UNIVERSITY OF BIRMINGHAM

Emerging Techniques and Technologies to Understand the Thalamus

Conference Brochure

Edgbaston Park Hotel,
University of Birmingham

Monday 12 – Tuesday 13 January 2026

Contents

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Welcome Letter

Dear Colleagues,

Welcome to **Emerging Techniques and Technologies to Understand the Thalamus**, hosted by the Centre for Human Brain Health at the University of Birmingham in collaboration with the Thalamic Nuclei Neuroimaging Group (TANGO, https://thalamicsegmentation.github.io/). This workshop builds on the excellent series of events organised by TANGO to promote understanding of the diverse and critical role played by the thalamus in healthy and pathological brain function. As reflected in the excellent line up of speakers, we aim to bring together researchers from a wide range of disciplines who use a variety of approaches to study the thalamus. It promises to be an exciting couple of days!

If you haven't been here before, Birmingham is the UK's second city, was at the heart of the Industrial Revolution, and has a young, vibrant and diverse population. You may hear that Birmingham has more canals than Venice, although they are not always comparable in aesthetic terms. The University of Birmingham is one of the city's five universities and one of the oldest in the UK. It was founded in 1900, recently rising to 76th in the QS world ranking, and is part of the Russell Group of research-intensive UK universities. If you get time, a walk around campus or a visit to Winterbourne Gardens (https://www.winterbourne.org.uk/) is highly recommended.

In addition to a great set of talks, we have plenty of time for networking and socialising, including a complimentary social event at Clays Bar in Birmingham city centre on Monday evening (https://clays.bar/birmingham, a short walk from Birmingham New Street station, which is ten minutes on the train from University station).

We would like to express our gratitude to all speakers and participants for joining us, and to Louise and Chelsea from the events team for organising the workshop. We are grateful to the BBSRC and the Centre for Human Brain Health for sponsoring the meeting. We look forward to meeting you all on Monday and we hope you enjoy your visit.

Best wishes,

Andy Bagshaw, Emmanuel Barbeau, Meri Bach Cuadra, Roy Haast, Steve Mayhew

About Emerging Techniques and Technologies to Understand the Thalamus

Emerging Techniques and Technologies to Understand the Thalamus, taking place on the Monday 12th– Tuesday 13th January 2026 at the Edgbaston Park Hotel, University of Birmingham, is a two-day, single-track conference bringing together leading experts in neuroscience, psychology, clinical practice, neurostimulation, and neuroimaging. Attendees will explore cutting-edge developments in recording from and stimulating the thalamus both invasively and non-invasively, and new insights into the use of these developments in pathology and translation.

Through keynote lectures, invited talks from both established and early-career researchers, and interactive panel discussions, the meeting will foster critical dialogue and future collaborations across the core themes of measurement, stimulation, pathology and translation.

This event is supported by funding from the UK Biology and Biological Sciences Research Council and the Centre for Human Brain Health, and is organised in collaboration with the Thalamic Nuclei Neuroimaging Group (TANGO, https://thalamicsegmentation.github.io/).

This event has been organised and supported by:

- **Andrew Bagshaw,** Centre for Human Brain Health, University of Birmingham, UK
- **Emmanuel Barbeau,** Centre de Recherche Cerveau et Cognition, Toulouse III University, Toulouse, France
- **Meritxell Bach Cuadra,** Department of Diagnostic and Interventional Radiology, Lausanne University Hospital (CHUV) and University of Lausanne (UNIL), Lausanne, Switzerland
- **Roy Haast,** Centre de Résonance Magnétique Biologique et Médicale, Aix-Marseille University, France
- **Stephen Mayhew,** Aston Institute of Health and Neurodevelopment (IHN), Aston University, UK

Key Information

Conference Venue

Edgbaston Park Hotel
53 Edgbaston Park Road
Birmingham
B15 2RS, United Kingdom

The conference will take place in The Writers' Suite at the Edgbaston Park Hotel, which is a short walk from our University Train Station. The hotel is marked as G23 in the green zone on the campus map, which is available to view/download here.

Conference Website

Conference information can also be found on the conference website.

Registration & Information Desk

Date	Time	Location
Monday 12th January	09:00 – 18:30	The Writers' Suite (Edgbaston Park Hotel)
Tuesday 13th January	09:00 – 14:00	The Writers' Suite (Edgbaston Park Hotel)

Social Event – Monday 12th January

Date	Time	Social Event
Monday 12th January	19:30	Clays 105 New Street Birmingham B2 4EU

Lunch and Refreshment Breaks

Lunch and Refreshments will be served outside The Writers' Suite at the times specified in the programme.

WiFi

Free Wi-Fi will be available throughout the venue, via the Edgbaston Park hotel - Ask4 network.

If you have any problems connecting, please ask for support at the Registration Desk

Programme

Monday 12th January

Time	Session
09:00 – 09:45	Registration & Welcome Refreshments
09:45 - 10:00	Welcome & Introduction
Session 1: *Chair - Emmanuel Barbeau*	
10:00 - 11:00	**Why So Smart? – Region Specific Neuronal Computation in Rodent and Human Thalamus** László Acsády, HUN-REN Institute of Experimental Medicine, Hungary
11:00 - 11:40	**Multiscale Organizational Principles of the Thalamus Across Development and Disease** Sofie Valk, Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig
11:40 - 12:15	Refreshment Break
12:15 - 13:00	**Promises and Challenges of Personalized Transcranial Ultrasound Stimulation** Jean-Francois Aubry
Short Talks	
13:00 - 13:10	**O3: Thalamic Mechanisms of Divided Attention** Brandon Ingram, University of Birmingham
13:10 - 13:20	**O5: Techniques for Enhanced Visualisation of the TRN** Ross Shaw, University of Nottingham
13:20 - 13:30	**O6: Towards Targeted Thalamic Ultrasound Interventions in Disorders of Consciousness** Daniel Torbett-Schofield, University of Birmingham
13:30 - 15:00	Lunch & Networking
Session 2: *Chair - Steve Mayhew*	
15:00 - 16:00	**Multi-Modal Mapping of the Thalamus** Anneke Alkemade, University of Amsterdam
16:00 - 16:40	**The Thalamus at the Crossroads of Network Failure and Neuroinflammation** Ismail Koubiyr, Amsterdam UMC
16:40 - 17:10	Refreshment Break
17:10 - 17:50	**Thalamic SEEG: What Have We Learned so Far?** Francesca Pizzo, Aix-Marseille University
Short Talks	
17:50 - 18:00	**O1: Toward a 3D Mesoscale Atlas of Intrathalamic Inhibitory Interneurons in the Human Brain** Michelle Antonios, University of Zurich
18:00 - 18:10	**O4: Nucleus-Specific Developmental Trajectories of Structural and Functional Thalamocortical Connectivity** Alexandra John, Max Planck Institute For Human Cognitive And Brain Sciences, Germany
18:10 - 18:20	**O2: A Multimodal Portrait of Thalamic Network Reorganisation in Paediatric Focal Epilepsy** Xiyu Feng, UCL Great Ormond Street Institute Of Child Health
18:30	Conference Close

Tuesday 13th January

Time	Session
09:00 - 09:15	Registration & Welcome Refreshments
Session 3: *Chair - Roy Haast*	
09:15 – 10:15	**From Connectomic Deep Brain Stimulation toward the 'Human Dysfunctome'** Andreas Horn, University of Cologne *(online presentation)*
10:15 - 11:00	**Thalamic Changes in Preclinical and Clinical Dementia** Michael Hornberger, University of Southampton
11:00 - 11:30	Refreshment Break
11:30 - 12:10	**Thalamic Deep Brain Stimulation – Window to the Brain** Elisabeth Kaufmann, LMU Munich
12:10 - 12:50	**Using Direct Thalamic Recordings and Stimulation to Investigate Human Cognition** Tobias Staudgil, Ludwig-Maximilians-University
12:50 - 13:30	Final Panel Discussion
13:30	Lunch & Conference Close

Invited Speakers

Anneke Alkemade, University of Amsterdam

Dr. Anneke Alkemade is a neuroanatomist at the University of Amsterdam whose research focuses on the detailed mapping of human brain structure using both in vivo and postmortem imaging and histology. She specializes in integrating ultra-high-resolution MRI data with anatomical information to improve our understanding of brain organization and its variability across individuals. Her work contributes to the development of anatomically informed models for neuroscience research, with applications in both basic and clinical science.

Talk Title: Multi-Modal Mapping of the Thalamus

Abstract: (Immuno-)histological and magnetic resonance imaging (MRI) research both provide information on the functional neuroanatomy of the human thalamus. Bridging between these complementary imaging modalities provides us with the best of both worlds. In our studies we acquired 7 Tesla quantitative MRI data from 105 adult individuals in vivo which we use for atlasing of subcortical structures. The structures that we cannot resolve in vivo are visualised in 7 individual postmortem brains of which we collected quantitative 7 Tesla MRI data at 400 um isotropic resolution, and which we have processed for microscopy. Coregistration of the microscopy and MRI data at a 200 um resolution in blockface space allows the subseqent transfer of the data to MNI-space, bringing together in vivo and postmortem data (Alkemade et al., 2020,2022). The resulting datasets can be used for MRI-validation, as well as for brain atlasing purposes. Our in vivo atlasing efforts have been funneled into the MASSP 2.0 algorithm that now allows the automated parcellation of 35 individual structures in both cerebral hemispheres (Bazin et al., 2025).

The resulting postmortem resources allow the retraining and expansion of the algorithm using an increased level of available detail. Developed brain models can be applied to create advanced atlasing tools for application in neuroimaging research and clinical applications, and open access publication and sharing of the datasets and derived algorithms and atlases will strongly benefit the progress of the research field.

László Acsády, HUN-REN Institute of Experimental Medicine, Hungary

László is a system neuroscientist interested in the structure and function of the thalamus and thalamocortical loops. His research over the past two decades has focused on the non-sensory thalamus and demonstrated that thalamus consists of highly heterogeneous microcircuits differing in the composition of its inputs. The data showed that inputs arising from variable sources, having distinct types of terminals and transmitters are integrated in a region selective manner. Thus, far from a simple canonical relay the core concept of thalamus is the variable forms of input integration.

László's vision which leads his research is that proper understanding of cortical functions and dysfunctions can only be achieved by deciphering region specific communication between cortex and thalamus. During his research he pay's special attention to rodent primate comparison.

Talk Title: Why So Smart? – Region Specific Neuronal Computation in Rodent and Human Thalamus

Abstract: Thalamus participates in surprisingly complex cognitive behaviours in a region-specific manner. The major questions are what connectional principles allows to perform the computations necessary for these tasks, how to provide accurate segmentation of these connections and how to link segmentation with region selective functions in the thalamus. Here I propose that mapping excitatory inputs in rodents and humans can provide comparable segmentations of the thalamus and can help to link input-based segmentation with functions. Mapping the excitatory afferents to the thalamus led us to identify a novel type of region-selective cortical input from the frontal cortex to the thalamus that target dendritic spines. Axo-spinous communication between the cortex and thalamus could add novel dimensions to understand the function of normal and pathological thalamocortical activity.

Jean-Francois Aubry, Physics for Medicine, Paris

Jean-Francois (Jeff) Aubry is a director of research at France's National Centre for Scientific Research (CNRS). He works at Physics for Medicine Paris (Paris, France) and is the scientific director of the Focused Ultrasound Foundation centre of excellence in Paris. His main research interests are MR-guided transcranial brain therapy and Neuronavigated transcranial ultrasound stimulation and is an expert in focusing ultrasound waves in complex media. Aubry holds five patents on adaptive focusing. He has been a consultant for Supersonic Imagine (Aix en Provence, France) and FUS Mobile (Alpharetta, GA, USA) and is a co-founder of SonoMind (Paris, France). He has given more than 60 invited talks at international conferences and published more than 100 papers in international scientific journals. He has been president of the International Society for Therapeutic Ultrasound (2015 – 2018).

Talk Title: Promises and Challenges of Personalized Transcranial Ultrasound Stimulation

Abstract: Transcranial ultrasound stimulation is the only technology that can non-invasively modulate the activity of deep-seated brain tissues. It thus has the potential to offer ground-breaking new approaches to treat mental and neurologic disorders. It has been demonstrated that ultrasound can excite neurons through a primarily mechanical mechanism mediated by the ultrasound-induced opening of mechano-sensitive channels on the cellular membrane [1]. Not only neurons but also astrocytes, endothelial cells, and pericytes are sensitive to mechanical ultrasound stimulation through mechanosensitive ion channels[2], leading to an overwhelming number of possible neuromodulation targets in the brain. It was proposed recently to specifically target fiber tracts: the dentato rubro thalamic tracts in essential tremor patients[3] and the crossing of the forceps minor, the cingulum bundle and the uncinate fasciculus in treatment-resistant depressed patients[4]. This lecture will present how these targets where selected and how accurately they were stimulated.

Andreas Horn, University of Cologne

Andreas received an MD from Freiburg University and a PhD from Charité Berlin. He is the Schilling Professor for Computational Neurology and inaugural director of the Institute for Network Stimulation at the University Hospital Cologne. He is further affiliated with the Centre for Brain Circuit Therapeutics at Mass General Brigham in Boston.

His lab studies how focal neuromodulation impacts the human connectome to refine clinical treatments for neurological and psychiatric disorders. A key question is which networks should be modulated for improvements of specific symptoms – in disorders such as Parkinson's Disease, Obsessive Compulsive Disorder, Depression, or Alzheimer's Disease. Further, the lab develops methods to segregate the human connectome into functional domains by combining brain stimulation with functional and diffusion-weighted MRI.

Talk Title: From Connectomic Deep Brain Stimulation toward the 'Human Dysfunctome'

Abstract: Brain disorders manifest along a spectrum of symptoms that involve disruptions in mood, cognition, or motor function. These symptoms originate from dysfunctions of specific brain circuits and may hence be seen as 'disorders of the human connectome', or 'circuitopathies' However, exactly which circuits become dysfunctional in which disorder remains elusive. Moreover, it remains unclear which circuits map to which specific symptoms. Invasive and non-invasive brain stimulation methods are applied to focal points in the depth or on the surface of the brain. However, their focal application leads to network effects that are distributed along brain circuits across the entire brain. By nature, applying brain stimulation is a causal intervention that engages specific brain circuits: If an intervention leads to symptom improvements, we may suspect that the modulated circuit was causally involved in these symptoms.

In this talk, I will review the effects of deep and superficial brain stimulation onto the human connectome. We will cover results in diseases ranging from the movement disorders spectrum (Parkinson's Disease, Dystonia, Essential Tremor) to neuropsychiatric (Tourette's & Alzheimer's Disease) and psychiatric (Obsessive Compulsive Disorder, Depression) diseases. I will also demonstrate how findings in seemingly different diseases (such as Parkinson's Disease and Depression) could be transferred to cross-inform one another and how the same method may be used to study neurocognitive effects, such as risk-taking behaviour or impulsivity.

Michael Hornberger, University of Southampton

Michael is the Professor of Applied Dementia Research at the Department of Clinical Neurosciences, Clinical and Experimental Sciences, Faculty of Medicine. His research is particularly focused on cognition, neuroimaging and devices in preclinical and clinical dementia populations.

Michael is originally from Germany but gravitated soon to the UK, where he did his PhD at University College London, followed by positions at the University of Cambridge, the University of New South Wales and the University of East Anglia. Michael arrived at the University of Southampton in 2025. In his free time, he likes to go long-distance cycling and running, as well as practising passionately, though badly, Yoga.

Talk Title: Thalamic Changes in Preclinical and Clinical Dementia

Abstract: Many people are not aware that the thalamus is one of the earliest regions involved in dementia and that it can contribute significantly to the symptomology. In this talk I present some of our research findings showing how the thalamus is differentially affected across different dementias. We will further explore, which thalamic nuclei are particularly vulnerable for different dementia pathophysiology's and how thalamic changes impact on disease symptomology.

Elisabeth Kaufmann, LMU Munich

Dr. Kaufmann is a neurologist and epileptologist at the Department of Neurology, LMU University Hospital, Munich, Germany. Her clinical and research focus is on the diagnosis and treatment of drug-resistant epilepsy, including neurostimulation techniques such as VNS, DBS, tDCS, and FCS.

She is internationally recognized as an expert in thalamic deep brain stimulation (DBS) for epilepsy, overseeing one of the world's largest ANT-DBS cohorts, coordinating a European consortium on best practices in ANT-DBS, and playing a leading role in the international ANT-DBS MORE registry as well as in expert panels. In addition to her clinical and scientific work at LMU Munich, she worked at Charité Berlin and completed research stays at Harvard University in Boston.

Talk Title: Thalamic Deep Brain Stimulation – Window to the Brain

Abstract: Deep brain stimulation of the anterior thalamic nucleus (ANT-DBS) has been established as a safe and effective treatment option for drug-resistant focal epilepsy. Several studies have demonstrated seizure frequency reductions of up to 75% at seven-year follow-up, with responder rates—defined as a reduction in seizure frequency of more than 50%—reported in up to 70% of patients. Nevertheless, the underlying pathophysiology of the antiepileptic effect, as well as the reasons why a subset of patients fails to respond, remain incompletely understood.

Thalamic EEG recordings obtained via externalized DBS leads, along with the measurement of thalamic local field potentials (LFPs), provide a unique opportunity to characterize the electrophysiological signatures of clinical responders and non-responders, thereby advancing our understanding of thalamo-cortical networks.

This talk will summarize the current evidence on the clinical effects of ANT-DBS, highlight persisting limitations, and discuss ongoing scientific efforts to identify electrophysiological biomarkers for outcome prediction.

Ismail Koubiyr, Amsterdam UMC

Dr. Koubiyr is a neuroscientist and Assistant Professor in the Department of Anatomy and Neurosciences at Amsterdam UMC. His work focuses on using advanced neuroimaging techniques to unravel the mechanisms underlying disability progression and cognitive impairment, primarily in multiple sclerosis but also in other neurological disorders such as stroke. By integrating multimodal imaging and network-based approaches, his research examines different aspects of disease at both the macro- and micro-scale. A key component of his work involves leveraging large datasets and machine learning methods to build predictive models and derive biologically meaningful insights. In addition, Dr. Koubiyr employs translational approaches, including postmortem imaging-histology data and animal models, to uncover the biological substrates driving imaging phenomena, with the ultimate goal of translating these findings back to the clinic to improve patient care.

Talk Title: The Thalamus at the Crossroads of Network Failure and Neuroinflammation

Abstract: The thalamus is a central hub within brain networks and one of the earliest and most consistently affected structures in neurological diseases. In this talk, I will present work showing that thalamic atrophy does not occur uniformly, but follows nucleus-specific and network-driven patterns. Using large-scale MRI datasets, advanced segmentation, and network dysconnectivity models, we demonstrate that certain thalamic nuclei are especially vulnerable and that their degeneration is closely linked to clinical disability and cognitive impairment. Moving beyond structure, I will show how combining neuroimaging with post-mortem histology and animal models reveals the biological mechanisms underlying thalamic vulnerability, highlighting the roles of disconnection, microglial activation, and inflammation.

Finally, I will discuss how these thalamic mechanisms are not unique to multiple sclerosis but also appear in other disorders such as stroke, suggesting a common pathway of network failure and remote neurodegeneration. Overall, I will argue that studying the thalamus through a network and multimodal lens provides a powerful framework for understanding disease progression, identifying biomarkers, and developing targeted neuroprotective strategies.

Francesca Pizzo, Aix-Marseille University

Dr Francesca Pizzo, MD, PhD, is an Associate Professor Neurologist and neurophysiologist in the Epileptology and Cerebral Rhythmology department of the Timone Hospital at the Assistance Publique - Hôpitaux de Marseille (France). She is a member of the Institut de Neurosciences des Systèmes (INS, Inserm) and she works at Aix-Marseille University.

Dr Pizzo is involved in the presurgical evaluation of patients with drug-resistant focal epilepsy, with particular expertise in SEEG recordings and signal analysis. She is principal investigator of the clinical trial "PuLSE – pulvinar stimulation in epilepsy", aiming at finding a better target for deep brain stimulation in patients with non-surgical drug resistant epilepsy. Her ongoing research is focusing on neurophysiological biomarkers of the epileptogenic networks and their correlations with the response to therapeutics (surgery, thermocoagulation, invasive and non-invasive brain stimulation).

Talk Title: Thalamic SEEG: What Have We Learned so Far?

Abstract: Thalamic stereo-electroencephalography (SEEG) has gained increasing attention worldwide; nonetheless, its indications, methodological approaches, and clinical implications remain to be clearly established. This presentation will primarily address the experience of the Marseille group with thalamic SEEG, encompassing both ictal and interictal recordings, as well as our monocentric results concerning stimulation of the medial pulvinar. The session will conclude with a discussion of our findings, a comparative overview of experiences from other centres, and considerations for future directions in this emerging field.

Tobias Staudigl, Ludwig-Maximilians-University

Tobias is a cognitive neuroscientist and Associate Professor for Cognitive Neuropsychology at the Department of Psychology, LMU Munich, Germany. He received his PhD from Regensburg University, Germany, after which he worked as a postdoctoral scientist in Germany, the Netherlands, and USA.

The Staudigl Lab investigates brain activity and behaviour to advance understanding of human cognition. Our research focuses on the neural mechanisms underlying perception, memory, navigation, and other cognitive processes, with a particular emphasis on the role of the oculomotor system in these processes. Using primarily electrophysiological methods, we examine the relationship between neural activity, action, and behaviour in both healthy individuals and patients, across wakefulness and sleep. A key focus is on subcortical structures—especially the thalamus—and their critical contributions to cognitive processing.

Talk Title: Using Direct Thalamic Recordings and Stimulation to Investigate Human Cognition

Abstract: Cognitive neuroscience has traditionally emphasized a corticocentric framework, in which cognition arises primarily through cortical processes in a hierarchical brain. While this perspective has certainly advanced our understanding of the neuronal basis of cognition, in-depth investigations of subcortical brain activity in humans and its contribution to cognition have lagged behind. A major factor contributing to this bias is the limited ability to access subcortical brain areas like the thalamus with sufficient spatial and temporal resolution in humans. To address this gap, we leverage the rare opportunity to record directly from and stimulate the human thalamus in epilepsy patients. This direct access allows us to characterize the electrophysiology of several thalamic nuclei in humans and probe their roles in cognitive processes.

In this talk, I will present recent findings from thalamic recordings in humans that shed light on how the neural activity of specific thalamic nuclei relates to different brain states across the sleep-wake cycle, as well as to higher-level cognitive processes, such as visual perception, and whether perturbing the thalamus may provide evidence for a causal involvement in cognition. I will discuss how studying the thalamus in humans advances our understanding of cognition and argue for a comprehensive model of cortical and subcortical interactions as the neuronal basis of cognition.

Sofie Valk, LMax Planck Institute for Human Cognitive and Brain Sciences, Leipzig

Dr Sofie Valk is Lise Meitner Research Group Leader of the group Cognitive Neurogenetics at the Max Planck Institute for Human Cognitive and Brain Sciences and Research Group Leader of the group Cognitive Neurogenetics at Forschungszentrum Juelich both in Germany. She is interested in understanding the interplay of brain structure and function across the lifespan, and in particular how this interplay is shaped by genes and social environment. She studied artificial intelligence and social philosophy at the University of Amsterdam.

Talk Title: Multiscale Organizational Principles of the Thalamus Across Development and Disease

Abstract: The thalamus serves as a critical hub coordinating brain activity, with emerging evidence suggesting its organization reflects both discrete nuclear boundaries and continuous functional axes. However, the organizational principles governing thalamic structure across scales, their developmental trajectories, and their disruption in psychiatric disease remain poorly understood. We integrated three complementary neuroimaging approaches to characterize thalamic organization across the lifespan and in early-onset schizophrenia (EOS):Study 1 derived low-dimensional organizational axes from thalamocortical structural connectivity in healthy adults, examining their correspondence with intrathalamic microstructure, functional connectivity, and structural covariance across multiple modalities. Study 2 examined developmental trajectories of individual thalamic nuclei from childhood to young adulthood, characterizing structural connectivity patterns targeting the cortical sensory-association (SA) axis and testing whether development follows nuclei-specific classifications (first-order/higher-order) versus cortical target organization. Study 3 investigated macroscale thalamic functional organization in antipsychotic-naïve first-episode EOS patients, examining alterations in thalamic hierarchy and their relationships to gene expression patterns and clinical symptoms.

The human thalamus exhibits low-dimensional organizational axes that coherently map across intrathalamic microstructure, functional connectivity, and structural covariance. A principal medial-lateral axis relates to myelin distribution and functional organization, while a secondary axis corresponds to core-matrix cell distribution, consistently differentiating large-scale cortical networks across modalities.

These findings establish coherent multiscale organizational principles of the thalamus characterized by continuous functional axes bridging microstructural features and large-scale network organization. Thalamic development follows cortical target organization along the sensory-association axis rather than classical nuclear classifications. Disruption of these organizational principles in EOS provides mechanistic insight into thalamocortical dysfunction, suggesting that altered thalamic hierarchy contributes to cognitive and perceptual impairments in schizophrenia. This work demonstrates that thalamic organization is developmentally sensitive and its disruption contributes to psychiatric pathophysiology.

Developmentally, individual thalamic nuclei exhibit distinct connectivity patterns targeting the cortical SA axis. Critically, developmental trajectories vary independently of first-order/higher-order classification but systematically follow the SA axis when decomposed by cortical targets, with association cortex connections maturing later than sensory connections. Antipsychotic-naïve first-episode EOS patients show increased segregation of macroscale thalamic functional organization, with altered interactions across unimodal and trans modal networks. These abnormalities particularly involve core cell distributions, align with schizophrenia-related gene expression patterns, and associate with impaired perceptual and cognitive functions and negative symptoms.

These findings establish coherent multiscale organizational principles of the thalamus characterized by continuous functional axes bridging microstructural features and large-scale network organization. Thalamic development follows cortical target organization along the sensory-association axis rather than classical nuclear classifications. Disruption of these organizational principles in EOS provides mechanistic insight into thalamocortical dysfunction, suggesting that altered thalamic hierarchy contributes to cognitive and perceptual impairments in schizophrenia. This work demonstrates that thalamic organization is developmentally sensitive and its disruption contributes to psychiatric pathophysiology.

O1: Toward a 3D Mesoscale Atlas of Intrathalamic Inhibitory Interneurons in the Human Brain

Michelle Antonios, University of Zurich, Zurich, Switzerland

The thalamus is central to complex brain networks and higher-order cognition, in addition to relaying sensory information (Halassa and Sherman 2019). Yet the human thalamic neuronal population, particularly inhibitory interneurons (ITIN), remains uncharacterised. ITIN densities vary across thalamic nuclei based on their functional roles, and their density overall increases from rodent to primates (Jager et al. 2021; Arcelli et al. 1997), suggesting that interneurons are critical for supporting more complex thalamic functions. Nevertheless, we do not have a complete map of ITINs across all thalamic nuclei. This limits our understanding of their role in health and disease. To address this gap, we aim to develop a novel 3D mesoscale atlas of the human thalamus that integrates structural and connectional organisation with detailed ITIN mapping. Advances in brain mapping increasingly integrate traditional histology with ultra–high-field MRI, transcriptomics, and connectomics, to generate more comprehensive, multiscale views of neural architecture. Our approach adds to this progress by aligning high-resolution 3D microscopy with MRI within the same spatial framework, improving cytoarchitectonic delineation and providing a more reliable anatomical reference.

Our initial work focused on optimising MRI and light-sheet microscopy. Thalami were excised from fixed post-mortem human brains, placed in a custom 3D-printed vessels, and scanned on a Bruker 9.4T small animal MRI scanner. A proton density sequence (200 µm isotropic resolution) provided structural images for delineating nuclei, while multi-shell diffusion imaging (b-values 2000–8000 s/mm^2; 300 µm isotropic resolution) enabled visualisation of microstructural features and fibre pathways. We successfully imaged unilateral thalami from six post-mortem donors. DTI identified fibre pathways within and around the thalamus, and scalar maps differentiated major nucleisuch as the pulvinar, mediodorsal, and lateral-motor nuclei. MRI datasets were aligned to a common space and averaged to generate template images for the atlas. Following MRI acquisition, samples underwent tissue clearing using the CleaLight protocol, which employs alcohol and detergent delipidation, permeabilisation steps, and photobleaching to reduce autofluorescence. Cleared tissue was then imaged with light-sheet microscopy, allowing deep 3D visualisation of neurons. The optimised clearing and staining protocol enabled high-quality imaging of 1-cm tissue blocks, revealing inhibitory interneurons and neuronal densities with NeuroTrace™. Our dataset provides new insights into thalamic organisation and establishes a foundation for mesoscale brain mapping. By integrating high-resolution connectional mapping with interneuron characterisation, this atlas captures features of thalamic architecture absent from current resources and offers a precise, anatomically grounded tool for neurosurgical planning and mechanistic studies of thalamic function.

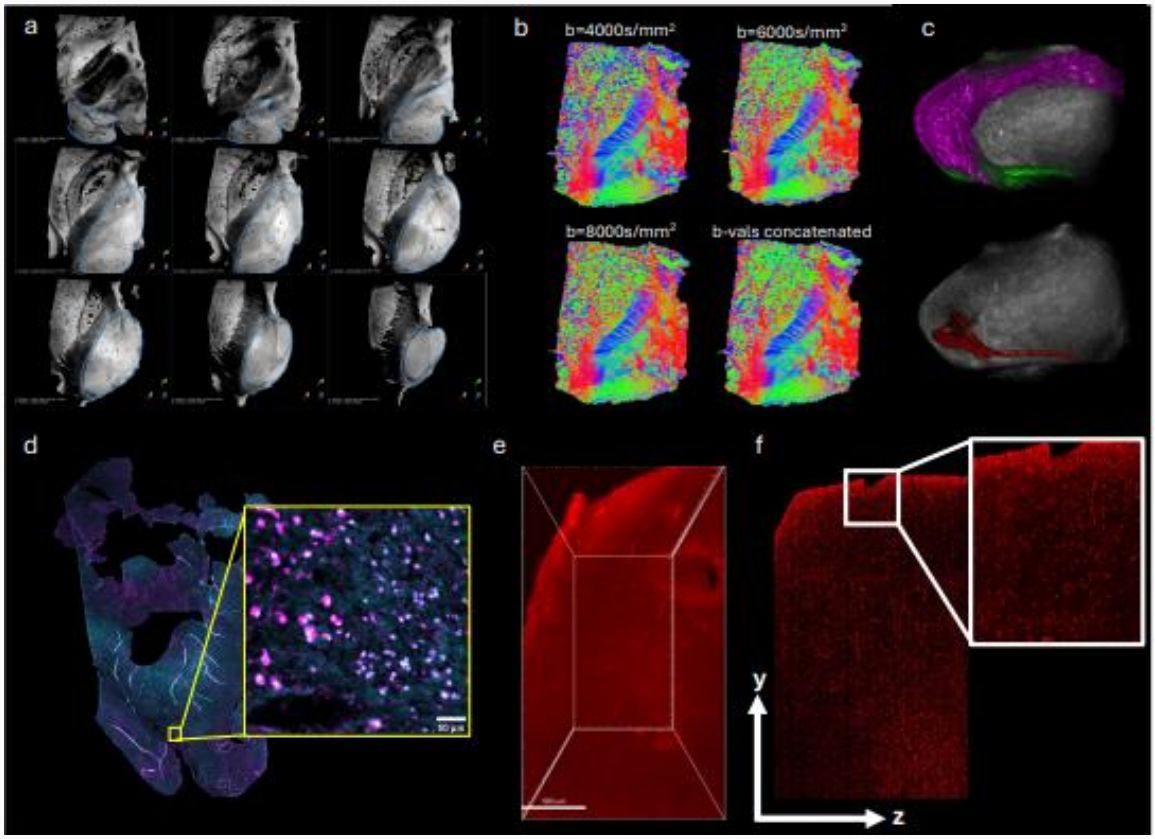

Figure 1.a. Proton density acquisition with the thalamus delineated, b. Fractional anisotropy (FA) maps displayed as colourorientation maps, c. Top figure: representative tracts from the pulvinar (magenta) and the lateral geniculate nucleus (green) to the whole thalamus. Bottom figure: representative tracts from the pulvinar to the lateral geniculate nucleus (red), d. GABA staining on thalamus, 10x magnification, e. Thalamic block labelled with Neurotrace for neuronal visualisation, imaged on the mesoSPIM 5x magnification, f. yz view from e, showcasing the homogeneity of the labelling.

O2: A Multimodal Portrait of Thalamic Network Reorganisation in Paediatric Focal Epilepsy

Xiyu Feng, University College London, London, UK

Background: The thalamus plays a central role in seizure propagation and is an emerging target for neuromodulation. However, nucleus-specific thalamocortical network alterations in paediatric focal epilepsy remain poorly understood, and optimal nucleus selection and patient stratification for neuromodulation interventions are unresolved. Multimodal neuroimaging provides a unique opportunity to disentangle complementary structural and functional thalamic signatures of epileptic networks.

Methods: We retrospectively conducted a thalamic network study integrating volumetric, diffusion, and functional MRI in children with focal-onset epilepsy and healthy controls. Thalamic nuclei were segmented using the THOMAS pipeline and combined with tractography to derive nucleus-specific connectivity strength. 1) Structural thalamocortical connectivity was assessed in 81 surgical epilepsy patients and 63 controls using diffusion MRI. 2) Functional connectivity and thalamic volumetry were examined in an overlapping cohort of 136 children with temporal, frontal, or posterior quadrant epilepsy and 70 controls using task fMRI and T1-weighted MRI. Analyses evaluated thalamic structural, functional connectivity strength and volume patterns associated with epilepsy syndrome, seizure generalisation, and post-surgical seizure outcome.

Results: Multimodal analyses revealed both convergent and divergent thalamic network abnormalities across paediatric focal epilepsies. Structurally, patients exhibited increased thalamocortical connectivity strength compared with controls. Centromedian, mediodorsal, and pulvinar connectivity was similarly elevated across epilepsy syndromes, whereas reduced anterior nucleus connectivity was specific to temporal lobe epilepsy with hippocampal sclerosis. Functionally, patients showed bilaterally reduced thalamic connectivity relative to controls, most consistently involving the pulvinar across epilepsy groups, indicating widespread thalamocortical decoupling. In contrast, increased anterior nucleus functional connectivity was specific to hippocampal sclerosis. Volumetric analyses demonstrated syndrome-dependent ipsilateral thalamic volume loss, alongside medial nucleus enlargement associated with seizure generalisation. Importantly, multimodal thalamic asymmetry—characterised by lower ipsilateral and higher contralateral structural connectivity strength and volumes—was associated with post-surgical seizure freedom.

Conclusions: Multimodal thalamic network mapping reveals nucleus-specific structural, functional, and volumetric signatures in paediatric focal epilepsy. Functional hypo-connectivity likely reflects thalamocortical decoupling for suppressing seizure activity, while accompanying structural hyper-connectivity suggests network reorganisation or compensatory mechanisms, rather than simple connectivity loss. These multimodal thalamic signatures provide mechanistic insight into epileptic networks beyond the epileptogenic zone and support the development of personalised, thalamic nucleus-targeted neuromodulation strategies.

O3: Thalamic Mechanisms of Divided Attention

Dr Brandon Ingram, University of Birmingham, Birmingham, UK

Introduction: The thalamus is the largest sub-cortical region within the human brain, but remains understudied within neuroimaging research. Extensive rodent and human literature has demonstrated its complex role in a wide range of functions, including facilitating sleep onset and inhibition during attention tasks. Furthermore, rodent research has demonstrated how these mechanisms are linked, with inhibition and the suppression of stimuli during sleep being orchestrated by the thalamic reticular nucleus (TRN). However, these results are yet to be demonstrated within humans. Here, we present preliminary results from a multi-session, multi-site study using behavioural measures and simultaneous EEG-fMRI to investigate shared thalamic mechanisms in sleep and attention. In this abstract, we focus specifically on the findings from the divided-attention component of the study.

Methods: A total of 22 participants (Mean age = 25.0 years, range: [18, 36]; Sex: 72.7% females, 27.3% males) completed a divided attention task both outside of the scanner and whilst acquiring simultaneous EEG-fMRI (3T Siemens Prisma, BrainProducts MR Plus, TE = 43.6 ms, TR = 1500ms, voxel size 1.5x1.5x2mm). The task followed a Posner-style cueing design in which participants were visually cued to attend to a specific sensory modality before being presented with a visual (a gabor patch in the bottom right visual field) and vibrotactile (a 100hz vibration to the left index finger) stimuli simultaneously. Depending on the cue, participants had to either discriminate the orientation of the gabor path (left or right) or the amplitude of the vibration (strong or weak), responding via a button box. A preliminary general linear model analysis was conducted in FSL to investigate the differences in blood oxygen level dependent (BOLD) activity during cue-to-stimulus period across modalities (e.g. visual cue period vs vibrotactile cue period).

Results: There was significantly greater BOLD activity within the default mode network and the left primary visual cortex during the visual cue period compared to the vibrotactile cue period (visual > vibrotactile, see red activations in Figure 1). Conversely, we found significant increases in BOLD activity within the insula and prefrontal cortex bilaterally during the vibortactile cue periods relative to the visual cue periods (vibrotactile > visual, see blue activations in Figure 1). Subcortically, some evidence of an increase in BOLD activity within the left lateral geniculate nucleus (LGN, visual > vibrotactile) and the right ventral posterior nucleus and putamen (vibrotactile > visual) was found.

Conclusions: Consistent with rodent literature, which found that neural spiking increases in thalamic nuclei during the cue period, we observe a similar pattern in BOLD activity in these regions (i.e. increased BOLD signal in LGN for visual cueing). Future analysis will utilise the THOMAS segmentation to facilitate region of interest based analyses, incorporate subject-specific TRN masks from the 7T session, and compare the task results with changes to thalamic BOLD activity during sleep onset.

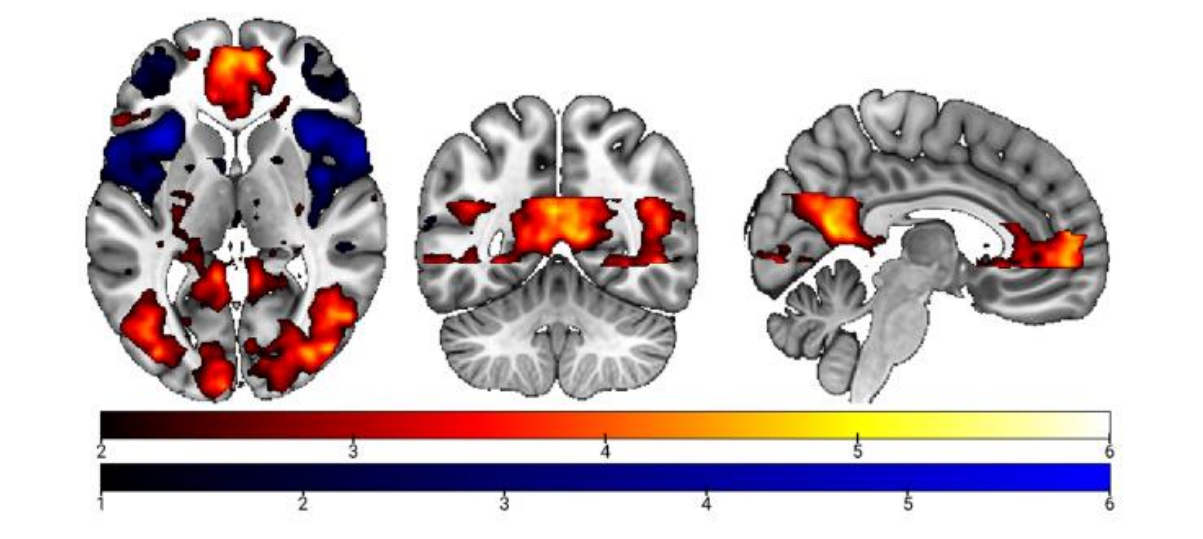

Figure 1: BOLD activations from the divided attention task. Results presented sub significance threshold. Red = visualcue > vibrotactile contrast. Blue = vibrotactile > visual contrast

O4: Nucleus-Specific Developmental Trajectories of Structural and Functional Thalamocortical Connectivity

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Childhood and adolescence are characterized by cognitive refinement and heightened vulnerability to neuropsychological disorders, making this a critical phase in brain development. During this phase, cortical development has been extensively studied, showing a spatiotemporal pattern where sensory regions mature earlier than association regions (sensory-association SA-axis, Sydnor et al., 2021). However, the cortex does not mature in isolation; from early development onward it is tightly coupled with the thalamus. Recent work shows that the maturation of global thalamocortical white matter connections parallels the cortical SA axis (Sydnor et al., 2025), yet the thalamus is not a uniform structure, but composed of structurally and functionally distinct nuclei that differentiate early in development (Govek et al., 2022). These nuclei form nucleus-specific thalamocortical networks that differentially support sensory perception and cognitive functions. Yet, the developmental trajectories of these specific nucleus-to-cortex connections, and their relation to functional connectivity remains unknown.

Leveraging diffusion-weighted imaging (1.5 mm isotropic) and resting-state functional MRI data (2 mm isotropic) from the Human Connectome Project Development (N = 604, ages 5-21 years; Somerville et al., 2018), this talk will present how nuclei-specific thalamocortical structural connectivity profiles evolve from childhood to adulthood and how they relate to functional connectivity. First, I will present, the mapping of nuclei-specific connections between 11 thalamic nuclei (T1-weighted-based HIPS-THOMAS segmentation; Vidal et al., 2024) and the 180 ipsilateral cortical parcels (Glasser et al., 2016), that were generated using probabilistic tractography (FSL, Behrens et al., 2007). The connection-specific microstructure was estimated using the mean fractional anisotropy (FA). Next, I will show nuclei-specific developmental trajectories of FA within the white matter connection that were modeled using Generalized Additive Models to capture both linear and non-linear age effects. A Principal Component Analysis was subsequently used to identify thalamic nuclei that exhibit similar or distinct maturational patterns. This pattern was then contextualized with established thalamic features (first/higher order, core matrix, cortical targets). In the final part, I will present the link between maturation of nuclei-specific structural connections and functional connectivity between nuclei and cortical target.

By moving beyond global thalamocortical measures, this work refines our understanding of nucleus-specific developmental connectivity profiles. The identified nucleus-specific developmental trajectories offer a crucial framework that provide insights into normative brain maturation and its relevance for cognitive development from a thalamocentric perspective and may illuminate specific pathways that confer vulnerability to neurodevelopmental disorders during this sensitive period.

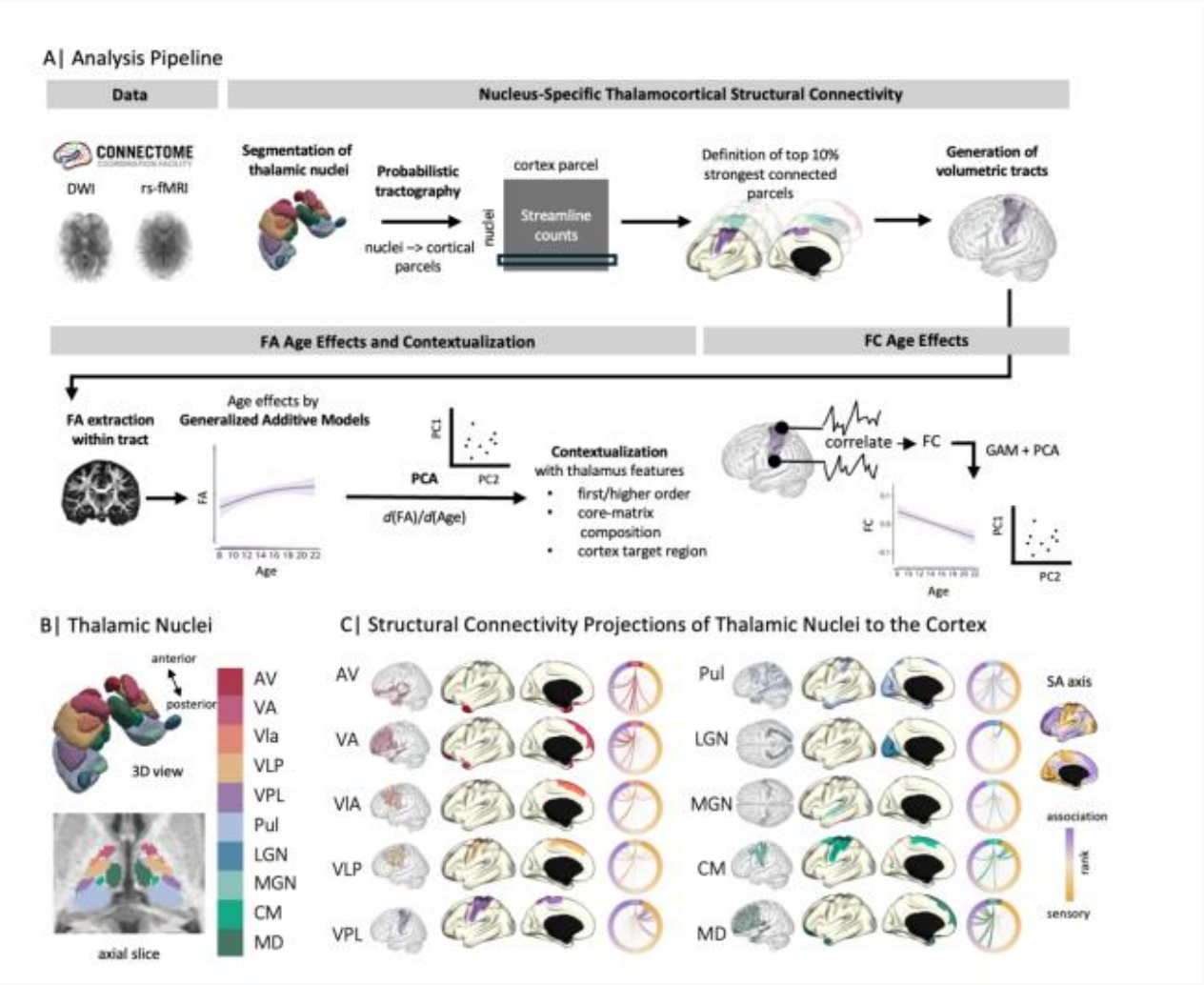

Fig 1: Generation of nuclei-specific thalamocortical connections and developmental trajectories. A) Analysis Pipeline: Diffusion-weighted MRI and resting-state fMRI data from the HCP Development cohort were used to map structural connectivity from 10 segmented thalamic nuclei to 180 ipsilateral Glasser cortical parcels via probabilistic tractography, yielding a nucleus-byparcel matrix of streamline counts. For each nucleus, the main connections were defined by selecting the top 10% cortical targets by streamline count and applying anatomically guided refinement, resulting in volumetric tract masks. Fractional anisotropy (FA) averaged within each connection and age effects were modeled with generalized additive models (GAMs); principal component analysis (PCA) was applied to the normalized first derivatives of the fitted trajectories. Structural patterns were contextualized using first-/higher-order class, core-matrix composition, and cortical target properties. Functional connectivity (FC) computed as Fisher z-transformed Pearson correlations between each nucleus time series and the mean time series of its structurally defined cortical targets; FC age effects were modeled with GAMs and summarized using PCA. B) Thalamic Nuclei Segmentation in 3D view and axial slice (HIPS-THOMAS). C) Nucleus-specific thalamocortical structural connections. For each nucleus volumetric connection (from an example subject), brain plot with target parcels (based on group-level mask), and network plots of connections to cortical regions (ordered based on SA rank) are shown. Abr. DWI: Diffusion weighted imaging, rs-fMRI: resting state- functional MRI, FC: Functional Connectivity, SA: sensory-association, AV:

anteroventral, VA: ventral anterior, Vla: ventral lateral anterior, VLP: ventral lateral posterior, VPL: ventral posterolateral, Pul: pulvinar, LGN: lateral geniculate nucleus, was MGN: medial geniculate nucleus, CM: centromedian, MD: mediodorsal

O5: Techniques for Enhanced Visualisation of the TRN

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Introduction: The Thalamic Reticular Nucleus (TRN) is a thin (<1mm) sheet of GABAergic cells following the dorsal edge of the thalamus. To investigate its role in corticothalamic and thalamocortical information flow, robust methods to visualise and segment the structure are essential. Acquisition methods and processing pipeline is demonstrated.

Method: 10 healthy volunteers were scanned using a Philips 7T Achieva scanner with 40 channel Nova Head coil. T1w MPRAGE, multi-echo (ME) FLASH (6 echoes), FLAIR and MP2RAGE (with White Matter nulled (WMn) inversion) scans were acquired. R2*maps, SWI and QSM were produced from the FLASH data and an enhanced PSIR image and T1 map were produced from the MP2RAGE data. The Iglesias atlas FreeSurfer segmentation was used to carry out a probabilistic segmentation of the MPRAGE image into 333segments including the TRN. A novel approach to enhance visualisation of TRN contrast, by identifying the intensity profiles along perpendicular line segments to the Iglesias TRN mask, was developed and applied. This approach creates a rectangular “flattened” image of the left and right thalamic periphery.

Results: An example of the acquired and derivative images in one participant zoomed over the thalamus are shown along in Figure 1 (top panel). The corresponding “flattened” images for the left and right hemisphere are shown in the bottom panel. Figure 2 shows the flattened QSM images for the left and right hemisphere for one slice of all 10 participants, with red arrows marking areas of visible TRN.

Discussion: Visualising the TRN in vivo is a critical first step in understanding its role in brain function. Figure 1 shows that while the WMn MP2RAGE image shows good contrast between inner thalamic nuclei (e.g. MDm, MDi, PuM, LD and LP), as previously reported, the FLASH scans and its derivatives show much stronger delineation between the outer thalamic nuclei (e.g PuL, VLa, VLp and VPL). These images are also where the TRN is visible. The contours seen in the flattened SWI and R2* align closely with the thin layer (TRN) between the thalamus and internal capsule shown on the QSM. This demonstrates that the contrast driving TRN visibility is induced by susceptibility eU’ects and as such QSM oU’ers the clearest contrast to delineate the TRN. Figure 2 demonstrates the cross-participant variability of TRN visibility. This variability is also seen across slices for a single participant. The cause of this variability is possibly due to individual variation in TRN thickness, brain iron content and participant motion during the scan, and requires further investigation.

Conclusion: We developed an optimised set of sequences to define the TRN, which also provide contrast within the thalamus allowing definition of thalamic nuclei. Using the developed flattening method, we can visualise the TRN in all participants. The next step with these images is to make individual masks of the TRN.

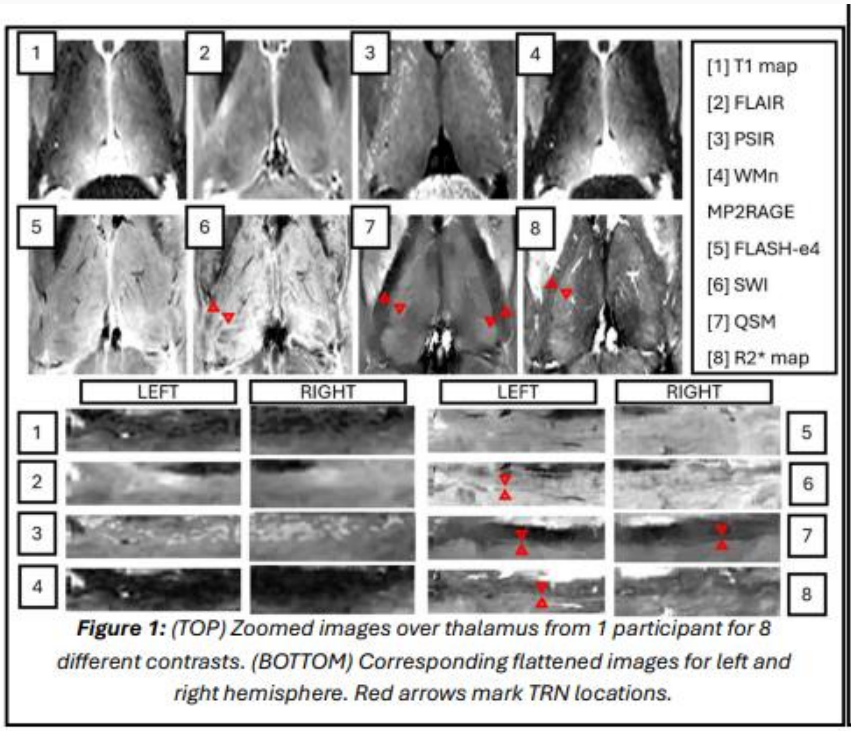

Figure 1: *(TOP) Zoomed images over thalamus from 1 participant for 8 different contrasts. (BOTTOM) Corresponding flattened images for left and right hemisphere. Red arrows mark TRN locations.*

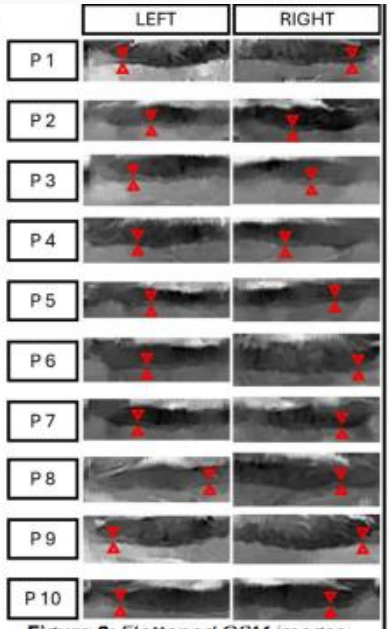

Figure 2: *Flattened QSM images for left and right hemisphere for all 10 participants. Red arrows*

O6: Towards Targeted Thalamic Ultrasound Interventions in Disorders of Consciousness

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Transcranial ultrasound stimulation (TUS) is an emerging non-invasive brain stimulation technique that has shown promise as a potential treatment for Disorders of Consciousness (DOCs). However, existing studies have only investigated the effects of TUS on the central thalamus, and the precision of sonication of the intended target in TUS interventions for DOC requires further validation. Additionally, existing interventions have not addressed the distinct roles of thalamic regions beyond the central thalamus in DOC pathologies.

This study therefore aims to advance the development of TUS as a reliable, adaptable and mechanistically informed treatment for DOCs. To this end, we will validate a novel TUS protocol in healthy participants by demonstrating differential modulation of two thalamic nuclei implicated in two distinct DOC clinical phenotypes: patients who show no behavioural or neuroimaging evidence of awareness, and those with cognitive motor dissociations (CMD). Specifically, we will present data on the behavioural effects of offline sonication of the mediodorsal and ventrolateral thalamic nuclei on performance on a backward masking task and a motor task involving graded force production. By establishing task- and region-specific effects, this study seeks to lay the groundwork for future applications of TUS as a personalised and evidence-based treatment for DOCs. Moreover, this work may extend our understanding of the causal roles of specific thalamic nuclei in mediating awareness versus responsiveness, offering insight beyond our intervention's therapeutic application.

Authors List