Program

Sep 22 – 24, 2026

2026 INCN + TEX meeting at SISSA

SISSA - via Bonomea 265, Aula Magna “Paolo Budinich”

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Tue, September 22

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Tue, September 22

9:30 – 10:15 AM

Turning temporal correlations from interference into structure: behavioral timescale synaptic plasticity in hippocampal memory circuits

Contribution | **Speaker:** Sandro Romani (HHMI Janelia)

Description

Experience unfolds continuously, so the activity patterns available to memory circuits are rarely independent. Classical Hebbian learning strengthens connections between neurons that are active together. In a recurrent network, this can bind correlated patterns into one expanding assembly. How can successive experiences remain distinct rather than collapse into a single memory?

Intracellular recordings in hippocampal area CA1 revealed an unexpected clue. A single dendritic plateau could create a place field in a silent neuron or relocate an existing field. The resulting behavioral timescale synaptic plasticity (BTSP) links presynaptic activity to a postsynaptic plateau across seconds rather than milliseconds and potentiates or depresses synapses depending on their existing strength. In CA3, targeted perturbations and modeling converged on a time-symmetric form of BTSP operating at recurrent synapses. Together, they showed how this rule can build memory-supporting attractor dynamics whose expression and updating remain controlled by external input.

Theoretical analysis showed that BTSP can reverse the effect of temporal correlation on memory storage. Under Hebbian learning, increasing correlation merges patterns and reduces memory capacity. With BTSP, potentiation near the plateau strengthens the selected representation, while depression in two temporal flanks weakens cross-pattern connections in both directions. This keeps successive representations distinct and allows attractor capacity to increase as correlation grows. These results raise broader questions. What does BTSP store when experience is hierarchically structured, and how do existing memories shape what is learned next? A plasticity rule measured in vivo can turn the continuity of experience from a source of interference into useful structure for continual learning.

10:15 AM

10:15 AM **Tue, September 22** 10:15 – 10:45 AM

On the relationship between equilibria and dynamics in large, random neuronal networks

Contribution | **Speaker:** Gianluigi Mongillo (CNRS)

Description

The dynamics of large neuronal networks are notoriously difficult to study analytically, because of their high dimensionality. Characterizing network equilibria, instead, is far more tractable. What information about the network's dynamics, then, can we infer from the knowledge of its equilibria? Here, we address this question by focusing on random networks. These networks exhibit a paradigmatic transition from a unique, stable equilibrium to extensive chaos as the synaptic gain increases. Employing the Kac-Rice formalism, we compute the typical number of hyperbolic equilibria, and determine their stability and their geometric organization in phase space. In the chaotic regime, an exponentially large number of equilibria is present; they are all saddles with an extensive, yet fractionally small, number of unstable directions. Surprisingly, despite the network's connectivity being completely random, the equilibria are strongly correlated and, as a result, occupy a small region in phase space. The attractor is inside this region. Because of this geometric organization, the quantitative features of the equilibria provide natural bounds on the network's dynamics. In particular, the fraction of positive Lyapunov exponents is bounded from above by the fraction of unstable directions of typical equilibria. This explains why the dynamics in these models can be described by a fractionally small number of effective degrees of freedom. Our results demonstrate how the spatial and spectral properties of the equilibria place strong, quantitative constraints on the dynamics.

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Tue, September 22

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Coffee break

Break

11:15 AM

11:15 AM **Tue, September 22** 11:15 – 11:45 AM

TBC - Mignacco

Contribution | **Speaker:** Francesca Mignacco (Princeton University)

Description

TBC

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Tue, September 22

11:45 AM – 12:15 PM

Contributed talks

Session

11:45 AM – 12:00 PM (15m)

Interneuron nonlinearity governs the storage capacity gain from feedforward inhibition

Speaker

Asem Wardak (Bocconi University)

Description

Feedforward inhibition acting alongside a direct excitatory pathway is a ubiquitous neural microcircuit, yet its contribution to associative learning capacity is unknown. We compute the storage capacity of this motif with the replica method, taking the cerebellar granule cell to Purkinje cell circuit as a concrete instance in which granule cells excite the readout directly and also drive inhibitory molecular layer interneurons. The circuit forms a committee machine with a sign constrained inhibitory hidden layer. Solving the replica symmetric saddle point equations in the limit of many interneurons, and confirming the solution by gradient descent training of finite networks, we find that the interneuron population reduces to a single effective noise channel whose statistics are fixed by the interneuron transfer function. The relay raises capacity above the single layer Gardner bound of one stored pattern per input synapse. The magnitude of this gain is set by the interneuron nonlinearity, not by the sign of the inhibition, which leaves capacity invariant, nor by the number of added synapses, which a linear relay merely amortizes. A bounded interneuron produces an optimal coupling strength, whereas an unbounded one increases capacity without saturation. The mechanism predicts a truncated half Gaussian distribution of learned input weights with a finite silent fraction, and, under biologically faithful shared wiring, anticorrelated excitatory and inhibitory weights onto shared granule cells; both are reproduced in finite networks. Interneuron biophysics thus governs how feedforward inhibition expands learning capacity, a prediction that extends to excitatory readouts paired with feedforward inhibition throughout cortical and hippocampal circuits.

12:00 – 12:15 PM (15m)

Topological Origins of Timescale Diversity in Recurrent Neural Circuits

Speaker

Marco Zenari

Description

Recurrent Neural Networks provide versatile models for studying dynamics in neural circuits (Barak, 2017). While numerical simulations can reproduce complex neural phenomena, analytical approaches are needed to uncover their underlying mechanisms. Dynamical Mean Field Theory (DMFT) has provided such a framework for large random networks, allowing the derivation of statistical descriptions of neural activity under simplifying assumptions (Sompolinsky et al., 1988). These assumptions typically include homogeneous connectivity statistics, which limit the ability to capture biologically relevant structural variability.

Here, we extend DMFT to heterogeneous network architectures by introducing heterogeneous Dynamical Mean Field Theory (hDMFT) (Park et al., 2024). This framework incorporates arbitrary degree distributions while preserving a tractable Gaussian effective description. We show that degree heterogeneity induces neuron-dependent dynamical properties and shapes the phase diagram of recurrent networks by enhancing dynamical instability compared to homogeneous architectures.

When partial symmetry is introduced to account for reciprocal connectivity (Song et al., 2005) or learning-induced structure (Clark and Abbott, 2024), hDMFT predicts the emergence of neuron-dependent effective self-interactions whose strength scales with neuronal degree. This mechanism produces a broad distribution of intrinsic timescales, with highly connected neurons exhibiting slower dynamics. The theoretical prediction that neuronal timescales correlate with in-degree is supported by analysis of the MICrONS dataset (Functional connectomics spanning multiple areas of mouse visual cortex, 2025), which combines structural connectivity with neural recordings.

The hDMFT framework provides an analytical link between structural heterogeneity and emergent network dynamics, including phase transitions, collective activity, and response properties. These results establish how connectivity statistics can shape the functional diversity and computational capabilities of large-scale recurrent neural systems.

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12:15 – 1:45 PM

Lunch

Break

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Tue, September 22

1:45 – 2:15 PM

Single neuron perturbations reveal a dynamical switch in decision computations in parietal cortex

Contribution | **Speaker:** Giulio Bondanelli (Université Claude Bernard Lyon 1)

Description

The neural activity patterns underlying decision formation and execution have been extensively characterized, yet the connectivity motifs that generate these computations remain difficult to measure directly. Although theoretical models propose diverse circuit architectures for decision-making, inferences based on measurements of neural activity alone cannot readily distinguish among them or even determine whether decision signals arise from local microcircuit connections or are inherited from distributed inputs. Here we used influence mapping — combining single-cell photostimulation with calcium imaging — to measure effective connectivity motifs in posterior parietal cortex (PPC) during a navigation decision task. We found that PPC connectivity is dominated by two inhibitory motifs that dynamically switch PPC between distinct computational regimes within single trials. During sensory evidence accumulation, photostimulation preferentially excited neurons with matching choice selectivity while suppressing neurons with opposite selectivity, consistent with an opponent inhibition motif that supports decision formation. During the subsequent delay period, neurons instead preferentially suppressed neurons with matching selectivity, forming an asymmetric like-suppresses-like motif that propagated choice information sequentially across neuronal populations. Computational modeling showed that competition between these inhibitory motifs enables PPC circuits to switch from decision formation to propagation of decision-related activity. Together, these results localize core decision computations to PPC microcircuits and reveal that, unlike in traditional models, inhibitory connectivity motifs are critical for decision-making, including as drivers of transitions between decision formation and execution.

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Tue, September 22

2:15 – 2:30 PM

Contributed talks

Session

2:15 – 2:30 PM (15m)

Distributed learning across fast and slow systems enables efficient adaptation of learned representations

Speaker

Leonardo Agueci (École Normale Supérieure Paris)

Description

Adaptation is a fundamental component of motor learning, enabling organisms to adjust to environmental changes while maintaining stable motor memories. A long-standing view is that this balance emerges from the interaction of learning processes operating at different timescales, yet the mechanisms that coordinate rapid adaptation with slower consolidation remain unclear. Because motor learning is distributed across multiple brain areas, this raises the question of how these systems interact to support both flexibility and stability.
Here, we propose a distributed learning framework in which adaptation and memory arise from the interaction of fast and slow systems that learn simultaneously but at different rates. We implement this in a multi-area architecture of two networks with distinct roles: a slow recurrent controller, corresponding to motor cortex, that stores stable, slowly evolving representations, and a fast feedforward adapter, corresponding to the cerebellum, that rapidly learns to predict the controller's error in response to perturbations.
We show that defining the two modules in this complementary way — with the adapter learning to predict the controller's error — allows a single signal to serve two roles: it supports efficient online correction of the system's output while simultaneously guiding the controller's local plasticity, enabling the gradual and efficient adaptation of its learned representations into long-term memory. This division of labor provides a mechanistic account of how fast error-driven learning can instruct slower, more stable representations through biologically plausible local rules. The model offers a unified perspective on how rapid adaptation and memory formation coexist within distributed circuits, and suggests how cerebellar–cortical interactions may support motor learning. More broadly, it highlights how predictive signals generated by fast processes can shape long-term representations in slower systems.

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Tue, September 22

2:30 – 3:00 PM

3:00 PM

Coffee break

Break

3:00 PM

Tue, September 22

3:00 – 3:30 PM

A network mechanism for perceptual learning

Contribution | **Speaker:** Samuel Muscinelli (University of Chicago)

Description

Organisms continually tune their perceptual systems to the features they encounter in their environment. We have studied how this experience reorganizes the synaptic connectivity of neurons in the olfactory (piriform) cortex of the mouse. We developed an approach to measure synaptic connectivity in vivo, training a deep convolutional network to reliably identify monosynaptic connections from the spike-time cross-correlograms of 4.4 million single-unit pairs. This revealed that excitatory piriform neurons that respond similarly to each other are more likely to be connected. We asked whether this like-to-like connectivity was modified by experience but found no effect. Instead, we found a pronounced effect of experience on the connectivity of inhibitory interneurons. Following repeated encounters with a set of odorants, inhibitory neurons that responded differentially to these stimuli both received and formed a high degree of synaptic connections with the cortical network. This experience-dependent organization of inhibitory neuron connectivity was independent of the tuning of either their pre- or their postsynaptic partners, suggesting a cell-intrinsic, non-Hebbian mechanism. We developed a recurrent network model of the piriform network that recapitulates this experience-dependent connectivity organization, and found that it increases the dimensionality of the entire network’s responses to familiar stimuli, thereby enhancing their discriminability. We confirmed that this network-level property is present in physiological measurements, which showed increased dimensionality and separability of the evoked responses to familiar versus novel odorants. Thus a cell-intrinsic plasticity mechanism acting on inhibitory interneurons may implement a key component of perceptual learning: enhancing an organism’s discrimination of the features particular to its environment.

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Tue, September 22

3:30 – 3:45 PM

Contributed talks

Session

3:30 – 3:45 PM (15m)

Multi-Task reservoir computing with latent variable readouts and its application to sensorimotor tasks in cognitive decline

Speaker

Mr Luca Falorsi (Fondazione Santa Lucia IRRCS; Istituto Superiore di Sanità)

Description

Reservoir computing (RC) provides an efficient framework for data-driven modeling of nonlinear dynamics, yielding an autonomous dynamical system that faithfully reproduces the driving dynamics. However, where contextual labels are not present, standard RC learns an independent readout for each time series, with no shared structure across tasks, no generalization to unseen parameters, and no sample efficiency across families of related systems. To overcome these limitations, we developed a modal decomposition describing each system's readout as a linear combination of a shared basis in the readout space, with task-specific mixing coefficients acting as latent variables. Both basis and coefficients are inferred jointly from raw data via expectation maximization with closed-form steps. The reservoir serves as a canonicalizing map: heterogeneous input sequences are projected into a common feature space where cross-task variability reduces to a low-dimensional structure. After orthonormalization, each basis element captures an independent mode of variation, and the latent coordinates spontaneously organize according to the governing physical parameters, enabling interpolation and extrapolation to unseen dynamical regimes in closed-loop generation. We first validate the methodology on families of dynamical systems and on a public dataset of locomotion patterns. We then apply this framework to build patient-specific digital twins of sensorimotor behavior in a clinical cohort of healthy, mildly cognitively impaired, and Alzheimer's disease participants performing reaching and catching movements in virtual reality. Each trial is compressed into a handful of coefficients that faithfully reproduce the recorded kinematics in closed loop. At the trial level, the coefficients encode kinematic features of the movement. Crucially, the latent-space organization degrades with cognitive impairment: the geometry of the distribution of the individual coefficients progressively deteriorates, reflecting reduced motor planning precision. Learned entirely without clinical supervision, these signatures separate diagnostic groups and track cognitive scores, yielding an interpretable dynamical biomarker of neurodegeneration derived from motor behavior.

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Poster session

Poster Session

Wed, September 23

9:30 AM

Wed, September 23

9:30 – 10:15 AM

Navigation from first principles

Contribution | **Speaker:** Máté Lengyel (University of Cambridge)

Description

Navigation is a defining signature of autonomous behaviour that presents animals with fundamental computational challenges. Here we studied how the hippocampal-entorhinal system solves two such challenges. First, efficient navigation requires a continuously updated representation of uncertainty about one's location. We formalised this uncertainty through an image computable Bayesian ideal observer model that infers location and heading direction as latent variables from self-motion, haptic (when available), and visual sensory inputs, the latter modelled as a retinal image obtained by a pin hole projection. The ideal observer's inferences about location were used to drive homing behaviour in spatial memory tasks and assumed to be represented in the population activity of entorhinal grid cells. Our model accounted for a wide range of ubiquitously described, but puzzling, forms of apparent suboptimalities in navigational behaviour and grid cell responses under deformed environmental geometries. Second, efficient navigation also requires rapid generalisation to novel tasks (goal locations or reward configurations) in a familiar environment. Here we propose the hierarchical successor representation (HSR) by incorporating temporal abstractions into the well-known successor representation (SR). HSR, unlike the classical SR, provides a policy-agnostic multi-scale map that effectively bridges model-free optimality and model-based flexibility, and scales well in topologically complex environments. Furthermore, the HSR successfully accounts for the multi-scale organisation of hippocampal place fields (the distribution of the number of place fields per cell, their sizes, and magnitudes, and how all these depend on the size and structure of the environment). These results suggest that widely described but seemingly idiosyncratic features of neural responses in the hippocampal formation are explained by the first principles of uncertainty representation and flexible generalisation.

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10:15 AM **Wed, September 23** 10:15 – 10:45 AM

TBC - Dipoppa

Contribution | **Speaker:** Mario Dipoppa (UCLA)

Description

TBC

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10:45 AM **Wed, September 23** 10:45 – 11:15 AM

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Coffee break

Break

11:15 AM **Wed, September 23** 11:15 – 11:45 AM

TBC - Posani

Contribution | **Speaker:** Lorenzo Posani (Paris Brain Institute)

Description

TBC

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11:45 AM **Wed, September 23** 11:45 AM – 12:15 PM

Contributed talks

Session

11:45 AM – 12:00 PM (15m)

Emergence of spatially structured orientation tuning in connectomics-based spiking network models of mouse V1

Speaker

Alberto Antonietti (Politecnico di Milano)

Description

Feature selectivity is a defining property of cortical computation, and across sensory systems it is often organized in space, from topographic maps to gradients in population codes. In **mouse primary visual cortex (V1)**, orientation selectivity has classically been described as “salt and pepper”, yet recent evidence indicates a subtler spatial organization: nearby neurons share more similar tuning than expected by chance, and correlations can persist over longer distances. Whether this structure reflects explicit feature-dependent wiring or emerges from generic anatomical constraints remains unresolved.

Here, **we integrate functional imaging with synaptic-resolution connectomics to constrain mechanistic models of layer 2/3 orientation selectivity in mouse V1**. Using the MICrONS dataset, we quantified tuning in excitatory neurons and characterized the spatial correlation profile of preferred orientation across short and long ranges. We then developed a cross-validated probabilistic wiring framework that learns population-specific connection probability and synaptic strength from proofread connectomic data, accounts for incomplete reconstruction by treating missing outputs as censored observations, and generalizes these statistics to full circuit realizations. Preferred-orientation difference was tested as an additional predictor, but distance-dependent models alone matched predictive performance and reproduced the apparent like-to-like modulation.

Embedding these anatomical constraints into a **spiking network model of layer 2/3 driven by structured layer-4 input**, we reproduced the empirical spatial correlation profile of orientation preference without imposing orientation-dependent synaptic rules. In silico ablations revealed dissociable mechanisms: recurrent L2/3 connectivity shaped the spatial arrangement of similarly tuned neurons without determining selectivity itself; structured feedforward projections were required for stimulus-responsive activity; and disrupting the layer 4 orientation map selectively weakened long-range correlations while preserving short-range clustering. These results suggest that **micro- and mesoscale functional organization can emerge from the interaction between distance-dependent wiring and structured feedforward input**, providing causal predictions for how local anatomy shapes the spatial scale of cortical computation.

12:00 – 12:15 PM (15m)

Shared dynamics with distinct population geometries across brain areas during decision-making

Speaker

Teo Fantacci (UniCam School of Advanced Studies, Center for Neuroscience, University of Camerino, Camerino, Italy;School of Advanced Studies Sant'Anna Pisa)

Description

Neural responses during behavior vary substantially across brain regions. Whether this variability reflects region-specific latent dynamics encoding distinct cognitive variables, or a shared latent dynamics expressed through different population geometries, remains unclear.
We analyzed simultaneous recordings from hippocampus (HC), parietal (PC), and prefrontal (PFC) cortex in rats performing a memory-guided decision in a double T-maze [1]. At a T-junction, animals turned left or right based on their position at trial onset (choice), or as imposed by a movable wall (matched guided control). From spike trains, we inferred a dynamical model for a one-dimensional latent variable x(t). Using nonparametric maximum-likelihood inference with NeuralFlow [2], we recovered, for each region and condition: the potential $\Phi(x)$ and diffusion coefficient D governing the dynamics; the two onset distributions $p_0(x)$, one per incoming direction; each neuron's tuning curve f(x), defining the population geometry.
The inferred potential was on average an inverted-U whose unstable midpoint drives x to one of the two latent space boundaries. This profile recurred across all three regions, indicating a shared computation rather than region-specific ones. By contrast, the $p_0(x)$ distributions differed across regions. HC showed the strongest modulation by working-memory demand, with distinct onsets during choice, but not guided, trials. PFC was the only region in which onsets encoded incoming directions in both choice and guided trials, tracking task-relevant information even when not required to guide behavior. The embedding geometry was likewise region-specific. Single-neuron tuning was sparser and more peaked in HC (lower entropy, higher Gini), broader and more mixed in PFC, and intermediate in PC.
Together, these results indicate that regions engaged in a common decision process share latent dynamics while embedding it through distinct population geometries. This supports the hypothesis of a collective computation with region-specific representations, rather than distinct computations implemented independently in each region.

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12:15 PM **Wed, September 23** 12:15 – 1:45 PM

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Lunch

Break

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Wed, September 23

1:45 – 2:15 PM

TBC - Cisotto

Contribution | **Speaker:** Giulia Cisotto (University of Trieste)

Description

TBC

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Wed, September 23

2:15 – 2:30 PM

Contributed talks

Session

2:15 – 2:30 PM (15m)

A framework for adaptive temporal weighting across behavior and neural network models

Speaker

Demetrio Ferro (Centre de Recerca Matemàtica, Barcelona)

Description

Perceptual decision-making relies on the accumulation of sensory evidence over time to form discriminations. Classical models link this process to distinct psychophysical effects, including primacy-related early weighting, uniform integration, and recency-related weighting arising from leaky integration. However, experiments show that humans and non-human primates can flexibly adapt temporal weighting strategies to stimulus statistics, a capacity that current models of cortical dynamics do not fully explain.
We found that macaque monkeys learn different temporal weighting strategies through exposure to a motion discrimination task with stimulus statistics (Figure 1A). Their pre-stimulus vigilance co-varied with the temporal weighting profile, highlighting the role of internal state in evidence accumulation. Moreover, analyses of middle temporal (MT) cortex reveal that while average population firing rates remain stable across weighting strategies, stimulus-related and choice-related activity depends on stimulus statistics in non-trivial ways.
To explain these findings, we introduce a two-area firing rate model comprising interconnected sensory and decision circuits (Figure 1B). A modulatory signal regulates the attractor dynamics of the decision circuit, initiating evidence integration and shaping decision timing. By varying manipulating this signal, the model reproduces early, flat, and late temporal weighting. Bidirectional connectivity dissociates choice probability (CP) into early stimulus-driven and late decision-related components, reproducing distinct CP time courses across conditions (Figure 1C).
Finally, task-optimized recurrent neural networks (RNN) show that introducing contextual signals enables flexible temporal weighting, faster learning, and generalization, identifying contextual modulation as a unifying mechanism for adaptive temporal integration.

Figure 1. A. Behavioral task. B. Computational model. C. Simulation outputs.

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Coffee break

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3:00 PM

Wed, September 23

3:00 – 3:30 PM

TBC - Neri

Contribution | **Speaker:** Peter Neri (IIT)

Description

TBC

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Wed, September 23

3:30 – 3:45 PM

Contributed talks

Session

3:30 – 3:45 PM (15m)

Geometrical and dynamical factors constraining the interpretability of subthalamic nucleus local field potential

Speaker

Federico Fattorini (The BioRobotics Institute, Sant’Anna School of Advanced Studies, Pisa, Italy)

Description

Local field potentials (LFPs), the low-frequency component of the extracellular potential, are widely interpreted as readouts of population synaptic activity[1], an assumption derived almost entirely from cortical recordings. Whether these principles extend to subcortical structures remains unclear. Here, we address this question in the subthalamic nucleus (STN), where LFPs are routinely recorded and used to guide adaptive deep brain stimulation for Parkinson's disease[2]. We built a biophysically detailed population model of the STN and validated it against patient microelectrode recordings[3]. As in the cortex, we found that STN extracellular potentials were dominated by synaptic currents. Unlike in the cortex[4], however, LFPs could not be reliably predicted from these currents or from other average population measures. We showed that this discrepancy arises from the STN's symmetric neuronal morphology and lack of recurrent connectivity, which promote destructive interference among single-neuron contributions, thereby decoupling the LFP from population-level dynamics. However, this decoupling was not absolute: when we introduced pathological beta synchrony and constrained the model using experimental data, a robust synapse–LFP relationship was restored through more consistent underlying dynamics. Furthermore, even in asynchronous settings, we found that the aperiodic slope of the power spectral density tracked STN neuronal morphology, firing rate, and excitatory–inhibitory balance.
Together, these findings challenge the prevailing view of LFPs as universal readouts of population activity. Our results show that the interpretability of extracellular signals depends critically on neuronal morphology and synchronization state, and provide a mechanistic framework for the use of STN LFPs as biomarkers in adaptive deep brain stimulation for Parkinson's disease.

1. https://doi.org/10.1038/nrn3599.
2. https://doi.org/10.1002/ana.23951.
3. https://doi.org/10.1073/pnas.2205881119.
4. https://doi.org/10.1371/journal.pcbi.1004584.

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Wed, September 23

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Poster session

Poster Session

Thu, September 24

9:30 AM **Thu, September 24** 9:30 – 10:15 AM

Revealing latent computations from neural activity and movement

Contribution | **Speaker:** Fanny Cazettes (CNRS)

Description

Behavior is visible, but the internal processes that generate it are not. Inferring these hidden computations and states is a central challenge in systems and computational neuroscience. The same action can arise from different strategies, while other ongoing processes may not be expressed in the current choice. We addressed this challenge in a mouse foraging task with multiple computational solutions. By combining behavioral modeling, large-scale neural recordings, optogenetic perturbations, and facial videography, we tracked latent variables across behavior, neural activity, and movement. We found that mice used distinct computations over reward and failure history to decide when to leave a foraging site. Yet population activity in the secondary motor cortex (M2) simultaneously represented variables supporting both current and unused alternative strategies. The same variables could be decoded from subtle and reproducible facial movements, and partial M2 inactivation reduced the accuracy and delayed the emergence of this facial readout. Together, these findings show that otherwise hidden internal processes can be exposed by linking formal models to high-dimensional neural and behavioral signals. More broadly, they expand what can count as a readout of internal processes: what is hidden from choice may leave structured traces in neural activity and movement that we are only beginning to read.

10:15 AM

10:15 AM **Thu, September 24** 10:15 – 10:45 AM

The distributed cortical network for perceptual decision making: from sensory encoding to consciousness

Contribution | **Speaker:** Umberto Olcese (University of Amsterdam)

Description

How does the brain transform sensory input into perceptual decisions? In this talk, I will present work from my lab addressing this question at multiple levels of the cortical hierarchy, combining large-scale population recordings, optogenetic manipulations, and behavioral tasks. I will begin with the primary visual cortex: our data reveal encoding that extends well beyond classical visual tuning — yet the functional significance of this non-visual information remains unclear. Moving upstream, higher-order areas exhibit rich, multiplexed representations of sensory, motor, and decision-related variables, but the link between these neuronal representations and behavioural output remains unresolved. I will then present preliminary results challenging canonical accounts of sensory tuning and sensorimotor transformation in the visual system, pointing toward a more dynamic and context-dependent picture than standard hierarchical models predict. Together, these findings paint a picture of the distributed cortical network for visual processing and decision making that raises as many questions as it answers — and reveals how little we still know about the neural mechanisms of perception.

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10:45 AM **Thu, September 24** 10:45 – 11:15 AM

Coffee break

Break

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Thu, September 24

11:15 – 11:45 AM

TBC - Martelli

Contribution | **Speaker:** Carlotta Martelli (Johannes Gutenberg University Mainz)

Description

TBC

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11:45 AM **Thu, September 24** 11:45 AM – 12:15 PM

Contributed talks

Session

11:45 AM – 12:00 PM (15m)

High-precision detection of monosynaptic connections unveils the wiring logic of the mouse visual cortex and post-subiculum

Speaker

Shuqi Wang (EPFL)

Description

Understanding how brain network structure gives rise to function requires measuring connectivity and activity in the same circuit. While inferring connections from spike trains has long been proposed as a solution, correlated inputs cause existing methods to detect many spurious connections. Using spiking network models, we systematically identified features of the spike-time cross-correlogram that distinguish true monosynaptic interactions from correlations due to common inputs, and trained a convolutional network to recognize such features (Dyad).
We validated Dyad using two simulated datasets (one EI balanced network, one ring model) and two published electrophysiological datasets with experimentally identified monosynaptic connectivity (one excitatory, one inhibitory). In all benchmarks, Dyad recovered more than half of the connections at a precision above 95%, substantially outperforming all previous approaches.

We then applied Dyad to two in vivo electrophysiological datasets — recorded in mouse visual cortex and post-subiculum. In both datasets, neurons with putative excitatory outputs had few putative inhibitory outputs, and vice versa, indicating a low rate of spurious connections.
In the visual cortex, when relating synaptic connectivity inferred from spontaneous activity to the pairwise similarity of Gabor responses, we found a like-to-like organization that extends beyond excitatory V1 neurons to span both cell classes across the visual cortex, and that cannot be explained by spatial proximity alone. We additionally identified a subpopulation of off-center, on-surround excitatory neurons that preferentially connect — both to and from — inhibitory neurons with overlapping but oppositely modulated receptive fields.
In the post-subiculum, part of the multi-stage head-direction system, we found sparse recurrent excitation (confirming in-slice work) together with unspecific inhibition, indicating that its head-direction attractor dynamics are inherited from upstream rather than locally generated.

Together, these results establish Dyad as a scalable, validated framework for inferring monosynaptic connectivity from large-scale recordings, opening a tractable route for dissecting circuit organization.

12:00 – 12:15 PM (15m)

Decoding Efficient Coding: Representation of Textures Defined by Multipoint Correlations in Rat Visual Cortex

Speaker

Chiara Di Domenico (SISSA)

Description

Efficient coding theory proposes that perceptual systems maximize information while minimizing redundancy by tuning neural representations to natural signal statistics (Simoncelli & Olshausen, 2001). In vision, these statistics take the form of local spatial correlations in the light distribution, known as multipoint correlations. Multipoint correlations that vary most across natural scenes should be more informative and perceptually salient. For configurations of up to four pixels, natural-image variability is highest for 2-point correlations, followed by 4-point and 3-point correlations. Human sensitivity follows the same ranking (Hermundstad et al., 2014), as shown using Maximum Entropy Textures (METs), synthetic binary textures that allow precise manipulation of individual correlations (Victor & Conte, 2012). However, the neural mechanisms underlying this efficient sensitivity remain unclear. The rat visual system offers a useful model for investigating these mechanisms, particularly because rats exhibit a perceptual sensitivity ranking for multipoint correlations similar to that reported in humans (Caramellino et al., 2021). We used METs to examine how these statistics are represented along the rat homolog of the primate ventral visual stream. Multi-unit extracellular activity was recorded with Neuropixels probes in early areas V1 and LM and higher-level areas LI and LL. Using a population decoding analysis, we found that the behavioral sensitivity ranking previously reported in rats is not reflected in neural responses upstream of area LI. Higher-level areas also showed greater visual invariance, consistent with progressive abstraction of stimulus representations along the hierarchy. Additionally, higher-order correlations elicited firing-rate suppression relative to noise in early areas, suggesting limited or indirect encoding. They also produced more heterogeneous response patterns across units than lower-order correlations, indicating a diverse population code. These findings provide a neural account of efficient sensitivity to multipoint correlations, suggesting that it develops progressively along the visual hierarchy through contextual modulation and higher-level representational transformations.

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12:15 PM **Thu, September 24** 12:15 – 1:45 PM

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Lunch

Break

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Thu, September 24

1:45 – 2:15 PM

Contributed talks

Session

1:45 – 2:00 PM (15m)

Predicting spatial memory performance from scaling of hippocampal activity

Speaker

Fabrizio Lombardi (University of Padova)

Description

In the hippocampus, reactivation of spatial memories during sleep enhances consolidation and recall. However, network dynamics may independently influence memory retention. We applied the Phenomenological Renormalization Group to CA1 neuronal activity in rats during sleep/rest epochs surrounding a spatial learning task. The scaling exponent of activity variance (α), assessed either before or after learning, predicted subsequent recall performance independently of reactivation. The prediction model was transferable across subjects, suggesting that it is a robust biomarker of learning ability. Single-cell features, such as burst propensity and intrinsic timescales, correlated with α and memory, α predicted retention even when controlling for these factors. Our results identified a link between scale-free circuit dynamics and memory stabilization, suggesting that the tuning of the underlying dynamical regime near criticality is a key determinant of memory longevity. Targeted modulation of these collective states could offer new avenues for memory enhancement.

2:00 – 2:15 PM (15m)

Atypical cortical feedback underlies failure to process contextual information in the superior colliculus of Scn2a+/- autism model mice

Speaker

Hiroki Asari (SISSA)

Description

Atypical sensory integration and contextual learning are common symptoms in autism spectrum disorder (ASD), but how sensory circuits are affected remains elusive. Here we focused on the early visual information processing, and performed in vivo two-photon calcium imaging and pupillometry of mice engaged in an implicit learning task in stable and volatile visual contexts. Wild-type (WT) mice show stimulus-specific contextual modulation of the visual responses in the superior colliculus (SC) and pupil dynamics, whereas SCN 2A-haploinsufficient ASD-model mice exhibit abnormal modulation patterns. In both genotypes, feedforward inputs from the retina to SC demonstrate no such contextual modulation. In contrast, feedback inputs from the primary visual cortex (V1) show modulation patterns similar to those of SC cells in WT mice, but no modulation in Scn2a$^{+/-}$ mice. Furthermore, chemogenetic perturbation reveals that this top-down signaling from V1 to SC mediates the observed contextual modulation both at the neurophysiological and behavioral levels. These results suggest that the corticotectal input is critical for contextual sensory integration in SC, and its anomaly underlies atypical sensory learning in ASD.

2:15 PM

2:15 PM

Thu, September 24

2:15 – 2:45 PM

2:45 PM

Coffee break

Break

2:45 PM

Thu, September 24

2:45 – 3:15 PM

TBC - Rossi

Contribution | **Speaker:** Federico Rossi (IIT)

Description

TBC

3:15 PM