Project A1

In vivo and in vitro investigation of synaptic transmission in the hippocampus

Marilena Griguoli, Rome and Meryl Malézieux, Bordeaux.

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Marilena Griguoli received her PhD degree at the International School for Advanced Studies in Trieste under the supervision of Enrico Cherubini. After a post doc at the Interdisciplinary Institute for Neuroscience in Bordeaux in the lab of Christophe Mulle, she joined the European Brain Research Institute in Rome as a senior scientist. Her research is focused on cholinergic regulation of the hippocampal circuits. During her PhD she studied how cholinergic signaling controls interneuron firing and plasticity using ex vivo patch clamp electrophysiology in slices. In the Mulle lab she implemented in vivo patch clamp combined with opto/chemogenetic tools to study glutamatergic and cholinergic inputs in the hippocampus. Meryl Malézieux is a PhD student under the supervision of Christophe Mulle.

Related articles

1. Stefano Zucca*, Marilena Griguoli*, Meryl Malézieux, Noëlle Grosjean, Mario Carta and Christophe Mulle. Control of spike transfer at hippocampal mossy fiber synapses in vivo by GABAA and GABAB receptor mediated inhibition (in revision).

General Description of the proposed mini-project.

Students will receive training for in vivo electrophysiology, with particular focus on single cell recordings through patch clamp juxtacellular recording techniques in anesthetized mice. The combination of in vivo recordings and optogenetic tools will allow to study how stimulation/silencing of neuro-modulatory input impact on hippocampal activity.
Project A2

Cellular and network mechanisms of hippocampal rhythms

Nikolaus Maier, Berlin - nikolaus.maier@charite.de

Nikolaus Maier has been studying the cellular and network mechanisms of hippocampal rhythms since 1999, contributing to this area of research with the establishment of an in vitro model of hippocampal sharp wave/ripples (SWRs). Using electrophysiological approaches on principal neurons and interneurons, his research focuses on both chemical and electrical neuronal synchronization during physiological and pathologically altered high-frequency oscillations.

Related articles:

General Description of the proposed mini-project.

Using an established in vitro model of SWRs in mouse hippocampal slices, we will investigate spiking and subthreshold activity in area CA1 pyramidal neurones and stratum radiatum interneurons.

The following experimental steps will be trained/performed: Students will prepare mouse hippocampal slices, and establish whole-cell recordings in CA1 pyramidal neurons (‘proof of principle’). On-cell recordings in CA1 radiatum interneurons will be followed by whole-cell recordings, in current-clamp and voltage-clamp modes. Biocytin stainings will be used to classify recorded interneurone cell types. Data analysis will include extraction and quantification of extracellular SWR events, as well as the comparison of synaptic input and spiking in different types of stratum radiatum interneurone.
Project A3

Re-organization of cortical connectivity during memory formation.

Andreas Frick, Bordeaux - andreas.frick@inserm.fr

Andreas Frick performed his PhD at the Max Planck Institute for Psychiatry (Munich, Germany; Supervisor: H.-U. Dodt), where he used a newly developed method of glutamate uncaging together with electrophysiology to investigate the distribution of glutamate receptors along the dendrites of neocortical output neurons, as well as the functional consequences of this distribution for neuronal signaling and plasticity. As postdoctoral researcher and Alexander von Humboldt Fellow, he joined the laboratory of Daniel Johnston (then Baylor College of Medicine, Houston, USA), where he discovered a novel cellular mechanism for storing information in dendritic branches, namely in the functional properties of their ion channels. He then became a Research Group Leader at the Max Planck Institute for Medical Research in the Department of Bert Sakmann (Heidelberg, Germany), where he investigated the properties of neocortical microcircuits, and also began research into the underlying mechanisms of autism spectrum disorders. In 2008, he joined the Neurocentre Magendie (Bordeaux) as a Group Leader where he investigates the role of connectivity and integrative properties of defined neuronal populations in cortical circuit function and dysfunction.

Related publications


General Description of the proposed mini-project.

The main goal of the project is to test the idea that memories might be stored in the connectivity of cortical circuits. The students will perform a learning task, stereotaxic injections of viral tracers for mono-trans-synaptic tracing, brain clearing methods, light-sheet microscopy imaging of whole cleared brains, and semi-automatic approaches for brain-wide quantification of neuronal connectivity.

Students will get hands-on experience in all of the above methods and will perform analysis on pre-prepared samples to ensure successful completion of the mini-project.
Project A4

Optogenetic manipulation of adult neurogenesis in behaving rats.

Nora Abrous and Nuria Masachs, Bordeaux

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Nora Abrous is a research director at INSERM. She heads a lab focusing on adult hippocampal neurogenesis in rodents. Using a longitudinal approach from embryonic stages to senescence, and by coupling in vivo electroporation, transgenic and viral tools, DREADDs and optogenetic technologies, we investigate the relationship between adult-born neurons, memory, emotion and hippocampal plasticity.

Nuria Masachs has received her PhD from University of Barcelona (Developmental Neurobiology and Regeneration lab) and is now a post-doc in the lab of Nora Abrous. During the course, Nuria will instruct how to manipulate adult-born neurons in behaving animals.

Related articles:


General Description of the proposed mini-project.

In this project students will be the use of optogenetics in vivo in behaving rats. Neurons born in the adult Dentate Gyrus will be tagged with ChR2/Arch to allow modification of their activity during the performance of a hippocampal-dependent learning task, the Morris Water Maze. During the project, Students will be taught how to prepare of optic fiber implants and stereotaxical surgeries to implant the fibers. Students will perform optogenetics in vivo while the animals is engaged in the behavioural task. Then we will visualize adult-born neurons using immunohistochemistry.
Project A5

Optogenetics and unit recordings during spatial learning

Peter Baracskay, Vienna, Austria - peter.baracskay@ist.ac.at

Peter Baracskay made a PhD at Eotvos Lorand University in the Institute of Biology. His work discovered (in collaboration with the Medical College of Wisconsin and with the MTA Research Group for Implantable Microsystems) how different local neurons in the brainstem reticular formation mediate arousal effects towards the neocortex. He then joined as a postdoc to the lab of Jozsef Csicsvari in the Institute of Science and Technology where he investigating with long term multi-channel recording how spatial memory traces are processed and disengaged from the hippocampus.

Related publications


General Description of the proposed mini-project.

In the course, the students will learn how to implant a microdrive with individually moveable tetrodes in rat and record extracellular unit activity when the animal explores different environments then analyze the sleep reactivation of the these spatial representations.
Project A6

Volumetric and surface-bases analysis of human hippocampus

Fabrice Crivello, Bordeaux - fabrice.crivello@u-bordeaux.fr

Fabrice Crivello studied signal and image processing before receiving his PhD in biological and medical engineering from Paris XII University in 1997. His PhD topic was on the detection and localization of cerebral activations with positron emission tomography. He then obtained a postdoctoral position in the context of the European Union Program BIOTECH (coord. Per Roland, Karolinska Institute) aiming at building a multiscale and multimodality neuroanatomical database. He was appointed as a research fellow at the Atomic Energy Commission in 1998, then at his current position at the Neurofunctional imaging group (GIN) in Bordeaux. His research focuses on the development of neuroanatomical data analysis methods to explore large imaging cohorts. In this context, he coordinates the setting-up, standardization and distribution of the automated procedures dedicated to the extraction of cerebral structural phenotypes from the various neuroimaging databases the GIN is working with.

Related articles


General description of the mini-project

In cohort neuroimaging studies, choosing the right brain phenotypes is a critical for optimal characterization of the relationships between brain anatomy and social, behavioral and/or educational characteristics. During this project, students will learn and use specific analysis procedures to automatically extract grey matter phenotypes such as grey matter volumes (using the Voxel-Based Morphometric approach, http://www.fil.ion.ucl.ac.uk/spm/), cortical thickness and/or surface area (using the surface-based Freesurfer package, (http://surfer.nmr.mgh.harvard.edu), at the global, regional (focusing on the hippocampus) and voxel levels.
Project A7

Hippocampal neuronal ensembles and the time organization of behaviour

Xavier Leinekugel and Maria Isabel Carreno, Bordeaux - xavier@arcadi.eu

Xavier Leinekugel has made seminal findings on the postnatal development and functional organization of the hippocampal circuit, as a PhD student with R. Khazipov and Y. Ben-Ari, Postdoc fellow with G. Buzsaki, and ENI-Net group leader. Now PI in Andrea Frick's lab (Neurocentre Magendie, Bordeaux), Xavier will instruct how to investigate the relationships between neuronal ensembles, recorded using multi-electrodes with single cell resolution, and the time-organization of behaviour, obtained from an innovative behavioural-phenotyping platform.

Related articles:

General Description of the proposed mini-project.

The hippocampal theta rhythm is tightly related to behaviour. As soon as a rat or a mouse is in motion, prominent theta oscillations are expressed, as the coordinated discharge of hippocampal pyramidal cells and interneurons. The amplitude of theta is highest at the time of movement initiation, and varies according to the strength involved in the movement. The hypothesis has recently been raised that some neuronal clock controlling rhythmic fluctuations of theta amplitude might underlie the time organization of behaviour at the time scale of seconds. In order to better understand the relationships between hippocampal rhythms and the time organization of behaviour, we will use state-of-the-art methods allowing to record simultaneously hippocampal neuronal ensemble activity and animal behaviour with a high degree of precision. Neuronal activity with single cell precision will be recorded in freely moving animals using multi-electrodes (tetrodes or silicon probes), and analyzed with spike sorting algorithms. Spontaneous behaviour will be recorded on an innovative behavioural phenotyping platform combining video monitoring and highly sensitive pressure sensors that allow to detect the finest animal movements (up to individual breathing and heart beat, as well as individual footsteps, sniffing, grooming, etc...), and analyzed with a combination of automatic animal tracking algorithms and matlab scripts.
Project A8

Multichannel recordings during complex spatial tasks

Kevin Allen, Heidelberg, Germany - allen@uni-heidelberg.de

Kevin Allen did a PhD with Jozsef Csicsvari at Oxford University. His work investigated how neurons in the hippocampus encode both spatial and non-spatial information during memory tasks. He then moved to the lab of Hannah Monyer where he studied the role of GABAergic interneurons for spatial coding and memory. Kevin is now a junior group leader at the University of Heidelberg. During the course, Kevin will instruct tetrode recording experiments in behaving rodents and analysis of electrophysiological data.

Related articles

General description of the mini-project

The project will involve 1) recording the activity of place cells in mice or rats as they explore an open-field arena and/or a linear track and 2) analyzing the recorded data (spike extraction, clustering of spikes, firing rate maps). The animals will be implanted with tetrodes above the hippocampus and allowed to recover before the course. The animals will be under food restriction for a 3 days and trained to forage in an open-field arena and/or on a linear track. The tetrodes will be lowered to the correct position and 2-3 recording sessions will be performed in each animal. The wide-band electrophysiological signals together with the position of the animal will be recorded. Action potentials will be extracted from the raw signals and the spatial properties of the recorded neurons will be characterized.
Project B1
Optogenetic activation of an hippocampal engram.

Michele Pignatelli, Cambridge, US - pignatelli.michele@gmail.com

Michele Pignatelli received is PhD from the EPFL working in the Laboratory of Neural Microcircuits under the supervision of Henry Markram. After an experience the Laboratory of Kathy Rockland (Cortical organization and Systematics, RIKEN institute Japan) working on cortical circuits, he is now a Research Associate at MIT in the Laboratory of Neural Circuit Genetics directed by Susumu Tonegawa where he combines multiple patch clamp recordings with optogenetic dissection of neural circuits to understand the neural substrates and mechanisms involved in learning and memory.

Related articles:

General Description of the proposed mini-project.

The purpose of this course is to learn theory and application of a new emerging technology centered on activity dependent cellular labeling and manipulation. By using a combination of behavioral conditioning and genetic tagging of active cells, the expression of Channelrhodopsin-2 can be restricted exclusively to active cells. Optogenetic reactivation of these cells, named engram cells, allows the artificial recall of the memory trace. The aim of the project is to allow the students to learn: 1) the use of genetically encoded activity reporters, 2) transgenic mice manipulation, 3) stereotaxic injection of viral vectors, 4) fiber optics implant, 5) behavioral conditioning, 5) optogenetic activation of a memory trace.
Project B2

Dendritic integration properties of single hippocampal neurons

Nelson Rebola, Paris and Judit Makara, Budapest
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Nelson Rebola did his PhD in the laboratory of Rodrigo Cunha (Coimbra, Portugal), where he studied the role of adenosine receptors in modulating the impact of neuroinflammation in hippocampal synaptic transmission. He then joined the laboratory of Christophe Mulle (Bordeaux), where he identified previous unknown mechanisms controlling synaptic NMDA receptors. Since 2012, he has joined the lab of David Digregorio (Paris, France) where he is using cutting edge live imaging techniques to study information processing in single neurons. He is the recipient of an ERC starting grant to develop a project on the role of NMDA receptors in the dendritic computation of cortical neurons.

Related articles

Judit Makara is a group leader at the Institute of Experimental Medicine of the Hungarian Academy of Sciences (Budapest, Hungary). After earning her PhD in cellular physiology, Judit joined Dr. Tamás Freund’s lab in Budapest where she studied the molecular mechanisms of endocannabinoid-mediated short-term plasticity of inhibitory neurotransmission. She then worked with Jeff Magee as a postdoc at Janelia Farm (Ashburn, VA, USA), where she investigated the forms and plasticity of active dendritic integration in hippocampal pyramidal neurons. In 2011 she moved back to her home country Hungary and started her own laboratory. Her lab focuses on understanding the rules and regulation of local interactions and integration of synaptic inputs, the relationship of dendritic properties and synaptic plasticity, and the role of these cellular mechanisms to the generation of functional neuronal ensembles in the hippocampus.

Related articles
Communications, 7:11380.

General Description of the proposed mini-project.

The main goal of the project will be to study dendritic integration properties of single neurons using experimental and computational approaches. The students will compare the dendritic integration properties of hippocampal pyramidal neurons versus GABAergic interneurons, using a combination of in vitro single cell electrophysiology with two-photon imaging. Specifically, the participants will estimate how different spatial and temporal patterns of synaptic inputs (evoked by glutamate uncaging or electrical stimulation) affect the magnitude of somatically recorded EPSPs and local dendritic calcium transients. We will explore the biophysical determinants responsible for the observed dendritic integration properties using model simulations.
Project B3

Juxtacellular recording and labeling of single neurons in-vivo.

Andrea Burgalossi, Tübingen, Germany - andrea.burgalossi@cin.uni-tuebingen.de

Andrea Burgalossi did his PhD in the laboratory of Nils Brose (Göttingen), where he investigated the molecular mechanisms of synaptic vesicle exocytosis. He then joined the laboratory of Michael Brecht (Berlin), where he developed innovative methodologies for recording and labeling single neurons in freely-moving rats (1-2). Since 2013 he is Junior Group Leader at the Werner-Reichardt Centre for Integrative Neuroscience (Tübingen), and his research focuses on the cellular basis of spatial navigation in rodents (3). During the course he will instruct how to perform juxtacellular recording and labeling of single cortical and hippocampal neurons in-vivo.

Related articles:


General Description of the proposed mini-project.

The main goals of the project will be to (i) perform juxtacellular (and intracellular) recordings of single neurons in-vivo, (ii) label the recorded neurons and (iii) correlate spiking activity to the morphological identity of the recorded cells.

Possible projects will involve recording and labeling hippocampal principal neurons and/or fast-spiking interneurons in-vivo in anesthetized rats. Students will thus learn the in-vivo preparation and gain hands-on experience on the juxtacellular (and intracellular) recording and labeling technique. In parallel, neurons successfully filled with Neurobiotin will be processed with standard histological protocols for revealing the morphology of the labeled neuron(s).
Project B4

In vivo and in vitro modulation of synaptic transmission in the hippocampus

Mario Carta and Ashley Kees, Bordeaux
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Mario Carta is interested in understanding how synapses and neuronal circuits function and how they can be regulated in various physiological or pathological states. During his M.A. and PhD Mario Carta first focused on the hippocampus and cerebellum to study how ethanol, neurosteroids and various pharmacological compounds, can modulate neural and synaptic plasticity and circuit functions. For the postdoc he moved to the laboratory of Christophe Mulle to broaden his technical skills and expertise to tackle molecular and cellular biological aspects of synaptic physiology and plasticity. Mario is now a Junior CNRS Researcher at IINS at the University of Bordeaux. Ashley Kees has received her PhD from UCLA (Mayank Mehta lab) and is now a post-doc in the lab of Christophe Mulle.

Related articles:


General Description of the proposed mini-project.

Students will combine in vivo viral gene transfer of optogenetic actuators, ex vivo patch clamp electrophysiology and in vivo single cell recordings (patch-clamp and juxtacellular recordings) in combination with optogenetic manipulation to study how neuromodulatory inputs can control single cell activity of single neurons.
Project B5

Interactions between global and local brain dynamics.

Francesco Battaglia and Tim Schröder, Nijmegen, the Netherlands

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Francesco Battaglia's group concentrates on neural dynamics and codes with particular emphasis on memory and sleep. We combine electrophysiology, optical imaging, behavior with computational and theoretical methods in order to understand how memory is encoded and consolidated, how different brain areas communicate with one another, and which codes (cell assemblies, phase sequences) encode memories. Tim Schröder is a PHD student in the Battaglia lab.

Related publications

2. Peyrache A, Battaglia FP, Destexhe A (2011) Inhibition recruitment in prefrontal cortex during sleep spindles and gating of hippocampal inputs, PNAS, 108, 17207-12

General description of the mini-project

Much of the input to any brain areas does not reflect directly sensory information from the external world, but the activity of other brain cells, that is, the global state of the brain. In this experiment, we will explore the correlation of single neurons, and Local Field Potentials in areas such as the hippocampus or the prefrontal cortex (as measured by silicon probes) with the global brain activity, measured using custom made Electrocorticography grids spanning much of the rat dorsal cortex. For this mini project, we will use rats under ketamine anesthesia, which will enable us to examine patterns similar to those observed during NREM sleep (hippocampal sharp waves, slow oscillations, spindles).
Project B6

Title: Multivariate pattern analysis of fMRI data

Maureen Ritchey, Boston, US - ritcheym@bc.edu

Maureen Ritchey joined Boston College as an Assistant Professor of Psychology in 2016. She completed her Ph.D. in Psychology & Neuroscience at Duke University, as a student in the interdisciplinary cognitive neuroscience training program. After then, she trained as a postdoctoral scholar at the Center for Neuroscience at the University of California, Davis. Her research is focused on the psychology and neuroscience of human memory. She uses functional magnetic resonance imaging (fMRI) to investigate the cortico-hippocampal systems involved in memory. Ongoing work in her lab centers on the influence of modulatory states, such as emotional arousal and stress, on these systems, and on the use of multivariate fMRI analysis techniques to illuminate the contents of episodic memory.

Related publications


General description of the mini-project

Maureen Ritchey will lead an experiment on multivariate pattern analysis of fMRI data. In the experiment, students will collect a set of task-related fMRI data at the local imaging facility. Students will learn how to pre-process and analyze the fMRI data using Matlab-based software (SPM). They will also learn about multi-voxel pattern analysis techniques, including pattern classification and representational similarity analyses, and apply these techniques to the data. We will compare the results from these methods, as well as the results from using a whole-brain searchlight approach versus a region-of-interest approach focused on the hippocampus. I will also give a talk on the role of medial temporal lobe structures in emotional memory.
Project B7

Title: Multivariate pattern analysis of fMRI data

Laura Libby, Davies, US - lalibby@ucdavis.edu

Laura Libby is a postdoctoral fellow at UC Davis in the laboratory of Charan Ranganath, where she received her PhD in Psychology in 2014. She has held a position as a post-baccalaureate research assistant at the NIMH in Bethesda, MD. Laura Libby's research focuses on understanding the functional properties of the human medial temporal lobe (MTL) and how the MTL interacts with distributed brain networks as we learn about the world and access stored information. To answer these questions, she uses advanced fMRI techniques, such as functional connectivity, high-resolution imaging of the hippocampus, and pattern similarity analysis, as well as behavioral modeling of memory processes.

Related publications


General description of the mini-project

Laura Libby will lead a project investigating the functional anatomy of the human medial temporal lobe through the lens of fMRI-based functional connectivity. We will collect and analyze fMRI data using a range of functional connectivity methods. Laura Libby will also teach a class on recent advances in MRI approaches to understanding human hippocampal structure, function, and connectivity.
Title: Role of the hippocampus in human episodic memory

Chris Bird, Brighton, UK - Chris.Bird@sussex.ac.uk

Chris Bird is a Senior Lecturer in Psychology (Psychology) at the University of Sussex, UK. Chris's research aims to understand both the psychological processes underpinning how memories are laid down and subsequently retrieved and also the brain regions necessary to do this. He investigates memory processes by using a combination of functional MRI and neuropsychology (and sometimes both) – which offers insight into how "normal" memory operates as well as how memory processes break down in the context of neurological damage. Chris's recent research uses virtual reality and video clips to probe memory for lifelike events. Chris is a recipient of a 5 year ERC Starting Grant award and winner of the Elizabeth Warrington Prize from the British Neuropsychological Society.

Related publications


General description of the mini-project

My project will involve investigating the brain regions involved in memory for complex, lifelike events, extending my recent work using video clips and multivariate pattern analysis of fMRI data (Bird et al., 2015). We will focus on setting up a hypothesis and then devising an experiment and collecting data to test that hypothesis. We will carry out representational similarity analyses using both "searchlight" and "region of interest" procedures. My talk will focus on the role of the human hippocampus in spatial memory (where we can be quite specific about the nature of the memory representations) as well as in episodic memory more generally. I will discuss evidence from individuals with hippocampal damage as well as neuroimaging data.
Project B9
Title: Virtual reality to investigate environmental influences on spatial cognition in human.

Christian Doeller, Jacob Bellmund and Tobias Navarro Schröder, Nijmegen, The Netherlands - c.doeller@donders.ru.nl

Christian Doeller is a Principal Investigator at the Donders Institute for Brain, Cognition and Behaviour and an Associate Professor at the Faculty of Science at Radboud University, Nijmegen, The Netherlands. After finishing his PhD with Prof Axel Mecklinger in Saarbrücken, he worked for several years as a Research Fellow and a Senior Research Fellow at University College London, UK with Prof Neil Burgess at the Institute of Cognitive Neuroscience/Institute of Neurology and in close collaboration with the Wellcome Trust Centre for Neuroimaging (FIL) and John O’Keefe’s electrophysiology group at the Department of Anatomy and Developmental Biology. In his research group, Christian Doeller leverages modern neuroimaging techniques such as functional magnetic resonance imaging (fMRI) and magnetoencephalography (MEG) to investigate brain systems that support transformation of experience into enduring memories. The research aims at understanding how mnemonic networks help us to map and navigate our geographical and memory landscapes and to assemble our rich inventory of knowledge. Jacob Bellmund is a PhD student, and Tobias Navarro Schröder is a postdoc under the supervision of Christian Doeller.

Related publications

Description Mini-Project
The hippocampal formation has been studied in two strands of research, which largely developed separately. On the one hand, electrophysiological recordings in freely moving rodents have implicated this brain region in spatial processing through the discovery of spatially tuned cells. On the other hand, data from human patients as well as neuroimaging studies suggest the hippocampus as a key region for episodic memory. Our research focuses on elucidating the computations underlying spatial and episodic processing in the human brain. In our mini-project, we aim to conduct a small behavioral experiment using desktop virtual reality (VR). A VR spatial memory task will be designed to investigate environmental influences on spatial cognition. Students will gain hands-on experience in developing a VR experiment and the analysis and visualization of the collected data.