Luke William Tait, PhD

Research

My research interests involve the use of computational techniques such as time series analysis, graph theory, and non-linear dynamical systems to understand brain dynamics during cognitive processes and in neurodegenerative disorders. I joined the Cardiff University Brain Research Imaging Centre in July 2019 as a Research Associate in Dr Jiaxiang Zhang's lab, integrating functional neuroimaging (primarily magnetoencephalography) with computational modelling and analysis techniques to understand the neuronal mechanisms underpinning resting-state functional connectivity dynamics. Prior to this, the focus of my PhD research was using similar techniques to understand alterations to brain dynamics in Alzheimer's disease.

Career & Education

Research Associate, Cardiff University, July 2019-Present.

Post-doctoral research with Dr Jiaxiang Zhang and the Cognition and Computational Brain Lab at Cardiff University Brain Research Imaging Centre. Using computational techniques to study the neuronal mechanisms underpinning resting-state functional connectivity dynamics.

Postgraduate Researcher, University of Exeter, 2015-2019.

Thesis title: Multi-scale Mathematical Modelling of Brain Networks in Alzheimer's Disease
Supervisors: Dr Marc Goodfellow (Mathematics), Dr Jon T Brown (Medical School)

The primary focus during my PhD as part of an Alzheimer's Society Doctoral Training Centre was characterising and modelling alterations to brain dynamics in Alzheimer's disease in order to gain mechanistic insight into the relationship between pathology, function, and phenotype. This work ranged from dynamics of individual or local networks of neurons in animal models of dementia pathologies, to whole brain oscillatory dynamics recorded by EEG. During my PhD, I developed tools to study EEG microstates of the brain as a biomarker to aid with early diagnosis of Alzheimer's disease. This work additionally included a three month secondment from seed-corn funding modelling neuronal dynamics in the spatial navigation systems of the brain.

MMath Mathematical Physics, University of Liverpool, 2011-2015

First Class Honours

Skills

Programming: I am an experienced user of Matlab, and also have experience with Python, R, and Maple. This has predominantly been applied to computational data analysis, statistical techniques, and numerical simulations. I several outputs of my research coding are freely available on Github.

Mathematical expertise: Time series analysis, graph theory, bifurcation theory & dynamical systems, numerical/ computational modelling, statistical analysis, model parameter fitting, inverse problems. Multi-scaled brain modelling including biophysical and phenomenological point neuron models, neuronal network models, neural mass/field models, and coupled oscillators.

Neuroimaging: My primary area of expertise is non-invasive human neuroimaging such as EEG, MEG, MRI, and fMRI. I am experienced with software such as Fieldtrip, Brainstorm, SPM, and Freesurfer for analysis of these data. I additionally have experience working with two-photon calcium imaging data in rodents, and spent six months performing whole cell patch clamp experiments from slice.

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github.com/lukewtait researchgate.net/profile/Luke_Tait bit.ly/GoogleScholar_LukeTait

Research Outputs

Preprints

Cortical source imaging of resting-state MEG with a high resolution atlas: An evaluation of methods
Tait L, Ozkan A, Szul MJ, Zhang J
bioRxiv 2020.01.12.903302 (2020)
Under review with NeuroImage (2nd round)

Journal Articles

EEG microstate complexity for aiding early diagnosis of Alzheimer's disease
Tait L, Tamagnini F, Stothart G, Barvas E, Monaldini C, Frusciante R, Volpini M, Guttmann S, Coulthard E, Brown JT, Kazanina N, Goodfellow M
Scientific Reports (*in press*)
Preprint available at bioRxiv 833244

Computational modelling in source space from scalp EEG to inform presurgical evaluation of epilepsy surgery
Lopes M, Junges L, **Tait L**, Terry JR, Abela E, Richardson MP, Goodfellow M
Clinical Neurophysiology 131(1):225-234 (2020)

Network substrates of cognitive impairment in Alzheimer's disease
Tait L, Stothart G, Coulthard E, Brown JT, Kazanina N, Goodfellow M
Clinical Neurophysiology 130(9):1581-1595 (2019)

Control of clustered action potential firing in a mathematical model of entorhinal cortex stellate cells
Tait L, Wedgwood K, Tsaneva-Atanasova K, Brown JT, Goodfellow M
Journal of Theoretical Biology 449:23-34 (2018)

Conference Proceedings

Graph-theoretical measures provide translational markers of large-scale brain network disruptions in human dementia patients and animal models of dementia
Stothart G, Petkov G, Kazanina N, Goodfellow M, **Tait L**, Brown JT
International Journal of Psychophysiology 108:71 (2016)

Oral Presentations

EEG Microstate Complexity of Aiding Early Diagnosis of Alzheimer's Disease. Alzheimer's Association International Conference, online, July 2020

AlzSM: Using EEG to understand Alzheimer's disease and develop biomarkers. Alzheimer's Society Annual Conference, London, May 2019.

Analysis of the EEG of Alzheimer's Patients. Computational Biology Symposium, University of Exeter, July 2018.

Control of Clustered Action Potential Firing in a Mathematical Model of Entorhinal Cortex Stellate Cells. Alzheimer's Research UK South West and Wales Scientific Network Meeting, Bristol, May 2018.

Multi-scale functional network dysfunction in dementia. Computational Biology Symposium, University of Exeter, June 2017.

Reduced Frontal Lobe Delta Power and Increased Network Homogeneity in a Mouse Model of Frontotemporal Dementia. Network Biology Symposium, University of Exeter, June 2016.
Alzheimer's Research UK Annual Conference PhD Day, March 2016.

Poster Presentations

EEG Microsate Complexity for Aiding Early Diagnosis of Alzheimer's Disease. Alzheimer's Research UK South West and Wales Scientific Network Meeting, online, July 2020.

Control of Clustered Action Potential Firing in a Mathematical Model of Entorhinal Cortex Stellate Cells.
International Conference on Mathematical Neuroscience, Juan-les-Pins, France, June 2018.
Alzheimer's Research UK South West and Wales Scientific Network Meeting, Bristol, May

2018.
Brain Networks and Neurological Disorders: From Theory to Clinic, University of Exeter, UK, April 2018.

Decreased Delta Synchrony, Reduced Frontal Lobe Delta Power, and Increased Network Homogeneity in a Mouse Model of Frontotemporal Dementia.
Alzheimer's Society Annual Conference, Bristol, UK, June 2016.
Alzheimer's Research UK Annual Conference, Manchester, UK, March 2016.

Manuscript peer-review

I have peer-reviewed an article in Frontiers in Aging Neuroscience.

Software (Github Repositories)

Evaluate Inverse Methods. Matlab codes to run the analysis presented in Tait et al. (2020) bioRxiv 2020.01.12.903302, which source reconstructs data using a range of methodologies and allows to compare and contrast performance using a variety of metrics.

Reduced Atlas. This subrepository of "Evaluate Inverse Methods" contains a novel MEG-optimized reduction to the Human Connectome Project's multimodal brain atlas, as well as codes to integrate it with Fieldtrip.

Human Brain Simulator. Matlab codes written during my PhD to run large scale simulations of the human brain. By default, the code runs the simulations presented in Tait et al. (2019) Clin Neurophysiol 130:1581-95, and a wide range of options are available to customize the simulations.

Matlab Data Visualization. A Matlab toolbox to plot data distributions in more informative manners than a bar chart with error bars. Options for kernel density plots, dot plots, box plots, and violin plots are included, and much control is given to the user to customize the appearance of the plot.

Intro to Modelling. Contains all slides for the workshop I organized entitled "An Introduction to Modelling Brain Dynamics", and contains the Matlab codes for the corresponding practical sessions.

FUNDING AND AWARDS

Travel Grant

Guarantors of Brain, £600

NA Software Honours Prize for Best Project in the Field of Mathematical Software

Awarded for my undergraduate dissertation.

TEACHING

Supervision

- 2019-Present: Co-supervision of a PhD student at Reading University School of Pharmacology using EEG to aid with diagnosis of Alzheimer's disease
- January-April 2019: Informal supervision of a 4 month PhD training year project combining diffusion MRI data with whole brain computational models to test how structural connectivity reflects dynamics in memory disorders.
- Summer 2018: Informal supervision of a 2nd year undergraduate summer project comparing 64-channel research-grade and 14-channel commercial EEG headsets.
- Summer 2018: Informal supervision of an M-level undergraduate summer project performing bifurcation analysis and numerical continuation of subthreshold oscillations and resonance in a neuron model.

Demonstrating Undergraduate/Postgraduate modules

- Neuroimaging: Methods and Applications, Psychology, Postgraduate. Planning and leading a tutorial in an area of my choosing.
- Mathematical Modelling in Biology and Medicine, Natural Sciences, 4th year. Assisting a series of lecturers in running tutorials.
- Differential Equations, Mathematics, 2nd year. Planning and leading weekly additional support sessions for a group of ten natural sciences students taking a course targeted to mathematics students.
- Mathematics and Computing: Integrative Tools for Natural Sciences, Natural Sciences, 1st year. Running tutorial sessions for natural sciences students.

IMPACT AND NETWORKING

Conferences and Workshops Organised

- An Introduction to Modelling Brain Dynamics. This workshop consisted of three practical tutorials, with an additional tutorial to take place in the future, led by researchers in CUBRIC. Each tutorial consists of a one-hour seminar and one hour Matlab practical session. I took the lead in planning and organising this workshop, including seeking funding for external speakers, and adjusting the workshop to an online format in light of COVID-19.

Conferences and Workshops Attended

- Alzheimer's Association International Conference, online, July 2020
- Alzheimer's Research UK South West and Wales Scientific Network Meeting, online, July 2020
- Cognitive Computational Neuroscience, Berlin, Germany, September 2019
- Computational Biology Symposium, Exeter, UK, July 2018
- International Conference on Mathematical Neuroscience, Juan-les-Pines, France, June 2018
- Alzheimer's Research UK South West and Wales Scientific Network Meeting, Bristol, May 2018
- BioDynamics, Royal College of Physicians, London, UK, April 2018
- Brain Networks and Neurological Disorders: from Theory to Clinic, Exeter, UK, April 2018
- Network Dynamics: Bridging Theoretical Advances and Applications, Exeter, UK, April 2018
- Integrated Systems Neuroscience, Manchester, UK, September 2017
- Computational Biology Symposium, Exeter, June 2017
- Alzheimer's Research UK Annual Conference and PhD Day, Aberdeen, UK, March 2017
- Symposia on Memory, Centre de Recerca Mathematica, Barcelona, Spain, March 2017
- Computational Neurology, Newcastle, UK, February 2016
- Model Parameter Estimation for Predictive Medicine, Birmingham, UK, July 2016
- Alzheimer's Society Annual Conference, Bristol, UK, June 2016
- Network Biology Symposium, Exeter, June 2016
- Alzheimer's Research UK Annual Conference and PhD Day, Manchester, March 2016
- Large Scale Brain Networks in Health and Disease: A GW4 Dissemination Event, M-Shed, Bristol, January 2016

Public Engagement

- Oral presentation at Alzheimer's Research UK South-West public open day, Exeter, June 2018
- Display stand at University of Exeter Public Engagement Day, Exeter, March 2018
- Meet a Neuroscientist Event, Exeter, March 2018
- Electrophysiology display stand at Brain Awareness Week Event for schools, Exeter, March 2018

- INSPIRE Lecture at Exeter Maths School, Exeter, December 2017
- Display stand at Alzheimer's Society Memory Walk, Exeter, September 2017
- Oral presentation at Alzheimer's Society Legacy Fundraiser, Exeter, July 2017
- Oral presentation at Exeter School, Exeter, March 2017
- Display stand at Alzheimer's Society Memory Walk, Plymouth, October 2016