

PRANJAL GARG

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AI and machine-learning approaches to neural activity and behavioral datasets

Education

B.S. in Data Science and Applications

2024 – Aug 2027 (expected)

Indian Institute of Technology (IIT) Madras

India

Medical studies (MBBS program; discontinued)

All India Institute of Medical Sciences (AIIMS) Rishikesh

India

Research Experience: Computational Neuroscience

Foundation models of neural activity during mouse navigation

Summer 2027 (planned)

Advisor: Dr. Vincent Bonin / Neuro-Electronics Research Flanders (NERF), VIB-KU Leuven

Leuven, Belgium

- Planned project on foundation models of neural activity during mouse spatial navigation.

Periodic structured state-space models of hippocampal dynamics (pS4)

Aug – Oct 2024

Independent research

- Method development. Introduced pS4, a periodic structured state-space model that treats hippocampal population activity as a linear time-varying control system aligned to ongoing oscillations.
- Interpreted the learned dynamics through control cost and feedback gains before and after stimulus perturbation. Lead-authored poster at NeurIPS 2024 WiML.

Orbitofrontal representations of social interaction and reward

Jun – Oct 2024

Advisors: Dr. Duda Kvitsiani, Dr. Ebru Demir / Southern Illinois University

USA

- Neural population analysis of calcium-imaging data from orbitofrontal cortex, comparing how social interaction and water reward are encoded.
- Trained recurrent neural networks to recover the underlying attractor dynamics, and used support vector machines to identify encoding and memory axes in population activity.

Generalized contrastive PCA and neural population dynamics

Aug 2022 – Jun 2024

Advisor: Dr. Luke Sjulson / Albert Einstein College of Medicine

USA

- Benchmarked generalized contrastive PCA (gcPCA), a dimensionality-reduction method that uncovers structure in complex neuroscience datasets differing across experimental conditions, against PCA on Allen Brain Observatory electrophysiology with supervised decoding.
- Showed the method generalizes beyond neural activity to image datasets and Allen Institute single-cell RNA-seq data.
- Designed behavioral tasks and trained continuous-time RNNs (CTRNNs), using ablations and representational analyses to study task-dependent dynamics.
- Co-author of the resulting *PLOS Computational Biology* paper (2025); presented at SfN 2024.

Criticality and sharp-wave ripples in the hippocampus

Jun – Dec 2023

Independent research

- Tested whether sharp-wave ripples relate to neuronal criticality in public LFP data, detecting avalanches and ripples with scale-invariant thresholds.
- Quantified deviation from criticality across sleep and awake states with avalanche and branching metrics, running the large-scale data analysis through distributed computation on Azure HPC. Presented at SfN 2024.

Astrocytic control of cortical Up–Down states

Jun 2022 – Aug 2023

Independent research

- Built a recurrent rate model of cortical circuit Up–Down dynamics with excitatory, inhibitory and astrocytic populations, extended to hyperpolarizing gliotransmission.
- Used linear stability analysis to find bistable regimes that support spontaneous state transitions, and Morris global sensitivity analysis to isolate the governing parameters.

Experimental Neuroscience

Retinal movements and visual processing in *Drosophila*

Oct 2024 – Oct 2025

Advisor: Dr. Lisa Fenk / Max Planck Institute for Biological Intelligence

Martinsried, Germany

- Ran tethered-*Drosophila* behavioral experiments under controlled and naturalistic visual stimuli.
- Wrote automated algorithms for extracting behavioral states (saccade-like retinal movements and drift) from eye-tracking and ball-walking recordings.

- Quantified natural-scene statistics with new metrics, and showed how spontaneous retinal movements adapt to them and reshape spatiotemporal visual input.

Mapping sensory neurons in *Steinernema hermaphroditum*

Aug – Oct 2021

Advisor: Dr. Paul W. Sternberg / California Institute of Technology (SURF)

Pasadena, USA

- Developed and optimized a DiI fluorescence staining protocol for mapping head sensory neurons in *Steinernema hermaphroditum*.
- Mapped amphid and inner labial neurons and established their positional homology with *C. elegans*. First author, *microPublication Biology*  (2022).

Selected Publications & Presentations: Neuroscience

- **de Oliveira E.F., Garg P., et al.** Identifying patterns differing between high-dimensional datasets with generalized contrastive PCA  *PLOS Computational Biology* (2025).
- **Garg P., Nema V.** Modeling neural dynamics using periodic structured state-space models.  *NeurIPS 2024 WiML Workshop*.
- **Garg P.** Mixed signatures for subcritical dynamics in rodent hippocampus during sleep and awake epochs.  *Society for Neuroscience* (2024).
- **Verma J., Garg P.** Computational modeling of hyperpolarising astrocytic influence on cortical Up–Down state transitions.  *Fourth International Symposium on the Mathematics of Neuroscience* (2023).
- **Garg P., Tan C.H., Sternberg P.W.** DiI staining of sensory neurons in the entomopathogenic nematode *Steinernema hermaphroditum*.  *microPublication Biology* (2022).

Research Experience: Artificial Intelligence

Predicting failure from model internals

Sep 2026

Collaborative research with Jacob Beck / *arXiv preprint, under review*

- Studied how language models recover from label-preserving corruption of their inputs, as a test of how models behave when their context is unreliable.
- Used activation patching to show that repair shifts from the corrupted positions in early layers to clean positions and the prediction position in later layers.
- Showed that early-layer hidden states predict repair failure (mean ROC-AUC 0.78), and linked failures to greater nonlinearity along corruption directions. Fine-tuning on moderate corruption improved robustness.
- Internal states flag likely failures before the model produces an answer, which is a candidate signal for runtime monitoring.

MetaLex: Literal-to-figurative grounding in vision–language models

Jan – Mar 2026

Advisor: Dr. Cheston Tan / A*STAR Centre for Frontier AI Research

Singapore

- Developed *MetaLex*, a controlled benchmark of literal-to-figurative grounding in vision–language models (VLMs), with matched visual and textual descriptions of the same scenes.
- Across 14 VLMs, identified an asymmetric grounding gap; used joint image–text conditions and captioner-based controls to separate the effects of visual access from the information provided.
- Research presented at the **CVPR 2026 Workshop on Any-to-Any Multimodal Learning (A2A-MML)**.

Selected AI Publications & Submitted Manuscripts

- **Garg P., Hoang C.** Relative Learning Rates Shape Compositional Computation Across Spiking and Artificial Agents. *Manuscript in submission.* (Oct 2026)
- **Garg P.** How High Is 0.6? Floors, Ceilings, and Headroom in Interpretability Probing.  *Manuscript in submission; arXiv:2610.08544* (Oct 2026).
- **Garg P., Beck J.** Spontaneous Context Restoration: How Language Models Recover from Corrupted Inputs.  *Manuscript in submission; arXiv:2609.35475* (Sep 2026).
- **Garg P., Tan C.H.** MetaLex: Probing Literal-to-Figurative Grounding in Vision–Language Models.  *CVPR 2026 A2A-MML Workshop; extended manuscript in submission.*
- **Garg P.** A Control-Theoretic Account of Cognitive Effort in Language Models.  *NeurIPS 2025 CogInterp Workshop.*

Other Technical Writing

- *Spontaneous verbal evidence synthesis in LLMs* , LessWrong (Oct 2026): showing that LLMs weigh conflicting verbal evidence by its certainty and attached numbers can override the words.

- *CoT Control: The Word Disappears, but the Thought Does Not* , LessWrong (Mar 2026): experiments comparing lexical suppression with semantic engagement in reasoning traces.

Training

Neuromatch Academy / *Computational Neuroscience course, online*

2020

BlueDot Impact / *Technical AI Safety course, online*

2026

Methods & Tools

Programming: Python (PyTorch, transformers), R, MATLAB; large-scale data analysis on Azure HPC.

Machine learning: deep learning, vision–language models, statistical modeling, dimensionality reduction, supervised decoding, reinforcement learning, representation probing, causal interventions.

Neural population analysis: state-space and control-theoretic models, RNN modeling, population decoding, dynamical systems and stability analysis.

Data: electrophysiology (Allen Brain Observatory, LFP), calcium imaging, single-cell RNA-seq, behavioral recordings (eye tracking, locomotion).

Experimental: *Drosophila* behavior and eye tracking, fluorescence staining and neuroanatomy.

Selected Awards & Research Service

- **Founder and Managing Trustee**, Project Encephalon Foundation (2020–2024), a trainee-led international neuroscience education initiative; organized volunteers, outreach, and research-related events.
- **Allen Institute:** OpenScope Program, Stage 2 selection (2023); **COSYNE:** Undergraduate Travel Awards (2024, 2023); **NIH SPARC FAIR Codeathon:** 3rd Prize (\$7,000, 2023); **Caltech:** SURF Fellowship (2021); **KVPY:** DST, India.
- **Reviewer:** NeurIPS CogInterp Workshop, AAAI AI Alignment Track, NeurIPS UniReps Workshop.

Research in Quantitative Humanities and Medicine

Popular culture and careers: Studied popular culture’s influence on perceived status of STEMM careers (CogSci, 2023).

Malaria epidemiology: Examined malaria-vaccine awareness and public-health perceptions in India (*Cureus*, 2022).

Sleep epidemiology: Stratified study of socioeconomic status, sleep hygiene and daytime sleepiness at AIIMS Rishikesh, with Dr. Rajesh Kathrotia (first author, 2021).