



Meeting Report: FENS - Chen Institute - NeuroLéman Summer School on Motor control: from thought to action

The FENS - Chen Institute – NeuroLéman 2023 Summer School, was successfully organized under the theme “Motor control: from thought to action” and held in Switzerland at the Ecole Polytechnique Federale de Lausanne (EPFL), Lausanne campus, from July 2 to 8. The workshop brought together experts in the field of Neuroscience, specifically in Motor Control, and early-career neuroscientists from across America, Asia and Europe. In all, there were 9 speakers and 34 early-career neuroscientists comprising graduate students and postdoctoral fellows.

Participants were received on the first day (2nd July) with a warm welcome and introduction ceremony by the scientific chairs, together with Chen Institute and FENS representatives. The tightly scheduled workshop strategically combined many interesting academic events, spiced with social activities. Most notable among these events were plenary sessions, poster presentations, students’ oral presentations, laboratory tours, lunch time pep talk with speakers, boat cruise and dinner on a mountain. All in all, while the 7-day event passed too quickly leaving nostalgic memories of bonding and knowledge acquisition, the experience was lasting and appears to have persevered over several weeks if not the months subsequent to the school.



Group photo of workshop attendees

Summer School Organizing committee members

Scientific Chairs

Carl Petersen (NeuroLéman and Brain Mind Institute, EPFL, Switzerland)

Brain McCabe (NeuroLéman and Brain Mind Institute, EPFL, Switzerland)

FENS Representatives

Karen Doyle

Tasia Asakawa

FENS Coordinator

Andreea Marginean

EPFL Coordinator

Egizia Carbone

Summer School Activities

Academic

Presentations by speakers: The special lectures spanned from Monday, July 3rd to Friday, July 7th, with two speakers each day, a morning session and an afternoon session separated by a lunch break. Each session had two parts; a lecture and an interactive section with a coffee break in between. The speakers presented their expert accounts in their fields, including their research advancements, current research outcomes and future exploits, highlighting interesting contemporary arguments in neuroscience and their expert opinion. In the interactive sessions, students had the opportunity to ask multiple questions in a more liberal way. In some

instances, interesting scientific arguments were raised for plenary discussions. Below, we highlight these presentations from each of the speakers.

Brian McCabe

Brian McCabe leads the Laboratory of Neural Genetics and Disease at the Brain Mind Institute of the EPFL School of Life Science. His research group is working on different genetic models of *Drosophila melanogaster*.

During his lecture entitled 'How motor neurons enable movement' he presented a variety of studies over neuromuscular junction synapses on *Drosophila* which thanks to shared features in motor systems can be translated onto different species. He pointed out that studies on motor circuits should also consider motor neurons as crucial executors of movements. He further elaborated on miniature neurotransmission (minis) which is essential to maintain synapse structure in the process of motor synapses aging or degeneration resulting from neuropathology. This issue and its possible implications in preventing motor synapse degradation were widely discussed with the students.

Ariel Levine

Ariel Levine is the research head at the Spinal Circuits and Plasticity at the National Institute of Neurological Disorders and Stroke under the auspices of the National Institute of Health, United States. She discussed spinal circuits for motor control.

She elaborated on her lab's interest in the spinal cord as the link between the brain and the body and how spinal local circuits mediate motor control.

She discussed the diverse array of spinal cord neurons and how these neurons integrate all afferent information and transform them into motor commands. Furthermore, the autonomic abilities of the spinal cord in terms of spinal reflexes were well discussed with several arguments and contribution by students and other present speakers. It was an exciting and informative presentation.

Pavan Ramdya

Pavan Ramdya is a professor at the Brain Mind Institute of the EPFL Faculty of Life Sciences in Switzerland, where he leads a group focused on the use of genetics, microscopy, modeling, and quantitative behavioral analysis to understand how the brain works.

His talk focused on the approaches for reverse engineering of insect action selection and limb control in *Drosophila melanogaster*. In his presentation, he elaborated on how his lab is capitalizing on reverse engineering (dismantling insect's functional mechanisms) to understand how these systems work and apply them to solving critical motor control issues. He demonstrated how his lab is using imaging techniques and algorithms to reconstruct the whole neural networks of the fruit fly, and the suitability

of the insect as an ideal model for such research due to their simple neural circuits, fewer neurons and the relatively ease of studying their central pattern generators.

Silvia Arber

Silvia Arber is a member of the Biozentrum, University of Basel, and also serves as a Senior Group Leader at the Friedrich Miescher Institute.

During her talk titled "The Brainstem as a Central Player in Motor Control," she emphasized the importance of the brainstem in motor control, highlighting the most recent findings in the brainstem. Particularly, she explained the roles discovered in the motor control of neuronal subpopulations in regions such as the mesencephalic locomotor region and the medulla. Subsequently, she established the findings regarding the role of the substantia nigra reticulata and the aforementioned regions. There was an emphasis on understanding the role and types of neuronal subpopulations in motor control, leading to a finer understanding of their contribution to motor behavior. Additionally, it was mentioned that understanding how a movement is generated is crucial, as it involves knowing the input from neurons that initiate a motor program encoded within them. This leads to the general idea that it is important to identify the regions that generate movements and be able to distinguish them from the regions that need to be aware of the movements.

Mackenzie Mathis

Mackenzie Mathis is the Bertarelli Foundation Chair of Integrative Neuroscience at the Swiss Federal Institute of Technology, Lausanne (EPFL). She is a professor at the Brain Mind Institute of the EPFL School of Life Sciences.

During her talk "Towards understanding dynamics in sensorimotor learning in biological and artificial systems", she discussed the concept of reverse engineering adaptive behavior, which is related to the use of machine learning in behavior analysis. She established the advantages of utilizing this concept and tool to improve precision in behavior analysis.

Across the interaction with the audience, the use of developed tools such as DeepLabCut and Cebra in the analysis of various types of behaviors and animal models was discussed. Additionally, an overview was provided regarding the future of these tools and new ones, which not only allow the analysis of behavior in isolation but also integrate it with other aspects such as neuronal activity recorded during said behaviors.

Daniel Huber

Daniel Huber is a professor in the Department of Basic Neurosciences at the University of Geneva, Switzerland, where his lab currently studies how different areas of the frontal cortex interact during decision-making and the control of goal-directed action. During his talk "Cortical representations of goal-directed action", he mainly discussed specific subsets of neurons in the cortex that specialize in encoding different aspects

of goal-directed behavior. Additionally, he demonstrated how these subsets participate at different times in the same behavior.

Over the interaction with the audience, fundamental aspects regarding questions of how to investigate thought and whether animals 'think' were discussed. He showcased how it is possible to investigate such a fundamental and complex concept.

Furthermore, the topic of neuroprosthetics was mentioned, highlighting how these technologies rely on sensory feedback to enhance the interaction between animals/humans and the technology.

Lastly, a significant aspect of the discussion revolved around conducting research in ecological environments with animals to obtain more natural measurements of animal behavior.

Cristin Welle

Cristin Welle is a Systems Neurophysiologist with expertise in the interaction between medical devices and the nervous system. She leads her lab in the Departments of Neurosurgery and Physiology at the University of Colorado.

During her lecture entitled 'Neuromodulation to drive plasticity and motor learning' she showed the students the power of vagus nerve stimulation (VNS). Her data indicate that it enhances motor learning via cholinergic signaling. Moreover, VNS influences another process crucial for motor learning which is myelin plasticity. Prof. Welle also presented different neuroprosthetic devices used for the treatment of various neurological conditions, such as epilepsy and Parkinson's disease.

This subject was very interesting for school participants as there were multiple questions asked, especially concerning the use of VNS and other stimulating devices to help patients with different medical conditions. All agreed that those are powerful tools and should be further developed to be more available for patients.

Claire Wyart

Claire Wyart is a group leader at the Paris Brain Institute, the Institute du Cerveau (ICM) in France. Her presentation centered on identifying long-term dynamics in motor patterns by using the zebrafish as a study model.

She elaborated on how her lab uses simple mechanisms employed in the zebrafish to reveal motor control systems including sensorimotor integration processes that contribute to shaping locomotion, posture and morphogenesis throughout life, and how the zebrafish uses sensory feedback to increase locomotion speed. She further touched on how semi-automatic motor patterns are generated by the specific structures and dynamics of motor circuits in the brainstem. She further argued how sensory inputs are relevant for motor control in animals.

Carl Petersen

Carl Petersen and his research group at the Brain Mind Institute of the EPFL Faculty of Life Science focus on the mechanisms underlying reward-based learning and context-dependent sensory perception in mice.

In his lecture entitled 'Neuronal circuits for goal-directed behavior' he presented his studies over interactions between sensory and motor cortices as well as dependencies in their neuronal activity. Moreover, he explained the results of his studies on cortical sensorimotor integration and cortical contributions to whisker and licking motor control. During the discussion, he answered multiple questions concerning behavioral tests conducted in his lab on mice as well as future directions in his research.

Lab visits

During the first day of the summer school the participants had a unique opportunity to visit three labs in EPFL. In two of them – Pavan Ramdya's and Brian McCabe's labs – they could see *Drosophila melanogaster* colonies, their housing and different experimental set ups to perform behavioral experiments as well as electrophysiological and neuroanatomical studies over this species. In the third lab, led by Carl Petersen, the students saw the equipment used for studying cortical contributions to goal-directed sensorimotor transformation. They were briefly presented with different experimental approaches to study this in mice, e.g. with the use of wide-field microscopy, two-photon microscopy and neuropixels recordings.

Visit to NeuroRestore

The visit to Lausanne University Hospital was one of the best experiences for understanding and witnessing the connection between research in the field of motor control, technology, and the pursuit of symptom improvement in various motor control-related diseases.

During this visit, we were shown different technologies aimed at improving symptoms of diseases or injuries in the spinal cord, as well as Parkinson's disease. These technologies emphasize innovation in surgical techniques and technology, as well as the quest to personalize treatment for each patient. Additionally, the focus is on empowering patients to have greater autonomy in deciding the use of this technology, combining it with commercially available technologies such as apps, smartphones, smartwatches, and tablets.

Furthermore, we were given the opportunity to interact with and test various technologies, which are primarily geared toward initial patient rehabilitation. This aspect made the experience even more enriching.

European Journal of Neuroscience (Christoph Michel)

Christoph Michel is a professor at the Department of Clinical Basic Neurosciences,

Medical Faculty, University of Geneva in Switzerland.

He gave an exposition on the European Journal of Neuroscience, which is the official journal of the Federation of European Neuroscience Societies (FENS). He emphasized the uniqueness and qualities of the journal and the advantages to publishing with them. His brief exposition was followed by questions from the audience, which he gracefully addressed without hesitation.

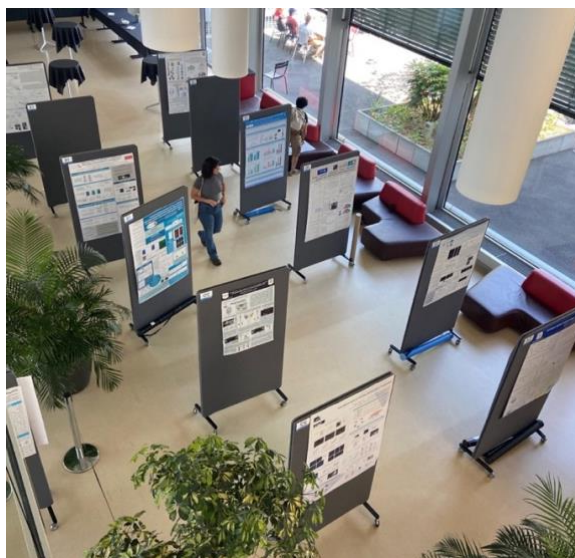
Chen Institute (Yan Li)

Dr. Yan Li spoke about the foundation history of the Chen Institute, touching on the brief backgrounds of the couple (Tianqiao Chen and Chrissy Luo) founders as well as the initial investment capital of USD 1 billion, with the rationale of promoting neuroscience research. She mentioned the commitments of the Chen Institute to fostering the advancement of science in general and neuroscience in particular by touching on some milestone achievements of the rather young institute which started from California Institute of Technology (Caltech) in the United States of America.

Students' Oral and Poster Presentations

Students' oral presentations were held in three series in the evenings of July 3rd, 4th and 5th. Each student presented their abstracts in 5 minutes by introducing themselves, and their research objectives as a teaser to invite participants to their poster. It was interesting and added more fun to the whole event, especially how the timekeeper, Brian McCabe gradually walked towards students to signal them to end their presentation when their time had elapsed.

The poster presentation was held on the evenings after oral presentations, together with dinner. The posters provided additional opportunities for student participants to further explain their research to colleagues and the speakers who visited their stands.



Students' poster boards

Social events

As a side attraction, students were treated with cruise and dinner on Lake Geneva, also known as Lac Léman, a monumental lake in the heart of Switzerland. The all-fun cruise was an opportunity for personal students' interactions with the scientific chairs and other supporting staff of the workshop, it was an exciting and lasting experience.



Cruise on Lac Lemman

To culminate the whole event, students were given another treat of “Dinner on the Mountain” at the vintage restaurant on the zenith of the beautiful Mont Chesau. Of interest was an unexpected hiking expedition in the pines on the mountain ahead of the dinner. Attendees were treated with a classical Swiss fondue meal, such a memory worth recalling.



Hiking on Mont Chesau.

Authors' Experiences and thoughts

We first wish to express our appreciation to the funders, organizers, chairs and all participants of the FENS – Chen Institute - NeuroLéman Summer School 2023, the experiences are enormous to be shared on a single occasion. With our colleague students alike, we are particularly grateful to the Scientific Chairs Carl Petersen and Brian McCabe, also to the FENS coordinator Andreea Marginean, the FENS representatives Karen Doyle and Tasia Asakawa, the EPFL coordinator Egizia Carbone, the Chen Institute representative Dr. Yan Li and all other stakeholders. It was our first-time hearing about the NeuroRestore project and learning more about central pattern generators. Although our research focuses on different aspects of the brain, the explicit presentations by the speakers facilitated a comprehensive understanding of the various directions involving the cerebral cortex and the brainstem that control motor activities. In contention, all speakers argued their study models were the ideal, at the same time highlighting the limitations that restrict the provision of absolute solutions to all the many begging neuroscience questions. So, the biggest question on our minds is “What are the best future research directions?”

While the program was largely successful, we believe that the addition of practical lab sessions would afford future student's hands-on experience. We therefore sincerely suggest an extension of the workshop duration from 7 days to between 10 to 14 days including practical lab training.

About the authors

Martyna Gokowska is a graduate student at Department of Neurophysiology and Chronobiology at the Jagiellonian University in Krakow, Poland. The aim of my PhD project is to understand the cortical neural circuits involved in motor learning, fine motor control and sensorimotor adaptation. Moreover, I am interested in the role of dopamine that is released in the cortex during motor skill learning and populations of neurons expressing dopamine receptors.

Richard Owusu Mensah is a graduate student at Tokyo Medical and Dental Sciences, Tokyo, Japan. My research focus is to understand the morphological basis for the motor and nonmotor functions of the cerebellum by employing anatomical, physiological, immunohistochemical, and microscopy techniques to identify specific topographic cerebellar connections.

Leonardo Molano Ramirez is a graduate student at the Faculty of Psychology at the University of Buenos Aires, Argentina. Currently, I am doing a PhD in Biological Sciences in the discipline of Neuroscience at the University of Buenos Aires. I am working at the Neurobiology of Movement laboratory in the Medical Physics department at National Center of Atomic Energy, Bariloche, Argentina. My research focus is to establish the role of the brainstem in motor learning.

