape. In contrast, higher raw sensor-level occipital alpha power was associated with a greater likelihood of reporting the unpredicted shape. These results suggest that content-specific alpha fluctuations and general occipital alpha power serve distinct functions in visual perception. Taken together, our findings demonstrate that sensory predictions are represented in pre-stimulus alpha oscillations and that these oscillatory signals shape how we perceive the world.

17:30 – 17:45 (Short talk)

Human Hippocampal Theta-Gamma Coupling Coordinates Sequential Planning During Navigation

Zimo Huang
University College London

Co-authors: James Bisby, Neil Burgess, Daniel Bush
Abstract: Human behaviour often relies on executing a specific sequence of actions to achieve a desired outcome. However, the neural mechanisms underlying the dynamic construction and maintenance of such sequences during goal-directed behaviour are not yet clear. Empirical and theoretical studies of working memory function suggest that sequential information may be encoded in neural circuits by bursts of gamma activity occurring at consecutive theta phases. Here, we asked whether similar coding schemes might support sequential planning during goal-directed navigation. Using non-invasive magnetoencephalography and an abstract navigation task, we found that hippocampal theta power during both planning and subsequent navigation decreased with proximity to the current goal, only during accurate navigation. At the same time, theta-gamma phase-amplitude coupling increased with goal proximity,

consistent with sequences of upcoming locations being represented by gamma bursts occurring at successive theta phases. Importantly, entorhinal high gamma and hippocampal low gamma dominated while traversing novel and previously experienced paths, respectively, consistent with previous rodent studies. These findings suggest that hippocampal theta-gamma phase amplitude coupling flexibly and dynamically coordinates sequences of actions during goal-directed behaviour across mammalian species, using different gamma bands for mnemonic and prospective planning.

Social evening with drinks and buffet

19:00 – 22:00
Coin Laundry, EC1R 4QP

Day 3 – 18th July 2025

Overview

Time	Speaker(s)	Title
09:00 – 09:50		Coffee Break
09:50 – 10:00	Yulia Bezsudnova, Gareth Barnes	Opening remarks
10:00 – 10:15	Krish Singh	MEG measures of target engagement in early-phase clinical trials: Modulation of task and resting-state oscillatory dynamics by a novel AMPAR PAM
10:15 – 10:30	Rasha Hyder	Modulation of auditory system neuroplasticity by a novel AMPAR PAM drug: Evidence from MEG
10:30 – 10:45	Lainya Knopik	Do we still need resting-state MEG?
10:45 – 11:00	Fabrice Guibert	Multi-Scale Brain Dynamics in M/EEG with Time-Delay Embedded Hidden Markov Models
11:00 – 11:30		Tea break
11:30 – 11:45	Rukuang Huang	Ephys-GPT: A foundation model for electrophysiological data
11:45 – 12:00	Sungjun Cho	Learnable Sample-Level Tokenisation for MEG Foundation Models
12:00 – 12:30	1) Rebecca Taylor 2) Harry Cook 3) Alireza Karami 4) Arnab Rakshit 5) Alexander Zhigalov 6) Thomas Pirenne 7) Xin Wang 8) Emily Todd	Flash Talks Session 2 1) What are the neural correlates of sensitivity to clothing fabrics? 2) Development of an atomic gradiometer for human brain stimulation 3) From Visual Features to Semantic Categories: MEG Evidence for the Time Course of Mathematical Object Processing 4) OPM-FLUX – an open-source analysis pipeline for OPM-MEG 5) Neural mechanisms of paced breathing 6) Whole-brain Granger Causality of source reconstructed MEG 7) Semantic Gist Prediction from Stereo-Electroencephalography (sEEG) Using Token-Level Semantic Features and Large Language Model 8) GABAa modulation of cortical neurophysiology in Progressive Supra-nuclear Palsy and frontotemporal dementia
12:30 – 14:00		Lunch and poster session 2
14:00 – 14:30	Hsi (Tiana) Wei	MEG in Psychosis: individual differences in neural oscillations underlying language disorganization and impoverishment
14:30 – 14:45	Olivier Burta	Weakened prefrontal activation dynamics associated with slowed information processing speed in multiple sclerosis
14:45 – 15:00	Oliver Kohl	Varying patterns of association between cortical large-scale networks and subthalamic nucleus activity in Parkinson’s Disease

Time	Speaker(s)	Title
15:00 – 15:15	Ingrid Martin	Impaired mPFC–hippocampal theta phase coupling during memory retrieval in Schizophrenia
15:15 – 15:30	Svenja Knappe	High-density full-head on-scalp MEG for Epilepsy
15:30 – 16:00	Yulia Bezsudnova, Gareth Barnes	Closing and award ceremony
16:00 – 17:00		Tea break

Full details

Coffee Break

09:00 – 09:50
Ground Floor

Opening remarks

09:50 – 10:00
Mary Ward Hall

Methods for MEG

Chair: Vladimir Litvak

10:00 – 10:15 (Short talk)

MEG measures of target engagement in early-phase clinical trials: Modulation of task and resting-state oscillatory dynamics by a novel AMPAR PAM

Krish Singh
Cardiff University

Co-authors: Krish D Singh, Rasha Hyder, John R. Atack, Simon E. Ward, Jennifer B. Swettenham, Natalie Jones and Neil A Harrison

Abstract: Development of novel pharmacological treatments for neurological and neuropsychiatric disorders is notoriously costly and difficult, with multiple decision-points at which the compound can fail. A critical factor is a lack of evidence that having crossed the blood-brain barrier, the drug engages with the neural target in humans in a way predicted by the pre-clinical evidence. As highlighted by the NIH Fast-Fail Trials (FAST) Initiative, CNS drug discovery could be substantially de-risked, with significant cost and time savings if non-invasive technology could be used to index human target-engagement in early phase clinical trials. MEG is ideal for this because of its enhanced spatial resolution, compared to EEG, and its direct sensitivity to post-synaptic potentials, unlike fMRI. However, MEG is not commonly used. Here, we present results of a novel approach to first-in-human Phase-1 clinical trials where we incorporated two separate MEG evaluations of target engagement in a new compound designed to increase AMPAR activity within the brain, with potential therapeutic indications across several neuropsychiatric disorders. MEG demonstrated that this novel drug modulated resting-state oscillatory activity within multiple brain regions consistent with the known distribution of AMPA receptors across the brain. The most widespread effects were found in the beta and gamma frequency ranges. The AMPAR-PAM also potentiated the 40Hz auditory steady-state response (ASSR) and enhanced cortical responses during a visual task. No effects were detected in a multi-deviant mis-matched negativity paradigm. The size of these drug-induced changes varied in a dose-dependent way and/or were correlated with individual blood assays of drug exposure at the time of MEG scanning. This study provides proof-of-concept for how drug-development scientists, MEG neuroimaging experts, clinicians, clinical-trials organisations and commercial pharma companies can collaborate to simultaneously and efficiently test compound target-engagement, pharmacodynamics and safety in a Phase-I clinical trial. We believe that wider scale adoption of this approach would significantly de-risk and accelerate the CNS drug-development process and increase the chance of successful

treatments being available to patients. Because of MEGUKI's high-quality research and highly integrated collaborative nature, we are in an excellent position to become international leaders in this exciting new innovation area.

10:15 – 10:30 (Short talk)

Modulation of auditory system neuroplasticity by a novel AMPAR PAM drug: Evidence from MEG

Rasha Hyder
Cardiff University

Co-authors: Rasha Hyder, John R. Atack, Simon E. Ward, Jennifer B. Swettenham, Natalie Jones, Luke Tait, Neil A Harrison and Krish D Singh

Abstract: The sensitivity of classical auditory measures such as auditory steady state response (ASSR) and auditory mismatch negativity (MMN) to pharmacological interventions has been confirmed both in human and animal research. Here, as part of a first-in-human Phase I clinical trial, we used pharmaco-MEG to assess the functional effects of target engagement of a novel positive allosteric modulator (PAM) of AMPA receptors developed at Cardiff University. This drug enhances AMPAR function in a use-dependent manner thereby impacting synaptic plasticity and overall brain health. This was a within-subject, placebo-controlled, double-blind crossover study during which we acquired MEG data during 40 Hz-steady-state auditory response task and auditory multi-feature MMN paradigm from 19 healthy volunteers. In each of 3 separate visits, participants received a single dose of placebo, low- or high-dose of the drug. MEG recording started an hour post-dose. In addition to MEG, we collected structural MRI scans of participants. All participants showed clear ASSR and MMN responses both in sensor and source-space in all three sessions. While no drug effects were found in the auditory MMN task, a clear enhancement in the 40Hz ASSR evoked power was seen in the right hemisphere with the high-dose. To better understand the mechanistic functioning of the drug and explain the enhancement in ASSR in the right hemisphere with the high dose only, we are currently analysing the 40Hz data using dynamic causal modelling (DCM), based on an optimised thalamo-cortical microcircuit model, with channel-specific conductance. Findings from this study provide further evidence for the potential of MEG-based neurophysiological measures, in particular ASSR, as novel translational biomarkers for indexing target engagement and de-risking CNS drug-development.

10:30 – 10:45 (Short talk)

Do we still need resting-state MEG?

Lainya Knopik
Cardiff University

Co-authors: Krish Singh, Luke Tait, Carolyn McNabb

Abstract: Resting-state paradigms have become ubiquitous in brain activity/connectivity studies of function in both health and disease, with MEG able to probe resting oscillatory dynamics in multiple frequency bands to reveal static/dynamic networks at the millisecond level. Yet, during rest, the cognitive state of participants is uncontrolled/unknown, yielding unwanted variance and potential group-level differences. In addition, when task paradigms are also used, resting-state paradigms significantly add to the scan time burden – this is especially problematic for challenging patient populations and young children. To address this, we examined whether static functional connectivity (FC) patterns derived from a visual task recording could reproduce those observed during rest, eliminating the need for a specific resting-state recording. Using MEG from 166 participants, leakage-corrected amplitude envelope correlations were calculated, yielding frequency-specific static connectivity maps for each person. This was done for both a resting-state recording and a visual-gamma recording i.e. in the latter the presence of the task was ignored during analysis. Connectivity maps, and sub-networks generated by hierarchical clustering, were compared across the two datasets using inter-session correlation. We also found a significant correlation between resting-state MEG connectivity and age and explored whether this was reproduced in the maps derived from the visual gamma data. Preliminary findings reveal moderate inter-session correlations (mean $r = 0.56$) in the beta-band (13-30 Hz) between FC matrices. Hierarchical clustering identified 26 stable sub-networks with significant cross-session correlations ($r = 0.50–0.71$, $p < .001$). We also observed highly reproducible age-related connectivity patterns in the alpha band (8-13 Hz) across both rest and task data ($r = 0.84$, $p < .001$). This work challenges the convention that resting-state MEG is uniquely suited for capturing connectivity and shows that task MEG data can reveal the same core features of intrinsic brain architecture, potentially substituting for rest in contexts where time, cost, or participant compliance is limited. This offers an efficient, pragmatic and powerful approach, streamlining MEG protocols and enhancing accessibility, especially in clinical or developmental populations. Future work will extend this analysis to study state-dynamics, activity, peak frequency, other tasks and clinical populations.

10:45 – 11:00 (Short talk)

Multi-Scale Brain Dynamics in M/EEG with Time-Delay Embedded Hidden Markov Models

Fabrice Guibert

Ecole Polytechnique Fédérale de Lausanne (EPFL); University of Geneva (UNIGE)

Co-authors: Fabrice Guibert, Jeroen Van Schependom, Chiara Rossi, Dimitri Van de Ville, Daphné Bavelier
Abstract: M/EEG studies have successfully described brain activity through the succession of different states. In the context of the time-delay embedding (TDE)-hidden Markov models (HMM) methodology, these spatiotemporal states have both spatial and oscillatory properties. TDE-HMM states reflect changes in spatio-temporal covariance structures. Yet, despite the well-accepted view that the brain functions at multiple temporal scales, current analyses have primarily focused on the trial level. Objective. We aim to investigate how TDE-HMM-state time courses behave across different temporal scales. Methods. We use cryogenic MEG data collected at two sites (Brussels, N=38; Nottingham, N=8-replication data set). Each task is structured in blocks of either 0-back, 1-back, or 2-back, interleaved in pseudo-random order, and separated by periods of instruction, as well as rest – thus providing a rich higher-order block structure. Following standard MEG preprocessing steps, we train a TDE-HMM model and extract state probability time courses. To investigate whether we can extract dynamics at multiple temporal scales, we first ask if probability time courses can be used to retrieve task-related conditions at the block level, such as being on-task versus off-task, N-back blocks of differing difficulty, and ordering effects of blocks. We then verify if probability time courses can also be used to contrast task-related conditions at the trial level i.e. hits against correct rejects. Importantly, these evaluations are conducted multiple window sizes in the TDE step of the HMM, and evaluate discriminability. Stability is assessed using multiple restarts. Results. We find that states exhibit a rich structure at the trial level, consistent with previous studies. We also demonstrate that states capture block-level structure, such that state activations distinguish between being on- and off-task, being in different N-back difficulty blocks, as well as ordering effects on N-back blocks. Thus, state time courses show striking temporal structure, yet also capture finer patterns at the trial level. Our results are stable across model restarts. Finally, we also demonstrate the influence of window size, as well as a phase transition in state power spectrum for window sizes longer than 80 ms. Conclusion. This study suggests that brain state dynamics should be considered not only at the trial level in M/EEG data, but also at a coarser level to unveil a greater range of temporal dynamics.

Tea break

11:00 – 11:30
Mary Ward Hall

Deep Learning

Chair: Daniel Bush

11:30 – 11:45 (Short talk)

Ephys-GPT: A foundation model for electrophysiological data

Rukuang Huang
University of Oxford

Co-authors: Sungjun Cho, Mark Woolrich
Abstract: Foundation models have demonstrated remarkable success across different domains by leveraging large-scale, unlabelled datasets and self-supervised learning to extract rich, transferable representations. For electrophysiological data, however, existing models are predominantly trained on transformed versions of the data in the time-frequency domain (e.g. with Fourier or wavelet transforms), which may compromise the temporal and frequency resolution and relies on pre-defined hyper-parameters of the transformations. We introduce Ephys-GPT, a foundation model pre-trained on large amount of raw resting-state magnetoencephalography (MEG) recordings. Inspired by the autoregressive objectives of the GPT models, Ephys-GPT is trained on tokenised raw data with a bespoke tokeniser to predict future tokens. We show that Ephys-GPT generates realistic neural recordings that preserves key statistical and physiological properties, including power spectral density, spatial patterns of frequency bands, between-subject variability, and importantly, oscillatory bursting dynamics (e.g. beta bursts in the motor cortex). Furthermore, the model can be efficiently fine-tuned on limited task-evoked data. Generated data from the fine-tuned model shows time-locked task responses to surrogate task event sequences. This work demonstrates the feasibility and potential of large-scale, self-supervised foundation models on raw electrophysiological signals, paving the way for powerful general-purpose, multi-modal tools in neural decoding and computational neuroscience.

11:45 – 12:00 (Short talk)

Learnable Sample-Level Tokenisation for MEG Foundation Models

Sungjun Cho
University of Oxford

Co-authors: Rukuang Huang, Oiwi Parker Jones, Mark W Woolrich
Abstract: Recent advancements in large language models have catalysed the development of transformer-based foundation models for MEG and other neuroimaging modalities, aiming to extract generalisable patterns from large datasets that can be flexibly adapted to various modalities and clinical disorders with minimal retraining. This endeavour in turn necessitated efficient tokenisation strategies that can compactly summarise neural data into transformer-compatible representations. Until now, existing tokenisers primarily adapted techniques designed for general, non-biological time-series data, such as patching, time-frequency transformations, or vector quantisation. However, these often sacrifice temporal resolution, limiting interpretability and precise temporal alignment essential for MEG data analyses. While some tokenisers do preserve temporal fidelity (e.g., mu-transform tokenisation), they are not data-adaptive and may poorly capture temporal dependencies and latent structures in MEG signals. To address these limitations, we propose a new learnable tokeniser that models tokens using convolution kernels. These kernels are simultaneously learnt and fit to the MEG data using a recurrent neural network (RNN). Crucially, this maintains full temporal resolution (i.e., a sample-level tokenisation) and enables a tokeniser to model causal structure in sequential data. We evaluated our method through a signal reconstruction task, benchmarking its performance against traditional non-learnable approaches. Our tokeniser achieved a strong reconstruction accuracy, explaining over 97% of the variance in both simulated and real resting-state MEG data, while also accounting for subject-level variability. Furthermore, it required significantly fewer tokens (90-120) than the conventional mu-transform method (256 tokens) and generalised robustly across datasets and MEG scanner types. When a transformer model was trained on the derived tokens, it achieved higher token prediction accuracy with our tokeniser, explaining more variance in the original signals. In conclusion, we present the first data-adaptive, sample-level tokenisation framework based on convolution kernels and RNN-based inference, capable of capturing fine-grained temporal dynamics suitable for transformer-based MEG foundation models. This method offers enhanced temporal resolution and prediction accuracy over existing approaches and holds promise for facilitating more reliable foundation models in neuroimaging.

Posters

Chair: Daniel Bush

12:00 – 12:30 (Flash talks)

Flash Talks Session 2

1) What are the neural correlates of sensitivity to clothing fabrics?
2) Development of an atomic gradiometer for human brain stimulation
3) From Visual Features to Semantic Categories: MEG Evidence for the Time Course of Mathematical Object Processing
4) OPM-FLUX – an open-source analysis pipeline for OPM-MEG
5) Neural mechanisms of paced breathing
6) Whole-brain Granger Causality of source reconstructed MEG
7) Semantic Gist Prediction from Stereo-Electroencephalography (sEEG) Using Token-Level Semantic Features and Large Language Model
8) GABAa modulation of cortical neurophysiology in Progressive Supra-nuclear Palsy and frontotemporal dementia

1) Rebecca Taylor
2) Harry Cook
3) Alireza Karami
4) Arnab Rakshit
5) Alexander Zhigalov
6) Thomas Pirenne
7) Xin Wang
8) Emily Todd
Mary Ward Hall

Lunch and poster session 2

12:30 – 14:00
Ground Floor

Clinical Neuroscience

Chair: Xin Zhang

14:00 – 14:30 (Long talk)

MEG in Psychosis: individual differences in neural oscillations underlying language disorganization and impoverishment

Hsi (Tiana) Wei
McGill University; Douglas Mental Health Institute

Co-authors: Hsi (Tiana) Wei, Dominic Boutet, Rukun Dou, Jessica Ahrens, Nadia Zeramdini, Alban Voppel, Fernando Miguel Gonzales Aste, Sylvain Baillet, Lena Palaniyappan
Abstract: Schizophrenia is characterized by incoherent speech and reduced linguistic output, associated with neural dysconnectivity and aberrant oscillatory activity. However, the relationship between these neuronal changes and communication deficits remains unclear. This project explores the hypothesis that neuronal dysfunction underlies language disorganization and impoverishment by investigating associations between neuronal oscillations during visuo-audio integration and language features derived via automated processing pipelines in individuals with and without psychosis. Twenty-five patients with schizophrenia and 25 healthy controls completed symptom and speech assessments, Magnetoencephalography (MEG) during an audiovisual task and resting state and structural MRI. MEG recordings were obtained during an audiovisual simultaneity judgment task and open-eye resting. MEG data were source-localized to each participant's normalized structural MRI, preprocessed, and epoched to motor responses and sensory stimuli to assess event-related power modulations. Speech data collected during interviews were analyzed for acoustic/linguistic features using Python. Preliminary analyses of 16 controls (Age M=31.81, SD=9.59) and 13 schizophrenia (SZ) patients (Age M=34.46, SD=9.38) revealed attenuated post-movement beta rebound (PMBR) in patients, bilaterally in frontal regions. Reduced PMBR likely suggests diminished interhemispheric beta-mediated functional inhibition. Notably, weaker PMBR correlated with hallucinatory behavior ($r(27)=-.38$, $p=0.04$) and blunted affect ($r(27)=-.38$, $p=0.04$) on the PANSS. Speech analysis showed that apathetic social withdrawal was linked to fewer syllables ($r(27)=-.41$, $p=0.03$) and unnatural mannerisms and postures on PANSS related with reduced syllables ($r(27)=-.51$, $p<0.01$), phonation time ($r(27)=-.48$, $p<0.01$), and pauses ($r(27)=-.38$, $p=0.04$). Stronger PMBR in the frontal region correlated with greater syllable production ($r(27)=.37$, $p<0.05$). These findings highlight associations between beta-band power, clinical symptoms, and speech performance, with PMBR strongest in controls, followed by more verbal patients, and weakest in less verbal patients. Upcoming analyses will include personalized spectral power characteristics, bilateral frontotemporal oscillatory connectivity. With a more comprehensive sample size and analysis, this project aims to elucidate individual differences linking neuronal oscillations to language symptoms in psychosis.

14:30 – 14:45 (Short talk)

Weakened prefrontal activation dynamics associated with slowed information processing speed in multiple sclerosis

Olivier Burta
Vrije Universiteit Brussel

Co-authors: Fahimeh Akbarian, Chiara Rossi, Diego Vidaurre, Marie Bie D'hooghe, Miguel D'Haeseleer, Guy Nagels, Jeroen Van Schependom
Abstract: Information processing speed (IPS) is a core cognitive deficit in people with multiple sclerosis (PwMS). Previous efforts have associated IPS performance to frontal regions, but were constrained by limited temporal resolution. In this work, we employed a data-driven method, the time delay embedded-hidden Markov model (TDE-HMM), to identify task-specific states that are spectrally defined with distinct temporal and spatial profiles. We used magnetoencephalographic (MEG) data recorded while healthy controls and PwMS performed a cognitive task designed to capture IPS, the Symbol Digit Modalities Test (SDMT). The TDE-HMM identified five task-relevant states, supporting a tri-factor contribution to IPS: sensory speed (occipital visual detection and processing), cognitive speed (prefrontal executive and frontoparietal attention shift), and motor speed (sensorimotor). We observed reduced prefrontal and increased frontoparietal activation in PwMS, which significantly correlated with offline SDMT performance. This work can drive future research for MS treatments targeting IPS improvements.

14:45 – 15:00 (Short talk)

Varying patterns of association between cortical large-scale networks and subthalamic nucleus activity in Parkinson's Disease

Oliver Kohl
Heinrich-Heine-University Düsseldorf

Co-authors: Chetan Gohil, Matthias Sure, Alfons Schnitzler, Esther Florin
Abstract: Parkinson's Disease (PD) is characterised by the progressive degeneration of dopaminergic neurons and the accumulation of Lewy bodies in the substantia nigra pars compacta. This pathology disrupts dopaminergic regulation of the basal ganglia, leading to motor impairments. While basal ganglia activity is known to synchronise with specific cortical regions, the broader dynamics of cortical network involvement remain unclear. To investigate this, we analysed simultaneous magnetoencephalography (MEG) and subthalamic nucleus (STN) local field potential (LFP) recordings from 25 individuals with PD, both on and off dopaminergic medication. We identified dynamic large-scale cortical networks with a Time-Delay Embedded Hidden Markov Model that showed distinct patterns of STN-cortical coherence. Notably, increased synchrony between the STN and supplementary motor area (SMA) occurred during activation of a sensorimotor network and a network characterised by widespread cortical power increases. The sensorimotor network was associated with elevated STN 9.5 to 23-Hz power and beta bursts, while the widespread activation network was linked to increased STN power in the 5 to 16.5-Hz range. These findings were replicated in a second dataset of 17 additional participants. Interestingly, dopaminergic medication most strongly reduced STN beta power during activation of cortical networks that did not show increased STN-motor cortical coherence. Overall, our results indicate that large-scale cortical networks exhibit STN-cortical communication in distinct ways. The sensorimotor and widespread activation networks, in particular, may serve as spatiotemporal windows into subcortical STN processing. These cortical network signatures in non-invasive recordings may offer a novel avenue for accessing subcortical information relevant to PD, potentially informing diagnosis and treatment strategies.

15:00 – 15:15 (Short talk)

Impaired mPFC–hippocampal theta phase coupling during memory retrieval in Schizophrenia

Ingrid Martin
Kings College London

Co-authors: Daniel Bush, Rick Adams, Neil Burgess
Abstract: Theta-band (1-7Hz) oscillations and long-range phase coupling within the hippocampal–medial prefrontal cortex (HPC–mPFC) network are critical for memory function and have been extensively characterized in animal models. However, their role in human cognition and psychiatric disorders such as schizophrenia remains poorly understood. This study used magnetoencephalography (MEG) to investigate theta oscillatory dynamics during an associative inference task in patients with schizophrenia and matched healthy controls. Patients exhibited marked impairments in recognition memory, including elevated false alarm rates, and showed deficits in both direct and inferential memory retrieval. While both groups demonstrated increased mPFC theta power and HPC–mPFC theta coupling during encoding, only healthy controls maintained this coupling at retrieval. In contrast, patients showed a breakdown in theta phase coupling during memory retrieval, pointing to a functional disconnection within the HPC–mPFC network. These findings extend prior rodent models of hippocampal–prefrontal interactions to the human domain and provide novel evidence that schizophrenia is associated with task-specific disruptions in theta synchrony. This suggests a potential neural mechanism underlying relational memory impairments in psychosis, with implications for targeting HPC–PFC network dysfunction in therapeutic interventions.

15:15 – 15:30 (Short talk)

High-density full-head on-scalp MEG for Epilepsy

Svenja Knappe
FieldLine Medical; University of Colorado Boulder

Co-authors: Svenja Knappe, Isabelle Buard, K. Jeramy Hughes, Orang Alem, Tyler Maydew, Eugene Kronberg, Peter Teale, Teresa Cheung
Abstract: Optically-pumped magnetometers (OPMs) have been identified as a possible candidate for use in evaluations of patients with epilepsy. We present first results of an ongoing cross-validation study performed in 20 adult patients with drug-resistant focal epilepsy to date. In addition, sensory-evoked activity was recorded and localized in the patients and a set of healthy controls. The goal of the study is to compare the data quality between OPM-based MEG and conventional cryogenic MEG, using simultaneous EEG and MEG recordings. Methods: To assess the OPM data quality, subjects underwent simultaneously EEG and MEG resting-state recordings on a cryogenic MEG system and an on-scalp MEG system for 30 min each. Co-registration with the subject's anatomy was performed by digitizing the positions of five head-position indicator (HPI) coils with respect to three fiducials and localizing them with the MEG system. The resting data were filtered with a bandpass filter from 3 – 70 Hz or 20 – 70

and a notch filter at 60 Hz. Bad segments containing muscle activity were marked, and a kurtosis was calculated. Thresholds in the volumetric images were used to identify the peak locations of high kurtosis, where virtual channels were computed. Peaks were marked for comparison with the EEG signals and for dipole fits. For the sensory mapping study, auditory, visual, somatosensory, and motor areas were localized both by performing dipole fits and event-related beamformer analysis. Results: Clear interictal spikes were recorded at the same time points and exhibit similar morphology in several patients between the EEG and OPM recordings, consistent with the EEG and cryogenic MEG results. There was also good agreement between the OPM and cryogenic MEG resting data. The results of the sensory study agreed closely between both the OPM and cryogenic MEG recordings and were consistent with results found in literature. Conclusions: Good agreement was found between the on-scalp MEG and the EEG data. The kurtosis beamformer presents a convenient method for localization of interictal activity and agreed well with the dipole fits. The sensory study showed that the OPM HEDscan system localized sensory-evoked fields reliably and yielded similar data quality to cryogenic MEG systems. The results will have to be validated systematically in a larger number of subjects.

Closing and award ceremony

15:30 – 16:00
Mary Ward Hall

Tea break

16:00 – 17:00
Ground Floor

Posters

Posters – 17th July 2025

Poster 1

Test-retest reliability of auditory MMN measured with OPM-MEG

Laszlo Demko
Translational Neuromodeling Unit

Co-authors: Sandra Iglesias, Stephanie Mellor, Chiara Bassi, Katja Brand, Alexandra Kalberer, Laura Köchli, Stephanie Marino, Noé Zimmermann, Jakob Heinzle, Klaas Enno Stephan

Magnetoencephalography (MEG) based on optically pumped magnetometers (OPM) is a relatively novel method to measure brain activity non-invasively in humans. It offers several advantages over traditional SQUID based MEG and EEG (Boto et al., 2018; Brookes et al., 2022; Holmes et al., 2023). However, its properties, in particular test-retest reliability and construct validity, need to be evaluated to make day-to-day, routine applications possible. In this quality control study, we investigated the reliability and validity of auditory mismatch negativity (MMN) recordings from a newly installed OPM-MEG system (Cerca Magnetics Limited, Nottingham, UK) utilizing 64 triaxial sensors (QuSpin, Louisville, CO, USA). The auditory MMN is an electrophysiological response to rule violations in auditory input streams (Näätänen et al., 2001), which has been interpreted as reflecting the update of a predictive (generative) model of the acoustic environment (Garrido et al., 2009). We recorded OPM-MEG from 30 healthy volunteers, measured twice within 24-72 hours, using an established auditory MMN paradigm (Weber et al., 2022). First, we focused on construct validity and investigated whether OPM-MEG measurements of MMN responses were qualitatively comparable in terms of event-related fields, timing and topography to previous MMN findings of studies using EEG and traditional MEG. Second, we assessed the test-retest reliability (quantified by intra-class correlation coefficients, ICC) of cognitive (MMN) and sensory (auditory M100) evoked fields, comparing the sensor-level response amplitude and latency over the two separate measurement sessions. The MMN responses recorded with our OPM-MEG setup are in good agreement with previously reported MMN results of EEG and SQUID-based MEG measurements in terms of both timing and topography. The qualitative comparison of group-level MMN topographies and timeseries shows excellent consistency across the two measurement sessions. Test-retest reliability analyses indicate moderate reliability for MMN amplitude (ICC=0.50-0.67 for the z-component of the triaxial sensor signal) but poor reliability for latency (ICC=0.00-0.22), in line with previous EEG literature (Wang et al., 2021). By contrast, test-retest reliability of the purely sensory M100 auditory evoked fields has been found to be excellent for amplitude (ICC=0.97) and good-to-excellent for latency (ICC=0.84-0.96), confirming the functionality of our setup in the “out-of-the-box” state.

Poster 3

Evaluating novel OPM-MEG in pre-surgical mapping for patients with epilepsy: a case study

Daisie Pakenham
Aston University

Co-authors: Sian Worthen, Zahrah Mahmood, Vivek Sharma, Boubker Zaaimi, Peter Bill, Andrew Lawley, Caroline Witton, Stefano Seri

Introduction Cryogenic MEG has been used for many years to localise epileptiform activity to identify regions for surgical resection in patients with epilepsy. However, traditional cryogenic MEG systems comprise a fixed, one-size-fits-all helmet, which limits the utility of cryogenic MEG in young children, leading to reduced signal-to-noise ratio (SNR) and degraded data quality with movement. Novel OPM-MEG technology may ameliorate these issues, by enabling the use of wearable sensor arrays which can adapt to different head sizes. In particular, helium-based OPM-MEG offers potential advantages over rubidium-based systems. Importantly, helium OPM sensors do not emit heat, allowing them to be placed directly on the scalp without the need for cooling or safety concerns. This proximity to the scalp may increase SNR. An additional benefit in the study of epilepsy is that helium OPMs offer high bandwidth (2000 Hz) which may allow detection of high frequency oscillations (HFOs). HFOs can be correlated with the seizure onset zone. This study aims to explore whether helium OPM-MEG can be used in patients with epilepsy by directly comparing to cryogenic MEG, using the first whole-head helium OPM-MEG system. Methods This project is a serial case study of up to 20 patients, aged 6-15 years, all referred to the cryogenic MEG service at Aston University as part of the Children’s Epilepsy Surgery Service (CESS) at Birmingham Children’s Hospital. Patients will undergo standard whole-head cryogenic MEG (102 magnetometers, 204 planar gradiometers; MEGIN, Helsinki, Finland) followed by whole-head OPM-MEG (96 triaxial magnetometers; MAG4Health, Grenoble, France). Twenty minutes of resting state data will be recorded while patients watch a video. Results Here, we present data from the first helium OPM-MEG

patient recording in the UK. We compare the SNR and amplitude of epileptiform activity across both systems as well as the morphology compared between the magnetometers. Future If successful, this study could enable future investigations in younger children (<6 years old), potentially allowing epilepsy surgery to take place earlier.

Poster 5

Comparing magnetoencephalography scanner platforms using primary brain responses and attentional effects

Zoe Tanner
University of Nottingham

Co-authors: Zoe Tanner, Lukas Rier, Jessikah Fildes, Gonzalo Reina Rivero, Holly Schofield, Christopher Marani, Niall Holmes, Ryan M. Hill, Sarah Wolfe, Vishal Shah, Cody Doyle, James Osborne, David Bobela, Matthew J. Brookes, Elena Boto

Introduction: Optically pumped magnetometers (OPMs) have emerged as viable alternatives to SQUIDs to measure neuromagnetic fields. OPM-based magnetoencephalography (MEG) systems have many advantages over the current state-of-the-art, including the ability to scan participants in more naturalistic environments, increased lifespan compliance and negating the need for expensive cryogenics. However, these systems are in their infancy and it is crucial that OPM-based instrumentation replicate results from established systems. Here, we compare a newly developed OPM-MEG instrument to an established SQUID-MEG system to test equivalence between the two. Methods: We hypothesised that primary brain responses, such as evoked responses and beta modulation, would be highly correlated between systems. We also anticipated that more complex attentional affects would be common across scanner platforms. We collected data from 16 participants on both a CTF SQUID-MEG and an 192-channel OPM-MEG system. Each participant was scanned twice on both systems, meaning we collected 64 MEG datasets in total. During the scans, participants performed a somatosensory spatial attention task, in which braille-like sensory patterns were presented to both index fingers and participants were asked to respond via button press when a predetermined target pattern was presented to the attended hand. Data were analysed in source space using MNE-Python. Results: Our results showed that both evoked and induced responses are measurable and highly correlated between systems, with correlation coefficients of 0.97 and 0.96, respectively, at the group level. There was no significant difference measurable in these responses between the two systems. We also successfully measured more subtle attentional effects in both systems; specifically, beta amplitude in contralateral primary sensory cortex dropped when the participant was told to attend to a specific hand. Conclusion: Our results show that OPM-MEG is capable of measuring the same primary brain responses as more established SQUID-MEG systems, as well as subtle attentional effects. We are now collecting OPM and SQUID-MEG data in a further 50 participants, where participants were asked to perform 4 different tasks: resting state, visuomotor, somatosensory and auditory mis-matched negativity. We intend to use this data to expand on our current comparison.

Poster 7

A pilot study using OPM-MEG: adapting attention tasks for pre-schoolers

Johanna Zumer
Aston University

Co-authors: Dan Ferris, Lucy Wight, Sian Worthen, Vivek Sharma, Daisie Pakenham, Boubker Zaaimi, Caroline Witton, Johanna Zumer

Neurodevelopmental disorders including ADHD typically become apparent and are diagnosed after a child begins attending school. However, the ability to study pre-schooler children with traditional neuroimaging is hampered by the need for the child to hold still and/or fixed adult-size helmets. Aston University has very recently (May 2025) completed installation of a new 4He OPM-MEG with 96 tri-axial sensors, aimed to be suitable for child-friendly scans. This initial pilot project has the overall aim of setting up child-friendly tasks (suitable for pre-reading-age preschoolers) in our new whole-head OPM-MEG and demonstrating feasibility in a small participant sample across different ages, both in terms of an engaging attention-demanding task (visual or auditory) and the practical setup. This early demonstration will pave the way to a future larger cohort study, including participants across a spectrum of ADHD symptoms and age ranges.

Poster 9

Integration of Degraded Speech Sounds and Prior Expectations in Clinical High-Risk for Psychosis Young People: An Ongoing MEG Study.

Chloe Clifford
University of Birmingham

Co-authors: Dr Hyojin Park, Dr Andrew Quinn, Professor Rachel Upthegrove, Dr Jack Rogers

Predictive processing frameworks suggest that perception is driven by the interaction between incoming sensory information and our prior expectations, beliefs or knowledge. In individuals with psychotic disorders, the balance between these processes is believed to be disrupted, with evidence suggesting that an over-reliance on prior expectations and impaired prediction error processing contribute to the experience of psychotic symptoms (e.g., hallucinations and delusions). However, evidence exploring this in individuals at clinical high-risk (CHR) for psychosis remains limited. This novel study uses magnetoencephalography (MEG) to investigate how CHR individuals integrate prior knowledge to resolve prediction errors while processing degraded speech. Participants aged 16–30 are currently being recruited, including CHR youth from early psychosis services and healthy controls (HC) from the community. During the MEG task, participants hear monosyllabic noise-vocoded words (e.g., chair) presented at three levels of sensory detail (3, 6, or 12 vocoded channels). Each auditory word is preceded by a written cue that either matches (e.g., chair) or mismatches (e.g., globe) with the spoken word. Participants are prompted to rate the clarity of each spoken word on a scale from 1 (not clear) to 4 (very clear). Analysis will investigate how sensory detail and prior information interact to influence neural responses to matched and mismatched speech in CHR and HC participants. Although unstudied in clinical populations, evidence from healthy individuals shows that increased sensory detail strengthens neural responses to sounds that are mismatched with prior expectations whilst suppressing neural responses to sounds that are matched with prior expectations. We hypothesise that CHR individuals will have a greater reliance on prior expectations for perceptual processing. This is expected to appear in behavioural data as higher clarity ratings for matched trials, but a smaller difference in clarity ratings between matched and mismatched trials. Similarly, MEG data is predicted to show increased neural activity for matched trials and attenuated activity for mismatched trials. This study aims to investigate how prior information influences subjective clarity and neural activity during ambiguous auditory perception in CHR individuals, with important implications for understanding the role of predictive processing in the development of psychotic symptoms.

Poster 11

Non-invasive evidence for rhythmic interactions between the human brain, spinal cord, and muscle using OPMs

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Voluntary human movement arises from dynamic interactions between the brain, spinal cord, and peripheral sensory inputs. However, non-invasively capturing spinal cord activity in humans remains a major technical challenge, limiting insight into its integrative role in sensorimotor function. We previously demonstrated the feasibility of using optically-pumped magnetometers (OPMs) to simultaneously record endogenous neural activity from the brain and cervical spinal cord, providing a proof-of-principle in a small sample. These preliminary findings suggested it may be possible to detect coupling between the brain, spinal cord, and muscle during a simple isometric contraction task. However, the spectral and directional characteristics of these coupling patterns - and how they should be interpreted in relation to well-established cortico-muscular coherence and underlying physiology - remain unclear. In this study, we aim to extend and refine this initial work by increasing the number of participants and collecting additional EEG-EMG recordings alongside OPM-EMG data, providing a comparative reference for interpreting coupling patterns. Our goal is to characterize the spectral, spatial, and directional features of brain–spinal cord–muscle coupling across participants and to directly compare these interactions to canonical cortico-muscular coherence measured with EEG. We expect to present updated findings from this expanded dataset, including new analyses that relate observed coupling patterns to established physiological frameworks of sensorimotor integration.

Poster 13

Developing Adaptive Multipole Models for interference suppression in OPM recordings of spinal cord neurography

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Simultaneous recording from the brain (MEG) and spinal cord (MSG) with Optically Pumped Magnetometers (OPMs) has the potential to facilitate research into cortico-spinal connectivity, furthering our understanding of sensorimotor processing and recovery following spinal cord injury. However, interference suppression must be carefully considered to advance this novel recording modality. Sources of physiological interference are larger in MSG than MEG, due to the close proximity of back muscles and the heart. Additionally, the differing geometry of the torso by comparison to the head means that methods developed for OPM-MEG may not be appropriate for OPM-MSG. In this study, we evaluate the validity of Adaptive Multipole Modelling (AMM) – a post-acquisition interference suppression method for

OPM-MEG (Tierney et al., 2024) – for OPM-MSG and suggest an extension to improve its suitability for spinal cord recordings. AMM is a spatial filtering method which has been shown to be highly successful for suppressing interference in OPM-MEG recordings. We will show in simulation that, due to the geometry of the torso, spheroidal harmonic functions arising from a single origin point provide a poor description of expected spinal cord signals. We show that extending the internal model to include multiple spheroid locations improves this performance, increasing the minimum correlation between the original and modelled signals (simulated from a 1-shell boundary element model of the torso) from 0.51 to 0.83 for a 9th order model, reflected in a decrease of the Bayesian Information Criterion (BIC) from -3.14e-4 to -3.37e-4. We consider the impact of different model parameters, including the shape of the reference spheroids used to generate the model basis functions and the model complexity. We then empirically validate performance with median nerve stimulation recordings and quantify the change in SNR of the spinal response after multi-spheroid AMM. In summary, we show that with a relatively small adaptation, AMM can be effective for interference suppression for neuromagnetic recordings from the spinal cord. This increases the feasibility of OPM-MSG recordings, opening up new research avenues into connectivity across the central nervous system.

Poster 15

Meaning construction in the anterior temporal lobe: a MEG/EEG study

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How the brain constructs meaning from words and phrases is a fundamental question for research in semantic cognition, language and their disorders. In this study, we brought together these two aspects of meaning. Not only would this address basic questions about semantic cognition, but also because, despite distinct focuses, both literatures ascribe a critical role to the anterior temporal lobe (ATL). Given these considerations, we explored the notion that common neurocomputational principles underlie semantic representation from words and phrases. The ATL has been implicated in semantic memory (Rogers et al., 2004; Patterson et al., 2007; Lambon Ralph et al., 2017) and semantic composition (Coutanche et al., 2019; Pylkkänen, 2019, 2020; C■linescu et al., 2023). Does the overlap in functional neuroanatomy imply shared computations across the two systems? A neural network model by Hoffman et al. (2018) offers a unifying framework. The model, within a set of common hub units, acquires representations that reflect the multimodal knowledge of each concept while also accounting for co-occurrence and information integration over time. By assimilating these ideas, we propose the ATLs provide a unified function essential to semantic representation in both systems. If so, we hypothesised that ATL activity would be modulated by conceptual specificity, regardless of word- or phrase-hood. 36 adults read stimuli with low (“bird”), mid (“nocturnal bird”), and high (“owl”) specificity while undergoing simultaneous MEG-EEG. We analysed ERPs and found that, relative to low-spec controls, both mid- (“nocturnal bird”) and high-spec items (“owl”) elicited more negative centroparietal N400s. In a later window (600–800 ms), responses to mid-spec items were more negative than low- and high-spec items. Source-localized ROI analyses revealed bilateral ATL and inferior frontal gyri (IFG) main specificity effects (high > low & mid). Clusters extended between 400-520 and 430-630 ms post noun onset, respectively. Time-resolved multivariate decoding revealed reliable decodeability of specificity (low vs high) around 420–490 ms, with marginal generalization from 400–600 ms. Our ERP analyses revealed distinct word and phrase response timings during conceptual processing. Bilateral ATL and IFG involvement highlighted the role of semantic control during conceptual processing. Time-resolved decoding revealed that specificity representations are both distinct and durable.

Poster 17

Neurocognitive Mechanisms of Local-Global Sensitivity and Syncopation Adaptation in Music Processing in Neurodiverse Children

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Music offers a temporally structured and hierarchically organised stimulus, making it a powerful tool for studying how the brain generates and updates predictions. Its ability to engage perceptual, cognitive, and motor systems across levels makes it especially suitable for investigating prediction in developmental and neurodivergent populations (Vuust & Witek, 2014). Yet empirical studies on how children track musical structure and respond to temporal irregularity remain limited. Autistic individuals tend to prioritise local over global information when processing complex stimuli, including music. This has been explained through weak central coherence (Happé & Frith, 2006), which posits a reduced tendency to integrate information into wholes. A complementary view, the Hierarchisation Deficit Hypothesis (Mottron et al., 1999), suggests global structure is not automatically prioritised due to impaired hierarchical integration. Predictive coding theories add that autistic perception involves atypical weighting of top-down predictions, especially under uncertainty (Van de Cruys et al., 2014). We designed two EEG and behavioural tasks to examine how children (6–11) and adults (18–35) process musical predictions across hierarchical levels. The first, Melodic and Harmonic Change Detection, presents stimulus pairs differing locally (pitch intervals) or globally (contour or progression), with

participants judging same or different. The second, Rhythmic Prediction with Syncopation, manipulates temporal predictability by introducing syncopation into a regular beat while participants synchronise their tapping. This builds on Witek et al. (2014), who found moderate syncopation elicits peak pleasure and movement, likely due to a balance between rhythmic complexity and metrical stability. We extend this logic to examine how developmental profiles adapt to rhythmic uncertainty. We will analyse EEG responses (e.g., N1, MMN) and behavioural measures (accuracy, latency, synchrony) as prediction indices. Rather than comparing groups, we take a dimensional approach, modelling individual variability using continuous measures of autistic traits, alexithymia, and musical engagement. We hypothesise that children with elevated neurodivergent traits will show enhanced sensitivity to local changes but reduced rhythmic adaptability under high syncopation. This study informs our understanding of predictive processing in neurodiverse development and supports music-based interventions.

Poster 19

Neurophysiological Progression in Alzheimer's Disease: Insights From Dynamic Causal Modelling of Longitudinal Magnetoencephalography

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Neurodegenerative diseases, including Alzheimer's disease, are characterised by selective neuronal vulnerability with regional, laminar, cellular and neurotransmitter specificity. The regional losses of neurons and their synapses are associated with neurophysiological changes and cognitive decline. Hypotheses related to these mechanisms can be tested and compared by dynamic causal modelling (DCM) of human neuroimaging data, including magnetoencephalography (MEG). In this paper, we use DCM of cross■spectral densities to model changes between baseline and follow■up data in cortical regions of the default mode network, to characterise longitudinal changes in cortical microcircuits and their connectivity underlying resting■state MEG. Twenty■nine people with amyloid■positive mild cognitive impairment and Alzheimer's disease early dementia were studied at baseline and after an average interval of 16 months. To study longitudinal changes induced by Alzheimer's disease, we evaluate three complementary sets of DCM: (i) with regional specificity, of the contributions of neurons to measurements to accommodate regional variability in disease burden; (ii) with dual parameterisation of excitatory neurotransmission, motivated by preclinical and clinical evidence of distinct effects of disease on AMPA versus NMDA type glutamate receptors; and (iii) with constraints to test specific clinical hypothesis about the effects of disease■progression. Bayesian model selection at the group level confirmed evidence for regional specificity of the effects of Alzheimer's disease, with evidence for selective changes in NMDA neurotransmission, and progressive changes in connectivity within and between Precuneus and medial prefrontal cortex. Moreover, alterations in effective connectivity vary in accordance with individual differences in cognitive decline during follow■up. These applications of DCM enrich the mechanistic understanding of the pathophysiology of human Alzheimer's disease and inform experimental medicine studies of novel therapies. More generally, longitudinal DCM provides a potential platform for natural history and interventional studies of neurodegenerative and neuropsychiatric diseases, with selective neuronal vulnerability.

Poster 21

Shifting States: Cortical Microstate Alterations Induced by Midazolam and Remifentanil

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Background/Aims: The neurophysiological mechanisms of sedative drugs on the human brain, particularly in relation to sedation, pain relief, and side effects, is not well understood. Remifentanil and Midazolam are widely used anaesthetic agents with fundamentally different central mechanisms of action within the nervous system. Remifentanil is an ultra-short-acting mu-opioid receptor agonist that modulates nociceptive pathways. In contrast, Midazolam is a short-acting benzodiazepine that enhances GABA-A receptor activity through positive allosteric modulation. These distinct receptor targets account for the different clinical effects of those drugs; Remifentanil is mainly used for analgesia (with mild sedation), while Midazolam is used for mild-deep sedation (with reliable amnesia). Previous sedation studies have demonstrated altered patterns of neural connectivity associated with the administration of these two drugs. In a novel approach, we used resting-state magnetoencephalography (MEG) to examine how two pharmacologically distinct sedatives; Remifentanil and Midazolam influence the dynamics of cortical brain networks. Methods: Participants were 18 healthy male adults (18-43 years). Participants were administered Remifentanil and Midazolam on different days, with resting-state MEG (10 minutes) before and after drug administration. MEG cortical microstate analysis was performed and microstate statistics calculated using the +microstate toolbox. Results: The identified microstates had spatial distributions that were consistent both with commonly found resting-state networks

and with previously reported MEG cortical microstates. An analysis of the temporal dynamics of the states showed changes to duration and transitioning statistics between pre- and post- administration of each drug. Discussion: Understanding the altered dynamic cortical networks induced by Midazolam and Remifentanil during the resting state could offer important clinical implications and in-depth knowledge of their mechanisms of action in the brain. Identifying drug-specific effects on brain dynamics could help detect novel neurophysiological biomarkers for safer monitoring of sedation depth in clinical settings. Insights from this study could also inform the treatment of disorders of consciousness, update the development of personalised sedation/anaesthesia protocols, and deepen our understanding of how sedative agents alter electrophysiological brain function.

Poster 23

How does array size impact beamformer reconstructions of OPM-MEG resting-state-like data?

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Introduction Optically Pumped Magnetometers (OPMs) are small, lightweight detectors enabling wearable magnetoencephalography (MEG). They offer several advantages over conventional MEG systems: - Sensors can be positioned closer to the head, providing higher amplitude field measurements and capturing more focal field patterns. - Sensor arrays can be adapted to head shape and size, leading to wider applicability of MEG across age groups. - Sensor arrays can move with the head, providing motion robustness. - Focused arrays can be created to improve sensitivity to regions of interest. While these advantages have been explored, most existing literature relies on measures of induced activity or evoked fields. Here, we assessed the effects of array configuration and channel count on resting-state-like measures of beamformed spectral power source leakage using a continuous video watching paradigm. Methods A single participant was scanned 5 times while watching a 10-minute-long video clip using a high-density OPM array constructed based on the participant's MRI. Data were acquired at a maximum of 128 locations using triaxial sensors (i.e. up to 384 channels) using two synchronised Quspin Neuro 1 systems. Using an atlas-based LCMV Beamformer, we compared source spectral power and signal leakage reconstructed using a full array (up to 351 clean channels), an array reduced to 64 evenly distributed sensors and 192 randomly selected channels. Results Spectral power measures showed that reducing channel count has the effect of increasing estimates, particularly when using random channel selection. This may be an effect of changes in coverage and source leakage. When estimating source leakage between pairs of atlas regions, we found a ~17% increase in mean global leakage when using a reduced channel count compared to a full array. We speculate that this is likely a result of increased capture of the field as set by the forward model. Conclusion To fully exploit the potential advantages of OPM-MEG, which allows for flexible placement of sensors and modular arrays with varying channel counts, we must understand the effect of channel count on source reconstruction. Here, we show preliminary results which suggest that reduced channel counts may add biases to beamformer estimates of resting-state source power and increase signal leakage between regions.

Poster 25

LAVI: a new tool to parameterize the electrophysiological spectrum and identify rhythmicity bands

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Neural oscillations are associated with many physiological, cognitive, behavioural, and pathological states. These brain-waves span a wide range of frequencies, and therefore segmenting them into categories (bands) is a vital step to uncover their functions. This categorization is commonly done according to spectral profiles based on power. However, increasing evidence suggests that brain oscillations may sometimes appear as transient, high-power bursts rather than continuous rhythms. To account for the transient nature of oscillations, we developed a tool to segment the spectrum according to rhythmicity, defined as consistency of the phase relations between time-points. We term this tool LAVI (Lagged-Angle Vector Index), and use it to identify a universal spectral architecture comprising two categories: high-rhythmicity bands linked to sustained oscillations, and new low-rhythmicity bands, dominated by transient bursts. LAVI is computationally efficient and allows automated and statistically inferred annotation of bands

on the single-subject level. We demonstrate the utility of the publically available Matlab package of LAVI in adding the rhythmicity dimension to different examples of existing datasets.

Poster 27

Inferring resting state networks from low density M/EEG for more accessible clinical applications

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Introduction The established association between default mode network (DMN) dysfunction and various mental health disorders and neurodegenerative diseases could be leveraged to improve diagnostics and treatments. For example, evidence already shows that DMN-based neurofeedback therapies can reduce depressive symptoms. The gold standard for inferring the DMN and other resting state networks (RSNs) from noninvasive electrophysiology is using high density (HD) magnetoencephalography (MEG), which has limited potential for widespread clinical adoption. The emergence of both MEG with optically pumped magnetometers (OPM-MEG) and cost-effective low density (LD) EEG devices could make RSN-based therapies more accessible and scalable. However, RSN detection methods in M/EEG, such as hidden Markov models (HMMs), typically rely on HD data. This project proposes three ways of inferring RSNs, expressed as HMM states, from LD data. Methods We used 107 participants' data from the Leipzig Study for Mind-Body-Emotion Interactions resting-state EEG dataset. Data were recorded from 61 sensors for 16 minutes. After preprocessing, we extracted the channels available in Dreem 3 headband data (F7, F8, O1, O2, and Fp2) to mimic an LD-EEG setup. After an additional source reconstruction step on the full dataset, we trained a four-state HMM in source space in order to infer the sequence of hidden states for each participant. Our approaches to estimating the HD state time courses (STCs) were to: 1) train an HMM on the LD data and match STCs with the HD model using a modified Jonker-Volgenant algorithm; 2) decode HD STCs via a balanced random forest classifier trained on LD data; and 3) use the observation model from a HD HMM to infer STCs for held-out LD data. Results When we compared the LD STCs to their HD counterparts on a per-participant basis, average balanced classification accuracy was 26.80% (SD=3.88), 56.56% (SD=5.96), and 47.96% (SD=8.69) in the state matching, decoding, and observation model methods, respectively. Conclusions These preliminary findings are promising. We will further explore the capabilities of these methods by varying the number of HMM states and by testing additional 16- and 32-electrode montages. Although ongoing, this research already highlights the potential power in more affordable and flexible alternatives to traditional neuroimaging modalities.

Poster 29

Investigating neural oscillations in multiple sclerosis with OPM-MEG: group comparison and longitudinal studies

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Background Multiple Sclerosis (MS) is a neuroinflammatory disease causing white matter lesions in the brain and spinal cord, resulting in physical and cognitive difficulties. Whilst traditional imaging techniques are used to identify structural alterations at advanced stages of disease progression, they lack the ability to explore functional measures and detect Progression Independent of Relapse Activity (PIRA), impeding clinical intervention. To help bridge this gap we have undertaken two studies: Our initial study used OPM-MEG to explore group differences in resting-state functional connectivity and task-positive electrophysiological activity, between MS patients and healthy controls. Following these initial findings, we are now undertaking a longitudinal study using OPM-MEG to explore functional changes over time, and how such changes might relate to symptomology. Overall, we aim to elucidate biomarkers for PIRA. Methods The initial study recorded MEG data in 20 patients and 20 healthy controls including responses from visuomotor tasks (circular grating and finger abduction) and in resting state. Data were recorded using a 192-channel OPM-MEG system with miniaturised electronics. This allowed us to repeat scans in both a seated and standing posture. Data were analysed using a beamformer. For the ongoing longitudinal study, we have so far scanned an additional 15 stable patients, 15 progressing patients, and 15 healthy controls. Results In patients, response to visual stimulation significantly ($p = 0.038$) reduced gamma oscillations and a significantly ($p = 0.014$) diminished alpha response, compared to controls. In response to finger movement the rebound post stimulation was significantly ($p = 0.004$) delayed. These results were repeatable with subjects sitting and standing. In resting state, we found a decrease ($p = 0.016$) in sensorimotor beta connectivity when standing versus sitting; but this was only observable in controls. We also observed a reduction ($p = 0.003$) in beta power when standing versus sitting, but only in patients. Conclusion We demonstrate the utility of OPM-MEG for measurement of putative biomarkers of MS. We have also

shown the importance of posture by elucidating significant differences in sensorimotor dynamics in patients seated compared to standing. Our study highlights the promise of OPM-MEG in providing a unique environment to probe brain function, how it changes over time, and how it might break down in disease.

Poster 31

Imaging memory-related hippocampal theta with OPM

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Wearable MEG systems use optically pumped magnetometer (OPM) sensor arrays that can move relative to the head and reduce sensor-source distance. This is thought to offer theoretical benefit when imaging deeper sources in the brain (Boto et al., 2016; Iivanainen et al., 2017). We have started collecting data in a pre-surgical epilepsy cohort to test memory-related effects. Nine people with epilepsy learned triads of images containing one famous person, one inanimate object and a place. In the recall phase, one image was shown and participants were asked to use a button press to determine whether they saw the image during encoding. Both direct and indirect relationships were tested. During the task, participants wore bespoke helmets, based on their anatomical MR images, which were fitted with QuSpin OPMs. Total available channels ranged from 59 to 121 depending on sensor operational status. All participants performed well at recognising old and new stimuli (median accuracy: 98.8%). Accuracy was reduced when inferring direct (87.5%) and indirect pairs (60.7%) respectively. Preliminary results show evidence that OPM can detect increased hippocampal theta (2-6 Hz) power during encoding. Adding to literature showing theta responses with OPMs (Rodes er al., 2023).

Poster 33

Sensory sensitivity and visual discomfort are not associated with altered gamma oscillations; a test of the excitation-inhibition hypothesis

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Across the population between 10% and 20% of people experience aversive hypersensitivity or discomfort to stimuli such as bright lights, striped patterns, strobing, motion or complex visual scenes such as supermarkets. Such sensory hypersensitivity can occur alone, but it is often associated with one or more of a range of neurological, psychiatric and neurodevelopmental conditions or neurodivergence. The cortical mechanisms of sensory hypersensitivity remain unknown. For three decades theories have focussed on excitation/inhibition balance; visual discomfort would reflect over-excitation relative to inhibition. Visual gamma oscillations induced by viewing stripes appear to be a robust biological trait marker indexing excitation/inhibition balance, and are therefore predicted to be altered is people with high visual discomfort. We tested this in a cohort of 170 healthy volunteers and found no meaningful correlation of subjective sensitivity with gamma frequency or amplitude (all $r<0.2$). We then recruited two groups of participants with high and low sensitivity to visual stripes. Again, we found no meaningful association with gamma frequency or amplitude. We conclude that visual discomfort is not explained by higher excitation/inhibition ratio in visual cortex, despite the dominance of this assumed explanation. Future research will explore connectivity across wider brain networks and also alpha power variation.

Poster 35

Towards OPM-MEG in a single MuMetal layer magnetically shielded room

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Background: Optically pumped magnetometer-based (OPM) MEG systems require magnetic shielding provided by a magnetically shielded room (MSR), containing 2–4 layers of high-permeability material and a highly conductive layer (e.g. MuMetal and copper). While effective, MSRs are heavy (2,500–13,000kg) and difficult to install (>3m high), limiting OPM-MEG deployment [Holmes et al., IEEE Trans. on Biomed. Eng., 72(2), 2024]. Here we present progress in the construction of a single MuMetal layer MSR. We investigated the capability of the spatiotemporal signal space separation (tSSS) method [Taulu et al., Phys Med Biol., 51(7), 2006] to de-noise data collected with large interference. Method: We built a MSR using one 1.5mm-thick MuMetal layer, with an internal/external footprint of $1.3\times1.3/1.6\times1.6\text{m}^2$, height of 2/2.5m, and weight of 1100kg (for compatibility with most rooms and floors). Fluxgate measurements in the single layer MSR show a DC field of 223nT (52dB shielding relative to the unshielded

measurement) and baseline noise of c.3pT/√Hz (>24.8dB, limited by fluxgate resolution). The largest spike is 50Hz at 1063pT/√Hz (31dB). Residual DC fields in the MSR remain too high for OPM operation but could be addressed by active shielding. To explore if OPM-MEG is possible at the baseline noise level of the single layer room, we performed an auditory experiment in a heavily shielded room (4 MuMetal and 1 copper layer) using a 192-channel OPM-MEG system with controlled interference. The stimulus was a 1kHz, 300ms tone that was presented centrally via speakers for 80 trials. A matrix coil field cancellation system [Holmes et al., NeuroImage, 274, 120157, 2023] generated the interference (white noise applied to one coil per face of the MSR) to mimic the light shield noise at six amplitudes: 34, 366, 750, 1100, 1470 and 3010 fT/√Hz across the 1-100Hz band. Results: Data were band-pass filtered to 1-40Hz and tSSS applied (Lin=10, Lout=6, correlation limit=0.93). Trial averaging revealed the evoked response for each dataset, despite increasing noise. The channel with the largest response was isolated and the SNR computed (range of response divided by the standard deviation in a later period). SNR values were 10.8, 11.8, 8.5, 8.7, 16.9 and 13.6 for each noise level. Outlook: Our controlled noise results suggest that OPM-MEG in the single-layer MSR is achievable. Active shielding will be developed to reduce the DC field and powerline.

Poster 37

Distort to Inform: can OPMs distinguish between true and distorted anatomical models?

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MEG signals derive predominantly from pyramidal neurons, which are oriented perpendicularly to the cortical surface. Previous work using head-casts to minimise co-registration errors in conventional MEG has shown that MEG functional estimates depend on precise anatomical models (Little et al., 2018). Specifically, the idea behind this approach is to quantify the reconstruction performance of different algorithms by applying them over progressively more deformed anatomical models (i.e., cortical meshes) and evaluate the resulting model evidence (i.e., free energy). In this context, one should expect model evidence to be maximised when the estimated current distribution lies on the true cortical mesh. The goal here is to identify the key constraints that we might come across when using this approach to validate future OPM current flow estimates. To do so, we make use of simulations of OPM data contaminated by different levels of unmodelled noise. For example: error in the estimate of the true sensor positions or orientations and the effects of gain changes that are spatially correlated with environmental interference. We leveraged diffeomorphic brain shape modelling (Ashburner et al., 2019) to provide more realistic surrogate brains deformed along a parameter space consistent with the healthy population. Mean surface distortions ranged from 0.5 to 4 mm. We used two source reconstruction algorithms (Empirical Bayes Beamformer - EBB and Minimum Norm - IID). We find that, for sparse simulated left-motor activity, only the evidence for the EBB algorithm (with corresponding sparse assumptions, in the absence of other errors) peaked at the true anatomy. We go on to quantify the amount of error (in mm) to the true cortical mesh that one might expect in empirical recordings (given gain, position and orientation errors). This work allows us to objectively quantify the validity of any MEG analysis pathway, from hardware gain distortions, to co-registration error, to inversion assumptions.

Poster 39

Investigating the cortical processing of alphanumeric characters and their mirrors with OPM – MEG

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Recognising and distinguishing numbers, letters and their mirror variants (e.g. p and q) is an important aspect of everyday life. Numbers and letters are cultural interventions. Recent research has shown that areas in the early ventral visual pathway are used to support our interactions with these stimuli. However, this pathway supports viewpoint independent encoding of visual stimuli, as usually an object remains the same regardless of viewpoint. This poses a problem for recognition of letters that are mirror variants of one another. Thus, some have proposed that this aspect of ‘mirror generalisation’ must be ‘unlearnt’ by the visual system to allow us to read proficiently. Numbers and letters are both taught during early instruction and expertise with these stimuli develops throughout childhood. Interestingly, children aged 4 – 6 years tend to mirror write numbers and letters, before this behaviour disappears with more expertise in reading and writing. This behaviour encourages the question of how alphanumeric characters, and their mirrored selves are represented cortically with different levels of expertise. We used OPM-MEG to record neural activity, while participants viewed alphanumeric characters, their mirrored and false font equivalents. As an attention check, participants had to detect a dot. To better understand similarities and differences in the underlying neural processing of these stimuli, we aim to use temporal decoding, temporal generalisation and source localisation analyses. We expect that letters and numbers can be dissociated temporally within the first 200 ms post stimulus onset in temporo-parietal areas. Alphanumeric characters and their mirrored equivalents may be perceived similarly at

first, but reliable dissociation may emerge later in the neural time course, around 400 ms. These stimuli may be dissociated in the visual word form area in the ventral visual stream, the ventral occipitotemporal cortex and the intraparietal sulcus. We plan to extend this paradigm by testing children to further understand the developmental aspect of normal and mirrored alphanumeric character representation.

Poster 41

Dopaminergic Modulation of Incentive Salience in Naturalistic Visual Search

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Reward-predictive stimuli influence human perception by biasing attention toward cues associated with motivational value. According to the incentive salience hypothesis, midbrain dopaminergic signalling enhances the salience of these cues, thereby amplifying the processing of both rewards and their predictors. While animal research supports this, human studies have relied primarily on correlational methods. Here, we test dopamine's causal contribution to incentive salience using a pharmacological manipulation combined with magnetoencephalography (MEG). Participants (n = 60) performed a visual detection task identifying category exemplars in real-world scenes containing reward-associated targets or task-irrelevant reward-associated distractors. Dopamine signalling was disrupted using haloperidol, a D2 receptor antagonist acting on midbrain dopamine systems. In a within-subjects design, participants completed the task on and off haloperidol. If dopamine supports incentive salience attribution, its antagonism should attenuate attentional capture by task-irrelevant reward-associated stimuli. We expect reduced slowing and fewer errors with reward-associated distractors under haloperidol versus placebo. Neural responses will be analysed using multivariate classification of MEG data, with machine learning classifier accuracy used to index the strength and quality of neural representations. We predict weaker encoding of reward-associated distractors and stronger attentional suppression signals under haloperidol. Event-related potential components linked to selection (N2pc) and suppression (Pd) will further characterise these effects. This study addresses the limitations of correlational designs by experimentally manipulating dopaminergic signalling during the visual processing of motivationally relevant stimuli. The findings have the potential to clarify whether dopamine causally modulates the perceptual salience of reward-predictive cues, thereby informing theoretical accounts of how incentive salience is instantiated in the human brain. More broadly, this research will advance understanding of the neurochemical mechanisms through which dopaminergic signalling supports motivated behaviour. Clinically, these mechanisms are relevant for understanding attentional biases observed in conditions characterised by disrupted reward processing, such as addiction.

Poster 43

Cluster-Level Parametric Inference is Valid for Electrophysiological Data in 1D and 2D

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Parametric statistical inference using the General Linear Model (GLM) with multiple comparisons correction based on Random Field Theory (RFT) is a powerful and versatile framework, widely applied for various neuroimaging modalities. Cluster-level inference within this framework is particularly advantageous for analysing evoked and induced electrophysiological responses. In their seminal 2016 study, Eklund et al. demonstrated that for fMRI 3D images, cluster inference can fail to control the type I error rate unless the cluster-forming threshold is stringent (e.g., $p < 0.001$, the standard recommendation). However, applying this heuristic to electrophysiological data (e.g., 1D time series, 2D scalp topographies, and time-frequency images) may be overly conservative, potentially missing most of true effects. As the Euler characteristic density, which underpins RFT-based p-value approximations, is highly sensitive to dimensionality, it remains uncertain whether Eklund et al.'s observations generalise to 1D and 2D data. We hypothesised that more lenient thresholds could maintain validity in these lower-dimensional contexts. We used single-channel EEG data capturing auditory oddball responses from one subject. After epoching, the data underwent time-frequency analysis, generating two datasets: a 1D time-domain peached dataset and a 2D time-frequency epoched dataset. Condition labels were randomly reassigned 1000 times, drawing 480 'standard' and 120 'oddball' trials from the total trial pool. Two-sample t-tests with cluster-level correction were performed and their significance was assessed with one-sided t-tests and F-tests. The percentage of iterations producing significant clusters by chance was quantified across varying cluster-forming thresholds ($p< 0.001, 0.005, 0.01, 0.05, 0.1$). The cluster-level threshold was set at $p < 0.05$; accordingly, we expected the percentage of false positives to remain below 5% if the type I error rate was properly controlled. The percentage of false positives remained below 5% across all analyses for cluster-forming threshold of $p<0.01$ and below. For $p<0.05$ the percentage was close to 5% for 2D but exceeded this level for 1D. For $p<0.1$, the family-wise error rate was not well-controlled and was between 9 and 18% for the different analyses. These findings support the validity of cluster-level inference for low-dimensional data with cluster-forming thresholds of up to $p<0.01$ and, for 2D data, possibly even $p<0.05$.

Poster 45

Quantification of head movement in Parkinson's disease patients with head casts

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Introduction: Using individualized head casts in healthy participants undergoing magnetoencephalography (MEG) studies leads to decreases in both within- and between-session head movement and greatly increases the Signal-to-Noise ratio (SNR, Meyer et al., 2017). In healthy participants, this increase in data quality has enabled the inference of the origin of brain activity in a cortical layer specific manner (Bonaiuto et al., 2018 and 2021). In Parkinson's disease (PD), the use of individualized head casts in a small cohort (n=2) demonstrated reduced localization errors for deep brain stimulation electrodes using MEG (Yalaz et al., 2025). Here, we evaluate the effectiveness of head casts in a larger patient cohort. Methods: Head casts were individually designed for each patient using their native MRI. Three-minute resting-state MEG recordings were acquired from nine PD patients. Head position was recorded using four continuous head position indicator (cHPI) coils, each of them emitting well defined periodic currents. Movement detection was applied to extract single coil movement traces over time using MNE-Python. To quantify movement characteristics linear mixed effect models were employed. Results: Within session head movement deviated less than one millimeter from the original starting position in all participants (x=0.04±0.21 mm, y=0.08±0.21 mm, z=-0.11±0.47 mm) regardless of cHPI coil placement. Time was a significant predictor of movement ($\chi 2(1)=77.13$, $p<.0001$). Post-hoc analyses revealed no significant displacement trends in the x- and y-axes (x: $\beta=-2.37e-5\pm7.08e-5$mm, $z=-0.334$, $p=.738$; y: $\beta=-3.88e-5\pm7.08e-5$mm, $z=-0.548$, $p=.584$) while a significant trend was observed along the z-axis ($\beta=0.001\pm7.08e-4$mm, $z=14.912$, $p<.0001$). Discussion: Our results demonstrate the effectiveness of head casts to reduce within-session movement in PD patients and are in line with prior studies utilizing head casts. In future work, we aim to exploit this high-precision MEG data to investigate cortical layer specific brain activity in PD.

Poster 47

Bridging subject variability and neural fingerprints between MEG and fMRI

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Recent methods for modelling brain activity are providing new insight into functional networks. These methods can capture meaningful variation in subject features (i.e. neural fingerprints) across the population in both fMRI and MEG, showing potential for prediction of cognition or clinical trait. Due to the inherent differences in the measurement of brain activity, linking functional networks between MEG & fMRI at the individual level remains a challenge. Nevertheless, by leveraging patterns of subject variability in the neural fingerprints, the connection between MEG & fMRI can be better understood. Using resting fMRI and MEG data from the same subjects, we computed functional connectivity(FC) with modality-specific methods at both group and individual levels.. At the individual level the FC was parameterized and used to create neural fingerprints. Imaging-derived phenotypes, such as volume of brain regions of interest, were extracted from T1w structural MRI and used as fingerprints. Combined with demographic and cognition features, these structural fingerprints helped interpret the underlying variability in the functional fingerprints. We used the Cam-CAN dataset(N=612; age:18-88y), in which fMRI, structural MRI and MEG are available in the same subjects among the healthy cohort. In modality-specific analysis, fMRI, MEG and structural fingerprints all separately performed well in predicting age, cognition, and differentiating subjects. Although performance did vary somewhat depending on modality and fingerprint method. In group-level cross-modal analysis, as demonstrated in previous studies, we found reasonable network similarity between resting-state MEG & fMRI. In individual-level cross-modal analysis between structural and functional modalities, age-related variability in both functional fingerprints can largely be explained by variability in the structural fingerprints, indicating that structural factors contribute to subject variability patterns in both modalities. However, when comparing subject variability in fingerprints between functional modalities, we found that shared variability was limited. As such, cross-modal subject identification showed limited success. Overall, these results indicate that while both MEG & fMRI are strongly linked to structural factors and each modality exhibits meaningful subject variability; While with regardless of structural factors, the nature of that functional variability is not well shared between modalities.

Poster 49

Recommendations for Quantifying Rhythmic and Arrhythmic Components of Brain Activity

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Neurophysiological brain activity comprises rhythmic (periodic) signal components that appear as peaks, which sit above the 1/f arrhythmic (aperiodic) background in the frequency domain. Over a century of research has demonstrated how brain rhythms relate to cognitive processes and are altered by neurological diseases. Despite novel pioneering techniques to parameterize these neural components, methodological choices in quantifying rhythmic brain activity challenge the interpretation of results. We elaborate on how methodological choices for quantifying brain rhythms impact the interpretability of results using synthetic and empirical neural time series data. We compare three methodological approaches for computing rhythmic power: i) Gaussian modelled, ii) log-detrended, and iii) linear-detrended spectral power. First, we show that standard detrending methods for quantifying rhythmic activity conflate the two neurophysiological components, which yields spurious correlations between spectral model parameters in 16,000 simulations. Error in the quantification of arrhythmic model parameters introduces spurious relationships between estimates of rhythmic power and the arrhythmic exponent and between different rhythmic narrow-bands. Second, we test the impact of missing data on the relationship between various spectral model parameters and demographic variables. Replacing missing spectral peak amplitudes with zeros accurately recovers the simulated relationship between spectral model parameters and demographic parameters while retaining all data. Last, we use resting-state recordings from a large cohort (N =606) to illustrate how methodological choices lead to diverging interpretations. We observed a rostro-caudal gradient of the relationship between rhythmic alpha power and the arrhythmic exponent for log-detrending methods, with posterior brain regions exhibiting an inverse relationship. In contrast, the relationship between alpha power and arrhythmic exponent was positive across the cortex when defining alpha power as the height of modelled Gaussians from specparam. These findings emphasize alternative, misleading interpretations that may arise depending on methodological choices. Based on our findings, we propose recommendations for spectral parameterization to enable the robust independent quantification of rhythmic (periodic) and arrhythmic (aperiodic) signal components at a critical point in this nascent field.

Poster 51

Representing wearable, multi-axis MEG data in two dimensions

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Interpreting sensor-level data requires effective visualisation, usually in two dimensions (2D). Such methods should support comparisons across individuals and between differing sensor array configurations. In EEG, this challenge is addressed through standardised electrode placement, such as the 10-10 system and its extensions, which can be represented in 2D by corresponding placement on a polar grid. This results in a system that is familiar to both researchers and clinicians, and has remained a standard for decades. In MEG, however, sensors are not positioned directly on the scalp, and the spatial relationship between the sensor array and the underlying brain anatomy may vary. Template topographies and polar projection methods are commonly applied in response to this. Wearable MEG, typically acquired using optically pumped magnetometers (OPMs), introduces further complexity because, although sensors now have a direct relationship to head geometry, sensor arrays can be sparse or focal and vary considerably between sites. This variability means that templates may not be practical and methods like polar projection may not be suitable. A final complexity is that field measurements are not just for a given position, but an orientation as well, and that the field at a single position may be represented by up to three orthogonal measurements. Focussing on wearable MEG, we sought to develop a method for standardising 2D representations of sensor positions and, later, orientations. We adapted the procedures of the familiar 10-10 system (originally completed using a pen and tape measure) to a digital implementation using spatially co-registered anatomical and sensor position data. We demonstrate that this automatic method outperforms polar projection in simulation. Anatomically veridical 2D topographies of radial channels can now be produced regardless of variation in sensor array or anatomy. Building on this framework, we provide a basis for representing full magnetic field measurements made up of one radial and two orthogonal (tangential) components at any given point on the scalp.

Poster 53

Cross-modal Emotional Transfer Between Naturalistic Music and Art Stimuli: Associations with Behavioural Traits and Audiovisual Features

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Recent work has documented associations between visual and auditory stimuli and specific emotions, and the ability for stimuli such as emotional music to transfer its emotional content cross-modally to visual stimuli. However, research has focused on simple, unnaturalistic stimuli and the effects of different auditory or visual feature combinations on emotional transfer remain unknown. Furthermore, there is a gap in understanding how emotional transfer effects vary across individual traits, or throughout development. In this study, we aimed to investigate cross-modal emotional

transfer effects, in both adults and adolescents, asking how stimulus features and individual differences impact cross-modal emotional transfer and how it is implemented by neural processes. Forty (18-40; 30 females) participants undertook a cross-modal prime-target emotional perception task, in which they were presented with semi-overlapping music/art stimuli with incongruent emotional content (i.e. one happy, one sad, frightening or angering). Participants then rated the likeability, emotional content and intensity of the latter-presented target stimulus and their perceived congruency of the stimulus pair. They also quantified their autistic trait via the AQ50 survey. An MEG experiment using a similar paradigm with adolescent participants is currently underway. Stimuli were decomposed into features including colour, pitch etc. Emotional transfer rates with different prime stimulus emotions and modalities were compared, and correlations with autistic traits and stimulus features were calculated. For MEG data, cross-decoder analysis and partial information decomposition will identify neural correlates of cross-modal emotional transfer in audiovisual integration areas and a linear mixture model will identify its associations with individual traits and audiovisual features of the stimuli. In the adult sample, negative audio primes transferred emotion significantly more reliably than positive and/or visual primes. Visual primes, particularly positive visual primes, transferred emotion less reliably as the autistic trait increased. These results demonstrate that cross-modal emotional transfer, particularly with a bias toward negative, auditory primes, persists even when using paired naturalistic stimuli. This suggests that aesthetic stimuli in our environment influence our emotional states through cross-modal emotional information.

Poster 55

MEG functional connectome fingerprints: robustness of MEG sub-networks using meta-heuristic optimization

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The magnetoencephalography (MEG) functional connectome has repeatedly shown that it contains patterns to re-identify subjects without using the full connectivity of the brain. This work explores MEG fingerprinting constructed from a small number of regions from the functional connectome and builds a sub-network of connectivities between them. Using Simulated Annealing optimization, we identified sub-networks in two cohorts: 43 healthy subjects with MEG sessions from different days and 106 healthy subjects from the same day. Those sub-networks converge to particular regions and region co-occurrences across different frequency bands. We further validate these sub-networks using volume-conduction robust measures and running the optimization only on a subset of subjects, validating on the remaining. For the optimally found regions, we additionally take assortativity, region-specific clustering coefficient, and a subject-specific measure of beneficial region co-occurrence to explore the underlying shared patterns of the fingerprint across frequency bands.

Poster 57

Optically Pumped Magnetometers are Better than SQUID Magnetometers in Multivariate Pattern Analysis on Visual Processing

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Background: Multi-variate pattern analysis (MVPA) is an increasingly important method for decoding brain activity from neural electrophysiological recordings by utilizing both temporal and spatial features. MVPA holds a strong promise to benefit from optically pumped magnetometers (OPMs), a novel type of magnetoencephalography (MEG) sensors, for theoretically higher spatial resolution compared to that of superconducting quantum interference devices (SQUIDs) [1]. As the OPM based system becomes available at more institutions, it is imperative to experimentally compare the two systems using MVPA. Methods: We adapted a paradigm from a previous study, originally implemented using a TRIUX MEGIN SQUID system [2], to an OPM system (HEDscan by FieldLine Medical). Nine subjects were recruited and completed the same experimental paradigm in both systems. Visual stimuli of different objects were presented in two modalities: pictures and the corresponding written words. For each modality, MVPA was used to pairwise classify the objects from OPM and SQUID magnetometer data respectively. This test was repeated for 10 to 68 sensors uniformly sampled from both systems. Results: We found that for both picture and word modalities, the classification accuracy was consistently higher for the OPM system compared to the SQUID system. The performance did not improve when going beyond 30 sensors for SQUID, while it kept increasing until about 40 sensors for OPM. This supports the assertion that OPM systems offer higher spatial resolution. Conclusion: Our OPM MEG outperformed SQUID MEG in MVPA on decoding of visual processing. The OPM system could benefit from a larger number of sensors before reaching its performance ceiling. [1] Brookes, Matthew J., et al. "Magnetoencephalography with optically pumped magnetometers (OPM-MEG): the next generation of functional neuroimaging." Trends in Neurosciences 45.8 (2022): 621-634. [2] Bezsudnova, Yulia, et al. "Spatiotemporal properties of common semantic categories for words and pictures." Journal of Cognitive Neuroscience 36.8 (2024): 1760-1769.

Poster 59

The relationship between pupil dilation and neural surprise in natural language comprehension

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Predictive processing theories propose that language comprehension involves generating and updating context-based expectations. We tested whether such semantic predictions are reflected not only in neural activity but also in pupil-linked responses. Using GPT-2, we derived contextual predictions and analysed MEG and pupil data recorded during audiobook listening. Replicating prior work (Heilbron et al., 2022), we find that MEG responses are modulated by both lexical surprise and semantic prediction error. Extending this, we show that pupil dilation selectively tracks semantic prediction error, suggesting sensitivity to meaning-level violations. We assess the mapping function from surprise to these pupil and MEG measures, focusing on linear vs non-linear response profiles and discuss their relation with respect to current predictive processing theories.

Poster 61

Using MEG to detect localised high-amplitude slow-waves during wakefulness: 'local sleep'

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Recent research has evidenced a novel oscillatory phenomenon characterised by brief and localised bursts of high-amplitude slow-wave activity (delta and/or theta band), similar to waves seen during sleep, observed during wakefulness: ‘local sleep’ (Andrillon et al., 2019; Pinggal et al., 2022; Massimini et al., 2024). These signatures have been associated with lapses of attentional control / episodes of mind-wandering (Andrillon et al., 2021), and have additionally been evidenced to be homeostatically regulated by sleep, occurring more often when tired (Nir et al., 2017). These previous studies have detected ‘local sleep’ events with EEG; this project aims to use MEG to assess deeper neural regions with greater precision, facilitating localisation of the underlying neural source and link to neural network connectivity. This study optimises existing ‘local sleep’ detection algorithms for MEG (rather than EEG) data. Using data from task-free rest state (eyes-open and eyes-closed), both in adults and children, we will show results of not only the ‘local sleep’ time series and topographies (typically shown in EEG studies), but also time-frequency representations (from delta to gamma) and source space evidence of local sleep events. Additionally, our future aims are to examine the occurrence of such events in relation to task performance (reaction time and response accuracy on a randomised digit sustained attention task), how they affect functional connectivity (DMN, FPN), and whether they occur in the developing brain (aged 8-11) distinct from in the adult brain. Within these investigations, the overall aim of this project is to assess if local sleep signatures hold clinical relevance; specifically, if they can be mechanistically linked with ADHD symptom experience, given both attention deficits and sleep disturbance are common to ADHD (Scarpelli et al., 2019; Miano et al., 2019). Demonstrating a significant role of ‘local sleep’ in underlying neural functioning could reshape how ADHD is interpreted and build towards an objective biological measure to complement current symptom-based diagnostic components, as well as real-time detection of mind-wandering likelihood.

Poster 63

Localization accuracy of a high-density tri-axis on-scalp MEG

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Recent advancements have led to the development of OPM sensor arrays exceeding 100 channels, which are now being employed in studies of functional brain activity. One of the major strengths of MEG lies in its capacity to localize the sources of neural signals detected by the sensors positioned around the scalp. Localization accuracy of OPMs share similar challenges to cryogenic MEG (cryo-MEG), such as how well we know the sensor locations and orientation relative to the head at any instant in time, how well we know the sensor gains, crosstalk and the relative signal strength relative to background noise. However, OPM systems also introduce unique factors that influence localization accuracy. Signal-to-noise ratio (SNR) and linearity have operational bandwidths. Remaining within the sensor’s linear range also relies on the amplitude of nearby magnetic fields. This is particularly relevant when head-position indicator (HPI) coils are located close to on-scalp sensors. Additionally, cross-axis projection errors can degrade localization precision. Unlike cryo-MEG systems, where sensors are fixed and factory-calibrated, OPM

systems require accurate measurement of sensor positions at each scanning session, which can impact localization accuracy. To evaluate the localization accuracy of the HEDscan system operating in 3-axis, we conducted experiments using three phantoms with known ground-truths. These included a five-dipole current dipole phantom and a single-dipole magnetic dipole phantom, both equipped with 3 to 5 HPIs. Additionally, a custom-built multi-dipole phantom was used, which mounted rigidly to the helmet to allow evaluation of localization accuracy independent of HPI use. Data were collected using various HEDscan systems with different smart helmets. Between 80 and 143 sensors each with 3 sensing axes were used in the data collection. We achieved localization accuracies of less than 1 mm in our best data, with typical results of under 2 mm. We will discuss the factors that most significantly influenced localization accuracy in our study.

Poster 65

Steady-state measures of somatosensory signal combination measured with OPM-MEG

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Introduction: Studies using electroencephalography (EEG) and magnetoencephalography (MEG) have shown that vibrating the fingers elicits somatosensory evoked potentials (SEPs) and evoked magnetic fields (SEFs). Importantly, research indicates that there is an interaction between afferent inputs from different digits. For instance, simultaneous stimulation of two adjacent digits can reduce the evoked response amplitude by up to 50% compared to the arithmetic sum of the responses to each digit stimulated separately at the same frequency. This inhibitory interaction is typically stronger between adjacent digits than between non-adjacent ones. Despite these findings, relatively little research has explored how such interactions are influenced by different stimulation frequencies. Here, we used OPM-MEG, and a two-input steady-state SEF paradigm to estimate the spatial location and amplitudes of cortical activity from different digits and to investigate how the human primary somatosensory cortex (SI) integrates vibration input across digits. Methods: We applied periodic air-puff-induced vibrations using a TTL-driven compressed-air delivery system (4DNeuroimaging, CA), to individual and paired digits using the same and different frequencies (23Hz and 26Hz). MEG data were measured using a HedScan 128ch OPM-MEG system (Fieldline, CO) and aligned to individual MRI data using a LIDAR-based coregistration pipeline. Postprocessing was performed in MNE. Results: We measured the position (estimated through a LCMV beamformer) and strength of the response (computed as the amplitude of the tagged frequency-domain response) for each digit. We also computed the strength of inter-digit inhibition (measured both from the reduction in response in the presence of a second ‘mask’ frequency, and as the amplitude of the nonlinear intermodulation terms) as a function of digit proximity. We found both suppression (indexed as a reduction in F1 response in the presence of the F2 mask) and robust intermodulation (at 1F1-1F2) for inputs on both the same- and different hands. These responses are well-fit by a gain control model of somatosensory interaction that is conceptually similar to that used to model interocular contrast gain control.

Poster 67

Mind to Motion: An MEG-Driven Real-Time Exoskeleton for Stroke Rehabilitation

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Recovering motor functions after stroke through traditional physiotherapy often results in slow or plateaued progress due to limited patient engagement in neuroplastic development. Motor imagery-based brain-computer interface (MI-BCI) driven exoskeletons offer a promising alternative by enabling patients to actively participate in their rehabilitation, using imagined movements to actively control limb motion by switching between active non-assist and passive assistance modes, resulting in enhanced engagement and neuroplasticity. Most MI-BCI systems use non-invasive electroencephalography (EEG) to record brain activity, decoded in real-time using artificial intelligence (AI) models. However, EEG has low spatial resolution, poor signal-to-noise ratio (SNR), and variable impedance between neural sources and sensors over time, which can compromise signal quality in long sessions and hinder longitudinal monitoring. In contrast, magnetoencephalography (MEG) offers superior spatial resolution , higher SNR, and stable signal transmission since the skull, scalp, and surrounding tissues have magnetic permeability like the brain and therefore do not distort the magnetic fields. Leveraging these advantages, we developed a real-time MEG-based BCI exoskeleton system for upper-limb stroke rehabilitation. MEG signals were acquired using a 306-channel MEGIN TRIUXTM system and decoded in real time. Given the extreme sensitivity of MEG sensors, all electronic components must remain outside the magnetically shielded room (MSR). To address this, we developed a MEG-safe exoskeleton system where decoded commands are transmitted wirelessly to an external control unit. A microcontroller then drives two solenoid valves connected to a pneumatic chamber with compressed air. These valves modulate the airflow to two pneumatically actuated muscles, which in turn control the movement of the exoskeleton hand. Despite the system's mechanical complexity, it exhibits low temporal latency in real-time control. System performance was validated on three control participants at varying pneumatic tank pressures. Additionally, we observed no significant SNR

degradation over long motor imagery sessions (80 training trials followed by 200 feedback trials, each 8 seconds long), highlighting MEG's potential advantages over EEG for reliable decoding in extended and longitudinal rehabilitation studies.

Poster 69

Interrogation of sensorimotor networks in ALS and MS using effective neural signal connectivity analysis

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Introduction: Neurophysiological biomarkers support the classification and monitoring of progression in neurodegenerative conditions while also providing insights into underlying mechanisms. Electroencephalography (EEG) and electromyography (EMG), due to their non-invasive nature, affordability, and high temporal resolution, are well-suited for developing functional biomarkers that can differentiate network alterations across neurodegenerative conditions. Amyotrophic lateral sclerosis (ALS) is a progressive neurodegenerative disorder marked by motor neuron degeneration in both the central nervous system (CNS) and peripheral nervous system, leading to severe motor deficits. In contrast, multiple sclerosis (MS) is a chronic autoimmune disease that primarily targets the CNS, characterized by inflammation, demyelination, gliosis, and neuroaxonal loss, resulting in diverse neurological impairments. Objective: To investigate directional connectivity between five motor-related EEG electrodes and effector muscle activity during a motor task in individuals with ALS, MS, and healthy controls, in order to identify disease-specific network alterations. Method: Directional cortical and corticomuscular coherence (CMC) were used to quantify causal interactions between cortical and muscular activity, providing an effective measure of sensorimotor integration. A total of 20 right-handed healthy controls, 20 ALS patients, and 4 MS participants performed a precision force-control task comprising 30 trials of a 5-second isometric pinch using the right hand. EEG was recorded from five electrodes (C3, C4, Cz, Pz, Fz), and EMG from three muscles: FDI (first dorsal interosseous), FPB (flexor pollicis brevis), and APB (abductor pollicis brevis). Multivariate connectivity measures were compared across the three groups using the Mann-Whitney U test. Results: In both MS and ALS groups, C3 exhibited reduced directional connectivity from neighboring cortical regions (C4 in MS, Cz in ALS), indicating impaired cortical communications. Afferent connections from muscles to C3 were also diminished, suggesting disrupted activity in sensory pathways. Stronger influences from Pz and Fz toward C3 were observed in MS but not in ALS. Discussion: Our findings suggest both direct and compensatory (indirect) aspects of disease-specific abnormal neural communications, highlighting directional connectivity as a valuable tool for quantifying sensorimotor network impairments in neurological conditions.

Poster 71

Neural Correlates of Predictable Targets in Visual Search: The Role of Alpha Oscillations

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Statistical regularities in the environment shape how attentional resources are allocated in space. In visual search, regularities regarding the location where a target is most likely to appear are implicitly learned, allowing for more efficient target detection. However, the neural mechanisms underlying this form of statistical learning remain poorly understood. Here, we used magnetoencephalography to explore how spatially predictable targets influence the allocation of attention during a visual search task. Participants were asked to search for a target stimulus while ignoring a colour-singleton distractor. Unbeknownst to the participants, the target stimulus was presented more frequently on one side of the visual field than the other. Behavioural results exhibited higher efficiency of target detection when the target was presented in the high probability location, confirming implicit statistical learning. To prove the neuronal signature of this learning, we analysed alpha-band oscillatory activity over posterior sensors. Results showed a lateralised pattern of alpha power, with decreased activity contralaterally to the high probability location compared to the low probability location. These preliminary findings suggest that posterior alpha oscillations underlie the changes in attentional allocation based on learned spatial probabilities of target stimuli, thus gating sensory processing accordingly to statistical expectations.

Poster 73

Decoding Semantics: A Multi-Modal CNN as a Model for Human Literacy Acquisition

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While visual objects (e.g. a picture of a rat) and words (e.g. the word “rat”) appear perceptually different, they evoke a similar semantic activation in the human brain. A key question in understanding human reading acquisition is how semantic representations emerge such that visual object representations and written words are meaningfully linked. We used a single convolutional neural network (CNN), to simulate this process. The model was pre-trained on ImageNet to approximate object naming abilities in pre-literate infants, and then jointly trained on both object images and rendered word stimuli referring to the same categories. By enforcing a shared output unit for both modalities, the model aligns visual and lexical representations. We examined the emergence of semantic structure in the network using representational similarity analysis (RSA) and a behavioral interference task. Accuracy dropped significantly when the model was tested on incongruent image-word overlays, demonstrating semantic interference analogous to humans. RSA revealed that representations of objects and words converge in the fully connected layers, indicating the formation of a shared high-dimensional semantic space. These findings suggest that semantic knowledge in CNNs can arise through projections of different visual features into a common representational substrate, supporting theories of distributed rather than modular semantic representations. To probe how these representations are formed, we used activation similarity maximization (ASM) to generate synthetic stimuli that maximized both output class activation and similarity to a reference word image in intermediate layers. Results showed that the network distinguished between within-class and between-class reference stimuli only in the fully connected layers, confirming that semantic representations are not present at the visual feature level and are rather formed by feature projections in later processing stages. Those findings allow for a multitude of predictions for follow-up experiments. E.g. a similar task as employed here could be used in an fMRI or MEG study. We predict that object and written word feature patterns can be distinguished using RSA in earlier visual cortex areas (e.g. V1 to V4), but not in more downstream regions like left anterior temporal lobe, where in turn the distinction between same and different class activation patterns should become more prominent.

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Poster 2

OPM-specific cardiac field artefact correction

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The activity of the heart creates a strong electro-magnetic field that is superimposed on measured (MEG or EEG) brain activity (Dirlich et al., 1997). This cardiac field artefact is especially problematic in the context of imaging neural activity time-locked to the cardiac cycle. Common approaches for cardiac field artifact (CFA) correction include independent component analysis (ICA), principal component analysis (PCA), as well as simple subtraction methods (Park & Blanke, 2019). While generally effective, these methods may simultaneously remove parts of the brain signal under investigation. We leverage the unique advantages of optically-pumped magnetometers (OPMs) to measure magnetic fields while participants can freely rotate their head with respect to the body. We develop an OPM-specific CFA correction that builds a template of the sensor-level projection of the magnetic field of the heart, dynamically accounting for the spatial relationship between thorax and scalp. We show, in simulation results and empirical data, that it is possible to create this CFA template with a small number of magnetic dipoles at the location of the heart. We base this approach on the fact that cardiac activity can be well-described in a three-dimensional vector space (Arnau et al., 2023; Dirlich et al., 1997); and that the tissues close to the heart (intra-cardiac blood, lungs, and thorax) can be modelled with a relatively simple, homogenous volume conductor model (Mäntynen et al., 2014). It thus becomes mathematically tractable, to predict how the magnetic field generated by the heart projects onto the OPM sensory array on the scalp, for any head rotation. The spatial relationship between the heart and the scalp is tracked via motion capture cameras combined with retro-reflective markers attached to the OPM scanner cast on the participant's scalp, as well as to the participants chest.

Poster 4

Relating attention deficits to the neural basis of attention during working memory tasks

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Alpha oscillations have been linked to attention in many attention-demanding tasks (e.g. Jensen & Mazaheri, 2010). However, most studies have been conducted in neurotypical adults. Alternatively, children with attention difficulties, including attention-deficit / hyperactivity disorder (ADHD), are often studied during the resting-state and/or with EEG with limited spatial resolution. This study aims to determine the reliability of the neural sources relating to control of attention through a working memory task, in participants across a range of ADHD symptoms. The current work analyses the neural sources during a working memory task, varying by load, and their correlation to the standard clinical assessments of ADHD. Test-retest reliability is assessed across two MEG sessions. The main task-related findings include robust posterior alpha and beta suppression during the encoding period of the working memory task, notable frontal and parietal beta suppression during the maintenance period, as well as frontal theta increases during both encoding and maintenance periods. Load-dependent effects were characterized by significantly greater occipital beta and frontal theta power in high-load conditions. Beta power modulation, particularly during maintenance in the right ITG, was significantly linked to attention metrics from the Continuous Performance Test (CPT). Task-related parietal (left SPL) beta oscillations exhibited fair to good test-retest reliability, whereas load-dependent effects demonstrated poor reliability. In conclusion, while initial hypotheses centred around the role of alpha power and attention, we instead found robust task manipulations of beta power, that link with task period, task-load, individual differences in attention metrics, and in test-retest reliability. This initial work has been conducted in adult participants. The project's next step will explore if these beta-band results replicate in children and link to connectivity measures.

Poster 6

GABAa modulation of cortical neurophysiology in Progressive Supra-nuclear Palsy and frontotemporal dementia

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Background: Prefrontal GABA deficits in progressive supranuclear palsy (PSP) and frontotemporal dementia (FTD) are associated with motor and cognitive impairment. Pharmacologically modifying GABA has been associated with short-term improvements in cortical neurophysiology and motor learning. Here we describe a new study paradigm, using the selective GABAa agonist Zolpidem (vs placebo) to examine neurophysiological effects in people with PSP and behavioural variant FTD. Materials and Methods: A double blind-placebo controlled cross-over design is underway, with 20 healthy controls, target = 30 people with bvFTD and 30 with PSP. Participants undertake two sessions of magnetoencephalography, two weeks apart: one 2h after oral 5mg Zolpidem, and one 2h after oral placebo. Each MEG session comprises three paradigms: resting-state, an auditory roving oddball, and a behavioural inhibition task. Separately, participants undergo MRI with MR-sLaser spectroscopy (7T or 3T) and additional cognitive assessments. Results: To date, 20 healthy controls, 21 bvFTD and 19 PSP are enrolled , with 90% of patients and 100% of controls successfully completing both sessions. A 1-year follow-up session has been completed by 65% of controls (expected 75% by study completion) and 33% of patients (expected 50% by study completion). Attrition reasons included disease progression, personal reasons or participant deceased. 53 % of patients and 100% of control participants underwent MRI. 70% of controls and 46% of patients [43% PSP] have had 7T, whilst 30% of controls and 6% patients [50% PSP] have had 3T. No serious adverse events have occurred and the study remains blinded. Conclusion: Zolpidem is well-tolerated in this study design and the environment optimises participant engagement and reduces attrition rates. We continue to recruit patients and will perform an interim partial unblinding to analyse preliminary neurophysiological and cognitive findings.

Poster 8

Investigating the feasibility of helium OPM MEG in Amiens

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MEG offers high temporal resolution and good spatial resolution for studying neural activity, complementing EEG. Traditionally, SQUID-based MEG systems, while effective, are costly and logistically challenging due to liquid helium. OPMs offer a promising, more accessible alternative, with closer sensor placement. This study showcases preliminary results of helium-based OPM system across four distinct experimental paradigms and diverse populations, demonstrating its versatility in neurophysiological research and clinical applications. In the first study, simultaneous MEG and EEG recordings were acquired from healthy adults during alternating eyes-open/eyes-closed periods to assess alpha rhythm modulation. Pre-processed MEG and EEG signals were visually compared, and power spectra were calculated. Both MEG and EEG exhibited simultaneous alpha wave activity, with a clear increase in alpha band power observed during eyes-closed states. The second study investigated epileptic activity in a 9-year-old child. Co-registered MEG and EEG data facilitated visual comparison, annotation of epileptic spikes, calculation of averaged spikes, and topographical plotting. Epileptic spikes showed clear alignment between MEG and EEG, and were localized to the left frontal area. A third study explored auditory processing in seven adults using MEG, exposing them to rhythmic percussion sounds. After preprocessing and epoching, power density spectra were normalized, averaged across subjects, and compared to the music's spectrum. MEG spectra revealed distinct spectral components corresponding to the rhythmic periodicities, demonstrating efficient capture of neural responses. The fourth study focused on fetal cardiac activity, recording a 38-week gestational age fetus. After filtering, ICA differentiated maternal and fetal cardiac activity, allowing annotation and averaging of fetal QRS complexes. Fetal cardiac activity, at approximately 140 Hz, revealed a normal QRS complex preceded by a P wave. Our findings demonstrate successful recording of expected neurophysiological activities: significant alpha rhythm modulation, clear epileptic spike detection and localization, robust brain responses to auditory stimuli, and reliable fetal cardiac activity identification. These results collectively highlight the broad utility and feasibility of OPM, validating its potential as a valuable, accessible tool for a range of neuroscientific and clinical investigations.

Poster 10

Detecting mid-range acoustic event-related brain responses: How many stimulus repetitions are necessary to identify a brain response in MEG and EEG through averaging across the stimulus repetitions?

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To address this question, the widely accepted procedure for extracting event-related activity from electrophysiological data and noninvasive measurements such as EEG and MEG is followed. The time series for each instance of stimulus presentation is systematically analyzed instead of simply averaging the data across all stimulus presentations to minimize noise in the signal. The brain’s response is evaluated using the signal-to-noise ratio (SNR). Noise data is collected from the baseline period before stimulus presentation, while the response signal is expected during a period following the stimulus presentation according to the literature [1]. The accuracy of the SNR for each stimulus

presentation was assessed through a bootstrapping procedure [2]. Surrogate datasets are generated by sampling from the available trials at a given time point. Specifically, surrogates are derived from the current trial and the expanding set of prior trials. For each stimulus presentation: (a) surrogate datasets are generated, (b) each dataset is averaged across trials, (c) the SNR of the averaged surrogates is calculated, and (d) the SNR estimates are statistically analyzed across the surrogates. Confidence intervals are established to identify both underestimated and overestimated SNR values based on the trials available at specific intervals. Furthermore, the significance of SNR estimates is evaluated against baseline noise. This systematic statistical testing of the SNR allows for (i) the assessment of response strength in the averaged data for each stimulus presentation, and (ii) the assessment of response detectability. The number of stimulus repetitions required for a statistically significant response strength reflects the latter. For demonstration purposes, the method is applied to simultaneous measurements of MEG and EEG in an auditory evoked response paradigm, utilizing optimized chirp stimuli to enhance response synchronization [3,4]. The stimuli were presented 1000 times. The MEG and EEG data are processed in a similar manner. The sensitivity of MEG and EEG sensors to brain responses in the auditory cortex is estimated based on the number of stimulus repetitions needed to achieve statistical significance. 1 Parkkonen et la., 2009, https://doi.org/10.1002/hbm.20788 2 Efron, Tibshirani, 1994, https://doi.org/10.1201/9780429246593 3 Dau et al., 2000, https://doi.org/10.1121/1.428438 4 Rupp et al., 2002, https://doi.org/10.1016/s0378-5955(02)00614-7

Poster 12

Investigating Long-term Effects of TMR on Memory Performance and Cortical Functional Connectivity

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Sleep is thought to support memory consolidation through the reactivation of newly formed memories, allowing memory traces to spread to neocortical areas. Targeted memory reactivation (TMR) works through associating an auditory cue with each item during learning and replaying that cue during sleep to bias reactivations, thereby providing a possibility to manipulate which items are replayed. For the present study, participants (N = 15) learned an object-location task, with half of those items being reactivated during subsequent slow-wave sleep. For the TMR procedure participants slept in the lab with a concurrent EEG recording. Retrieval of these items was tested immediately after learning and on 3 consecutive time points following TMR (days:1, 2, 8, 22), the first three of those were done during an MEG scan. It was hypothesized that memory performance would decrease over time (H1a) and that memory performance would be improved for cued compared to un-cued items (H2a). Additionally, an interaction was proposed, in the sense that memory performance of cued items is more robust to the decay over time (H3c). Parallel to these behavioural effects, functional connectivity effects between the PPC and the ATL were postulated for remembered items based on previous studies without TMR. More specifically, it was hypothesized that functional connectivity would increase with time, indicating consolidation (H1b) and would be higher for cued compared to un-cued items (H2b). Furthermore, an interaction was proposed in the sense of more connectivity increases for cued items over time (H2c). Results demonstrate a memory performance decay over time, but no behavioural TMR or interaction effects. Analyses of the MEG data are currently being conducted, which might also inform explanations of the missing behavioural TMR effect. Results pertaining to MEG data will be available in time to be presented at the conference.

Poster 14

An Independent component analysis method based on K-LED(Legendre exponential dispersion) model

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The MEG (magnetoencephalography) system, which measures brain neural activity, is highly sensitive and thus easily mixed up with various artifacts, such as heart movements and environmental interferences. As a result, there is a strong demand to effectively separate these artifacts from brain neural data. A typical approach to address this issue is to use independent component analysis (ICA). In this poster, we present an ICA methodology based on a moment-limited statistical distribution known as the k-LED (Legendre exponential dispersion) model. This k-LED model utilizes Bregman-divergence, which is generated by a convex function of Legendre type. We demonstrate a relationship between the parameterized k-LED statistical distribution based on a parameterized convex function of Legendre type and the performance of independent component analysis. For this purpose, as an example, Tweedie distribution is employed. We have conducted a thorough comparison of the proposed method with well-known ICAs used in Brainstorm and MNE-Python.

Poster 16

Neural mechanisms of paced breathing

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A paced breathing exercise in which participants breathe at certain pace according with an external pacer, has mental health benefits, particularly in reducing stress and anxiety. While the effects of paced breathing on mental health are evident, its underlying neurophysiological mechanism remains elusive. A deeper understanding of the impact of paced breathing on neuronal activity and cognition provides the basis for developing more effective therapies chronic stress and anxiety. In this pilot study (N=8), we acquired magnetoencephalography (MEG) data while participants either quietly rested, or performed visually cued paced breathing exercise at a fast (12 breaths per minute) or slow (6 breaths per minute) pace. The behavioural impact of the exercise was assessed using a go/no-go task, which was administrated immediately after the exercise while the participant remained in MEG scanner. The behavioural results showed that slow breathing significantly reduced the number of omission errors ($p < 0.05$, Wilcoxon test), while the number of commission errors and correct responses remained similar for fast and slow breathing rates. This shows that slow breathing has a clear, immediate effect on behaviour. Using MEG data, we assessed the impact on paced breathing on long-range temporal correlations (LRTC) in neural activity [1], which shown to be impaired in several neuropsychiatric disorders. We found that breathing at a fast pace significantly reduces LRTC in the parietal areas within the alpha band (DFA=0.63, $p < 0.03$, Wilcoxon test) compared to resting state (DFA=0.68). This is in line with previous studies [2] showing that cognitive tasks decrease LRTC by disrupting endogenous neural activity. However, slow breathing reduced LRTC only modestly (DFA=0.66, $p > 0.16$) compared to resting state (DFA=0.68). Considering that LRTC are largest at rest, slow breathing may induce a physiological state that is distinct from both rest and engagement in a cognitive task. Our study showed that paced breathing at a slow, but not fast, rate modulates both behaviour and neural activity, specifically, temporal autocorrelations of alpha oscillations. Considering that alpha oscillations are often disrupted by anxiety and chronic stress; slow paced breathing may alleviate these conditions through regulating the alpha activity. [1] Zhigalov et al., J Neurosci. 2015; 35(13): 5385-5396 [2] Palva*, Zhigalov* et al., Proc Natl Acad Sci USA. 2013; 110(9): 3585-90

Poster 18

Building and validating a 384 channel OPM-MEG system

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Introduction Optically-pumped magnetometers (OPMs) offer a wearable alternative to cryogenic-MEG, with reduced sensor-to-scalp distance meaning higher signal strengths and more focal field patterns compared to conventional MEG. However, OPM-MEG arrays have lower channel counts (the largest array in published work is 192-channels, compared to ~300 in cryogenic systems). This means that improvements in sensitivity or spatial resolution that simulation suggests are possible using OPM-MEG have not yet been fully realised. Here, we aim to increase channel density in OPM-MEG, by building and validating a 384-channel system. Methods We constructed a 384-channel OPM-MEG system using a unique configuration of synchronised miniaturised electronic control units (QuSpin Inc., Colorado). 128 triaxial sensors (giving 384 channels) were housed in a 3D printed helmet, and distributed evenly across the scalp. A newly developed external calibration sequence was available, using a matrix coil system embedded into the walls of the MSR to provide precise knowledge of the array geometry. The system was tested using a PCB-based phantom containing 5 magnetic dipoles, with the inter-dipole distance precisely known. Data were recorded whilst all 5 dipoles were energised sequentially. In addition, a single participant was scanned whilst viewing a centrally presented circular grating (60 trials) to elicit narrowband visual gamma. The paradigm was repeated 5 times in the same subject. The MEG data underwent basic pre-processing and were then source-localised (beamformer). Results For the phantom data, a dipole fit was used to estimate the relative locations of the dipoles. Comparing inter-dipole distances from the dipole fit to the known PCB geometry, we found location errors to be <1 mm. Further, correlation between the modelled and measured dipolar field patterns was >0.99. In our human experiments, visual gamma activity was successfully measured and localised to visual cortex, with an average SNR of 5.3±0.5 (mean and standard deviation across the 5 runs). Discussion We have successfully demonstrated a 384-channel OPM-MEG system. We have shown that it can accurately detect and characterise magnetic field patterns from both a phantom and from the brain. This paves the way for the introduction of high channel count OPM-MEG systems that have the potential to significantly outperform conventional cryogenic systems.

Poster 20

Trust approaches on (neural) foot, but leaves on (neural) horseback

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The timescale over which brain-states central to computational psychotherapy, such as trust or antipathy, evolve are very long compared to those typically studied in most computational neurosciece. The call for a naturalistic neuroscience faces computational psychiatry with a very serious challenge: to develop models and identify brain mechanisms exemplified by dynamics such as 'trust approaches on foot, but leaves on horseback'. Tools have started to be developed, especially combining task-immersed experience sampling with neurophysiological state space modelling, to study neural processes over similar, naturalistic time-scales, but this approach has scarcely been applied to social neuroscience, let alone computational psychotherapy. Furthermore, it is rarely underpinned by generative modelling at the computational level, that is, what the individual brain is trying to achieve. I propose that the evolution of key relational states – for example, trust as constructed and experienced by the brain, not as reified by economic operationalizations – should be studied by generative modelling of experience sampling data, constrained by Brief Structured Recall qualitative methods, and, crucially, by modelling of transitions between electrophysiological states. This is must be a long-term effort making systematic and economically efficient use of electrophysiological modalities: development in EEG, refinement in MEG, and translational-clinical applications in EEG. It is essential that computational neuroscientists collaborate with frontline stakeholders in the design of this research and its translational applications.

Poster 22

Altered oscillatory activity in Parkinsons patients during turning

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Introduction: Magnetoencephalography (MEG) has been used widely to record neurophysiological activity. However, conventional systems are limited to static postures with restricted movement. By contrast, MEG using optically pumped magnetometry (OPM-MEG) allows free movement and enables data collection in any posture. Here we exploit OPM-MEG to image patients with Parkinson's disease during a naturalistic movement task. Methods: To date we have scanned 8 patients with Parkinson's disease and 7 age-matched healthy controls (N=7). OPM-MEG data were recorded during a turning task. Briefly, in a single trial participants were asked to turn 90 degrees either to their right or left, following the turn there was a 12 s rest window. A beamformer was used to localise modulation of beta band oscillatory amplitude during the turn versus after the turn. Results: All patients/controls were able to complete the task, and despite the very large movements made by the patients we were able to see clear beta modulation during the task. Initial analysis indicates a difference between the patient and healthy control groups, with the patient group showing a significantly smaller beta power reduction ($p = 0.02$) during the turn. Conclusion Our study suggests that OPM-MEG can be used to image patients during a naturalistic movement task, and further that beta modulation during the task was abnormal in patients. The finding of diminished beta reduction during movement is in line with existing literature (albeit for simpler tasks involving finger movement). Further work will be undertaken to gather more data in more patients, and to integrate motion tracking data into our analysis pipeline.

Poster 24

At-home screening for early detection of Alzheimer's disease using ear-electroencephalography

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In recent years, electroencephalography (EEG) has undergone significant technological advancements to extend its utility to real world settings. Ear-EEG has emerged as one of the potential implementations combining unobtrusive designs with signal-to-noise ratio comparable to that of scalp EEG. In particular, one device, the NeuroBuds, has been validated against polysomnography and enabled unsupervised home-based sleep recordings in a variety of clinical samples, including patients with chronic pain. Alzheimer's disease (AD) is the most common neurodegenerative disorder. From its earliest stages, AD is associated with progressive neurophysiological changes that can be measured using scalp EEG and are mirrored by gradual decline in cognition and sleep quality. However, the complexity and limited accessibility of lab-based EEG recordings precludes their widespread clinical application for early disease detection or treatment outcome monitoring, two areas in desperate need of scalable innovation. The At-Home EEG screening for early detection of AD (AHEAD) study aims to investigate the utility of ear-EEG in measuring AD-related neurophysiological alterations in prodromal stages of the disease and to assess the acceptability of the NeuroBuds devices to patients. Data collection for this study is ongoing. In total, the study sample

will include 70 age and gender-matched individuals, encompassing mild cognitive impairment (MCI) due to AD (MCI+, n = 25), MCI due to other causes (MCI-, n = 25) or normal cognition at the time of testing (controls, n = 20). We will measure their sleep and awake resting state and task-based ear-EEG followed by user experience questionnaires remotely over eight sessions in a period of two weeks. Sleep staging will be performed using an AI-based algorithm that shows high agreement with human raters. The analysis will focus on the ability of ear-EEG features derived from different types of recordings to classify the three participant groups and the relative feature importance. If successful, this study will facilitate the wider use of remote EEG testing in clinical neurology, not only aiding early detection of AD but differentiating it from other disorders such as Lewy body dementia, as well as in the diagnosis and management of other conditions such as epilepsy and sleep disorders.

Poster 26

OPM-FLUX – an open-source analysis pipeline for OPM-MEG

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MEG systems based on Optically Pumped Magnetometers (OPMs) are the next generation of MEG systems for non-invasive brain imaging. Unlike conventional MEG, which relies on cryogenic cooling and rigid helmets, OPMs operate at room temperature, are wearable, and can be placed directly on the scalp. This enables the detection of stronger signals, and the technique has great promise for, e.g., paediatric recordings. To support researchers in analysing the complex data produced by OPM systems, we introduce OPM-FLUX (http://www.neuosc.com/flux), an open-source, standardised analysis pipeline developed specifically for OPM-MEG data based on the MNE-Python toolbox. OPM-FLUX is designed to guide researchers through all the steps of OPM signal analysis, including preprocessing, artefact removal, noise attenuation, event-related fields, time-frequency spectral analysis, source localisation, and multivariate pattern analysis. Each analysis step is implemented and documented in Jupyter Notebook scripts used to analyse an OPM dataset on spatial attention, which is also provided. Each chapter combines code with detailed explanations, justifications for parameter choices, and graphical outputs. In each chapter, we also provide text suggestions to be used for preregistration and publications . This aim is to support learning, making advanced analysis methods accessible to users who are new to the field, but also to provide a standard for best practices. OPM-FLUX is also designed to develop over time as OPM technology and analysis methods improve. It is a community project, and researchers are encouraged to contribute and help it develop further. OPM-FLUX and the training datasets are free and open for everyone to use. It follows the principles of open science, making tools and knowledge available to researchers worldwide, including those with limited resources . The pipeline is regularly updated and will develop as OPM technologies are improved. By providing a clear and tested procedure to analyse OPM data, it helps more scientists use OPM-MEG and support rigour in data analysis. OPM-FLUX can be used for self-studies, but also in educational settings to teach students and new users how to analyse OPM data.

Poster 28

Oscillatory Waveform Shape as a Marker of Neural Perturbations

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Neuronal oscillations measured at the scalp with an EEG electrode or MEG sensor reflect the ‘mean field’ produced by many thousands of neurons. Many common models of gamma (40-100Hz) oscillations posit that they arise due to alternating period of (relative) excitation and (relative) inhibition. While alterations in observed oscillatory power may reflect changes in the synchrony of a population, alterations in oscillatory waveform shape may instead reflect a change in the temporal balance of those periods of excitation and inhibition, e.g., a population spending relatively longer in an ’excited’ state and shorter in an ‘inhibited’ state. Taken together, the power, frequency and waveform shape of an oscillation may therefore offer an interesting window into neuronal dynamics. Here, we will present data from experimental and theoretical work designed to elucidate the neural effects of transcranial brain stimulation; Transcranial Electrical Stimulation (tDCS, tACS), and Focused Ultrasound Stimulation (FUS). Previous work (Marshall, bioRxiv, 2022) demonstrated that tDCS to occipital cortex alters the waveform shape of cortical gamma oscillations in a manner consistent with changes in cortical excitability. We will present ongoing work applying the same theoretical approach to data recorded while tACS was applied to visual cortex. We will also present ongoing modelling work on the effects of changing calcium dynamics – one purported mechanism of action of FUS – on gamma oscillations. This work is part of a larger research programme designed to answer a key question in cognitive neuroscience: Given that many techniques exist to alter brain activity and thereby behaviour, which technique, in which circumstance, is most likely to produce a desired outcome?

Poster 30

Cross-species Auditory Steady State Responses in Genetic Risk of Psychosis

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Schizophrenia is a chronic mental disorder affecting 20 million people globally, with symptoms including psychosis, delusions, and disorganised thinking. A key symptom is distorted perception, such as auditory and visual hallucinations. Treatments primarily target symptoms and not the underlying disorder, and are often ineffective. This highlights the need to better understand mechanisms of schizophrenia/psychosis and develop translational cross-species markers. Two key areas of advancement in recent years have included genetic underpinnings and electrophysiological markers. Large-scale consortia have identified a number of rare schizophrenia-associated copy number variants (scz-CNVs) – deletions or duplications of sections of DNA. Furthermore, electrophysiological studies have identified robust markers of schizophrenia/psychosis such as the reduced power of the 40 Hz auditory steady state response (ASSR). Here, we aimed to understand how these scz-CNVs alter the electrophysiological dynamics of the brain such as the 40 Hz ASSR, and potentially lead to schizophrenia-like symptoms such as perceptual distortion. We measured 40 Hz ASSR in children with scz-CNVs (MEG) and in a mouse genetic model (EEG). Source localisation identified activation in thalamus, auditory cortices, prefrontal cortex, hippocampi, and parietal cortex in humans and auditory/prefrontal/parietal cortices in rodents. In both humans with 22q11 deletion and a mouse genetic model of this CNV, reduced 40 Hz ASSR power was found in auditory cortex. To understand the synaptic mechanisms underpinning these alterations, we built a novel dynamic causal model of the thalamocortical auditory pathway based on known anatomy of the 40 Hz ASSR. Reduced excitation/inhibition balance onto the granular circuitry in auditory cortex was found to be a likely driver of reduced 40 Hz ASSR power, and was consistent across species. These results validate our hypothesis that scz-CNVs such as 22q11 deletion change the electrophysiology of early sensory cortices in similar ways to chronic schizophrenia, and that rodent models are a useful tool to better understand these electrophysiological markers. Ongoing work involves testing our computational predictions against pharmaco-MEG and rodent pharmacology/LFP, and comparing against chronic schizophrenia and other scz-CNVs.

Poster 32

Comparing standard Evoked Responses of Cryogenic and Helium (4He)-OPM MEG data

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Background: Helium optically pumped magnetometers (4He-OPMs) operate at room temperature, neither requiring cooling, as in cryogenic MEG systems or heating, as in OPM-MEG systems using rubidium. This affords the opportunity of recording brain function by placing sensors directly onto the scalp and the use of flexible and adjustable caps makes it ideal for studying brain function in young children. The close placement of sensors to the scalp offers potential for excellent signal-to-noise ratio. The aim of this pilot study was to directly compare the morphology and field patterns of primary sensory evoked fields recorded with whole-head cryogenic MEG and whole-head 4He-OPMs, taking advantage of the direct comparability of recordings from the magnetometer sensors in each device. These evoked responses (ER), provide an important ground-truth for investigations of more complex sensory and neuro-cognitive processes, and also continue to play a role in clinical neurophysiological practice for a number of neurological disorders. Methods: 306 channel (102 triplet sensors) whole-head cryogenic-MEG (MEGIN, Helsinki, Finland) and 288 channel (96 tri-axial sensors) whole-head OPM-MEG (Mag4Health, Grenoble, France) data were recorded in participants following median nerve stimulation and presentation of auditory tones. Open-source analysis packages were used to directly compare the morphologies of the magnetic evoked fields recorded at sensor level over primary sensory cortices in both MEG systems. Results: ER relative amplitude and latency are reported for magnetometer data from both devices. Signal-to-noise ratio is compared, both with and without proprietary noise reduction methods applied in the cryogenic MEG data. The contribution of the additional measurement axes, in particular the potentially-useful first tangential axis, in the OPM data, is explored. Preliminary results indicate typical ER latencies and morphologies in both cryogenic MEG and OPM-MEG data. Discussion: This is the first whole-head 4HE OPM-MEG recording of primary sensory evoked fields and shows comparable data with cryogenic MEG data. Typically, the recording of simple evoked fields with cryogenic MEG in young children yields variable results due to the distance of the sensors from scalp and increased head movement. We anticipate that the wearable nature of the 4HE OPM-MEG system will permit more accurate recording of these fundamental processes in very young children.

Poster 34

Semantic Gist Prediction from Stereo-Electroencephalography (sEEG) Using Token-Level Semantic Features and Large Language Model

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Decoding natural language from brain activity is a promising direction in brain–computer interface (BCI) research. While functional magnetic resonance imaging (fMRI) and electrocorticography (ECoG) studies have shown the feasibility of language reconstruction from neural signals, the potential of stereo-electroencephalography (sEEG)—offering high temporal resolution and deep-brain access—remains underexplored. A recent fMRI study by Tang et al. (2023) demonstrated that coherent word sequences can be reconstructed from semantic representations in cortical activity. Motivated by this research, we aim to bring semantic decoding into high-resolution sEEG settings for word-level prediction. We propose a novel model that leverages high-resolution sEEG signals to predict upcoming words during naturalistic speech comprehension, shifting the focus from post hoc reconstruction to real-time semantic prediction. Our dataset comprises sEEG recordings from 14 Chinese patients with medically intractable epilepsy, each of whom passively listened to 30 minutes of spoken Mandarin Chinese excerpts from curated story collections. We extract token-level semantic embeddings and linguistic features from large-scale language models (Qwen2.5 7B and DeepSeek R1), forming a composite representation aligned to individual word onsets. These features capture both contextual meaning and predictive uncertainty, and serve as input to our encoder model, which learns to map linguistic representations to neural responses. To address inter-subject variability arising from heterogeneous electrode coverage, we map all contacts into Montreal Neurological Institute (MNI) space and aggregate them by anatomical region using a region-based normalization strategy. Rather than predicting the exact lexical form of the next word, our model aims to anticipate its semantic representation—capturing the gist of forthcoming content within the evolving discourse context. This word-level predictive decoding approach allows us to examine how the brain encodes and preactivates upcoming meaning during naturalistic language comprehension. By extending semantic decoding to a typologically distinct language and a high-resolution electrophysiological modality, this study offers new insights into both the universality and variability of neural language representations.

Poster 36

The influence of forward models on simulated spinal cord activity

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Optically Pumped Magnetometer Magnetospinography (OP-MSG) offers a promising new avenue for non-invasive imaging of spinal cord activity with millisecond temporal resolution and improved spatial access compared to conventional MEG and MRI. However, the accuracy of spinal source localisation in OP-MSG critically depends on the quality of the forward model, particularly given the spinal cord's complex geometry, deep location, and conductive environment. In this study, we evaluate how anatomical and numerical modelling choices affect forward model accuracy in cervical OP-MSG, focusing on the influence of bone representation and source space constraints. We compare three models featuring different representations of the vertebral column: a homogeneous toroidal model, an inhomogeneous toroidal model, and a continuous vertebral structure. For each, we apply both unconstrained and grey-matter-confined source models to assess the impact of spread confinement on dipole localisation and lead field properties. Finite element methods (FEM) are used to generate magnetic field predictions under multiple source orientations and positions within a segmented spinal cord mesh. Our early results show that source confinement significantly reduces monopolar source spread without meaningfully affecting lead field topography, while the choice of bone model notably influences signal strength and field shape, particularly for non-superior-inferior source orientations. These modelling insights lay the groundwork for the development of reliable OP-MSG pipelines. We aim to use these forward models to compare simulation outputs against recently acquired real OP-MSG recordings in participants. This validation step will inform best practices for anatomical model complexity, numerical methods, and source space definition, ultimately advancing the clinical and research utility of spinal OPM systems.

Poster 38

Whole-brain Granger Causality of source reconstructed MEG

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Estimating causal interactions between signals in electrophysiological data provides unique insights into brain dynamics. Magnetoencephalography (MEG) is especially well suited to reveal fast cortical interactions. The magnetic field spread between MEG sensors is known to hinder causal inference. Source recon- struction reduces the field

spread at the cost of an increase in data dimension- ality. As causal inference is subject to the curse of dimensionality, MEG source reconstructed data must be reduced before analysis. The extent to which source reconstruction and dimensionality reduction affect causal inference remains elu- sive. To shed light onto these effects and their nature, we simulated source ac- tivity with known causal interactions. Using the anatomy and head positions of 25 healthy participants, we projected the simulated signals to MEG sensor space, and reconstructed the sources. Doing so for different numbers of sources indicated that source reconstruction spreads information relevant to causal infer- ence locally among sources, which causes false positive detections. In addition, increasing the number of MEG sources reduces the effective coupling strength between them, to a point where causal interactions become undetectable. An- other typical approach in MEG analysis is to reduce the dimensionality based on an atlas. Interestingly, in our simulations, causalities are detectable again after this process, provided that they align with the atlas in use. However, many false positives arise. Overall, our findings reveal that current causal analyses of source reconstructed MEG suffer from high false positive rates, effectively masking the true causal interactions.

Poster 40

Exploring Grip-Type Specific Cortico-Muscular Coherence with Whole-Head OPM-MEG

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While the precision grip is consistently associated with activity in the primary motor cortex (M1), the cortical contributions to the power grip remain less clearly defined. Although both grip types activate overlapping muscle groups, evidence from animal and human studies suggests differential recruitment of corticospinal and intracortical circuits. For example, precision grip is thought to rely more heavily on direct corticomotoneuronal pathways, whereas power grip may depend on more indirect or distributed control mechanisms. However, non-invasive human recordings have struggled to clearly resolve these distinctions. Cortico-muscular coherence (CMC) in the beta range offers a way to assess functional coupling between motor cortex and muscles, but limitations in spatial resolution and sensitivity to signal direction in standard EEG, ECoG, and cryogenic MEG have made it difficult to disentangle grip-specific contributions. Here, we aim to explore whether a whole-head 96-sensor Mag4Health OPM-MEG system—with each sensor capturing one radial and two orthogonal tangential field components—can begin to address this gap. The increased directional sensitivity and spatial flexibility of this system may allow us to resolve finer-scale differences in cortical dynamics during power and precision grip. As a proof of concept, we will functionally localise M1 by identifying somatosensory cortex (S1) using median nerve stimulation and somatosensory evoked fields (SEFs), and then compare CMC patterns across grip types. Our immediate goal is to assess whether OPM-MEG can access signal features that have remained elusive using traditional methods. In doing so, we hope to establish whether this technology has the necessary sensitivity and spatial resolution to distinguish between grip-specific cortical dynamics. Ultimately, our aim is to definitively map the control networks underlying power and precision grip in humans—a question that has so far resisted clear answers with existing non-invasive techniques.

Poster 42

GABAergic modulation of response inhibition in health and dementia

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Inhibitory motor control depends on a frontal cortical network including inferior frontal gyrus, preSMA and motor cortex, within a broader task relevant brain-wide network. Movement initiation and inhibition modulates synchronous beta power across these frontal regions, indexing different cognitive elements of motor control. In frontotemporal dementia, clinical manifestations of disinhibition arise from disrupted frontal networks and impaired beta power, associated with a loss of GABAergic neurotransmission. This raises a key question: could pharmacologically enhancing GABA restore beta power and improve inhibitory control? We used pharmaco-magnetoencephalography in a double-blind placebo controlled study. 22 people with frontotemporal lobar degeneration, (11bvFTD and 11PSP) and 20 age matched controls completed a bimanual Stop-signal Nogo task, once after placebo, and once after the GABAA receptor agonist Zolpidem 5mg. Task conditions, (Go, successful Nogo, successful and failed Stop), were source-localised using linear-constraint minimum variance (LCMV) beamformer. Beta power images from three time windows were baseline-corrected and analysed with mixed ANOVAs to compare groups, drug conditions, and task performance. All conditions elicited event related reductions of beta power (ERD) in bilateral motor and premotor cortex, consistent with action execution and inhibition. The ERD was impaired in the patient groups in left motor cortex, independent of trial condition. Concurrent to the ERD, beta power increased across prefrontal and temporal regions, which was attenuated in patients but only during response inhibition trials. Zolpidem had differential effects depending on inhibition type and disease group: during successful NoGo, beta power in the left IFG was enhanced for Control and PSP groups, and during successful stop, beta power in left premotor, temporal and parietal regions was enhanced for those with bvFTD.

During failed stop trials, Zolpidem enhanced the beta rebound in right premotor and motor areas in the patient groups. We interpret the spectral changes in response to Zolpidem, and consequent task related behavioural changes, as a function of disease physiology and atrophy, GABA concentration (MR Spectroscopy), and cognitive assessments. Ongoing analyses will map the network dynamics of inhibitory motor control, identifying key sites and connections for drug interaction to provide evidence for beneficial effects of GABAergic intervention.

Poster 44

LibriBrain: Over 50 Hours of Within-Subject MEG Recordings to Improve Speech Decoding Methods at Scale

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Recent advances in speech decoding have shown that linguistic representations at different levels of granularity—such as phonemes and words—can be read out from intracortical neural recordings. However, decoding speech reliably from non-invasive neural recordings remains an open challenge. Deep learning methods are well-suited to capture complex spatiotemporal relationships that linear models typically fail to represent. Two major limitations preventing the effective application of deep learning to non-invasive neural recordings are: (1) the limited availability of large scale single-subject datasets, and (2) difficulties in integrating data across subjects. To address this gap, we present LibriBrain, the largest single-subject MEG dataset to date for speech decoding. It comprises over 50 hours of MEG recordings—five times larger than the next comparable dataset and fifty times larger than most existing datasets. A single participant listened to naturalistic spoken English sentences, covering nearly the entire Sherlock Holmes canon. For each sentence, we labeled speech and non-speech segments. In addition, for each speech segment, we extracted detailed phoneme and word annotations using forced alignment. We evaluated deep learning model performance on three different tasks: speech detection, phoneme classification, and word classification. Speech detection can be framed as a binary classification task (speech vs. non-speech segments). Phoneme classification is a multiclass classification task (39 ARPABET phonemes). Word classification consists in predicting word embeddings using a contrastive learning approach and estimating predictive probabilities for a restricted vocabulary (250 most frequent words). For each task, we show that decoding performance improves substantially with increased data volume, underscoring the value of scaling within-subject datasets for non-invasive speech decoding. Crucially, except for word classification—where we replicated an existing model—we used simple model architectures and parameter configurations for speech detection and phoneme classification. To further investigate model architecture and hyperparameter tuning, we are hosting a competition focused on optimizing deep learning models for speech detection and phoneme classification using the LibriBrain dataset.

Poster 46

Auditory mismatch negativity can identify patients with Alzheimer's Disease from healthy controls and track disease progression over time

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Alzheimer's Disease (AD) is characterised by accumulation of amyloid (Aβ) and τ proteins, which are in turn associated with synaptic dysfunction and cognitive impairments. Neural activity as measured by magnetoencephalography (MEG) is dependent on synaptic functioning and may therefore be sensitive to disease (progression). Here, we examined neural signatures of AD with an auditory mismatch negativity (MMN) task. The MMN is an early event-related potential component reflecting automatic detection of a change ('deviant') following a sequence of standard sounds. Its automaticity makes it particularly suited to study clinical populations. We tested if the MMN showed: 1) between-group differences between patients with AD and healthy controls (identifying disease), and 2) within-participant changes over time (tracking progression). We analysed data from 34 healthy controls and 69 patients with AD or mild cognitive impairment from the New Therapeutics in Alzheimer's Disease study cohort. All patients showed evidence of substantial amyloid accumulation ('amyloid-positive') as established by positron emission tomography images or cerebrospinal fluid. MEG was recorded at baseline during a 10-minute MMN task, in which participants passively listened to a tone every 500 ms. The tones varied in frequency every 3-11 trials. Fifty-one patients repeated the task in a follow-up session (ranging 10-24 months after baseline, mean = 14 months). We extracted the root mean square across the gradiometers and calculated the average wave form across trials, separately for each tone type. Next, we calculated the difference in evoked MMN amplitude (140-160ms post-stimulus) between the deviant and each repetition. These differences scores were averaged – resulting in one overall MMN score for each participant. A one-sided Bayesian independent sample t-test showed that patients had on average

larger MMN compared to controls (BF10 > 1000). Furthermore, a paired t-test showed that patients on average had larger MMN at baseline compared to their follow-up session (BF10 = 6.3). Overall, our first set of analyses suggest that the MMN can distinguish patients from healthy controls, and is sensitive to progression of disease over time. Next steps include further analysis of the waveforms as well as source localisation.

Poster 48

Understanding the relevance of high frequency oscillations (HFOs) using simultaneous stereo-electroencephalography (SEEG)/magnetoencephalography (MEG) recordings

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There is increasing evidence that high-frequency oscillations (HFOs) are a sensitive biomarker for delineating the epileptogenic zone (EZ) during pre-surgical planning in epilepsy. HFOs are typically identified using intracranial EEG (iEEG), which offers excellent temporal resolution but limited spatial coverage. More recently, non-invasive methods such as magnetoencephalography (MEG) have shown promise in detecting HFOs, but their efficacy, especially for deep sources, remains uncertain. In this study, we leverage a unique dataset of simultaneous iEEG/MEG recordings from 25 patients with drug-resistant epilepsy to compare the two modalities in terms of HFO detection, spatial localisation, and relevance to surgical outcomes. HFOs in the 80-150 Hz frequency band were identified using a customized, semi-automatic pipeline. Our results showed that iEEG had significantly higher sensitivity for detecting HFOs within the EZ compared to MEG. In addition, HFOs detected by MEG had significantly higher oscillatory frequency than those detected by iEEG, across all events and within the EZ. Finally, MEG source localisation of iEEG-derived HFOs was not accurate, with the distance between significant clusters in the source localised MEG data and the location of iEEG contacts being no better than expected by chance. Overall, in this dataset, our method for HFO detection demonstrated that MEG exhibits reduced sensitivity to HFOs, particularly for deep brain regions. We aim to refine our methodology and apply it to additional datasets to validate and extend our findings. These results also highlight the need for more quantitative and automated approaches to further enhance the reliability of non-invasive HFO detection in pre-surgical evaluation.

Poster 50

Generating Realistic Anatomical Templates for OPM Magnetospinography using Conditional 3D Deep Learning

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Recording neuromagnetic fields from the spinal cord with Optically Pumped Magnetometers (OPMs) has the potential to offer new insights into spinal cord function. To realise the full potential of OPM based magnetospinography (OPM-MSG), accurate forward models incorporating subject-specific anatomy are required [1]. These models depend on torso and internal tissue geometry (heart, lungs, etc.) but acquiring MR images for each participant is resource-intensive. This hinders large-scale adoption of OPM-MSG. To investigate whether a template anatomy could be used instead, we propose a deep learning approach to generate individual organ structure from a person's torso shape. From the TotalSegmentor CT dataset [2], [3], we obtained segmented meshes of the torso and parts like heart, lungs and bones, from 500 participants. We split this randomly into a training set of 440 participants and a test set of 60 participants. 5-fold cross-validation was used during the training to protect against overfitting. To enable convolutional network processing, input torsos and organs were converted into fixed-resolution volumetric grids (e.g., 192x192x192 voxels) and a 3D U-Net [3] was trained on these pairs. We will simulate OPM-MSG data generated from the participants' own anatomy [1] and reconstruct the source of the simulated data under three conditions: using the participants' own anatomy, using an existing template warped to the participants' torso surface and finally using a template generated from the participants' outer torso surface through a deep learning approach. By considering the distance between the simulated and reconstructed MSG sources in these conditions, we can begin to answer whether a template could reasonably be used in an empirical OPM-MSG recording. REFERENCES: [1] G. C. O'Neill, M. E. Spedden, M. Schmidt, S. Mellor, M. Stenroos, and G. R. Barnes, "Volume conductor models for magnetospinography," Apr. 07, 2025, bioRxiv. doi: 10.1101/2024.11.04.621905. [2] J. Wasserthal et al., "TotalSegmentator: robust segmentation of 104 anatomical structures in CT images," Radiol. Artif. Intell., vol. 5, no. 5, p. e230024, Sep. 2023, doi: 10.1148/ryai.230024. [3] F. Isensee, P. F. Jaeger, S. A. A. Kohl, J. Petersen, and K. H. Maier-Hein, "nnU-Net: a self-configuring method for deep learning-based biomedical image segmentation," Nat. Methods, vol. 18, no. 2, pp. 203–211, Feb. 2021, doi: 10.1038/s41592-020-01008-z.

Poster 52

Magnetoencephalography (MEG) as an objective measure of the brain effects of heading in footballers.

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Background There is growing concern regarding the potential short- and long-term neurological effects of repetitive head impacts in sport, particularly in football where players use their heads to pass, shoot, direct and control the ball. However, the precise mechanism by which heading a football may affect brain function remains poorly understood. Aims This is a pilot study to determine whether magnetoencephalography (MEG) can detect changes in brain function resulting directly from heading footballs. Methods A small sample of healthy adult participants with the ability to competently perform football headers took part in 3 MEG recordings, following experiment conditions designed to isolate the effects of heading while controlling for physical exertion, as follows. Initially, participants completed a standardised football warm-up, followed by 10 long-distance passes (40 meters) executed with the feet, before the first MEG session (pre-heading baseline). In the second condition, after a repeat of the same warm-up, participants performed 10 headers from 40-meter deliveries, prior to the second MEG session. Following this, participants rested for 90 minutes to allow for acute recovery, before undergoing a third MEG session to evaluate any short-term recovery or progression of neural responses to heading. Each MEG session consisted of two parts: 1) “resting state” recording of 5 minutes, eyes open. 2) Simple finger movement task recording. Each MEG session started within 5 minutes of completion of the preceding football task (passing and heading). All participants also undertook a structural MRI scan for co-registration with the MEG data. Concussion symptoms and behavioural measures of working memory were also collected after each scan session. Data Analysis 1) Spectral analysis of resting state data to examine changes in spectral power across football conditions, with specific interest in the delta band which has previously been associated with acute concussion. 2) Analysis of event-related changes in beta-band activity in the finger-movement task; beta band activity changes have also been associated with concussion. Implications This study aims to determine whether MEG can offer quantitative insights into the immediate neural responses of heading footballs. Our findings will contribute to the ongoing discourse surrounding player safety in football and the development of evidence-based guidelines for heading exposure.

Poster 54

Distinguishing insular cortex regions with OPM-MEG: a simulation study

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The insula is a key region of the cortex. It supports the integration of multiple functions, including perception of internal bodily states (interoception), and cognitive and social-emotional processing. The human insular cortex is located deep within the lateral sulcus and can be subdivided in regions with distinct cytoarchitectonic and functional properties. Although previous magnetoencephalography (MEG) work has demonstrated the possibility of accurately reconstructing signals from the insula (Tait et al., 2021), the resolution at which insular regions can be separated remains an open question. In this study, we examine this question for Optically Pumped Magnetometer based MEG (OPM-MEG), which, compared to the classical cryogenic MEG, allows the study of insula processing through experiments with greater flexibility in terms of participant mobility and sensor distribution. We based our simulation on 16 cytoarchitectonic regions of the insular cortex (3 agranular, 3 granular, and 10 dysgranular areas) from the Jülich atlas (Amunts et al., 2023). We projected these regions to a cortical mesh and, for each region, simulated OPM signals from a single dipole. For all simulations, the sensor positions from the Cerca Magnetics whole-head adult helmet were used (64 triaxial OPMs). We considered a range of signal-to-noise ratios (-20, -10, 0 and 5 dB) and possible coregistration errors resulting from plausible misalignments between the assumed and actual orientations and positions of the sensors. The source of each simulated dipole was reconstructed using 3 different distributed source reconstruction methods: an LCMV beamformer, eLORETA and Minimum Norm Estimation, each implemented in DAiSS in SPM. We compared the location of the maximum estimated source power from each method with the simulated location. Encouragingly, under the assumption of low noise and low coregistration error, we observe that signals from specific insula regions were reconstructed to the same region with high accuracy. However, we found that signals from deeper areas, such as the agranular region, are more challenging to reconstruct and can be mistaken for those from nearby dysgranular zones. Our work may serve as a guide for future experiments focusing on OPM-MEG signals originating from the insula. Specifically, it could help inform the resolution at which insula areas can be reconstructed, depending on the setup conditions.

Poster 56

What are the neural correlates of sensitivity to clothing fabrics?

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Sensitivities to tactile stimulation are seen across the general population and are particularly prevalent in a range of neurodevelopmental and psychiatric conditions. Currently, the cortical mechanisms underlying tactile sensitivity are unclear, although an increased excitation: inhibition ratio has been proposed. Previous research has shown that brushing the skin is associated with suppression of beta oscillations in the sensorimotor cortex, followed by a beta rebound upon cessation of the movement. The spatiotemporal pattern of neural activity to gentle brushing has also been well characterised, with recent findings disentangling the relative contribution of different nerve fibres to the neural response. The aim of this research is to explore the neural basis of sensitivity to clothing fabrics, a commonly reported source of discomfort to those who experience tactile sensitivities. Pilot work has been carried out which confirms that brushing fabrics along the arm generates a suppression in beta oscillations over the sensorimotor cortex. Using a MEG compatible robotic arm, we aim to explore whether the strength of the neural response varies depending on participants' subjective sensory sensitivity. As beta suppression has been linked to changes in the excitation: inhibition ratio, determining whether the magnitude of beta suppression varies depending on subjective experience will allow us to test this theory of sensory sensitivity. Additionally, the spatiotemporal profile of neural activity in response to different fabrics will allow us to examine the relative contributions of different nerve fibres and brain regions to the experience of tactile sensitivity. A follow-up experiment aims to examine the role of prediction and attention in tactile sensitivity.

Poster 58

Temporal Dynamics of Prediction Errors on Perceptual Content and Awareness of Content

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Current theories of perception struggle to reconcile cases where perceptual information influences behaviour but fails to reach conscious awareness (Dehaene & Changeux., 2011; Graziano, 2019; Lau & Rosenthal., 2011). Computational proposals have suggested a hierarchical generative model of perception where awareness is implemented as a second-order inference on first-order perceptual content (Fleming 2020). A recent fMRI study showed that the neural signatures of prediction errors (PE) at both levels are spatially segregated (Dijkstra et al., 2024), with PEs on content being tracked in the early visual cortex (EVC) and PEs on awareness (detection of content) in the prefrontal cortex (PFC), in line with a hierarchical architecture. In this study, we sought to characterise the temporal dynamics of awareness and content PEs using magnetoencephalography (MEG). Given the proposed hierarchical relationship between inferences on content and awareness, we hypothesised content PEs would precede awareness PEs. To experimentally tease these two types of PEs apart, we used compound cues that generated expectations about both whether a stimulus is likely to be detected (awareness) and what that stimulus is likely to be (content). Participants (N=40) learned the statistical regularities between cue-stimulus: the shape of a cue indicated whether a stimulus or pure noise would be more likely to be presented (detection expectation), and the colour signalled whether the stimulus would more likely be a face or house (content expectation). They went on to complete a no-report version of the task during MEG scanning. We used the Higher Order State Space (HOSS) model (Fleming 2020), to compute the KL divergences, the degree of belief updates, as proxies for both content and awareness PEs for each cue-stimulus pairing. We performed a multiple linear regression on the broadband data using the model derived KL divergence for both content and detection PEs across all MEG channels at each time point. Preliminary univariate analyses suggest content PEs emerge at posterior sensors around 200ms post-stimulus, occurring earlier in time than awareness PEs. To further characterise these effects, we applied multivariate decoding techniques that more sensitively captured the informational content, stability and transformation of the neural representations associated with content and awareness predictions and PEs across time.

Poster 60

An integrated virtual reality platform for naturalistic neuroimaging with magnetoencephalography

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Understanding the neural basis of real-world behaviour requires neuroimaging technologies that allow for movement and naturalistic perception. Optically pumped magnetometers (OPMs) enable wearable magnetoencephalography (MEG), offering high spatiotemporal resolution even during participant motion. However, integrating OPMs with virtual reality (VR)—which enables immersive, controllable environments—has been hindered by the electromagnetic

interference of conventional head-mounted displays (HMDs). Here, we present and validate a novel, OPM-compatible VR platform designed for immersive neuroimaging. We developed a custom HMD using low-noise liquid crystal displays and open-source electronics, generating two orders of magnitude less magnetic interference than commercial VR systems. The headset integrates with optical motion capture and standard VR software (e.g., Unity, Unreal Engine) to enable naturalistic behavioural paradigms. We validated the system through a combination of hardware-level tests and seven experimental tasks across perceptual and cognitive domains. Results show that magnetic noise introduced by the HMD is minimal, and does not impair source localization accuracy. We also show that the system reliably captures canonical experimental effects: alpha-band increases during eye closure, visual cortex responses to lateralized flickering stimuli, beta-band suppression and source localization in motor cortex during grasping, and theta-band activations in medial frontal gyrus and hippocampus during N-back and imagination tasks, respectively. Together, our results confirm that this VR system enables whole-brain OPM-MEG recordings in immersive environments without compromising data quality. The open-source design offers a scalable platform for studying embodied cognition under ecologically valid conditions, expanding the possibilities for naturalistic neuroscience.

Poster 62

From Visual Features to Semantic Categories: MEG Evidence for the Time Course of Mathematical Object Processing

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The ability to recognize mathematical objects as belonging to specific categories—such as identifying "one" and "two" as integers, or "triangle" and "rectangle" as geometric shapes—is a fundamental aspect of human cognition. However, how this symbolic information is represented in the human brain remains far from being fully understood. In our study, we recorded brain activity using MEG while participants performed a non-mathematical stimulus detection task. During the task, they were presented with mathematical objects from three categories: integers, fractions, and geometric shapes. These objects were shown in two formats: a verbal format (e.g., "one," "two," "rectangle") and a visual format (e.g., "1," "2," "■"). We used Representational Similarity Analysis (RSA) to model the contributions of low-level visual features and category-level representations. Our preliminary, time-resolved RSA results indicate that low-level visual features are processed early for both formats, while category-level information—reflecting semantic processing—emerges later in time.

Poster 64

Layered cortical dynamic causal modelling of magnetoencephalographic somatosensory evoked responses

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Translational Neuromodeling Unit

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The layered architecture of cortex is thought to play a crucial role in understanding its local computations. However, there is no way to directly infer the spatiotemporal structure of layered cortical activity from non-invasive electrophysiological measurements as sensor data arise from a combination of activity from all cortical layers. Previous studies using magnetoencephalographic data have focused on spatial aspects and could reliably distinguish between sensor data originating from upper/lower layer cortical surfaces by constructing layer-specific lead field matrices which take into account the spatial distance between the two surfaces. Other approaches focused on dynamical aspects by modelling activity with a layer-specific canonical microcircuit (CMC) which posits that measured data can be explained by the combination of supragranular and infragranular pyramidal cell populations. However, these models do not consider the distinct spatial properties of the two populations as both populations are modelled in a single equivalent current dipole in the forward model. In our study, we used a dynamic causal model (DCM) for the CMC as implemented in SPM to model somatosensory responses evoked by median nerve stimulation measured by MEG. Here, we combined the dynamical modelling with a spatial model which consists of two separate current dipoles for the modelled supra/infragranular populations. We first tested the approach with simulated MEG data where the two dipoles were positioned in the centre of area Ba3b of the primary somatosensory cortex with the same orientation and a distance of ~2mm perpendicular to the cortical surface. Model comparison correctly distinguished ($\Delta F>3$) between a model that assigns the dipoles to the correct population activities (i.e. upper layer dipole to supragranular population and lower layer dipole to infragranular population) and a model where the assignment is reversed. Second, we illustrate the application of the layered DCM to a real dataset. While in simulations, dipole position/orientation were fixed and chosen a priori, here they were constrained to vertices of a laminar mesh and source localisation was applied in order to infer the optimal vertex before inverting the layered DCM. Model comparison indicated that the correct layered model was favoured when the model is applied to real data, suggesting that the assumed assignment of population activity to layers holds true for actual MEG measurements.

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Brain-to-Speech: Non-invasive Decoding of Imagined Speech enhanced with Large Language Model (LLM)

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Decoding of speech holds the potential to support patients with severe brain injuries or late-stage neurodegenerative diseases. Depending on stage and severity, these patients who suffer from a state called “locked-in syndrome”, are fully conscious but unable to move or communicate. While these conditions cannot be cured, communication aids based on decoding language directly from brain activity could have a transformational impact on their life. In recent years, there has been significant progress in the decoding of speech representations in the human brain. However, most of these advances have relied on invasive neuroimaging techniques such as intracranial electroencephalography (iEEG). This study investigates a novel MEG based decoding pipeline for imagined speech as an alternative to invasive approaches, by demonstrating its decoding abilities on a 50-word set and a set of 50 unique sentences built exclusively from this word corpus. It combines approaches that have successfully decoded language and visual perception from non-invasive MEG recordings with pipeline architectures developed for invasive communication brain–computer interfaces. These pipelines rely on language models as a correction signal for sentence decoding, enriching neural predictions with most likely next word in natural language. The decoding methodology is a combined architecture, which (1) identifies imagined speech from raw MEG recordings, (2) maps the signal to the latent representation of a deep artificial neural network architecture, to evaluate the most likely next word prediction, and (3) enhances the imagined speech prediction on a sentence level with a language model. We will compare the performance of mapping to latent representations of two pre-trained open-source models, comparing wave2vec, a transformer-based model which was trained exclusively on auditory data and UniAudio, a novel foundational model for audio generation. For the language model, we will further compare the potential performance increase of using in-context learning on OpenAI’s ChatGPT 4o model against 5th-order interpolated Kneser-Ney n-gram. The proposed pipeline is tested on a single subject which has conducted 5 experimental sessions of 2 hours in the MEG laboratory. The decoder is trained on a total of 3500 single word trial recordings and tested on 50 unique sentences. We will present preliminary results from our proposed pipeline that benchmark against previously reported results in the field.

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Determining sensor geometry and gain in a wearable MEG system

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Optically pumped magnetometers (OPMs) are compact, lightweight sensors capable of detecting the pico-to-femtotesla magnetic fields generated by neuronal activity in the brain. These sensors enable the development of advanced magnetoencephalography (MEG) systems with significant advantages over conventional MEG technologies, including adaptability to individual head shapes, tolerance for subject movement, and improved data quality[1]. However, fully realizing the potential of OPM-based MEG depends critically on accurate system calibration—determining each sensor’s position, orientation, sensitivity, and gain (the relationship between sensor output and the measured magnetic field. This calibration is particularly challenging in OPM systems, where sensor placement can vary between subjects, unlike conventional MEG systems with fixed sensor arrays. In this work, we present two novel methods for OPM calibration, both relying on the generation of accurate, well-characterised magnetic fields across the sensor array[2]: 1) HALO – A head-mounted calibration system that produces dipole-like magnetic fields using a set of coils placed around the head. 2) Matrix Coil – A room-scale system with coils embedded in the walls of a magnetically shielded room to generate uniform, controllable fields[3]. Both approaches provide precise calibration, with sensor position errors within 2 mm of ground truth, and show strong agreement with each other. When applied in human MEG experiments, both methods significantly improve signal-to-noise ratio compared to calibrations based on assumed sensor configurations. Since publication of this work[4], we have refined the matrix coil method, reducing acquisition time from approximately 20 seconds to just 1 second and enhancing repeatability. These improvements have lowered localisation error variability from ~1.5 mm to ~0.4 mm. Overall, we demonstrate the essential role of accurate calibration in OPM-based MEG and take a substantial step toward the routine use of OPM technology in neuroimaging applications. [1] Brookes et al. (2022), Trends Neurosci 10.1016/j.tins.2022.05.008; [2] Iivanainen et al. (2022), Sensors 10.3390/s22083059; [3] Holmes et al. (2023), Neuroimage 10.1016/j.neuroimage.2023.1201; [4] Hill et al. (2025), Imaging Neuroscience 10.1162/imag_a_00535;

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Localization of non-cortical sources in MEG

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There has been active debate about whether MEG can be used to measure sources beyond the cortex. Several groups have reported the detectability of activity in the cerebellum, thalamus, hippocampus, and even the spinal cord. We present two studies that support these claims. Data were collected using a 275-channel CTF axial gradiometer system. In the first study, we used a sensory-motor task designed to elicit cross-hemispheric communication to probe activity in the corpus callosum. Specifically, we employed the Sperry task, an interhemispheric transfer task involving visual stimuli and assigned button responses, to evoke bilateral responses in regions associated with visual, language, facial processing, and motor control, thereby driving communication between the brain hemispheres. A cohort of eight participants was scanned using MEG during the Sperry task and underwent structural MRI (T1-weighted) scans. An LCMV beamformer was used to construct a source model of the MEG data. The data were analyzed using both virtual channel evoked field methods and a general linear model (GLM) relating stimulus onset to button response. In both, we found significant evidence of white matter activation ($p < 0.05$). In the second study, we investigated the detectability of cerebellar activity using an eye-blink conditioning (EBC) paradigm. Event-related beamformer results revealed dynamic interactions between the cerebellum and prefrontal cortex during trace EBC. Notable findings included bilateral auditory components, lateralized responses in the medial and lateral prefrontal cortices, and activation in the right cerebellar lobules HVI and HVII. We conclude with simulations that explore the limits of detectability for these deep brain structures.

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Development of an atomic gradiometer for human brain stimulation

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In recent work [1], we showed the efficacy of an intrinsic gradiometer for the detection of human biomagnetism. We now present the next generation of this sensor. By using simplified integrated optics, printed circuit boards, and a modular design, we have improved the mechanical rigidity and decreased the standoff from the human scalp. Due to these factors, the extraction of human brain signals is more robust and can be achieved with fewer trials. The purpose of this sensor is to record MEG signals right after transcranial magnetic stimulation pulses. We are now at the stage of phantom testing and validation. We will show a sensor recovery time of ~20ms post-TMS pulse, which will allow for measurement of TMS-evoked oscillations. We will describe the setup used to perform the experiment, as well as preliminary results. [1] H. Cook et al., An optically pumped magnetic gradiometer for the detection of human biomagnetism, Quantum Sci. Technol. 9 035016 (2024).

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Infra-slow oscillations across the human brain and their role in the oscillatory hierarchy

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Infra-slow neural oscillations (<0.2 Hz) have long been suggested to play a role in top-down information processing, but the phenomenon has remained understudied. Previous non-invasive imaging (M/EEG, fMRI) and invasive intracranial (ECoG) studies in humans have shown infra-slow oscillations supporting network connectivity during resting-states and sleep vs. wakefulness. However, there is limited intracranial electrophysiological evidence on their spatial organization, inter-areal coherence in the infra-slow range, and their role in the oscillatory hierarchy above 1 Hz, which is commonly considered the oscillatory domain of cognition and behaviour. In this study, we explored the properties of infra-slow oscillations in intracranial depth EEG recordings of 33 epileptic patients undergoing epileptic monitoring while completing a variety of tasks. Contacts with most-prominent infra-slow spectral power (top 15%) were distributed more medially in comparison to the rest, but the two populations did not differ on the dorso-ventral and antero-posterior axes. Cross-contact phase locking analysis on infra-slow prominent contacts revealed temporally coherent pairs in the infra-slow range with significant lags in the order of seconds and in various grey matter areas, such as the amygdala, insula, and hippocampus, precluding the possibility that they resulted from a common driving source. In terms of local processing, multiple infra-slow prominent contacts demonstrated statistically significant phase-amplitude-coupling between infra-slow phase and delta (1-3 Hz), theta (4-8 Hz), gamma (35-70) or broadband high gamma (70-150 Hz) power, while a small subset of all contacts revealed simultaneous multi-level phase amplitude coupling between all band pairs up to the gamma band. In summary, we spatially map the distribution of

prominent infra-slow oscillatory activity in the human brain during wakefulness in a large number of participants, show spatial patterns of inter-areal coherence in the infra-slow range and demonstrate phase-coupling across the oscillatory hierarchy to the infra-slow phase. These findings lend support to the suggestion that infra-slow oscillations represent a broad organizational timescale on which state-dependent brain activity is orchestrated