

Dr Alexander D Shaw

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Research Interests

Computational Neuroscience, Generative Models, Computational Psychiatry, Dynamical Systems, Neuroimaging, Machine Learning, Neuropharmacology, Optimisation, Translational Neuroscience, Active Inference, Variational Methods, Theoretical Neurobiology

Profile

Computational neuroscientist and research leader focused on building neuro-inspired AI and understanding brain function through generative modelling, active inference and neuroimaging. I lead the Computational Psychiatry & Neuropharmacological Systems (CPNS) Lab at the University of Exeter, where we combine predictive coding, synaptic modelling and translational neuroscience to investigate psychiatric disease and develop intelligent systems.

As a Senior Lecturer and Lab Director, I've led interdisciplinary programmes spanning theoretical neuroscience, human neuroimaging (M/EEG, MRI, PET) and pharmacological challenge studies with psychedelics, ketamine and GABAergic compounds. My work bridges deep computational modelling and experimental science, with open-source tools for variational inference, neural mass modelling and agent-based learning. Passionate about translating brain-based principles into AGI, mental health technology and cognitive enhancement.

Qualifications

- PGCert Academic Practice, University of Exeter, 2024
- PhD Medicine (Neuroscience), Cardiff University, 2014 (MRC-funded)
- MSc Psychology & Education (BPS route), University of Bristol, 2010
- BA (Hons) Music, Rolle College of Music & Drama, 2009

Appointments

- Senior Lecturer, University of Exeter, 2023–Present
- Fellowship of the Higher Education Academy (FHEA), 2023.
- Lecturer, University of Exeter, 2021–2023
- Research Fellow, Cardiff University, 2017–2021
- Visiting Research Fellow, University of Auckland, 2019–Present
- Research Associate, University of Cambridge, 2015–2017

- Postdoctoral RA, Cardiff University, 2014–2015

Leadership & Strategic Roles

- PI, Computational Psychiatry & Neuropharmacological Systems (CPNS) Lab
- Director of Business Engagement and Innovation for Psychology (DoBEI)
- Member, Senior Leadership Team (SLT), Department of Psychology
- Member, Exeter Brain Network Steering Committee
- Member, Exeter Psychedelic Interdisciplinary Centre (EPIC)

Current & Recent Funding

- EPSRC PhD Studentship – Neural Mass Model Calibration (£98k, PI, 2025)
- GABA Labs PhD Studentship – EEG assay for functional drinks (£~80k, ad hoc, PI, 2025)
- GABA Labs EEG Study – Developing an EEG based Functional Drinks Assay (PI, 2022)
- Awakn Life Sciences – Ketamine Therapy in Addiction (£441k, Co-I, 2023)
- Wellcome Trust – Sleep Detectives: Modelling psychosis risk (£1M, Co-I, 2022)
- MRC – Convergent endophenotypes in Psychiatric Genetics (£3.5M, Collaborator, 2021)

Grants Recently Submitted / Under Review

- BBSRC – Perceptual Learning: A Computational Neuroscience Approach (£600k, Co-I, 2026)
- ESRC - Computational and Neurocognitive Basis of Perceptual Learning (£611k, Co-I, 2026)
- EPSRC Standard Grant – Data-driven calibration of neural mass and whole-brain models; integrating mechanistic modelling with optimisation and AI (£600k, Co-I, 2026)
- BBSRC – Seeing Numbers: Neural Foundations of Numerical Fluency (£825k, Co-I 2026)
- SparkNS – Biomarker-Guided Development of NMDA-PAM Therapeutics for CNV-Associated Neurodevelopmental Disorders (£2M, Co-I, 2026)
- AstronauTx (Industry Contract) – Computational modelling of novel neuropharmacological compounds to predict network-level effects (£TBC, PI, 2026)
- ESRC – Slim Chances: How Ozempic Reshapes Social and Economic Decision-Making (£150k, Co-I, 2026)

Grants In Preparation

- Wellcome Discovery Award – Follow-on to Sleep Detectives; longitudinal mechanistic characterisation of sleep, synaptic pathology and psychosis risk (£5M, Co-I, 2026)
- MRC: research grant: applicant-led – Computational Neuropharmacology Platform for Mechanistic Biomarkers from Human M/EEG & Preclinical LFP (£2.14M, PI, 2026)
- Industry: Functional Drinks EEG Assay – A Platform for Neurofunctional Evaluation of Drinks Using M/EEG Biomarkers and Computational Modelling (£TBC, PI, 2026)

Research Programme

My research integrates human neurophysiology (EEG/MEG), computational modelling and neuropharmacology to identify circuit-level mechanisms underlying psychiatric and neurological disorders and to translate these mechanisms into biomarkers, assays and neuro-inspired intelligent systems. I lead and co-lead experimental studies across clinical, developmental and pharmacological contexts, alongside the development of advanced Bayesian and dynamical-systems methods for mechanistic inference.

Experimental & Clinical Research

- The *Sleep Detectives* programme: large-scale at-home sleep EEG in children and adolescents at elevated psychiatric risk due to neurodevelopmental CNVs, alongside unaffected siblings. The programme integrates longitudinal sleep phenotyping (spindles, slow waves, micro-architecture) with mechanistic thalamo-cortical modelling and parallel rodent pharmacological neurophysiology, enabling cross-species generative modelling to identify circuit-level biomarkers of cognitive and psychosis risk.
- Neuropharmacology and EEG assay development in collaboration with GABA Labs: involving EEG and cognitive testing of non-alcoholic functional drinks with putative GABAergic mechanisms. This work benchmarks behavioural and neurophysiological effects against pharmacological GABA modulators, developing scalable *in silico* assays of receptor-level function.
- Experimental EEG studies of ketamine and naloxone examining NMDA-opioid interactions, antidepressant mechanisms and fronto-parietal network dynamics (PhD project: Joy Krecke).
- Clinical MEG and modelling studies in movement disorders, including co-supervision of a clinical fellowship at Cardiff University applying biophysical modelling to motor system dysfunction in dystonia (Dr Claire MacIver).
- Experimental paradigms spanning perception, learning and plasticity, including visual LTP, sensory plasticity, motor adaptation and task-based EEG/MEG across psychiatric, neurological and pharmacological cohorts.

Computational & Modelling Research

- Development and application of biophysical generative models of brain dynamics, including thalamo-cortical and neural mass models fitted to EEG/MEG data with explicit receptor- and synapse- level interpretation (GABA, NMDA, AMPA, neuromodulatory systems).
- Advanced Bayesian inference methods, including extensions of Variational Laplace with thermodynamic integration, low-rank curvature approximations, heteroscedastic noise modelling and hierarchical empirical Bayes for cohort-level inference.
- Computational psychiatry approaches to schizophrenia, depression, epilepsy, neurodevelopmental CNVs and neurodegeneration, linking inferred circuit parameters to symptoms, cognition and treatment response.
- Neuro-inspired AI and active inference, involving the development of agentic systems grounded in the Free Energy Principle, including reusable generative architectures, perception-action loops and biologically interpretable control systems.

PhD Supervision & Research Leadership

I supervise and co-supervise postdoc, PhD and postgraduate research spanning experimental neurophysiology, computational psychiatry, neuropharmacology and neuro-inspired AI. Current projects include:

- Lio Berndt (Postdoc): sleep EEG and computational modelling in young people at elevated risk of psychosis, with a focus on thalamo-cortical mechanisms underlying sleep disruption and neurodevelopmental vulnerability (Sleep Detectives programme).
- Alessia Caccamo (PhD): development of mathematical and computational methods for calibrating neural mass models, with applications to epilepsy and treatment mechanisms using M/EEG data.
- Rosina (Crow) Diebel (PhD): computational modelling of patient cohorts to characterise circuit-level dysfunction across psychiatric disorders, linking model parameters to clinical phenotypes.

- Joy Krecke (PhD): experimental EEG and computational modelling of ketamine and mu-opioid receptor interactions, investigating mechanisms of antidepressant response and network-level effects.
- Victoria Smart (PhD): computational modelling of the pharmacodynamics of psychedelic compounds, focusing on receptor-mediated changes in cortical dynamics and plasticity.
- Sam Kirwan (PhD): neurophysiological and behavioural assays of GABAergic functional drinks, combining EEG, cognitive testing and biophysical modelling in collaboration with industry partners (GABA Labs).
- Olivia Hill-Cousins (PhD): computational ethics and moral cognition, modelling human moral judgements toward AI versus human agents to inform the design of explainable and ethically aligned AI systems.
- Regan Mills (PhD): striatal connectomics and multi-modal data analysis using large-scale open datasets to characterise psychosis-linked network dysfunction and clinical heterogeneity.

In addition, I co-supervise clinical and translational research fellows applying MEG and computational modelling to motor system dysfunction in movement disorders (e.g. dystonia) and regularly supervise MSc (Clinical Psychology) and undergraduate (BSc Psychology) research projects integrating experimental design with computational analysis.

Select Recent Publications

Full list: [Google Scholar](#). Visit [CPNS Lab](#) for PDFs

Preprints / Submitted

- Coordination Without Command: Active Inference and the Route to Embodied Intelligence. [\[link\]](#)
- Polyphonic Intelligence: Constraint-Based Emergence, Pluralistic Inference and Non-Dominating Integration. [\[link\]](#)
- The Embodied Octopus: Distributed Intelligence and Active Inference in a Flexible Body. [\[link\]](#)
- Toward a reusable architecture for intelligent agents. *OSF*, 2025. [\[link\]](#)
- A Neuro-Inspired Computational Framework for AGI: Predictive Coding, Active Inference and Free Energy Minimisation. *OSF*, 2025. [\[link\]](#)
- Females with epilepsy show abnormal changes to perimenstrual sensory induced long-term potentiation. *BioRxiv Preprint*, 2025. [\[link\]](#)

Published

- Sleep as a window into thalamocortical pathology: generative modeling implicates NMDA receptor hypofunction in 22q11.2 deletion syndrome. *Translational Psychiatry*, 2025. [\[link\]](#)
- Dynamics-Informed Priors (DIP) for Neural Mass Modelling. *Imaging Neuroscience*, 2026. [\[link\]](#)
- Predictive Coding and Neurocomputational Psychiatry: A Mechanistic Framework for Understanding Mental Disorders. *Frontiers in Psychiatry*, 2026. [\[link\]](#)
- Restoring Synaptic Balance in Schizophrenia: Insights from a thalamo-cortical conductance-based model. *Schizophrenia Bulletin*, 2025. [\[link\]](#)
- GABAergic modulation of beta power enhances motor adaptation in frontotemporal lobar degeneration. *Alzheimer's and Dementia*, 2025. [\[link\]](#)
- WAND: A multi-modal dataset integrating advanced MRI, MEG and TMS for multi-scale brain analysis. *Nature Scientific Data*, 2025. [\[link\]](#)
- Neurophysiological evidence that frontoparietal connectivity and GABA-A receptor changes underpin the antidepressant response to ketamine. *Nature Translational Psychiatry*, 2024. [\[link\]](#)
- Modulation of long-term potentiation following microdoses of LSD captured by thalamo-cortical modelling in a randomised, controlled trial. *BMC Neuroscience*, 2024. [\[link\]](#)
- Changes in Visual Long-Term Potentiation Show Preserved Cyclicity in Human Females Taking Combined Oral Contraceptives. *Neuroendocrinology*, 2023. [\[link\]](#)

- Neurophysiological consequences of synapse loss in progressive supranuclear palsy. *Brain*, 2022. [link]
- GABAergic cortical network physiology in frontotemporal lobar degeneration". *Brain*, 2022. [link]
- A comparison of GABA-ergic (propofol) and non-GABA-ergic (dexmedetomidine) sedation on visual and motor cortical oscillations, using MEG. *NeuroImage*, 2021. [link]
- Tiagabine-induced modulation of oscillatory connectivity and activity matches PET-derived GABA_A receptor distributions. *European Neuropsychopharmacology*, 2021. [link]
- Dopamine and Glutamate in Antipsychotic-Responsive Compared With Antipsychotic-Nonresponsive Psychosis: A Multicenter Positron Emission Tomography and Magnetic Resonance Spectroscopy Study (STRATA). *Schizophrenia Bulletin*, 2021. [link]
- Modelling thalamocortical circuitry shows that visually induced LTP changes laminar connectivity in human visual cortex. *PLOS Computational Biology*, 2021. [link]
- Generative modelling of thalamo-cortical mechanisms underlying ketamine effects on oscillations. *NeuroImage*, 2020. [link]
- Juvenile myoclonic epilepsy shows increased posterior theta and reduced sensorimotor beta resting connectivity. *Epilepsy Research*, 2020. [link]
- GABA-ergic Dynamics in Human Frontotemporal Networks Confirmed by Pharmaco-Magnetoencephalography. *The Journal of Neuroscience*, 2020. [link]
- Oscillatory, Computational and Behavioral Evidence for Impaired GABAergic Inhibition in Schizophrenia. *Schizophrenia Bulletin*, 2020. [link]
- In Vivo Assay of Cortical Microcircuitry in Frontotemporal Dementia: A Platform for Experimental Medicine Studies. *Cerebral Cortex*, 2020. [link]
- Exploring the neurobiological and psychological mechanisms of ketamine in problematic gambling: a mechanistic study. *The International Journal of Neuropsychopharmacology*, 2025. [link]
- Magnetoencephalography insights to dementia and drug intervention. *Alzheimer's & Dementia*, 2021. [link]
- Correction: WAND: A multi-modal dataset integrating advanced MRI, MEG and TMS for multi-scale brain analysis. *Scientific Data*. [link]
- Peak visual gamma frequency is modified across the healthy menstrual cycle. *Human Brain Mapping*, 2018. [link]
- Neurophysiologically-informed markers of individual variability and pharmacological manipulation of human cortical gamma. *NeuroImage*, 2017. [link]
- Structural and neurochemical correlates of individual differences in gamma frequency oscillations in human visual cortex. *Journal of Anatomy*, 2015. [link]
- Evidence that Subanesthetic Doses of Ketamine Cause Sustained Disruptions of NMDA and AMPA-Mediated Frontoparietal Connectivity in Humans. *The Journal of Neuroscience*, 2015. [link]
- Ketamine amplifies induced gamma frequency oscillations in the human cerebral cortex. *European Neuropsychopharmacology*, 2015. [link]
- Increased visual gamma power in schizoaffective bipolar disorder. *Psychological Medicine*, 2015. [link]
- Marked Reductions in Visual Evoked Responses But Not gamma-Aminobutyric Acid Concentrations or gamma-Band Measures in Remitted Depression. *Biological Psychiatry*, 2013. [link]

Referees

- Prof Krish Singh – singhkd@cardiff.ac.uk
- Prof Celia Morgan – Celia.Morgan@exeter.ac.uk
- Prof James Rowe – james.rowe@mrc-cbu.cam.ac.uk
- Dr Suresh Muthukumaraswamy – sd.muthu@auckland.ac.nz