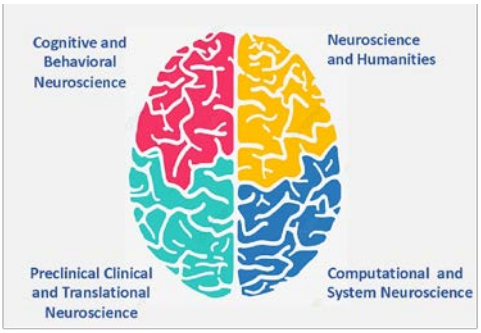
Theoretical and Applied Neuroscience

Research PhD Program



Cycle 39°

Academic year 2023-2024

List of the Research Topics

Curriculum	Research Project	Host Institution	Number of fellowships
Curriculum 1: Cognitive and Behavioral Neuroscience			
1.1	Advanced methods for characterizing functional correlates in cognitive and affective neuroscience	IMT School for Advanced Studies Lucca	1
1.2	Promoting Hebbian plasticity through multi-site stimulation of brain networks and its impact on cognitive and affective functions	University of Torino	1
1.3	Cognitive, behavioral and neurophysiological investigation of sensory disorders in autism spectrum disorder	University of Palermo	1
1.4	Neurophysiology of action-perception coupling in interpersonal sensorimotor communication	University of Ferrara	1
Curriculum 2: Neuroscience and Humanities			
2.1	Neuroscience and education	Pegaso University	1
2.2	Neuroscience, motor learning and inclusion	Pegaso University	1
2.3	Artificial intelligence and learning	Pegaso University	1
2.4	The body in the metaverse: brain representation of corporeal awareness in immersive virtual reality	Sapienza University of Rome	1
2.5	Psychophysiological differences in Pavlovian fear conditioning and their application to the study of social cognition	University of Messina	1
Curriculum 3: Preclinical, Clinical and Translational Neuroscience			

3.1	To study the neurobiological, behavioral and pharmacological basis of drug addiction and related psychopathologies	University of Camerino	1
3.2	Preclinical validation of new therapeutic approaches for neurodevelopmental disorders	Roma Tre University	1
3.3	Molecular basis of drug addiction focusing on oxidative and inflammatory aspects of SUD	Alma Mater Studiorum-University of Bologna	1
3.4	Preclinical study on probiotics mediated reshaping of the gut microbiota and its ability to counteract the metabolic and energy dyshomeostasis induced by hypoxic conditions	University of Camerino	1
3.5	Study in mice on the circuit mechanisms underlying socio-cognitive abilities relevant to psychiatric disorders.	Istituto Italiano di Tecnologia	1
3.6	Studying sleep-like intrusion in the awake brain after cortical injury	Università degli Studi di Milano	1
3.7	Experimental Investigation of cell- and network-level excitability, under physiological and pathological conditions.	Scuola Internazionale Superiore di Studi Avanzati	1
3.8	Epigenetic and immunological control of psychiatric disorders	Università di Teramo	1
3.9	Identification of the neuro-mediators and related pathways that regulate tendon regeneration.	Università di Teramo	1
3.10	Neural correlates of acute administration of intravenous ketamine in patients with pharmacoresistant depression	Università di Siena	1
3.11	Evaluation of the EBV infection in Multiple sclerosis	University of Cagliari	1
3.12	Psycho-biological and psychometric correlates of the effects of meditative practices	University of Pisa	1
3.13	Zebrafish exposure to endocrine disruptors and neurodevelopmental alterations	University of Teramo	1
3.14	Predictive factors of cognitive decline in patients with minor neurocognitive disorder	Università di Modena e Reggio Emilia	1
3.15	Pre- and post-synaptic mechanisms in the pathogenesis and treatment of neuropsychiatric diseases	University of Naples Federico II	1

3.16	Investigating the role of ion transport in the CNS during degenerative, inflammatory and genetic brain diseases	University of Naples Federico II	1
3.17	Linking inflammation to synapse loss and neurodegeneration in innovative models of Parkinson's disease	University of Milano	1
3.18	Sleep enhancement in neurodegenerative diseases	University of Camerino	1
3.19	Biological mechanisms linking synaptic plasticity and sleep in health and disease	University of Camerino	1
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curriculum 4: Computational and System Neuroscience			
4.1	Personalized mapping of structural, functional and effective connectivity in humans	Università degli studi di Milano	1
4.2	European Brain ReseArch InfrastructureS-Italy (EBRAINS-Italy): computational-based analysis of human task-evoked and spontaneous activity to validate predictive coding accounts of cognitive processing	CNR Institute of Cognitive Sciences and Technologies (ISTC-CNR)	1
4.3	"Multifunctional, adaptive and Interactive AI systems for acting in multiple contexts: a machine learning approach from neural data"	Università di Bologna	1
4.4	Deep learning for the analysis of calcium fluorescence-based brain activity images	Università di Camerino	1
4.5	Functional modeling of brain dynamics: investigation of cognitive functions through the lens of dynamical systems.	Sant'Anna School of Advanced Studies	1
4.6	Response theory in brain activity acquired by intracranial electroencephalography	Università di Padova	1
4.7	Connectivity-based parcellation of human and non-human primate brains: a comparative approach integrating structural and functional dimensions	Università di Parma	1
4.8	Methods to study the dynamic architecture of large-scale communication in the human brain	University of Chieti-Pescara	1
4.9	Bio-signals analysis and imaging in epilepsy	University of Messina	1
4.10	European Brain ReseArch InfrastructureS-Italy (EBRAINS-Italy): electrophysiological responses to perceptual or perturbational stimuli across humans and animals	CNR Institute of Neuroscience, Parma (IN-CNR)	1
4.11	Generative computational neuroscience models of the representational, motivational and selective processes	CNR Institute of Neuroscience, Parma (CNR)	1

	underlying human metacognition and consciousness and autonomous robot self-improvement.		

Curriculum 1: Cognitive and Behavioral Neuroscience

Code 1.1

Project title: Advanced methods for characterizing functional correlates in cognitive and affective neuroscience

ERC Field: SH4_1 Cognitive basis of human development and education, developmental disorders; comparative cognition - SH4_2 Personality and social cognition; emotion -SH4_4 Neuropsychology - SH4_5 Attention, perception, action, consciousness - LS5_2 Systems neuroscience and computational neuroscience (e.g. neural networks, neural modelling) - LS5_4 Sensation and perception (e.g. sensory systems, sensory processing, pain) - LS5_5 Neural bases of cognitive processes (e.g. memory, learning, attention) - LS5_6 Neural bases of behaviour (e.g. sleep, consciousness, addiction)

Key words: brain functional organization, neuroimaging, brain development and sensory experience, knowledge organization, social cognition and emotions, sleep

Host Institution: IMT School for Advanced Studies Lucca

Reference person/supervisor: Emiliano Ricciardi **emiliano.ricciardi@imtlucca.it**

Research topic description

Human neuroscience has made remarkable progresses in understanding the basic aspects of brain functional organization, primarily thanks to the advent of neuroimaging that provided scientists of various disciplines with an unprecedented opportunity to investigate the neurobiological bases of mental activities, in the healthy brain or in the presence of disease.

This project aims to provide the theoretical and methodological necessary for the study of the brain and mind, the interpretation and representation of the external world and the cognition and of human behaviors. The PhD candidate will receive intensive training on experimental design, neuroimaging (structural and functional MRI) and neurophysiological (EEG and peripheral signals) techniques and their use in humans. Different experimental paths could be developed across these macro-themes:

- Brain development and sensory experience, the complexity of neural systems and their adaptations when deprived of their typical sensory input;
- Mental representation of the external world, semantic and conceptual processing;
- Social and affective processing in humans, empathy, theory of mind and emotions and how these are represented in the brain;
- Sensory disconnection during sleep, the relationship between slow waves and conscious experience during sleep, the behavioral and neural correlates of local sleep-like episodes during wakefulness;
- Methods for integrated analysis and modeling of biosignals, (f)MRI, M/EEG; peripheral signal recordings and development of automated algorithms with clinical diagnostic and prognostic value; application of computational models for the coding of visual, acoustic and linguistic stimuli and development of multivariate approaches to study brain correlates.

Research team and environment

The Host Institution of this project is the IMT School, one of the Advanced Schools in Italy, and one of the highest-rated graduate schools in Europe (U-Multirank). The IMT School provides rigorous training and close supervision in variety of disciplines in the social, human and natural sciences, welcoming multidisciplinary and interdisciplinary approaches at their boundaries.

This research project enters the research activities of MoMiLab (https://momilab.imtlucca.it/). The MoMiLab integrates basic neuroscience methods with experimental psychophysiology, cognitive neuroscience and structural/functional brain imaging. In the thematic context of the ERC SH4 'The Human Mind and Its Complexity', the research areas of the MoMiLab include integrated and multidisciplinary aspects that focus on the study of mental activities and cognitive functions.

The PhD candidate will have access to the Multidisciplinary Lab (equipped for EEG, psychophysics and psychophysiology measures) and the Neuroscience Lab (the conjoint research lab with Innovation Center Intesa Sanpaolo) at IMT School, to the thematic laboratory for research on sleep, wakefulness and their mutual interactions (equipped for polysomnographic measures at the Fondazione Toscana 'Gabriele Monasterio' in Pisa) and to external MRI facilities (scanner from 1.5T to 7T are available in Pisa and Massa).

PhD candidates could also be involved in collaborative research programs with national and international institutions.
Within the interdisciplinary orientation of the IMT School, candidates will be exposed to seminars and conjoint research projects on different topics, ranging from molecular neurobiology of behavior to advanced computational methods for the analysis of complex systems, from social neuroscience to complex networks.

Preferred Research Skills and Competences
Candidates with a solid background in psychology, neuroscience, cognitive science, medicine, bio-engineering, physics and mathematics, computer sciences, are strongly encouraged to apply. Because of the multidisciplinary nature of this research project, applications are anyhow welcome from any area of knowledge.
Candidates with (even basic) neuroimaging data analytics experience and statistical/computer programming skills will be preferred.

Curriculum 1: Cognitive and Behavioral Neuroscience

Code 1.2

Project title: Promoting Hebbian plasticity through multi-site stimulation of brain networks and its impact on cognitive and affective functions.

ERC Field: SH4_4 Neuropsychology - SH4_5 Attention, perception, action, consciousness - LS5_2 Systems neuroscience and computational neuroscience (e.g. neural networks, neural modelling) - LS5_4 Sensation and perception (e.g. sensory systems, sensory processing, pain) - LS5_5 Neural bases of cognitive processes (e.g. memory, learning, attention) - LS5_6 Neural bases of behaviour (e.g. sleep, consciousness, addiction)

Key words: neurocognitive disorders; Hebbian plasticity; transcranial magnetic stimulation; visual awareness; emotion recognition

Host Institution: Department of Psychology – University of Torino

Reference person/supervisor: name SARA PALERMO email **sara.palermo@unito.it**

Research topic description

Neuroplasticity allows the brain to reorganize itself, making it possible to acquire new skills and be resilient in the face of trauma, injury, aging or neurodegeneration. This project aims to provide the theoretical and methodological foundation to study and promote neuroplasticity for visual and affective functions. It also aims to provide possible restorative interventions in the clinical setting after focal brain damage. The project will leverage non-invasive techniques such as cortico-cortical paired associative stimulation (ccPAS) through TMS and focused ultrasound stimulation (FUS) to promote Hebbian plasticity in networks involved in the visual processing of affective and social information. The PhD student will receive training on experimental design techniques, neuropsychological, neurophysiological and neuro-modulatory techniques applicable to healthy and brain-damaged subjects. This will lead to opening several lines of research:

- Cognitive and behavioral models that sustain neuroplasticity
- Biomarkers of functional recovery
- Integrated methods for analyzing and modeling biosignals that can help researchers gain greater insight into the underlying biological processes.
- Neuromodulatory approaches (TMS, MRgFUS) application in the experimental and clinical setting

The effects of interventions on different neuropsychological populations (hemianopsia, ABI, MCI, neurocognitive disorders) will be assessed. Restorative interventions will provide insights into how to maximize the neuroplastic potential in the aftermath of brain damage through multi-site and non-invasive brain stimulation able to promote Hebbian plasticity.

Research team and environment

The project is embedded in a highly interdisciplinary context. The Department of Psychology of the University of Turin will serve as the primary institution. The Department has an established tradition in neuropsychology, brain stimulation and neuropsychological rehabilitation and is equipped with modern neuroimaging (fMRI), neurophysiology (EEG), and brain stimulation facilities, including dual coil TMS for ccPAS protocols. The project also sees the collaboration of the Department of Psychology of the University of Bologna, that has pioneered the application of ccPAS protocol to healthy participants. This interdisciplinary context will offer a comprehensive platform for the PhD candidate and will enable him/her to make significant contributions to research on neuroplasticity through non-invasive brain stimulation.

The supervisor is an expert in experimental neuroscience, clinical neuropsychology, and neuroimaging. The research group is made up of young researchers, fellows and trainees with different backgrounds including neuroscience, psychology, neuropsychology, neurology, engineering, and physics.

Preferred Research Skills and Competences

The PhD student will receive training in the most commonly used techniques in experimental neuroscience, including psychophysiological and electrophysiological techniques, neuropsychological testing and the observation of complex human behavior according to an integrated multidimensional approach. Skills in psychobiology, physiological psychology and cognitive neuroscience are required, as well as previous research experience in neuromodulation through non-invasive techniques. Candidates with experience in the use of TMS, neuronavigation and basic neuroimaging data analytics experience and will be preferred.

Curriculum 1: Cognitive and Behavioral Neuroscience

Code 1.3

Project title: Cognitive, behavioral and neurophysiological investigation of sensory disorders in autism spectrum disorder

ERC Field: SH4_1 Cognitive basis of human development and education, developmental disorders; comparative cognition - SH4_4 Neuropsychology - SH4_5 Attention, perception, action, consciousness - LS5_4 Sensation and perception (e.g. sensory systems, sensory processing, pain) - LS5_5 Neural bases of cognitive processes (e.g. memory, learning, attention) - LS5_6 Neural bases of behaviour (e.g. sleep, consciousness, addiction)

Key words: autism spectrum disorders, brain development and sensory experience, social cognition and emotions, EEG, evoked potentials

Host Institution: University of Palermo

Reference person/supervisor: Massimiliano Oliveri **massimiliano.oliveri@unipa.it**

Research topic description

Sensory over-responsivity is a core symptom of autism spectrum disorders (ASD). Understanding sensory over-responsivity and ways of measuring it in ASD patients has huge implications for both research and clinical settings.

This project aims to shed further light in sensory over-responsivity in different sensory domains (i.e. visual, somatosensory, auditory) and to correlate this feature with cognitive/behavioral traits such as deficits of executive functions in ASD. To this aim, the PhD candidate will receive intensive training on neuropsychological assessment methods as well as on neurophysiological instruments to evaluate sensory thresholds and habituation. Different lines of research will be exploited:

- Neuromodulatory approaches in experimental and clinical environments;
- Social and affective processing, empathy, theory of mind and emotions and how these are represented in the ASD brain;
- Neuropsychological investigations and their correlation with ASD behavioral and sensory processing profiles;
- Development of AI algorithms with clinical diagnostic and prognostic value

Research team and environment

The Host Institution of this project is the neuropsychology lab of the University of Palermo, in collaboration with the Euro-Mediterranean Institute of Science and Technology (IEMEST).

The neuropsychology lab of the university of Palermo has a consolidated expertise in neuropsychology, brain stimulation, psychophysiology and neuropsychological rehabilitation and it is equipped with modern neurophysiology, neuropsychology and brain stimulation facilities. The project also sees the collaboration of the IEMEST Institute of the University of Palermo, that has an interdisciplinary expertise in molecular neurobiology. In addition, the neuropsychology lab has a consolidated scientific and clinical collaboration with clinical facilities examining high numbers of ASD and other neurodevelopmental disorders, as well as with startups developing digital methods for cognitive rehabilitation.

This environment will offer to the PhD candidate multidisciplinary competencies to make significant contributions to research on the role of sensory processing disorders to the pathogenesis of ASD. PhD candidates will also be involved in collaborative research programs with national and international institutions, including the research department of biomedical enterprises.

The supervisor is an expert in experimental neuroscience, clinical neuropsychology and neurorehabilitation. The research group is made up of young researchers, fellows and trainees with different backgrounds including psychology, neuropsychology, neuroscience, neurology.

Preferred Research Skills and Competences

Candidates with a solid background in psychology, neuroscience, cognitive science, medicine, bio-engineering, physics and mathematics, computer sciences, statistics are strongly encouraged to apply.

Curriculum 1: Cognitive and Behavioral Neuroscience

Code 1.4

Project title: Neurophysiology of action-perception coupling in interpersonal sensorimotor communication

ERC Field: SH4_5 Attention, perception, action, consciousness - LS5_5 Neural bases of cognitive processes (e.g. memory, learning, attention) - LS5_2 Systems neuroscience and computational neuroscience (e.g. neural networks, neural modelling) - LS5_4 Sensation and perception (e.g. sensory systems, sensory processing, pain) - - LS5_6 Neural bases of behaviour (e.g. sleep, consciousness, addiction) - PE6_11 Machine learning, statistical data processing and applications using signal processing (e.g. speech, image, video)

Key words: motor control, neurophysiology, action-perception coupling, social cognition

Host Institution: University of Ferrara

Reference person/supervisor: Alessandro D'Ausilio **alessandro.dausilio@unife.it**

Research topic description

The nervous system is sensitive to statistical regularities of the external world and forms internal models of these regularities to predict environmental dynamics. Given the inherently social nature of human behavior, being capable of building reliable predictive models of others' actions may be essential for successful interaction. While social prediction might seem to be a daunting task, the study of human motor control has accumulated ample evidence that our movements follow a series of kinematic invariants, which can be used by observers to reduce their uncertainty during social exchanges. Anchoring perceptual decisions to such kinematic invariants provides a key computational advantage for interpersonal motor coordination.

This project will leverage on the most salient regularities that shape biological motion, to examine the role of these invariants in recognizing others' actions, allow planning of appropriate behavioral plans and online adapt own motor outputs to those of our partners.

This project aims to provide the theoretical and methodological necessary for the study of how multiple brains generate successful behavioral negotiation and thus effective sensorimotor communication.

The PhD candidate will receive intensive training on experimental design, neurophysiological (EEG and peripheral signals) and motion capture techniques and their use in humans. Different experimental paths could be developed across these macro-themes:

- The multiscale nature of action and perception neurophysiological oscillatory coupling
- Motor synergies in interpersonal motor coordination
- The impact that stable individual motor signatures have on interpersonal motor coordination
- The role of neurophysiological inhibition in regulating interpersonal motor coordination
- Motor variability as a the mechanism by which mutual learning emerge during motor interaction
- The study of neurobehavioral mutual interpersonal adaptation

Research team and environment

The Host Institution of this project is the University of Ferrara (UNIFE), Department of Neuroscience and Rehabilitation. The supervisor is also affiliated to the Center for Translational Neurophysiology (CTNSC) of the Italian Institute of Technology. The research group (4 full professors, 4 researchers, 2 technicians, 7 postdocs, 3-4 new PhDs each year) conducts research in the area of Neurophysiology of Speech and Sensorimotor Communication. From the development of innovative brain interfaces to advanced neural signal processing and machine learning, from speech-based communication to implicit sensorimotor coordination in healthy and neuropsychiatric or neurological populations, the goal is to develop a new understanding of how brains generate

effective informational coupling and, when compromised by pathology, to devise new technologies for theranostic purposes.
The PhD candidate will have full access to the state-of-the-art CTNSC facilities that include 1 Motion Capture Lab (e.g., Vicon, AMTI force platforms, Eyetracking, etc.), 2 noninvasive human neurophysiology Labs (e.g., 3 EEG systems, 4 TMS systems, 3 EMG systems, etc.), 2 animal neurophysiology Labs, 1 mechanical Lab, and 1 electronic Lab. The research group has strong collaborations and authorizations to conduct data collections in clinical populations in the areas of neurosurgery (Udine Hospital, Ferrara Hospital), neurology (S. Lucia Rehabilitation Hospital in Rome, Gaslini Pediatric Hospital in Genoa, and Rehabilitation Unit of Ferrara Hospital), psychiatry (Ferrara Hospital). PhD candidates could also be involved in collaborative research programs with national and international institutions.
Within the interdisciplinary orientation of the UNIFE-CTNSC collaboration, candidates will be exposed to seminars and conjoint research projects on different topics, ranging from artificial intelligence to robotics and from human neurophysiology to clinical and pre-clinical research in neurology and psychiatry.

Preferred Research Skills and Competences
Candidates with a solid background in psychology, neuroscience, cognitive science, medicine, bio-engineering, physics and mathematics, computer sciences, are strongly encouraged to apply. Candidates with data analytics experience and statistical/computer programming skills will be preferred.

Curriculum 2: Neuroscience and Humanities

Code 2.1

Project title: Neuroscience and education

ERC Field: SH4_13 Education: principles, techniques, typologies; SH4_2 Human life-span development

SH4_11 Education: systems and institutions, teaching and learning.

Key words: education, pedagogy, Neuropedagogy, psychology, neuroscience, teaching and learning processes**.**

Host Institution: Department of Human Sciences - Pegaso University

Reference person/supervisor: Cristiana D'Anna email: **cristiana.danna@unipegaso.it**

Research topic description

The dialogue between neuroscience and education represents prolific ground for structuring effective educational processes and for understanding some of the mechanisms essential to learning.

Education has the task of "shaping" the brain; a better understanding of the functioning of our brain and the characteristics of its development can certainly offer an enormous contribution to pedagogy, which while retaining the freedom of its epistemological and philosophical reflection, as well as its generalist vocation, must also be based on the empirical results of neuroscience.

This research topic aims to create a dialogue between neuroscience and education in order to make functional the scientific contributions offered by recent discoveries to the improvement of teaching practices in educational contexts.

The goal of educational neuroscience is to improve educational outcomes, largely by changing the most proximal factors to learning outcomes such as: ability, motivation and attention, health and nutrition. However, it should be borne in mind the range of barriers to change that may be encountered beyond optimizing learning itself.

Understanding the processes involved in learning is complex. One of the most interesting aspects concerns teacher training and in particular how to enable teachers to translate neuroscientific and psychological theoretical knowledge into good teaching practices.

Research team and environment

This research project will be carried out in the laboratories of the Pegaso University in Naples, Rome and Milan. The research activity focuses mainly on the study of the relations between neuroscience and education by investigating the pedagogical and educational consequences of cognitive neuroscience, cognitive and behavioral psychology.

The research activity investigates complex issues in neuroscience with a multidisciplinary approach involving a research team consisting of several professors, researchers, PhD students and experts with different backgrounds including biology, neurobiology, sports science, pedagogy, philosophy, psychology and physics. Due to the multidisciplinary nature of this research project, applications are still welcome from any area of knowledge.

Preferred Research Skills and Competences

A high level of motivation to study and research and perseverance are always required. Following the principal research skills and competences preferred: analytical and problem solving, critical thinking, teamwork, digital and communication skills.

Curriculum 2: Neuroscience and Humanities

Code 2.2

Project title: Neuroscience, motor learning and inclusion

ERC Field: SH4_13 Education: principles, techniques, typologies; SH4_2 Human life-span development

Key words: affordances, constraints, ecological dynamic approach, inclusion, Neuropedagogy , motor learning, non-linear logic, specific skills.

Host Institution: Department of Human Sciences - Pegaso University

Reference person/supervisor: Cristiana D'Anna email: **cristiana.danna@unipegaso.it**

Research topic description

Numerous studies have been carried out in the wake of the ecological perspective of Gibson (1979), emphasize the qualitative aspects of movement considering motor coordination as an organization emerging from the peripheral constraints of the system rather than from central control structures. An approach of this kind seeks to understand globally the ability of movement in its various levels of complexity, focusing on the complex interaction between individual and environment and the circular relationship between perception and action

The acquisition of a given movement in a particular learning context takes place through practice through the action of specific constraints - individual, environmental, and task constraints (i.e., rate limiters, affordances), which interact, according to a non-linear logic, favouring the explication of coordination emergencies, product of a process of self-organization in response to constraints.

Recognizing these constraints on an ad hoc basis, both with a stabilizing and destabilizing objective, becomes a fundamental aspect for practitioners, that must effectively design different teaching proposals to better manage the different variables that influence the acquisition of specific skills.

The research topic focuses on the analysis of complex processes underlying motor control by searching for the most effective solutions to promote self-organization of movement and consequent improvement of motor learning in special populations (people with disabilities, the elderly, etc.), starting from the basic skills finalized to personal autonomy. In this sense, educators/coaches seek to implement affordance-rich landscapes, that is, all the information that the subject can grasp from the environment.

Research team and environment

This research project will be carried out in the laboratories of the Pegaso University in Naples, Rome and Milan. The research activity focuses mainly on the study of the relations between neuroscience and education by investigating the pedagogical and educational consequences of cognitive neuroscience, cognitive and behavioral psychology.

The research activity investigates complex issues in neuroscience with a multidisciplinary approach involving a research team consisting of several professors, researchers, PhD students and experts with different backgrounds including biology, neurobiology, sports science, pedagogy, philosophy, psychology and physics. Due to the multidisciplinary nature of this research project, applications are still welcome from any area of knowledge.

Preferred Research Skills and Competences

A high level of motivation to study and research and perseverance are always required. Following the principal research skills and competences preferred: analytical and problem solving, critical thinking, teamwork, digital and communication skills.

Curriculum 2: Neuroscience and Humanities

Code 2.3

Project title: Artificial intelligence and learning

ERC Field: SH4_13 Education: principles, techniques, typologies; SH4_11 Education: systems and institutions, teaching and learning; PE6_8 Intelligent systems

Key words: artificial intelligence, Neuropedagogy, cognitive science, corporeality, digital environments, education, teaching and learning processes.

Host Institution: Department of Human Sciences - Pegaso University

Reference person/supervisor: Cristiana D'Anna email: **cristiana.danna@unipegaso.it**

Research topic description

The use of Artificial intelligence (AI) in education is mainly based on machine learning. Modern AI focuses creating autonomous machines that do not require human control for learning and contextual adaptation. The first publication about 'AI in education' (AIEd) date to 1989 in the International Journal of Artificial Intelligence in Education. AIEd is basically framed by pedagogy and conceptualized through cognitive science.

The topic focuses on the strong link between Artificial Intelligence and Personalized Learning (PL) from a philosophical and neuroscientific point of view, and identifies the main hypotheses used in learning and PL and their related objectivism, knowledge based and subjectivism aspects.

It is necessary underline the impact of digitization on transforming the scheme of learning designs. These designs are moving forward with learning from its collective approach to a more personalized one.

In this sense, neuroscientific research in the educational field in recent years can provide numerous information and empirical evidence on the issues of learning and teaching in analogue and digital environments, with a specific focus also on corporeality and its importance for the effectiveness of the development process in the awareness of the great potential of the body in the digital learning experience. It is necessary to capitalize on the enormous transformations that have taken place in society, linking them with the new neuroscientific knowledge on learning processes and integrating them with new cognitive, communicative and knowledge management practices.

Research team and environment

This research project will be carried out in the laboratories of the Pegaso University in Naples, Rome and Milan. The research activity focuses mainly on the study of the relations between neuroscience and education by investigating the pedagogical and educational consequences of cognitive neuroscience, cognitive and behavioral psychology.

The research activity investigates complex issues in neuroscience with a multidisciplinary approach involving a research team consisting of several professors, researchers, PhD students and experts with different backgrounds including biology, neurobiology, sports science, pedagogy, philosophy, psychology and physics. Due to the multidisciplinary nature of this research project, applications are still welcome from any area of knowledge.

Preferred Research Skills and Competences

A high level of motivation to study and research and perseverance are always required. Following the principal research skills and competences preferred: analytical and problem solving, critical thinking, teamwork, digital and communication skills.

Curriculum 2: Neuroscience and Humanities

Code 2.4

Project title: The body in the metaverse: brain representation of corporeal awareness in immersive virtual

ERC Field:

SH4_3 Neuropsychology and cognitive psychology - SH4_4 Clinical and experimental psychology; LS5_7 Cognition (e.g. learning, memory, emotions, speech) - LS5_9 Systems neuroscience

Key words: Immersive Virtual Reality – Non invasive brain stimulation - EEG - Body ownership and agency - social neuroscience -

Host Institution: Sapienza University of Rome (Department of Psychology)

Reference person/supervisor: Salvatore Maria Aglioti email: **salvatoremaria.aglioti@uniroma1.it**

Research topic description Thanks to the increasing immersive properties of Virtual Reality (IVR) devices, a significant amount of our real-time multisensory social interactions are shifting toward the metaverse, a computer generated environment in which people act and communicate via embodied avatars. Thus, IVR offers unique advantages for manipulating higher-order cognitive and emotional functions in relationship to social processes. In particular, studies indicate that embodying physical agents may imply feeling their body becomes our own body and we are responsible of the actions of the virtual agent. The fellowship is offered for conducting research that integrates NIBS, EEG and virtual reality with the aim of developing a causative-correlational approach that allows to unravel the cortical dynamics underpinning the sense of ownership and agency and how these processes can be perturbed. The studies have implications both for understanding brain connectivity and for fostering novel treatments of neuro-psychiatric conditions in which sense of body ownership and agency are altered.

Research team and environment. The research will be conducted under the supervision of Salvatore Maria Aglioti (salvatoremaria.aglioti@uniroma1.it), who heads three different laboratories, namely: the CoSAN lab at Department of Psychology Sapienza University of Rome (https://agliotilab.org/), the Neuroscience and Society Research Line (the https://www.iit.it/research/lines/neuroscience-and-society) at the Life Nano- and Neuro-Science Center (CLN²S), Italian Institute of Technology and the Santa Lucia Foundation, IRCCS, Rome. The supervisor has been working for the past 25 years on a vast range of topics at the intersection between social neuroscience and humanities using a variety of theoretical approaches and state-of-the-art systems neuroscience techniques. Somewhat unique to the research environment is the close interaction between different profiles of scholars ranging from psychologists and social neuroscientists to physicists, engineers, and experts in computational modeling.

Preferred Research Skills and Competences. While there are no specific limitations in terms of the degree needed for applying for the position may attract potential PhD students coming primarily from psychology and neuroscience. Crucially applicants from diverse domains belonging into the humanities (e.g., aesthetics, art history) are encouraged to apply. Degrees in STEM or in other quant areas are very welcome. While experience

in experimental psychology, cognitive, social and affective neuroscience may be expected, a strong background in computer graphics and data analysis is considered a plus.

Curriculum 2: Neuroscience and Humanities

Code 2.5

Project title: Psychophysiological differences in Pavlovian fear conditioning and their application to the study of social cognition

ERC Field:

- SH4_2 Personality and social cognition; emotion
- SH4_3 Clinical and health psychology
- SH4_4 Neuropsychology
- SH4_5 Attention, perception, action, consciousness
- SH4_6 Learning, memory; cognition in ageing

Key words: Pavlovian fear conditioning, Personality, Consciousness, Social Cognition, Non-invasive brain stimulation, Learning and memory, Exposure therapy, Metaverse.

Host Institution: Department of Cognitive, Psychological, Educational, and Cultural studies, University of Messina.

Reference person/supervisor: Carmelo M Vicario email: **cvicario@unime.it**

Research topic description

Fear is closely connected to social cognition, behavior and ideological orientation through processes such as threat perception, group dynamics, emotional contagion, cognitive biases, ideological frameworks. The goal of this proposal is to study the predictive role of Pavlovian fear conditioning, a well-established laboratory protocol for studying the mechanisms underlying fear and anxiety disorders, for social cognition, ideological orientation, and respective behaviors.

Research team and environment

The project will be implemented at the Cognitive Neuroscience laboratory, founded in 2020 by prof. Carmelo M Vicario at the Department of Cognitive, Pedagogical Psychological and Cultural Studies of the University of Messina. The laboratory has the mission to expand knowledge of neural bases of cognitive and affective processes through a multidisciplinary and interdisciplinary approach that includes the use/involvement of non-invasive brain stimulation, electrophysiological techniques, and clinical populations. The main research focus of the Cognitive Neuroscience laboratory concerns the study of the reward system and its impact on cognitive and affective processes. The environment offers several facilities including virtual reality, non-invasive brain stimulation and electrophysiological techniques.

Preferred Research Skills and Competences

The ideal candidate is a highly motivated psychologist, physician, or biologist (or related disciplines) with a solid background in social and cognitive neuroscience. Previous experience with the use of non-invasive brain stimulation methods, data collection, E-prime/MATLAB programming is desired but not mandatory. social skills

such as empathy, altruism, and a desire to be part of a team while respecting the roles of other colleagues are highly desirable.

Curriculum 3: Preclinical Clinical and Translational Neuroscience

Code 3.1

Project title: To study the neurobiological, behavioral and pharmacological basis of drug addiction and related psychopathologies.

ERC Field: LS5_3 Neurochemistry and neuropharmacology; LS7_3 Pharmacology, pharmacogenomics, drug discovery and design, drug therapy;LS5_12 Psychiatric disorders

Key words: Reward and Motivation, Environment, Neurocircuitry, Pharmacology, Electrophysiology,

Host Institution: University of Camerino

Reference person/supervisor: Roberto Ciccocioppo **roberto.ciccocioppo@unicam.it**

Research topic description
Substance Use Disorder (SUD) is a psychiatric condition associated with increased health risks and social harm with dramatic impact to the global disease burden. In humans addictive behavior is characterized by a shift from recreational to compulsive drug seeking as described in the DSM-IV. Long-term consumption of substances of abuse induces neuroadaptations that are associated with loss of control, compulsive drug taking and negative emotional states (i.e. anxiety, depression). However, not all subjects develop SUD in response to prolonged exposure to drugs. Inter-individual vulnerability to lose control of drug consumption and develop addiction depends upon genetics, environment, personality traits, psychiatric comorbidities and the interplay of all these factors. Our laboratory is aimed at investigating the mechanisms through which these factors (and their interaction), contribute to SUD vulnerability with the ultimate objective of identifying novel molecular targets and therapies to treat SUD. To exploit these projects, in addition to classical pharmacological manipulations, in vivo optogenetic, chemogenetic and neurophysiological approaches will be used. Viral mediated upregulation and downreulation of specific receptors in selected brain areas are used to determine the role of specific neurocircuitry in encoding vulnerability to SUD. *Ex vivo* brain slice electrophysiology will be also used to support the study.

Research team and environment
This research project will be carried out in the School of Pharmacy, Center for Neuroscience, University of Camerino, Italy. The laboratory headed by Prof. Roberto Ciccocioppo is conceived as a multidisciplinary environment to investigate complex questions in neuroscience. The main research focus of the laboratory is on the study of the neurobiological basis of abnormal behavior and brain functions relevant to human psychopathology with emphasis on motivation and reward-related disorders. The majority of this work is directed at the understanding the neurological mechanisms responsible for these aberrant behaviours and at identifying innovative pharmacological targets to aid the development of new more effective treatments. Attention to the study of neurocircuitry and molecular mechanisms controlling emotional and cognitive disturbances associated with protracted exposure to drugs of abuse or chronic stress is also an important area of research. Over the years this research team contributed to the preclinical development of at least 3 compounds that reached various clinical development stages. The team consists of several researchers, post-doctoral fellows and PhD students with different backgrounds including biology, pharmacology, philosophy, psychology and physics. Researchers have access to 1500 m^2 of animal facility equipped with operant self-administration chambers, EPM equipments, Porsolt swimming tubes, open field arenas for social interaction, Noldus Etovision system for behavioral monitoring, etc. Fully equipped lab for immunohistochemistry, light, confocal and scanning electron microscopes

are available. One laboratory is equipped an Electrophysiological setup for patch-clamp recordings in slices. Finally, equipment for molecular and cellular studies is available.

Preferred Research Skills and Competences
The doctoral candidate will receive training in the techniques most commonly used in basic neuroscience, including brain activity recording, imaging, electrophysiology, proteomics, behavioural testing, molecular biology, histology and data analysis. Pharmacological, chemogenetic and optogenetic approaches will be also experienced. Candidates with training backgrounds in life sciences, behavioral pharmacology, electrophysiology, pharmaceutical sciences, molecular genetics, are preferentially considered for this position.

Curriculum 3: Preclinical Clinical and Translational Neuroscience

Code 3.2

Project title: Preclinical validation of new therapeutic approaches for neurodevelopmental disorders

ERC Field: LS5_6 Neural bases of behaviour (e.g. sleep, consciousness, addiction), LS5_8 Psychiatric disorders (e.g. affective and anxiety disorders, autism, psychotic disorders), LS7_4 Pharmacology and pharmacogenomics (including drug discovery and design, drug delivery and therapy, toxicology)

Key words: neurodevelopmental disorders, animal models, pharmacology, social behavior, cognition

Host Institution: Roma Tre University

Reference person/supervisor: Viviana Trezza **viviana.trezza@uniroma3.it**

Research topic description
In this PhD project, sophisticated behavioral and neurochemical approaches will be used in validated genetic and environmental animal models of neurodevelopmental disorders, to test the efficacy and safety of new drugs and diagnostic medical devices. The PhD student will therefore acquire skills in preclinical drug development. In particular, the PhD student will become familiar with the pharmacological characterization of molecules active on the central nervous system.

Research team and environment
This research project will be carried out in the Pharmacology Laboratory of the Department of Science of Roma Tre University, Viale Marconi 446, Rome, Italy.
The Department of Science of Roma Tre University was conceived as a multidisciplinary research Institution in 3 broad thematic areas: Environmental, Molecular, and Physiophatological areas. It harbors 30 research groups from different scientific backgrounds, with several staff members working in the Neuroscience field.
The primary goal of the Pharmacology Laboratory headed by Viviana Trezza is to investigate the brain mechanisms underlying functional and dysfunctional socio-emotional behavior, with the long term of goal of identifying novel pharmacological targets for neuropsychiatric and neurodevelopmental disorders characterized by aberrant socio-emotional processing. Experimental approaches in the Pharmacology Laboratory include a combination of sophisticated behavioral, neurochemical and pharmacological methods in mouse and rat models of psychiatric diseases induced by genetic, pharmacological or environmental manipulations. The members of the Pharmacology Laboratory have established successful collaborations with neuropsychiatrists, psychologists, molecular neurobiologists, neuroimaging experts, organic chemists, and electrophysiologists to develop and implement experimental translational tools to study socio-emotional traits under normal and pathological conditions. Furthermore, a close interaction exists between the Pharmacology Laboratory and pharmaceutical/biotechnological Companies.

Preferred Research Skills and Competences
Experience in rodent models of neuropsychiatric and neurodevelopmental disorders.
Experience in behavioural pharmacology.

Experience in biochemical and molecular techniques.

Curriculum 3: Preclinical Clinical and Translational Neuroscience

Code 3.3

Project Title: Molecular basis of drug addiction focusing on cell oxydative and infiammatory aspects of Substance Use Disorders.

ERC Field: LS5_3 Neurochemistry and neuropharmacology; LS7_3 Pharmacology, pharmacogenomics, drug discovery, drug therapy; LS5_8 Psychiatric disorders (e.g. affective, anxiety disorders and psychiatric disorders).

Key words: drug use disorders, Reward, Neuropharmacology, oxidative stress, neuroinflammation

Host Institution: Alma Mater Studiorum-University of Bologna

Reference person/supervisor: : Patrizia Romualdi **patrizia.romualdi@unibo.it**
Laura Calzà **laura.calza@unibo.it**

Research topic description

This PhD project will develop specific neurochemical and pharmacological approaches both in animal models of neuronal disorders and in models in vitro as alternative methods. The molecular aspects of inflammation and oxidative stress will be investigated in SUD. The PhD student will acquire skills in preclinical drug development. In particular, the PhD student will become familiar with the use of alternative methods to study neurochemical alterations related to SUD.

Research team and environment

This research project will be carried out in the Molecular Pharmacology Laboratory of the Department of Pharmacy and Biotechnology via Irnerio 48 Alma mater Studiorum University of Bologna, and CIRI-SDV, University of Bologna, Via Tolara di Sopra 41/E, Ozzano Emilia (Bologna). The Department of Pharmacy and Biotechnology of the University of Bologna is organized in several research thematic areas: Genetic, Environmental, Molecular, Pharmacological, Chemical Neuroanatomy, Physiophatological and Pharmaceutical areas. It consists of almost 40 research groups with different scientific backgrounds, with several staff members working in the different fields, one of these is the Neuroscience field. The primary goal of the Molecular NeuroPharmacology Laboratory headed by Patrizia Romualdi is to investigate the neuronal molecular mechanisms underlying possible involvement of inflammation and oxidative stress in substance use disorders. Another aim will be to use alternative methods to study the molecular mechanisms at cellular level by means of 3D-culture and organoids, thanks to the collaboration with Laura Calzà. 3D-cultures will be established from neural stem cells derived from normal and SUD rodents, and inducible pluripotent cells. The Experimental approaches in the Pharmacology Laboratory include a combination of neurochemical and pharmacological methods in rodent models of SUD. The members of the Pharmacology Laboratory have established successful collaborations with neuropsychiatrists, molecular neurobiologists, anatomists, pharmaceutical chemists, to develop and implement experimental translational tools to study neurobiological basis of SUD development.

Preferred Research Skills and Competences
Experience in biochemical and molecular technique.
Experience in behavioural pharmacology.
Experience in chemical neuroanatomy, 3D microscopy and image analysis
Experience in cell cultures (2D, 3D, 4D).
Experience in neuroinflammation

Curriculum 3: Preclinical Clinical and Translational Neuroscience

Code 3.4

Project title: The effect of a multi-strain probiotic under chronic hypoxic conditions with a focus on brain damages and cognitive functions: a preclinical study

ERC Field: LS1_10 Molecular mechanisms of signalling pathways; LS5_7 Neurological disorders (e.g. neurodegenerative diseases, seizures);

Key words: microbiota, gut-brain axis, probiotics, hypoxia, cognitive abilities, metabolic and energy homeostasis

Host Institution: University of Camerino

Reference person/supervisor: Anna Maria Eleuteri **annamaria.eleuteri@unicam.it**
Laura Bonfili **laura.bonfili@unicam.it**

Research topic description
Hypoxia is one of the most common and severe stressors to an organism's homeostasis, characterized by insufficient energy supply to tissues and organs. It occurs in various physiological and pathological conditions contributing to the onset of diseases, among them neurodegenerative diseases like Alzheimer's disease (AD). In AD cerebral oxygen supply is impaired generating brain damages and, consequently, altered cognitive abilities. Dysbiosis is another hallmark of AD patients, being involved in the pathogenesis of the disease through the gut-brain axis, a bidirectional communication between the gut and the brain. Microbiota modulation has been described as a promising strategy to restore metabolic and cognitive functions with Hypoxia Inducible Factor 1 alpha (HIF-1alpha) regulating host microbial crosstalk. Using a mouse model of AD, the project will aim at demonstrating the effect of a probiotic mixture to prevent neuronal damages induced by hypoxia exploring specific pathways such as the learning and memory processes, the hypoxia pathway, the oxidative and inflammatory status, including the mitochondria functionality. The probiotics mediated reshaping of the gut microbiota and its ability to counteract the metabolic and energy dyshomeostasis induced by hypoxic conditions will be analyzed.

Research team and environment
This research project will be carried out in the School of Biosciences and Veterinary Medicine, University of Camerino, Italy. The laboratory headed by Prof. Anna Maria Eleuteri works on neurodegenerative disorders, in particular Alzheimer's disease (AD) , studying the pathways being involved in the onset of the disease as potential targets for therapeutic and preventive approaches. The main research focus of the laboratory is on microbiota modulation, obtained through the use of probiotic formulations, and its effects on the gut-brain axis influencing several neuronal processes like inflammation, oxidation, immune response and metabolic and energy homeostasis with the consequent improvement in cognitive abilities. The main purpose of the study is to identify possible strategies which could help in delaying and/or counteracting the development of AD. Studies are conducted using in vitro AD cell models and AD transgenic murine models.
This research team is composed by several researchers, post-doctoral fellows and PhD students with backgrounds in biochemistry and clinical biochemistry. The lab is equipped for ELISA, SDS-PAGE, western blotting and Chemidoc imaging system analyses, plus spectrophotometers, spectrofluorimeters for spectroscopic determinations, and end-point and real time PCR. The doctoral candidate will have access to the new laboratory equipped with instruments for genomic and proteomic advanced studies and to a Morphological Sciences laboratory equipped for immunochemical analyses (cryostat, microtome, light/confocal microscopes, digital camera and imaging software). In addition the PhD student will have access to the University Animal Facility, fully equipped for behavioral studies (self-administration boxes, open field arenas, Ethovision (Oldus) video tracking system, radial maize, Morris maize, conditioning place preference boxes), including aseptic surgery room and quarantine room.

Preferred Research Skills and Competences
The doctoral candidate will receive training in the techniques most commonly used in biochemistry and clinical biochemistry, molecular biology including omics approaches, behavioral testing and data analysis. Candidates with training backgrounds in life sciences, with a focus in clinical and molecular diagnostics, are preferentially considered for this position.

Curriculum 3: Preclinical Clinical and Translational Neuroscience

Code 3.5

Project title: Study in mice on the circuit mechanisms underlying socio-cognitive abilities relevant to psychiatric disorders.

ERC Field: LS5_2 Systems neuroscience and computational neuroscience

Key words: social behavior, cognition, genetics, circuits, calcium imaging, optogenetics, neurodevelopmental disorders.

Host Institution: Istituto Italiano di tecnologia

Reference person/supervisor: Francesco Papaleo, **francesco.papaleo@iit.it**

Research topic description

The research focuses on multidisciplinary research projects to investigate the neuromodulation and circuits involved in the expression and development of high-level socio-cognitive abilities in *in vivo* genetically modified models relevant to neurodevelopmental disorders (e.g. 22q11.2, 16p11.2, Williams syndrome etc.). To achieve this goal, we will employ a combined approach strictly linking advanced behavioral outputs (social tasks including emotion recognition, cooperation, altruism, hierarchy, social reward etc.) with cell- specific circuit-level manipulations using *in vivo* chemo- and opto-genetics, *in vivo* miniscopes, *in vivo* fiberphotometry, and *in vivo* electrophysiology. For reference to recent work, please see: Scheggia et al., *Nature Neuroscience* 2022; Mastrogiacomo et al., *Molecular Psychiatry* 2022; Scheggia et al., *Nature Neuroscience* 2020; Ferretti et al., *Current Biology* 2019; Scheggia et al., *Nature Communications* 2018.

Research team and environment

At IIT we work enthusiastically to develop human-centered Science and Technology to tackle some of the most pressing societal challenges of our times and transfer these technologies to the production system and society. Our Genoa headquarter is strictly inter-connected with our 11 centres around Italy and two outer-stations based in the US for a truly interdisciplinary experience.
You'd be working in a multicultural and multi-disciplinary group, where biologists, pharmacologists, psychologists, medical doctors, mathematicians and bioengineers collaborate, each with their own expertise, to carry out common research.
The Genetics of Cognition Research line is coordinated by Dr. Francesco Papaleo, who has extensive experience in the Neuroscience area.

Preferred Research Skills and Competences

Within the team, your main responsibilities will be:

- Design and analyze neuronal activity data from in vivo socio-cognitive behaviors
- Cell type and circuit specific recordings and manipulations during socio-cognitive tasks

WHAT WOULD MAKE YOU SHINE

- Strong experience in coding.
- Master degree in Neuroscience, Statistics, Bioengineering, Mathematics, Physics or comparable fields.
- Good spoken and written English

EXTRA AWESOME

- Experience on brain circuits manipulations.
- Good communication skills.
- Strong problem solving attitude.
- High motivation to learn.
- Spirit of innovation and creativity.
- Good in time and priority management.
- Ability to work in a challenging and international environment.
- Ability to work independently and collaborativel

Curriculum 3: Preclinical Clinical and Translational Neuroscience

Code 3.6

Project title: Studying sleep-like intrusion in the awake brain after focal cortical injury

ERC Field: LS5_2 Systems neuroscience and computational neuroscience

Key words: TMS**,** EEG, stroke, brain lesion, sleep, rehabilitation

Host Institution: Universityà degli Studi di Milano

Reference person/supervisor: Simone Sarasso **simone.sarasso@unimi.it**
Andrea Pigorini **andrea.pigorini@unimi.it**

Research topic description
This project aims to explore the presence of sleep-like cortical dynamics in awake patients with chronic focal and multifocal brain injuries. The research investigates the link between EEG slowing and the intrusion of sleep-like patterns within the injured brain region. The main methodology used is a combination of transcranial magnetic stimulation and electroencephalography (TMS/EEG) to assess cortical reactivity and identify distinct brain states (coma, sleep, wakefulness) coexisting within the same brain. Previous findings have already indicated that the occurrence of sleep-like TMS-evoked slow waves and transient suppressions of neuronal activity in the area surrounding focal cortical injuries are responsible for the disruption of network activity (Sarasso et al. , Brain 2020). Here we propose, by applying a longitudinal assessment of stroke patients, to study the potential reversibility of these sleep-like responses and their implications for the rehabilitation strategies.

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, scalp EEG, peripheral evoked potentials and Transcranial Magnetic Stimulation (TMS). The ideal candidate has a background of psychology / neurophysiology/ neurology/ neurorehabilitation and should be willing to work not only in the 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 3: Preclinical Clinical and Translational Neuroscience

Code 3.7

Project title: Experimental Investigation of cell- and network-level excitability, under physiological and pathological conditions.

ERC Field: LS5_1 Neural cell function, communication and signalling, neurotransmission in neuronal and/or glial cells; LS5_3 Neuronal development, plasticity and regeneration; LS5_2 Systems neuroscience and computational neuroscience (e.g. neural networks, neural modelling); LS5_7 Neurological disorders (e.g. neurodegenerative diseases, seizures)

Key words: Time-scales of excitability, Neurocircuitry, Electrophysiology, Human cortical tissue, *in vitro* models

Host Institution: Scuola Internazionale Superiore di Studi Avanzati

Reference person/supervisor: Michele GIUGLIANO **michele.giugliano@sissa.it**

Research topic description

The project focuses on fundamental and translational research on human cortical electrophysiology and on epilepsy. It leverages on experience of the hosting laboratory (i.e., with drug discovery; as well as with human brain slice electrophysiology), employing cellular and circuit-electrophysiology for the characterisation of dynamical response properties of cortical neurons. The project benefits from an existing infrastructure (i.e., an experimental SISSA lab, hosted on the premises of the ASUFC neurosurgery unit in Udine, near Trieste) funded by the Italian Ministry and the EC through a PNRR grant. Unlike existing drug screening methods and approaches, based on animal tissue models, the research concept and technological/data-analysis platform to be developed in this project will capture the complexity of neuronal circuits disorders and employ high-density microelectrode arrays (MEAs), optionally combined with single-cell intracellular electrophysiology. The ultimate vision includes *a)* fast delivery of results by routine tissue availability; *b)* pathophysiological marker preservation, for a time course sufficient to address patients' post-surgical symptoms; *c) a* proven transferability to different experimental settings.

In the long term, this project will make it possible to bring the bench closer to the bed, facilitating the transferability of the service to be delivered into a network of Italian (and European) neurosurgery hospitals, sharing expertise, knowledge, and a common societal mission. In such a network, each center will ideally adopt and run the optimized experimental protocols, electrophysiological analysis, and screening technological methods, and upload data into a cloud-based analysis pipeline. This will make the project result relevant for 1) improving quality of life of drug-resistant epileptic/BTRE patients in a clinical context, as well as for 2) biotech/pharma companies developing neurotherapeutics, benefitting of an innovative drug-screening service, truly recapitulating the human brain microenvironment.

Research team and environment

This project will be carried out at SISSA (www.sissa.it), Trieste, a world-recognized international research center, active in physics, mathematics and neurosciences. SISSA features a staff of 80 professors, 302 PhD students and over 200 post-docs and other researchers and with a yearly average of about 500 visiting scientists, carrying out all of its activity in English. SISSA is located at the north-easter border (with Slovenia) and it is known as the City of Science, given its tradition as a meeting hub for research, science and innovation, with one of the largest concentrations of scientific institutions in Italy.

The project will be supervised by GIUGLIANO, active in cellular and network electrophysiology, Neuroengineering, and Computational Neuroscience. His lab focuses on understanding the biophysical bases of information processing in cortical microcircuitry, on excitability, and collective emerging electrical activity arising from synaptic interactions. Over the last fifteen years, first in Belgium and later at SISSA - where he relocated his lab in 2020 - Giugliano and his collaborators advanced the study of neuronal cortical cell excitability, by *in vitro* electrophysiology and computer simulations. This involved the innovative design of experimental protocols, grounded in theoretical frameworks. Giugliano's lab unveiled a new functional class of pyramidal cells in the rat medial prelimbic cortex (Arsiero *et al.*, 2007), and was the first to measure the *dynamical* response properties of sensory cortical neurons, while quantifying experimentally their *bandwidth* (Koendgen *et al.*, 2008). Giugliano's team repeated the same experiments in L2/3 human cortical cells, obtained from resective neurosurgery (Testa-Silva *et al.*, 2014) and discovered an unexpectedly broader *bandwidth*, linked to species-

specific differences initiation of action potentials. Giugliano's team generalized these findings exploiting dynamic-clamp (Biro *et al.*, 2018). Giugliano and his collaborators demonstrated for the first time that human (stem-cell derived) pyramidal cells do reintegrate upon grafting into functional circuits (Espuny-Camacho *et al.*, 2013) and contributed to the design of models of dysfunctional cell connectivity *in a dish* (Peelaerts *et al.*, 2015). They investigated the emergence by Optogenetic stimulation of gamma-rhythms *in vitro* (Pulizzi *et al.*, 2016) and improved simulation techniques for stochastic ion channels *flickering*(Linaro *et al.*, 2011), remedying a 15 years ``vacuum". Giugliano also proposed a theory for the emergence of (a)symmetric connections across cortical areas (Vasilaki & Giugliano, 2014). The team consists of several post-doctoral fellows and PhD students, with diverse backgrounds including neurobiology, engineering, and physics. They all learn a common language, pushing the boundaries of interdisciplinary and multidisciplinary research in the Neurosciences. The lab is funded from the European Innovation Council as well as from the PNRR infrastructure funding and, in 2023 has launched and equipped a new lab on the premises of the Udine Hospital neurosurgery, turning SISSA and Giugliano's team one of the very few in Europe to have access to live human brain tissue slices, as an alternative biological preparation for performing fundamental and translational studies at the cell-, microcircuit-, and network-levels.
As a whole, the lab includes three dedicated setups for (intracellular) patch-clamp electrophysiology in brain tissue slices and dissociated cell cultures, four setups for (extracellular) multisite recordings by means of *in vitro* substrate-integrated MicroElectrode Arrays, and extensive access to standard tissue preparation and culture equipment, as well as to SISSA's facilities (i.e. 2-photon and confocal imaging, viral vector productions, high-performance computing) over extensive and world-class lab facilities.

Preferred Research Skills and Competences
The doctoral candidate will receive training in the techniques most commonly used in basic neuroscience, including brain tissue electrical activity recording, electrophysiology and data analysis. Pharmacological, optogenetic and computational approaches will be also experienced. Candidates with a strong background in life sciences, pharmacology, electrophysiology, bioengineering, physics, and mathematics are preferentially considered for this position.

Curriculum 3: Preclinical Clinical and Translational Neuroscience

Code 3.8

Project title: Epigenetic and immunological control of psychiatric disorders

ERC Field: LS5_8 Psychiatric disorders; LS2_5 Epigenetics and gene regulation; LS1_10 Molecular mechanisms of signalling pathways

Key words: gene x environment interactions; psychiatric disorders; epigenetic mechanisms; brain-immune system axis

Host Institution: University of Teramo

eference person/supervisor: Claudio D'Addario **cdaddario@unite.it**

Research topic description

A great deal of recent literature has supported the notion that the brain and the immune systems are connected in ways that only recently are attracting increasing interest. The main aim of this study will be to explore and understand how specifically the immune system influences the functioning of the brain focusing specifically on cellular and molecular pathways underpinning this crosstalk. Within this framework of investigations we will try to unveil, at preclinical and clinical level, how different environmental and living conditions might control the Gut Microbiome-Immune System-Brain Axis considering the key role played in this communication by epigenetic mechanisms. A classic example of this modulation is the well-known effects of stress on psychological well-being, immune response, microbial dysbiosis and potentially on the development of mental health problems. The availability of these results will be a stepping stone towards the design of novel therapeutic approaches that simultaneously control the brain and the immune response.

Research team and environment

The research team has a well-documented experience in the study of the mechanisms of genetic and epigenetic regulation of different key neurotransmitter systems in the predisposition to pathologies of the Central Nervous System using different techniques of biochemistry and molecular biology. The team consists of researchers, post-doctoral fellows and PhD students with backgrounds in biotechnology, pharmacology and physics. The research will be conducted in the Laboratory of Molecular Biology at the Department of Bioscience of the University of Teramo. There is access to several laboratories where the following equipment is available: Equipment QIAcube (Qiagen) for nucleic acids extraction; Thermo Scientific Scientific NanoDrop 2000 Spectrophotometer for the evaluation of macromolecules; ABI Prism7900 (Applied Biosystem) and Opticon Monitor2 (Biorad) for quantitative evaluation of genes expression and miRNAs; Pyromark Q24 and Q48 (QIAGEN) for SNPs and DNA methylation study; Enspire Alpha Plate Reader (PerkinElmer) for DNA/protein binding studies; CytoFlexFlow Cytometer (Beckman) to characterize cells of the immune system; Azure C300 Digital Imager for Western Blotting. The main laboratory space also contains shaking incubators, -80° and -20° freezers, as well as +4° refrigerators.
The program will foresee international mobility in collaboration with Karolinska Institutet, Sweden, and Roehampton University, UK.

Preferred Research Skills and Competences

The doctoral candidate will receive training in different molecular biology techniques Candidates with training backgrounds in life sciences and molecular genetics are preferentially considered for this position.

Curriculum 3: Preclinical Clinical and Translational Neuroscience

Code 3.9

Project title: Identification of the neuro-mediators and related pathways that regulate tendon regeneration.

ERC Field: LS5_3 Neuronal development, plasticity and regeneration; LS7_5 Applied gene and cell therapies, regenerative medicine; LS6_3 Regulation and effector functions of the immune response; LS9_3 Applied animal sciences

Key words: Tendon, Tissue Engineering, Neuro-mediators, Axon guidance, Immune system

Host Institution: University of Teramo

Reference person/supervisor: Valentina Russo e Barbara Barboni **vrusso@unite.it e bbarboni@unite.it**

Research topic description

The identification of the mechanisms that regulate tendon regeneration in an adult organism remain an essential objective in order to succeed in developing new and effective therapeutic approaches capable of providing a clinical solution to tendinopathies, a highly prevalent pathology that afflicts a tissue with a reduced spontaneous regeneration. The reduced regenerative capacity of an adult tendon seems to be attributable to its hypo-cellularity and rapid depletion of progenitor cells, which are probably responsible for the reduced effectiveness of currently available pharmacological or surgical treatments. In recent decades, it has been highlighted how the support systems (i.e. circulatory, lymphatic, immune and peripheral nervous systems) influence tissue regeneration. Recent evidences suggest a key role of the peripheral nervous system, which through specific neuro-mediators and their related pathways are capable of regulating the homeostatic mechanisms of the tendon district as well as intervening in the resolution of tendinopathies in an active dialogue with the immune system. The available data, although encouraging, are however fragmentary and incomplete to demonstrate how axon guidance and specific neuromediators are essential to control neo-vascularisation and/or proliferation and differentiation of different cell types involved in tendon tissue repair in the presence or absence of exogenous stem cells. It is therefore more essential than ever to fill this knowledge gap in order to codify the role of tendon innervation in regeneration and the related mechanisms in order to codify innovative therapeutic approaches based on the development of pharmaceuticals but at the same time on the mere use of tissue engineering approaches.

Research team and environment

This research project will be carried out in the Unit of Basic and Applied Biosciences, University of Teramo, Italy. The research unit main research field is focused on moving basic science evidences towards the translation in regenerative medicine and tissue engineering of musculoskeletal diseases. These are achieved by integrating advanced experience on molecular morphology, cell/tissue culture and molecular biology experimental labs. Its credibility to carry out *in vitro* and *ex vivo* experiments in this field of research is strengthened and documented by National (PRIN and PON R&I) and EU (H2020 MSCA-ITN-EJD and COFUND) projects' Coordination and participation ensuring thus to the PhD students belonging to the unit an international, interdisciplinary and intersectoral environment thus guaranteeing a training profile with a qualified dimension of excellence. The team consists of several researchers, post-doctoral fellows and PhD students with different backgrounds including stem cell biology, morphology, physiology, immunology, tissue engineering and regenerative medicine. Each doctoral student will experience one to one up to date research and techniques available in the Unit's facilities (e.g. molecular biology labs; cell culture labs; microscopy and morphometry center: time-lapse, confocal, TEM, SEM microscopes; tissue engineering lab, etc.). A 6 months secondment will be conducted in the Dept. of Molecular Medicine and Surgery of the Karolinska Institute (Sweden).

Preferred Research Skills and Competences

The doctoral candidate will receive training in the techniques that will allow to reach the proposed research topic, including molecular biology, cell culture, advanced morphology and data analysis. Candidates with training backgrounds in life sciences and molecular, cellular and tissue biology are preferentially considered for this position.

Curriculum 3: Preclinical Clinical and Translational Neuroscience

Code 3.10

Project title: Neural correlates of acute administration of intravenous ketamine in patients with pharmacoresistant depression

ERC Field: LS5_6 Neural bases of behaviour (e.g. sleep, consciousness, addiction); LS5_8 Psychiatric disorders (e.g. affective, anxiety disorders and psychiatric disorders).

Key words: Ketamine, depression; fMRI; EEG

Host Institution: University of Siena

Reference person/supervisor: Simone Rossi **simone.rossi@unisi.it**

Research topic description

In MDD subjects decision-making processes is particularly reduced and the prefrontal cortex will be studied. Indeed the prefrontal cortex with anterior cingulate cortex, amygdala and nucleus accumbens are involved and usually related to the emotional and attention-regulating circuits.. Dysfunctions in pathways including the orbitofrontal cortex, anterior cingulate

cortex, prefrontal cortex and hippocampal and parahippocampal regions appear to be related to the development of severe depressive phenomena. The cerebral perfusion and the different connectivity of the orbitofrontal cortex will be studied because related to emotions, apathy and loss of motivation. Hippocampus and amygdala, that are the center of emotional control, shows a profoundly altered activity in depression. The hippocampus seems to be atrophic in depressed subjects and many studies suggest morpho-volumetric (VBM) changes after ketamine treatment. The main goal pf the project is to demonstrate structural and functional cerebral changes in different timing during and after ketamine administration.

This study will explore oscillatory activity (EEG) hemodynamics, morfovolumetrics and connectivity brain changes, in patients who underwent short and long-time ketamine's treatment, by using multimodal MRI acquisitions and EEG. All of these data may be useful for understand how ketamine works in pathological condition, how the brain activity is modified during administrations of this drugs and which brain structures are involved after a long-time and short-time ketamine's treatment.

Research team and environment

This research project will be carried out at Siena Brain Investigation and Neuromodulation Lab (SiBIN Lab), in collaboration with with Psychiatry Unit chaired by Prof. Andrea Fagiolini and with the NiNT Unit (Dr. Lucia Monti) for neuroimaging investigations. Multimodal MRI acquisitions (ASL, VBM, IVIM, rs-fMRI and DTI) will be acquired, as well as 32-channel EEG.

Preferred Research Skills and Competences

The doctoral candidate will receive training in the techniques that will allow to reach the proposed research topic, including neuroimaging and neurophysiological investigations and data analysis. Candidates with training backgrounds in life sciences and biology are preferentially considered for this position.

Curriculum 3: Preclinical Clinical and Translational Neuroscience

Code 3.11

Project title: Evaluation of the EBV infection in Multiple sclerosis

ERC Field: LS5_7 Neurological disorders; LS6_4 Immunological mechanisms in disease (e.g. autoimmunity, allergy, transplantation immunology, tumor immunology); LS6_8 Infectious diseases in animals and plants

Keywords: Environment, EBV, genetics, multiple sclerosis

Host Institution: University of Cagliari

Reference person/supervisor: Eleonora Cocco **ecocco@unica.it**

Research topic description
This research proposal aims to understand the interplay between Epstein Barr Virus (EBV) and the host genetic background in multiple sclerosis (MS). The study will characterize with molecular techniques the human and viral genome (EBV virus) and the immune response (cellular B) in human samples (blood and CSF) from people with MS. Moreover, the effect of the disease-modifying drugs on B cells and EBV will be explored. The results will contribute to the understanding of the complex interaction between the environment and the human genome and will potentially open new possibilities for personalized therapy in MS.

Research team and environment
The PhD student will mainly collaborate with the team working in the Regional MS Center of Cagliari which represents one of the biggest clinical structures in Italy following people with MS. The team is fully dedicated to MS and is composed by 8 neurologists, 11 nurses, 2 neuro-physiopathology technicians, and 9 biologists. The MS Center has all the facilities to carry on the project. Moreover, the research will be developed in the University of Cagliari and partner institutions (University Roma, La Sapienza; University of Verona; the CNR; Italian National Institute of Health) and will foresee international mobility (active collaborations with Harvard University).

P**referred Research Skills and Competences**
The ideal candidate must have skills in molecular biology and should have a background in medicine/biology/immunology/genetics. The ideal candidate must be able to carry out his/her work in an attentive, autonomous, and highly cooperative manner.

Curriculum 3: Preclinical Clinical and Translational Neuroscience

Host University/Research Institution: University of Pisa

Code 3.12

ERC Field: SH4_3, SH4_5

Project title: Psycho-biological and psychometric correlates of the effects of meditative practices

Key words: slow breathing, pranayama, sensory processing, sleep, perception attention, decision making, emotions, sleep

Host Institution: Department of Surgical, Medical and Molecular Pathology and Critical Care Medicine, University of Pisa
Reference person/supervisor: Angelo Gemignani **angelo.gemignani@unipi.it**

Research topic description
Max 250 worlds

Approaches based on meditative practices have recently shown their influence in the psychological treatment of various psychopathological conditions and there is scientific evidence to suggest that some of the effects of meditative practices may be based on the synchronizing effect that slow breathing has on brain rhythms and activities mediated by olfactory bulb. On this basis, the project aims to study how simple and complex behaviours, from sensation, perception to decision making and emotion processing and regulation, can be altered by meditative practice and which psychophysiological correlates could sustain the putative behavioural changes. Also sleep functions as modified by meditative practice would be the object of investigation.

Research team and environment
Max 250 words

Research team will involve psychologists and bioengineering profiles. The PhD student could benefit from facilities resident at University of Pisa for the psychophysiological investigation in humans, from high-density EEG to high field MRI. Also perturbational approaches such as TMS/tDCS protocols could be implemented.

Preferred Research Skills and Competences
Max 100 words

Ideal profiles for the project should express expertise in cognitive neuroscience combined with fundamentals of biological signal analysis and modelling.

Curriculum 3: Preclinical Clinical and Translational Neuroscience

Code 3.13

Project title: Zebrafish exposure to endocrine disruptors and neurodevelopmental alterations

ERC Field: LS5_7 Neurological disorders; LS1_10 Molecular mechanisms of signaling pathways; LS2_15 Systems biology

Key words: neurodevelopmental disorders; zebrafish model; endocrine disruptors; social behavior; molecular mechanisms

Host Institution: University of Teramo

Reference person/supervisor: Monia Perugini, Sabrina Tait **mperugini@unite.it** **sabrina.tait@iss.it**

Research topic description

Neurodevelopmental disorders (NDDs) caused by aberrant brain growth and development are life-long, debilitating illnesses that markedly impair the quality of life. Zebrafish model is a useful organism for studying NDD, possessing both high physiological homology to humans and sensitivity to pharmacological and genetic manipulations. Several animal and human epidemiological studies demonstrated a causal link between exposure to Endocrine disrupting chemicals (EDCs) during embryonic/early life, and neurological impairments. Understanding and identifying of the modes of action of EDCs and their associated impacts on tissue development and function will be performed using the zebrafish model, in particular early life stages, and will help to understand the EDCs main molecular targets, NDDs pathogenesis and neurobehavioral development. Specific molecular biomarkers at gene and protein expression level will be analysed at Istituto Superiore di Sanità, with a special focus on sex-specific adverse effects. The project will involve the use of an in vivo model, the zebrafish (Danio rerio).

Research team and environment

The research will be developed in the Unit of Pharmacology and Toxicology, University of Teramo and partner institution, the Istituto Superiore di Sanita (ISS), and will foresee international mobility (active collaborations with UFZ, Helmholtz, Center for Environmental research, Leipzig, Germany). The research group consists of researchers, post-doctoral fellows and PhD students with backgrounds in biotechnology, molecular science, pharmacology and toxicology. This multidisciplinary team ensures the complementarity of the expertise. The research team has a well- documented experience in the study of the endocrine disruptors using in vitro and in vivo models and the PhD student will use instruments and techniques available in the Unit's facilities. The PhD student will have access to the laboratories equipped with microscopes (time-lapse, confocal, TEM, SEM microscopes) and instruments for genomic and proteomic advanced studies and will have access to the University Zebrafish Facility.

Preferred Research Skills and Competences

The doctoral candidate will receive training in the techniques most commonly used in molecular biology including omics approaches, behavioral testing and data analysis. Candidates with training backgrounds in life sciences and zebrafish model are preferentially considered for this position.

Curriculum 3: Preclinical Clinical and Translational Neuroscience

Code 3.14

Project title: Predictive factors of cognitive decline in patients with minor neurocognitive disorder

ERC Field: LS5_7 Neurological disorders - LS5_2 Systems neuroscience and computational neuroscience (e.g. neural networks, neural modelling) - LS5_6 Neural bases of behaviour (e.g. sleep, consciousness, addiction) - LS5_9 Neural basis of cognition - SH4_2 Personality and social cognition; emotion - SH4_4 Neuropsychology - SH4_5 Attention, perception, action, consciousness

Key words: Mild Cognitive Impairment, Dementia, Minor Neurocognitive Disorder, Alzheimer's Disease, Frontotemporal dementia, cognitive reserve

Host Institution: University of Modena and Reggio Emilia

Reference person/supervisor: Giovanna Zamboni, **Giovanna.zamboni@unimore.it**

Research topic description: Minor neurocognitive disorder (also indicated as Mild Cognitive Impairment, MCI) is a clinical condition that captures the stage between normal aging and dementia along the continuum of different phases of cognitive impairment. It has become the focus of increasing scientific interest aimed at the understanding of which factors contribute to its worsening and progression to dementia due to neurodegenerative diseases such as Alzheimer's Disease (AD) and frontotemporal dementia. Studies have mainly focused on clinical and imaging predictive factors of conversion to AD. The present project will add on the known predictive factors of cognitive decline by also modelling and integrating information related to brain functioning (as well as several other proxies of cognitive reserve) and biomarker status. It will also focus on predictive factors of the different clinical presentations of neurodegenerative diseases (including atypical presentations of AD and different variants of primary progressive aphasia)

The project will involve the collection and analysis of clinical data from an ongoing longitudinal study on a rich clinical court of subjects with a diagnosis of MCI. These include longitudinal neuropsychological assessments, questionnaires on lifetime habits and activities, multimodal Magnetic Resonance Imaging (MRI) including resting functional MRI, blood and cerebrospinal fluid biomarkers.

Research team and environment

The research will be developed in the Cognitive Neurology and Neuroimaging Centre of the Department of Biomedical Metabolic and Neural Sciences of the University of Modena and Reggio Emilia led by Giovanna Zamboni and will foresee international mobility (active collaborations with University of Oxford, UK, and Northwestern University Chicago, Illinois). The research group consists of researchers, post-doctoral fellows and PhD students with backgrounds in neurology, psychology, mathematics and physics. This multidisciplinary team ensures the complementarity of the expertise. The research team has a well-documented experience in the analysis of multimodal imaging data including functional MRI as well as in clinical neurosciences and neuropsychology. Professor Zamboni has been recently awarded a grant from the European Research Council for a parallel study on AD. The PhD student will have access to the 3 Tesla scanner of Azienda Ospedaliero Universitaria di Modena, which has established sessions for dedicated use for research purposes. The PhD student will also directly collaborate with the clinical team of the Cognitive Neurology Clinic of the same hospital.

Preferred Research Skills and Competences

Candidates with the following skills/backgrounds are encouraged to apply:

- imaging processing skill; computing and data analysis background (to develop and validate algorithms for combination of multimodality MRI and extraction of quantitative single-subject information); degree in medicine or psychology, with a training in neurology or neuropsychology; demonstrated research activity and/or degree dissertation in neuroimaging, neuropsychology, neurodegenerative diseases

Curriculum 3: Preclinical Clinical and Translational Neuroscience

Code 3.15

ERC Field: LS7_3 Pharmacology, pharmacogenomics, drug discovery and design, drug therapy

Project title: Pre- and post-synaptic mechanisms in the pathogenesis and treatment of neuropsychiatric diseases

Key words: Multiple Sclerosis, Cannabinoids, Glia, Myelin, neuroinflammation

Host Institution: Dept. of Neuroscience, School of Medicine, University of Naples Federico II

Reference person/supervisor: Prof. Francesca Boscia **boscia@unina.it**

Research topic description (Max 250 words)
The project will explore the potential mechanisms underlying the neuroprotective and inflammation-resolution actions of endocannabinoids and the pharmacological strategies to enhance endocannabinoid-mediated effects. Specific interest will be dedicated to inflammatory brain diseases, including multiple sclerosis. The approach will involve multiple experimental approaches, including in vitro explant cultures and in vivo disease models; possible translational approaches with validation in samples from healthy and diseased individuals will also be exploited.

Research team and environment (Max 250 words)
Our group has a long-standing tradition in the study of the pathophysiological role of the molecular mechanisms involved in neuropsychiatric diseases, and in exploiting this role for pharmacological intervention. The overall team of the Section of Pharmacology is composed of several independent Principal Investigators with specific interests in acquired brain ischemia, channelopathies responsible for genetic epilepsies, Alzheimer Disease, Parkinson Disease, multiple sclerosis, amyotrophic lateral sclerosis, among others. Technical approaches and methodologies range from molecular biology, biochemistry, electrophysiology, and microfluorimetry to advanced cellular (including IPSCs-derived neurons) and animal models.
Relevant publications: 1. Cammarota M, et al. Br J Pharmacol. 2023 May;180(10):1316-1338. doi: 10.1111/bph.16014. Epub 2023 Jan 6. PMID: 36526591.; 2. Magli E, et al. J Med Chem. 2021 Dec 23;64(24):17901-17919; 3. Gonati D, et al. J Med Chem. 2021 Jun 24;64(12):8333-8353; 4. Ostacolo C, et al. J Med Chem. 2020 Jan 9;63(1):163-185; 5. de Rosa V, et al. EMBO Mol Med. 2019 Jan;11(1):e9278.

Preferred Research Skills and Competences (Max 100 words)
The Candidate must have a solid background in physiology, pathophysiology and pharmacology; pre- or post-master experience of at least 12 months in a research lab is preferred. Familiarity with cellular and/or molecular biology techniques is also highly desired. A sincere interest in setting the basis for a career in neuroscience research is a must, with good English reading and comprehension abilities, attitude to teamwork, and willingness to learn novel techniques in stimulating environments. Both national and international collaborations will allow the candidate to spend periods in other labs.

Curriculum 3: Preclinical Clinical and Translational Neuroscience

Code 3.16

ERC Field: LS7_3 Pharmacology, pharmacogenomics, drug discovery and design, drug therapy

Project title: Investigating the role of ion transport in the CNS during degenerative, inflammatory and genetic brain diseases

Key words: Epilepsy, Alzheimer Disease, Potassium channels, Neuroprotection

Host Institution: Dept. of Neuroscience, School of Medicine, University of Naples Federico II

Reference person/supervisor: Prof. Anna Pannaccione **pannacio@unina.it**

Research topic description (Max 250 words)
The project will explore the potential role of ion channels and transporters in the pathogenesis and progression of disease conditions characterized by neuronal hyperexcitability. Specific interest will be dedicated to epilepsy (both acquired and genetic) and aging-related neurodegeneration, including Alzheimer disease. The approach will involve multiple experimental approaches, including in vitro cell cultures and in vivo disease models; possible translational approaches with validation in samples from healthy and diseased individuals will also be exploited.

Research team and environment (Max 250 words)
Our group has a long-standing tradition in the study of the pathophysiological role of the molecular mechanisms involved in neuropsychiatric diseases, and in exploiting this role for pharmacological intervention. The overall team of the Section of Pharmacology is composed of several independent Principal Investigators with specific interests in acquired brain ischemia, channelopathies responsible for genetic epilepsies, Alzheimer Disease, Parkinson Disease, multiple sclerosis, amyotrophic lateral sclerosis, among others. Technical approaches and methodologies range from molecular biology, biochemistry, electrophysiology, and microfluorimetry to advanced cellular (including IPSCs-derived neurons) and animal models.
Relevant publications: 1. Piccialli I, et al. Cells. 2022 Sep 9;11(18):2820. doi: 10.3390/cells11182820. PMID: 36139395; PMCID: PMC9497218.; 2. Magli E, et al. J Med Chem. 2021 Dec 23;64(24):17901-17919; 3. Gonati D, et al. J Med Chem. 2021 Jun 24;64(12):8333-8353; 4. Ostacolo C, et al. J Med Chem. 2020 Jan 9;63(1):163-185; 5. de Rosa V, et al. EMBO Mol Med. 2019 Jan;11(1):e9278.

Preferred Research Skills and Competences (Max 100 words)
The Candidate must have a solid background in physiology, pathophysiology and pharmacology; pre- or post-master experience of at least 12 months in a research lab is preferred. Familiarity with cellular and/or molecular biology techniques is also highly desired. A sincere interest in setting the basis for a career in neuroscience research is a must, with good English reading and comprehension abilities, attitude to teamwork, and willingness to learn novel techniques in stimulating environments. Both national and international collaborations will allow the candidate to spend periods in other labs.

Curriculum 3: Preclinical Clinical and Translational Neuroscience

Code 3.17

Project title: Linking inflammation to synapse loss and neurodegeneration in innovative models of Parkinson's disease

ERC Field: LS7_3 Pharmacology, pharmacogenomics, drug discovery and design, drug therapy; LS5_3 Neurochemistry and neuropharmacology;

Key words: Neurodegeneration, Synapse, Pharmacology, Glutamate, Striatum.

Host Institution: University of Milano

Reference person/supervisor: Monica Di Luca **monica.diluca@unimi.it**

Research topic description

Parkinson's Disease (PD) is the second most common neurodegenerative disorder. Multiple mechanisms contribute to PD pathogenesis with a clear involvement of inflammatory events, oxidative stress and mitochondria dysfunctions in disease progression. In addition, accumulating evidence demonstrated that misfolded proteins and inclusions contribute to the pathology of familial and sporadic PD. Alpha-synuclein (α-syn) is the main component of these inclusions.

Inflammation is a key factor in the initiation and propagation of α-syn aggregates and the contribution of microglial activation to α-syn pathology has been put forward. In particular, the Nrf2 pathway has been shown to interact with α-syn. Accordingly, recently published data show an increase of Nrf2 in PBMCs of PD patients, paralleled by an elevation of α-syn.

Our group will use *state-of-the-art* α-syn mice model allowing for a careful evaluation of the toxic effects induced by α-syn preformed fibrils (α-syn-PFFs) from early to late stages of disease. A combination of confocal imaging, biochemistry, molecular biology and behavioral assays will be used for the analysis of the progression of the disease and to evaluate the efficacy of a NRF2 activator, i.e. dimethyl fumarate (DMF), to counteract α-syn-mediated toxicity.

Research team and environment

This research project will be carried out in the Department of Pharmacological and Biomolecular Sciences (DiSFeB), University of Milano, Italy. The laboratory of Pharmacology of Neurodegeneration headed by Prof. Monica Di Luca and Prof. Fabrizio Gardoni is focused on the identification and characterization of the molecular mechanisms leading to failure of the glutamatergic synapse in the pathogenesis of neurodegenerative disorders. The outcomes of these studies provide the basis for designing new therapeutic strategies, which specifically target the dysfunction of the complex network of proteins forming the glutamatergic synapse.

The DiSFeB is among the best Italian departments from the Italian "Ministry of Education, University and Research" with a top-up grant for 2018-2022 and 2023-2027 to support the purchase of up-to-date instruments, the implementation of existing facilities and the reinforcement of educational and training activities. The DiSFeB combines multidisciplinary approaches in Pharmacology, Endocrinology, Pathophysiology and Applied Biology and hosts the Centre of Excellence on Neurodegenerative Diseases, making this department a leading centre for research on neurodegenerative diseases in Italy. Several facilities and a large set of equipment are available including a newly refurbished and fully equipped animal facility with behavior rooms, in vivo imaging apparatus for small laboratory animals, imaging facility (including two-photon confocal microscopy for imaging in live animals, confocal imaging microscopes with SIM and AiryScan super-resolution live imaging and FLIM for live imaging analysis of protein-protein interactions), Sehorse XFe24 for metabolic analysis, the MiniSeq System and the NextSeq 550 System, cell sorter (BD FACSMelodyTM), laser capture microdissector, facility for data processing and storage, EchoMRI, NMR laboratory, the Mass spectrometry laboratory, facilities for cellular and bacterial culture, laboratory for lentivirus and adenovirus production/purification, facility for culturing hiPSCs, microarray platform, flow cytometry, Real-Time PCR, ultracentrifuges, ChemiDoc System. The laboratory of Pharmacology of Neurodegeneration brings together biochemistry, cell biology, static and dynamic imaging, in vitro and in vivo approaches, behavioral competences, allowing mukltilevel levels.

Preferred Research Skills and Competences

The doctoral candidate will receive training in the techniques most commonly used in basic and translational neuroscience, including mice surgery, confocal imaging, main biochemical and molecular biology techniques,

behavioural testing and data analysis. Pharmacological and in vivo imaging (i.e. miniscope, fiber photometry) approaches will be also experienced. Candidates with training backgrounds in life sciences, behavioral pharmacology, and pharmaceutical sciences are preferentially considered for this position.

Curriculum 3: Preclinical Clinical and Translational Neuroscience

Code: 3.18

Project title: Sleep enhancement in neurodegenerative diseases.

ERC Field: LS5_7 Neurological disorders (e.g., neurodegenerative diseases, seizures); LS5_6 Neural bases of behavior (e.g., sleep, consciousness, addiction); LS5_1 Neural cell function, communication and signaling, neurotransmission in neuronal and/or glial cells.

Key words: Tauopathies, Neuropathology, Closed-Loop brain stimulation, Electrophysiology, Molecular biology, In vivo models.

Host Institution: University of Camerino – Brain and Sleep Research Laboratory

Reference person/supervisor: Michele Bellesi **michele.bellesi@unicam.it**

Project description

Tauopathies are a broad range of neurodegenerative diseases including Alzheimer's and other diseases. They are characterized by the pathological aggregation of tau protein within brain cells and its spreading to other brain cells. Recent research demonstrated that loss of sleep favors pathological accumulation and spreading of tau-protein. This implies that sleep may exert a protective role from the development of tauopathies or in preventing their progression.

The goal of this PhD project is to understand whether we can slow down tau protein accumulation and spreading by enhancing sleep. Recent research demonstrated that rocking or playing tones while one is asleep can boost the intensity of sleep in both humans and rodents. In this project we will apply these approaches to a mouse model of tauopathy, in which we will evaluate the extent of tau accumulation and spreading using microscopy and molecular biology methods, and consequent behavioral deficits. This research will help clarify why sleep is good for our health and whether more intense sleep can reduce the accumulation and spreading of tau protein. This research may lead to the development and use of alternative approaches to treat neurodegenerative diseases based on improved sleep, such as "smart rocking beds" or "wearable audio-headbands" that take advantage of sensory stimulation during sleep to increase efficacy of sleep.

Research team and environment

The lab aims at understanding the functions and mechanisms of sleep in health and disease. Our research combines morphological and functional methods of analysis in both animals and humans to investigate why sleep is beneficial for the brain at the molecular, circuit and behavioral level.

One line of research aims to address the consequences of sleep impairment across the lifecycle and to characterize the interaction between sleep disruption and other environmental and genetic factors. Another research topic focuses on the therapeutic potential of sleep enhancement to improve health and cognition at different levels. The lab explores also scientific questions linking sleep to glial cells, gut microbiome, cellular metabolism, adipose tissue, torpor, etc., thanks to the collaboration with other research groups within the University of Camerino and outside. Relevant publications and key interests of the research group can be found at **https://www.bsr-laboratory.org/**

The supervisor is neurologist and neuroscientist with experience in experimental neuroscience. The research group includes post-doctoral fellows, PhD students, and trainees with different backgrounds including neuroscience, biology, engineering, and physics.

Facilities available include: 1500m^2 vivarium fully equipped for rodent breeding, maintenance and behavioral testing (Ethovision and multiple test apparata), 40 operating chambers, surgery rooms, 2 Open Ephys acquisition boxes for in vivo electrophysiology recordings, 1 miniaturized microscope (Inscopix nVoke), 14 sleep deprivation chambers; equipped histology labs, wet labs with all basic molecular biology and biochemistry equipment including HPLC, plate reader Tecan and multiplex Luminex; equipment for single-cells sorting and transcriptomics; Nikon confocal microscope, Zeiss Axio Imager fluorescent microscope, STEM electron microscope Zeiss with Zen connect for CLEM.

Preferred Research Skills and Competences

The ideal candidate has a genuine interest for neuroscience and sleep research, a proactive attitude in studying relevant literature, formulate plausible hypothesis and experiments to test them. Self-motivation and ability to work both alone and in team are essential characteristics. Background in neurophysiology and molecular biology is desirable. An interest in assembling circuits and other electronic components (e.g., Arduino), and basic knowledge of Matlab or Python could be of advantage.

Curriculum 3: Preclinical Clinical and Translational Neuroscience

Code: 3.19

Project title: Biological mechanisms linking synaptic plasticity and sleep in health and disease.

ERC Field: LS5_6 Neural bases of behavior (e.g., sleep, consciousness, addiction); LS5_1 Neural cell function, communication and signaling, neurotransmission in neuronal and/or glial cells. LS5_5 Neural bases of cognitive processes (e.g., memory, learning, attention).

Key words: Sleep homeostasis, Neuroanatomy, Calcium imaging, Molecular biology, In vivo models of psychiatric disorders.

Host Institution: University of Camerino – Brain and Sleep Research Laboratory

Reference person/supervisor: Luisa De Vivo **luisa.devivo@unicam.it**

Project description

Sleep is a universal behavior important to ensure correct brain functioning and adaptation to a continuously changing environment. Synaptic potentiation and weakening occur across the sleep-wake cycle in different ways depending on the brain region, are essential for many cognitive functions (e.g., learning, emotion regulation, and motivated behavior), and are altered in several neuropsychiatric disorders.

The aim of this project is to map the link between sleep, synaptic plasticity, and neuropsychiatric disorders by probing the molecular, ultrastructural, and functional changes occurring across the sleep/wake cycle in health and disease. To this aim, the candidate will measure synaptic plasticity using light and electron microscopy, calcium imaging, and single-cell omics techniques in healthy animals and in preclinical models of neuropsychiatric disorders. The candidates will be also trained to carry out chronic polysomnography, in vivo electrophysiology, and behavioral testing.

Research team and environment

The lab aims at understanding the functions and mechanisms of sleep in health and disease. Our research combines morphological and functional methods of analysis in both animals and humans to investigate why sleep is beneficial for the brain at the molecular, circuit and behavioral level.

One line of research aims to address the consequences of sleep impairment across the lifecycle and to characterize the interaction between sleep disruption and other environmental and genetic factors. Another research topic focuses on the therapeutic potential of sleep enhancement to improve health and cognition at different levels. The lab explores also scientific questions linking sleep to glial cells, gut microbiome, cellular metabolism, adipose tissue, torpor, etc., thanks to the collaboration with other research groups within the University of Camerino and outside. Relevant publications and key interests of the research group can be found at **https://www.bsr-laboratory.org/**

The supervisor is a neuroscientist with experience in microscopy, in-vivo imaging, and electrophysiology. The research group includes post-doctoral fellows, PhD students, and trainees with different backgrounds including neuroscience, biology, engineering, and physics.

Facilities available include: 1500m^2 vivarium fully equipped for rodent breeding, maintenance and behavioral testing (Ethovision and multiple test apparata), 40 operating chambers, surgery rooms, 2 Open Ephys acquisition

boxes for in vivo electrophysiology recordings, 1 miniaturized microscope (Inscopix nVoke), 14 sleep deprivation chambers; equipped histology labs, wet labs with all basic molecular biology and biochemistry equipment including HPLC, plate reader Tecan and multiplex Luminex; equipment for single-cells sorting and transcriptomics; Nikon confocal microscope, Zeiss Axio Imager fluorescent microscope, STEM electron microscope Zeiss with Zen connect for CLEM.

Preferred Research Skills and Competences

The ideal candidate has a genuine passion for neuroscience and sleep research, a proactive attitude in studying relevant literature, formulate plausible hypothesis and experiments to test them. Self-motivation, curiosity, and ability to work both alone and in team are essential characteristics. Background in neurophysiology, interest in learning microscopy techniques, and a propensity to care for details are desirable.

Curriculum 3: Preclinical Clinical and Translational Neuroscience

Code 3.20

Project title: Drug delivery in gliobrastoma

ERC Field: LS7_3 Pharmacology, pharmacogenomics, drug discovery and design, drug therapy; LS5_3 Neurochemistry and neuropharmacology.

Key words: Neuro-oncology; glioblastoma; neuroinflammation.

Host Institution: University of Messina

Reference person/supervisor: Emanuela Esposito **eesposito@unime.it**

Research topic description

Research team and environment

This research project will be carried out in the Department of Chemical, Biological, Pharmaceutical, and Environmental Sciences (ChiBioFarAm), University of Messina, Italy. The laboratory of Neuropharmacology of ChiBioFarAm headed by Prof. Salvatore Cuzzocrea and Prof.ssa Emanuela Esposito is focused on the identification and characterization of the molecular mechanisms underlining the pathogenesis of neurooncological pathologies such as glioblastoma. The outcomes of these studies provide the basis for the validation of new therapeutic approaches, which specifically target tumor microenvironment by modulating inflammation, apoptosis, and angiogenesis.

The Research team will consist of: 3 Full/Assistant Professors, 3 Researchers, 2 Post-Doctoral researchers and 6 PhD students. The inclusive nature of this research team, each with their own skills, responsibilities and their own research sectors, will concur to move towards neuronal research investigations to promoting the research topic. The Research program will be located at the University of Messina (UniME). UniME is constituted of 12 Departments, one of each is the Department of Chemical, Biological, Pharmaceutical and Environmental Sciences, located in Viale Ferdinando Stagno D'alcontres 98166 Messina. This Department is constituted by laboratories for cell cultures, laboratories for histology and molecular biology analysis and one Animal house. The Laboratories at the Department of Chemical, Biological, Pharmaceutical and Environmental Science, University of Messina, in which PhD student will be perform its research project are fully equipped with cell culture room areas with laminar flux hoods, incubator, optical microscope with digital cameras, stereoscopy microscope, cryo-biological storage system, spectrophotometer, apparatus for protein/DNA electrophoresis, real time and RT-PCR apparatus for plate development and reader, magnetic stirrer, sonicator, thermostatic bath, chemical hood, refrigerated bench centrifuge, mini see-saw rocker, bath for histology, security cabinets, balance, pH-meter, distillatory, stove for paraffin, microtome. Moreover, an animal house connected to a treatment area for general treatment in conscious or anaesthetized animals and surgical facility available for *in vivo* experiments. The office space for PhD students will be fully equipped with a desk, pc and printer to analyze data, presentation of reports and research results and write papers.

Preferred Research Skills and Competences

The doctoral candidate will receive training in the techniques most commonly used in basic and translational neuroscience and neuro-oncology, including in vitro and in vivo methodological approaches, confocal imaging, main biochemical and molecular biology techniques, histological procedures, behavioral testing and data analysis. Pharmacological and in vivo imaging (i.e. miniscope, fiber photometry) approaches will be also experienced. Candidates with training backgrounds in behavioral pharmacology, pharmaceutical sciences, and molecular biology are preferentially considered for this position.

The program of this curriculum will focus on the need to facilitate the translation of neuroscientific knowledge from laboratory to clinic. Therefore, PhD students will acquire the experience to bridge the gap between the design, execution and interpretation of preclinical experiments and experimental medicine in neuro-oncological clinical settings, with a focus on preventive therapies and pharmacological development.

Curriculum 3: Preclinical Clinical and Translational Neuroscience

Code 3.21

ERC Field: LS_5, LS_7 Life Sciences

Project title: Neural substrates of neuropsychiatric diseases

Key words: brain diseases, neurotechnologies, advanced therapies

Host Institution: University of Ferrara

Reference person/supervisor: Silvia Zucchini **silvia.zucchini@unife.it**

Research topic description

The primary objective is to identify the intricate neurobiological mechanisms underlying neurological and psychiatric diseases, while concurrently devising innovative strategies for their effective management and rehabilitation. These innovative approaches encompass advanced therapies, specifically gene and cell therapy, with a focus on restoring essential physiological interactions and communication functions. To achieve these goals, an array of innovative methodologies will be employed, ranging from alternative research techniques to comprehensive data analysis spanning from molecular investigations to cutting-edge neuroimaging technologies. Last but not least, ethical and foundational implications will be investigated in order to identify and address the ethical issues connected to the development of the newly developed treatment technologies.

Research team and environment

The team includes a group of researchers of the University of Ferrara, expert in different, complementary fields of neuroscience, from physiology to pharmacology, from molecular biology to clinical neuroscience. The research group includes a full professor, some tenure-track researchers, post-doctoral fellows, PhD students, and trainees with different backgrounds including medicine, neuroscience, biology, and. medicinal chemistry. Facilities available include modern equipment for cell and molecular biology, as well as immunohistochemical/immunofluorescence analyses. In addition, a state-of-the-art animal facility (LARP) provides researchers with a set of expertise, services, infrastructure, and technologically advanced equipment that facilitate the study of biological processes, in different biomedical fields: basic research for understanding physiological and pathological mechanisms and preclinical research for developing advanced diagnostic and therapeutic strategies. In addition, LARP features cutting-edge imaging systems, such as bioluminescence/fluorescence imaging and single-photon emission computed tomography/positron emission tomography computed tomography (SPECT/PET CT) scanning. These advanced imaging modalities allow researchers to visualize molecular and cellular processes within the brain, providing valuable insights into disease mechanisms and treatment responses.

Preferred Research Skills and Competences

The optimal candidate should have a background in biology, medicinal chemistry and/or medicine, with experience in laboratory work, possibly both in vitro and in vivo models of disease.

Curriculum 4: Computational Neuroscience

Code 4.1

Project title: Personalized mapping of structural, functional and effective connectivity in humans

ERC Field: LS5_2 Systems neuroscience and computational neuroscience

Key words: Connectivity, intracranial EEG, MRI, DTI

Host Institution: Università degli Studi di Milano

Reference person/supervisor: Andrea Pigorini; **andrea.pigorini@unimi.it**

Research topic description
This research proposal aims to capitalize on the extensive collection of intracerebral data obtained from patients undergoing presurgical evaluation. With a rich database encompassing over 200 subjects, the study seeks to develop a personalized mapping framework that comprehensively characterizes the structural, functional, and effective connectivity in the human brain. By employing advanced neuroimaging techniques and data-driven analytical approaches, this research will uncover individualized patterns of brain connectivity and their associations with cognitive function, behavior, and neurological disorders. The findings will contribute to enhancing presurgical planning and potentially enable personalized interventions and treatments for patients in the future.

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.

Curriculum 4: Computational 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.

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 Neuroscience

Code 4.3

Project title: "Multifunctional, adaptive and Interactive AI systems for acting in multiple contexts: a machine learning approach from neural data"

ERC Field: LS5_5 Neural networks and plasticity
LS5_9 Neural basis of cognition
LS5_16 Systems and computational neuroscience

Key words: neural networks, neural data decoding, deep learning, parietal cortex

Host Institution: Università degli Studi di Bologna

Reference person/supervisor: Patrizia Fattori, **patrizia.fattori@unibo.it**

Research topic description
The complex neural discharges hosted in the parietal cortex require a computational approach to be fully understood and exploited for brain-computer interfaces. Advanced computational techniques are becoming critically important in this field of neurophysiology. In particular, algorithms based on deep learning, also exploiting high-performance computing resources, appear to be the most promising tools. However, while such techniques have already found widespread use in different research sectors, their adoption in neuroscience is an emerging trend that only very recently has started rising the interest in the research community. The goal of this project is to develop interdisciplinary research activities, focusing on the adoption of deep learning techniques for the analysis of brain activity.
The research will be undertaken in Bologna, and will foresee international mobility, also with partners of ongoing European projects.

Research team and environment
The PhD student will carry out his/her studies in a highly interdisciplinary context, with the support of UNIBO neuroscientists who are already active in the field of neuroscience and brain physiology. The team has also experience in the use of deep learning techniques for the study of neural discharges in parietal cortex.

Preferred Research Skills and Competences
The ideal candidate has computational and programming skills (ideally, knowledge of python and Matlab) and a background in biomedical sceinces/engineering / physics /math. The ideal candidate must be able to carry out his/her work in a diligent, independent, and highly collaborative manner.

Curriculum 4: Computational Neuroscience

Code 4.4

Project title: Deep learning for the analysis of calcium fluorescence-based brain activity images

ERC Field: LS5_2 Systems neuroscience and computational neuroscience

Key words: deep learning, brain activity imaging

Host Institution: Università degli Studi di Camerino

Reference person/supervisor: Sebastiano Pilati; sebastiano.pilati@unicam.it

Research topic description
Calcium fluorescence-based imaging of brain activity is one of the most promising techniques in neuroscience. It allows seeing complex networks of neuronal activations, which can then be correlated with reactions and behaviors of the individual and with the effect of drugs. This analysis requires extracting hidden correlations from enormous amounts of data. For this reason, advanced computational techniques are becoming critically important. In particular, algorithms based on deep learning, also exploiting high-performance computing resources, appear to be the most promising tools. However, while such techniques have already found widespread use in different research sectors, especially in the study of complex physical systems such as quantum matter and spin glasses, their adoption in neuroscience is an emerging trend that only very recently has started gathering momentum. The goal of this project is to develop interdisciplinary research activities at the interface between neuroscience and physics, focusing on the adoption of deep learning techniques for the analysis of brain activity.

Research team and environment
The PhD student will carry out his/her studies in a highly interdisciplinary context, with the support of Unicam neuroscientists and physicists who, one the one hand, are already active in the field of neuroscience and brain functioning and, on the other hand, have experience in the use of deep learning techniques for the study of complex physical systems. The research groups involved will be the Quantum Matter group at the Physics Section of UniCam, in particular professors Sebastiano Pilati and Andrea Perali, with the strong collaboration of the researcher group led by Prof. R. Ciccocioppo at the School of Pharmaceutical and Product Sciences of health.

Preferred Research Skills and Competences
The ideal candidate has computational and programming skills (ideally, knowledge of python) and 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.

Curriculum 4: Computational Neuroscience

Code 4.5

Project title: Functional modeling of brain dynamics: investigation of cognitive functions through the lens of dynamical systems.

ERC Field: PE6_11 Machine learning, statistical data processing and applications using signal processing; PE6_12 Scientific computing, simulation and modeling tools; LS5_9 Neural basis of cognition; LS5_16 Systems and computational neuroscience; LS5_18 Innovative methods and tools for neuroscience.

Key words: neural coding, neuronal manifolds, modeling, dynamical system reconstruction, RNN, statistical mechanics

Host Institution: Sant'Anna School of Advanced Studies, BioRobotics Institute

Reference person/supervisor: Russo Eleonora; **eleonora.russo@santannapisa.it**

Research topic description

Understanding the dynamical system governing neuronal activity is crucial for unraveling how the brain performs cognitive functions. Historically, various forms of recurrent neural networks (RNNs) have been suggested as simplified models of the cortex. Recently, owing to remarkable advancements in the field of machine learning, RNNs' inherent ability to capture temporal dependencies has been leveraged to develop tools for approximating unknown dynamical systems directly by training on observed time-series data. Concurrently, improvements in electrophysiological recording techniques have enabled the simultaneous recording of hundreds of neurons in animals performing complex behavioral tasks. These parallel developments present a unique opportunity to characterize comprehensively population dynamics and parametrize the neuronal manifold, thereby constructing functional models of cognitive functions. The objective of this research project is to further refine RNN-based algorithms, tailoring them to investigate neuronal dynamics, and applying them to experimental data.

Research team and environment

The PhD student will carry out his/her studies at the BioRobotics Institute of Sant'Anna School of Advanced Studies. The project will expose the student to a highly interdisciplinary context, in tight collaboration with theoretical and experimental neuroscientists. At the BioRobotics Institute, the research groups involved will be the Brain Dynamics Lab, the Computational Neuroengineering Lab and the Bioelectronics and Bioengineering Area. During the second year of the PhD, the student might be able to spend a period abroad.

Preferred Research Skills and Competences

The ideal candidate has computational and programming skills (ideally, knowledge of Matlab and/or Python), a strong interest in neuroscience and a background in physics / math / biomedical engineering. The ideal candidate must also be able to carry out his/her work in a diligent, independent, and highly collaborative manner.

Curriculum 4: Computational Neuroscience

Code 4.6

Project title: Response theory in brain activity acquired by intracranial electroencephalography

ERC Field: PE3_15 Statistical physics: phase transitions, condensed matter systems, models of complex systems, interdisciplinary applications; Statistical physics: phase transitions, condensed matter systems, models of complex systems, interdisciplinary applications; LS5_16 Systems and computational neuroscience; LS5_18 Innovative methods and tools for neuroscience.

Key words: Response and Control Theory; Network Neuroscience; Stochastic Modelling; Whole brain models; Dynamical Mean Field Theory.

Host Institution: Physics and Astronomy Department, Laboratory of Interdisciplinary Physics and Padova Neuroscience Center, University of Padova.

Reference person/supervisor: Samir Suweis; **samir.suweis@unipd.it**

Research topic description
There is evidence that large-scale brain dynamics is stochastic, non-linear and multi-stable, with several attractors corresponding to different large-scale network states. Recently, developments in experimental approaches have allowed to measure the response of the brain after target neurostimulation. Being able to develop a theoretical framework to study the response of the brain system to weak and strong perturbations would be both of high theoretical and clinical relevance. It could, at once, allow new ways of probing brain network dynamics, inferring connectivity and design perturbation to induce specific activity state (i.e., brain controllability). Blending tools from whole brain dynamical modelling, response and control theory, networks neuroscience, and dynamical mean field theory, we will develop a theoretical and computational framework to study linear and non-linear state switches and design perturbations evoking global network reconfigurations. Our proposal will be trained and validated on multimodal data of intracranial electroencephalography data acquired both at rest and in the presence of electrical stimulation

Research team and environment
The PhD student will carry out his/her studies at the Laboratory of Interdisciplinary Physics and Padova Neuroscience Center of the University of Padova. The project will expose the student to a highly interdisciplinary context, in tight collaboration with physicists, neuroscientists and neurologists.During the first year the candidate will have the opportunity to attend doctoral level courses both in Neuroscience and in Statistical Physics and during the second year of the PhD, the student might be able to spend a period abroad.

Preferred Research Skills and Competences
The ideal candidate has strong quantitative and analytical skills, with a solid background in Statistical Physics and Stochastic processes.Computational and programming skills (ideally, knowledge of Mathematica and/or Python), a strong interest in biological physics. No background in neuroscience is required at this stage. The ideal candidate must also be able to carry out his/her work in a diligent, independent, and highly collaborative manner.

Curriculum 4: Computational Neuroscience

Code 4.7

Project title: Connectivity-based parcellation of human and non-human primate brains: a comparative approach integrating structural and functional dimensions

ERC Field: LS5_2 Systems neuroscience and computational neuroscience (e.g. neural networks, neural modelling); LS5_18 Innovative methods and tools for neuroscience; PE6_12 Scientific computing, simulation and modeling tools; PE6_11 Machine learning, statistical data processing and applications using signal processing; LS5_5 Neural bases of cognitive processes; LS5_6 Neural bases of behaviour;

Key words: connectivity-based parcellation, dynamic system reconstruction, resting state, fMRI, tractography.

Host Institution: Università degli Studi di Parma

Reference person/supervisor: Luca Bonini; **luca.bonini@unipr.it**

Research topic description

Non-invasive neuroimaging methods have paved new ways for investigating the neurobiological foundations of brain architecture. One field of substantial interest in this context is brain connectivity, which allows exploring functions by examining how different brain regions communicate with each other. It is now possible to conduct comprehensive investigations into the various interconnections across different brain regions. In doing so, we can partition larger regions of the brain into subunits, each reflecting unique and distinct connectivity profiles at the functional or anatomical level. Despite these strides, the focus of research employing connectivity-based parcellation methods has largely remained on humans, leading to a gap in cross-species comparisons. The present project aims to address this gap by undertaking a comparative analysis of brain parcellation-based connectivity in the cingulate cortex across three primate species - humans, chimpanzees, and macaques.

The PhD candidate involved in this project will undergo training in neuroimaging techniques, such as structural and functional MRI in both human and non-human primates, along with electrophysiology and neural tracers in macaques. The primary focus will be to apply and enhance computational methods for brain parcellation, by integrating multimodal data sources. Through this endeavour, we aim to contribute significantly to our understanding of the brain's complex connectivity patterns across different primate species.

Research team and environment

The project is embedded in a highly interdisciplinary context. The University of Parma will serve as the primary institution and is renowned for the outstanding studies on macaques' neurophysiology and neuroanatomy. The project also sees the collaboration of the CNR Institute of Neuroscience of Parma, that has a longstanding tradition in computational approaches to electrophysiological data from human intracranial recordings, and of the Department of Psychology, University Torino, with an established expertise in tractography and fMRI studies in healthy and brain-damaged human subjects. This interdisciplinary context will offer a comprehensive platform for the PhD candidate and will enable him/her to make significant contributions to research on brain parcellation-based connectivity across human and non-human primates. The student is also expected to spend a period abroad.

Preferred Research Skills and Competences

The ideal candidate has computational and programming skills (ideally, knowledge of Matlab and/or Python), a strong interest in neuroscience and a background in physics / math / biomedical engineering.

Curriculum 4: Computational Neuroscience

Code 4.8

Project title: Methods to study the dynamic architecture of large-scale communication in the human brain

ERC Field: PE6_11 Machine learning, statistical data processing and applications using signal processing; PE6_12 Scientific computing, simulation and modeling tools; LS5_18 Innovative methods and tools for neuroscience, PE3_16 physics of biological systems; LS5_16 Systems and computational neuroscience; LS5_18 Innovative methods and tools for neuroscience.

Key words: Functional connectivity, Topology, Effective connectivity, Modeling, MRI Physiological measures, Magnetoencephalography, fMRI.

Host Institution: University G. d'Annunzio of Chieti-Pescara, Department of Neuroscience, Imaging and Clinical Sciences

Reference person/supervisor: Stefania Della Penna and Richard Wise stefania.dellapenna@itab.unich.it

Research topic description

The analysis of large scale connectivity in the human brain relies on the implementation and application of cutting edge analysis methods, e.g. including graph theory, to data obtained with different non-invasive imaging techniques on healthy subjects (e.g. MEG, fMRI, MRI-based physiological measures). MEG and fMRI demonstrated that connectivity architecture is dynamically changing over time. The objective of this research project is to implement novel approaches to model and merge information obtained by these imaging techniques to understand the mechanisms explaining the dynamics of functional connectivity topology, with specific attention to the balancing of integration/segregation. The project will optimize and apply generative models to explain, reconcile and predict the hubs of functional connectivity, their dynamics and their metabolism at the group and individual level, obtained with the different imaging techniques. Eventually, task- and/or condition-induced modulations of the effective connectivity will be linked to changes of centrality with the aim at understanding their functional significance.

Research team and environment

The PhD student will carry out his/her studies in a highly interdisciplinary context at ITAB and at the Department of Neuroscience, Imaging and Clinical Sciences (DNISC) - University of Chieti-Pescara. The research team consists of physicists and engineers, together with psychologists and neurophysiologists/radiologists. The team is expert in innovative methods for non-invasive human brain imaging (anatomical, functional, physiological) from techniques (e.g. design and implementation of new devices and systems for brain imaging, new sequences for NMR-based imaging) to analysis methods (e.g. dynamic architecture of brain functional, directed and effective connectivity). ITAB-DNISC at UdA is equipped with cutting edge human imaging instrumentation (3T MRI scanner, MEG system, HDEEG system, TMS, NIRS), allowing also validation of new devices and approaches.

Preferred Research Skills and Competences

The ideal candidate has computational and programming skills (ideally, knowledge of Matlab and/or Python), a strong interest in neuroscience and a background in physics / math / biomedical engineering. The ideal candidate must also be able to carry out his/her work in a diligent, independent, and highly collaborative manner.

Curriculum 4: Computational and System Neuroscience

Code 4.9

ERC Field: SH4

P**roject title:** Bio-signals analysis and imaging in epilepsy

Key words: imaging, genetics, advanced MRI

Host Institution: University of Messina

Reference person/supervisor: Prof. Angelo LABATE **alabate@unime.it**

Research topic description

Predictive biomarkers are becoming important tools in drug development and clinical research and represent the new frontier for researcher to definitively improve the individual management of people with epilepsy. A possible method might be to identify robust and validated biomarker cut-points, using innovative and automated instruments such as brain imaging techniques. Because of the frequent association of imaging abnormalities with epilepsy regardless their drug response, imaging techniques are attractive candidates for diagnostic or prognostic biomarkers. The identification of neuroanatomical biomarkers, providing essential links between genotype and phenotype, could have a high impact on the diagnostic work-up as well as on therapeutic planning in the majority of epilepsy patients. Engel et al. already suggested that a first step to identify potential biomarkers for pharmacoresistance may be to classify several well-defined epilepsy syndromes that are associated with drug resistance but in which there are also patients that are well controlled. In this way the cohort of patients with mild mesial temporal lobe epilepsy (MTLE), a common and often unrecognized clinical entity with onset in adulthood and good response to the medications that our group as extensively studied in since many years, suitably symbolizes an ideal epileptic syndrome to be studied with imaging as potential diagnostic/prognostic biomarker.

Research team and environment

The project will be implemented at the BIOMORF Department, Neurophysiopathology and Movement Disorders Clinic of the University of Messina. This Clinic together with the regional center of diagnosis and treatment of Epilepsy have the mission to improve management of epilepsy subjects and to expand knowledge of analysis of bio-signals coming from electroencephalogram (EEG) and magnetic resonance imaging (MRI).
The main research topic will be to look for MRI biomarkers in epilepsy, especially those capable of identifying neuroanatomical epileptogenic abnormalities, because that would be of huge value for choosing proper diagnostic work-up as well as the best therapeutic pharmacological or surgical planning. The environment offers several facilities including clinical expertise in the field of epilepsy, a very complete and deep electrophysiological lab and techniques. Furthermore, the close relationship with the group of neuroradiology will let to use 1.5 and very soon 3 Tesla MRI scans.

Preferred Research Skills and Competences

The ideal candidate is a highly motivated physicist or biomedic engineer (or related disciplines) with a solid background in signal analysis, pre and post-processing analysis of imaging signals.

Curriculum 1: Cognitive and Behavioral Neuroscience

Code 4.10

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

Project title: European Brain ReseArch InfrastructureS-Italy (EBRAINS-Italy): electrophysiological responses to perceptual or perturbational stimuli across humans and animals

Key words: intracranial recordings, conscious perception, TMS or electrical stimulation, EEG, data curation, local field potentials, humans, monkeys.

Host Institution: CNR Institute of Neuroscience, Parma (CNR)

Reference person/supervisor: Pietro Avanzini **email: pietro.avanzini@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 document 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. Parallel recordings will be made also in animal models (non-human primates) into federated laboratories, leading to a translational perspective onto the mechanisms sustaining conscious perception and their perturbability through intracranial or transcranial stimulations.

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 1: Cognitive and Behavioral Neuroscience

Code 4.11

ERC Field: PE6_11 Machine learning, statistical data processing and applications using signal processing; PE6_12 Scientific computing, simulation and modeling tools; LS5_18 Innovative methods and tools for neuroscience, PE3_16 physics of biological systems; LS5_16 Systems and computational neuroscience; LS5_18 Innovative methods and tools for neuroscience.

Project title: Generative computational neuroscience models of the representational, motivational and selective processes underlying human metacognition and consciousness and autonomous robot self-improvement.

Key words: Consciousness; metacognition; working memory; representation learning; motivation; internal attention; computational models; generative large language models; transformers; deep and shallow neural networks.

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

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

Research topic description

The PhD project will be carried out within the context of the project EBRAINS-Italy. The LENAI group has extensive highly-interdisciplinary expertise in the fields of: embodied computational neuroscience of brain and behavior, bio-inspired AI (machine learning and neural networks), and open-ended learning autonomous robots. The PhD will use the approaches of LENAI, building system-level computational models (architectures) mimicking the macro-structure and functions of the brain, to study the high-level brain and cognitive process underlying consciousness and metacognition. Relevant literature for the work will come from neuropsychology, machine consciousness, machine learning, and autonomous robotics. The models will reflect the view, recently proposed by the LENAI, for which consciousness and metacognition relies on the key process of the internal manipulation of representations, guided by motivations and context information (goals, state conditions) stored in working memory. Within this view, the project will in particular focus on the metacognitive aspects of consciousness that allow the self-monitoring of goal-directed behavior directed to plan and execute actions to accomplish desired goals. This will be investigated both to understand how these processes work in the brain, and how they can be used in autonomous-robot applications for self-monitoring own failures and open-ended learning. Examples of models used to implement the architecture are as follows: shallow/deep neural networks for perceptual representations, generative large language models for high-level reasoning and working memory, transformers for internal representation selection, supervised/unsupervised/reinforcement learning for adaptation. The architectures will be tested both with tasks from neuropsychology and tasks involving autonomous robots solving real world problems. Overall, the PhD research should have a relevance for both computational neuroscience and cognitive robotics.

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, psychology, artificial intelligence and machine learning, 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 EU funded projects such as EBRAINS.

Preferred Research Skills and Competences

Ideal applicants are expected to have: (a) a strong interest and commitment to study and work on natural and artificial intelligence with an interdisciplinary approach; (b) a good knowledge in computational neuroscience, AI and machine learning, in particular on neural networks, and possibly knowledge on generative large language models and transformers; (c) both speaking and writing English capabilities, and good analysis/synthesis capabilities, for reading, understanding, and writing scientific papers; (d) good programming skills in python;

(e) a professional attitude towards work and the capacity to work in autonomy; (f) the capacity to collaborate within a highly interdisciplinary team and an international context.