Richard Gao

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Education & Research Experience

University of Tübingen & Tübingen AI Center — Tübingen, Germany
Postdoctoral Researcher, Machine Learning in Science, Advisor: **Jakob H. Macke** — February 2021-Present

- Developing ML/AI tools to infer circuit mechanisms from neural data. MSCA Postdoctoral Fellow.

University of California, San Diego — La Jolla, USA
Ph.D. in Cognitive Science, Advisor: **Bradley Voytek** — September 2014–November 2020

- Thesis: "Bridging cognition and neurobiology with large-scale cortical dynamics and multimodal brain data."

University of Toronto — Toronto, Canada
BASc in Engineering Science (Biomedical Engineering) + PEY — September 2009–June 2014

- Thesis: "Designing closed-loop electrical stimulation system for treatment of intractable epilepsy."

Professional Experience

NeuroMatch Academy (NMA2020), Computational Neuroscience — Remote
Lead Teaching Assistant and Content Developer — Summer 2020

- Taught and assisted in developing course content for online computational neuroscience summer school.

University of California, San Diego — La Jolla, USA
Instructor on Record (Lecturer) — Summer Session I, 2019

- Designed and taught advanced undergraduate course: Neural Signal Processing (COGS118C). Received college-level teaching training as a part of Summer Graduate Teaching Scholar program.

University of California, San Diego — La Jolla, USA
Graduate Writing Consultant, Teaching & Learning Commons — January 2019–March 2020

- Conducted consultation sessions with PhD students on technical writing projects (including journal manuscripts, fellowship/grant proposals, cover letters, etc.). Received training on peer-mentoring and postgraduate writing.

InteraXon Inc. (Muse) — Toronto, Canada
Research Associate (BASc Degree Professional Internship) — July 2012–August 2013

- Developed consumer-grade EEG brain-computer interface (BCI) algorithms for mindfulness meditation neurofeedback training. Conducted user-research studies with real-time visual and audio feedback.

Research Fellowships, Grants, and Awards

- **Marie Skłodowska-Curie Actions (MSCA) Postdoctoral Fellowship** 2021–2023
- **UCSD Chancellor's PhD Dissertation Medal** 2021
- Boehringer Ingelheim Fonds PhD Travel Grant 2019
- **Kavli Institute for Brain and Mind, Innovative Research Grant** 2017–2018
- **NSERC Postgraduate Scholarship-Doctoral (PGS-D)** 2016–2019
- **NSERC Alexander Graham Bell Canada Graduate Scholarship (awarded & declined)** 2016
- UCSD Frontiers of Innovation Scholar Program Research Grant 2015–2016
- **UCSD Katzin Prize (Doctoral Fellowship)** 2014–2019
- University of Toronto Engineering Science Award of Excellence 2014

Publications & Preprints

1. **Gao, R.**, Deistler, M., Schulz, A., Gonçalves, P. J., & Macke, J. H. (2024). Deep inverse modeling reveals dynamic-dependent invariances in neural circuit mechanisms. *bioRxiv*. [paper] [code]

2. Vetter, J., Macke, J. H.*, & **Gao, R.*** (2024). Generating realistic neurophysiological time series with denoising diffusion probabilistic models. *Patterns*. [paper] [code]

3. Kapoor, J., Schulz, A., Vetter, J., Pei, F., **Gao, R.***, & Macke, J. H.* (2024). Latent Diffusion for Neural Spiking Data. *arXiv*. [paper]

4. van Bree, S.*, Levenstein, D., Krause, M. R., Voytek, B., & **Gao, R.*** (2024). Decoupling measurement and process: on the epiphenomenon debate surrounding brain oscillations and field potentials. *PsyArXiv*. [paper]

5. Schulz, A., Vetter, J., **Gao, R.**, Morales, D., Lobato-Rios, V., Ramdya, P., Gonçalves, P. J., & Macke, J. H. (2024). Modeling conditional distributions of neural and behavioral data with masked variational autoencoders. *bioRxiv*. [paper]

6. Vetter, J., Moss, G., Schröder, C., **Gao, R.**, & Macke, J. H. (2024). Sourcerer: Sample-based Maximum Entropy Source Distribution Estimation. *arXiv*. [paper]

7. Bischoff, S., Darcher, A., Deistler, M., **Gao, R.**, Gerken, F., Gloeckler, M., & others. (2024). A Practical Guide to Sample-based Statistical Distances for Evaluating Generative Models in Science. *Transactions on Machine Learning Research*. [paper]

8. Martin-Burgos, B., McPherson, T. S., Hammonds, R., **Gao, R.**, Muotri, A. R., & Voytek, B. (2024). Development of neuronal timescales in human cortical organoids and rat hippocampus dissociated cultures. *Journal of Neurophysiology*. [paper]

9. **Gao, R.***, Deistler, M.*, & Macke, J. H. (2024). Generalized bayesian inference for scientific simulators via amortized cost estimation. *Advances in Neural Information Processing Systems*, 36. [paper] [code]

10. Boelts, J., Harth, P., **Gao, R.**, Udvary, D., Yáñez, F., Baum, D., Hegde, H.-C., Oberlaender, M., & Macke, J. H. (2023). Simulation-based inference for efficient identification of generative models in computational connectomics. *PLoS Computational Biology*, 19(9), e1011406. [paper]

11. Boelts, J., Lueckmann, J.-M., **Gao, R.**, & Macke, J. H. (2022). Flexible and efficient simulation-based inference for models of decision-making. *eLife*, 11, e77220. [paper]

12. **Gao, R.**, van den Brink, R. L., Pfeffer, T., & Voytek, B. (2020). Neuronal timescales are functionally dynamic and shaped by cortical microarchitecture. *eLife*, 9, e61277. [paper] [code]

13. Donoghue, T., Haller, M., Peterson, E. J., Varma, P., Sebastian, P., **Gao, R.**, Noto, T., Lara, A. H., Wallis, J. D., Knight, R. T., Steytluk, A., & Voytek, B. (2020). Parameterizing neural power spectra into periodic and aperiodic components. *Nature Neuroscience*, 23(12), 1655–1665. [paper] [code]

14. Ghatak, S., Dolatabadi, N., **Gao, R.**, Wu, Y., Scott, H., Trudler, D., Sultan, A., Ambasudhan, R., Nakamura, T., Masliah, E., Talantova, M., Voytek, B., & Lipton, S. A. (2021). NitroSynapsin ameliorates hypersynchronous neural network activity in Alzheimer hiPSC models. *Molecular Psychiatry*, 26(10), 5751–5765. [paper]

15. Trujillo, C. A.*, **Gao, R.***, Negraes, P. D.*, Gu, J., Buchanan, J., Preissl, S., Wang, A., Wu, W., Haddad, G. G., Chaim, I. A., Domissy, A., Vandenberghe, M., Devor, A., Yeo, G. W., Voytek, B., & Muotri, A. R. (2019). Complex oscillatory waves emerging from cortical organoids model early human brain network development. *Cell Stem Cell*, 25(4), 558–569.e7. [paper] [code]

16. Moore, S. M., Seidman, J. S., Ellegood, J., **Gao, R.**, Savchenko, A., Troutman, T. D., Abe, Y., Stender, J., Lee, D., Wang, S., Voytek, B., Lersch, J. P., Suh, H., Glass, C. K., & Muotri, A. R. (2019). Setd5 haploinsufficiency alters neuronal network connectivity and leads to autistic-like behaviors in mice. *Translational Psychiatry*, 9(1), 24. [paper]

17. Núñez, R., Allen, M.*, **Gao, R.***, Miller Rigoli, C.*, Relaford-Doyle, J.*, & Semenuks, A.* (2019). What happened to cognitive science? *Nature Human Behaviour*, 3(8), 782–791. [paper]

18. Cole, S., Donoghue, T., **Gao, R.**, & Voytek, B. (2019). NeuroDSP: A package for neural digital signal processing. *Journal of Open Source Software*, 4(36), 1272. [paper] [code]

19. **Gao, R.**, Peterson, E. J., & Voytek, B. (2017). Inferring synaptic excitation/inhibition balance from field potentials. *NeuroImage*, 158, 70–78. [paper] [code]

20. **Gao, R.**, Donoghue, T., & Voytek, B. (2017). Automated Generation of Cognitive Ontology via Web Text-Mining. *Proceedings of the Annual Meeting of the Cognitive Science Society*, 39. [paper] [code]

21. **Gao, R.** (2016). Interpreting the electrophysiological power spectrum. *Journal of Neurophysiology*, 115(2), 628–630. [paper]

** denotes equal contribution, co-first, or co-last/supervisory author.*

Invited Workshop, Conference, and Tutorial Talks

1. **Tutorial:** Spectral parameterization and simulation-based inference for neurophysiological recordings. *Cutting Gardens, Frankfurt.* Ernst Strüngmann Institute, Frankfurt, Germany. October 16–19, 2023.

2. **Lectures:** Spectral parameterization and simulation-based inference for neurophysiological recordings. *Harmonic and Multifractal Analyses Summer School: from Mathematics to Quantitative Neuroscience.* Centre de Recherches Mathématiques, Université de Montréal, Montreal, Canada. July 4–14, 2023.

3. **Talk:** Pushing and pulling: how the interplay of excitation and inhibition shapes network dynamics (Workshop). *German Neuroscience Society.* Göttingen, Germany. March 23, 2023.

4. **Talk:** Brain rhythms in health and disease (Mini-Symposium). *European Conference on Mathematical and Theoretical Biology.* Heidelberg, Germany. September 22, 2022.

5. **Talk:** Advances in network dynamics of *in vitro* neural systems (Workshop). *Bernstein Conference.* Berlin, Germany. September 13, 2022.

6. **Co-Organizer:** Mechanisms, functions, and methods for diversity of neuronal and network timescales (Workshop). *COSYNE 2022.* Lisbon & Cascais, Portugal. March 21, 2022.

Teaching Experience

- **Graduate Seminar Co-Organizer** at University of Tübingen, Germany — Winter 2023
  Literature seminar: Large language models and sequence models for scientific discovery
- **Lead Teaching Assistant** at NeuroMatch Academy — Summer 2020
  Computational Neuroscience & Machine Learning (NMA2020)
- **Instructor on Record (Lecturer)** at University of California, San Diego — Summer Session I, 2019
  Neural Signal Processing (COGS118C) - [link]
- **Graduate Seminar Co-Organizer** at University of California, San Diego — Spring 2018
  Representation in the Mind (COGS200)
- **Teaching Assistant** at University of California, San Diego — Fall 2018, Fall 2017
  Introduction to Data Science (COGS9)
- **Teaching Assistant** at University of California, San Diego — Fall 2016, Winter 2015
  Introduction to Cognitive Science (COGS1)
- **Teaching Assistant** at University of California, San Diego — Spring 2015
  Introduction to Statistical Analysis (COGS14B)
- **Teaching Assistant** at University of California, San Diego — Fall 2015
  Introduction to Machine Learning II (COGS118B)
- **Teaching Assistant** at University of Toronto — Fall 2014
  Praxis I. Engineering Design (ESC101)

Training Courses

The CAJAL Advanced Neuroscience Training Programme — Lisbon, Portugal
Computational Neuroscience — August 10–31, 2019

Redwood Center for Theoretical Neuroscience — Berkeley, USA
CRCNS Course on Mining and Modeling of Neuroscience Data — July 9–20, 2015

Supervision and Mentorship

- **Zinovia Stefanidi**, PhD co-supervision — University of Tübingen, 2022–Present
- **Julius Vetter**, PhD co-supervision — University of Tübingen, 2022–Present
- **Jan Boelts**, PhD mentorship — University of Tübingen, 2022
- **Aleksejs Timcenko**, MSc. Literature review essay supervision — University of Tübingen, 2023
- **Apoorva Vikram Singh**, MSc. Literature review essay supervision — University of Tübingen, 2022
- **Anastasia Lado**, MSc. Thesis co-supervision — University of Tübingen, 2022
- **Brian Barry**, Bachelors research supervision — UCSD Cognitive Science, 2019–2022
- **Lucas Henry**, Bachelors research supervision — UCSD Cognitive Science, 2019–2021
- **Christopher Caligiuri**, High school research supervision — Canyon Crest Academy Highschool, 2017–2021
- **Adrianna Hohil**, Bachelors research supervision — UCSD Cognitive Science, 2019
- **Lauren Liao**, Bachelors research supervision — UCSD Mathematics (Probability & Statistics), 2016–2019
- **Dylan Christiano**, Bachelors research supervision — UCSD Cognitive Science, 2017–2018
- **Sitan (Stan) Liu**, UCSD Exchange student research supervision — Sichuan University, 2017
- **Tanner Turner**, Bachelors research supervision — UCSD Applied Mathematics & Computer Science, 2016–2017

Review Services

- **Neuroscience:** Nature Neuroscience, Nature Communications, eLife, Cell Reports, PLoS Computational Biology, Cerebral Cortex, Journal of Neuroscience, NeuroImage, eNeuro, Human Brain Mapping, Neuropsychopharmacology, Journal of Neurophysiology, Journal of Cognitive Neuroscience, Imaging Neuroscience, Clinical Neurophysiology
- **Machine Learning, AI, and Computations:** NeurIPS, ICLR, ICML, COSYNE, Nature Computational Science, NBDT

Science Communication & Blog Articles

1. See www.rdgao.com/blog
2. Waschke, L., **Gao, R.** (2019). The Magical Number 3. *Nature Human Behavior*, https://socialsciences.nature.com/posts/54636-the-magical-number-3
3. **Gao, R.** (2019). Searching for the Hidden Factors Underlying the Neural Code. *Simons Collaboration Global Brain*, https://www.simonsfoundation.org/2019/07/31/searching-for-the-hidden-factors-underlying-the-neural-code/