Testi del Syllabus

Resp. Did.	**LONGO RENATA**	**Matricola: 003135**

Docenti	**BARATELLA ELISA, 1 CFU** **CINGOLANI LORENZO ANGELO, 7 CFU** **LONGO RENATA, 2 CFU**

Anno offerta:	**2020/2021**
Insegnamento:	**895SM - TECNICHE NEUROFUNZIONALI**
Corso di studio:	**SM54 - NEUROSCIENZE**
Anno regolamento:	**2019**
CFU:	**10**
Settore:	**FIS/07**
Tipo Attività:	**C - Affine/Integrativa**
Anno corso:	**2**
Periodo:	**Primo Semestre**
Sede:	**TRIESTE**

🇮🇹 Testi in italiano

Lingua insegnamento	English
Contenuti (Dipl.Sup.)	The course in Neurofunctional Techniques will cover both theoretical and practical aspects of the major techniques used to investigate brain function, with special emphasis on recent developments. Part 1: (prof. Renata Longo & Baratella Elisa) neuroimaging techniques Computed Tomography: basic principles, recent techniques and application in brain imaging. Magnetic resonance imaging (MRI): basic principles. Functional MRI: physical and physiological basis. fMRI experimental design: blocks and event relates paradigms data analysis in fMRI: images processing and statistical analysis Exercise in small groups at the MRI unit of the Cattinara hospital: Block design experiments, image acquisition and data analysis. Diffusion weighted images (DWI) and diffusion tensor imaging (DTI): physical basics. DTI in brain imaging: a technique for neurons bundles study Fiber tacking based on DTI data set. Exercise in small groups at the MRI unit of the Cattinara hospital: DTI experiments, image acquisition and data analysis. Radioisotopes imaging: single photon emission tomography (SPECT) and positron emission tomography (PET). Physical and physiological basics. Introduction to biological effects of ionizing radiation and radiobiology. The challenge of integration: EEG and MRI or PET, PET and CT or MRI. Part 2 (prof. Lorenzo Cingolani) Calcium imaging: We will learn how calcium imaging can be used to reveal the activity of brain networks and of subcellular compartments. We will give special emphasis to the theoretical foundations, molecular aspects and recent achievements. Optical approaches: We will learn about the other optical approaches used to investigate brain function, with special emphasis to those aimed at investigating synaptic vesicle release.

Electrophysiology: We will learn the theoretical and practical aspects of single cell electrophysiology with special emphasis to advanced analysis techniques.

Optogenetics and chemogenetics: we will cover both the theoretical bases and molecular aspects of optogenetics / chemogenetics. We will see how these techniques can be used in combination with electrophysiology and behavioral tests to dissect brain function.

Behavior: we will discuss the major behavioral tests used to assess brain function (motor, social and cognitive).

Statistics: we will cover the major statistical tests useful to interpret data sets in neuroscience

Testi di riferimento	The essential of functional MRI. P. W. Stroman CRC press 2011. Handbook of Neural Activity Measurements. Romain Brette & Alain Destexhe, Cambridge University Press 2012 Ion Channels of Excitable Membranes, 3rd edition Bertil Hille Sinauer Associates 201 Original papers discussed and provided during lessons Further relevant slides and pdf files will be provided during classes.
Obiettivi formativi	The aim is to provide the students with the theoretical bases necessary to interpret and design electrophysiological and imaging experiments. Knowledge and understanding: -Understanding the physical and physiological basis of the modern techniques used in human brain mapping; -To understand the theoretical foundations of electrophysiology, optogenetics and imaging experiments; -To be familiar with the practical aspects and technical constrains. Applying knowledge and understanding: By the end of the course the students should be able to -design and perform an MRI study for brain mapping; -to read critically a scientific paper that makes use of the neurofunctional techniques presented in the course; -to choose the most suitable experimental approaches for a given scientific question. Making judgments: The capability to make judgments will be developed through the interaction with the lecturers during the frontal lessons, and by preparing the final examination, which requires the student to elaborate and comprehend the topics discussed over the course. Communication skills: The lessons will be given using the appropriate scientific language. Students will be encouraged to interact with the lecturers and among themselves to improve their scientific vocabulary, their ability to pose questions and to expose their ideas. The written examination will include some open questions in which the student will demonstrate his/her ability to elaborate the acquired knowledge, to communicate the key points in a concise and effective way. The oral examination will give students further stimuli to improve their communication skills. Learning skills: The ability to learn will be stimulated by studying the concepts presented during the frontal lessons, and will be assessed through the evaluation procedures described above. The students will acquire the knowledge necessary to understand the neurofunctional techniques used to investigate brain function in health and disease.
Prerequisiti	Basic knowledge of neurophysiology.

Metodi didattici	Lectures, discussion of scientific papers and small group tutorials at the MRI unit.
Altre informazioni	The material used during the lessons will be made available through the moodle platform. Any necessary change in the course modalities due to COVID19 emergency will be published at the Department, Master Programme and Course websites.
Modalità di verifica dell'apprendimento	Part1: Students are required to take a final oral examination and to prepare a report of the MRI experiment. The oral examination consists in a discussion of 30 min, during which the student is invited to describe and comment on a few topics covered in the course. Part2: Written examination with multiple choice and open questions. Marks will be attributed to a maximum of 30/30 lode. To pass the exam (18/30), the student should answer correctly to at least 2/3 of the multiple-choice questions and 2/3 of the open questions, to get the maximum score (30/30 lode) the student should answer correctly to all the questions. The final mark will be a weighted average of parts 1 and 2
Programma esteso	Computed Tomography: basic principles, recent techniques and application in brain imaging. Magnetic resonance imaging (MRI): basic principles. Functional MRI: physical and physiological basis. fMRI experimental design: blocks and event relates paradigms data analysis in fMRI: images processing and statistical analysis Exercise in small groups at the MRI unit of the Cattinara hospital: Block design experiments, image acquisition and data analysis. Diffusion weighted images (DWI) and diffusion tensor imaging (DTI): physical basics. DTI in brain imaging: a technique for neurons bundles study Fiber tacking based on DTI data set. Exercise in small groups at the MRI unit of the Cattinara hospital: DTI experiments, image acquisition and data analysis. Radioisotopes imaging: single photon emission tomography (SPECT) and positron emission tomography (PET). Physical and physiological basics. Introduction to biological effects of ionizing radiation and radiobiology. The challenge of integration: EEG and MRI or PET, PET and CT or MRI. Introduction to the technical problems and the expected results. Calcium Imaging. Types of fluorescent calcium indicators, small molecules indicators, genetically encoded calcium indicators, intracellular calcium dynamics, calcium binding, calcium influx, calcium extrusion, calcium diffusion, general formulation of calcium dynamics, calcium-dependent fluorescence properties, fluorescence intensities, relative fluorescence change, fluorescence ratio, fluorescence lifetime, FRET efficiency, calibration of calcium indicators, simplified models of calcium dynamics, calcium microdomain model, buffered calcium diffusion, cable equation analog, single-compartment model, non-linear calcium dynamics, how to estimate the endogenous calcium binding ratio, how to quantify total calcium fluxes, how to characterize calcium-dependent processes, how to reconstruct neural spike trains. Optical imaging of synaptic vesicle release: synaptic vesicle pools and dynamics, types of fluorescent indicators for monitoring vesicle release, the alkaline trapping method: isolating exocytosis from endocytosis, optical mapping of release properties at synapses Electrophysiology. Bioelectricity: electrical potentials, electrical currents, resistors and conductors, Ohm's law, the voltage divider, perfect and real electrical instruments, ion in solutions and electrodes, capacitors and their electrical field, currents through capacitors, current clamp and voltage clamp, glass microelectrodes and tight seals. Counting ion channels and measuring fluctuations: fluctuation of macroscopic current amplitudes as measure of the number and size of elementary units, microscopic kinetics, single channel recordings. Optogenetics and chemogenetics. Types of microbial opsins, optogenetic tools for neuronal excitation, optogenetic tools for neuronal inhibition, chemogenetic tools for biochemical control, delivering optogenetic tools into neuronal systems, transgenic animals, developmental and layer-specific targeting, circuit targeting, light delivery and readout hardware

for optogenetics, how to use optogenetics/chemogenetics to dissect the engram.

Behavioral studies in animal models of neurodevelopmental disorders. What is an animal model. Validity of an animal model: construct, face and predictive validity. Study of the face validity of an animal model: general health, motor functions , anxiety, social behavior, learning and memory. Examples of animal models of neurodevelopmental disorders: episodic ataxia, autism, epilepsy

Statistics: how to choose the correct statistical test: parametric and non-parametric statistical tests, paired and unpaired Student's t-Test, one and two-way ANOVA.

🇬🇧 Testi in inglese

	English

The course in Neurofunctional Techniques will cover both theoretical and practical aspects of the major techniques used to investigate brain function, with special emphasis on recent developments.

Part 1: (prof. Renata Longo & Baratella Elisa) neuroimaging techniques Computed Tomography: basic principles, recent techniques and application in brain imaging. Magnetic resonance imaging (MRI): basic principles. Functional MRI: physical and physiological basis. fMRI experimental design: blocks and event relates paradigms data analysis in fMRI: images processing and statistical analysis Exercise in small groups at the MRI unit of the Cattinara hospital: Block design experiments, image acquisition and data analysis. Diffusion weighted images (DWI) and diffusion tensor imaging (DTI): physical basics. DTI in brain imaging: a technique for neurons bundles study Fiber tacking based on DTI data set. Exercise in small groups at the MRI unit of the Cattinara hospital: DTI experiments, image acquisition and data analysis. Radioisotopes imaging: single photon emission tomography (SPECT) and positron emission tomography (PET). Physical and physiological basics. Introduction to biological effects of ionizing radiation and radiobiology. The challenge of integration: EEG and MRI or PET, PET and CT or MRI.

Part 2 (prof. Lorenzo Cingolani)
Calcium imaging: We will learn how calcium imaging can be used to reveal the activity of brain networks and of subcellular compartments. We will give special emphasis to the theoretical foundations, molecular aspects and recent achievements.

Optical approaches: We will learn about the other optical approaches used to investigate brain function, with special emphasis to those aimed at investigating synaptic vesicle release.

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Bertil Hille
Sinauer Associates 201
Original papers discussed and provided during lessons
Further relevant slides and pdf files will be provided during classes.

The aim is to provide the students with the theoretical bases necessary to interpret and design electrophysiological and imaging experiments.
Knowledge and understanding:
-Understanding the physical and physiological basis of the modern techniques used in human brain mapping;
-To understand the theoretical foundations of electrophysiology, optogenetics and imaging experiments;
-To be familiar with the practical aspects and technical constrains.
Applying knowledge and understanding:
By the end of the course the students should be able to
-design and perform an MRI study for brain mapping;
-to read critically a scientific paper that makes use of the neurofunctional techniques presented in the course;
-to choose the most suitable experimental approaches for a given scientific question.
Making judgments:
The capability to make judgments will be developed through the interaction with the lecturers during the frontal lessons, and by preparing the final examination, which requires the student to elaborate and comprehend the topics discussed over the course.
Communication skills:
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Learning skills:
The ability to learn will be stimulated by studying the concepts presented during the frontal lessons, and will be assessed through the evaluation procedures described above. The students will acquire the knowledge necessary to understand the neurofunctional techniques used to investigate brain function in health and disease.

Basic knowledge of neurophysiology.

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Calcium Imaging. Types of fluorescent calcium indicators, small molecules indicators, genetically encoded calcium indicators, intracellular calcium dynamics, calcium binding, calcium influx, calcium extrusion, calcium diffusion, general formulation of calcium dynamics, calcium-dependent fluorescence properties, fluorescence intensities, relative fluorescence change, fluorescence ratio, fluorescence lifetime, FRET efficiency, calibration of calcium indicators, simplified models of calcium dynamics, calcium microdomain model, buffered calcium diffusion, cable equation analog, single-compartment model, non-linear calcium dynamics, how to estimate the endogenous calcium binding ratio, how to quantify total calcium fluxes, how to characterize calcium-dependent processes, how to reconstruct neural spike trains.
Optical imaging of synaptic vesicle release: synaptic vesicle pools and dynamics, types of fluorescent indicators for monitoring vesicle release, the alkaline trapping method: isolating exocytosis from endocytosis, optical mapping of release properties at synapses
Electrophysiology. Bioelectricity: electrical potentials, electrical currents, resistors and conductors, Ohm's law, the voltage divider, perfect and real electrical instruments, ion in solutions and electrodes, capacitors and their electrical field, currents through capacitors, current clamp and voltage clamp, glass microelectrodes and tight seals.
Counting ion channels and measuring fluctuations: fluctuation of macroscopic current amplitudes as measure of the number and size of elementary units, microscopic kinetics, single channel recordings.

Optogenetics and chemogenetics. Types of microbial opsins, optogenetic tools for neuronal excitation, optogenetic tools for neuronal inhibition, chemogenetic tools for biochemical control, delivering optogenetic tools into neuronal systems, transgenic animals, developmental and layer-specific targeting, circuit targeting, light delivery and readout hardware for optogenetics, how to use optogenetics/chemogenetics to dissect the engram.
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Statistics: how to choose the correct statistical test: parametric and non-parametric statistical tests, paired and unpaired Student's t-Test, one and two-way ANOVA.