Testi del Syllabus

Resp. Did.	**CINGOLANI LORENZO ANGELO** **Matricola: 031478**
Docenti	**CESCA FABRIZIA, 1 CFU** **CINGOLANI LORENZO ANGELO, 6 CFU** **LONGO RENATA, 2 CFU** **UKMAR MAJA, 1 CFU**

Anno offerta:	**2023/2024**
Insegnamento:	**967SV - NEUROFUNCTIONAL TECHNIQUES**
Corso di studio:	**SM54 - NEUROSCIENZE**
Anno regolamento:	**2022**
CFU:	**10**
Settore:	**FIS/07**
Tipo Attività:	**C - Affine/Integrativa**
Anno corso:	**2**
Periodo:	**Primo Semestre**
Sede:	**TRIESTE**

Testi in italiano

Lingua insegnamento	INGLESE
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 & Ukmar Maja) 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 & Fabrizia Cesca) Functional imaging: We will explore various functional imaging methods, with a focus on calcium imaging, and learn how they can be used to

reveal the activity of brain networks in ex vivo an in vivo preparations. This entails gaining knowledge about the underlying principles, practical considerations and recent advancements in the field.

Electrophysiology: We will learn principles and practical aspects to conduct single cell and multielectrode array recordings. Special emphasis will be on in vivo applications and advanced analysis techniques.

Optogenetics, chemogenetics and mechanogenetics: We will explore how these techniques can be used in combination with functional imaging, electrophysiology and behavioral tests to dissect brain function and memory engram. We will concentrate on the most recent accomplishments recorded in literature.

Behavior: we will explore the major behavioral tests used to assess brain function, including those related to motor skills, social behavior and cognitive abilities. We will particularly highlight the significance of tests that assess behavioral phenotypes relevant to human pathologies such as autism, depression, ataxia and epilepsy.

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 2001

Original papers discussed and provided during lessons

Relevant slides and pdf files will be provided during classes and posted in Moodle.

Obiettivi formativi

The aim is to provide the students with the basic knowledge necessary to interpret and design electrophysiological and imaging experiments.

D1 - 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 involved.

D2 - Applying knowledge and understanding:
By the end of the course the students will be able to:
-design and perform an MRI study for brain mapping;
-design and perform a functional imaging experiment;
-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.

D3 - Making judgments:
The ability to make informed judgments will be developed through the interaction with the lecturers during class time, as well as through the preparation of the final examination, which requires the student to elaborate and comprehend the topics discussed over the course.

D4 - 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 oral examination will give students further stimuli to improve their

communication skills, demonstrate their ability to elaborate the acquired knowledge and communicate the key points in a concise and effective way.

D5 - Learning skills:
The ability to learn will be stimulated by studying and applying 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 in biophysics and 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	Part 1: 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. Part 2: Student assessment includes: a) A written test consisting of 10 multiple-choice questions. Each question has only one correct answer, and each correct answer is awarded 1 point. Maximum score: 10. The test will be conducted on the Moodle platform. b) A 30 min presentation of a scientific paper assigned at the beginning of the course. Students will be asked to (i) identify the scientific questions addressed in the paper, (ii) evaluate how appropriate the neuro-functional techniques employed to address the questions are and (iii) judge strengths, weaknesses and impact of the paper conclusions. Presentations will be conducted in small groups (6 students). Maximum score: 20. The written test contributes one-third (maximum 10 points), while the oral presentation contributes two-thirds (maximum 20 points) to the evaluation of Part 2 of the course. The final mark will be a weighted average of parts 1 and 2. The exam score is given on a thirty-point scale. To pass the exam, the student must achieve a score of 18/30. To attain the highest score (30/30 with honors), the student must answer all questions correctly in the written test and demonstrate full mastery of the neurofunctional techniques in the oral examinations. The examination procedure is explained at the beginning of the course and is also available in the course introduction presentation.
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, 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, single-compartment model, how to estimate the endogenous calcium binding ratio, how to reconstruct neural spike trains, in vivo calcium imaging: fiber photometry, 2-photon and miniscope calcium imaging.

Optical imaging of synaptic activity: 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, ion in solutions and electrodes, capacitors and their electrical field, currents through capacitors, current clamp and voltage clamp, glass microelectrodes and tight seals.

Optogenetics, chemogenetics and magnetogenetics. Types of microbial opsins, optogenetic tools for neuronal excitation and inhibition, chemogenetic tools for biochemical control, delivering optogenetic tools into neuronal systems, transgenic animals, developmental and layer-specific targeting, light delivery and readout hardware for optogenetics, how to use optogenetics/chemogenetics to dissect the memory engram. Recent advances in magnetogenetics.

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 brain disorders: episodic ataxia, autism, depression and 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.

Obiettivi Agenda 2030 per lo sviluppo sostenibile

The contents explore topics related to the objectives of the United Nations 2030 Agenda for Sustainable Development.
Specifically,
N.3 Health and wellbeing
N.4 Education of quality

Obiettivi per lo sviluppo sostenibile

Codice	Descrizione
3	Salute e benessere
4	Istruzione di qualità

Testi in inglese

English

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Basic knowledge in biophysics and neurophysiology.

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The material used during the lessons will be made available through the moodle platform.
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Electrophysiology. Bioelectricity: electrical potentials, electrical currents, resistors and conductors, Ohm’s law, ion in solutions and electrodes, capacitors and their electrical field, currents through capacitors, current clamp and voltage clamp, glass microelectrodes and tight seals.

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Obiettivi per lo sviluppo sostenibile

Codice	Descrizione
3	Good health and well-being
4	Quality education