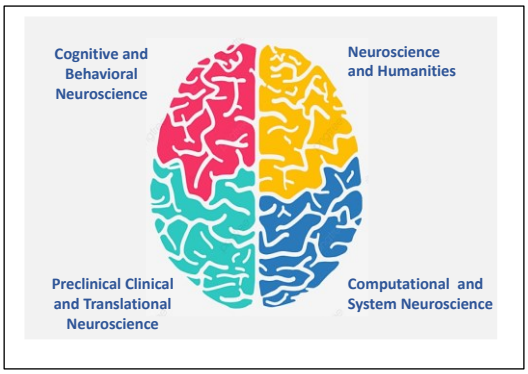

PhD in **TAN**
THEORETICAL AND APPLIED NEUROSCIENCE

Research Program

Cycle 38°

Academic year 2022-2023

List of the Research Topics

Curriculum	Research Project	Host Institution	Number of fellowships
Curriculum 1: Cognitive and Behavioral Neuroscience			
1.1	The role of multisensory and sensorimotor functions in higher-order cognition and social functions	University Sapienza of Rome	1
1.2	To study the network-level, region-level, and gene-level brain function correlates of unresponsive phenotypes in psychosis	University of Naples"Federico II"	1
1.3	Topographic mapping of multisensory processing and representation exploiting resting state or long-lasting naturalistic stimulation fMRI protocols	IMT School for Advanced Studies Lucca	1
1.4	Behavioral neurophysiology in macaques	University of Parma	1
1.5	Language Acquisition in Typical Development and Hearing Impairment: Early Plasticity	University of Padua	1
1.6	The role of the motor system in associative learning	University of Bologna	1
Curriculum 2: Neuroscience and Humanities			
2.1	Educational neuroscience in physical education and sport: embodied design to promote effective teaching and learning processes also in an inclusive approach	Pegaso University	1
2.2	Analysis of physical activity and sleep in Cystic Fibrosis patients and healthy subjects	Pegaso University	1
2.3	Learning by playing: action and interaction to enhance learning processes	Pegaso University	1
2.4	Neuroscience and implications for education and lifelong learning	Pegaso University	1
2.5	To study the psychophysiological correlates of hesitation and resistance to vaccination	University of Messina	1
Curriculum 3: Preclinical Clinical and Translational Neuroscience			

3.1	Advanced approaches to define new diagnostic and prognostic biomarkers in amyotrophic lateral sclerosis (ALS) and other motor neuron diseases (MNDs)	University of Torino	1
3.2	Neural correlates of a wearable supernumerary finger use in healthy subjects and paretic patients	University of Siena	1
3.3	Study of innovative drugs and medical devices for developmental psychiatric diseases	Roma Tre University	1
3.4	To study the cellular and molecular mechanisms of neurodegeneration and neuroinflammation in vivo and in vitro	University of Modena and Reggio Emilia	1
3.5	The role of neuroinflammation signaling in substance use disorders	Pegaso University – University of Bologna	1
3.6	Psycho-biological and psychometric correlates of the effects of meditative practices	University of Pisa	1
3.7	New methodologies for neurorehabilitation in pediatric patients	IRCCS MEDEA	1
3.8	Role of sleep in shaping neural circuits and behavior	University of Camerino	1
3.9	To study the neurobiological, behavioral and pharmacological basis of drug addiction and chronic pain: Focus on the opioid system.	University of Camerino	1
3.10	To study individual vulnerability in substance use disorders: A genetic, molecular and neurocircuitry level approach in rodents.	University of Camerino	2
3.11	To study individual vulnerability to social isolation-induced psychopathologies: Focus on the therapeutic effects of psilocybin in preclinical models.	Pegaso University – University of Camerino	1
3.12	Dissecting the neurobiological mechanisms underlying emotional and social dysregulations in anorexia nervosa	University of Milan	1
3.13	Modulators of ion channels and transporters as new therapeutic options for neuropsychiatric diseases	University of Naples"Federico II"	1
3.14	Neural substrates of neuropsychiatric diseases	University of Ferrara	1
3.15	To study dysfunctional neuronal autophagy in spinal cord and traumatic brain injury	University of Messina	1
3.16	To study the impact of different neuromodulation strategies on cognitive rehabilitation in neurological disease	University of Palermo	1
3.17	The brain renin angiotensin system as a target for intervention in Alzheimer's disease	University of Cagliari	1

Curriculum 4: Computational and System Neuroscience			
4.1	Innovative technologies for probing the gut-brain axis in health and disease	CLN2S - IIT	1
4.2	The Neurophysiological Bases of Biological Motion: From Laboratory to Clinics	University of Bologna	1
4.3	Methods to study the mechanisms for large-scale functional connectomics	University of Chieti-Pescara	1
4.4	Deep Neural Networks of emotional perception in the subcortical visual system	Pegaso University – University of Turin	1
4.5	Neuro-inspired artificial intelligence for healthcare	Pegaso University – Scuola Superiore Sant'Anna	1
4.6	Computational models for neuroprosthetics	Scuola Superiore Sant'Anna	1
4.7	Brain decoding for neuroprosthetic control	Scuola Superiore Sant'Anna	1
4.8	Bio-signals analysis and imaging in epilepsy	University of Messina	1

Curriculum 1: Cognitive and Behavioral Neuroscience

Code 1.1

ERC Field: SH4_5 Attention, perception, action, consciousness

Project title: The role of multisensory integration and sensorimotor functions in higher-order cognition and social functions

Key words: multisensory integration, sensorimotor transformations, social functions, body and space representation

Host Institution: Sapienza University of Rome

Reference person/supervisor: Matteo Candidi

Research topic description
Modern theories of cognitive functions support the idea that perceptual, behavioral, emotional, cognitive and social functions are not separated but are interdependent and all share the function of supporting efficient individual-environment interactions by predicting external events. It happens, however, that for many different reasons, individuals may suffer from partial or global, transitory or stable sensory alterations and deprivation which may have great impacts on cognitive, emotional and social skills along both typical and atypical development. By means of behavioral, psychophysiological, electroencephalographic (EEG), motion kinematics and brain stimulation methods, the project aims at establishing the impact of typical and atypical sensory functions on higher-order cognitive and social behaviors studied ate the level of individual functioning and in the light of interpersonal interactions.

Research team and environment
The team in which the PhD will work is a large lab of around 20-30 PhD students and post-docs researchers in the fields of cognitive, affective and social neuroscience with th supervision of experimental neurologists, psychologists and neuroscientists.
The research will be developed in International laboratories at Sapienza and partner institutions (CNR-ISTC Rome, University of Ferrara), and will foresee international mobility.
In Rome, the PhD will be based at the Sapienza University and at the research-oriented hospital IRCCS Fondazione Santa Lucia.

Preferred Research Skills and Competences
The ideal candidate has experience in behavioral, psychophysiology, EEG, brain stimulation, motion kinematics, as well in basic psychometric methods.
The ideal candidate has some experience in grant hunting, has good communication skills, and the ability to translate research evidence to clinical and technology scenarios.
The ideal candidate must be able to carry out her work in a diligent, independent and highly collaborative manner.

Curriculum 1: Cognitive and behavioral Neuroscience

Code 1.2

Host University/Research Institution: University of Naples "Federico II"

ERC Field: LS5_8 (LS5_5; LS5_6)

Project title: To study the network-level, region-level, and gene-level brain function correlates of unresponsive phenotypes in psychosis

Key words: schizophrenia, neurodevelopment, fMRI, PET, synaptic plasticity

Reference person/supervisor: Felice Iasevoli

Research topic description
The project will aim to dissect the neural and genetic correlates of non-response to pharmacological treatments in psychosis. Based on our and other groups' previous studies, non-responsive psychosis has large genetical communalities with neurodevelopmental disorders, including intellectual disability and autism spectrum disorders. Moreover, our recent studies have demonstrated a bilateral prefrontal hypometabolism and temporo-occipital hypermetabolism in psychotic patients non-responsive to treatments as compared to responsive psychotic patients and controls. Additionally, a significant correlation of these metabolic patterns has been found with conceptual disorganization, a proxy of disease-specific cognitive impairment.
The PhD student is expected to study the neural correlates of unresponsive phenotypes in terms of neural network and discrete brain regions associated to unresponsive positive symptoms and conceptual disorganization. Moreover, the student is expected to study the genetic correlates of neural dysfunctions in unresponsive patients in terms both of genome-wide lesions (e.g., pathogenic CNV implicated in neurodevelopmental disorders and their biological roles) and neuronal-deriving circRNA.

Research team and environment
The research team includes members from the unit of Psychiatry, who will work in tight (and already ongoing) collaboration with the unit of Genetics and the unit of Neuroradiology. The supervisor is Associate Professor in Psychiatry and head of the Residency School in Psychiatry. He has solid background in translational psychiatry and is among worldwide experts in treatment resistant schizophrenia. The Psychiatry staff also includes two PhD students and at least three resident students collaborating in patients' recruitment and assessment, collection and processing of blood samples, preclinical and translational analyses (if needed). The Psychiatry unit includes outpatient and inpatient facilities, as well as a molecular laboratory. The Genetic unit will provide high-throughput genetic analyses. The Neuroradiology unit will provide functional MRI and PET studies.
In general, the staff environment is friendly, cooperative, welcoming, and enthusiastic, but, above all, firmly committed to reach the research objectives.

Preferred Research Skills and Competences
The candidate is expected to have theoretical competences on basic and translational neuroscience, with specific focus on the neurobiology of behavioral disorders, and practical skills on basic wet lab techniques, human neuroimaging techniques and data analysis, R and SPSS software, including graph theory analysis, basic statistical competences. The candidate is expected to have good proficiency in written and spoken English language and familiarity with scientific literature. The candidate is expected to have already obtained documented scientific acquirements and to have solid propensity to work in team. Recommendations from experts in the field are welcome.

Curriculum 1: Cognitive and behavioral Neuroscience

Code 1.3

ERC Field: SH4_4; LS_10; SH4_3; LS5_4

Project title: Topographic mapping of multisensory processing and representation exploiting resting state or long-lasting naturalistic stimulation fMRI protocols

Key words: resting state, functional magnetic resonance imaging, spontaneous activity, sensory deprivation, plasticity

Host Institution: IMT School for Advanced Studies Lucca

Reference person/supervisor: Emiliano Ricciardi

Research topic description

Primary sensory areas receive a variety of crossmodal inputs, but how this information is locally processed, and possibly shared with and conveyed to other sensory systems, remains ill-defined. It is also largely unknown the extent to which crossmodal remapping is 'resilient' in responding to temporary and permanent loss of information, or whether and how it can be boosted and driven in both physiological and pathological conditions.

The project will focus on assessing how visual and non-visual information is represented or cross-modally remapped in non-visual primary areas and in V1, respectively, to assess whether a functionally active, task-related and topographically organized response exists in primary areas during the multisensory interplay. The project will also determine how spontaneous neural activity impacts brain maturation and refinement of primary sensory in typically-developed and sensory-deprived individuals.

Recently, our group have been assessing the coherence of neural responses evoked during a long-lasting auditory and visual stimulation across independent samples of typically developed and sensory deprived groups. In particular, we exploited the intersubject correlation analysis to determine brain regions that synchronize across individuals when processing and representing the same naturalistic stimulus. This research topic will capitalize on prolonged naturalistic stimulations across modalities to assess the perceptual information contents in early sensory areas. Is sensory deprivation necessary for this cross-modal information to occur? Is a temporary deprivation sufficient for this crossmodal remapping to occur? Does this crossmodal remapping extend also to tactile information?

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 1.4

ERC Field: LS5_2

Project title: To study the neuronal correlates of perceptual and cognitive processes in non-human primates

Key words: single neurons, macaque, neurophysiology, multielectrode recording, perception, behavior.

Host Institution: University of Parma

Reference person/supervisor: Luca Bonini

Research topic description
The research will involve the recording of single neuron activity with state-of-the-art multielectrode systems from different brain areas, to dissect the neuronal circuitries underlying perceptual and behavioral functions. Details on the research activities and publications of the lab can be found here: https://boninilab.unipr.it/index.php/publications/

Research team and environment
The team benefits from funding from the European Research Council and the Italian Ministry of University and Research that can cover all the needs to support the research activities. It includes, in addition to the PI (full professor), 2 researchers and a group of ~15 PhD students and post-doc/research fellows, see https://boninilab.unipr.it/index.php/lab-members/

Preferred Research Skills and Competences
Sound background in neurophysiology and neuroscience, availability to work with non-human primates; competences in statistics and programming and previous experience with non-human primates are a plus

Curriculum 1: Cognitive and behavioral Neuroscience

Code 1.5

ERC Field: SH4

Project title: Language Acquisition in Typical Development and Hearing Impairment: Early Plasticity

Key words: speech perception, language acquisition, early development, infants, EEG, NIRS

Host Institution: University of Padua

Reference person/supervisor: Judit Gervain

Research topic description
Language is the tool humans use to transmit knowledge, integrate into society and create culture. Yet, language development may be compromised due to biological or environmental factors. The project aims to advance our understanding of the neural mechanisms of early language development in order to improve language outcomes and thus educational and clinical opportunities for typically developing and hearing impaired children. State-of-the-art brain imaging (EEG-NIRS co-registration & hyperscanning) will be used to investigate typical and hear-impaired infants' speech perception and early production abilities. Linking perception and production early in development is an innovative avenue of research, aiming to better explain language outcomes in typical infants and such special populations as deaf and cochlear-implanted children. Investigating neuroplasticity as a key mediating factor in developmental trajectories will allow us to establish early markers of developmental risks.

Research team and environment
The candidate will join an ERC-funded research team specializing in early speech perception and language development. The team focuses on the earliest stages of life, from birth till the preschool period. We use behavioral (e.g. looking time, observational and production) methods as well as NIRS and EEG imaging to explore how infants and young children break into their native language. Our studies investigate typical and atypical development (e.g. hearing impairment) as well as special populations (e.g. bilinguals). We are involved in several large-scale open science projects and have a great number of international research collaborations. We have agreements with local maternity wards, the city of Padua, daycare centers and the local hospital for participant recruitment. The team comprises the PI, several post docs, doctoral students, Master students and undergraduates. It is highly international and values diversity and inclusivity.

Preferred Research Skills and Competences
The project involves using behavioral and NIRS imaging methods with young infants. The successful camdidate will thus have experience with infant testing and good relational skills. Strong programmming, data analysis and/or statistical skills (e.g. MatLab, R, python) are a plus. A theoretical background and a Master's degree in Linguistics, Speech Pathology, Cognitive Neuroscience, Developmental Psychology or related disciplines is necessary. Fluency in English and Italian are a must. As the candidate will work in a larger research group, team spirit and collaborative skills are required.

Curriculum 1: Cognitive and behavioral Neuroscience

Code 1.6

Project Title: The role of the motor system in associative learning

ERC Fields: SH_4 The Human Mind and Its Complexity; SH4_5 Attention, perception, action, consciousness; SH4_6 Learning, memory; cognition in ageing; LS5 Neuroscience and Neural Disorders; LS5_5 Neural bases of cognitive processes (e.g. memory, learning, attention); LS5_6 Neural bases of behaviour (e.g. sleep, consciousness, addiction)

Keywords: associative learning; motor system; fear; reward

Host University/Research Institution: University of Bologna

Reference person/supervisor: Prof Giuseppe di Pellegrino

Research Project description

Learning to predict the delivery of appetitive and aversive stimuli from environmental cues is a fundamental skill in changing environments. These learning processes are exemplified by classical conditioning in which the contingent presentation of predictive cues (conditioned stimuli, CS) and reinforcing outcomes (unconditioned stimuli, US; e.g., food/water or electric shocks) engages a process of associative learning.

In classical conditioning, the relation of the CS to the US is totally unaffected by the subject's response: delivery of the US is entirely outside the subject's control. Accordingly, research work has mainly focused on the formation of CS-US associations, while less attention was devoted to the role of the motor system.

Here, we test an alternative account based on intimate links between associative learning and motor control. We submit that what is learned during associative learning is an optimal action policy, namely the propensity to activate motor responses that maximize rewards or minimize punishments. On this view, outcome prediction is equivalent to, and largely overlaps with, motor preparation, whether defending against a threat or securing resources. Moreover, we argue that changes in motor activity do not simply report the occurrence of associative learning, but are causally involved in associative learning.

To this aim, we will conduct a series of behavioral, electrophysiological, and brain stimulation studies investigating whether perturbing the state of the motor system affects associative learning.We predict that the project will significantly enhance the current understanding of the interactions of motor activity and cognitive processes.

Research team and environment

Giuseppe di Pellegrino leads the Neuroscience of Motivation, Decision and Learning (MoDel) group, which studies the neural substrates and functional mechanisms of reinforcement learning and decision-making.
Over the course of the year, the group has acquired specific expertise in the investigation of the neural basis and cognitive processes that allow individuals to learn the predictive relationships between environmental stimuli and discover the causal links between their actions and the likelihood of obtaining rewards and avoiding punishments. These skills are at the very core of choice and action selection and, more generally, of the flexible and optimal behavioral adaptation of the individual to his environment. However, in some circumstances, these adaptive processes can evolve into maladaptive behaviors (such as substance addiction or anxiety-related disorders).
For these studies, the group uses electrophysiological, psychophysiological measures, behavioral evidence, and techniques of noninvasive neurostimulation, both in populations of healthy subjects, in different age groups, and populations of neurological and psychiatric patients.

Research Skills and Competences

The candidate will be required to have familiarity with the theoretical basis of associative learning and to have hands-on experience in recording and analyzing behavioral, electroencephalography (EEG), and psychophysiological (e.g., skin conductance, heart rate) data. More specifically, expertise will involve both the signal acquisition phase (electrode placement, amplification and filtering, visualization, and signal recording) and the data analysis phase (identification and removal of artifacts, spectral analysis, filtering, ERP averaging, time-frequency analysis) that characterize an experimental setting.

Curriculum 2: Neuroscience and Humanities

Code 2.1

ERC Field: SH4_13 Education: principles, techniques, typologies

Project title: Educational neuroscience in physical education and sport**:** embodied design to promote effective teaching and learning processes also in an inclusive approach

Key words: educational design, embodied learning, inclusive education, motor development, physical education

Host Institution: Pegaso University, Faculty of Humanistic Sciences

Reference person/supervisor: Cristiana D'Anna

Research topic description

Scientific studies in the neuroscience field highlight the presence of strong links among brain, mental and motor activity, developing new perspectives on the study of health and individual functioning. The logic of non-linearity that characterizes the neuroscientific approach allows us to understand, through the study of motor behavior and targeted actions, realities apparently far from the movement itself such as cognition and behavior, affectivity and relationship. In the light of dialogue between Neuroscience and Education, the perspective of Embodied Cognition supports the rethinking of the teaching-learning process through the enhancement of corporeity, intersubjectivity, embodied simulation and dimensions implicit in development and learning (Embodiment).

The topic focuses on educational design in physical education and sport in educational contexts, starting from the awareness that any targeted movement of our body, from fundamental to specific sports movement skills, must be studied as a complex process involving multiple aspects from biomechanical to physiological, psychological, social, etc. The action that the subject performs results from a series of complex mechanisms strongly conditioned by the surrounding environment, where the boundary between what is motor and what is cognitive is not well identified.

The teaching-learning process in particular in physical activities, is characterized as an embodied process, situated and distributed, in which both the behaviors and the adaptive responses of our neurobiological system emerge in response to different inputs. At the basis of this statement is the awareness that our every behavior is a phenomenon emerging from a bi-directional organism-environment synergy. The systemic perspective, in this sense, opens up new scenarios on which to reflect in order to face the unpredictability, emergency and self-organization which act in and on the quality of teaching-learning process, creating effective learning environments able to facilitate and guarantee full inclusion of all students.

Research team and environment

Cristiana D'Anna – Pegaso University
Filippo Gomez Paloma – University of Macerata
Silvia Coppola – University of Salerno
Valeria Minghelli- University of Salerno
Antinea Ambretti – Pegaso University
Lucia Martiniello – Pegaso University

The research focuses on children and adolescents, also with special educational needs and disabilities.
The following are the main educational contexts where the research topic will be implemented:

- Physical education and sport in school
- Inclusive physical education in educational and recreational environment
- Disability and rehabilitation

The subject of the research will be:

- Fundamental-movement-skills learning (gross-fine abilities)
- Complex and specific sport skills learning
- Personal and social autonomy skills learning in children with special needs

The student will be part of a wider project aiming to develop embodied design models and the consequent implementation of research-training towards different educators (teachers, therapists, coaches, etc.)

Recent publications of research team

D'Anna, C. Romano, B. & Vastola, R. (2021). Planning learning environments rich of affordances to lead the learners in the successful performance of a motor task: a preliminary study. In *Italian Journal of Health Education, Sports and Inclusive Didactics* - Anno 5(3), pp..115-126.

D'Anna, C., Albano, D., Romano, B. & Vastola, R. (2021). Physical education between neuroscience and complexity: the systemicperspective applied to inclusive didactics. In *Italian Journal of Health Education, Sports and Inclusive Didactics* Anno 5(2), pp.340-350. https://doi.org/10.32043/gsd.v5i2.377

Gomez Paloma, F. (Ed.) (2017). *Embodied Cognition. Theories and Applications in Education Science*, New York: Nova Science Publisher.

Damiani, P., Minghelli, V., D'Anna, C. & Gomez Paloma, F. (2021). The Embodied Cognition based approach in teacher training. A recursive training model for the integrated skills of the teacher, in "*Online Annals of Teaching and Teacher Training*", Vol. 13, n. 21/2021, pp. 106-128.

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

ERC Field: LS5_8 Behavioral neuroscience (e.g. sleep, consciousness, handedness)

Project title: Analysis of physical activity and sleep in Cystic Fibrosis patients and healthy subjects.

Key words: Physical activity, sleep, Cystic Fibrosis, health, educative strategies

Host Institution: Pegaso University, Faculty of Humanistic Sciences

Reference person/supervisor: Ausilia Elce

Research topic description

Cystic fibrosis (CF) is one of the most commonly inherited diseases characterized by a severe decline in pulmonary function associated with metabolic perturbations and altered body composition. Physical activity (PA) has important beneficial effects on human health status. Little is known about the role of sleep and PA in Cystic Fibrosis patients. The aims are: a) to investigate the effects of long-term (5 years) period of PA on a cohort of CF patients that performed monitored PA compared to a matched control group of CF sedentary patients; b) to identifya relationship between good sleep, cognition and clinical severity of phenotype. Preliminary Results: Previously, we demonstrated that regular and long-term PA improves the health status of CF patients, reducing lung function decline and counteracting inflammation. More recently, we analyzed the effects of PA on anthropometric parameters observing that CF patients have an improved body composition proposing PA as a useful complementary strategy in the management of CF.The final scope is an amelioration of the general health conditions of CF patients through PA, a non-invasive approach. The device will favor the performance of PA in patients allowing the observation and analysis of the physiological changes.

Research team and environment

Research team
Ausilia Elce (Pegaso University)
Aurora Daniele (Federico II University)
Ersilia Nigro (Luigi Vanvitelli University)
Vincenzo Manzi (Pegaso University)
Clorinda Sorrentino (Pegaso University)
Angelina Vivona (Pegaso University)
Simona Iannaccone (Pegaso University)
Lucia Martiniello (Pegaso University).

The Ph student will be able to work on human subjects, using validated tests, anthropometric measurements, and portable instruments for PA analysis.
Latest publications on this topic:

1) Elce, A.; Daniele, A.; Loperto, I.; De Coppi, L.; Sangiorgio, A.; Vivona, A.; Sorrentino, C.; Iannaccone, S.; Martiniello, L.; Nigro, E. COVID19 Pandemic and Physical Activity: An Observational Study on Sleep Quality and Anxiety. Sports 2022, 10, 44. https://doi.org/10.3390/sports10030044
2) Elce V, Del Pizzo A, Nigro E, Frisso G, Martiniello L, Daniele A, Elce A (2020). Impact of Physical Activity on Cognitive Functions: A New Field for Research and Management of Cystic Fibrosis. DIAGNOSTICS, vol. Jul 18;10(7):489, ISSN: 2075-4418, doi: 10.3390/diagnostics10070489
3) Elce A, Nigro E, Gelzo M, Iacotucci P, Carnovale V, Liguori R, Izzo V, Corso G, Castaldo G, Daniele A, Zarrilli F. (2018). Supervised physical exercise improves clinical, anthropometric and biochemical parameters in adult cystic fibrosis patients: A 2-year evaluation. THE CLINICAL RESPIRATORY JOURNAL, ISSN: 1752-6981, doi: doi: 10.1111/crj.12796 11 15 2017
4) Elce A, Del Pizzo A, Castaldo G (2021). Wearable Sensors and Telemedicine Strategies for Cystic Fibrosis Patients. AMERICAN JOURNAL OF BIOMEDICAL SCIENCE & RESEARCH, vol. 12, p. 369-370, ISSN:

2642-1747, doi: 10.34297/AJBSR.2021.12.001774

Preferred Research Skills and Competences

Attitude to the scientific method, attitude to the use of technologies (especially Microsoft Excel software and statistic programs), capacity to work in a team, capacity tospeak and present scientific data.

Curriculum 2: Neuroscience and Humanities

Code 2.3

ERC Field: SH4_13 Education: principles, techniques, typologies

Project title: Learning by playing: action and interaction to enhance learning processes

Key words: children, embodied education, neuroscience, teaching and learning

Host Institution: Pegaso University

Reference person: Cristiana D'Anna
Co-supervisor: Antinea Ambretti

Research topic description

The scientific literature emphasizes the strong relationship between neuroscience and education, highlighting the potential applications of neuroscientific principles in teaching practices. The current findings in the neuroscientific contribute to outline a development of intelligence and closely interconnected learning experiences, with an attribution of meaning of "more authentic" if you lived them through the body. Mind - body - environment, and the relationships between them represent the primary context within which the educational process should take place through enhancement of bodily, emotional and relational dimensions.

According to this theoretical framework, the present topic wants to investigate on efficacy of embodied-based learning environments using the body as an object, the image of what was experienced and was created in the mind. In this way, acting and interacting in moving, during the activity proposed in playful form, becomes a means to learn different learning objects through different stages and levels. Learning always implies a process of transformation, and thus a change, when present as an extension of our abilities to make explicit, outline, recognize, justify, validate and act in reference to some aspect of our involvement with the environment, other people and ourselves. Learning involves the cognitive sphere since it is characterized by the interaction between the continuous perceptive experience and the mnemonic experience that allow us to construct a meaning within which we choose what and how to place our subsequent experiences.

The individual interprets the signs that have been obtained through the perception (sensorimotor phase) and reworks them by anchoring them to what is present in his/her memory (symbolic-representative phase).

The intention is to help demonstrate that learning by playing in the multidimensional perspective of the embodied approach can foster a better understanding of the contents of knowledge and a progressive construction of a more effective and meaningful track study of learning.

Research team and environment

Research team:
Clorinda Sorrentino (Pegaso University)
Angelina Vivona (Pegaso University)
Simona Iannaccone (Pegaso University)
Generosa Manzo (Pegaso University)
Lucia Martiniello (Pegaso University)
Cristiana D'Anna (Pegaso University)

This research topic aims to understand the educational implications of embodied-based learning environment on the knowledge acquisitions and applications. Through a multi-disciplinary approach, it wants to investigate a series of psychological variables, in a broad framework including developmental, cognitive, and affective processes, and neuroscience research, spanning multiple levels from genetics to systems, in order to better understand core educational areas such as reading, math, science, and socio-emotional development.

Research will be implemented in the primary school context, involving children and teachers.

Somepublications on this topic:

Anna Landi, Lucia Napolitano, Cristiana D'Anna, Debora Tarolla, Filippo Gomez Paloma (2013). Learning mathematics through the body. In *International Conference on Education and New Developments*. Lisbona Mafalda Carmo. pp.373-375 ISBN:978-989-97866-5-3.

Lucia Napolitano, Anna Landi, Cristiana D'Anna, Debora Tarolla, Filippo Gomez Paloma (2013). Word…moving.In *International Conference on Education and New Developments* 2013. Lisbona: Mafalda Carmo. pp.370-372 ISBN:978-989-97866-5-3.

Pastena, N. Palladino, N. & D'Anna, C.(2016). The geometry through the body: doing, acting, thinking, Published in*: INTED2016 Proceedings*, Pages: 3151-3156, Publication year: 2016, ISBN: 978-84-608-5617-7, ISSN: 2340-1079.

Preferred Research Skills and Competencies

A high level of motivation to study and research and perseverance are always required. Following the principal research skills and competencies preferred: analytical and problem solving, critical thinking, teamwork, and digital and communication skills. Application of technologies to the study of the nervous system and scholastic learning Use evaluation tools, equipment, and computer programs with refers didactic.

Curriculum 2: Neuroscience and Humanities

Code 2.4

ERC Field: SH4_13 Education: principles, techniques, typologies

Project title: Neuroscience and implications for education and lifelong learning

Key words: neuroscience, lifelong learning, memory, flexible.

Host Institution: Pegaso University

Reference person/supervisor: Clorinda Sorrentino

Research topic description

The dialogue between neuroscience and education undoubtedly represents a prolific ground for the structuring of effective educational processes and for the understanding of some essential ones for learning. Pedagogy and didactics, in dialogue with neuroscience, can deal precisely with the translation of the discoveries on the functioning of the brain into educational practices applicable in everyday life. These possibilities can be extended with great success to the field of adult education and lifelong learning. Overcoming the conception that there was a time for learning and one for putting into practice the things learned, through activity in working life, today we are faced with another way of understanding these different moments. Learning belongs to all phases of the life cycle, even in a functional dimension for learning and relearning to give stability to own job position in one or more organizations. The concept of professional growth as a transversal action that increases human capital has acquired centrality; this aspect has had over time a growing consideration for investments by production companies.

Training in the workplace is currently neither seen nor perceived as an enabling element meant to improve business competencies and, consequently, competitiveness. Rather, it is perceived as an obligation to be complied with, to be achieved in the minimum requirements and at minimum costs. The spread of notions, practices, regulations, and procedures within companies rarely occurs in a structured and organized way, just as voluntary learning is neither valued nor encouraged.

The organization of information useful for advising and training employees at all levels, on the other hand, should represent a fundamental tool for increasing company preparation and, consequently, it's the best positioning on the market being recognized as a competent company if not even a leader in their sector. Factories, workplaces, and production models are changing rapidly and the production processes themselves, as theorized by Industry 4.0, are no longer monolithic, but change quickly according to needs. Companies, therefore, need to prepare their staff to address these needs. It is, therefore, necessary that training courses are liquid, just as business processes are becoming liquid.

Traditional teaching approaches are no longer useful to deal with the bets set in place by the smart factory, it is necessary, instead, to find methodologies and tools that meet the new needs and support changes and evolution in a quick and intelligent way.

Research team and environment

Research team:
Clorinda Sorrentino (Pegaso University)
Angelina Vivona (Pegaso University)
Simona Iannaccone (Pegaso University)
Generosa Manzo (Pegaso University)
Lucia Martiniello (Pegaso University)

Cristiana D'Anna (Pegaso University)

This research topic aims to develop teaching models, content models, and training tools designed and verticalized for the needs of 4.0 companies, which allow to support the processes of change and use the new paradigms of corporate training: personalized training and training in the places of work.
New teaching approaches will be explored such as liquid learning, microlearning, dynamic learning, semantic web, Artificial Intelligence, and augmented reality.

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 competencies preferred: analytical and problem solving, critical thinking, teamwork, and digital and communication skills.

Curriculum 2: Neuroscience and Humanities

Code 2.5

ERC Field: SH4

Project title: To study the psychophysiological correlates of hesitation and resistance to vaccination

Key words: COVID-19 anti-vaccination attitude; Motor Evoked Potentials, Skin Conductance Response, Embodiment, Emotions, Personality traits.

Host Institution: University of Messina

Reference person/supervisor: Carmelo Mario Vicario

Research topic description

COVID-19 (SARS-CoV-2) pandemic is playing a devasting impact on worldwide public health (physical and psychological) and economy. Although the discovery of COVID-19 vaccine represents a turning point of historical importance in the fight of this virus and its devastating effects, the current challenge is securing a capillary vaccination of population.

An important obstacle in this regard is the hesitation and/or resistance to accept the vaccine, which is estimated to involve about the 26% of population. The World Health Organization (WHO) has recently established that vaccine hesitancy and resistance must be considered among the top public health threats (WHO, 2019), for its crucial role in maintaining the COVID-19 pandemic. Therefore, it is urgent to increase current knowledge about the mental processes at the origin of the antivaccination attitude, to figure out new strategies for promoting vaccine acceptance.

Epidemiological and psychological research have provided preliminary evidence on the mental and sociocultural profile of these individuals. For example, it was reported that antivaccination individuals are characterized by high levels of disgust and fear toward needles, lack of altruism, anti-immigration attitude and paranoia. Yet, an important missing piece of knowledge is about the neural correlates of hesitation/resistance to accept vaccination against COVID-19 infection. This project aims to provide new insights in this direction by investigating the neurophysiological correlates of these individuals. This research will help to draw a more complete profile of individuals hesitant or resistant to vaccination, providing new insights in support of current attempts to promote vaccination among these people.

Research team and environment

Max 250 words

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 and previous experience with the use of non-invasive brain stimulation methods, laboratory data collection, E-prime programming

Curriculum 3 : Preclinical Clinical and Translational Neuroscience

Code 3.1

ERC Field:

Project title: Advanced approaches to define new diagnostic and prognostic biomarkers in amyotrophic lateral sclerosis (ALS) and other motor neuron diseases (MNDs)

Key words: Amyotrophic lateral sclerosis, motor neuron disease, biomarker, diagnosis, artificial intelligence, diagnosis, prognosis

Host Institution: University of Turin

Reference person/supervisor: Andrea Calvo

Research topic description

Motor neuron diseases (MNDs) are a group of disorders characterized by a huge heterogeneity in clinical presentation, causing diagnostic and therapeutic delays, and difficulties in the design of clinical trials. Amyotrophic lateral sclerosis (ALS) is the most frequent disorder of this group. Considering the growing number of emerging disease-modifying therapies, a diagnostic delay covering approximately one-third of the disease course is becoming always more troubling. Available criteria for diagnosis currently used in ALS are quite specific, but poorly sensitive; the newly proposed Gold Coast criteria shows a higher sensitivity, allowing inclusion of a greater number of patients in trials, but have a lower specificity. There is a strong need to study these aspects with new strategies and approaches. One way may be the use of computational analysis to develop a disease model that can help defining the ALS signature in the early stage of disease, integrating clinical, neurophysiological and neuroimaging tools with fluid biomarkers. This could help in differentiating ALS from its mimics and evaluating the same signature in pre-symptomatic subjects converting to ALS, in order to understand the process underlying motor neuron degeneration.

Research team and environment

The Turin Expert Center for ALS (CRESLA, University of Torino) in the last 30 years has achieved a strong experience in the study of ALS, in particular main areas of research are epidemiology, cognition, neuroimaging, clinical trials, and genetics: ALS Turin Center has contributed to the discovering of several ALS genes, including *C9ORF72, VCP, MATR3* and *KIF5A*. CRESLA is one of the most relevant providers for the ALS data, taking care of the PARALS register, one of the largest and complete ALS database in Europe. CRESLA is also leader and partner of a number of international and national research projects on ALS/MND (Horizon 2020, FP7, PRIN, CDC, Italian Ministry of Health research grants, ARISLA grants). This Unit has all the facilities available for this project and the expertise to perform the experimental activities in which it is directly involved. In particular the laboratories of the ALS Center in Turin are equipped for molecular and cellular biology, neuropathology, and imaging at different levels.

The genetic research uses advanced techniques such as GWAS, exome sequencing and genome sequencing and is aimed at the identification of both causal genes of disease and phenotype regulatory genes (onset age, clinical presentation, and disease progression).

Preferred Research Skills and Competences

Max 100 words

Expertise in the clinical aspects of ALS/MND, including participation to multidisciplinary treatment groups. Knowledge of ALS genetics and of genetic-phenotype characterization. Adequate knowledge of statistical methods for data analysis and databases organization and implementation. A good expertise in biomarkers of ALS.

Curriculum 3 : Preclinical Clinical and Translational Neuroscience

Code 3.2

ERC Field: LS Lfe-sciences; subflieds: LS5_8 Neural basis of behaviour, LS5_18 Innovative methods and tools for neuroscience

Project title: Neural correlates of a wearable supernumerary finger use in healthy subjects and paretic patients

Key words: Rehabilitation; wearable robotics; hand paresis; neuroimaging; Embodiment; Motor synergies; Neurophysiology

Host Institution: University of Siena

Reference person/supervisor: Simone Rossi

Research topic description
The use of wearable robotic extra-fingers to augment manual performances in the healthy (i.e., augmentation) or to ameliorate grasping abilities in paretic patients (compensation) is an emerging/expanding field. We capitalize from the technological development of our wearable robotic supernumerary finger, the Soft Sixth Finger, to investigate (in normal subjects and paretic patients, post-stroke or spinal cord injured) the neural underpinnings of these behavioral augmentations by using a multimodal neuroimaging/neurophysiological approach that will allow us to address not only psychophysical variables, but even underlying modifications of functional brain dynamics, as acquisition of new motor synergies and potential embodiment processes, eventually favoring the inclusion of the device into the user's body schema. Such steps of knowledge are vital because human augmentation will shortly impact the quality of life of both healthy and impaired people, meanwhile pioneering novel paradigms of human robot interaction. We will also verify the amount of recovery of uni- and bimanual task in paretic patients after a prolonged use of the device at home, meanwhile evaluating by fMR the pre-post changes in brain functional connectivity and eventual correlations with the behavioural gain.

Research team and environment
The neuro-engineering cooperative research will involve the Siena Brain Investigation and Neuromodulation Lab (Si-BIN Lab) chaired by Simone Rossi and the Siena Robotics and Systems Lab (SIRSLAB) in Siena chaired by Domenico Prattichizzo. We have a longstanding collaboration (3 4-year EU projects together), common patents (including the soft sixth finger) and scientific activity.
Comprehensive info in this sense can be found at: www.sibinlab.it and http://sirslab.diism.unisi.it.
All technical and scientific facilities to carry out the project are already available on site. The SiBIN lab is located inside the local university hospital, that will guarantee paretic patients recruitment.

Preferred Research Skills and Competences
Required research skills of the doctoral student are: clinical neurological and neurophysiological background, as most of the research will carried out on patients. Basic knowledge of TMS, EEG, TMS-EEG and of actigraphic recordings. Ability to cope with patients and to coordinate the clinical/rehab/neurophysiological database. The doctoral student will be supported by experienced team members for brain imaging analysis.
Curriculum 3: Preclinical Clinical and Translational Neuroscience

Curriculum 3 : Preclinical Clinical and Translational Neuroscience

Code 3.3

ERC Field: LS5, LS5_6, LS5_8, LS7_4

Project title: Study of innovative drugs and medical devices for developmental psychiatric diseases

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

Host Institution: University Roma Tre,

Reference person/supervisor: Viviana Trezza

Research topic description
In this PhD project, sophisticated behavioral and neurochemical approaches will be used in validated animal models of neurodevelopmental disorders, to test the efficacy and safety of new drugs and diagnostic medical devices developed by a biotechnology Company that is cofounding this PhD program. The most promising products will be clinically tested. The PhD student will therefore acquire skills in all phases of the preclinical and clinical development of drugs, including regulatory aspects.

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. In particular, this PhD project involves a training period in a biotechnology Company that is cofounding this PhD program.

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 3.4

Project Title: To study the cellular and molecular mechanisms of neurodegeneration and neuroinflammation in vivo and in vitro

Key words: neuroinflammation, microglia, neuroimaging, RNA/protein quality control

Host Institution: University of Modena and Reggio Emilia

Reference person/supervisor: Michele Zoli

Research project description
Max 250 words
Specific research projects include:
- Role of non-neuronal cells in the pathophysiology and treatment of psychiatric and neurodegenerative disorders
- Pathophysiology of neuronal nicotinic receptors of neuronal and non-neuronal cells in neurodegeneration, inflammation and drug dependence
- Role of molecular chaperones in regulating the properties and functions of membraneless organelles, thus enabling dynamic cellular compartmentalization in response to physiological and external stimuli, and preventing age-related neurodegenerative and neuromuscular diseases.
- Understanding how mutations in genes encoding for several small heat shock proteins and co-chaperone BAG3 cause neurodegenerative and muscular diseases and to what extent pathogenesis is linked to PQC failure.
- 2-photon microscopy live imaging of neuronal circuits, microglia and astrocytes in pathophysiological conditions and reconstruction of their functioning through computational approaches
- Kynurenine pathway dysregulation in the pathophysiology and treatment of psychiatric disorders

Research team and environment
Max 250 words
The Molecular and cellular neurobiology environment at UNIMORE shares facilities (SPF and conventional animal facility, Large instrument Center [https://www.cigs.unimore.it/index.php], Advanced laboratory for bioimages, iPSC facility, Cell culture facility [http://www.cell-lab.unimore.it/site/home.html]) and multiple research collaborations and projects and comprises several PIs including Dr. Silvia Alboni, Johan Blom, Serena Carra, Giulia Curia, Jonathan Mapelli, Luca Pani, Fabio Tascedda, Antonietta Vilella (see the UNIMORE website for details on CV).

Research skills and competences
Max 100 words
Basic cell and molecular biology, confocal (live, STED) imaging, in vitro and in vivo 2-photon imaging, proteomics, analysis of RNA and protein quality control mechanisms, production and analysis of iPSC differentiated to neural and muscular cells, quantitative neurohistology, stereotaxic neurosurgery, small rodent behavioral analysis, neural circuit modelling.

Curriculum 3: Preclinical Clinical and Translational Neuroscience

Host University/Research Institution: UniPegaso/University of Bologna

Code 3.5

ERC Field: LS5_1; LS5_6; LS7_4;

Project title: The role of neuroinflammation signaling in substance use disorders

Key words: substance use disorders, neuroinflammation, gene expression, epigenetics, cytokines and chemokines, reward.

Host Institution: University of Bologna

Reference person/supervisor: Patrizia Romualdi

Research topic description

Neuroinflammation involvement has been proposed in several CNS diseases, including substances use disorders (DOI: 10.1016/j.pbb.2019.01.007). Indeed, inflammatory processes seems to participate to neuronal adaptation following chronic exposure to drugs of abuse, increasing brain vulnerability to develop neuropathologies. In the last few years several studies have suggested relationships between addictive diseases and systemic and central nervous system inflammation, playing a role in the onset and progression of these pathologies (DOI: 10.3390/biom11121824 ; DOI: 10.1007/s11481-021-10046-z).

However, mechanisms by which brain dysfunctions and the related cognitive impairment could promote drug use as well as seeking behavior are not completely understood.

The aim of this PhD project will be to investigate the neuroinflammatory processes underlying the molecular mechanisms of drug abuse, with particular attention to chemokines, cytokines in neuronal and glial cells. Therefore, the study will focus on different immune system components in order to better define their role in SUD and their potential exploitation as biomarkers of addictive disorders.

The PhD student will carry out in vitro and in vivo studies to obtain molecular informations on endogenous neuromodulators, including prokineticines / cytokines and receptors, including PKRs or nuclear receptors such as PPARs, possibly involved in SUD.

Gene expression alterations will be also investigated in different experimental conditions of addicitive drug exposure. Moreover, post-trascriptional epigenetic modifications for genes encoding for inflammatory proteins will be assessed.

This project will be useful to obtain new neuroscience knowledge with high translational value to identify pharmacological targets for the diagnosis and treatment of addictive disorders.

Research team and environment

Our research teams consists of 2 associate professors of Pharmacology, 1 postdoc researcher, 1 PhD students in Biotechnological, Biocomputational, Pharmaceutical and Pharmacological Sciences, 1 Fellowship researcher. This team has been involving for long time in neuroscience and neuropharmacology, focusing the interest on the molecular mechanisms underlying addiction, pain and neurodegenerative diseases. In the last 10 years special attention has been paid to epigenetic mechanisms involved in the above topics.

Preferred Research Skills and Competences

The PhD student should be highly motivated with a degree in a relevant scientific discipline and preferably with experience in laboratory practice (in vitro/in vivo).

Curriculum 3: Preclinical Clinical and Translational Neuroscience

Code 3.6

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: University of Pisa

Reference person/supervisor: Angelo Gemignani

Research topic description
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
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
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 3.7

ERC Field: LS5_5 Neural bases of cognitive processes (e.g. memory, learning, attention)

Project title: New methodologies for neurorehabilitation in pediatric patients

Key words: neurodevelopmental disorders; neuromodulation; virtual reality; neurorehabilitation; neuropsychology.

Host Institution: IRCCS MEDEA

Reference person/supervisor: Cosimo Urgesi

Research topic description
The present research aims to study the use of novel methodologies for boosting the effects of rehabilitation in neurological, psychiatric and neurodevelopmental disorders by using noninvasive brain stimulation techniques combined with new technologies to promote neuroplasticity. The research program will analyze the mechanism of functioning in either healthy or clinical populations, the applications and the potentialities of the main available noninvasive brain stimulation, such as Transcranial magnetic stimulation (TMS), transcranial direct current stimulation (tDCS), transcranial alternating current stimulation (tACS) and transcutaneous vagal nerve stimulation (tVNS), as well as of new technologies, such as Virtual or Augmented Reality, with particular reference to their application for the neurorehabilitation of neurodevelopmental disorders. The research program concerns the study of innovative neurorehabilitation protocols for neurological, psychiatric and neurodevelopmental disorders in developmental age. A multidisciplinary approach to neurorehabilitation allows the integration of different methodologies thanks to the high profile of advanced technological equipment in the diagnostic and therapeutic field and the multimodal evaluation of rehabilitation outcomes.

Research team and environment
The IRCCS Eugenio Medea is a scientific institute specialized in research, treatment and training in the field of neurological and neuropsychic pathologies in the developmental age. It has obtained the IRCCS recognition from the Ministry of Health in different regions. Through the network of rehabilitation centers of the Associazione La Nostra Famiglia, the IRCCS Eugenio Medea has access to the widest range of cases in Italy in the field of neurological and neuropsychological disabilities in the age of development. The research facilities are equipped with:
- Bioinformatics Laboratory, for genetic analysis for clinical and research purposes;
- Bioengineering laboratory, with virtual reality systems and movement analysis, for the development of new technologies applied to neurorehabilitation;
- Neuroimaging laboratory, with a 3T scanner in place and access to a 7T scanner, for the study of the anatomical and functional correlates of neurodevelopmental disorders and the effects of neurorehabilitation;
- Baby Lab (with EEG, NIRS and eye-tracking system) for the early diagnosis of neurodevelopmental disorders;
- Laboratory of Neuromodulation, with transcranial magnetic stimulation systems, transcranial electrical stimulation and transcutaneous vagus nerve stimulation, for the facilitation of cerebral plasticity during neurorehabilitation.

Preferred Research Skills and Competences
The ideal candidate has previous experience and/or interests in neurorehabilitation, neuropsychology and neuromodulation studies in developmental age. He/she has strong background in cognitive neuroscience, cognitive psychology, neuropsychology and aims to foster his/her knowledge in neuropsychology, neurorehabilitation, and neuromodulation of neurological, psychiatric, and neurodevelopmental disorders, with particular emphasis on the potentialities of their application in developmental age.

Host University/Research Institution: University of Camerino

Code 3.8

ERC Field: LS5_6 (Neural bases of behaviour), LS5_1 (Neural cell function, communication and signalling, neurotransmission in neuronal and/or glial cells)

Project title: Role of sleep in shaping neural circuits and behavior

Key words: neurodevelopment, sleep loss, rodent, neuroinflammation, optogenetics, EEG, calcium imaging, glia

Host Institution: University of Camerino

Reference person/supervisor: Luisa de Vivo

Research topic description
Sleep is essential to ensure correct brain functioning and, in the long term, to maintain mental health. Sleep is involved in ameliorating a variety of cognitive processes including emotional regulation and motivated behaviour, but the biological mechanisms linking sleep to maturation of neuronal circuits are still unclear.
The aim of this project is to understand how sleep regulates neuronal activity of key brain regions involved in emotion regulation and motivation. Specifically, the candidate will probe the role of sleep in shaping the structure and function of mesocortical limbic connectivity by using in vivo electrophysiology, calcium imaging and optogenetics in freely behavior rodents. In these brain regions, the candidate will further dissect the cellular pathways modulated by sleep at the molecular level by using single-cell omics techniques to identify potential targetable mechanisms at the basis of behavioral disorders and poor mental health induced by poor sleep during neurodevelopment.

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 main line of research wants 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 is to study 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/

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 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 3.9

Project title: To study the neurobiological, behavioral and pharmacological basis of drug addiction and chronic pain: Focus on the opioid system.

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

Key words: opioid use disorders, pain, opioid agonists, drug abuse, reward and motivation

Host Institution: University of Camerino

Reference person/supervisor: Roberto Ciccocioppo

Research topic description

Opioid abuse is a serious global problem that affects the health, social and economic welfare of all societies. Opioid use disorder (OUD) is a medical condition characterized by the compulsive use of opioids despite adverse consequences from continued use and the development of a withdrawal syndrome when opioid use ends. Animal models provide a rigorous, convenient means to precisely control environmental context and drug exposure, and assess behavioral, molecular and cognitive changes associated with opioid use. Effective utilization of such models can be used to identify more efficacious pharamacotreatments for pain based on opioid agonism while simultaneously limiting their abuse potential. The aim of this PhD project is to study at behavioral, cellular and molecular levels the mechanisms through which is possible to treat pain and addiction by targeting the opioid receptor system.

Research team and environment

This research project will be carried out in the Laboratory of Neuropsychopharmacology, School of Pharmacy, University of Camerino, Italy. The laboratory, headed by 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 50 operant self-administration chambers, EPM equipments, Porsolt swimming tubes, open field arenas for social interaction, Noldus Etovision system for behavioral monitoring, and areas dedicated to surgical procedures etc. Fully equipped lab for immunohistochemistry, light, confocal and scanning electron microscopes are also 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, neurophysiology, pharmaceutical sciences, are preferentially considered for this position.

Curriculum 3: Preclinical Clinical and Translational Neuroscience

Code 3.10

Project title: To study individual vulnerability in substance use disorders: A genetic, molecular and neurocircuitry level approach in rodents.

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, Genetics, Environment, Neurocircuitry, Pharmacology, Electrophysiology,

Host Institution: University of Camerino

Reference person/supervisor: Nazzareno Cannella

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. Two projects in our laboratory are aimed at investigating the mechanisms through which these factors (and their interaction), contribute to SUD vulnerability. Protective factors conveying resilience to SUD will be also scrutinised. 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, University of Camerino, Italy. Nazzareno Cannella and Esi Domi, researchers in the Laboratory of Neuropsychopharmacology, headed by Roberto Ciccocioppo, are responsible of coordinating these projects. The laboratory 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 50 operant self-administration chambers, EPM equipments, Porsolt swimming tubes, open field arenas for social interaction, Noldus Etovision system for behavioral monitoring, and areas dedicated to surgical procedures etc. Fully equipped lab for immunohistochemistry, light, confocal and scanning electron microscopes are also 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 3.11

Project title: To study individual vulnerability to social isolation-induced psychopathologies: Focus on the therapeutic effects of psilocybin in preclinical models.

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

Key words: Electrophysiology; Psychedelics; Neuropharmacology; Brain Mapping and Neurocircuitry

Host Institution: University of Camerino

Reference person/supervisor: Roberto Ciccocioppo

Research topic description

Social isolation and loneliness feeling have profound and lasting negative consequences on physical and mental health. This is particularly relevant during adolescence, a critical period for brain development and proper acquisition of social, affective and cognitive skills. Adverse experiences during adolescence are indeed associated with altered neuronal development and onset of psychiatric illness such as depression, anxiety and stress-related disturbances. Not all subjects do, however, develop such disturbances in response to social isolation. This research project is designed to determine individual vulnerability to this aversive experience by scoring anxiety-, depression- and stress-related behaviors in adult rats isolated earlier in life. Propensity to develop alcohol use disorder will be also evaluated. Analysis will be applied to score the individual behaviors and compute them to determine a global vulnerability score distinguishing rats into vulnerable and resilient. Once identified, these two populations will be compared at genetic, epigenetic and neurofunctional levels to determine the biological factors conferring vulnerability or protection to the consequences of social isolation. Using optogenetic, chemogenetic and *in vitro* patch-clamp electrophysiological techniques experiments will be also conducted to evaluate the impact of social isolation at brain circuitry levels. Finally, the therapeutic effect of psychedelic compound psilocybin on social isolation-induced these psychopathological traits will be studied.

Research team and environment

This research project will be carried out in the Laboratory of Neuropsychopharmacology, School of Pharmacy, University of Camerino, Italy. The laboratory, headed by 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 50 operant self-administration chambers, EPM equipments, Porsolt swimming tubes, open field arenas for social interaction, Noldus Etovision system for behavioral monitoring, and areas dedicated to surgical procedures etc. Fully equipped lab for immunohistochemistry, light, confocal and scanning electron microscopes are also 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 *in-vitro* patch-clamp electrophysiology, optogenetic and behavioral pharmacology, are preferentially considered for this position.

Curriculum 3: Preclinical Clinical and Translational Neuroscience

Code 3.12
Project title: Dissecting the neurobiological mechanisms underlying emotional and social dysregulations in anorexia nervosa

ERC Field: LS_7

Project title: Dissecting the neurobiological mechanisms underlying emotional and social dysregulations in anorexia nervosa

Key words: anorexia nervosa, reward circuitry, adolescence, neuroplasticity

Host Institution: University of Milan

Reference person/supervisor: Fabio Fumagalli

Research topic description
Anorexia nervosa (AN) is a multifactorial psychiatric disorder with the highest mortality and relapse rate among all psychiatric diseases. AN is characterized by a constant fear of gaining weight and begins with a strict self-imposed diet coupled with strenuous exercise regimens, a rewarding experience that progress towards an out-of-control spiral. The first onset of AN is primarily concentrated at puberty in females.
An altered balance of reward and inhibition mechanisms, coupled with emotional dysregulation, contributes to fuel the maintenance of the anorexic phenotype, thus making treatment elusive, and increasing the risk of relapse. Even though AN patients show significant impairments in cognitive, emotional and social processing, corroborated by functional alterations of different brain areas, the underlying molecular mechanisms are still unknown.
The overall aim of the PhD research program will be to dissect the neurobiological mechanisms underlying the socio-emotional dysregulations of AN by means of a preclinical rodent model, Activity-Based Anorexia. Molecular and structural analysis, coupled with specific behavioral tests, will be performed, thus linking molecular alterations in peripheral organs to plastic dysregulations in the brain with AN endophenotype. Besides, the influence of sex will be evaluated given the rising incidence rate of AN in males. These results will be combined with analyses in the blood of adolescent patients in order to translate preclinical findings into the clinical setting.
The expected results are to identify 1) gender-specific molecular signatures of AN, to find predictive and diagnostic markers and 2) molecular mechanisms underlying relapse, which may occur also after weight remission.

Research team and environment
The laboratory of Experimental Psychopharmacology, directed by Prof Fabio Fumagalli, is a dynamic, young and motivating environment. Thus, lab meetings are planned once a month, to better define the research strategy, to share ideas and approaches and to discuss about the progress of experiments. Moreover, young researchers have the possibility to attend scientific meetings with oral and poster presentations. In details, the research team is composed by two associate professors, two post-docs, two PhD students, three pre-doctoral fellows and numerous Master students.
At the Department of Pharmacological and Biomolecular Sciences, awarded as Department of Excellence, we have at our disposal a room in the vivarium [recently renovated to assure high standard level of animal housing, equipped with individual ventilated cages (to avoid bacterial and virus contamination), July 2019] where we have arranged the wheel running cages. The Animal facility is also equipped with specific apparatus for behavioral testing. Laboratories are fully equipped for studies in molecular biology and biochemistry. General equipment includes thermostatic baths, micro-, Beckman ultra- and refrigerated centrifuges, shaking incubators, GeneAmp PCR System, Gel Doc molecular imager, TissueLyser for RNA isolation, nanodrop spectrophotometer and BIO-RAD CFX384 Real Time, western blot systems, fridges, - 20°C and -80°C freezers as well as liquid nitrogen storage units, Star System Virgin autoclaves. In addition, core facilities are available including Flow Cytometry Facility: 13-(Novocyte, ACEA) and 20-paramiters (Fortessa, BD Biosciences) computer assisted flow analyzers and a 17-parameters cell sorting.

Preferred Research Skills and Competences

We look for a highly motivated person with good collaborative and social skills and an open-minded mind-set who is interested in psychiatric disorders and neuroscience. Basic knowledge in neuropsychopharmacology is required.

Preferred technical expertise:

- animal manipulation (rodent model of psychopathologies) and basic knowledge in behavioral tests;
- gene (mRNA extraction, real-time PCR) and protein expression (subcellular fraction extraction, western blot, IF, ELISA) studies;
- morphological dendritic spine analyses using confocal microscopy;
- Skills on the most common Office applications, use of programs for image acquisition and analysis (Image Lab, Photoshop, Fiji) and for statistical analysis (Prism).

Curriculum 3: Preclinical Clinical and Translational Neuroscience

Code 3.13

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

Project title: Potassium channel modulators as new therapeutic options for neuropsychiatric diseases

Key words: Ion channels and transporter; monogenic epilepsies; Developmental disorders; potassium channel openers; genotype-phenotype correlations

Host Institution: University of Naples Federico II

Reference person/supervisor: Prof. Maurizio Taglialatela

Research topic description
The project will explore the potential use of modulators of specific classes of potassium channels (such as those belonging to the Kv7 or KCNT subfamilies) and ionic transporters (SCL8, SCL24) to treat neuropsychiatric diseases characterized by neuronal hyperexcitability. In particular, we aim to use in vitro models represented by primary rodent neurons of neurons differentiated from induced pluripotent stem cells obtained from somatic cells isolated from patients with specific neuropsychiatric diseases to assess the role of specific ion channel and transporter classes in disease pathophysiology, and to verify whether their pharmacological modulation with newly-synthesized or repurposed molecules may positively affect the in vitro phenotype. Subsequently, the most promising drugs will be further validated as promising therapeutic tools in relevant acquired- or genetically-determined in vivo models of the disease.

Research team and environment
Our group has a long-standing tradition in the study of the pathophysiological role of ion channels and transporters 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. Nappi M, et al. Proc Natl Acad Sci U S A. 2022 Apr 12;119(15):e2116887119; 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
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 3.14

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: Michele Simonato, Luigi Grassi

Research topic description
The aim is to identify the neurobiological mechanisms of neurological and psychiatric diseases and to develop innovative strategies for the management and rehabilitation of these disorders. These innovative approaches will include the design of brain machine interfaces, in particular with regard to restoring interaction and communication functions, and advanced therapies, in particular gene and cell therapy. All activities will rely on innovative approaches of data analysis, from machine learning to neuroimaging. 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.

Preferred Research Skills and Competences
The optimal candidate should have a background in biology and/or medicine, with experience in laboratory work, possibly both in vitro and in vivo.

Curriculum 3: Preclinical Clinical and Translational Neuroscience

Code 3.15

ERC Field: LS_5, LS_7 Life Sciences

Project title: To study dysfunctional neuronal autophagy in spinal cord and traumatic brain injury

Key words: autophagy, SCI, TBI, neuroinflammation

Host Institution: University of Messina

Reference person/supervisor: Emanuela Esposito

Research topic description (max 250 words)
Spinal cord injury (SCI) and Traumatic brain injury (TBI) represent major causes of death and long-term disability worldwide; despite important pathophysiological differences between these disorders, in many respects, mechanisms of injury are similar. Autophagy, a lysosome-dependent cellular degradation pathway with neuroprotective properties, result to be implicated clinically and experimentally in the delayed response to TBI and SCI. However, until recently, its mechanisms and function remained unknown, reflecting in part the difficulty of isolating autophagic processes from ongoing cell death and other cellular events. Emerging data suggest that the autophagy flux may be either increased or decreased after central nervous system trauma. While increased autophagy flux may be protective after mild injury, after more severe trauma inhibition of autophagy flux may contribute to neuronal cell death. In this perspective, the understanding of augmentation and/or restoration of autophagy flux may provide a potential therapeutic target for treatment of neuronal injures. Therefore, in this PhD program, the mechanisms of autophagy in neuronal trauma and the frequently used methods to monitor autophagy, the functions of autophagy in SCI and TBI will be investigated, as well as its potential molecular mechanisms based on the pharmacological regulation of autophagy. The *in vitro* and *in vivo* modulation and the data relating to the histological and molecular analyses on preclinical studies, compared with clinical data relating to patients, will allow to facilitate the translation of neuroscientific knowledge on dysfunctional neuronal autophagy from laboratory to clinic, defining new targets of therapeutic or diagnostic interest for the treatment of injuries.

Research team and environment (Max 250 words)
The Research team will consist of: 5 Full/Assistant Professors, 5 Researcher, 3 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 by 12 Department 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 laboratory for cell cultures, laboratories for 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 are available for *in vivo* experiments. The office space for PhD students will be full equipped with desk, pc and printer to analyze data, presentation of reports and research results and write papers.

Preferred Research Skills and Competences (Max 100 words)
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 clinical settings, with focus on preventive therapies, neurorehabilitation and pharmacology development. To acquire this competences, PhD students will perform various activities, including the use of innovative data analysis

methodologies and experimental techniques for the study of the cellular and molecular mechanisms underlying neuronal trauma, like SCI and TBI, to develops novel pharmacological targets or diagnostic markers.

References

1. Lipinski MM, Wu J, Faden AI, Sarkar C. Function and Mechanisms of Autophagy in Brain and Spinal Cord Trauma. Antioxid Redox Signal. 2015;23(6):565-77.
2. Dumont RJ, Okonkwo DO, Verma S, Hurlbert RJ, Boulos PT, Ellegala DB, and Dumont AS. Acute spinal cord injury, part I: pathophysiologic mechanisms. Clin Neuropharmacol. 2001; 24: 254–264.
3. Werner C. and Engelhard K. Pathophysiology of traumatic brain injury. Br J Anaesth. 2007; 99: 4–9.
4. Zhang L, Wang H. Autophagy in Traumatic Brain Injury: A New Target for Therapeutic Intervention. Front Mol Neurosci. 2018;11:190.

Curriculum 3: Preclinical Clinical and Translational Neuroscience

Code 3.16

ERC Field: LS5_7

Project title: To study the impact of different neuromodulation strategies on cognitive rehabilitation in neurological diseases

Key words: neuromodulation; rehabilitation; neural plasticity

Host Institution: University of Palermo

Reference person/supervisor: Massimiliano Oliveri

Research topic description

Non-invasive neuromodulation techniques aim to modify neural plasticity in order to modulate cortical excitability in neurorehabilitation settings. In addition to brain stimulation techniques, such as TMS and tDCS, a new research field proposes the use of visuomotor adaptation integrated with cognitive training as an effective form of neuromodulation. The research topic will investigate the neurophysiological effects of different forms of visuomotor adaptation and cognitive training, administered in the form of serious games, and their impact on cognitive rehabilitation.

Series of patients with neurological disorders (i.e. stroke, dementia of Alzheimer's type) will be investigated in randomized clinical trials, aimed at investigating the effects of this neuromodulation approach as compared with control clinical populations treated with conventional methods

Research team and environment

The research team involves different competencies: neurologists, neuropsychologists, neurophysiologists, working together in a research lab and in clinical settings. The research lab is equipped with techniques for non invasive neuromodulation (TMS, tDCS, tACS) and neurophysiological recordings (motor evoked potentials) and has also access to neuroimaging facilities thanks to well established research collaborations.

Preferred Research Skills and Competences

Competences in neuropsychology; research skills in clinical neurophysiology and application of neuromodulation tools for neurorehabilitation.

Curriculum 3: Preclinical Clinical and Translational Neuroscience

Code 3.17

ERC Field: LS - Life Sciences

Project title: The brain renin angiotensin system as a target for intervention in Alzheimer's disease

Key words: renin angiotensin, Alzheimer's disease, ACE/MasR/AT1R, transgenic mice

Host Institution: University of Cagliari

Reference person/supervisor: Paola Fadda

Research topic description
The PhD program through in vitro and in vivo studies has as main objective to study the role of the renin-angiotensin system (RAS), expressed in the brain where it intervenes in the control of physiological processes, in inflammatory processes and in endothelial problems typical of Alzheimer's disease (AD), to identify new molecular targets.
The program would lead to the training of researchers who will be able to contribute to the identification of new molecular targets and pharmacological interventions with important clinical and social consequences, given that AD has a growing incidence all over the world, high unmet needs, and very few therapeutic options.
The PhD student will be directly and conscientiously involved in the research, in the statistical analysis of the data obtained and in the critical interpretation through the analysis of the available scientific literature. An important objective of the doctoral program will be the inclusion of the student in the local, national, and international scientific system.

Research team and environment
The Division of Neuroscience of the Dept Biomedical Science is in two modern building, situated inside the Campus “Cittadella Universitaria” of the University of Cagliari. It is well equipped for research activities and among its facilities it includes several research laboratories. Infrastructural arrangements are such that the PhD student will have direct and free of charge access to the arsenal of equipment cumulatively available in the laboratories.
The Laboratory Animal Resources unit maintains a secured, animal facility in the building
adjacent to the DiSB. The facility is maintained by a staff of full time animal caretakers.
The PhD student will be coordinated by Professor Paola Fadda who has a broad background in Neuroscience, with high profile expertise in Neuropharmacology. In addition, her laboratories have long-standing experience in behavioral pharmacology and neurochemistry and expertise in molecular and cellular biology techniques.

The members of Prof. Fadda’s team have the multidisciplinary competences needed to support the PhD student. Prof. Fadda will monitor the progression of the experimental procedures and will be responsible for sharing data and for the establishment and maintenance of a constant information flow among the Team components and the PhD student. In-person weekly meetings will be organized, to share and discuss the results, as well as to evaluate the opportunity of possible changes in orientation of the experimental strategies.

Preferred Research Skills and Competences
The PhD student must have no problems with animal research activities and a general laboratory background is well accepted. She/he must work in team and possess an attitude to share it experimental and research experiences

Curriculum 4: Computational and Systems Neuroscience

Code 4.1

ERC Field: PE7 – LS5 - SH4

Project title: Developing a new class of ingestible and new recording techniques for testing gastro-intestinal physiology at correlational and causative levels

Key words: Ingestible devices - electrogastrography- magnetogastrography - Gastroenteric interoception – Neuropsychiatric disorders

Host Institution: CLN2S - Istituto Italiano di Tecnologia (IIT) - Rome

Reference person/supervisor: Giancarlo Ruocco

Research topic description
The gut-brain axis has not just the clear homeostatic purpose of regulating food intake, but also modulates a variety of higher-order processes ranging from emotion regulation to decisions. Moreover, alterations of gut-brain axis seems to be of relevance for different neuro-psychiatric disorders like for example depression and anxiety. Organs located in the abdominal cavity, such as the stomach and the intestine, are arduous and complex to access and monitor without relying on invasive and expensive methods. The proposed research program, aims to foster a radical change in basic and applied research, by developing a new class of ingestible devices and a new technology for recording magneto-gastric activity for exploring the gastro-intestinal physiology at both causative and correlational level. The proposed research program aims to the production of new technology that has the potential to change basic and applied in fields ranging from clinical medicine to neuro-psychiatry.

Research team and environment
The selected Phd student will work closely with: I) a team of physicists and bio-engineers based at the CLN2S - IIT in Rome, and dealing with the development of new technologies for studying the gut-brain axis; ii) a team of biologists and veterinarians for testing the developed devices in animal models (mainly piglets) ; iii) team of neuroscientists and neuro-gastroenterologists interested in testing the devices in humans once appropriate patents are obtained.

Preferred Research Skills and Competences
Experience in research concerning one (or more) out of the points listed below: 1) design of biomedical applications with particular reference to ingestible and wearable diagnostic devices; 2) design and implementation of electronic systems (developing board, communication systems, data storage and transfer,…) with particular emphasis on applicability to scientific research; 3) basic knowledge concerning neuro-muscular gastrointestinal activity and its recording with established (electro-gastrogram) and innovative technology (magneto-gastrogram); 4) basic knowledge about the principles of optically pumped magnetometers.

Curriculum 4: Computational and Systems Neuroscience

Code 4.2

ERC Field: LS5_16 Systems and computational neuroscience

Project title: The Neurophysiological Bases of Biological Motion: From Laboratory to Clinics

Key words: **transcranial magnetic stimulation,** behavioural neuroscience, neurophysiology, system neuroscience

Host Institution: University of Bologna, Department of Biomedical and Neuromotor Sciences

Reference person/supervisor: Patrizia Fattori

Research topic description

Transient inactivation of parietal regions with TMS during reaching and grasping.

Parietal cortex is essential to perform accurate interactions within the peripersonal space. This research topic aims at understanding the functional role of brain areas (in particular the medial parietal ones) in encoding reaching-grasping and in reacting to dynamic perturbation by creating transient 'virtual lesions' with transcranial magnetic stimulation (TMS) in healthy humans. The PhD student will design and perform TMS experiments using common TMS protocols, reaching/grasping apparatuses and kinematic systems. In particular, experimental designs including perturbation of grip size and wrist orientation will be developed. She/He will be involved in all the phases of the experiments, from literature reviews to experimental design, participant recruitment, data collection, analysis and manuscript publication. She/he will also learn the most used statistical approaches for sample size estimation and for data analysis performed to find the causal link between brain areas and visuomotor behavior. The knowledge of the functions of the parietal cortex will consent the development of rehabilitation protocols based on dynamical perturbations, driven by the idea that to help recovery it should be better to force the brain to find solutions to perturbing forces rather than just help the motor periphery in executing motor tasks.

Research team and environment

The PhD student will be involved in a team which includes researchers with different expertise in systems and computational neuroscience, and also having different levels of expertise in transcranial magnetic stimulation. The lab has also national and international collaborations with other labs where the PhD student can learn other techniques and increase her/his knowledge about experimental skills and data analysis. The PhD student will operate in a fully equipped laboratory with:

- monophasic and biphasic stimulators (Duomag, DeyMed) which enable to perform all the common experimental TMS protocols such as single pulses and repetitive TMS.
- EMG amplifier (Digitimer)
- trigger box and signal management unit (CED1401, Signal).
- pupil-based eye tracker (EyeLink)
- a neuronavigator (Cortexplore)
- motion tracking system (Vicon)
- Touch screens and grasping apparatus.
- Modern and fast computers equipped with Matlab and Statistica for data analysis.

The TMS lab belongs to the Department of Biomedical and Neuromotor sciences of the University of Bologna, which offers students and faculties a rich scientific environment made of periodic seminars, journal clubs and scientific meetings where the students can interact with expert faculties of the department or invited external speakers. Moreover, the University of Bologna offers important initiatives of communication and dissemination

such as the ‘Festival della Scienza Medica’, where Nobel laureates are often invited to give talks, and the ‘Researchers night’, where the PhD student will be involved and acquire dissemination skills.

Preferred Research Skills and Competences

The ideal PhD student for this research topic may have competences in the followings:
- Neuronavigation procedures
- TMS stimulation procedures and safety rules
- programming with Matlab and/or other languages.
- basic statistical tests and use of softwares for statistical analyses (e.g. Statistica).
- kinematic data collection (with Vicon system) and analysis
- eye tracking data collection and analysis.

The knowledge of the bases of TMS and its protocols and of the basic functions of cortical areas is required.
Abilitiy to critically read bibliography in the field is appreciated.

Curriculum 4: Computational and Systems Neuroscience

Code 4.3

ERC Field: LS5_18 Innovative methods and tools for neuroscience, PE3_16 physics of biological systems

Project title: Methods to study the mechanisms for large-scale functional connectomics

Key words: Topology, Functional connectivity, Effective connectivity, Physiological measures

Host Institution: University of Chieti-Pescara, Department of Neuroscience, Imaging and Clinical Sciences

Reference person/supervisor: Stefania Della Penna and Richard Wise

Research topic description

Overall, the PhD student will gather high quality training in the field of systems and computational neuroscience and will specifically deal with methods for non-invasive functional imaging of the human brain. The research activity will be carried out at the University of Chieti-Pescara. Specific attention will be devoted to the study of functional connectomics, its architecture and its dynamics, for example, (i) developing new methods and procedures to non-invasively record the cerebral signal with the aim of improving the estimation of the connectome through multimodal imaging with the same setup, (ii) focusing on specific topological properties of the functional large-scale connectome obtained from non-invasive techniques (e.g. MEG, fMRI, etc.) and their relationship with physiological measures (e.g. obtained from MRI, or other electromagnetic measures) and (iii) examining generative models of connectivity also to explain these relationships. Part of the research will be conducted at a lab abroad among the experts in this field of research. Notably, the architecture of communication found in this research could also be of interest for the other institutions participating in the PhD programme in Theoretical and Applied Neuroscience, providing multidisciplinary knowhow that may be used in different employments in public and private institutions, in addition to the possibility to start an academic career, or a freelance activity with a higher qualification. Finally, the mechanisms studied in this research could be tested in different areas of application (e.g. networks of computers).

Research team and environment

The research will be conducted 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.

The research team participated in BRAINSYNC (EUFP7) on large scale connectivity in the human brain, to the Human Connnectome Project (NIH-2010), to MEGMRI (EUFP7), devoted to the development of a prototype able to record MEG and ULF-MRI from humans with the same setup, to the project Breakben (EU-FET) aiming at breaking the non-uniqueness barrier of MEG through the implementation of a system providing MEG, ULF-MRI, NCI (Neural Current Imaging) and CDI (Current Density Imaging) on the same setup, and is participating to the OXiNEMS (EIC-Pathfinder) aiming at implementing a new generation of field-tolerant magnetic field detectors to allow innovative multimodal imaging.

Preferred Research Skills and Competences

The candidate should have a master degree with *technical/scientific background*'s possibly in the area of physics or engineering. Background in physics applied to medicine or biology or biomedical engineering will be particularly appreciated. Moreover, skills in programming, e.g. Matlab, or Python, or C++ will also be an advantage.

Curriculum 4: Computational and Systems Neuroscience

Code 4.4

ERC Field: LS5 / SH4

Project title: Deep Neural Networks of emotional perception in the subcortical visual system

Key words: Deep neural networks, self-supervised learning, blindsight, superior colliculus, amygdala, non-conscious perception

Host Institution: University of Turin

Reference person/supervisor: Marco Tamietto

Research topic description
Deep neural networks (DNNs) are computational models emerging from the interaction between artificial intelligence (AI) and neuroscience. DNN are making strides in bridging the gap between cognitive functions and neurobiology, as they approximate how complex information-processing functions, such as visual recognition and categorization, may be carried out by biological neural networks at the single-unit and population response level. Current DNN models of the primary (geniculo-striate) visual system attain human-like performance, predict representational transformations, and reflect organizing principles of the primate vision (e.g., fine-to-coarse retinotopy, hierarchy, increasing perceptual invariance). However, these applications have been essentially grounded on models of the ventral cortical stream, starting from V1 and progressing to the temporal lobe, and there is no attempt to implement the architecture and constraints of the extra-geniculate visual system. Recent literature in human and non-human primates neuroscience is revealing a role for such subcortical visual structures in more complex analyses of retinal input than previously believed, especially for biologically salient (e.g., emotional) signals. The project aims at building up a neurobiologically-inspired convolutional DNN model that approximates physiological, anatomical, and connectional properties of the subcortical visual circuit involved in the perception of socially meaningful visual signals (e.g., facial and bodily expressions). This should enable us to characterize and isolate the initial computations and discriminations that the subcortical visual system can perform, based uniquely on the information it directly receives from the retina. Capitalizing on this knowledge, model predictions can then be tested in human and non-human primate with permanent damage to V1, who base their vision on extra-geniculate visual system.

Research team and environment
The project is embedded in the context of an ERC Consolidator Grant (LIGHTUP; PI: Marco Tamietto) devoted to the investigation of V1-independent vision in human and non-human primates with neuroimaging, electrophysiological and AI methods. Current Lab facilities include a broad range of methods and techniques: 3T and 7T (f)MRI, neurophysiological recordings and brain stimulation (TMS). In addition to facilities at two university belonging to the national consortium, such as University of Torino and University of Parma, the successful applicant will have access also to NIH (USA, prof. D.A. Leopold), the University of Oxford (UK, Prof. H. Bridge) and Tilburg University (NL). Current team members include researcher from different background in neuroscience, including neuropsychologists, experts in fMRI, and neurophysiologists investigating V1-independent vision in non-human primates.

Preferred Research Skills and Competences
Candidates should have a background in either computational neuroscience, physics, biomedical engineering, or equivalent fields.
The ideal candidate should have a keen interest in investigating the visual system combining AI methods, particularly deep neural networks, with neuroimaging and neurophysiological measures. Strong expertise in scripting and scientific programming with Python and MatLab, computational modelling and command of quantitative data analysis and statistics is required, along with high proficiency in written and spoken English.

Curriculum 4: Computational and System Neuroscience

Host University/Research Institution: Scuola Superiore Sant'Anna

Code 4.5

Project title: Neuro-inspired artificial intelligence for healthcare

Key words: artificial intelligence, healthcare, big data, data processing

Host Institution: Scuola Superiore Sant'Anna

Reference person/supervisor: Silvestro Micera, Sara Moccia

Research topic description
Neuroscience today plays a vital role in new medical procedures. For example, it helps people suffering from neurodegenerative disorders and seizures. Despite this, its study and application in healthcare research lags far behind the rest of the industry sector. This may be attributed to concerns and implications from the perspective of ethics and guidelines. Studying patterns and predicting behavior change in healthcare holds a huge potential. Finding new, accurate and reliable ways of doing so could also be of great benefit to the medical community. In the public administration, neuroscience could help give more accurate data on fields ranging from packaging testing to ad concepts, and from purchasing decisions to enhancing product positioning. Here, merging neuroscience with the emerging artificial intelligence algorithms may represent the key for tackling current limitations and translated the research methodology into the actual practice.

Research team and environment
The team consists of Silvestro Micera (full professor), Sara Moccia (junior assistant professor), Alberto Mazzoni (assistant professor) from the Bioelectronics Area of the BioRobotics Insitute at Scuola Superiore Sant'Anna (SSSA). The team has large experience in neuroscience and artificial intelligence algorithms in the medical field. Prof. Micera (H-index 56), who is the head of the Bioelectronics Area, is a worldwide recognized researcher in the neuroengineering field, while Dr. Moccia (H-index 12) is an emerging researcher in the field of deep learning for medical data analysis. As a public institution, SSSA plays its role in favor of the community, proposing as a center of reference for avant-garde training, with paths of excellence from bachelor to PhD. The BioRobotics Institute at SSSA was specifically created to host the research activities of SSSA at the cutting edge of the most important sectors of interdisciplinary engineering-oriented technological innovation. The Institute has built a wealth of knowledge and expertise in several fields of bionics, such as: neuroscience, artificial intelligence, implantable devices and medical robotics. The Institute includes over 200 persons, including PhD students, Post-Doc researchers, and 17 Faculty members leading 9 Research Areas and 8 Laboratories

Preferred Research Skills and Competences

People involved in the research project should have research skills such as ability to (i) collect and identify relevant data to investigate the research questions, (ii) advance the state of the art through the design of trustworthy artificial-intelligence algorithms to tackle the challenges encoded in the data (e.g., large variability, large size, poor standardization), (iii) implement and test the algorithms using the newest hardware solutions available at the state of the art. Competences will range from data management, data processing, programming, and artificial-intelligence algorithm implementation.

Curriculum 4: Computational and System Neuroscience

Code 4.6

Project title #1: Computational models for neuroprosthetics

Key words: artificial intelligence, biophysics, neuroprosthetics

Host Institution: Scuola Superiore Sant'Anna

Reference person/supervisor: Silvestro Micera, Alberto Mazzoni

Research topic description – Project #1

Neuroengineering is a discipline combining engineering including micro and nanotechnology, electrical and mechanical, and computer science with cellular, molecular, cognitive neuroscience with two main goals: (i) increase our basic knowledge of how the nervous system works; (ii) develop neuroprosthetic systems able to restore functions in people affected by different types of neural disability.

The student enrolled in this project is going to develop advanced computational models based on biophysics and machine learning to design personalized neuroprosthetic systems. In particular, the student is going to model both the neural structure to stimulate and the neural interface to be used to gather useful information about the main characteristics of the stimulation device and the way to select and optimize the stimulation strategies. We are going to investigate both invasive and non-invasive approaches.

Research team and environment

The team consists of Silvestro Micera (full professor), Sara Moccia (junior assistant professor), Alberto Mazzoni (assistant professor) from the Bioelectronics Area of the BioRobotics Insitute at Scuola Superiore Sant'Anna (SSSA). The team has large experience in neuroscience and artificial intelligence algorithms in the medical field. Prof. Micera (h-index 56), who is the head of the Bioelectronics Area, is a worldwide recognized researcher in the neuroengineering field, while Dr. Mazzoni (h-index 22) and Moccia (h-index 12) are an emerging researcher in the field of computational neuroscience and deep learning for medical data analysis, respectively. As a public institution, SSSA plays its role in favor of the community, proposing as a center of reference for avant-garde training, with paths of excellence from bachelor to PhD. The BioRobotics Institute at SSSA was specifically created to host the research activities of SSSA at the cutting edge of the most important sectors of interdisciplinary engineering-oriented technological innovation. The Institute has built a wealth of knowledge and expertise in several fields of bionics, such as: neuroscience, artificial intelligence, implantable devices and medical robotics. The Institute includes over 200 persons, including PhD students, Post-Doc researchers, and 17 Faculty members leading 9 Research Areas and 8 Laboratories.

Preferred Research Skills and Competences

People involved in the research project should have research skills such as ability to (i) collect and identify relevant data to investigate the research questions, (ii) advance the state of the art through the design of trustworthy artificial-intelligence algorithms and/or biophysical models to tackle the challenges encoded in the data (e.g., large variability, large size, poor standardization), (iii) implement and test the algorithms using the newest hardware solutions available at the state of the art. Competences will range from biophysics, data management, data processing, programming, and artificial-intelligence algorithm implementation.

Curriculum 4: Computational and System Neuroscience

Code 4.7

Project title #2: Brain decoding for neuroprosthetic control

Key words: artificial intelligence, biophysics, neuroprosthetics

Host Institution: Scuola Superiore Sant'Anna

Reference person/supervisor: Silvestro Micera, Sara Moccia

Research topic description
In the recent past, neuroengineers have developed promising solutions to restore grasping motor functions in people after neurological disorders by stimulating the peripheral nerves. The selectivity of these devices in terms of single finger control gives hope to restore the full range of hand and finger movements. However, it becomes necessary to develop advanced solutions to allow the patients to get full control of the neuroprosthetic system. This will be the goal of the student enrolled in this project. In particular, we are going to investigate how invasive cortical recordings can be used to decode hand and finger functions. The project will involve experiments with non-human primates and patients with epi and intracortical implants and it is part of the ITN ReWire.

Research team and environment
The team consists of Silvestro Micera (full professor), Sara Moccia (junior assistant professor), Alberto Mazzoni (assistant professor) from the Bioelectronics Area of the BioRobotics Insitute at Scuola Superiore Sant'Anna (SSSA). The team has large experience in neuroscience and artificial intelligence algorithms in the medical field. Prof. Micera (h-index 56), who is the head of the Bioelectronics Area, is a worldwide recognized researcher in the neuroengineering field, while Dr. Mazzoni (h-index 22) and Moccia (h-index 12) are an emerging researcher in the field of computational neuroscience and deep learning for medical data analysis, respectively. As a public institution, SSSA plays its role in favor of the community, proposing as a center of reference for avant-garde training, with paths of excellence from bachelor to PhD. The BioRobotics Institute at SSSA was specifically created to host the research activities of SSSA at the cutting edge of the most important sectors of interdisciplinary engineering-oriented technological innovation. The Institute has built a wealth of knowledge and expertise in several fields of bionics, such as: neuroscience, artificial intelligence, implantable devices and medical robotics. The Institute includes over 200 persons, including PhD students, Post-Doc researchers, and 17 Faculty members leading 9 Research Areas and 8 Laboratories.

Preferred Research Skills and Competences
People involved in the research project should have research skills such as ability to (i) collect and identify relevant data to investigate the research questions, (ii) advance the state of the art through the design of trustworthy artificial-intelligence algorithms and/or biophysical models to tackle the challenges encoded in the data (e.g., large variability, large size, poor standardization), (iii) implement and test the algorithms using the newest hardware solutions available at the state of the art. Competences will range from biophysics, data management, data processing, programming, and artificial-intelligence algorithm implementation.

Curriculum 4: Computational and System Neuroscience

Code 4.8

ERC Field: SH4

Project title: Bio-signals analysis and imaging in epilepsy

Key words: imaging, genetics, advanced MRI

Host Institution: University of Messina

Reference person/supervisor: Angelo LABATE

Research topic description

Predictive biomarkers are becoming increasingly important tools in drug development and clinical research and represent the new frontier for researcher even in epilepsy 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. Since 1990s brain imaging techniques, have become routine in the evaluation of patients with epilepsy. Because of the frequent association of imaging abnormalities with epilepsy regardless their drug response, imaging techniques are attractive candidates for diagnostic or prognostic biomarkers. In the last twenty years, a mass of abnormalities has been described in patients with epilepsy, in particular, using routine MRI with specific epileptic protocols as well as morphometric analysis, magnetic resonance relaxometry, diffusion-weighted imaging, MR spectroscopy, volumetry, voxel-based analysis and PET imaging. Many of these abnormalities could, in theory, serve as biomarkers of epilepsy. First of all, the use of an optimal epileptic worldwide imaging protocol represents the background to look for potential and specific biomarkers. Indeed, a typical clinical scanning protocol for a patient with epilepsy must include T1-weighted imaging, T2-weighted imaging, fluid-attenuated inversion recovery (FLAIR) imaging, and 3D volume acquisition sequences. T1-weighted is commonly used to initially define the brain anatomy, T2-weighted and FLAIR images to detect specific brain pathologies such as hippocampal sclerosis; a high resolution 3D volume acquisition provides a useful degree of T1-weighted contrast between grey and white matter, and helps greatly in the identification of subtle abnormalities, such as malformations of cortical development. Moreover, finding a lesion at MRI in a patient with epilepsy does not automatically mean that the lesion is the culprit. Some lesions are epileptogenic, whereas others are not. 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, mainly the surgical therapy, in the majority of epilepsy patients. Likewise, in epilepsy 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.

Nevertheless, in this context, only prospective epidemiologic studies may allow the identification of early and accurate electro-clinical and imaging biomarkers of a mild course in MTLE. Keeping that in mind, with a mean follow-up of more than 11 years, our group recently showed that mild MTLE remained drug-responsive in about three-fourths of patients and became refractory in the remaining one-fourth. Furthermore, at seizure onset, earlier age at onset, history of febrile convulsions, and the presence of hippocampal sclerosis on MRI, represent prognostic epileptic biomarkers of refractoriness. Using advanced MRI technique, [9,10,11] we further showed a significant reduction of fractional anisotropy along the white matter of the temporal lobes in drug-resistant MTLE, implying it as a valuable biological marker of refractoriness. Afterwards, we extended these findings and showed diffusion abnormalities and reduced cortical thickness of the corpus callosum only in patients with refractory MTLE, suggesting that differences in the distribution of such alterations might represent a biomarker of refractoriness. The other major group of pathologies in which MRI has made massive contributions to epilepsy throughout imaging is in malformations of cortical development (MCDs). Imaging dramatically helped to identify very subtle and occult lesion cause of epilepsy before considered syndromes with negative MRI. MCDs are usual

in children and should be sought in children with epilepsy. MRI can correctly define diffuse malformations such as lissencephaly, periventricular nodular heterotopia, and band heterotopia. It can also define hemimegalencephaly, schizencephaly, and focal subcortical heterotopia. Focal lesions such as focal cortical dysplasia (FCD) are the most common developmental pathologies in children with extratemporal lobe seizures and recognition of these lesions can have an important bearing on the management and prognosis. Despite an overlap of imaging features, each type of FCD can variably exhibit these features. General MRI features of FCD include cortical thickening, blurring of white matter-grey matter junction with abnormal architecture of subcortical layer, T2/FLAIR signal hyperintensity of white matter with or without the transmantle sign, T2/FLAIR signal hyperintensity of grey matter, abnormal sulcal or gyral pattern, segmental and/or lobar hypoplasia/atrophy. Hence, MRI features could differentiate between Taylor's FCD and non-Taylor's FCD in most cases, although there is some overlap. As in TLE, detailed MRI diagnosis may modify the presurgical workup and surgical planning and may have prognostic value in MCDs patients.

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.