BRAIN DAY 2020

of the PADUA NEUROSCIENCE CENTER

The Padua Neuroscience Center is a unique multidisciplinary environment that integrates many different scientific backgrounds with the common effort to understand the brain mechanisms. In this scenario, sharing scientific ideas and technical expertise represents a crucial and fundamental step to establish collaborative networks and to draft powerful scientific plans.
The PNC Brain Day 2020 is the opportunity for the PIs:

1) to get to know each other in a series of short seminars and round tables.
2) to contribute to the identification of cross-platform research lines characterizing the PNC scientific plan
3) to render PNC a unique and competitive research unit

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SETTEMBRE

08:45

AULA IPPOLITO NIEVO

Cortile Antico Palazzo Bo via 8 Febbraio 2

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Padova Neuroscience Center

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UNIVERSITÀ DEGLI STUDI DI PADOVA

PNC Brain Day September 25th 2020, Sala Ippolito Nievo, Cortile Antico Palazzo del Bo

8.45: Welcome addresses
Magnifico Rettore Prof. Rosario Rizzuto and PNC Director Prof. Maurizio Corbetta

9.00: Session 1 - Overview of the research and perspectives (12+3Q&A)
Prof. Megighian
Prof. Caleo
Prof. Zorzi
Prof. Finos

10.00: Session 2 - Overview of the research and perspectives (12+3Q&A)
Prof.ssa Pietrobon
Prof.ssa Pennuto
Proff. Angrilli e Spironelli
Prof.ssa Gervain

11.00 Coffee break (30 minutes)

11.30: Session 3 - Overview of the research and perspectives (12+3Q&A)
Prof.ssa Del Felice
Dr. Bonato
Dr. Cona
Prof. Vallesi

12.30: Session 4 - Overview of the research and perspectives (12+3Q&A)
Prof. Vassanelli
Prof. Bortolozzi
Dr. Suweis
Dr. Dal Maschio

13.30: Lunch

14.30: Session 5 - Overview of the research + PNC funded project (15+5Q&A)
Dr.Visalli (12+3)
Dr.ssa Lodovichi
Prof. De Marchi
Prof.ssa Bertoldo
Prof. Corbetta

16.15: Coffee break (45 minutes)

17.00: Session Future directions - Round tables and discussion
17.30: "Padova Neuroscience Center-PNC" news: town hall discussion
19.00: Aperitive and end of the workshop

Ore 8.45 Welcome addresses

Magnifico Rettore prof. Rosario Rizzuto and PNC Director Prof. Maurizio Corbetta

Ore 9.00: Session 1 - Overview of research and perspectives (12+3Q&A)

Visuomotor responses. Are flies so different from higher vertebrates?
Prof. Megighian (DSB)

Navigation of an individual in the environment is an essential part of his adaptive and social behavior.
Visuomotor responses to visual stimuli are a key point for navigation and it appear now clear that they rely on specific basic mechanisms which seem to be substantially maintained from the evolutive point of view. These mechanisms will be briefly discussed considering the acquired knowledge in invertebrates (mainly flies and bees) and behavioral experiments carried on in our lab.

Plasticity and recovery after stroke
Prof. Caleo (DSB)
Ischemic injuries within the motor cortex results in profound functional deficits, and current rehabilitation protocols achieve only limited recovery of motor abilities. The brain reorganizes spontaneously after injury, and it is believed that appropriately boosting these neuroplastic processes may restore function via recruitment of spared areas and pathways. In this presentation, I will describe our recent work on novel experimental therapies for the recovery of motor function in a mouse model of focal stroke. Specifically, we have tested experimental approaches in which robotic training is coupled with “plasticizing” therapies drugs that render the spared, undamaged pathways more sensitive to experience-dependent modifications.

“***Number sense" in humans, animals, and machines: A computational cognitive neuroscience approach***.
Prof. Zorzi (DPG)

I will discuss research carried out in my laboratory at the frontiers between cognitive science, computer science and neuroscience aimed at understanding the computational bases of the visual "number sense" - i.e., the ability to perceive and represent numerosity. I will show how computational modeling based on deep neural networks complements and informs behavioral and neuroimaging studies

Inference in Neuroscience
Prof. Finos (DPSS)

I'm interested in statistical inferential problems in Neuroscience. This cover the topic of statistical modeling in single and multi subjects studies, univariate and multivariate multiple testing in fMRI, EEG and fNRIS.
I'm also very focused on informal inferential problems such as machine learning and classification problems (e.g. Brain-Computer interface)

Ore 10.00: Session 2 - Overview of the research and perspectives (12+3Q&A)

Migraine: a disorder of excitatory-inhibitory balance in multiple brain networks? Insights from genetic mouse models of the disease.

Prof.ssa Pietrobon (DSB)

Migraine is much more than an episodic headache. It is a complex brain disorder, characterized by a global dysfunction in multisensory information processing and integration, as e.g. indicated by the fact that i) during the attack, the headache is associated with amplification of percepts from multiple senses, ii) in the interictal period, altered brain processing of noxious and non-noxious sensory information is revealed by functional imaging and neurophysiological studies, which point to alterations in multiple brain networks in addition to those related to pain; iii) in a third of migraineurs the headache is preceded by an aura (a typically sensory hallucination, whose neurophysiological correlate is cortical spreading depression, CSD). The molecular, cellular and circuit mechanisms of the primary brain dysfunctions that underlie migraine onset, susceptibility to CSD and altered sensory processing remain largely unknown and are major open issues in the neurobiology of migraine. Genetic mouse models of a rare monogenic form of migraine with aura provide a unique experimental system to tackle these key unanswered questions. I will describe the functional alterations we have uncovered in the cerebral cortex of genetic mouse models and discuss the insights into the cellular and circuit mechanisms of migraine obtained from these findings.

A molecular biology and biochemistry approach to link basic and preclinical neuroscience

Prof. Pennuto (DSB)

The goal of our lab is to gain insights into the pathological processes underlying neurological disorders, and to use this information for therapy development. Our central hypothesis is that the alteration of the native structure and function of disease-related proteins is responsible for neurodevelopmental and neurodegenerative diseases. Our experimental approach is based on the analysis of the physiological function of disease-related proteins at the molecular and biochemical level in cells and mice. This approach is complemented by the use of in vitro and in vivo models of neurodevelopmental and neurodegenerative diseases. Our rationale is that elucidating the physiological relationship between protein structure and function and the pathological processes occurring in neurological disease may ultimately lead us to identifying novel biomarkers and molecular targets for therapeutic purposes. By undertaking this approach, we have previously characterized the impact of specific post-translational modifications of proteins linked to neurodegenerative diseases, such as ALS and SBMA, which affect protein structure and function and suppress toxicity, and we identified specific drugs that induce these modifications and attenuate neurodegeneration.

Effects of supine vs sitting position on cortical and cognitive activity: implications for fMRI method and clinical research.

Prof. Angrilli, Prof.ssa Spironelli (DPG)

An important portion of neuroscience research in the last two decades has been carried out by means of PET and fMRI methods. These necessarily measure brain activity while the subject lays down horizontally. Another portion of research was carried out with Evoked Potentials, Electroencephalography, Magnetoenecefalography, Transcranial Magnetic Stimulation, methods that require the participant to be typically seated. All these methods measure different aspects of functional activation of the brain: indeed, results achieved by measuring the electrical cortical activity with the EEG or MEG can not be compared easily with the metabolic measures (PET, fMRI) of brain activation. In addition to the instrument, also body position might play an important role in the differences typically found among the methods. The sitting position can be considered a more ecological condition for awake active individuals, but fMRI and PET methods force individuals to lay down in a supine position. Our past research showed how supine compared to the sitting control posture was associated with altered cortical, perceptual and cognitive processing. Current research is further investigating the nature of this phenomenon which should help understanding the comparability/generalization of the studies carried out with fMRI in which participants are typically held in supine position.

The role of early speech perception in language acquisition

Prof.ssa Gervain (DPSS)

Infants first encounter speech in the womb and in a very short time after birth they acquire their native language(s) with remarkable ease and efficiency despite their immaturity and without explicit instruction.
My work explores the hypothesis that the sound patterns of the speech input, starting from the prenatally heard speech signal, correlate with abstract grammatical properties of language and thus help infants bootstrap language acquisition. The talk will present some of my current work exploring this hypothesis.

Ore 11.00 Coffee break at Caffe' Pedrocchi (30 minutes)

Ore 11.30: Session 3 - Overview of the research and perspectives (12+3Q&A)

Investigating neurophysiology in the development of robotic devices for healthy ageing and rehabilitation
Prof. Del Felice (DNS)

An ageing population poses an increasing strain on health care systems in terms of increased disability due to disease (e.g, stroke, falls and consequent fractures, etc) or loss of abilities and independence related to older age. Assistive technologies may reduce this burden both as preventive and rehabilitative tools. In fact, fine-tuned devices, i.e. exoskeletons, that adapt to end-user physiological reactions are still missing. This research line focuses on the development of exoskeletons which support healthy elderly during walking or promote rehabilitation after central nervous system (CNS) lesions with a feed-back feedforward control system dictated by neuromuscular [electroencephalografic (EEG) and electromyographic (EMG)] control. Towards this goal, neurophysiological mapping of cerebral and muscular activity during walking and balance is mandatory as well as the definition of the neurophysiological changes induced by the Human Machine Interaction (HMI).

Multitasking allows exhacerbating cognitive deficits after stroke (talk) and might allow detecting early symptoms in dementia
Prof. Bonato (DPG)

Cognitive Neuroscience and Lifespan
Dr. Cona (DPG)

The main interest of our lab is exploring the neural mechanisms and temporal dynamics underlying high-level cognitive functions by means of a variety of neuroimaging techniques (TMS, EEG, ERPs, MEG, fMRI). In particular, we investigate the neural correlates of prospective memory (PM), which is the ability of remembering to accomplish goals at the appropriate time in the future. We also explore brain structures that are relevant for processing magnitudes, such as space, time and numbers. We are interested in the lifespan perspective, looking at the cognitive and functional cerebral changes occurring from infants to elderly, in both healthy and pathological populations.

Studi di asimmetrie emisferiche funzionali frontali
Prof. Vallesi (DNS)

Ore 12.30: Session 4 - Overview of the research and perspectives (12+3Q&A)

Connecting brain and artificial neurons
Prof. Vassanelli (DSB)

The brain, with its remarkable computational properties, provides animals with capabilities of physical autonomy, interaction and adaptation that are unmatched by any artificial system. The brain is a complex network that has evolved to optimize processing of real-world inputs by relying on electrical events and self-reorganizing connectivity. Spikes (the events) are transmitted between neurons through synapses which undergo continuous 'birth'-'death' and adjustment, reconfiguring brain circuits and adapting processing to ever changing inputs. SYNCH will create a hybrid system where a neural network in the brain of a living animal and a silicon neural network of spiking neurons on a chip are interconnected by neuromorphic synapses, thus enabling co-evolution of connectivity and co- processing of information of the two networks (project website: https://synch.eucoord2020.com/)

Human brain organoids as a model to recapitulate neuronal dysfunction in Parkinson's disease
Prof. Bortolozzi (DFA)

Increasing evidence suggests that Parkinson's disease might be driven by lysosomal dysfunction with cellular waste-clearing1. The project aims to characterize functional midbrain organoids derived from patients carrying pathological variants of the gene encoding the beta-glucocerebrosidase (GBA) lysosomal enzyme, known to confer a 5- to 7-fold increased risk to develop Parkinson's disease. Brain organoids have recently emerged as a three-dimensional tissue culture platform to study neuronal and glial functional properties in physiological and pathological conditions2. We will study organoids both at single cell and network level using a combination of electrophysiology (patch-clamp) and imaging equipment (wide-field, confocal, 2 photon-STED). The results will be correlated to key pathological pathways including alpha-synuclein aggregation, lysosomal and endoplasmic reticulum stress.

Complex System approaches to study the brain
Dr. Suweis (DFA)

A complementary strategy to the standard viewpoint in biology, which consists in analysing each molecular component individually, is looking at complex biological problems from a global perspective, shifting the focus from specific details to integral aspects. System approaches to biology rely on the fact that some phenomena of living systems, deriving from the interactions of many basic units, each one exhibiting some sort of nonlinear dynamics, are collective ones and might not be reducible to the understanding of elementary components as an individual basis. I will overview some of the approaches from complexity theory that can help to study brain dynamics in both humans and animal studies. In particular I will introduce the hypothesis of brain criticality.

Linking Neurons to Network Function and Behavior: toward an integrative framework for systems neuroscience
Dr. Dal Maschio (DSB)

A neuroscientist can rely on sharp investigation tools to investigate the brain mechanisms of sensory processing and behavior control. Light-based approaches, in particular, allow reconstructing the activity of the different cellular populations, the underlying wiring diagram and the inter-dependency relations linking the different components. I will present the current state of the art applied to a simple model organism, describing the available building blocks for an integrative investigation framework and its applications. I will conclude sharing some perspectives on the possible applications of this approach to scenarios of circuit plasticity and circuit re-tuning.

Ore 13.30: Lunch. Buffet at Caffe' Pedrocchi.

Ore 14.30: Session 5 - Overview of the research and perspectives PNC funded project (15+5Q&A)

Neur(on)al implementation of Hierarchical Bayesian Inference.
Dr. Visalli (DNS, 12+3)

Leading theories of information processing cast the brain as a predictive machine whose functioning, given its biological organization, can be mathematically modeled as hierarchical Bayesian inference (HBI). This research line aims to provide a comprehensive experimental verification of the neural and neuronal implementation of HBI. For this purpose, we plan to validate two animal models (Danio rerio and Drosophila melanogaster) of HBI and to adopt an evolutionary and comparative approach to inform behavioral and neural HBI correlates obtained from human participants. Studying HBI in animals will allow us (i) to investigate the circuital implementation of inferential processes with a cellular resolution and (ii) to trace a first phylogenetic trajectory of the predictive brain**.**

Characterizing and controlling neuronal activity in health and disease.
Dr. Lodovichi (CNR-IN, VIMM)

Percept, memory and motor actions result from the coordinated activity of many neurons and disruption of these pattern of activity is a telltale signature of neurological diseases. Combining electrophysiological and light-based approaches, we are interested in dissecting the neuronal ensemble that form the building blocks of functional neuronal circuits, characterizing their rhythms and connectivity. We use mathematical models to identify the critical nodes of neuronal networks to probe the plasticity of the circuits and retune aberrant rhythms in pathology, in animal models, mostly mice and fish.

A computational tool for neurodegenartive stratification using PET/RM
Prof. De Marchi (DM)

We present some preliminary ideas on sampling in PET/RM. This is motivated on how to apply segmentation. Reconstruction methods usually fail around boundaries or discontinuities of images due to the so-called Gibbs phenomenon. A new approximation technique, based on a suitable mapping-bases approach without resampling, is presented. We show that thistechniques is equivalent to work with "fake nodes". Some examples on phantoms and images from MPI sampling are also shown.

In-silico brain: computational modeling of neurostimulation
Prof.ssa Bertoldo (DEI)

Computational modeling helps in formalizing the relationships between structural architecture and functional/metabolic activity that we observe. A multitude of in-silico models are available that are based on different assumptions, parameters (and corresponding parameter spaces), dynamics, making them useful only for specific aims. Simplistic models usually are limited in their ability to explain transitions between network states observed in empirical time-varying data. Complex models based on bottom-up strategies are helpful to monitor the impact of microscopic variables (mesoscale) on the whole system (macroscale) but difficult to be used if one wants to study and manipulate the fundamental properties relevant to the process under investigation.
We claim that the development of a computational model able to describe the effect of stimulation on brain activity, shall allow for a rational design of stimulation protocols. In addition, based on this model, we hypothesize that the development of closed-loop stimulation is essential in order to optimize the neurostimulation output and to minimize the inference with healthy ongoing brain activity.

The function and organization of spontaneous activity in health and disease
Prof. Corbetta (DNS)

The Corbetta Lab is interested in understanding the function and organization of spontaneous brain activity in the living human brain, with possible links to the rodent brain, both in healthy and disease states. We are testing the general hypothesis that spontaneous brain activity, i.e. activity recorded in the absence of any task, underlie spatiotemporal patterns of activity that represent high probability statistical configurations of the environment, body, cognition, and internal milieu, a.k.a. neural synergies. This activity uses the majority of the energy budget, and it is modified by lesions and diseases functioning as a potential biomarker.
We are conducting experiments to: a) measure the relative structural and dynamic factors that explain the metabolic variability among brain regions; b) measure the covariance of behavioral states across many subjects to show that they are low dimensional and potentially represented in patterns of spontaneous activity; c) measure the effect of lesions (stroke, tumors) on spontaneous actvity to measure the network effects of focal injury and as a potential biomarker of outcome or therapy response; d) relate metabolic patterns of spontaneous activity measured with PET or fMRI to dynamic neural patterns measured with HD-EEG or LFP in rodents.

Ore 16.15 Coffee break at Caffe' Pedrocchi.

Ore 17.00: Session Future directions - Round tables and discussion

Ore 17.30: "Padova Neuroscience Center-PNC" news: town hall discussion
Live Streaming for all PNC PIs, PNC PostDoc and PhD Students

Ore 19.00: Aperitive and end of the workshop

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Suggested topic of general discussion

Prof.ssa Pietrobon Daniela
"How to bridge the gap in knowledge and methods between animal and human studies"
Prof. Angrilli and other contributors
"Neurovisceral integration in psychiatric and neurological disorders and minimal state of consciousness"
Prof. Zorzi
i) Predicting behavioral performance from neuroimaging data (with emphasis on neurological conditions - eg stroke) [More general topic: Machine learning in neuroscience]
ii) Connectomics and whole-brain modelling
Prof. Bortolozzi
Stem cell-based models of neurodegeneration.
Prof. Finos
metodi inferenziali e la modellizazione legati alla connectivity
dr. Cona

- Brain – Behaviour link: novel approaches and challenges
- Big data in cognitive neuroscience

Dr. Bonato
a) studio dell'esordio dei primi disturbi cognitivi negli anziani (con EEG ed eye tracker)
b) studio dei disturbi cognitivi ed emotivi dopo ictus (con anatomia ed EEG)
Prof. Caleo

(i) plasticità neuronale; (ii) strategie per una effettiva integrazione tra ricerca clinica, animale e computazionale

Prof. Vassanelli
brain and artificial intelligence: challenges and opportunities

Prof.ssa Bertoldo

- Which model to capture the mechanistic understanding of the effect of stimulation, allowing for a rational design of stimulation protocols?
- Based on this model, is it possible to develop a MPC closed-loop stimulation procedure in order to avoid inference with healthy ongoing brain activity?
- Physiological/mechanistic model versus machine learning approach: which is the best in predicting the effect of stimulation protocols?

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Prof. Finos

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