NRSN
Norwegian Research School in Neuroscience

NRSN Summer School in Neuroscience 2017 at NTNU

Neural Circuits and Behavior

Kavli Institute for Systems Neuroscience, NTNU, Trondheim

13 - 19 August 2017

Summary

Understanding the brain and how it generates behavior remains one of the greatest frontiers facing humanity. An amazing amount of progress has been made over the last 50 years in studying the function, anatomy, chemistry and connectivity of brain circuits from the single neuron level to complete neural systems. It is yet still fascinating to observe the complexity of neural circuits with many emergent properties that are not always easy to predict from the properties of individual neurons. To link the activity of millions of single neurons to animal behavior, which is dynamically modulated by internal states and the sensory world alike, is still one of the greatest challenges of today's neuroscience. To meet these challenges, the field is quickly becoming a multidisciplinary endeavor combining approaches of life sciences with the tools of physics, mathematics and engineering.

Our goal is to bring together a wide range of experts in diverse approaches from electrical and optical measurements of brain activity to molecular, anatomical, behavioral and computational tools to study the function of brain circuits. We aim to show students the application of these wide ranges of techniques in a range of model species including rodents, zebrafish, flies, and humans.

We will also discuss about the advantages of these techniques, their potential pitfalls and how they can be synergistically combined. In addition to lectures, research talks and journal club sessions, the course will provide practical experience through demos and hands on training. Moreover, we will have group discussions and students' presentations for combining the theoretical and the practical parts of the course. These daily discussions will also continue during networking session in the evenings, in order to facilitate broad interactions of students with scientist at different levels. We hope that such interactions will seed future collaborations between the course attendants.

We expect every participant to prepare well before the course, using the reading materials that we will distribute in advance. We also expect full commitment of the participating students for the entire duration of the course.

Target student profile

The summer school is intended for PhD candidates in neuroscience and the program is suitable for candidates with a variety of educational backgrounds and research specializations: neuroscience, engineering, life sciences, mathematics, computer sciences, and physics. Priority will be given to members of NRSN. Other participants may be accepted if there are still places available.

Organizers and lecturers

The summer school will be organized by Kavli Institute for Systems Neuroscience at NTNU, with support from the Norwegian Research School in Neuroscience (NRSN).

Scientific coordinator
Dr. Jonathan Whitlock, Group leader at Kavli Institute for Systems Neuroscience
jonathan.whitlock@ntnu.no, 73598268.

Program coordinators
Karoline Hovde, PhD student at Kavli Institute for Systems Neuroscience/Centre for Neural Computation
karoline.hovde@ntnu.no, 99465984

Tanja Doller, Dip.-Psych., NRSN coordinator
tanja.i.doller@ntnu.no, 90852322

Kavli Institute for Systems Neuroscience, NTNU - lecturers/instructors:
Benjamin Dunn, Nathalie Jurisch, Clifford Kentros, Edvard Moser, Christian Doeller, Jonathan Whitlock (organizer), Menno Witter, Emre Yaksi.

Special guest lecturers:
Alessandro Treves, International School for Advanced Studies (SISSA), Italy
Eugenia Chiappe, Sensorimotor Integration, Champalimaud Centre for the Unkown in Lisbon, Portugal.
Panayiota Poirazi, Computational Biology Laboratory Institute of Molecular Biology and Biotechnology (IMBB) Foundation of Research and Technology-Hellas (FORTH), Greece

Practicalities

Arrival: Sunday August 13, 2017, by 17:30, **Departure:** Saturday August 19, 2017 after lunch

Location: Kavli Institute for Systems Neuroscience, NTNU, Trondheim

Number of students: Max. 20

Credits: The Faculty of Medicine at NTNU recommends that participation in the summer school is accredited with 3 ECTS credits. Participants must apply to their respective universities in order to have the course formally approved as part of their PhD education.

Examination: To obtain a certificate participants need to hand in an essay, which will be evaluated as pass or fail.

Course fee: Participation is free for NRSN members. Participants who are **not NRSN members** must cover their own expenses for travel and accommodation (approx. 13 000 NOK).

Registration: Deadline: 3 April 2017 – **register online**

Accommodation for participants: Scandic Lerkendal Hotel, Trondheim

Travel and accommodation:
NRSN members from outside Trondheim must book their own travel. *Please do not book until you have a confirmed place in the summer school*. NRSN will reimburse travel expenses after the event for the members of the research school. The travel reimbursement is limited to 2000 NOK for the round trip, including public transportation (not taxi or private car) to and from the airport. The organizers have reserved rooms for the period of 13-20 August 2017 at Scandic Lerkendal Hotel in Trondheim.

You need to **confirm your reservation for a room before 1 July 2017** to the NRSN coordinator tanja.i.doller@ntnu.no. The summer school takes place in the week of the annual fishing convention in Trondheim, which means that all hotels in Trondheim are fully booked and prices are extraordinary high.

Meals:
Lunch will be served daily. The program includes four organized dinners and socials events.

Course overview

Day	Topic	Lecturers/instructors
Sun 13 August	Arrival, welcome, students and faculty members present themselves, dinner and social event.	
Mon 14 August	Measuring anatomical and functional connectivity of neural circuits in the vertebrate brain. **Module 1**	*Witter*
Tues 15 August	Measuring, perturbing and analyzing activity in the rodent brain. **Module 2**	*Moser/Kentros*
Wed 16 August	Decoding memories and spatial mapping in the human brain. **Module 3**	*Doeller*
Thurs 17 August	Measuring neural activity and behavior using optical methods. **Module 4 – Rat and mice**	*Whitlock*
Fri 18 August	Measuring neural activity and behavior using optical methods. **Module 4 - Zebrafish**	*Yaksi*
Sat 19 August	Students' presentations, career discussions and departure	

Detailed description of course modules

Practical module 1 (One day – Witter): Measuring anatomical and functional connectivity of neural circuits in the vertebrate brain

In this module, students will get hands-on experience in anatomical tracing, combined with postsynaptic target identification, synapse localization and characterization using a combination of light microscopy, confocal microscopy and electron microscopy. Moreover, students will learn to use (3D) atlases to design stereotaxic surgeries and represent experimental data, together with a demonstration of stereotaxic surgery. In parallel, students will learn the use of various transgenic and viral technologies in order to perform cell-type specific neuroanatomical studies. The students will learn about distinct viral vectors used for

anterograde and retrograde tracing methods, and compare them to classical techniques. On the next day, students will get hands-on experience with *in vitro* approaches to study local circuits with electrophysiological approaches using voltage sensitive dye imaging, single-cell patch clamp recordings, and electrical and optical stimulation. Finally, students will be provided example data sets for the experiments described above in order to learn how to analyze such data sets.

Practical module 2 (One day – Moser/Kentros): Measuring, perturbing and analyzing activity in the rodent brain.

In this module, students will work together with experts to record neural activity in the rodent hippocampus and the medial entorhinal cortex (MEC) while animals explore different spatial environments and see first-hand how the brain generates distinct maps for each enclosure. The students will record activity from cells in MEC while animals explore a spatial environment, before and after activation of the transgenic receptor. The next day, using a number of recorded hippocampus place cells and grid cells from the MEC, the students will learn to write their own program, or modify previously written codes (depending on their background), to use this data and predict the position of the animal in an environment. They will learn about simple generalized linear models as well as concepts such as training data set, test data set as and ways to quantify prediction errors. The students will then learn how including interactions between neurons can improve the prediction of the animal's position.

Practical module 3 (One day - Doeller): Decoding memories and spatial mapping in the human brain

In this module, the students will get an introduction into a basic framework for human memory research: Memory systems and cellular and molecular underpinnings of neural plasticity. The students will learn how the human brain maps space and helps us to navigate the world by combining cutting-edge functional neuroimaging with virtual-reality techniques. Students will visit the virtual reality lab and get hands-on experience in navigation tasks. They will learn about experimental designs to investigate spatial maps in the human brain. Moreover, they will get familiar with proxy measures of cellular aspects of cognition in combination with functional magnetic resonance (fMRI) imaging.

Practical module 4 (Two days – Whitlock, Yaksi): Measuring neural activity and behavior using optical methods

In this module, the students will get hands-on experience in the use of optical methods for imaging brain activity both in rodents and in zebrafish. This set of experiments aims to train the students for the basics of optical imaging techniques for measuring brain activity and the instrumentation surrounding the microscope. The students will be divided into two groups in order to join experiments with the experts in rotations. In parallel, the students will experience performing two-photon calcium imaging experiments in the zebrafish brain and epifluorescence imaging of brain activity in freely behaving mice using head attached mini-microscopes. These imaging experiments will also be accompanied by video tracking of

diverse sets of animal behavior. The next day the students will learn how to be critical and how to analyze both functional imaging and animal behavior data sets. These large and challenging microscopy and video imaging data sets will provide the students with a good understanding of some of the mathematical tools for image processing and multivariate statistical analysis. Moreover, this module will also provide the students with the basics of building a microscope.

Students' presentations, career discussions and a small final event (last day)

The students will be given a case study (questions) in which they will have to come up with a research proposal on how to address that questions with which methods and which steps. This experience will also provide the students with basic principles of designing a scientific project and a solid project proposal. The students will organize panel discussions with faculty members about career choices and paths after the PhD. The day will finish by a networking event organized by the students.

Daily Schedule

Time	Event
9:15 – 10:15	Lectures: State of the art in neural circuit research
10:15-10:30	Coffee break
10:30-11:45	The students form four teams and each team identifies five questions. There will also be questions by the lecturer. Discussing the questions together with the lecturer.
11:45-12:45	Lunch break
12:45- 13:30	Research talks by the lecturers and discussions
13:30-13:45	Break
13:45-18:00	Practical rotations, group work and students' presentations
18:00-19:00	Special lectures or free time
19:00-	Dinner and group activities

Lectures:

- Molecular Genetic Tools for Systems Neuroscience (Kentros)
- What sets the metric of mental spaces? (Treves)
- Combining anatomy and electrophysiology to study brain circuits (Witter)
- Methods for imaging brain activity: a comparative approach.
  Studying neural circuits mediating fear in zebrafish brain (Jurisch-Yaksi) (Yaksi)
- Synaptic Plasticity and Memory (Whitlock)
- Decoding memories in the human brain (Doeller)
- Memory and Space (Moser)
- Studying the neural bases of visuo-motor interactions in walking flies (Chiappe)
- Information coding within dendrites: insights from computational models (Poirazi)

Research talks:

- Transgenic Investigation of the Neural Circuitry of Memory (Kentros)
- Functional architecture of the cortico-hippocampal system (Witter)
- Cognitive motor functions of parietal & frontal cortex (Whitlock)
- Spatial mapping in the human brain (Navarro-Schroder)