Robert L. Peach

Group leader and Principal Investigator

Website www.robertpeach.com **Personal E-mail** robertlucienpeach@gmail.com

Phone : +44 785 447 6074 / + 49 162 813 4345 **Work E-mail :** peach_r@ukw.de / r.peach13@imperial.ac.uk

Address : Dürerstrasse 8, Würzburg, 97072, Germany **Nationality :** UK/Irish Citizen

Researcher fascinated by the emergence of neural dynamics from neural network structure and their role in behaviourally relevant computation. I develop the theory and build mathematical tools to explore the role of higher-order inteactions and their role in driving non-linearity and compositionality in neural dynamics. Published 30+ articles in peer-reviewed journals and 9+ years experience teaching and supervising undergraduate/postgraduate students, including PhD students.

Education

2018 | **PhD in Applied Mathematics and Computational Biology**
Department of Chemistry, Imperial College London, London, UK
Thesis title : Exploring protein dynamics using graph theory and single-molecule spectroscopy
Thesis Supervisors : Prof. Mauricio Barahona, Prof. Sophia Yaliraki, Prof. Keith Willison, Prof. David Klug

2014 | **MRes in Chemical Biology, Distinction**
Department of Chemistry, Imperial College London, London, UK
Supervisors : Prof. Mauricio Barahona, Prof. Sophia Yaliraki, Prof. Keith Willison, Prof. David Klug

2012 | **MSci (Hons) Physics, 1st class**
Department of Physics, University of Bristol, Bristol, UK
Thesis title : A study of Penetration Depth Anisotropy in Sr_2RuO_4
Thesis Supervisors : Prof. Antony Carrington

Professional Appointments

2020-Present | **Group Leader, University Hospital Würzburg**
Department of Neurology, University Hospital Würzburg, Würzburg, Germany
Principal Investigator leading research that combines dynamical systems theory and deep learning to decode brain signals with a focus on mvoement disorders. Co-supervising 5 MD students and 1 PhD student. Designed and taught Methods of Data Science lecture course for MSc in Translation Neuroscience.

2020-Present | **Senior Honorary Research Fellow, Imperial College London**
Department of Brain Sciences, Imperial College London, London, UK
On-going collaborative projects with the labs of Dr. Nir Grossman (Brain Sciences) and Prof. Mauricio Barahona (Mathematics). Co-supervising 2 PhD students.

2020 | **Visiting Scholar, Harvard University**
Department of Biostatistics, School of Public Health, Harvard University, Boston, US
Research stay with lab of Professor JP Onnela to study time-series data in healthcare.

2017-2020 | **Research Associate, Imperial College London**
Centre for Mathematical Precision Healthcare, Department of Mathematics, Imperial College London, London, UK
Development of graph theoretical tools and methodologies within applied mathematics, with application to learning analytics and neuroscience. Supervising 5+ MSc students.

Publications

Peer-reviewed Publications. (10 First Author, 4 Final Author)

* 2024 **Peach, R.** et al, Implicit Gaussian process representation of vector fields over arbitrary latent manifolds, accepted at the Twelfth International Conference on Learning Representations, ICLR 2024

* 2024 Luff, C., **Peach, R.** et al., The neuron mixer and its impact on human brain dynamics, accepted at Cell Reports

* 2024 **Peach, R.** et al., Quantitative assessment of head movement dynamics in dystonia using visual perceptive deep learning : a multi-centre retrospective longitudinal cohort study, accepted at npj Digital Medicine

2024 Nurisso, M. et al, A unified framework for Simplicial Kuramoto models, accepted at Chaos

2024 Chirumamilla, Venkata C., et al. Non-linear dynamic state-space network modeling for decoding neurodegeneration. Neural Regeneration Research 19.9 : 1879-1880.

2024 Arnaudon, Alexis, et al. ”PyGenStability, a multiscale community detection with generalized Markov Stability.” ACM Transactions on Mathematical Software.

†2024 Friedrich, M et al. ”Validation and application of computer vision algorithms for video-based tremor analysis” accepted at npj Digital Medicine.

2024 Auer, T. et al, Functionally annotated electrophysiological neuromarkers of healthy ageing and memory function, accepted at Human Brain Mapping

2023 Liu, Z., **Peach, R.** et al., Interaction Measures, Partition Lattices and Kernel Tests for High-Order Interactions, Proceedings of Neural Information Processing Systems (NeurIPS)

2023 Liu, Z., **Peach, R.** et al., Kernel-based Joint Independence Tests for Multivariate Stationary and Nonstationary Time-Series, Royal Society Open Science, 10.11

†2023 Sil, T. et al. Wavelet-Based Bracketing, Time–Frequency Beta Burst Detection : New Insights in Parkinson’s Disease. Neurotherapeutics, s13311-023-01447-4

2023 Lange, Florian, et al. ”Machine versus physician-based programming of deep brain stimulation in isolated dystonia : A feasibility study.” Brain Stimulation 16.4 : 1105-1111.

†2023 De, A., et al., ”Machine Learning in Tremor Analysis : Critique and Directions.” Movement Disorders. 38,5:717-731

2023 Lange, F., et al., ”Distinct phenotypes of stimulation-induced dysarthria represent different cortical networks in STN-DBS.” Parkinsonism and Related Disorders, 105347.

†2023 Friedrich, M., et al., ”Smartphone video nystagmography using convolutional neural networks : ConVNG.” Journal of Neurology 1-13.

2022 Butler, R. C. et al., ”Transcranial ultrasound stimulation to human middle temporal complex improves visual motion detection and modulates electrophysiological responses.” Brain Stimulation 15, 5.

* 2022 **Peach, R. L.**, Arnaudon, A., and Barahona, M., ”Relative, local and global dimension in complex networks.” Nature Communications 13.1 : 1-11.

2022 Myall, A., Price, J., **Peach, R.**, et al., ”Predicting hospital-onset COVID-19 infections using dynamic networks of patient contact : an international retrospective cohort study”, The Lancet Digital Health 4 (8), e573-e583.

2022 Arnaudon, A., **Peach, R.**, Petri, G., Expert, P., ”Connecting Hodge and Sakaguchi-Kuramoto through a mathematical framework for coupled oscillators on simplicial complexes”, Communications Physics 5 (1), 1-12.

* 2021 **Peach, R. L.**, et al. ”HCGA : Highly comparative graph analysis for network phenotyping.” Patterns 2.4 : 100227.

2021 Liu, Zhaolu, **Peach, R. L.**, et al. ”Listening to mental health crisis needs at scale : using Natural Language Processing to understand and evaluate a mental health crisis text messaging service.” Frontiers in Digital Health 3 : 779091.

2021 Ming, Damien K., et al. ”Informing antimicrobial management in the context of COVID-19 : understanding the longitudinal dynamics of C-reactive protein and procalcitonin.” BMC infectious diseases 21.1 : 1-7.

* 2021 **Peach, R. L.**, et al. ”Understanding learner behaviour in online courses with Bayesian modelling and time series characterisation.” Scientific reports 11.1 : 1-15.

2021 Myall, A. C., **Peach, R. L.**, et al. ”Network memory in the movement of hospital patients carrying antimicrobial-resistant bacteria.” Applied Network Science 6.1 (2021) : 1-23.

2021 Chrysostomou, S., et al. ”Repurposed floxacins targeting RSK4 prevent chemoresistance and metastasis in lung and bladder cancer.” Science translational medicine 13.602 : eaba4627.

2021 Knorr, S., et al. ”The evolution of dystonia-like movements in TOR1A rats after transient nerve injury is accompanied by dopaminergic dysregulation and abnormal oscillatory activity of a central motor network.” Neurobiology of Disease 154 : 105337.

* 2021 Schreglmann, S. R., Wang, D., **Peach, R. L.**, et al. ”Non-invasive suppression of essential tremor via phase-locked disruption of its temporal coherence.” Nature communications 12.1 : 1-15.

***** 2020 Arnaudon, A., **Peach, R. L.**, and Barahona, M. ”Scale-dependent measure of network centrality from diffusion dynamics”. Physical Review Research, 2.3 : 033104.

* 2020 **Peach, R. L.**, Arnaudon, A., and Barahona, M., ”Semi-supervised classification on graphs using explicit diffusion dynamics.” Foundations of Data Science 2.1 : 19.

* 2019 **Peach, R. L.**, et al. ”Data-driven unsupervised clustering of online learner behaviour.” npj Science of Learning 4.1 : 1-11.

2019 Sowley, H., et al. ”Detection of Drug Binding to a Target Protein Using EVV 2DIR Spectroscopy.” The Journal of Physical Chemistry B 123.17 : 3598-3606.

***** First or joint-first author publications. † Final or joint-final author publications.

Preprints and other Publications

2023 Gosztolai, A., **Peach, R.** et al., Interpretable statistical representations of neural population dynamics and geometry, arXiv:2304.03376

2021 Myall, Ashleigh, et al. ”Characterising contact in disease outbreaks via a network model of spatial-temporal proximity.” medRxiv.

* 2019 **Peach, R. L.**, Saman, D., Yaliraki, S. N., Klug, D. R., Ying, L., Willison, K. R., and Barahona, M. Unsupervised graph-based learning predicts mutations that alter protein dynamics. bioRxiv, 847426.

Honors and Awards

2017 30-under-30 Award, Forbes

2015 CDT Poster Prize, Imperial College and Warwick collaborative conference, Imperial College London

2011 Commendation for excellence, Faculty of Science, University of Bristol

2010 Commendation for excellence, Faculty of Science, University of Bristol

2008 Award for best scientist in 2008, De-Lisle Science College

2006 Gold in the Intermediate National Maths Olympiad award, De-Lisle Science College

Grants and Fellowships

2024 Cross Research Collaboration grant between Wurzburg and Berlin, ReTune, (rated excellent, expected 10 million euros), DFG, Germany
2023 Transformative Technologies , £50k, Innovate UK
2022 MedTech Superconnector, £45k, Imperial College London
2021 Digital Innovation Fund, £141,537, Imperial College London
2020 Pilot project grant, £40k, UK Dementia Research Institute
2017 Innovation competition prize, £5k, Shell Livewire
2017 Innovation competition prize, £10k, CDT den, Imperial College London
2017 Travel grant, £1k, IC Trust, Imperial College London
2017 Travel grant, £1k, Analytical Biosciences, Royal Society of Chemistry
2016 Innovation Grant, £5k, Climate-KIC, Imperial College London
2015 Innovation Grant, £5k, Greenhouse Climate-KIC, Imperial College London

Presentations

Invited Talks

2022 Network Science, Workshop for ReTune Fall School, Apolda Thuringen.
2022 Machine-learning to analyse educational data, Workshop for SBVER bank, Imperial College London.
2021 Diffusion on networks and peaks in the transient responses, Hatano-lab, Osaka University, Japan (on-line).
2021 Neural membrane frequency mixing phenomenon mechanically linked to neural circuit memory impairment, Connectome, Dementia Research Institute, London, UK.
2021 Highly comparative graph analysis, SNAC, Sydney, Australia (on-line).

Panel member

2019 Good practices in distributed and online learning, iFest 2019, Alexandria, US.

Contributing Talks

2022 Frustrated oscillator dynamics with higher order interactions, NetSci 2022, Shanghai, China (on-line).
2022 Characterization of tremor via un-biased, feature-based signal analysis, DGKN, Wuerzburg, Germany.
2020 Highly comparative graph analysis, Complex Networks conference, Rome, Italy (on-line).
2020 Overshooting behaviours in networks, COXIC, London, UK.
2019 Tremor Analysis in Essential Tremor patients, Complexity in the 21st Century, Institute of Physics, London.
2019 Using time-series engagement data to predict student performance, GMAC Leadership conference, Fort Lauderdale, US.
2019 Highly comparative graph analysis, Onnela Lab, Harvard School of Public Health, Boston, US.
2018 Learning analytics dashboard and student engagement behaviours, FOME, Oslo, Norway.

Campus talks

2023 The frequency mixing neuron, Complexity Seminar, Department of Mathematics, Imperial College London
2022 Centre of Mathematical Precision Healthcare, Imperial College London, UK.
2021 Detecting Endogenous Frequency Mixing in Animals and Humans, Grundlagenwissenschaftlichen Seminaren, University Hospital Würzburg, Germany.
2018 Business School Round Table, Imperial College Business School, Imperial College London, UK.
2018 Predicting patient tremor response to TACS, CMPH, Imperial College London, UK.

Teaching Experience

Lecture courses

2022-Present | **Methods of Data Science : Applications to the Life Sciences**
Department of Neurology, Universität Klinik Würzburg, Würzburg, Germany
Developed and ran the lecture course.

Teaching Assistant

2019-2022 | **Imperial Business School**
Imperial College London, London, UK
Business Analytics MSc : Statistics and Econometrics, Network Analytics, Maths and Statistics, Workforce analytics.

2018-2019 | **Department of Mathematics**
Imperial College London, London, UK
Methods of Data Science

2014-2015 | **Department of Chemistry**
Imperial College London, London, UK
2nd year Thermodynamics, 2nd year electronics lab

Additional Activities

Industrial Engagement

2022-Present | **Co-founder and CTO**
NEXQ, Imperial College London, London, UK
AI powered decision support tool for Infection Prevent Control teams.

2021 | **Consultant**
Imperial Consultants, Imperial College London, London, UK
Provided academic insights into the translation of natural language processing into healthcare applications for a London GP company.

2015-2018 | **Chief Finance Officer**
FreshCheck Ltd, London, UK
Co-Founded a biotech spin-out company from Imperial College London. Successfully seed-funded and still operational.

2011 | **MBDA**
Stevenage, UK
Systems Design Engineer.

Outreach

2022 Introduction to Network Science, ReTune workshop, Apolda Thuringen, Germany.

2020 - Present Gathering and open-sourcing code for network algorithms from Barahona group, Imperial College London.

2021 Network Science, Public online seminar, Sydney Systems Neuroscience and Complexity.

2019 Public talk on time-series analysis of Essential Tremor, Complexity in the 21st Century, Institute of Physics, London

2018 Visualising deep learning, Imperial Lates (science fair), Imperial College London.

2017 Ambassador to Tokyo Tech collaboration workshop on behalf of Imperial College.

2016 - 2017 Detecting bacteria with a colour change, Festival of Science, Imperial College London.

Open-source Software

- MARBLE : `https://github.com/agosztolai/MARBLE`
- RVGP : `https://github.com/agosztolai/RVGP`
- PyGenStability : `https://github.com/barahona-research-group/PyGenStability`
- Highly comparative graph analysis : `https://github.com/barahona-research-group/hcga`
- Dimension of networks : `https://github.com/barahona-research-group/DynGDim`
- Graph diffusion reclassification : `https://github.com/barahona-research-group/GDR`
- Multiscale centrality : `https://github.com/barahona-research-group/MultiscaleCentrality`
- Frequency mixing : `https://github.com/ImperialCollegeLondon/freqmix`

Other

2019 - Present Founding member of Precision Education initiative at Imperial College London.

2019 - Present Organising and leading book club on maths and machine learning, Imperial College London.

Languages and Skills

Languages	English - Native ; German - Advanced ;
Programming	Python ; MatLab ; R ; Bash ;
Patents	PCT for chemical invention that changes colour in presence of bacteria of harmful chemicals, IPN : WO 2018/185486 A1, Owner : Fresh Check Ltd.

International relations

Key external collaborators

- Prof. Mauricio Barahona (Department of Mathematics, Imperial College London)
- Dr. Adam Gosztolai (Medical University Wien + EPFL, Switzerland)
- Dr. Nir Grossman (Department of Brain Sciences, Imperial College London)
- Dr. Alexis Arnaudon (Blue Brain Project, EPFL, Switzerland)
- Dr. Paul Expert (Global Business School for Health, University College London)

Supervision

PhD students (direct/co-supervision)

2021 - Present	Zhaolu Liu. Imperial College London. Co-supervisor. Statistical framework for detecting higher-order interactions.
2021 - Present	Tanmoy Sil. University Hospital Würzburg. Co-supervisor. Developing methods for robust detection of beta-bursts in human LFP data.
2020 - Present	Ashleigh Myall. Imperial College London. Co-supervisor. Complex networks for modelling disease dynamics in hospitals.
2019 - 2024	Junheng Li. Imperial College London. Co-supervisor. Sleep on-set dynamics in large-scale EEG data set.

Master's students

Present	Timo Trilk, Department of Neurology, University Hospital Würzburg.
Present	Mansur Ahmed, Department of Mathematics, Imperial College London
2023	Veronika Selzam, Department of Neurology, University Hospital Würzburg.
2023	Verena Haering, Department of Neurology, University Hospital Würzburg.
2021	Xiaoqing Fan, Department of Mathematics, Imperial College London
2020	Minyoung Kim, Department of Mathematics, Imperial College London
2019	Isabel Ashman, Department of Mathematics, Imperial College London
2019	Eduardo Conesa, Department of Mathematics, Imperial College London
2018	Hossein Abbas, Department of Mathematics, Imperial College London
2018	Dominik Klein, Department of Mathematics, Imperial College London

Undergraduate students

2021	Mansur Ahmed, Department of Mathematics, Imperial College London
2021	Matthew Packham, Department of Mathematics, Imperial College London
2020	Sara Vallejo Mengod, Department of Mathematics, Imperial College London
2019	Jose Folch, Department of Mathematics, Imperial College London
2019	Henry Palasciano, Department of Mathematics, Imperial College London
2017	Dominik Saman, Department of Chemistry, Imperial College London