



Kavli Institute
for Systems Neuroscience

EXTENDED WORKSHOP 1-10 JULY 2024, TRONDHEIM

Theories of neural computation in the era of large-scale recordings

Organised by: Soledad Gonzalo Cogno, Rainer Friedrich and Yoram Burak





Kavli Institute
for Systems Neuroscience

10 days

25 speakers

23 posters

09 panel discussions

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Discoveries related to individual neurons, such as orientation and selectivity in the visual cortex and spatial selectivity of place cells and grid cells, were breakthroughs that greatly advanced our understanding of how neurons encode features of the external world in their spiking activity. Yet, most cognitive functions are thought to emerge from the collective activity of large neuronal populations. While developments from the past decade are opening doors to investigate the neural bases of cognition, extracting common mechanisms underlying brain functions and developing unified frameworks for generalization and interpretation of complex data requires close and coordinated interactions between experimentalists and theoreticians. We therefore feel that the timing for a program that catalyses a synergistic approach to the field of network dynamics and computation could not be more appropriate. The main goal of this meeting is to discuss how we can leverage recent technological advances to develop and test theories of neural computation in this new experimental landscape.

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MONDAY JULY 1

Bob Datta

The neural basis of natural behavior across timescales

Soledad Gonzalo Cogno

Minute-scale periodic sequences of neural population activity

Michael Long

Using forebrain population activity to understand neural mechanisms of vocal behavior

Panel discussions

TUESDAY JULY 2

SueYeon Chung

Multi-level theory of task-efficient neural representation

Misha Ahrens

Flexible computation in brain-wide zebrafish circuits

Elad Schneidman

Design Principles of Large Population Codes and Connectomes

Panel discussions

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WEDNESDAY JULY 3

Lisa Giocomo

Learning and adapting the structure of neural maps on behavioral timescales

Rainer Friedrich

Representational geometry in a balanced olfactory memory network

Ila Fiete

Modeling the emergence of complex cortical structure from simple precursors in the brain: maps, hierarchies, and modules

Panel discussions

THURSDAY JULY 4

Nachum Ulanovsky

Neural codes and population replays of natural behaviors in flying bats

Yoram Burak

Randomness and regularities in hippocampal circuits

Edvard Moser

Network computation in grid cells: The intrinsic dynamics

Panel discussions

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FRIDAY JULY 5

Carlos Brody

Large-scale cross-brain recordings, analysis, and modeling during a decision-making task.

Haim Sompolinsky

Exploring Neural Manifolds through the Prism of Deep Learning and Generative AI

Tatiana Engel

Unifying neural population dynamics, manifold geometry, and circuit structure

Panel discussions

SATURDAY JULY 6

Ashok Litwin-Kumar

Solution spaces of connectome-constrained networks

Friedemann Zenke

Learning neural representations through prediction

Panel discussions

Poster presentations

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SUNDAY JULY 7

Social activities

*Hiking to Trondheim region's second largest waterfall, Storfossen.
Boat trip to the islet Munkholmen*

MONDAY JULY 8

Vivek Jayaraman & Larry Abbott

Fly navigation: circuit structure, dynamics, and behavior – I

Larry Abbott & Vivek Jayaraman

Fly navigation: circuit structure, dynamics, and behavior - II

Karel Svoboda

Neural dynamics underlying decision-making, planning, and movement

Panel discussions

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TUESDAY JULY 9

Yaniv Ziv

Representational drift in the hippocampus and cortex

Julijana Gjorgjieva

Synaptic plasticity shapes organization and computations during development and learning

Omri Barak

Learning from learning systems

Panel discussions

WEDNESDAY JULY 10

Sara Solla

Low Dimensional Manifolds for Neural Population Dynamics

Michael Hausser

TBD

Panel discussions

Closing remarks





This was one of the best workshops I've attended. The timely topic, small size, and thoughtful blend of interactive theorists and experimentalists at different career stages made for exciting and useful discussions. Having just three long talks per day allowed those discussions to go much deeper than most conferences allow.

- Vivek Jayaraman, Janelia Research Campus, Howard Hughes Medical Institute

The KISN workshop has been wonderful: a perfect blend of experimentalists and theoreticians, with ample time for discussions, which allow new ideas to emerge. I myself went away with a couple of new ideas that emerged during the workshop, and which I will want to try out in the lab. The atmosphere was great and the organization impeccable -- I only wish you could organize another such workshop in the future.

- Nachum Ulanovsky, Weizmann Institute of Science





Thanks to the diverse perspectives featured in the workshop, which spanned multiple model systems and levels of analysis, I gained a deeper and more nuanced understanding of leading theories of neural computation.

A particularly outstanding feature of this workshop was the ample time allotted for discussion, which extended across both space and time! This helped me forge new connections with theoreticians and sparked ideas for concrete predictions I can test as an experimentalist.

- Frances Cho, Stanford University

I found the format and the duration of the scientific program especially engaging and motivating since we got to see prominent scientists of the field think and respond on their feet and not only present results but share and discuss foundational ideas behind their current work and their future plans. As a student, this was a very unique opportunity and left me with a sense of real excitement for the field and many new ideas.

- Nischal Mainali, Hebrew University of Jerusalem



Thanks a lot for the discussion and the very unique exceptionally successful workshop, which was highly informative, interactive and stimulating (as you saw, it stimulated a lot of equations...). And above all, you and the KISN team managed to foster a wonderful warm and fun atmosphere. Looking forward to continued interaction.

- Haim Sompolinsky, Harvard University/Hebrew University of Jerusalem



Neuroscience research is undergoing a major transformation- our biggest challenge is no longer a lack of data, but the need for more abstract thinking to interpret the super complex datasets we're collecting. The KISN workshop taught me that our best strategy to understand higher-order brain function involves combining approaches from physics, math, and computer science with physiological insights and theory to guide the application of these methods.

- Jo Carpenter, Kavli Institute for Systems Neuroscience, NTNU



It has been an immense pleasure to organize this workshop with Soledad and Yoram, and with the support of Edvard. The format with talks interrupted by in-depth discussion has been an experiment that was, in my view, extremely successful, last not least due to the enthusiasm of the participants. I took away many new insights and inspirations from the crosstalk between experimentalists and theoreticians. This has been the most interactive meeting I ever attended - I thank all participants for that, and the staff at KISN for their tremendous support!

- Rainer Friedrich, Friedrich Miescher Institute for Biomedical Research





Our goal for the meeting was to discuss how the new experimental tools that emerged in the past decade could push forward the synthesis between theory and experiment in computational and systems neuroscience. I came out of the meeting with a new perspective on these questions, and many new ideas for my own research. I think that the long format of the lectures, in which questions and discussions were encouraged, worked very well. It was an absolute pleasure to work together with Soledad and Rainer on the scientific program, with the support of Edvard and the entire leadership of the Kavli Institute. The administrative team at the institute has done a superb job in the logistic organization, and this was key to the meeting's success. Finally, I am very thankful to all the participants for their intense engagement in the scientific discussion, and for the excellent talks and posters.

- Yoram Burak, Hebrew University of Jerusalem



It has been an absolute pleasure to organize this workshop together with Rainer and Yoram, and with the help and support of Edvard and the entire KISN team. Moreover, it has been an immense privilege, as a KISN member, to welcome all the speakers and participants to our institute. This event went beyond all my expectations. I enjoyed the long talks, the extended discussions, and the relaxed atmosphere – I'm full of new ideas! I thank all the participants for making this workshop such a memorable experience.

- Soledad Gonzalo Cogno, Kavli Institute for Systems Neuroscience, NTNU



HIKE TO STORFOSSEN

After long days of science, our group set off on a hike through the boreal rainforest of Homla Nature Reserve to Storfossen, a 40m high waterfall whose spray zone supports the survival of twelve red-listed and endangered species.

We were treated to an authentic mid-Norwegian experience. The rain was pouring down. The charming path that had promised to guide us safely through the steep terrain turned into a mudslide. Many a knee made a semi-controlled touch-down, but our spirits remained uplifted.













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