

Mikail Khona

Personal Info

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Current Experience

May 2023 - **NTT Research**

September *Research Scientist Intern*

2023 Supervisor: Hidenori Tanaka

Studying causal reasoning in transformer-based large language models (LLMs). Developing mechanistic interpretability technique to reverse engineer transformers on synthetic algorithmic reasoning tasks.

Education and Research

2018 - 2024 **Massachusetts Institute of Technology, MA**

(expected) *PhD candidate in Physics*

Advisor: Ila Fiete, Secondary: Mehran Kardar

Graduate research in theoretical and computational systems neuroscience and deep learning.

Summer 2021 **Methods in Computational Neuroscience (MCN) Summer School**, Marine Biological Laboratory, Woods Hole MA

2014 - 2018 **Indian Institute of Technology (IIT), Bombay, India**

Bachelor of Technology in Engineering (GPA: 9.6/10)

Major: Engineering Physics (+honours in Physics)

minor: Mathematics

High School **The Bombay Scottish School**, Mahim, India

Publications

- [Khona, Mikail, Fiete, Ila.](#) **Attractor and Integrator Networks in Neuroscience.** Nature Reviews Neuroscience. [\[link\]](#)
- Schaeffer, Rylan, [Khona, Mikail](#), Meshulam, Leenoy, Fiete, Ila. **No Free Lunch from Deep Learning in Neuroscience: A Case Study through Models of the Entorhinal-Hippocampal Circuit.** NeurIPS. 2022. [\[link\]](#)
- Schaeffer, Rylan, [Khona, Mikail](#), Fiete, Ila. **Reverse-engineering recurrent neural network solutions to a hierarchical inference task for mice.** NeurIPS. 2020. [\[link\]](#)
- [Khona, Mikail*](#), Chandra, Sarthak*, Fiete, Ila. **Spontaneous emergence of topologically robust grid cell modules: A multiscale instability theory.** Submitted. [\[link\]](#)
- Duan, Sunny*, [Khona, Mikail*](#), Bertagnoli, Adrian*, Fiete, Ila. **See and Draw: Generation of complex compositional movements from modular and geometric RNN representations.** Proceedings of Machine Learning Research. [link](#)
- [Khona, Mikail*](#), Chandra, Sarthak*, Ma, Joy, Fiete, Ila. **Winning the lottery with neurobiology: faster learning on many cognitive tasks with neural connectivity constraints.** Neural Computation (2023). [\[link\]](#)
- G. Madirolas, A. Al-Asmar, L. Gaouar, L. Marie-Louise, A. Garza-Enriquez, [M. Khona](#), C. Ratzke, J. Gore, A. Pérez-Escudero. **A taste for numbers: *Caenorhabditis elegans*. foraging follows a low-dimensional rule of thumb.** Nature communications biology (2023). [\[link\]](#)
- Schaeffer, Rylan*, Bordelon Blake*, [Khona, Mikail*](#), Pan, Weiwei, Fiete, Ila. **Efficient Online Inference for Nonparametric Latent Variable Time Series.** UAI. 2021. [\[link\]](#)

- Rylan Schaeffer, Khona, Mikail, Zachary Robertson, Akhilan Boopathy, Kateryna Pistunova, Jason W. Rocks, Ila Rani Fiete, Oluwasanmi Koyejo. **Double Descent Demystified: Identifying, Interpreting Ablating the Sources of a Deep Learning Puzzle.** [*arXiv link*]

Publications in prep/to appear

- Mikail Khona*, Sarthak Chandra*, Talia Konkle, Ila Fiete. **Self-organized emergence of modularity, hierarchy, and topography from competitive synaptic growth in a developmental model of the visual pathway**
- Mikail Khona*, Rylan Schaeffer*, Ila Fiete. **Self-Supervised Learning of Representations for Space Generates Multi-Modular Grid Cells (to appear, NeurIPS, 2023)**

Awards / Achievements

- 2022 - 2023 K. Lisa Yang ICoN Graduate Student Fellow (\$100k)
- 2021 - 2022 MathWorks Science Fellowship (one of 20 across the School of Science at MIT) (\$100k)
- 2018 - 2019 Seigel Fellowship, Department of Physics (\$100k)
- 2016 - 2018 Institute Academic Award for the highest GPA among undergraduates in the Physics department at IIT Bombay (9.95/10)
- 2016 - 2017 DAAD-WISE scholarship for an undergraduate project in Germany in 2017 [declined].
- 2014 An All India Rank of 562/1.4M (Percentile 99.96) in the **IIT - JEE** 2014.
- 2014 INSPIRE Scholarship for Higher Education - A scholarship awarded by the Government of India to meritorious students in high school who plan to pursue a degree in the natural sciences.

Relevant courses

- IIT-Bombay Mathematics and Statistics: Real analysis, Complex analysis, Differential equations, General Topology, Abstract Algebra, Lie groups and Lie Algebras, Stochastic processes. Physics: Statistical physics, Advanced statistical physics, Quantum mechanics sequence (I,II,III).
- MIT Mathematics: Probability Theory, Computational neuroscience. Physics: Statistical physics for biology, Systems Biology

Technical Skills

- advanced Deep learning with Python: Pytorch
- advanced Scientific computing with Python (NumPy, SciPy, NetworkX, etc..) and MATLAB

Peer-Review Conference and Workshop Posters

- Khona, Mikail, Schaeffer, Rylan, and Fiete, Ila. **Self-Supervised Learning of Efficient Algebraic Codes generates Grid Cells**, NeurIPS Self-Supervised Learning: Theory and Practice Workshop, 2022.
- Khona, Mikail, Chandra, Sarthak, Konkle, Talia and Fiete, Ila. **Modelling the development of the primate visual cortical hierarchy**. Cosyne Abstracts 2022, Lisbon, Portugal.
- Khona, Mikail, Chandra, Sarthak, Acosta, Francisco, Fiete, Ila **The emergence of discrete grid cell modules from smooth gradients in the brain**. Cosyne Abstracts 2021.
- Khona, Mikail, Xu, Qianli and Fiete, Ila. **A model of oscillatory gating of information flow between neural circuits as a function of local recurrence**. Cosyne Abstracts 2020.
- Schaeffer, Rylan, Khona, Mikail, and Fiete, Ila. **No Free Lunch from Deep Learning in Neuroscience: A Case Study through Models of the Entorhinal-Hippocampal Circuit**, ICML AI4Science Workshop. 2022.

Academic Services

- 2022 Reviewer for NeurReps: Symmetry and Geometry in Neural Representations, Workshop, NeurIPS 2022, Reviewer for NeurIPS 2022 Workshop: Self-Supervised Learning - Theory and Practice, Reviewer for NeurIPS AI4Science workshop.

Teaching and Mentoring

- Fall 2019 8.01L: Physics I
Spring 2021 8.592: Introduction to Biological Physics
Fall 2021 Physics Mentorship program, Physics Department, MIT
Fall 2023 8.03 Waves and Oscillations