"Maturation and Plasticity in Biological and Artificial Networks"

Cargèse, October 21-25, 2024

Invited Speakers

Omri Barak

Learning from learning systems

The word “learning” often conjures images of school or other human endeavors. Neuroscientists have used the word for a wide range of phenomena in the animal kingdom. For those engulfed in python code, perhaps learning is also associated with gradient descent or other technical terms from computer science. What do we gain from using the same name for all these cases?
In this talk, I will argue that systems that learn can be useful models of one another. This is because of general principles that seem to transcend specific instances, such as multiplicity of solutions, low-rank perturbations and more. I will demonstrate these properties using several examples. These include representational drift, the connection (or lack thereof) between neural activity and behavior, and more.
Throughout the talk I will try to highlight the benefits, dangers and challenges of this approach.

Laurent Bourdieu

Sensori-motor learning in the barrel cortex

Rodents have facial whiskers that enable them to explore the position, shape and texture of surrounding objects. These whiskers are represented in the somato-sensory cortex by a map called the barrel cortex map, the development and functions of which have been a major subject of study in developmental biology and neuroscience.

Using two-photon imaging experiments in anaesthetized rats, we showed that different functional maps were superimposed on the barrel map, in particular a selectivity map for the direction of deflection of individual vibrissae. We will show that the late emergence of this direction selectivity map can be explained by unsupervised learning of the spatio-temporal statistics of natural tactile stimuli.

The vibrissae system can also be used to study reinforcement learning of tactile information. In mice, we have developed a behavioral protocol in which a mouse is rewarded if it makes several successive active contacts with an object. Our preliminary results using wide-field imaging of neuronal activity suggest that this learning is accompanied by a specific adaptation of neuronal responses in the barrel cortex. Furthermore, by introducing omissions of the expected tactile stimuli in expert animals performing this task, specific responses to these sensory-motor omissions seem to be revealed in the barrel cortex.

Francesca Cacucci

Post-natal development of spatial and memory networks in the rat

The hippocampus contains a neural map of space, thought to be the basis of both spatial and episodic memory. I will discuss recent work from my group addressing the post-natal development of both neural representations of space, and mechanisms for encoding general memory.
Regarding representations of space, I will focus on the key role that boundaries have in defining the hippocampal map, looking at the development of both allocentric and egocentric boundary responses.
To address mechanisms of general memory coding, I will discuss the development of place cell reactivation and replay, as well as unpublished work describing the development of the dentate gyrus, thought to support specificity in episodic memory.

Rosa Cossart

Day after day: evolution of early activity in developing cortical circuits

Brain function arises from the ability of neuronal circuits to integrate external environmental inputs onto self-referenced and internally-generated dynamics. Developing brain circuits are well-known to display “spontaneous activity”, in the form of recurring synchronous network events. In the cortex, these activities initially cannot be classified as *internally-generated* because they are first sparked by self-generated peripheral stimuli. Subsequently, these activities detach abruptly from the external input and transition to being internalized. In rodents, this salient developmental shift, occurs during the second postnatal week (P10-P14), a time signaling drastic circuit and behavioral changes. We have recently developed an experimental approach and designed analysis tools to resolve the individual trajectories of identified neurons *in vivo* across several consecutive days during that critical develpental period in the growing brain. With this, we can track the emergence of functional cortical circuits over the course of development in vivo. In this presentation, I will present mostly unpublished data, highlighting the dual influence of early developmental programming and interaction with sensory signals.

Jérôme Epsztein

Using virtual reality to probe hippocampal distance coding in adults and during post-natal development

The hippocampus is critical for spatial navigation and memory. Hippocampal place cells encode allocentric position with respect to external landmarks, but also idiothetic distance through path integration. The neural mechanisms of hippocampal distance coding remain poorly understood. In particular, it is unclear how distance coding maps onto the heterogeneity of the hippocampal CA1 network and how much distance coding relies on the activity of grid cells from the entorhinal cortex, one synapse upstream, which have traditionally been implicated in distance coding and path integration. While hippocampal place cells can be recorded early in postnatal development (around postnatal day 15), grid cells with adult-like properties appear one week later (around postnatal day 23). However, it is not known whether hippocampal place and distance coding develop in parallel or sequentially. In this talk, I will show how rodent virtual reality, which provides good control of external landmarks used for self-location, can be used to isolate and characterize hippocampal distance coding. Our results show the prevalence of distance coding in cue-poor but not cue-rich environments in different hippocampal cell types, including CA1sup and CA1deep place cells. The distance travelled along the trace can be mapped onto a low-dimensional manifold, imposing rigid distance relationships between place fields, as observed for grid cells. Medial septum (MS) inactivation, which disrupts grid cell firing, altered distance coding and associated rigid distance dynamics, suggesting a modification (but not abolition) of the underlying attractor. Interestingly, allocentric position coding persists under MS inactivation in the presence of local visual cues. These results are consistent with a preferential contribution of grid cells and associated rigid attractor dynamics to hippocampal distance, but not position, coding. During development, early place cells gradually switched from landmark coding cells (around P17-P18) to position coding cells in cue-rich parts of the environment (around P20), with a protracted development of landmark-independent coding in cue-poor parts of the environment (around P23). Whether this developmental sequence is partly explained by the late development of entorhinal grid cells remains to be investigated. Taken together, these results highlight the distinct mechanisms and developmental trajectories of hippocampal distance and position coding, suggesting possible specific alterations in neurodevelopmental disorders.

Tania Rinaldi Barkat

Plasticity in the developing auditory system

The ability of our brains to create a sensory map of the outside world develops during childhood. It is indeed well established that brain circuits are shaped through so-called critical periods for plasticity. In my talk, I will present results exploring such development plasticity. First, I will show how, using electrophysiology combined with immunohistochemistry and sound exposure in the mouse auditory system, we identified critical periods for different sound features and the related

molecular triggers and brakes. I will also discuss how these critical periods, although sequentially organized, can be independent of each other. Finally, I will present how we identified changes in deviance detection taking place during brain maturation across the central auditory system, and the characteristics of the neural circuits underlying these changes. To conclude my talk, I will posit that the adolescence period, marked by heightened neural plasticity, serves as a crucial window for the brain to establish its playbook of strategies and tactics. This assertion is supported by our exploration of deviance detection and the broader discourse on critical periods. Within this developmental phase, the brain lays the foundation for its internal model, shaped by both intrinsic organization and adaptation to the external environment.

Hitoshi Sakano

Plasticity of Neural Circuit Formation and Olfactory Perception in Mice

Odor information detected in the olfactory epithelium is converted to a topographic map of activated glomeruli in the olfactory bulb (OB). Although the arrangement of glomeruli in the OB is genetically determined, the glomerular structure is plastic and circuits can be modified by environmental odor signals. If the pups are exposed to a particular odorant during the critical period, responding glomeruli become larger recruiting the dendrites of connecting projection neurons and interneurons. This imprinting not only increases the sensitivity to the exposed odor, but also imposes the positive quality on imprinted memory. Odor signals represented as an odor map in the OB is then transmitted to the piriform cortex and amygdala for decision making to elicit behavioral responses via two distinct pathways, innate and learned. For instinctive decisions, odor signals are directly delivered by mitral cells to the valence regions in the amygdala, while for learned decisions, odor-map information is conveyed by tufted cells to the anterior olfactory nucleus for identification of odors and recollection of the associated memory scene. In this presentation, I will summarize the recent progress in the study on the plasticity of neural circuits and odor perception in mice.

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Jordi Soriano

Altering dynamics in neuronal cultures through stimulation: from plasticity to reservoir computing

Engineered neuronal cultures allow to tailor the distribution of neurons in a substrate and, at some extent, their connectivity layout. The interest of these cultures is that they mimic key organizational features of the brain such as modularity. In this talk we will first present some examples of engineered neuronal networks *in vitro* and their monitoring through either calcium imaging or high-density multielectrode arrays. Experiments were carried out either on primary rat neuronal cultures or human induced pluripotent stem cells. In the experiments, we used topographical polydimethylsiloxane (PDMS) molds to induce anisotropies in the connectivity of the networks, which favors the trapping of axons or neurons or promotes axonal directionality. These alterations effectually shape regions in the culture with different connectivity blueprints which, in turn, give rise to an abundance of coactivation patterns. The analysis of the repertoire of activity patterns serves as proxy to evaluate the capacity of the neuronal networks to accommodate diverse dynamical states, and even operate in a state close to criticality.
Next, we will present experiments aimed at altering, or even inducing through plasticity, the dynamical behavior of these cultures either by chemical action or electrical stimulation. For chemical stimulation, we will show the important changes in dynamics promoted in the cultures and, more importantly, the homeostatic capacity of the cultures to cope with such changes and return to their basal, optimal state. For electrical stimulation, we will show experiments in which we induced plasticity through stimulation, altering the dynamics and functional organization of the investigated neuronal cultures. However, precise guidance of plasticity appeared to be extremely difficult. To finish the talk, we will discuss some of the obtained results in the context of reservoir computing, *in vitro* and *in silico*.

German Sumbre

Principles of functional circuit connectivity: Insights from the zebrafish optic tectum

Spontaneous neuronal activity in sensory brain regions is spatiotemporally structured, suggesting that this ongoing activity may have a functional role. Nevertheless, the neuronal interactions underlying these spontaneous activity patterns, and their biological relevance, remain elusive. We addressed these questions using two-photon and light-sheet Ca2+ imaging of intact zebrafish larvae to monitor the fine structure of the spontaneous activity in the zebrafish optic tectum (the fish's main visual center. We observed that the spontaneous activity was organized in topographically compact assemblies, grouping functionally similar neurons rather than merely neighboring ones, reflecting the tectal retinotopic map. Assemblies represent all-or-none-like sub-networks shaped by competitive dynamics, mechanisms advantageous for visual detection in noisy natural environments. Furthermore, the spontaneous

activity structure also emerged in “naive” tecta (tecta of enucleated larvae before the retina connected to the tectum). We thus suggest that the formation of the tectal network circuitry is genetically prone for its functional role. This capability is an advantageous developmental strategy for the prompt execution of vital behaviors, such as escaping predators or catching prey, without requiring prior visual experience.

We found that mutant zebrafish larvae for the mecp2 gene displayed an abnormal functional connectivity showing a significant decreased of the pair-wise correlations between neurons. The mutant larvae showed visual responses involving a significantly larger number of neurons but with smaller amplitudes. Using the visual responses to decode the presented stimuli, we found that the wild type larvae can better decode the intensity and the position of visual stimuli. Moreover, mutant larvae are less efficient in capturing prey.

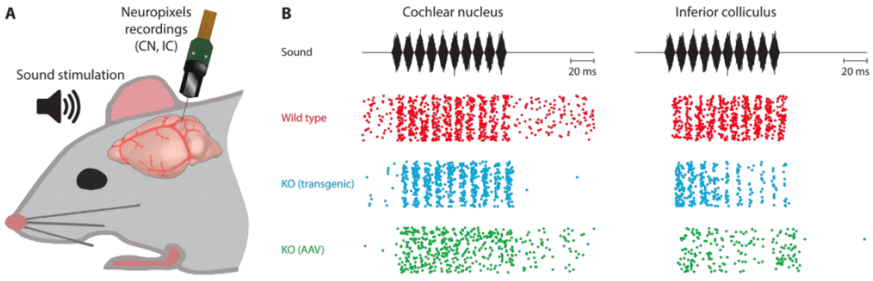
We suggest that tectal neuronal assemblies delimit the visual response to improve visual spatial resolution and serving as pattern completion allowing a better detection of prey-like stimuli.

Contributed speakers

Jérémie Barral

Deficits in spike timing and transmission of auditory information in a mouse model lacking ribbon synapses

Hearing and balance rely on the precise transmission of information between the sensory inner hair cells and the afferent auditory neurons. The synaptic ribbon is a presynaptic structure that coordinates rapid and sustained vesicle release. Ribeye protein is a major constituent of the synaptic ribbon in auditory hair cells. In this work, we studied 3 groups of mice that have 1) normal ribbon synapses, 2) deleted Ribeye protein before hearing onset, and 3) deleted Ribeye protein after hearing onset. All mouse models exhibited auditory brainstem responses confirming that the Ribeye deletion could be compensated at the peripheral level to some extent. Using large-scale Neuropixels recordings simultaneously targeting two sequential structures of the auditory pathway (the cochlear nucleus and the inferior colliculus), we studied spike activity in both structures in response to sound modulated noise or pure tones with various modulation frequencies. We analyzed single unit activity in terms of synchronization and ability to follow the sound input with sustained activity as well as the ability to decode auditory stimuli using both spike timings and firing rates.
In mice lacking the ribbon structure, we found deficits in spike synchronization with fewer neurons being entrained especially when the deletion happened after hearing onset. This led to a lack of sustained response in the inferior colliculus. Although temporal information about the carrier and modulation frequencies was degraded at the level of the cochlear nucleus in mutant mice, information was still available from the average firing rate in the inferior colliculus in the 3 mouse models. This suggests that compensatory mechanisms operate not only at the peripheral but also at the central network level. Because deficits were more severe when the deletion happened after hearing onset, these results indicate that the compensatory mechanism was not as effective at late developmental stages and that a critical period for plasticity closed after hearing onset.



Neuronal activity along the auditory pathway in control and Ribeye-deleted mouse models.
A. Probe insertion targeting the contralateral inferior colliculus down to the ipsilateral cochlear nucleus. **B.** Example of single unit activity in the two structures for wild type mice (red) and for mice with deleted Ribeye protein before (blue) or after (green) hearing onset upon modulated white noise stimulation at 90 dB.

Francesco Borra

Supervised task learning via stimulation-induced plasticity in rate-based neural networks

Biological neural systems are known to be able to learn new task by reshaping synaptic connectivity via plasticity. However, the degree to which a generic computational task can be taught with such mechanisms is not known. This is an important question in the context of recent advancements in organoid technologies, which allow to create the minimal hardware for small neuron based computers. We tackle this problem by proposing a self-contained procedure to control Hebbian-like plasticity in neural system via external stimulation in non-linear rate models. We apply this procedure to two problems in silico: a non-linear input-to-output mapping and the creation of a continuous attractor.

Johanni Brea

Multi-factor synaptic consolidation reconciles robust memory with pruning and homeostatic scaling

Memory consolidation involves a process of reorganization and stabilization that is thought to occur primarily during sleep through a combination of memory replay, homeostatic plasticity, synaptic maturation, and pruning. From a compu- tational perspective, however, this process remains puzzling, as it is unclear how the underlying neural mechanisms can be incorporated into a common mathe- matical model of learning and memory. Here, we propose a solution by deriving a consolidation model that uses replay and bi-compartmental synapses to store memories in recurrent neural networks with sparse connectivity and maximal noise robustness. The model offers a unified account of experimental observa- tions of consolidation, such as multiplicative homeostatic scaling, task-driven synaptic pruning, increased neural stimulus selectivity, and preferential strength- ening of weak memories. The model further predicts that intrinsic synaptic noise scales sublinearly with synaptic strength; this is supported by a meta-analysis of published synaptic imaging datasets.

Cécile Delacour

Model neural network to study plasticity and maturation on-chip

For the past decade, we have been developing various tools to construct model neural networks on-chip and to record their electrical activity at the scale of individual neurites and neurons. These devices are useful for probing the links that may exist between the organization and activity of cellular networks. We are particularly interested in the emergence of connectivity and spontaneous activity in neural networks, and how their architecture and environment can

impact it. Thus, in microfluidic circuits (figure 1), we have grown neurons extracted from the hippocampus (E16 mouse embryos), which are involved in memory and learning processes. Microfluidic circuits are especially useful for guiding the geometry of neural networks. These devices impose physical barriers that confine cell compartments or cell types, such as axons in microchannels or cell bodies in somatic chambers. In parallel, we fabricate arrays of microelectrodes and microtransistors (GFET arrays) for the extracellular detection of the voltage/current activity. About 40 to 60 microsensors are positioned at predefined locations within the network, in the somatic chambers and along the axonal microchannels.1 Their synchronous and multisite detection allows us to track the propagation of unitary spikes along the axons and to monitor the establishment of connectivity between neurons in a micrometer size network.2 The analysis of the voltage time traces recorded during cellular maturation (DIV0-DIV15) shows a complex connectivity despite the network structuration, as well as an accelerated maturation in these confined systems which agrees with previous structural studies.3 This approach opens many perspectives for probing the individual and collective properties of cell networks during maturation and learning process.

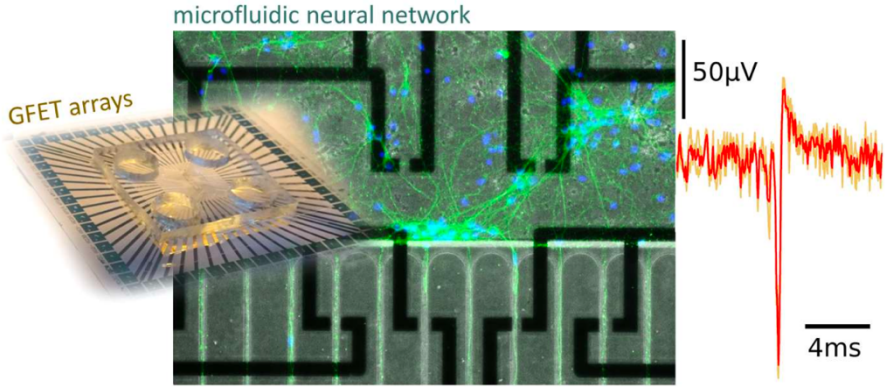


Figure 1. ***Neural networks cultured within microfluidic circuit and above an array of microsensors*** *(chip is 4.4×4.4 cm²). Here graphene field effect transistors (20×10µm²) record the extracellular potential of primary hippocampal neurons growing within somatic chamber and axonal microchannels (soma and microtubule are labelled with DAPI-350nm and YL1/2-488nm respectively). Being transparent and therefore compatible with optogenetic tools and high-resolution microscopy, this approach could provide a versatile lab-on-chip for studying the organization and activity of cells.*

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Ariane Delrocq

Towards a bio-plausible model of learning in the ventral visual pathway

Biological networks have inspired artificial neural networks and both are very powerful to solve complex tasks; yet they learn with different, incompatible 'algorithms' or 'synaptic learning rules'. I propose a model of biologically plausible learning in the ventral visual pathway based on a Contrastive, Local And Predictive Plasticity (CLAPP) learning rule. Synaptic plasticity is driven by lateral and feedback connections to apical dendrites. Natural eye movements alternating between fixations and saccades provide the “predictive” and “contrastive” samples for learning. The learning rule is local in the sense that synapses only use locally available signals without backpropagation of errors. Importantly, our simulations show that a 'developmental' learning scheme improves performance significantly. The developmental learning scheme consists in respecting “critical periods” — very sensitive periods of high plasticity during development of an infant. Since critical periods in V1 are earlier than in higher areas, different cortical areas (which correspond to layers of a deep network) are trained in our model individually one after the other from bottom to top.
Following standards in machine learning, our work evaluates the performance of learning rules on a large image data base as well as an existing hierarchical object model for artificial data. Our results indicate that learning representations in the visual cortical stream from V1, over V2, V4 to IT is possible without BackProp and without image labels with only a minor performance drop compared to the BackProp based methods in machine learning.

Pierre-Pascal Lenck-Santini

GABAergic neurons are major contributors of network inhibition in the neonatal hippocampus

Activity in the immature brain is characterized by the presence of recurrent, correlated bursts of activity that emerge in the absence of environmental stimuli. Evidence suggests that these early network events (ENE) play a critical role in neural network maturation, both locally and in downstream structures and that the gamma aminobutyric acid (GABA) neurotransmitter is essential for this maturation. This is the case in the hippocampus where GABAergic activity is necessary for the the emergence and termination of ENEs in-vitro. In-vivo, the first hippocampal ENE recorded consist of early sharp waves (eSPWs) (starting at P1) that are triggered myoclonic twitches or startles that propagate to the sensory cortex and the upstream entorhinal cortex. Recent calcium imaging data suggests that, in contrast to in-vitro ENEs, eSPWs have an external, bottom-up excitatory origin that it is weakly controlled by GABAergic inhibition.

To reconcile these contrasting results, we recorded hippocampal CA1 acvtivity in neonatal mice using single unit electrophysiology with silicon probes and analyzed with template matching algorithms to better sort the spiking activity of multiple neurons. This technique is coupled with an optotagging approach, allowing us to discriminate, through optogenetic stimulations,

between the activity from GABAergic interneurons and PN. We show that eSPWs are associated with the inhibition of a significant number of PNs and interneurons and that this inhibition increases with age, accelerating abruptly at P7. Stimulation of GABAergic neurons inhibits neural activity as early as P3 and this effect also increases with age. Finally, local GABAergic neurons are particularly sensitive to inhibition. These results, together with the fact that perisomatic inhibition only emerges during the second post-natal week, suggest eSPWs constitute a bottom up maturation signal that activates recurrent, dendritic GABAergic networks. In turn, and as demonstrated in-vitro, we propose that the presence of these recurrent networks orchestrates the population response to entorhinal stimulation, hereby avoiding epileptic activity.

Jure Majnik

Tracking spontaneous and evoked activity of the same neurons throughout development reveals the emergence of stable neocortical representations

Brain development is a dynamic process that unfolds with great variability across individuals. In mice, sensory systems develop rapidly after birth, with active whisking and eye openning occuring during the second postnatal week. Acute recordings of neural activity have revealed important global principles of this developmental period, most striking being the sparsification of neocortical dynamics. Due to the limitations of acute recordings however, an understanding of this developmental process unfolding within a cortical circuit of a single individual is still lacking.
To overcome this gap we developed a protocol allowing us to record the activity of the same neurons throughout early neocortical development using longitudinal 2-photon calcium imaging (30Hz, Gcamp8m). We recorded from a total of 10 subjects (8 in S1, 2 in V1). Recordings were started started at P7 and repeated daily up to P17, each session consisting of a period of spontaneous followed by evoked activity, delivering one of two stimuli in the form of whisker deflections. We also simultaneously tracked behaviour using videography. To match the recorded cells across days we developed a novel open-source tracking algorithm (Track2p), specifically tailored to development. Matching cells across days yielded on the order of hundreds of neurons per mouse identified across all days.
Studying the relationship between spontaneous acitvity and behaviour showed a striking rise in state-dependence at the very onset of sensation. Once developed, this representation is stable, with the same neurons exhibiting state-coupling, allowing for cross-day decoding. Applying decoding analysis to periods of evoked activity, we showed that the cortical representation of the two stimuli gradualy diverged and stabilised throughout development, exhibiting a representation better suited for guiding behaviour by downstream circuits.
Based on the described results, we suggest that during this period the role of neocortical activity patterns switches from supporting activity dependent developmental mechanisms to enabling adult-like sensory processing.

Mikel Ocio-Moliner

Burst Initiation Points displacement upon electrical stimulation

A crucial feature of neuronal cultures is their capacity to spontaneously and synchronously fire. On the other hand, electrical stimulation, delivered through microelectrode arrays (MEAs), has proven able not only to elicit bursts but to modify spontaneous activity due to the reshaping of functional connectivity [1]. Despite its relevance, the mechanisms underlying these bursts and their relation with synaptic plasticity remain elusive.
In this study, we employed a high-density MEA with a physiologically plausible stimulation protocol, combining tetanic and low frequency [2], to induce long-term potentiation in dissociated in vitro cultures. Culture activity monitoring up to an hour after stimulation reveals a displacement of the burst initiation points towards apparently random locations. However, this change was observed only in certain spatial configurations of the stimulated electrodes, suggesting that burst initiation is not governed solely by local interactions [3]. In addition, we performed experiments in rat primary cultures as well as in solely excitatory networks of human induced Pluripotent Stem Cells, which display a more malleable behaviour.
To analyze the impact on the network connectivity, we used transfer entropy to quantify the change in the connection weights. Our findings show a reduction in the post- stimulation average weights, but also the emergence of a few stronger interactions within the network. Overall, our study represents a first step towards deciphering the interplay between plasticity and spontaneous in in vitro neuronal networks.

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Maria Shujah

The role of neural plasticity in Curriculum Learning

Curriculum Learning (CL) is a strategy that structures learning tasks in increasing complexity to enhance learning efficiency. Despite its widespread use in educational systems and machine learning, the neural mechanisms, particularly how they relate to neural plasticity are not well understood. To investigate the efficacy of CL, we utilized a multi-staged Go/No-Go auditory discrimination task with mice, progressing sequentially from a simpler to a more complex task. We monitored behavioral performance and conducted in vivo electrophysiological recordings from the primary auditory cortex (A1) to assess changes in neural discriminability.
Our behavioral assessments indicated that mice demonstrated notably better and faster learning under a sequentially structured task regimen. Electrophysiological recordings showed enhanced neural discriminability with training. Remarkably, prior training on simpler task alone

led to improved neural discriminability in the complex task, highlighting the adaptive capabilities of the neural circuitry.
Further analysis of neural firing patterns revealed a convergence on common discriminable features across tasks, reflecting a dynamic process of feature abstraction. This finding underscores the potential of CL to harness the inherent plasticity of the brain to optimize learning.
Moreover, our ongoing research examines the impact of CL across different developmental stages, focusing on how early-life neural plasticity influences the effectiveness of this learning strategy. This line of inquiry is critical for understanding how CL can be tailored to leverage developmental windows of heightened neural plasticity, potentially guiding educational programs.

Jasmine Stone

Reinforcement of valence through action

Associating a stimulus with rewarding or punishing reinforcement leads to the production of approach or avoidance behaviors in response to subsequent stimulus presentations. We examined whether such behaviors themselves, absent external reinforcement, may serve as reinforcers of stimuli, using the Drosophila fruit fly model system. In this animal, the activation of descending neurons called “moon- walker neurons” promotes backward walking, an avoidance behavior.1 We found that odors paired with optogenetic activation of moonwalker neurons acquire a negative valence, leading to subsequent avoidance of those odors. Dopamine neurons in the fly mushroom body, an associative learning center, are activated during moonwalker neuron activation. A model of the mushroom body as a reinforcement learning system demonstrates that this influence of avoidance behavior on dopamine neuron activity prolongs the lifetime of avoidance memories. Such an effect may provide a resolution to the so-called “avoidance paradox”—the observation that animals continue to avoid a conditioned stimulus even after they have learned to successfully avoid the associated punishment.2 Our study establishes for the first time that, in flies, the production of an avoidance behavior can support associative learning. Such observations may also apply to other species, including mammals, in which dopamine activity has also been observed to correlate with both reinforcement prediction error and movement.3,4 The model of the mushroom body as a reinforcement learning system also illuminates some interesting degeneracies of learning behavior when biological constraints are enforced. We investigate these degeneracies and explore mechanisms to address them.

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Pierfrancesco Urbani

Dynamical mean field theory analysis of FORCE training in recurrent neural networks

FORCE is an algorithm developed by Sussillo and Abbott to train the weights of recurrent neural networks.
I will describe how it is possible to analyze the corresponding training dynamics in the limit of large networks via dynamical mean field theory and I will discuss the properties of the attractors reached by this training process as a function of the training time.

Antoine Wystrach

Ant navigation: understanding the resilience and self-developing nature of mini-brains in interaction with their environment

The navigational skills of insects in natural environments are proof of the exquisite sophistication of their mini-brain. In the last decade, the explosion of insect neurobiological techniques has enabled us to understand, not only the mechanisms underlying ant navigation, but how these are implemented in their brain circuits. For instance, the field has developed biologically realistic neural models of 'path integration', based on a brain area called the Central Complex, as well as neural models of how ants memorise visual scenes, based on a brain area called the Mushroom bodies. However, ants, as any organism, shows a degree of plasticity and resilience that lies beyond our current models. They change through time and can compensate for severe sensory-motor defect in a matter of hours. The desired breakthrough is to characterise how insects' different brain areas interact and change through plasticity, to produce plastic and resilient behaviours, as well as the emergence of an ontogeny.