Theoretical and Applied Neuroscience

Research Program

Cycle 38°

Academic year 2022-2023

List of the Research Topics

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Curriculum 1: Cognitive and Behavioral Neuroscience

Code 1.1

ERC Field: LS5_2 Systems neuroscience and computational neuroscience.

Project title: Whole-brain circuits for fear attenuation: European Brain ReseArch InfrastructureS-Italy (EBRAINS-Italy).

Key words: neural circuits, optogenetics, chemogenetics, Calcium imaging in behaving animals, PTSD, fear learning.

Host Institution: National research Council, Institute of Neuroscience – Milan.

Reference person/supervisor: Bianca Silva **email: bianca.silva@in.cnr.it**

Research topic description
This project, within the frame of EBRAINS Italy, will create whole-brain activity maps and causally test selected hubs mediating attenuation of fear memories. In particular, we will dissect the neural circuits underlying the attenuation of real-life like traumatic memories induced by exposure to naturalistic threats. To this end, we will first compile a comprehensive atlas of brain activity underlying extinction of these ethological traumas by whole-brain activity mapping. These data will provide a substrate to generate brain-wide network organization models, which will be causally probed by pathway-specific chemogenetic and optogenetic manipulations. Subsequently, we will characterize the functional input-output connectome of ethological extinction centers using a combination of viral tracing, neuronal activity and optogenetically assisted circuit mapping. Lastly, we will investigate whether impairments at the level of these newly identified networks underlie extinction deficits at the basis of trauma-related disorders. The PhD student will be involved mainly in behavioral experiments, causal neuroscience, manipulations, tissue collection, microscopy and whole-brain activity data analysis. The PhD student will be also involved in international collaborations and will present his/her project in national and international conferences.

Research team and environment
The team in which the PhD will work is an ERC-funded group of around 2 PhD students (1 on this project) and 2 post-docs researchers in the field of causal circuit neuroscience.
The research will be developed in the Institute of Neuroscience of the National Research Council of Italy in the Neuroscience department of the Humanitas Research Hospital. The department directed by prof. Matteoli offers a wide variety of techniques and facilities ranging from in vivo and ex vivo physiology, neuroinflammation, neurodevelopment and advanced microscopy. The project foresees international mobility (active collaborations with Biozentrum Basel and EPFL, Lausanne).

Preferred Research Skills and Competences
The ideal candidate has experience in rodents behavioral neuroscience, neurocomputation, causal neuroscience. Coding skills (python/mathlab) are a plus. The ideal candidate has a background of neurophysiology and should be willing to work with rodents. The ideal candidate must be able to carry out his/her work in a diligent, independent and highly collaborative manner.

Curriculum 3: Computational and System Neuroscience

Code 3.1

ERC Field: LS5_11 Neurological and neurodegenerative disorders

Project title: Metabolic reprogramming of senescent microglia to fight neurodegeneration: European Brain ReseArch InfrastructureS-Italy (EBRAINS-Italy).

Key words: microglia senescence, neurodegeneration, extracellular vesicles, iron, metabolic reprogramming

Host Institution: CNR Institute of Neuroscience, Milan (IN-CNR)

Reference person/supervisor: Claudia Verderio **email: c.verderio@in.cnr.it**
Martina Gabrielli **email: martina.gabrielli@in.cnr.it**

Research topic description
Neuron survival and function are highly dependent on microglia, the brain immune cells, and microglial dysfunction have significant impact on neuronal viability. However, it remains unknown whether the gradual deterioration of both microglia and neurons during neurodegenerative diseases is connected or interdependent. In neurodegenerative diseases, microglia sense neuronal damage and acquire a disease-associated microglia (DAM) signature that may favour tissue repair in early disease but become detrimental at late stages. However, recent evidence shows that the extent of neuron damage is not correlated with expression of DAM genes but with reduction of homeostatic genes, thus implicating that loss of homeostatic function rather than DAM differentiation contributes to neurodegeneration. Microglia normally lose their homeostatic function during senescence. Senescent microglia exhibit a proinflammatory phenotype, deficits in phagocytic functions, cell cycle arrest and impaired metabolism, and can in principle propagate senescence to neighbouring cells through the release of SASP (secretory associated senescence phenotype) factors and/or of extracellular vesicles (EVs).
IN-CNR will study the relationship between microglia and neuron dysfunction during neurodegenerative diseases. We will investigate whether senescent microglia are capable of affecting neighboring neurons and converting them to senescence in a paracrine manner. We will also investigate whether metabolic reprogramming of microglia may mitigate microglial senescence and its paracrine propagation both *in vitro* and in the mouse brain, in view of future therapy. The PhD student will be involved mainly in experimental activities and data analysis.

Research team and environment
The team in which the PhD will work is a lab including 3 PhD students (2 on this project) and 3 post-docs researchers in the fields of neurobiology and neurophysiology.
The research will be developed at IN-CNR and partner institutions (University of Genoa, Università La Sapienza), and will foresee international mobility (active collaborations with INSERM, Paris and Goteborg University).

Preferred Research Skills and Competences
The ideal candidate has experience in microglia isolation from mouse brain, in the isolation and characterization of extracellular EVs and immuno-fluorescence analysis of brain cell cultures and brain slices. The ideal candidate has a background of neurophysiology/neurobiology and should have experience in working with rodents and in vivo procedures. The ideal candidate must be able to carry out his/her work in an independent and highly collaborative manner.

Curriculum 3: Preclinical Clinical and Translational Neuroscience

Code 3.2

ERC Field: LS5_8 Psychiatric disorders (e.g. affective and anxiety disorders, autism, psychotic disorders)

Project title: The brain anti-reward center in autism spectrum disorders: European Brain ReseArch InfrastructureS-Italy (EBRAINS-Italy).

Key words: Autism spectrum disorder, Lateral habenula, Ventral tegmental area, Reward, Social behavior, Cognitive flexibility

Host Institution: Neuroscience Institute, CNR, Pisa (IN-PI)

Reference person/supervisor: Laura Baroncelli **email: laura.baroncelli@in.cnr.it**

Research topic description

The disruption of reward processing has been identified as a major pathogenetic mechanism underlying core social and cognitive traits of autism spectrum disorder (ASD). Multiple studies linked aberrant mesolimbic reward pathway to the dysfunction in social interaction as well as to restricted behaviors. However, the lateral habenula (LHb), which is considered the brain anti-reward center and is tightly connected to the ventral tegmental area (VTA), has been neglected so far. We hypothesize that an exaggerated activation of LHb neurons is responsible for the reward failure and the endophenotype of ASD. Indeed, the resulting inhibition of VTA dopaminergic neurons might explain the inability of ASD individuals to experience social and environmental stimuli as rewarding. Accordingly, previous studies suggest that the LHb is involved in sociability and behavioral flexibility, and magnetic resonance imaging revealed that this structure is enlarged in individuals with ASD. Coupling behavioral assessment with in vivo and ex vivo electrophysiology, and calcium imaging, we aim to demonstrate that the LHb-VTA circuit regulates social behavior and cognitive flexibility in physiological conditions and that this neuronal network is altered in ASD. In the context of EBRAINS Italy, this project will: a) generate novel knowledge on the pathophysiology of autism, exploring neurobiological substrates and cellular mechanisms affected in ASD to identify new potential targets for treatment; b) understand whether the analysis of superficial electrophysiological signals provides information about ASD-related alterations in deep brain structures; c) investigate the efficacy of brain stimulation strategies and drug administration to restore lost functions in ASD. The PhD student will be involved in experimental planning, data collection and analysis.

Research team and environment

The team in which the PhD will work envisages 2 postdocs and 2 PhD students with expertise in the field of neurophysiology and neurodevelopmental disorders. A collaboration with a second IN-PI team is foreseen. The research will be carried out in Neuroscience Institute, CNR and partner institutions (IRCCS Fondazione Stella Maris and University of Verona).

Preferred Research Skills and Competences

The ideal candidate has experience in behavioral assessment, electrophysiological recordings and imaging. The ideal candidate has a background of neurophysiology. The ideal candidate must be able to carry out his/her work in a diligent, independent and highly collaborative manner.

Code 3.3

ERC Field: LS5_2, LS5_1

Project title: Data-driven reconstruction of a computational model of human hippocampus: European Brain ReseArch InfrastructureS-Italy (EBRAINS-Italy).

Key words: Two-Photon Microscopy, Light-sheet microscopy, Human Hippocampus, Scaffold model of neuronal networks

Host Institution: University of Modena and Reggio Emilia

Reference person/supervisor: Jonathan Mapelli - jonathan.mapelli@unimore.it

Research topic description
Modeling human brain circuits is one of the main challenges of modern Neuroscience and although the amount of collected data is increasing, imaging data on human neuronal cells required to implement single cell models is limited to a few cortical regions. Cellular imaging on human tissues is typically obtained through methods requiring sectioning of thin slices such as confocal microscopy or light microscopy on fixed samples through classical neurohistological staining. High resolution imaging can be performed with light-sheet and multiphoton microscopies to obtain morphological reconstruction of intact neurons in thick human tissues. The project aims at collecting high resolution imaging data which will be used to generate a scaffold model of the human hippocampus. Results will be integrated into the EBRAINS-KG platform

Research team and environment
The team in which the PhD student will work is a growing lab of around 10 PhD students and post-doc researchers in the field of experimental and computational Neuroscience with different backgrounds spanning from physics and bioengineering to medicine and biology. The research will be developed in UNIMORE and partner institutions within the EBRAINS framework (IBF-CNR Palermo, UNIPV, LENS, CNR Rome) and will foresee national and international mobility. In UNIMORE the PhD student will work in close collaboration with the Neurosurgery Unit of the Ospedale Civile di Baggiovara.

Preferred Research Skills and Competences
The ideal candidate has experience in cellular and network imaging, possibly in non-linear microscopy and skill in some programming language (e.g., python, Matlab). The ideal candidate has also experience in data analysis, good communication skills and the ability to translate experimental data in abstract models and must be able to carry out work in an independent but collaborative manner.

Curriculum 3: Preclinical Clinical and Translational Neuroscience

Code 3.4

ERC Field: LS5_2 Systems neuroscience and computational neuroscience

Project title: The Perturbational Atlas: studying loss and recovery of consciousness in humans by employing invasive and non-invasive stimulation and recordings techniques: European Brain ReseArch InfrastructureS-Italy (EBRAINS-Italy).

Key words: intracranial recording, intracranial stimulation, TMS, EEG, sleep, brain lesion, sensory stimulation

Host Institution: University of Milan (UNIMI)

Reference person/supervisor: Andrea Pigorini **email: andrea.pigorini@unimi.it**
Marcello Massimini **email: marcello.massimini@unimi.it**

Research topic description
In the context of the project European Brain ReseArch InfrastructureS-Italy (EBRAINS-Italy), UNIMI will create datasets, analysis pipelines and experimental set-ups to explore human cortical circuits from a causal perspective, whereby cortical perturbations and recordings are performed both intracranially and extracranially. Specifically, UNIMI will collect two large curated and standardized datasets. The first one comprises simultaneous intracranial (stereo-EEG) and extracranial (high-density EEG) recordings in humans (including also recordings after localized cortical lesions performed for epilepsy treatment) during intracerebral stimulation (>2000 sites), which constitute the gold-standard for estimating effective connectivity, and during peripheral stimulation (somatosensory, auditory and visual). And the second one combines transcranial magnetic stimulation and electroencephalography (TMS-EEG) in healthy subjects as well as in pathological conditions such as stroke and disorders of consciousness. All these data will be used to study the mechanistic underpinning of loss and recovery of brain functions in physiological (wake and sleep), pharmacological (anesthesia) and pathological conditions (traumatic brain injury, stroke, epilepsy). The PhD student will be involved mainly in data collection, data preprocessing, data storage and analysis.

Research team and environment
The team in which the PhD will work is a large lab of around 10-15 PhD students (2 on this project) and post-docs researchers in the fields of neurophysiology, bioengineering and system neuroscience with the supervision of experimental neurologists, bioengineers and neuroscientists.
The research will be developed in University of Milan and partner institutions (Niguarda Hospital, IRCCS Fondazione Don Gnocchi, IRCCS Fondazione Maugeri and IN-CNR), and will foresee international mobility (active collaborations with Harvard University and Stanford University).

Preferred Research Skills and Competences
The ideal candidate has experience in intracerebral EEG, scalp EEG, peripheral evoked potentials and brain stimulation. The ideal candidate has a background of neurophysiology/neurology and should be willing to work not only in laboratory but also in clinical environments such as stroke unit and epilepsy surgery unit, interacting with clinicians, physicians and patients. The ideal candidate must be able to carry out his/her work in a diligent, independent and highly collaborative manner.

Curriculum 4: Computational and System Neuroscience

Code 4.1

ERC Field: LS5_2 Systems neuroscience and computational neuroscience
LS5_6 Neural bases of behaviour (e.g. sleep, consciousness, addiction)

Project title: Unraveling conscious perception through large, curated datasets of intracranial human recordings: European Brain ReseArch InfrastructureS-Italy (EBRAINS-Italy).

Key words: intracranial recordings, consciousness, intracranial stimulation, EEG, data curation, sleep, brain lesion, sensory perception.

Host Institution: CNR Institute of Neuroscience (CNR)

Reference person/supervisor: Pietro Avanzini **email: pietro.avanzini@cnr.it**
Maria Del Vecchio **email: maria.delvecchio@in.cnr.it**

Research topic description
In the context of the project EBRAINS Italy, CNR will create datasets, analysis pipelines and protocols of data curation to exploit the activity of human cortical networks through the lenses of intracranial stereo-electroencephalography. Since 10 years, CNR is collecting large datasets comprising intracranial (stereo-EEG) and non-invasive (high-density EEG) recordings in healthy volunteers and patients with drug-resistant epilepsy, including recordings after localized cortical lesions performed for clinical purposes (representing the gold-standard for estimating effective connectivity) and during peripheral stimulation (somatosensory, auditory and visual). All these data will be organized in a structured platform to allow the storage, retrieval and query of information at the single subject and population level. Overall, these data will be used to tackle the neural mechanisms sustaining conscious perception in physiological conditions as well as determining its impairment in pathological ones (traumatic brain injury, stroke, epilepsy). The PhD student will be mainly involved in data collection, preprocessing, organization and analysis.

Research team and environment
The team in which the PhD will work is a large lab of about 10-15 PhD students (2 on this project) and post-docs researchers in the fields of neurophysiology, bioengineering and system neuroscience with the supervision of experimental neurologists, bioengineers and neuroscientists.
The research will be developed at CNR and partner institutions (Niguarda Hospital, CINECA, University of Milan and University of Genoa), and will foresee international mobility (active collaborations with CNRS in Marseille and Lyon as well as).

Preferred Research Skills and Competences
The ideal candidate has experience in the collection and analysis of human electrophysiological data, and a background in the management of average-sized databases of curated biological data. He/she should be willing to work not only in laboratory but also at the interface with clinical environments, interacting with clinicians, physicians and patients. The ideal candidate must be able to carry out his/her work in a diligent, independent and highly collaborative manner.

Curriculum 4: Computational and System Neuroscience

Code 4.2

ERC Field: LS5_2 Systems neuroscience and computational neuroscience

Project title: Computational-based analysis of human task-evoked and spontaneous activity to validate predictive coding accounts of cognitive processing: European Brain ReseArch InfrastructureS-Italy (EBRAINS-Italy).

Key words: Computational models; generative models; Bayesian inference

Host Institution: Institute of Cognitive Sciences and Technologies, National Research Council (ISTC-CNR)

Reference person/supervisor: Giovanni Pezzulo **email: giovanni.pezzulo@istc.cnr.it**

Research topic description

In the context of the project EBRAINS Italy, ISTC-CNR will create computational models of advanced cognitive abilities and automated pipelines for the analysis of multimodal neural datasets collected with various techniques (e.g., electrophysiology and functional magnetic resonance), within the EBRAINS-Italy platform. The novel computational models developed by ISTC-CNR (using e.g., Bayesian inference, deep generative models) will test key predictions of leading models of brain processing in computational neuroscience (e.g., Bayesian brain, active inference, predictive coding) and advance our understanding of how the brain supports advanced cognitive functions (e.g., decision-making, planning, spatial navigation). Furthermore, ISTC-CNR will realize pipelines for the analysis of multimodal neural datasets. This work will extend previous studies of the ISTC-CNR team about various topics in theoretical and computational neuroscience, such as the neuronal underpinnings of spatial navigation and planning in the hippocampal system, the neural implementation of predictive coding and active inference across cortical and subcortical systems, the ways spontaneous and task-evoked activity contribute to shaping the brain's generative models of the body and the environment and then deploying them for advanced cognitive tasks, the neuro-cognitive mechanisms that support interactive inference and collaborative joint actions, and the normative principles underlying adaptive, goal-directed actions.

The PhD student will design and program brain-inspired computational models of cognitive abilities and automated pipelines for the analysis of multimodal neural datasets in the EBRAINS-Italy platform. The main focus will be the computational-based analysis of human task-evoked and spontaneous activity (with data from e.g., fMRI, EEG, MEG, intracranial recordings) and the validation of predictive coding accounts of cognitive processing. The PhD student will collaborate with other members of the CONAN Lab as well as national and international partners, write scientific papers for international journals and conferences, and participate in the training activities of EBRAINS-Italy.

Research team and environment

The team in which the PhD will work is the CONAN (Cognition in Action) Lab: a large lab of around 10 PhD students (2 on this project) and around 10 post-doc researchers in the fields of computational neuroscience, cognitive psychology and artificial intelligence. The research will be developed at the Institute of Cognitive Sciences and Technologies, National Research Council, Rome, and will foresee international mobility (active collaborations with several neuroscientists involved in the EU-funded Human Brain Project and EBRAINS).

Preferred Research Skills and Competences

The ideal candidate must have a strong quantitative background (e.g., in physics or mathematics), solid computational and programming skills (python and/or matlab are required) and a genuine interest in understanding the neuro-computational mechanisms of the brain. Prior knowledge of computational modeling (especially in relation to Bayesian inference, active inference, deep generative models, predictive coding) as well as information theory, graph theory, time series analysis, and/or statistical physics is very welcome. The ideal candidate must be able to carry out his/her work in a diligent, independent and highly collaborative manner.

Curriculum 4: Computational and System Neuroscience

Code 4.3

ERC Field: LS5_2 Systems neuroscience and computational neuroscience

Project title: Realization of novel computational pipelines to analyse brain signals of humans and other animals engaged in cognitive tasks: European Brain ReseArch InfrastructureS-Italy (EBRAINS-Italy).

Key words: computational models; generative models; Bayesian inference

Host Institution: Institute of Cognitive Sciences and Technologies, National Research Council (ISTC-CNR)

Reference person/supervisor: Giovanni Pezzulo **email: giovanni.pezzulo@istc.cnr.it**

Research topic description

In the context of the project EBRAINS Italy, ISTC-CNR will create computational models of advanced cognitive abilities and automated pipelines for the analysis of multimodal neural datasets collected with various techniques (e.g., electrophysiology and functional magnetic resonance), within the EBRAINS-Italy platform. The novel computational models developed by ISTC-CNR (using e.g., Bayesian inference, deep generative models) will test key predictions of leading models of brain processing in computational neuroscience (e.g., Bayesian brain, active inference, predictive coding) and advance our understanding of how the brain supports advanced cognitive functions (e.g., decision-making, planning, spatial navigation). Furthermore, ISTC-CNR will realize pipelines for the analysis of multimodal neural datasets. This work will extend previous studies of the ISTC-CNR team about various topics in theoretical and computational neuroscience, such as the neuronal underpinnings of spatial navigation and planning in the hippocampal system, the neural implementation of predictive coding and active inference across cortical and subcortical systems, the ways spontaneous and task-evoked activity contribute to shaping the brain's generative models of the body and the environment and then deploying them for advanced cognitive tasks, the neuro-cognitive mechanisms that support interactive inference and collaborative joint actions, and the normative principles underlying adaptive, goal-directed actions.

The PhD student will design and program brain-inspired computational models of cognitive abilities and automated pipelines for the analysis of multimodal neural datasets in the EBRAINS-Italy platform. The main focus will be the realization of novel computational pipelines to analyse brain signals of humans and other animals engaged in cognitive tasks, using existing techniques (based on e.g., dimensionality reduction, statistical inference, deep networks) and new computational methods developed within the project. The PhD student will collaborate with other members of the CONAN Lab as well as national and international partners, write scientific papers for international journals and conferences, and participate in the training activities of EBRAINS-Italy.

Research team and environment

The team in which the PhD will work is the CONAN (Cognition in Action) Lab: a large lab of around 10 PhD students (2 on this project) and around 10 post-doc researchers in the fields of computational neuroscience, cognitive psychology and artificial intelligence. The research will be developed at the Institute of Cognitive Sciences and Technologies, National Research Council, Rome, and will foresee international mobility (active collaborations with several neuroscientists involved in the EU-funded Human Brain Project and EBRAINS).

Preferred Research Skills and Competences

The ideal candidate must have a strong quantitative background (e.g., in physics or mathematics), solid computational and programming skills (python and/or matlab are required) and a genuine interest in understanding the neuro-computational mechanisms of the brain. Prior knowledge of computational modeling (especially in relation to Bayesian inference, active inference, deep generative models, predictive coding) as

well as information theory, graph theory, time series analysis, and/or statistical physics is very welcome. The ideal candidate must be able to carry out his/her work in a diligent, independent and highly collaborative manner.

Curriculum 4: Computational and System Neuroscience

Code 4.4

ERC Field: LS5_2 Systems neuroscience and computational neuroscience

Project title: Chaotic recurrent neural networks to study the brain basal ganglia-thalamo-cortical system: European Brain ReseArch InfrastructureS-Italy (EBRAINS-Italy).

Key words: computational models; chaotic and dynamic neural network models; basal-ganglia cortical system

Host Institution: Institute of Cognitive Sciences and Tecnologies, National Research Council (ISTC-CNR)

Reference person/supervisor: Gianluca Baldassarre **email: gianluca.baldassarre@istc.cnr.it**

Research topic description

Reservoir computing is an approach of artificial intelligence based on recurrent neural networks. These networks are in particular formed by a core neural 'dynamic reservoir' that is activated by input patterns and produces output patterns through 'readout neurons' that can possible feedback to the reservoir. This kind of networks are capable of keeping a temporal trace of the input patterns and of modelling nonlinear systems. For these reasons, reservoir neural networks have been used to simulate the complex dynamics of the brain cognitive and motor cortex. In addition, reservoir computing has been used to learn to solve complex AI problems and to guide robots in manipulation and navigation tasks. In the context of the project EBRAINS Italy, the PhD research project will be highly interdisciplinary. First it will aim to study, through computational models, the advantages and implications of using deterministic chaos to guide exploration and learning in reservoir networks in ways similar to what happens in the brain (e.g., with echo state networks, Hoerzer et al., 2014; Matsuki & Shibata, 2020). Then it will use the produced knowledge and models to study the brain basal ganglia-thalamo-cortical system underlying the selection and dynamic performance of manipulation actions in both physiological and pathological conditions (Mannella & Baldassarre, 2015). Finally, the models will be applied to control simulated and real autonomous camera-arm-gripper robots that should be able to autonomously acquire and perform behaviours directed to manipulate objects.

Research team and environment
The team in which the PhD will work is the LENAI research group (Laboratory of Embodied Natural and Artificial Intelligence) working at the Institute of Cognitive Sciences and Technologies, National Research Council (ISTC-CNR). This is a research group of about 12 researchers, postdocs and PhD students working in the fields of computational neuroscience, artificial intelligence, and autonomous robotics. The research will be developed at ISTC-CNR in Rome. The research foresees national and international collaborations with research groups involved in the EU-funded Human Brain Project and EBRAINS.

Preferred Research Skills and Competences

Applicants are expected to have a strong background in computational neuroscience, a good knowledge of the scientific literature on basal ganglia and cortex, knowledge on AI and machine learning and in particular on neural networks, possibly knowledge on reservoir computing, the capacity to build computational models within a brain-AI interdisciplinary framework. The candidate should have solid computational and programming skills in python. Applicants are expected to have both speaking and writing English capabilities, and good analysis/synthesis capabilities, for reading, understanding, and writing scientific papers on the relevant topics. Applicants are expected to have interdisciplinary interests and a strong commitment to study and work on natural and artificial intelligence, a professional attitude towards work, the capacity to work in autonomy, and the capacity to collaborate within an interdisciplinary team and an international context.

References:
• Hoerzer G.M., Legenstein R., Maass W. (2014). Emergence of Complex Computational Structures From Chaotic Neural Networks Through Reward-Modulated Hebbian Learning. Cerebral Cortex 24: 677-690.

• Matsuki T., Shibata K. (2020). Adaptive balancing of exploration and exploitation around the edge of chaos in internal-chaos-based learning. Neural Networks 132: 19-29.
• Mannella F., Baldassarre G. (2015). Selection of cortical dynamics for motor behaviour by the basal ganglia. Biological Cybernetics 109: 575-595.

Curriculum 4: Computational and System Neuroscience

Code 4.5

ERC Field: LS5_2 Systems neuroscience and computational neuroscience

Project title: Implementation of data-driven multi-scale models of neurons and brain networks of rodents and humans, under physiological and pathological states: European Brain ReseArch InfrastructureS-Italy (EBRAINS-Italy)

Key words: Computational Modeling, Hippocampus, Alzheimer's Disease, Epilepsy, Cognitive Functions

Host Institution: Institute of Biophysics, National Research Council (CNR-IBF)

Reference person/supervisor: Michele Migliore **email: michele.migliore@cnr.it**
Rosanna Migliore **email: rosanna.migliore@cnr.it**

Research topic description
In the context of the project EBRAINS Italy, CNR-IBF will provide: (1) Automated online workflows and facilities for the data analysis and implementation of data-driven models of synaptic transmission and plasticity, single neurons, and full-scale brain regions of rodents, non-human primates, and humans. (2) Detailed models of neurons and microcircuits of the hippocampus (3) Virtual brain models based on connectomics and functional recordings (fMRI, EEG, coEEG, MEG), allowing to reconstruct Digital Brain Twins of neurological and psychiatric patients. These can be used to simulate functional and pathological states as well as the consequences of pharmacological interventions. The PhD student will be involved mainly in defining and programming the modeling and analysis pipelines, and he/she will be also involved in data collection and preprocessing.

Research team and environment
The team in which the PhD will work is a lab of around 10 staff scientists, postdocs, and PhD students (2 of which on this project), in the field of computational neuroscience working in close collaboration with leading experimental laboratories. The research will be developed at CNR-IBF and it will foresee international mobility and dissemination activities.

Preferred Research Skills and Competences
The ideal candidate must have a background in scientific disciplines, programming skills (python and/or matlab and/or other programming languages) and at least a basic knowledge/experience of neuronal modeling and data analysis. He/she must be able to carry out the work in a diligent, independent, and highly collaborative manner.

Curriculum 4: Computational and System Neuroscience

Code 4.6

ERC Field: LS5_2 Systems neuroscience and computational neuroscience

Project title: Filling the gap between invasive and non-invasive stimulation and recordings techniques in humans: European Brain ReseArch InfrastructureS-Italy (EBRAINS-Italy).

Key words: intracranial recording, intracranial stimulation, TMS, EEG, sleep, brain lesion, epilepsy

Host Institution: University of Milan (UNIMI)

Reference person/supervisor: Andrea Pigorini **email: andrea.pigorini@unimi.it**
Marcello Massimini **email: marcello.massimini@unimi.it**

Research topic description
In the context of the project European Brain ReseArch InfrastructureS-Italy (EBRAINS-Italy), UNIMI will create datasets, analysis pipelines and experimental set-ups to explore human cortical circuits from a causal perspective, whereby cortical perturbations and recordings are performed both intracranially and extracranially. Specifically, UNIMI will collect two large curated and standardized datasets. The first one comprises simultaneous intracranial (stereo-EEG) and extracranial (high-density EEG) recordings in humans (including also recordings after localized cortical lesions performed for epilepsy treatment) during intracerebral stimulation (>2000 sites), which constitute the gold-standard for estimating effective connectivity. And the second one combines transcranial magnetic stimulation and electroencephalography (TMS-EEG) in healthy subjects as well as in pathological conditions such as stroke and disorders of consciousness. All these data will be used to study the mechanistic underpinning of loss and recovery of brain functions in physiological (wake and sleep), pharmacological (anesthesia) and pathological conditions (traumatic brain injury, stroke, epilepsy). The PhD student will be involved mainly in defining and programming analysis pipelines. The PhD student will be also involved in data collection, data preprocessing and data storage.

Research team and environment
The team in which the PhD will work is a large lab of around 10-15 PhD students (2 on this project) and post-docs researchers in the fields of neurophysiology, bioengineering and system neuroscience with the supervision of experimental neurologists, bioengineers and neuroscientists.
The research will be developed in University of Milan and partner institutions (Niguarda Hospital, IRCCS Fondazione Don Gnocchi, IRCCS Fondazione Maugeri and IN-CNR), and will foresee international mobility (active collaborations with Harvard University and Stanford University).

Preferred Research Skills and Competences
The ideal candidate must have computational and programming skills (python and/or matlab are required) and experience in EEG and imaging data analysis. The ideal candidate has a background in biomedical engineering / physics / math. The ideal candidate must be able to carry out his/her work in a diligent, independent and highly collaborative manner.