Robert Rosenbaum

Department of Applied and Computational Mathematics and Statistics
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Education

M.S. and Ph.D. in Mathematics (2008, 2011)
University of Houston

B.S. in Mathematics and in Computer Science (2006)
University of Houston

Positions

Associate Professor with Tenure (2020 - Present)
University of Notre Dame
Department of Applied and Computational Mathematics and Statistics
Director of Graduate Studies (2021 - Present)

Huisking Foundation Assistant Professor of Applied and Computational Mathematics and Statistics (2019 - 2020)
University of Notre Dame
Department of Applied and Computational Mathematics and Statistics

Assistant Professor (2014 - 2019)
University of Notre Dame
Department of Applied and Computational Mathematics and Statistics

Postdoctoral Associate (2011 - 2014)
University of Pittsburgh
Department of Mathematics

Publications

1. R. Rosenbaum. *Modeling Neural Circuits Made Simple with Python (Textbook)*. Under Contract with MIT Press, 2024

2. A. R. Andrei, A. E. Akil, N. Kharas, R. Rosenbaum, K. Josić, and V. Dragoi. Rapid compensatory plasticity revealed by dynamic correlated activity in monkeys in vivo. *Nature Neuroscience*, pages 1–10, 2023

3. N. Shervani-Tabar and R. Rosenbaum. Meta-learning biologically plausible plasticity rules with random feedback pathways. *Nature Communications*, 14(1):1805, 2023

4. V. Zhu and R. Rosenbaum. Learning fixed points of recurrent neural networks by reparameterizing the network model. *arXiv preprint arXiv:2307.06732*, 2023

5. R. Rosenbaum. On the relationship between predictive coding and backpropagation. *PLoS One*, 17(3):e0266102, 2022

6. V. Zhu and R. Rosenbaum. Evaluating the extent to which homeostatic plasticity learns to compute prediction errors in unstructured neuronal networks. *Journal of Computational Neuroscience*, pages 1–17, 2022

7. A. E. Akil, R. Rosenbaum, and K. Josić. Balanced networks under spike-time dependent plasticity. *PLOS Computational Biology*, 17(5):e1008958, 2021

8. B. C. Schwab, D. Kase, A. Zimnik, R. Rosenbaum, M. G. Codianni, J. E. Rubin, and R. S. Turner. Neural activity during a simple reaching task in macaques is counter to gating and rebound in basal ganglia–thalamic communication. *PLoS Biology*, 18(10):e3000829, 2020

9. C. Baker, V. Zhu, and R. Rosenbaum. Nonlinear stimulus representations in neural circuits with approximate excitatory-inhibitory balance. *PLoS Computational Biology*, 16(9):e1008192, 2020

10. C. Ebsch and R. Rosenbaum. Spatially extended balanced networks without translationally invariant connectivity. *Journal of Mathematical Neuroscience*, 10(1):1–14, 2020

11. C. Baker, E. Froudarakis, D. Yatsenko, A. Tolias, and R. Rosenbaum. Inference of synaptic connectivity and external variability in neural microcircuits. *Journal of Computational Neuroscience*, pages 1–25, 2020

12. C. Huang, D. Ruff, R. Pyle, R. Rosenbaum, M. Cohen, and B. Doiron. Circuit models of low-dimensional shared variability in cortical networks. *Neuron*, 101(2):337–348, 2019

13. C. Baker, C. Ebsch, I. Lampl, and R. Rosenbaum. Correlated states in balanced neuronal networks. *Physical Review E*, 99(5):052414, 2019

14. R. Pyle and R. Rosenbaum. A reservoir computing model of reward-modulated motor learning and automaticity. *Neural Computation*, 31(7):1430–1461, 2019

15. C. Ebsch and R. Rosenbaum. Imbalanced amplification: A mechanism of amplification and suppression from local imbalance of excitation and inhibition in cortical circuits. *PLoS Computational Biology*, 14(3):e1006048, 2018

16. R. Rosenbaum, M. Smith, A. Kohn, J. Rubin, and B. Doiron. The spatial structure of correlated neuronal variability. *Nature Neuroscience*, 20(1):107, 2017

17. G. Koch Ocker, Y. Hu, M. Buice, B. Doiron, K. Josić, R. Rosenbaum, and E. Shea-Brown. From the statistics of connectivity to the statistics of spike times in neuronal networks. *Current Opinion in Neurobiology*, 46:109–119, 2017

18. R. Pyle and R. Rosenbaum. Spatiotemporal dynamics and reliable computations in recurrent spiking neural networks. *Physical Review Letters*, 118(1):018103, 2017

19. B. Doiron, A. Litwin-Kumar, R. Rosenbaum, G. Ocker, and K. Josić. The mechanics of state-dependent neural correlations. *Nature Neuroscience*, 19(3):383–393, 2016

20. R. Pyle and R. Rosenbaum. Highly connected neurons spike less frequently in balanced networks. *Physical Review E*, 93:040302, 2016

21. R. Rosenbaum. A diffusion approximation and numerical methods for adaptive neuron models with stochastic inputs. *Frontiers in Computational Neuroscience*, 10, 2016

22. A. Litwin-Kumar, R. Rosenbaum, and B. Doiron. Inhibitory stabilization and visual coding in cortical circuits with multiple interneuron subtypes. *Journal of Neurophysiology*, 92:3844–3848, 2016

23. R. Rosenbaum and B. Doiron. Balanced networks of spiking neurons with spatially dependent recurrent connections. *Physical Review X*, 4(2):021039, 2014

24. R. Rosenbaum, T. Tchumatchenko, and R. Moreno-Bote. Correlated neuronal activity and its relationship to coding, dynamics and network architecture. *Frontiers in Computational Neuroscience*, 8, 2014

25. R. Rosenbaum, A. Zimnik, F. Zheng, R. Turner, C. Alzheimer, B. Doiron, and J. Rubin. Axonal and synaptic failure suppress the transfer of firing rate oscillations, synchrony and information during high frequency deep brain stimulation. *Neurobiology of Disease*, 62:86–99, 2014

26. R. Rosenbaum. Short term plasticity, biophysical models. In *Encyclopedia of Computational Neuroscience*, pages 1–5. Springer, 2014

27. S. Reich and R. Rosenbaum. The impact of short term synaptic depression and stochastic vesicle dynamics on neuronal variability. *Journal of Computational Neuroscience*, 35(1), 2013

28. R. Rosenbaum, J. Rubin, and B. Doiron. Short term synaptic depression and stochastic vesicle dynamics reduce and reshape neuronal correlations. *Journal of Neurophysiology*, 108(2), 2013

29. R. Rosenbaum, J. Rubin, and B. Doiron. Short term synaptic depression imposes a frequency dependent filter on synaptic information transfer. *PLoS Computational Biology*, 8(6), 2012

30. A. Hazra, R. Rosenbaum, B. Bodmann, S. Cao, K. Josić, and J. Ziburkus. Beta adrenergic modulation of spontaneous spatiotemporal activity patterns and synchrony in hyper-excitable hippocampal circuits. *Journal of Neurophysiology*, 108(2), 2012

31. R. Rosenbaum and K. Josić. Membrane potential and spike train statistics depend distinctly on input statistics. *Physical Review E*, 84, Nov 2011

32. R. Rosenbaum, J. Trousdale, and K. Josić. The effects of pooling on correlated neural variability. *Frontiers in Neuroscience*, 5(58), 2011

33. R. Rosenbaum and K. Josić. Mechanisms that modulate the transfer of spiking correlations. *Neural Computation*, 23(5), Jan 2011

34. R. Rosenbaum, F. Marpeau, J. Ma, A. Barua, and K. Josić. Finite volume and asymptotic methods for stochastic neuron models with correlated inputs. *Journal of Mathematical Biology*, 35(1), 2011

35. R. Rosenbaum, J. Trousdale, and K. Josić. Pooling and correlated neural activity. *Frontiers in Computational Neuroscience*, 4(9), 2010

36. K. Josić and R. Rosenbaum. Unstable solutions of nonautonomous linear differential equations. *SIAM Review*, 50(3), 2008

Research Funding

Air Force DEPSCOR Award 2021-2024
Award amount: $600,000
Title: *Using Meta-plasticity to Discover the Biophysics of Learning*

Role: Lead PI

Huisking Foundation, Inc. Award 2019-2020
Award amount: $5,000

NSF NeuroNex Theory Team 2017-2022 (DBI-1707400)
Award amount: $387,096 to Rosenbaum ($4,393,191 total)
Title: *Inferring interactions between neurons, stimuli, and behavior*
Role: Co-PI

NSF CAREER 2017-2022 (DMS-1517828)
Award amount: $400,000
Title: *Form and Function in Cortical Neuronal Networks*
Role: Sole PI

NSF Mathematical Biology 2015-2018 (DMS-1654268)
Award amount: $180,000
Title: *Statistical Dynamics of Balanced Cortical Networks*
Role: Sole PI

Other Funding

NSF Funding for 2017 International Conference on Mathematical Neuroscience (DMS-1642544)
Award amount: $20,000.
Role: Co-PI

Burroughs Wellcome Funding for 2017 International Conference on Mathematical Neuroscience 2016-2017 (1016529)
Award amount: $5,000
Role: Co-PI

SIAM Funding for 2017 International Conference on Mathematical Neuroscience 2016-2017
Award amount: $5,100
Role: Co-PI

Awards and Honors

Edmund P. Joyce Award for Excellence in Undergraduate Teaching 2022

Huisking Foundation Assistant Professor Appointment. 2019-2020

NSF CAREER Award. 2017-2020

Research Supervision

Postdocs
Navid Shervani-Tabar (current postdoc)

Marzieh Alireza Mirhoseini (current postdoc)

Graduate Students

Vicky Zhu (former PhD student. First position: Tenure track assistant professor at Babson College)

Cody Baker (former PhD student. First position: Data Scientist at CatalystNeuro)

Christopher Ebsch (former PhD student. First position: Researcher at Pacific NW Natl Lab)

Ryan Pyle (former PhD student. First position: Postdoc at Rice University)

Undergraduate Students

Sarah Duessing (former undergraduate student)

James Galante (former undergraduate student)

Maria Pope (former undergraduate student)

David Connelly (former undergraduate student)

Gabrielle Thivierge (former undergraduate student)

Nikhat Dharani (former undergraduate student, co-advised)

Steven Reich (former undergraduate student, co-advised)

Pedagogical Activities and Service

Director of Graduate Studies in the ACMS Department (2021-Present)

I manage all aspects of the PhD programs in Applied Mathematics and Applied Statistics at the University of Notre Dame. This includes recruitment, admissions, and management of ongoing PhD students.

Member of the Graduate Studies Committee in the ACMS Department (2016-Present)

This committee manages all aspects of the PhD and Professional Master's programs in Applied Statistics, Applied and Computational Mathematics, Predictive Analytics, and Actuarial Science.

Courses Designed:

Artificial Neural Networks (undergraduate)

Mathematical and Computational Modeling in Neuroscience (undergraduate)

Computational Neuroscience (graduate)

Optimization and Deep Neural Networks (graduate)

Other Courses Taught:

Numerical Analysis (undergraduate)

Mathematical Modeling (undergraduate)

Methods in Applied Mathematics II (undergraduate)

Calculus I (undergraduate)

Calculus II (undergraduate)

Ordinary Differential Equations (undergraduate)

Wrote an undergraduate Computational Neuroscience textbook.

Organizational and Scholarly Activities

Computational and Systems Neuroscience (COSYNE)
Program Committee (2018, 2019, 2020)
Session Chair (2018)
Abstract Reviewer (2017-2020)

International Conference on Mathematical Neuroscience (ICMNS) 2017
Co-organizer (with Z Kilpatrick and J Gjorgjieva)

Special issue of Frontiers in Computational Neuroscience: *Correlated neuronal activity and its relationship to coding, dynamics and network architecture* **(2013)**
Guest editor (with Tatjana Tchumatchenko and Ruben Moreno-Bote)

Reviewer for:
eLife, Proceedings of the National Academy of Sciences USA, The Journal of Neuroscience, IEEE Transactions on Neural Networks and Learning Systems, The Journal of Neurophysiology, The Journal of Mathematical Neuroscience, PLoS Computational Biology, PLoS One, Physical Review Letters, Physical Review E, Physical Review X, The Journal of Computational Neuroscience, Frontiers in Computational Neuroscience, Biological Cybernetics

Workshop on Linking Neuronal Network Architecture and Collective Dynamics at SIAM Conference on Applications of Dynamical Systems (2011)
Co-organizer (with Ashok Kumar)

Texas Applied Mathematics Meeting for Students (2010)
Co-organizer (with Chinmaya Gupta)

Outreach Activities

Collaboration with Riley High School Robotics Team
(2017-2019)
I worked with the Riley High School Robotics Team, which competes in the annual FIRST Robotics competition.

Introduction to scientific computing for Riley High School students
(2015-2018)
Each year, I spent one week visiting the Computer Science class at Riley High School. I gave guest lectures and guided a creative programming project involving computational mathematics.