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OMEGAS 2025
DUNDEE

SYMPOSIUM PROGRAMME

Programme overview

Tuesday, 9 December

Time	Venue	Event	Speakers
8:45	Foyer	Registration & Coffee	
9:15	LT4	Welcome	
9:30	LT4	Guest talks	Caroline Witton Krish Singh
10:45	Mezzanine	Coffee break	
11:00	LT4	Guest talks	Tim Tierney Mark Woolrich
12:15	Mezzanine	Lunch	
1:30	LT4	Short talks	Negin Ghahremani Arekhloo Simon Hanslmayr Isla Barnard James Dowsett Charlotte Keach Daniele Faccio
3:00	Mezzanine	Coffee break	
3:15	LT4	Guest talks	Svenja Knappe Olaf Hauk
4:30	Foyer	Poster session & wine reception	
5:45		Poster session ends	
7:00	DCA	Speakers' dinner with consortium members	

Wednesday, 10 December – For consortium members

Time	Venue	Event	Speakers
8:45	Foyer	Registration & Coffee	
9:15	LT4	OPM manufacturer talks NatMEG	Cerca Mag4Health Fieldline Daniel Lundqvist
10:45	Mezzanine	Coffee break	
11:00	LT4	Short talks from local facilitators	TayMedConnect SINAPSE Quantum ARC
12:00	2G14	Business meeting	OMEGAS
1:00		Symposium ends	

The OMEGAS consortium

We started the OMEGAS consortium – OPM-MEG Action Scotland – to acquire an optically pumped magnetoencephalography (OPM-MEG) device at a Scottish University that will be available to researchers and clinicians across Scotland. This would be the first OPM-MEG system in Scotland, and it would open novel neuroimaging capabilities for basic, clinical, and applied research.

More information here: https://sites.dundee.ac.uk/omegas/

The OMEGAS consortium is currently funded through the SFC

Organisation committee

Anne Keitel	Reader in Cognitive Neuroscience, University of Dundee
Christopher Benwell	Senior Lecturer in Cognitive Psychology, University of Dundee
William McGeown	Reader in Psychology, University of Strathclyde
Christian Keitel	Lecturer in Cognitive Neuroscience, University of Dundee

With support from

Sanna Fraser	PhD student in Psychology, University of Dundee
Bryony Buck	Research Associate, Psychology Technician, University of Dundee

Talks

9:30 – 10:05 (online)

Setting up a paediatric clinical research lab with Helium-based OPMs

Caroline Witton, Aston University Birmingham

In this talk, I will share our experience establishing a new OPM-MEG research laboratory and present our first findings. I will outline the clinical MEG background that motivated the creation of this facility, which is designed with a specific focus on recording data from young children. I will discuss the key questions that guided our decision to adopt 4Helium OPMs, along with the technical and practical challenges we encountered during setup. Finally, I will present our initial results, including fundamental neuroscience recordings and early clinical insights from children with epilepsy.

10:10 – 10:45

MEG-measured oscillatory markers of brain function: Understanding mechanisms of disease and pharmacological target engagement

Krish Singh, University of Cardiff

In recent years there has been significant lack of progress in understanding both the neurobiological mechanisms underpinning neuropsychiatric conditions such as schizophrenia and bringing forward effective new pharmacological treatments that help ameliorate symptoms for each individual.
In this talk, I will argue that MEG, whether based on OPM or SQUID sensors, represents the best non-invasive tool we have to probe brain function disruption in these diseases, including changes in synaptic excitation/inhibition balance arising from impairments in specific neurotransmitter systems. This is because, within an individual, MEG provides a high-resolution window on to bulk estimates of layer-specific local-field potentials that are sensitive to disease-related disruptions of synaptic function, but also can probe whether novel drug targets show target engagement with the relevant neuronal circuitry. Importantly, these MEG-derived measures are directly translatable from the in-vitro and in-vivo animal models that are often used in both mechanistic studies of disease and early-phase pre-clinical animal models of new drug compounds.
In this talk I will illustrate this with some recent work from our lab showing MEG-measured oscillatory markers of network disruption in Schizophrenia, pharmaco-MEG work using a variety of drug targets and finally our recent early-phase clinical trial work helping a new drug company to understand whether their new AMPAR modulating drug, designed to treat depression, shows modulations of brain oscillations in the human brain, hence demonstrating the expected target engagement.

11:00 – 11:35 (online)

Mobile OPM systems

Tim Tierney, University College London

OPMs enable imaging of the entire human nervous system during natural, unrestrained behaviour. In this talk, I will present our work to realize this goal. I will focus on overcoming technical challenges through novel system design and computational modelling. I will also highlight the novel neuroscience applications enabled by this technology. These include simultaneously imaging the brain and spinal cord, brain imaging during whole-body movement, and mapping cognitive functions such as memory and spatial navigation.

11:40 – 12:15

Brain network dynamics in clinical research

Mark Woolrich, University of Oxford

This talk outlines methods for extracting rapid brain network dynamics from MEG data using Hidden Markov Models (HMM). We demonstrate how this framework provides subject-specific summary measures for clinical research, categorized into features describing the network states themselves (e.g., power and coherence) and features describing how they dynamically activate (e.g., fractional occupancy and switching rates). The clinical utility of these measures is illustrated through an application to Alzheimer's disease, where distinct alterations in network dynamics are observed. Finally, we introduce a new "Canonical HMM" approach which leverages large-scale MEG datasets to allow smaller, lower-quality clinical research studies—including those using lower-quality modalities (e.g. EEG) —to be effectively denoised and mapped into a common reference space.

3:15 – 3:50 (online)

Towards clinical high-density full-head on-scalp MEG

Svenja Knappe, Fieldline & University of Colorado, Boulder

Optically-pumped magnetometers (OPMs) combine high spatial and temporal resolution with the ability to track brain activity even when a subject is moving, making them ideal for long-term monitoring—especially for children or others who have difficulty staying still. OPMs offer the advantage of being cryogen-free, potentially lowering operational costs and simplifying the setup compared to traditional MEG systems. Although several research sites have already begun using wearable OPM-based MEG systems in both children and adults with epilepsy and autism, the technology still needs to be tested systematically in larger groups. We present first results of an ongoing cross-validation study performed in 28 adult patients with drug-resistant focal epilepsy to date. To assess the OPM data quality, subjects underwent simultaneously EEG and MEG recordings on a cryogenic MEG system and an on-scalp MEG system. Interictal activity was localized from resting-state recordings and the locations were compared between the recordings with different modalities. In addition, somatosensory-evoked activity was recorded and localized. 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.

3:55 – 4:30

Multidimensional connectivity methods for EEG/MEG analysis

Olaf Hauk, University of Cambridge

My talk will most cover material summarised in this paper:
https://www.tandfonline.com/doi/full/10.1080/23273798.2023.2226268#abstract.

Short talks

1:30 – 1:45

Scalable and low-cost magnetic sensors-Neuranics MCG-TMR.

Negin Ghahremani Arekhloo, Neuranics

Magnetocardiography (MCG) measures the tiny magnetic fields generated by the heart's electrical activity. The presentation begins with a brief overview of the potential diagnostic advantages of MCG from a clinical perspective. It then demonstrates contactless MCG measurements acquired inside a magnetically shielded room, followed by recordings obtained in ambient, unshielded environments using the Tunnelling Magnetoresistive (TMR) sensors developed at Neuranics. These sensors are capable of detecting magnetic fields of a few pico-tesla, enabling reliable cardiac measurements without contact. Also, their low cost and scability offer a pathway toward portable and wearable out-of-hospital cardiac monitoring.

1:45 – 2:00

MEG and flickering movies, from basic science to neurotech

Simon Hanslmayr, University of Glasgow

Over the past eight years, we have employed rhythmic sensory stimulation (RSS) using flickering movies and sounds to entrain hippocampal oscillations. Combining this approach with MEG and EEG enabled us to test fundamental principles of synaptic plasticity, including spike-timing-dependent plasticity (STDP) and theta-phase-dependent plasticity. In this talk, I will present a series of studies where RSS in the theta and gamma frequency ranges allowed us to confirm key predictions derived from these mechanisms in human episodic memory tasks. These findings are exciting for two reasons: (a) they bridge the gap between plasticity processes observed in animal brain slices and those operating in humans during memory formation, and (b) they open avenues for developing wearable neurotechnologies aimed at improving memory function in clinical populations.

2:00 – 2:15

Focused ultrasound neuromodulation of mediodorsal thalamus disrupts decision flexibility during reward learning

Isla Barnard, University of Dundee

Value-based decisions rely on prefrontal cortex computations, yet work in animals suggests these processes are shaped by thalamic input. If the thalamus can regulate value-based choice in humans, this has clinical implications; as impaired decision flexibility contributes to apathy and impulsivity, and the thalamus is already a routine neuromodulation target for tremor.
We studied patients undergoing MR-guided focused ultrasound (MRgFUS) thalamotomy for essential tremor (n=37) using the restless bandit reinforcement learning task pre and post operatively (with n=32 healthy controls). Thalamotomy reduced switch behaviour ($P<0.001$) without affecting accuracy or response time, indicating a selective loss of decision flexibility and adoption of a more deterministic strategy. Reinforcement learning fits reproduced this change when the model increased exploitation of learnt value estimates.

The degree of reduced flexibility correlated with post-operative oedema extending into the mediodorsal (MD) nucleus ($R=0.64$, $p<0.001$), but not the clinically targeted ventral

intermediate nucleus (VIM). A probability map of a region in MNI space where oedema is most likely to reduce switch behaviour is presented.
To explore whether this MD region can be modulated directly, we are running an intraoperative study. The restless bandit task is administered before and during surgery, after applying a low-temperature HIFU sonication of the MD region. Matched intraoperative controls perform the task under identical conditions after sonication of the VIM (as standard during MRgFUS). This ongoing study is designed to determine whether reversible thermal neuromodulation of the MD thalamus alters value-based choice during surgery. Preliminary findings indicate, in a subset of patients, low-dose MD sonication produces short-lived changes in choice behaviour consistent with altered flexibility, indicating neuromodulation of the thalamocortical circuit identified in the main cohort.

2:15 – 2:30

Decoding real-world visual scenes from the human gamma band with flicker-evoked oscillations

James Dowsett, University of Stirling

Current approaches to investigate the role of neural oscillations in natural scene processing have been limited to artificial stimuli and long data collection. We present a new way to decode real-world scenes participants are viewing from the steady-state visual evoked potentials (SSVEPs) evoked while wearing flickering LCD glasses. We discovered that SSVEP responses from real world scenes are surprisingly complex and have distinct waveform shapes: they differ markedly across scenes and participants but are consistent within individuals, even across multiple days. SSVEP shape varies greatly between stimuli, but is reliable, meaning that decoding works even with a single electrode. Decoding is highly accurate with 5-10 seconds of data and was still above chance level with less than a second of data. Decomposing the SSVEPs into frequency bands showed that the information about the visual scene is present across all of the harmonics of the flicker frequency, but with 40 Hz (gamma band) showing the highest amount of information across the different flicker frequencies tested. These findings implicate a broad range of oscillations in encoding real-world scenes, with a particular importance for 40 Hz. The SSVEP's temporal profile is a rich source of information for decoding.

2:30 – 2:45

Measuring Brain Response Using Simultaneous Transcutaneous Vagus Nerve Stimulation (tVNS) and Magnetoencephalography (MEG)

Charlotte Keatch, Swinburne University of Technology; Elisabeth Lambert, Swinburne University of Technology; Will Woods, Swinburne University of Technology; Tatiana Kameneva, Swinburne University of Technology

Transcutaneous vagus nerve stimulation (tVNS) is a form of non-invasive brain stimulation that delivers a sequence of electrical pulses to the auricular branch of the vagus nerve and is used increasingly in the treatment of health conditions such as epilepsy and depression. Recent research has focused on the utilisation of tVNS to treat different medical conditions, although there is little conclusive evidence into the optimal stimulation parameters, such as stimulation frequency, pulse type or amplitude. Understanding whether variation of these stimulation parameters can directly influence the brain response could improve treatment efficacy. There are relatively few studies that have combined simultaneous tVNS with a neuroimaging modality such as magnetoencephalography (MEG) due to the presence of large stimulation artifacts produced by the electrical stimulation which are several orders of magnitude larger than underlying brain activity. We developed a novel stimulation artifact

removal method to allow simultaneous MEG and tVNS. Through application of this stimulation artifact removal method, we used MEG to gain insight into the regions of the brain most strongly influenced by tVNS and how variation of the stimulation parameters affected this response. The results from a preliminary study in healthy participants suggests that different stimulation frequencies can activate different areas of the brain. This has led to the development of a personalised stimulation protocol where we measure an individual's brain activity and then stimulate based of the individual's neural dynamics, which we are currently trialling in a cohort with depression. It is hoped that this personalised stimulation methodology may improve the efficacy of stimulation for each individual by activating brain areas that have been linked to mood and cognition. This may lead to the development of tVNS as a therapy tool for depression and other mood disorders.

2:45 – 3:00

Single-shot visual semantic classification with commercial TD-fNIRS

Daniele Faccio, University of Glasgow

Functional near-infrared spectroscopy (fNIRS) is a promising sensing modality for monitoring brain activity, with significant potential applications in non-invasive medical diagnostics and monitoring, and brain computer interfaces (BCIs). We demonstrate single-shot classification of visual semantic meaning using a commercially available time domain fNIRS device, illustrating applicability of fNIRS for future real-time BCIs.
Participants veiwed images from 5 classes, randomly sampled from a dataset of 60 images per class. 1600 channels are measured with TD-fNIRS, using the Kernel Flow 2 device, and HbO and HbR concentrations are calculated according to. We then multiclass classification, predicting the label of a given trial across all 5 classes, with average accuracy of 48% respectively, where 20% accuracy corresponds to random chance. While we do not currently see significant transfer between subjects i.e. train on one, test on the other, we do observe similar test performance on all participants, with small training sets captured in under 30 minutes. We will also discuss the opportunity for future work to be based on multimodal brain sensing e.g. in combination with MEG.

Posters

1 Normative Modelling of Resting-State EEG Across the Lifespan for Application in the Early Diagnosis of Alzheimer's Disease and Frontotemporal Dementia

Sanna Fraser, University of Dundee; Mihaela Lyutskanova, University of Dundee; Tom Gilbertson, University of Dundee; Douglas Steele, University of Dundee; Christian Keitel, University of Dundee; Christopher Benwell, University of Dundee

We aim to develop normative models to facilitate the early diagnosis of Alzheimer's disease (AD) and frontotemporal dementia (FTD) using resting-state electroencephalography (EEG) signatures. We hypothesise normative modelling provides more accurate biomarkers than traditional case-control studies. This project will develop open-source normative models of resting-state EEG data (as a function of age, sex, and cognition), enabling iterative growth of the models by researchers worldwide. EEG is a non-invasive, cost-effective technique that is widely available in hospitals and normative modelling addresses the heterogeneity in neurodegenerative disorders (a factor often overlooked in case-control studies that focus primarily on average group differences). Existing and new resting-state EEG datasets from >8000 healthy controls (HC), >200 AD participants, and 23 FTD participants (aged 5-91 years) have been collected. Data preprocessing is conducted using MATLAB, and the normative model will be developed in Python. Preliminary resting-state eyes-closed EEG case-control comparisons were conducted. AD showed increased δ & θ and reduced α & β relative to HC. FTD showed decreased α and increased θ relative to HC, while AD showed increased θ relative to FTD. We will assess whether normative modelling provides better data separation than case-control analysis. EEG appears to be a promising tool in the early detection of AD. This project may advance normative modelling by facilitating research into other diseases. By incorporating richer data than traditional case-control studies, we may identify novel biomarkers that could inform new therapeutic interventions.

2 Dynamics underlying auditory working memory

Pradeep Dheerendra, University of Glasgow & Newcastle University; Timothy D Griffiths, Newcastle University, Wellcome Centre for Human Neuroimaging, University College London

We aim to understand the dynamics underlying auditory working memory for maintaining 'simple' tones. We recorded magnetoencephalography (MEG) in 17 subjects while they maintained one of the two presented tones (or ignore both in the control condition). After 12s, subjects compared the pitch of a test tone with the maintained tone.
Analysis of evoked responses showed persistent activity throughout maintenance compared to the pre-stimulus silent baseline but only at the start of maintenance when compared to the control condition. The evoked response during maintenance was source localised against baseline to bilateral auditory cortex. Analysis of induced responses showed suppressed alpha in the left auditory cortex, enhanced theta in medial prefrontal cortex, and enhanced beta in cerebellum.
In a second experiment, 19 new subjects were presented with a tone and a Gabor patch and a retro-cue indicating which to maintain for 12s. Analysis of the induced responses in auditory condition yielded similar results to first experiment.
Connectivity analysis showed that the theta activity in medial prefrontal was phase-locked to left hippocampus and left auditory cortex. The beta activity in cerebellum's phase-locking to left Inferior Frontal Gyrus (IFG) was correlated to subject's task accuracy.

Using MVPA, a LDA classifier was trained to decode the contents of AWM (discriminate b/w low vs high pitched tone) using beta band Phase Locking Value with right cerebellum as its features. A channel searchlight analysis showed that decoder performance at right Anterior Cingulate Gyrus (56.17% acc.) was above chance. Further, the decoder performance at Right STG was correlated (rho=0.725, $p<0.01$) to subject's task accuracy, showing a correspondence between encoding distance and behavioural performance.
Our data clearly shows a network of brain areas involving pre-frontal and hippocampus, IFG and cerebellum for maintaining sounds in the auditory cortex, consistent with previous fMRI [1] and ECoG experiments [2].

3 Enhancing memory in humans via MEG-closed-loop Rhythmic Sensory Stimulation (RSS) tuned to the frequency of hippocampal theta oscillations

Eleonora Marcantoni, University of Glasgow; Christoph Daube, University of Glasgow; Danying Wang, UCL; Chunyan Cao, Shanghai Jiao Tong University; Bomin Sun., Shanghai Jiao Tong University; Shikun Zhan, Shanghai Jiao Tong University; Daniel Bush, UCL; Simon Hanslmayr, University of Glasgow;

Hippocampal theta oscillations play a crucial role in the formation of episodic memories by binding multisensory information into coherent episodes. While Rhythmic Sensory Stimulation (RSS) at fixed theta frequencies (i.e., 4-Hz) has been reported to enhance memory, findings remain inconclusive. Fixed-frequency approaches do not distinguish genuine oscillatory activity from spurious rhythmicity, nor do they account for inter- and intra-individual variability in brain oscillations. Characterising hippocampal dynamics non-invasively in humans, however, poses a challenge, since the ability of MEG/EEG source reconstruction to reliably capture activity in deep brain regions remains debated.
Here, we provide evidence that hippocampal signals are visible in MEG sensors, and we propose a MEG-based analysis pipeline that tracks hippocampal theta dynamics over time.
To assess the hippocampal contribution to MEG measurements, we analysed a simultaneous MEG-iEEG dataset. Using a data-driven approach without biophysical priors, canonical correlation analysis (CCA), we identified shared components that were temporally, spectrally, and spatially aligned across modalities, indicating clear hippocampal contributions to the MEG signal. Notably, a simpler atlas-based univariate cross-correlation approach also recovered spatially specific hippocampal signatures.
To validate the ability of the pipeline to detect genuine theta oscillations reliably, we first applied it to a rodent dataset and replicated the well-established correlation between theta frequency and running speed. We then tested the pipeline on human MEG data using 4-Hz RSS, demonstrating that the estimated hippocampal frequencies shifted significantly toward the stimulation frequency of 4-Hz during the stimulation window. Finally, applying the pipeline to the simultaneous MEG-iEEG dataset, we demonstrated a statistically significant, above-chance correlation between theta frequencies estimated from MEG and those directly measured from hippocampal iEEG.
These findings provide evidence that MEG can reliably track individual hippocampal dynamics, providing a validated framework for future closed-loop interventions that adapt stimulation frequency and timing to ongoing oscillations.

4 Effects of focused ultrasound thermal neuromodulation of the mediodorsal thalamus on value-based decision making

Isla Barnard, University of Dundee; Graeme MacKenzie, University of Dundee & NHS Tayside; Will Gilmour, University of Dundee & NHS Tayside; Jen MacFarlane, NHS Tayside; Sadaquate Khan, University of Dundee & NHS Lothian; Douglas Steele, University of Dundee & NHS Tayside; Tom Gilbertson, University of Dundee & NHS Tayside

Previous work indicates that modulation of the mediodorsal nucleus could alter human choice stochasticity in reinforcement learning tasks. We are conducting an intraoperative study in patients undergoing MR-guided focused ultrasound (MRgFUS) for essential tremor to test whether reversible low-temperature sonication of the MD thalamus produces measurable effects on exploration–exploitation behaviour. A four-armed restless bandit task is delivered pre-operatively and again after a brief non-ablative thermal exposure to the MD region. This approach allows direct assessment of thalamic contributions to choice behaviour while avoiding tissue damage. To characterise the neuromodulatory dose, we simulate subject-specific volumetric acoustic and thermal fields to estimate the low-dose thermal energy deposition during the initial sonication. Behavioural data are fitted using reinforcement learning models to quantify changes in choice stochasticity, reliance on learnt value estimates, and exploration–exploitation balance.
This ongoing work is designed to determine whether transient thermal neuromodulation of the MD thalamus systematically shifts human behaviour. The study provides a mechanistic test of thalamic involvement in human decision flexibility and establishes a method for integrating assessments of cognition and decision making into the established MRgFUS neurosurgical infrastructure.

5 Toward EEG-Based Screening for Parkinson's Disease: Consistent Spectral Slowing in the Resting State

Mihaela Lyutskanova, University of Dundee; Sanna Fraser, University of Dundee; Christian Keitel, University of Dundee; Tom Gilbertson, University of Dundee; Douglas Steele, University of Dundee; Christopher Benwell, University of Dundee

Prior work consistently reports spectral slowing of EEG in Parkinson's Disease (PD) patients, characterized by increases in theta power and alpha power. These power increases are observed in both eyes open (EO) and eyes closed (EC) conditions, though findings vary across studies.
Building on these observations, this study hypothesized that EEG power in the theta and alpha frequency bands could reliably distinguish PD patients from healthy controls (HC). We analyzed EO RS-EEG from UC San Diego (HC: n = 16; PD: n = 15) and EC RS-EEG from Ninewells Hospital, University of Dundee (HC: n = 16; PD: n = 22). Spectral power was extracted from 1-40 Hz, and group differences were statistically compared.
In EO recordings, PD patients showed increased power in delta and theta bands. Similarly, in the EC dataset PD patients exhibited elevated power in the theta/low-alpha frequencies (6-8 Hz). These findings align with the established pattern of spectral slowing in PD.
Our study highlights the potential of EEG as a tool for PD screening by revealing consistent power differences in patients with PD across cohorts and recording conditions. Theta and low-alpha power emerged as the most reliable EEG markers in distinguishing groups.

6 Endogenous brain rhythms predict individual differences in speech comprehension

Tanja Atanasova, University of Dundee; Rosanne H. Timmerman, University of Dundee & Newcastle University; Anne Keitel, University of Dundee

Individuals differ widely in their ability to understand speech under challenging conditions, such as background noise, rapid speech, or intermittent interruptions. Endogenous brain rhythms, which are ubiquitous neural oscillations that vary across individuals may shape language processing. Our large-scale study (N = 400, age range 16 to 76, with diverse recruitment to address WEIRD [Western, Educated, Industrialised, Rich, and Democratic] population biases) investigates whether resting-state EEG rhythms predict speech comprehension abilities, independent of peripheral hearing. Participants complete a 10-minute EEG recording and three behavioural speech comprehension tasks: noise-masked, time-compressed, and interrupted speech. In all comprehension tasks, difficulty level was parametrically modulated. By modelling individual peak frequencies and amplitudes, we aimed to disentangle how these rhythms might facilitate comprehension.

Initial analyses confirmed broad inter-individual differences in task performance across all tasks. However, we also observed that task performance was correlated across participants. Individuals who were good at comprehending noise-masked speech tended to also perform well with time-compressed and interrupted speech, suggesting a potential role of general top-down mechanisms that influences comprehension. Electrophysiologically, brain rhythms were organised into topographically distinct patterns, with for example theta being most prominent in central auditory electrodes and alpha being most prominent in occipital electrodes. We found several rhythmic patterns that influenced speech comprehension, particularly at more difficult levels. For example, the individual auditory theta peak frequency predicted comprehension in the time-compressed speech task: faster theta rhythm was associated with better comprehension of fast speech. On the other hand, individual theta amplitude was associated with comprehension of noise-masked speech. Interestingly, the auditory alpha amplitude at rest predicted overall speech comprehension - lower alpha was associated with better performance across tasks. These associations persisted after controlling for hearing thresholds, underscoring the role of central auditory processing.

Our study bridges a critical gap between basic neurophysiology and real-world listening. These findings could inform personalised interventions (e.g., hearing aids tailored to neural profiles) and refine theoretical models of speech perception across populations. Ultimately, our findings suggest that the brain's rhythmic architecture is a foundational aspect of auditory comprehension, offering a neurophysiological framework to better understand individual variability in communication abilities.

7 Localising long-term oscillatory and aperiodic trends using MEG

Martina Kopčanová, University of Dundee; Daniel Kluger, University of Münster; Elio Balestrieri, University of Münster; Niko Busch, University of Münster; Joachim Gross, University of Münster; Gregor Thut, CNRS-University of Toulouse; Christopher Benwell, University of Dundee; Christian Keitel, University of Dundee

Research on brain-behaviour relationships often assumes these derive from trial-to-trial stochastic fluctuations, neglecting long-term non-stationarities in EEG signals. In an earlier EEG study, we showed that during a visual discrimination task, alpha and beta power systematically increased over time, while alpha frequency decreased. These results established the oscillatory nature of long-term EEG non-stationarities and emphasised the need to account for time-on-task when testing oscillatory brain-behaviour relationships. Controlling for time-on-task enables better understanding of oscillations' functional roles by removing spurious correlations and separating different

oscillatory contributors to behavioural variability. However, whether alpha non-stationarities arise from different mechanisms with separable functions remains unknown. We aimed to identify brain areas showing changes in power, frequency, or both using an existing MEG dataset with anatomical MRI scans. We replicated our earlier findings: widespread power increases across 1-30Hz and decreased peak alpha frequency. Although these effects were oscillatory, we also observed time-on-task effects on aperiodic activity (contrary to our EEG results). LCMV beamforming with Brainnetome atlas were used to localise the non-stationarities in peak alpha power and frequency in the brain. We found brain regions showing significant changes in power only, frequency only, and both combined. Power increases occurred in sensorimotor and early-visual structures within parietal, cingulate, and thalamic areas. Frequency decreases appeared in higher-order association areas across occipital, temporal, and inferior parietal regions. Functionally, areas showing only power increases primarily belonged to the dorsal attention network (DAN), while areas showing only frequency decreases mainly belonged to the default-mode network (DMN) and its visual-association extensions. These results demonstrate distinct alpha non-stationarities in different streams along the visual processing hierarchy, suggesting separable mechanisms underlying power and frequency changes during sustained task performance.

8 Intrinsic neural peak frequencies predict rhythmic behavioural preferences

Zillah Boardman, University of Dundee; Efstratios Koukouvinis, University of Glasgow; Sarah Allen, University of Dundee; Saara Varjopuro, University of Turku; Christian Keitel, University of Dundee; Anne Keitel, University of Dundee

Rhythmic behaviour (e.g., walking, speaking, tapping) is present in the daily lives of the majority of the population. Spontaneous Motor Tempo - the rate at which we show rhythmic motor behaviour with no external influence - varies substantially between individuals but has also been found to be consistent within individuals. This raises the question of where these individual differences in generating motor behaviour at specific rates arise. Some theoretical frameworks suggest that intrinsic neural rhythms are related to rhythmic preferences, but these hypotheses have not been empirically tested. We investigated whether Spontaneous Motor Tempo is predicted by EEG resting-state peak frequencies. We were additionally interested in how perceptual preference is related to intrinsic neural peak frequencies. Participants completed a finger tapping task (motor preference), a rhythm preference task (perceptual preference) and underwent 5 minutes of eyes-open resting state EEG recording. Peak Frequencies were extracted from the resting state EEG across all electrodes using a spectral fingerprinting approach. Our results show that theta peak frequency predicted both Spontaneous Motor tempo and perceptual preferences, albeit in different electrode clusters. Individuals with a faster theta frequency tapped faster and preferred to listen to faster rhythms, and vice versa. In addition, gamma peak frequency also positively predicted finger tapping tempo. These findings suggest that intrinsic neural rhythms are implicated in rhythmic and perceptual preferences, as predicted by neuroscientific theories.

9 The impact of rhythm on language and reading development

Justyna Skop-Wach, University of Dundee; Anne Keitel, University of Dundee; Lynne Duncan, University of Dundee

Regular rhythmic primes - musical sequences with evenly spaced beats - have been shown to enhance grammatical and syntactic processing in French-speaking children with developmental language disorder (DLD) and dyslexia. Rhythmic priming is thought to support language by enhancing temporal–attentional mechanisms shared with musical

rhythm, but it is unclear whether gains reflect improved auditory–phonological processing, enhanced syntactic parsing, or both. Evidence from English-speaking children remains limited and mixed, leaving open whether rhythmic priming generalises to English or benefits children with language and reading difficulties.
This study tests whether regular rhythmic primes improve grammaticality-judgment performance in English-speaking children aged 7-9 and whether individual differences in syntactic, phonological, reading, and rhythmic skills modulate any effects. Children will play a computer game in which, after hearing regular or irregular rhythmic primes, they either judge sentence grammaticality (main task) or complete a visual cancellation control task. Standardised language assessments and the Child Beat Alignment Test (ChildBAT) will provide cognitive–linguistic and rhythmic profiles.
Priming effects will be evaluated using signal detection metrics, reaction times, and regression models linking performance to language and rhythm abilities. Findings will inform targeted sampling for future studies and advance understanding of shared temporal–attentional mechanisms in speech/language and music, with implications for rhythm-based interventions."

10 Tractography identifies thalamo-cortical circuit linked to behavioural change after neurosurgical intervention

Shenshen Yang, University of Dundee; Tom Gilbertson, University of Dundee; Douglas Steele, University of Dundee; Isla Barnard, University of Dundee

Tractography is a neuroimaging technique that reconstructs and visualizes white matter fibre pathways in the brain using diffusion magnetic resonance imaging (MRI) data. The structural white matter connectivity can account for the behavioural effects induced by brain surgery. Here, a group of patients undergoing a surgery called MR guided focused ultrasound for essential tremor targeted at thalamus, were tested using the restless bandit, a decision flexibility task. We use probabilistic tractography to construct the thalamo-cortical circuit to explain the behaviour of choice inflexibility. Probabilistic fibre tractography confirmed significant clusters of connectivity between voxels where thalamus lesion and prefrontal cortex which was maximal with the frontal pole and dorsolateral prefrontal cortex. The significant clusters of thalamo-cortical structural connectivity correlated with the change in task behaviour are dorsolateral prefrontal cortex (BA9/46), orbitofrontal cortex (BA11) and frontal pole. Postoperative behavioural effects can be accounted for by thalamo-cortical white-matter connectivity. These findings demonstrate the utility of tractography for linking structural pathways to behavioural outcomes following neurosurgical intervention.

11 Goal-oriented plasticity of cortical speech tracking

Pepita Alex, University of Aberdeen; Marta Brzeska, University of Aberdeen; Irina Guliaeva, University of Aberdeen; Anastasia Klimovich-Gray, University of Aberdeen

Background: Cortical tracking of speech (CTS) is thought to be automatic, extended across the hierarchy of linguistic features, and serve as the key neural mechanism for speech analysis. CTS is modulated by both exogenous (noise) and endogenous (age, proficiency) factors, showing functional plasticity under varied cognitive profiles and demands. Here, we asked whether CTS also displays task-specific plasticity adapting to listening goals. We recorded 64-channel EEG from 30 participants (MeanAge = 22.7; 15 females) listening to stories in three conditions: a) No Goal, b) focused on narrator accents (Auditory Goal), or c) story content (Semantic Goal). We hypothesised that CTS of goal-compatible features would be selectively enhanced: acoustic (Envelope) and semantic (Surprisal) tracking would increase for Auditory Goal and Semantic Goal conditions, respectively. Methods: EEG signals were 0.5-15Hz bandpass-filtered, ICA-ed

for artefact removal, downsampled to 128Hz. CTS was measured via multivariate temporal response function modelling, predicting EEG from Envelope and Surprisal. Model prediction accuracy (r-values) estimated CTS fidelity across data-driven ROIs (significantly-decoding sensors across conditions). Results: Consistent with predictions, Surprisal CTS was reduced marginally for Auditory Goal compared to No Goal ($p = .056$), particularly in the temporo-parietal region ($p = .013$). However, Envelope CTS was also reduced for Auditory Goal compared to No Goal ($p = .026$) condition. No CTS changes were observed for Semantic Goal condition. Discussion: These results suggest that cortical tracking of both acoustic and semantic features shows goal-oriented flexibility only when attention is diverted away from the "default" content monitoring listening state.

12 Pupil Dilation and Eye Movements Track Emotion Content in Natural Speech

Sümeyye Şen Alpay, University of Dundee; Christian Keitel, University of Dundee; Rosanne Timmerman, Newcastle University; Anne Keitel, University of Dundee

Cortical tracking of speech features is a well-established marker of how the brain processes continuous speech, and recent evidence suggests that ocular responses may also show sensitivity to speech rhythm. Here, we examined whether pupil dilation and eye movements track the acoustic speech envelope, and how this tracking relates to emotion-related factors, including subjective emotion ratings, mood, and trait empathy. In a behavioural study (N = 100), participants listened to TED talks that had been divided into short segments and provided valence (negative–positive) and arousal (low–high) ratings for each segment. These ratings showed substantial variability across segments, indicating meaningful differences in the perceived emotional content of the speech. In a second study (N = 41), participants completed the same task while pupillometry and electrooculography (EOG) were recorded. Ocular tracking of the acoustic speech envelope was quantified using a mutual information framework focusing on low-frequency ranges between 0.5 and 12 Hz. Emotion-related effects were analysed using linear mixed-effects models. All ocular measures tracked the speech envelope and its derivative, with signal-specific frequency limits: pupil dilation up to ~7 Hz, vertical EOG up to ~9 Hz, and horizontal EOG up to ~12 Hz. Emotional factors modulated these effects. High-arousal speech increased pupil tracking but reduced vertical and horizontal EOG tracking, whereas negative valence was associated with stronger tracking in the pupil and vertical EOG signals. Interactions between emotion dimensions and listeners' mood further contributed to distinct patterns across measures. Together, these findings highlight the putative role of ocular envelope tracking as a complementary index of continuous speech processing and emphasise the importance of considering both the emotional characteristics of the stimuli and listeners' internal states.

13 Comparing Machine Learning Approaches for Seizure Detection in Neonates Using Multi-Channel EEG

Girijalakshme Erran Bothalraj, University of Dundee; K A Vidhya, Anna University

Neonatal seizures are a common neuropathic condition in Infants. Using EEG, accurate prediction of seizures is possible. Early detection of seizures can potentially prevent infants from adverse effects on infant neurocognitive development. In recent years, machine learning has been used to detect neonatal seizures. For seizure detection, this study presents a machine A learning (ML) -based architecture that operates on an equivalent architecture with predictive performance similar to previous models but minimized Level composition. The proposed classifier is trained and tested on public datasets of NICU seizures recorded in Helsinki University Hospital. Our architecture achieved the best performance at 87% sensitivity, 6% higher than standard The ML model

selected in this study. Machine learning algorithms support Vector Machine (SVMs), and K-Nearest algorithm (KNN) are used as a classifier to distinguish between seizure and non-seizure EEG epochs.

14 Disentangling the oscillatory neural mechanisms behind the maintenance and manipulation of internal memory representations: A multimodal M/EEG - TMS-EEG study

Katarzyna Jaworska, University of Glasgow; Mate Gyurkovics, University of East Anglia; Matias Palva, University of Helsinki; Gregor Thut, Universite de Toulouse; Satu Palva, University of Helsinki

Working memory (WM) and short-term memory (STM) are often used interchangeably in cognitive neuroscience literature, yet they denote different cognitive processes. Short term memory refers to the temporary storage of information, whereas working memory involves additional goal-directed manipulation of this information. Previous studies have shown correlational as well as causal evidence for involvement of brain oscillations at alpha (8-12Hz) and theta (4-8Hz) frequencies in the maintenance stage of visual WM/STM but without explicit differentiation of these two processes. Here, we investigate the causal relationship between oscillatory neural activity and behavioural performance in a task where participants had to either mentally manipulate the maintained information (WM) or not (STM).
In a change detection task, participants were retro-cued to maintain all stimuli (polygons and gratings) during a delay period (STM condition) or only stimuli belonging to one feature category (polygons or gratings), while ignoring non-cued stimuli (WM condition). Importantly, the retro-cue indicated the stimulus category, but not the visual field, to remember, thereby engaging feature-based memory processing. In the first part of this study, we recorded brain activity with simultaneous M/EEG from a sample of 50 participants. Source localized oscillatory power in the high-frequency alpha (10-14 Hz) band in parieto-occipital regions was increased during the maintenance (post-retrocue) period for WM compared to STM trials, while prefrontal theta power was decreased. We used these results to design the second study, where rhythmic transcranial magnetic stimulation (rhTMS) was applied at 11 Hz (to intraparietal sulcus) and 7 Hz (to prefrontal cortex) during the maintenance stage of the task, in a subset of the same participants (N = 26), while concurrently measuring EEG.
Rhythmic TMS had little effect on behavioural performance measured with accuracy or reaction times, when compared against sham stimulation. However, compared with performance in the first (M/EEG) part of this study, TMS stimulation at alpha frequency led to more improvement in WM accuracy, specifically in mid-range performers. Similarly, biggest TMS-induced improvements in accuracy were related to mid-range task-related MEG alpha power, suggesting an optimal level of alpha oscillations relevant for behaviour.

15 Are Facial action units to express communication difficulty perceived differently by people with and without hearing loss?

Ikraam Abukar University of Nottingham; **Bryony Buck, University of Dundee**

Hearing loss (HL) affects over 430 million people worldwide and is a major cause of communication difficulty. Increasing evidence indicates that individuals with HL rely more heavily on visual and facial cues during conversation, positioning HL as a form of disordered communication (DC) with meaningful multimodal implications relevant for healthcare intervention. This review synthesises research on facial action units (FAUs), facial expression recognition (FER), gaze behaviour, conversation repair, and facial

mimicry in HL to identify which facial cues most strongly support conversational understanding.
Using the Facial Action Coding System (Ekman & Rosenberg, 2002) as a framework, the review highlights gaps in the HL literature and extends interpretation through comparison with other forms of DC (e.g., autism, Parkinson's disease, schizophrenia, traumatic brain injury). Across studies, FAU 6 (cheek raiser) and FAU 12 (lip corner puller) muscle groups, which are key components of positive affect signalling (e.g. smiling), emerge as cues HL individuals attend to more frequently than normal-hearing (NH) populations, potentially facilitating speech comprehension. Evidence from DC populations also suggests altered or reduced facial mimicry in HL, particularly for FAU 4 (brow lowerer) and FAU 12.
Across domains, converging findings indicate that people with HL may generate or rely on different facial cues than normal-hearing (NH) individuals when navigating conversation. Identifying these FAU patterns provides a foundation for future research into underlying processes of multimodal communication strategies, compensatory mechanisms, and the design of socially informed support for people with HL.

16 Benefits of music training for learning to read: Evidence from cortical tracking of speech in children

Maria Garcia-de-Soria, University of Aberdeen; Brian Mathias, University of Aberdeen; Anne Keitel, University of Dundee; **Anastasia Klimovich-Gray, University of Aberdeen**

Reading development relies on strong auditory and phonological processing skills, both of which may be enhanced through musical training. Early childhood marks a sensitive period for rapid cognitive and neural changes where neural networks involved in language processing undergo specialization, potentially making them particularly receptive to experience-based activities like musical training. This study investigated the impact of musical training on children's reading abilities, focusing on neural and cognitive mechanisms linking music training and reading success. Sixty children aged 5 to 9 (half with formal musical training, matched on age, gender, socio-economic status, and cognitive ability) completed behavioural assessments of reading and phonological awareness (PA), alongside electroencephalogram recordings during audiobook listening. Using Mutual Information analyses, we examined Cortical Tracking of Speech (CTS) —how well brain activity synchronizes with auditory input— a known neural correlate of speech analysis. The results showed that musically trained children outperformed their peers in reading and PA tasks and exhibited a trend towards a more left-lateralized CTS, implying more mature cortical speech analysis. Regression analyses showed that greater left-hemispheric CTS lateralization predicted higher reading scores, especially in non-musical children. Finally, PA mediated the relationship between musical training and reading: better musicality predicted better PA skills which in turn predicted better reading. These effects were independent of age, gender, socio-economic status, and cognitive ability. These results show that musical training enhances reading development through phonological skills and in parallel aids maturation of the auditory speech processing within left-lateralized language networks. Furthermore, preliminary findings from a longitudinal follow-up conducted a year later showed that musically trained children continued to outperform controls on reading fluency, comprehension and PA tasks. These sustained benefits highlight the potential for musical training to support literacy through improved auditory and linguistic processing, with implications for educational interventions targeting children with reading difficulties like dyslexia.

17 A meta-(Re)analysis of periodic and aperiodic MEG/EEG components in Parkinson's disease

Hamzeh Norouzi, University of Stirling; Magdalena Ietswaart, University of Stirling; Jason Adair, University of Stirling; Gemma Learmonth, University of Stirling

Parkinson's disease (PD) presents with highly variable motor and non-motor symptoms, making the identification of consistent neurophysiological biomarkers both clinically valuable and scientifically challenging. Despite numerous studies reporting candidate electrophysiological signatures, findings often lack replication due to small sample sizes and methodological variability. To address this, we performed a meta-(re-)analysis of six open-access resting-state M/EEG datasets (4 EEG, 2 MEG), including 368 PD patients and 570 healthy controls. We examined both periodic (alpha/beta power and peak frequency) and aperiodic (exponent, offset) components of the power spectrum. Across datasets, PD patients showed robust increases in alpha power and slower alpha peak frequency, along with elevated aperiodic offset and exponent. No consistent group differences were observed in beta power or peak frequency. The observed alternations in aperiodic and alpha oscillations may reflect a complex interaction between disease progression and individual differences in physical and cognitive function. This meta-analysis offers a replicable electrophysiological profile of PD, and supports the potential of M/EEG as a tool for identifying consistent cortical electrophysiological changes in PD.

Further information

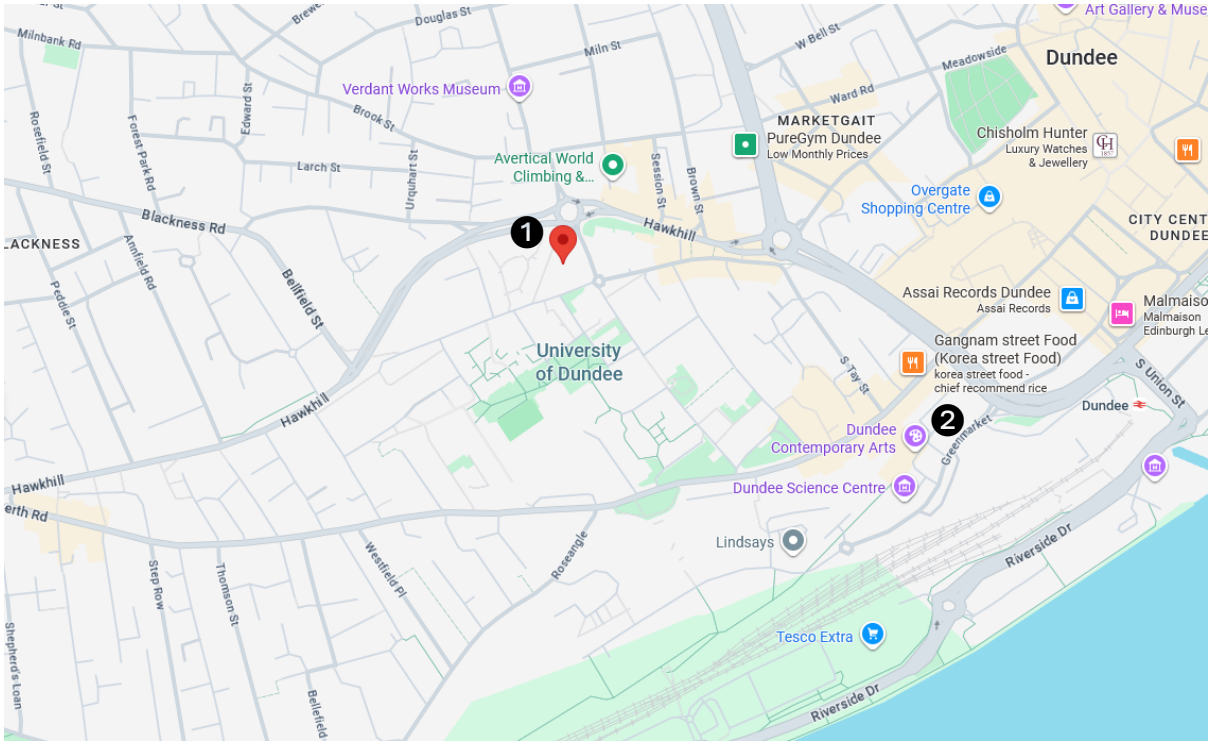
More information about OMEGAS here: https://sites.dundee.ac.uk/omegas/

Symposium venue

❶ Dalhousie Building, University of Dundee

Old Hawkhill, Dundee DD1 5EN

Location on Google maps – also see below



Speakers & consortium dinner venue

❷ DCA (Dundee Contemporary Arts / Jute Bar)

152 Nethergate, Dundee DD1 4EA

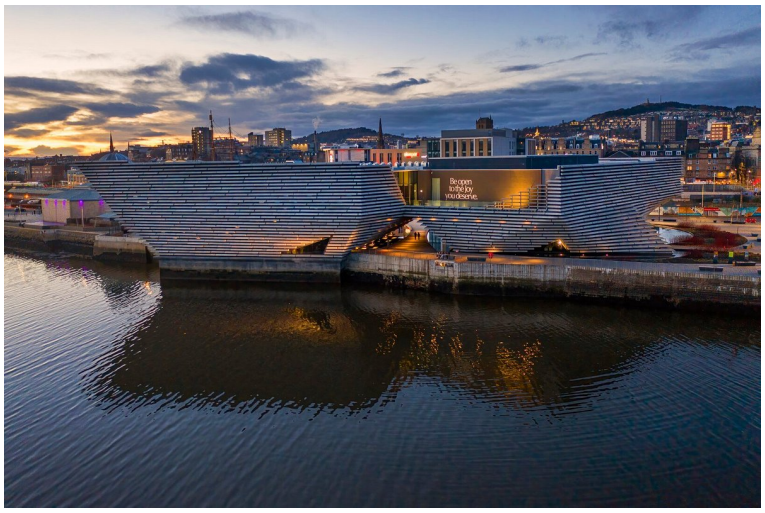
Things to do in Dundee

Dundee Law

If you are feeling like a refreshing walk, try going up Dundee Law. If the weather is nice, you'll be rewarded with fantastic views of the city and the surrounding areas. A round trip from the city centre and back should take about 1-1.5 hrs. (Of course, you can also take a taxi...)

V&A and the waterfront

Visit the museum or have an excellent coffee and the best freshly-made(!) donut in the city (outside food truck - "Heather Street Food") at the waterfront gardens.



McManus museum and art gallery

Learn more about Dundee's rich history and visit a range of galleries.