UNIVERSITY OF SURREY

MULTILEVEL DYNAMICS OF HUMAN AND ANIMAL SLEEP: MATHEMATICAL MODELS MEET DATA
ONLINE EVENT
WORKSHOP PROGRAMME

12-21 July 2021

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The Institute of Advanced Studies (IAS) at the University of Surrey sponsors workshops and Fellowships at the 'cutting edge' of science, engineering, social science and the humanities. Through this scheme the Institute fosters interdisciplinary collaborations and encourages a flow of international scholars to visit, enjoy their stay at Surrey and leave behind excellent ideas and innovations.

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INTRODUCTION

Mathematical models have been very successful at explaining different aspects of the sleep and circadian system but with greater understanding of regulatory mechanisms coming from transcriptomics, genomics, metabolomics, the proliferation of data from wearables, new EEG methods and new light sensors, there is considerable opportunity to make mathematical models that are more predictive, that include differences in genotype, physiology and environment and describe individual differences in phenotype.

We are hosting 5 discussion sessions to facilitate interdisciplinary collaboration, connecting those with data to those who build mathematical models and develop analysis tools. Each discussion session will last about 1 hour. In each session, two speakers will set the scene, one from a biology perspective and one from a computational / mathematical perspective.

Organising committee:
Prof Anne Skeldon, University of Surrey
Prof Derk-Jan Dijk, University of Surrey

Administrative support:
Ms Vicki Blamey, Institute of Advanced Studies

PROGRAMME

MONDAY 12TH JULY

15:30 - 17:30 (BST)
Multilevel Dynamics of Human and Animal Sleep: Mathematical Models Meet Data
Prof Derk-Jan Dijk *(Surrey)* and Prof Anne Skeldon *(Surrey)*

TUESDAY 13TH JULY

12:00 - 13:00 (BST)
Models and data for real life sleep restriction, performance and circadian rhythmicity
Prof Steven Lockley (Harvard/Surrey) and Dr Svetlana Postnova (Sydney)

WEDNESDAY 14TH JULY

16:00 - 17:00 (BST)
Models and data for the dynamics of the NREM, REM, wake cycle, effects of homeostasis and circadian rhythmicity
Prof Paul Franken (Lausanne) and Prof Cecilia Diniz-Behn (Colorado School of Mines)

TUESDAY 20TH JULY

12:00 - 13:00 (BST)
Omics-based biomarkers for sleep and circadian status
Prof Simon Archer (Surrey) and Dr Rebecca Richmond (Bristol)

WEDNESDAY 21ST JULY

16:00 - 17:00 (BST)
Circadian clock models for sleep-wake modelling
Guest Speaker Prof Victoria Booth (Michigan)

PARTICIPANTS

Prof Derk-Jan Dijk

Derk-Jan Dijk PhD, FRSB, FMedSci, is Professor of Sleep and Physiology, Distinguished Professor at the University of Surrey, Director of the Surrey Sleep Research Centre. He has been a Royal Society-Wolfson Research Merit Award holder, a Senior Research Associate in the Institute of Pharmacology at the University of Zurich, an Assistant Professor of Medicine at Harvard Medical School, and an Associate Neuroscientist in the Brigham and Women's Hospital in Boston.
He has more than 35 years of experience in clinical sleep research. His current research interests include the circadian and homeostatic regulation of sleep; the contribution of sleep to brain function in healthy ageing and dementia; the role of circadian rhythmicity in sleep regulation; identification of novel-biomarkers for sleep debt status and circadian rhythmicity, susceptibility to the negative effects of sleep loss; understanding age and sex related differences in sleep physiology and sleep disorders. His research has been or is funded by the Dementia Research Institute, the Biotechnology and Biological Science Research Council, the Wellcome Trust, The Air Force Office of Scientific Research, Philips Lighting and several major pharmaceutical companies.
Prof Dijk has published more than 250 research and review papers in the area of sleep and circadian rhythms. He has served as an Associate and Deputy Editor to SLEEP and Editor of the Journal of Sleep Research. He also serves as consultant to the pharmaceutical industry.

Prof Anne Skeldon

Prof Skeldon is a mathematician with a keen interest in applying mathematics in the real world. Her background is in dynamical systems and bifurcation theory.
Much of Prof Skeldon's early work was in fluid mechanics, particularly the Faraday wave problem. More recently she has shifted towards biology/sociology. Prof Skeldon was a co-investigator on the 6 year complexity science project, Evolution and Resilience of Industrial Ecosystems. She currently co-leads the Centre for Mathematical and Computational Biology and Is Research Director for the Department of Mathematics. Prof Skeldon's current research interests are largely centred on sleep and circadian rhythms and data science. She collaborates with researchers at the Surrey Sleep Research Centre developing and analysing mathematical models of sleep-wake regulation. This work recently featured in the UK parliamentary debate ``School should start at 10am because teenagers are too tired''. Prof Skeldon has a particular interest in the impact of our light environment on sleep, including the impact of permanent DST.

Prof Steven Lockley

Prof Lockley is a Neuroscientist in the Division of Sleep and Circadian Disorders at Brigham and Women's Hospital and an Associate Professor of Medicine in the Division of Sleep Medicine, Harvard Medical School. He Is also a Professor and VC Fellow at the Surrey Sleep Research Centre and an Affiliated Faculty Member of the Centre for Health and the Global Environment, Harvard School of Public Health.

With over 25 years of research experience in circadian rhythm and sleep, Prof Lockley is a specialist in ways to reset the circadian clock, particularly the role of light and melatonin. He has studied the effects of light on the circadian pacemaker extensively, including the role of light wavelength, timing, duration and pattern. This work has led to development of 'smart' lighting applications designed to improve alertness, safety and productivity, translation of the physiological effects of light into architecture and design and light therapies for several clinical disorders.

Prof Lockley has also studied the impact of circadian disruption, long work hours, sleepiness and sleep disorders on performance and health in occupational groups, including doctors, police and firefighters and has led several workplace interventions that have reduced workplace errors and injury. He also advises NASA on how to alleviate jetlag for astronauts travelling the globe and how to reduce the problems associated with shift work at NASA mission control.

Prof Lockley has published more than 180 original reports, reviews, chapters and editorials on circadian rhythms and sleep. He co-edited the first textbook on sleep and health 'Sleep, health and society: from Aetiology to Public Health', and co-authored 'Sleep: A Very Short Introduction' from Oxford University Press.

Dr Svetlana Postnova

Dr Postnova is a Senior Lecturer In Neurophysics and Brain Dynamics at the School of Physics, the University of Sydney, Australia and an honorary affiliate at the Woolcock Institute of Medical Research. Dr Postnova obtained her PhD in Computational Neuroscience form the University of Marburg, Germany, and a BSc in Physics from the Saratov State University in Russia. Her research interests are in computational modelling of sleep and circadian dynamics, brain-body interaction, and computational medicine more generally. She leads Chronophysics research group focusing on physics of circadian rhythms and sleep.

Dr Postnova focuses on research problems that are of both fundamental and translational value, such as interplay between the environmental and endogenous factors in control of sleep-wake cycles and circadian rhythms, homeostatic brain clearance, and predictions of sleep, circadian rhythms and alertness in real-life conditions of circadian misalignment.

Prof Paul Franken

Prof Franken received his PhD from the University of Groningen,The Netherlands, in 1993 for his work on sleep homeostasis and thermoregulation at the University of Zurich under the direction of Alexander A. Borbély. He was a postdoctoral fellow with H. Craig Heller at Stanford University, USA, where he studied the cellular mechanisms underlying circadian clock resetting. In 1996 he joined Mehdi Tafti at the University of Geneva where he used QTL analysis to map sleep and EEG traits in mice. He then moved back to Stanford in 2000 as a senior research scientist to establish an independent lab. At Stanford he continued to work on the genetics of sleep homeostasis and further focused on the molecular interactions between circadian rhythms, sleep homeostasis, and brain metabolism. He joined the CIG in 2005.

Prof Franken's research interests include sleep and energy homeostasis, circadian clock genes, QTL analysis, genetics of EEG activity.

Prof Cecilia Diniz-Behn

Prof Diniz-Behn is an Associate Professor in the Department of Applied Mathematics and Statistics at Colorado School of Mines. She also has an appointment as an Adjoint Assistant Professor in the Department of Pediatrics at the University of Colorado School of Medicine.

Prof Diniz-Behn's research applies multiscale mathematical modelling to investigate key research questions in metabolism, sleep, and circadian rhythms. Specifically, she models key dynamics in sleep and circadian (~24 h) neurophysiology; whole-body metabolism including changes in glucose, glycerol, and insulin, and the diverse interactions among these systems. Dysregulation of sleep and/or metabolism has dramatic implications for human health, and the complex ways in which these systems interact, both on a mechanistic and on a behavioural level, are just beginning to be understood. Her research in mathematical and computational neuroscience focuses on understanding neurophysiologic mechanisms for sleep/wake regulation and her work in whole-body glucose-insulin dynamics focuses on insulin resistance in adolescents. Mathematically, Prof Diniz-Behn's research contributes to the development of novel techniques to understand high-dimensional multiscale systems of differential equations; analyse connections between structure and dynamics of general networks; and investigate dynamics at the interface of deterministic and stochastic behaviour.

Prof Simon Archer

Prof Archer is a Professor of Molecular Biology of Sleep in the Surrey Sleep Research Centre. His research has focussed upon the genetics and molecular biology of human sleep and circadian rhythms, and individual differences therein. His work on polymorphisms within human circadian clock genes has led the field in human targeted sleep and circadian genomics. This has been particularly successful with the discovery within *PER3* of a variable number tandem repeat (VNTR) polymorphism that associates with a wide range of healthy and clinical phenotypes including chronotype, delayed sleep phase disorder (DSPD), behavioural activity, sleep homeostasis, cognitive performance, fMRI-assessed brain activity, neuronal structure, light sensitivity, melatonin suppression, mood disorders, anxiety, body mass, addiction, and cancer. Prof Archer has extended the human work to transgenic animal models where he has investigated the effects of PER3 on sleep and circadian rhythms in transgenic knock out mice, and also humanised knock in mice where he introduced the primate-specific VNTR into the mouse PER3, phenocopying sleep homeostasis characteristics measured in humans.

Prof Archer has also pioneered methods to measure gene expression in human whole blood samples and Surrey has led the field in the development of protocols to measure genome-wide human time series gene expression in clinical studies. More recently, he has used time series whole-blood gene expression to investigate circadian disruption caused by simulated microgravity during a constant bed rest protocol (with ESA). With the application of machine learning to these datasets, he and his team have also developed and validated human blood transcriptome biomarkers for circadian phase and sleep loss.

Dr Rebecca Richmond

Dr Richmond is a Vice-Chancellor's Research Fellow in Molecular Epidemiology at the University of Bristol. Her research aims to: 1) highlight the relative importance and inter-relationships of several health behaviours (including smoking, e-cigarette use, alcohol, sleep, physical activity) for prioritization in disease prevention strategies and 2) identify molecular pathways (e.g. epigenetic and metabolomic) which could serve as therapeutic targets for intervention. Dr Richmond's major areas of focus are on the large-scale integration of molecular data in population-based and clinical health science as well as the development and application of causal inference methods, including Mendelian randomization. She has specific interests in cancer, women's health and lifecourse epidemiology.

Prof Victoria Booth

Prof Booth is a Professor of Mathematics and Associate Professor of Anesthesiology at the University of Michigan.

Prof Booth and her research group use mathematical modelling to gain insight to the workings of the brain. Their goal is to help reveal and understand the physiological mechanisms generating experimentally observed brain and neural activity. Their approach is guided by two primary motivations : 1) to provide the neuroscience community with quantitative support of experimental hypotheses and rigorous theoretical frameworks for exploring and developing experimentally-testable predictions; and 2) provide the mathematical community with rigorous analyses of the solution structure of our models to identify nonlinear dynamics in neural processing.

Current research projects address: neuronal control of sleep-wake regulation; acetylcholine modulation of network dynamics and rhythms; the influence of neuron and network properties on neural activity, and spinal cord circuits for pain processing.

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