PERSONAL DETAILS

Family name, First name: Wodeyar, Anirudh
ORCID: 0000-0003-2577-5139
URL for web site: www.anirudhwodeyar.com

Profile & fit. I develop real-time, uncertainty-aware multivariate signal processing and apply it to human electrophysiology, ideally positioning my lab to enable invasive **closed-loop phase-locked stimulation** and its non-invasive translation.

- **Education and key qualifications**

3/6/2019 PhD in Psychology with focus on Cognitive Neuroscience
Faculty of Cognitive Science, Department of Social Sciences, University of California, Irvine, USA
PhD Supervisor: Ramesh Srinivasan

2018 Master in Statistics
Department of Statistics, University of California, Irvine, USA

2014 Bachelor in Computer Science (honors)
Department of Computer Science, BITS Pilani, K.K. Birla Goa Campus, Goa, India

- **Current position**

08 - 2024 Assistant Professor of Statistical Learning
Faculty of Science and Engineering, Department of Advanced Computing Sciences, Maastricht University, Netherlands

- **Previous position(s)**

03/23 – 07/24 Postdoctoral Research Fellow (PI: Catherine J. Chu, Epileptologist)
Department of Neurology, Massachusetts General Hospital and Harvard Medical School, Boston, MA, USA

09/19 – 02/23 Postdoctoral Associate (PI: Mark A. Kramer, Computational Neuroscientist)
Department of Mathematics and Statistics, Boston University, Boston, MA, USA

RESEARCH ACHIEVEMENTS AND PEER RECOGNITION

Research achievements [RA]

Real-time Phase Estimation:

1. Wodeyar, A., Schatza, M., Widge, A. S., Eden, U. T., & Kramer, M. A. (2021). **A State Space Modeling Approach to Real-Time Phase Estimation**. *eLife*.
   Significance: I developed a novel state-space model for real-time neural phase estimation, leading conception, methods and validation. This was a methodological breakthrough that overcame the critical limitations of traditional filtering. This method has garnered significant attention in the field, leading to multiple invited talks and several collaborations.
2. Wodeyar, A., Marshall, F. A., Chu, C. J., Eden, U. T., & Kramer, M. A. (2023). **Different methods to estimate the phase of neural rhythms agree, but only during times of low uncertainty**. *eNeuro*.
   Significance: In this critical follow-up to [1], I showed how phase is not a uniquely defined measure (there is no "ground-truth phase" for real data). By simulating various *dynamical* and *phenomenological* models, I showed that acknowledging and managing uncertainty in phase is a key

factor for the correct application and interpretation of phase-based analyses, a crucial consideration for **real-time stimulation**. I led conception, data curation, analysis and writing.

Understanding Epilepsy and Epileptic Dynamics:

3. Wodeyar, A., Chinappen, D., Mylonas, D., Baxter, B., Manoach, D. S., Eden, U. T., Kramer, M. A., & Chu, C. J. (2024). **Thalamic epileptic spikes disrupt sleep spindles in patients with epileptic encephalopathy**. *Brain*.
4. Wodeyar, A., Kramer, M. A., & Chu, C. J. (2025). **Thalamic engagement by epileptic spikes as a mechanism for widespread slow oscillation–spindle decoupling**. *Epilepsia*.
   Significance: My key personal observation of post-epileptic spike thalamic activity suppression led to this study. I enabled this inference by developing a novel Poisson generalized linear model analysis to prove that epileptic spikes indirectly impair cognition by disrupting thalamic sleep spindles. This work, which I presented at the MGH-MIT iBrain Symposium, is now shifting the field's focus from epileptic spikes themselves to their disruptive impact on healthy sleep brain rhythms.
5. Wodeyar, A., Chinappen, D., Kwon, H., Shi, W., Richardson, M., Kramer, M. A., & Chu, C. J. (2025). **A hierarchical cascade of sleep rhythms drives memory consolidation in humans and is disrupted in epilepsy**. *bioRxiv*, 2025-05. (*under review at PNAS*)
   Significance: In this follow-up study to [3], I designed and led the analysis showing that epileptic spikes hijack the brain's memory consolidation oscillatory cascade at its apex—the orbitofrontal slow oscillation. This provides a circuit-level mechanism for cognitive dysfunction in epilepsy. My time studying epilepsy and how rhythms can be disrupted by epileptic spikes – an event similar to single-pulse stimulations.

Real-Time Stimulation:

6. Kwon, H., Chinappen, D. M., Wodeyar, A., Kinard, E., Goodman, S., Shi, W., Kramer, M. & Chu, C. J. (2025). **Changes in slow oscillations and sleep spindles by auditory stimulation positively correlate with memory consolidation in children with epilepsy and controls**. *bioRxiv*, 2025-05.
   Significance: We showed that confidence-gated, phase-aligned stimulation is feasible in children with epilepsy, delivering timing precisely locked to endogenous sleep rhythms. I contributed the phase-analysis tools and supported the real-time implementation and data collection. These results demonstrate the end-to-end timing, safety gating, and clinical workflow I will reuse for phase-locked seizure control.

Non-Invasive Computational Modeling

7. Wodeyar, A., & Srinivasan, R. (2022). **Structural Connectome constrained Graphical Lasso for MEG Partial Coherence**. *Network Neuroscience*.
   Significance: I created a new method to infer brain networks from M/EEG data by extending the Graphical Lasso to the frequency domain and integrating anatomical constraints such as the structural connectome. I supported conception, and led simulation development, analysis and validation. The boundary element modelling skills I developed to validate this method are directly applicable to the whole-brain modelling **needed for non-invasive translation**.

Activity Propagation over the Structural Connectome

8. Wodeyar A, Cassidy JM, Cramer SC, Srinivasan R. (2020). **Damage to the structural connectome reflected in resting-state fMRI functional connectivity.** *Network Neuroscience*.
   Significance: I led this study building a statistical model linking whole-brain structural connectivity to whole-brain functional connectivity demonstrating that activity in the brain diffuses across multiple pathways between any pair of regions. This understanding is critical for setting up simulation of seizure propagation in **Objective 3**.

Abnormal Oscillations in Stroke

9. Cassidy, J. M., Wodeyar, A., Wu, J., Kaur, K., Masuda, A. K., Srinivasan, R., & Cramer, S. C. (2020). **Low-frequency oscillations are a biomarker of injury and recovery after stroke**. *Stroke*, *51*(5), 1442-1450.
10. Cassidy, J. M., Wodeyar, A., Srinivasan, R., & Cramer, S. C. (2021). **Coherent neural oscillations inform early stroke motor recovery**. *Human brain mapping*, *42*(17), 5636-5647.
    Significance: A pair of studies demonstrating another area – increasing or suppressing oscillations to

enable stroke recovery. I contributed the analytic tools to enable this pair of projects.

Peer Recognition
Grants and Prizes

2023 Epilepsy Foundation New England Blue Skies Award ($75000, co-PI with Catherine Chu and Mark Kramer)
2024 American Epilepsy Society Young Investigator Award ($1200)
2023 American Epilepsy Society Fellow ($3000)
2018 Falmagne Fellowship, University of California, Irvine ($3000)
2018 Associate Dean's Fellowship, University of California, Irvine (estimated $10200)
2016 Yellott Fellowship Honourable Mention, University of California, Irvine ($1000)

Reviewer

Clinical Neurophysiology, iScience, Scientific Reports, PLOS Comp Bio, Brain Topography, J. Neuroscience, Neurorehabilitation and Neural Repair, J. Neuroscience Methods, Frontiers in Neurology, Pattern Recognition

Talks

2024 American Epilepsy Society, Los Angeles, USA [Result of Young Investigator Award]
"Epileptic spike coupled sleep oscillations in the orbitofrontal cortex, hippocampus and thalamus predict disrupted memory consolidation"
2024 DGKN24, Frankfurt, Germany
"Using State Space Models to Estimate Phase"
2023 Stickgold Science of Sleep Series, Boston, USA
"Triple-coupling of sleep oscillations across the Pre-frontal Cortex, Thalamus and Hippocampus"
2023 New England Statistical Society, Boston, MA, USA
"Using State Space Models to Estimate Phase"
2023 Cognitive Rhythms Collaborative Working Group, Boston, MA, USA
"Modeling Brain Rhythms as Damped Harmonic Oscillators Driven by Noise"
2022 MGH-MIT iBrain Human Intracranial Neuroscience Symposium, Boston, MA, USA
"Human Thalamic Recordings Reveal Competing Spikes and Spindles"
2018 Invited Seminar in Department of Cognitive Science, University of California Irvine, CA, USA
"Fronto-occipital Fasciculus: A Structural and Functional Connectivity Analysis"
2017 Workshop on Big Data in Brain Science
"Complex Gaussian Graphical Models of Electroencephalographic Data"
2016 Invited Seminar in Department of Cognitive Science, University of California Irvine, CA, USA
"Estimation of Sparse Directed Brain Networks underlying Memory Encoding, Retention and Retrieval"

ADDITIONAL INFORMATION

Research Path
My interdisciplinary training in computer science, statistics, and neuroscience has equipped me to create novel real-time algorithms, design targeted interventions, and build in silico models to validate new therapies for abnormal brain oscillations.

During my doctoral work, I moved from research on fitting biophysical models of EEG towards more robust, data-driven statistical models. This culminated in developing a network-based generative model, constrained by the white matter connectivity, to infer functional brain networks from MEG/EEG/fMRI data [RA 7-8]. This work and collaborations with clinicians [RA 9-10] provided me with foundational expertise in computational modeling, network neuroscience, brain oscillations and accounting for the complex artifacts in macroscale recordings—skills that are central to enabling non-invasive translations. As a postdoctoral researcher with Drs. Kramer and Eden, I focused on creating a key enabling technology for understanding the function of brain oscillations. I developed a novel state-space modeling approach for real-time, high-fidelity estimation of oscillatory phase, published in *eLife* [RA 1-2]. This methodological breakthrough, which overcomes the core limitations of traditional filtering, provides the foundational technology for the closed-loop interventions.

For my second postdoc, I joined Dr. Catherine Chu at Massachusetts General Hospital/Harvard Medical School, to pursue the unique opportunity to study rare human thalamic recordings in epilepsy. There, a key observation I made - periods of thalamic silence following epileptic spikes - led us to identify a mechanism for cognitive dysfunction [RA 3-4]. I led funding acquisition for this project receiving the New England Epilepsy Society's Blue Skies award. For this project, I developed a new analytical framework based on Poisson GLMs, demonstrating that spikes disrupt sleep spindles. In a follow-up study, I showed that spikes hijack the entire cortico-thalamo-hippocampal memory consolidation cascade at their origin by coupling with orbitofrontal slow oscillations [RA 5]. I gained experience in understanding epileptic dynamics and contributed to ongoing real-time stimulation experiments in Dr. Chu's lab [RA 6] – supporting the basic knowledge needed for this grant.

Now, as an Assistant Professor at Maastricht University, I am synthesizing these threads into a comprehensive research program. The Maastricht University environment, with its strong focus on computational science and direct links to clinical research at the MUMC+ (Maastricht University Medical Centre). My lab is focused on developing novel real-time methods for oscillation tracking in service of brain-computer interfaces.

Career breaks, diverse career paths and major life events

04/2024 – 07/2024 Parental Leave in Boston, MA, USA
08/2024 – ongoing 0.2 FTE reduction for Parental Leave

Other Contributions to the Research Community

Teaching Activities and University Responsibilities

2024 - Examiner for Semester 1 and 2 Projects for Bachelor of Data Science students, Faculty of Science and Engineering, Maastricht University
2024 - Coordinator (lectures, course organization and administration, exams) of "Principles of Data Science" for Bachelor of Data Science, Faculty of Science and Engineering, Maastricht University
2024 - Coordinator (lectures, course organization and administration, exams) of "Statistics" for Bachelor of Computer Science, Faculty of Science and Engineering, Maastricht University
2024 - Coordinator (lectures, course organization and administration, exams) of Probability Theory for Bachelor of Brain Science, Faculty of Psychology and Neuroscience Maastricht University
2017-2018 Co-organizer and Speaker of/in Summer Seminar series on "Computational Models of Macroscale Electrophysiology", University of California, Irvine, USA
2014-2018 Teaching Assistant (grading, discussion sections, office hours) for Introduction to Psychology, Probability and Statistics and MATLAB Programming, School of Social Sciences, University of California, Irvine, USA

Supervision

01/2024 – 06/2024	Nikitas Savvides, Bachelor's thesis
	Ismael Belhaouari, Bachelor's thesis
	Luuk Dobbelaar, Bachelor's thesis
08/2024 – 04/2025	Gijs Bekkers, Master's thesis
07/2021 – 09/2021	NeuroMatch Academy, Master's Students, FENS Poster Presentation