Master de Sciences et Technologies
Mention Biologie Intégrative et Physiologie
Parcours : Neurosciences
Responsable : Professeur Régis Lambert

Internship Proposal
Academic Year 2019-2020

1. Host team:

Research Unit: **Department of Integrative and Computational Neuroscience (ICN), Neuro-PSI, CNRS Gif-sur-Yvette**
Research Unit Director: **Philippe Vernier**
Research Team Director: **Daniel Shulz**
Team name: **Sensorimotor processing and plasticity**

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Supervisor of the Research Intern for this project: **Valerie Ego-Stengel**
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2. Internship project title:

Neuronal mechanisms underlying sensorimotor learning studied in a closed-loop BMI setup.

3. Internship Description:

This M2 project aims to investigate how sensory feedback takes part in learning a motor task, using a bidirectional Brain-Machine Interface (BMI) setup in the head-fixed mouse.
During voluntary movement, ongoing feedback from our senses, in particular touch and proprioception, allows us to correct both the position of body parts and the forces they exert. This sensori-motor closed-loop control is critical for proper execution and rapid learning. Thus, recent efforts in the development of BMIs for motor-impaired patients aim to add rich sensory feedback to motor prostheses.
However, the neuronal mechanisms by which feedback information is integrated by the motor system are unknown. We hypothesize that this integration takes place in the motor cortex (M1), a major actor in the control of voluntary movement, heavily interconnected with the primary somatosensory cortex (S1).
Thus, our approach is to focus on the cortical level by recording and manipulating activity in M1 and S1 during learning of a new sensorimotor task.
Our team has recently built a closed-loop BMI tailored to the sensorimotor whisker system of the mouse (Abbasi, et al., 2018, Journal of Neural Engineering). On the motor side, the mouse learns to modulate the activity of individual M1 neurons to drive an actuator towards a target in order to obtain a reward (similarly to Arduin et al., 2013, 2014 from the lab). On the sensory side, tactile feedback signals are delivered by optogenetic cortical stimulation in the whisker representation of S1, according to spatially-structured light patterns. This setup enables us to examine neuronal mechanisms of sensorimotor integration in S1 and M1.
In the context of the Master 2 internship, the student will focus on the impact of feedback latency on motor execution and learning, taking advantage of the fast speed of our current implemented loop (5 ms M1-to-S1 latency), below the ~30 ms of the natural sensorimotor loop. We will thus be able to inject artificially a delay in the loop, in order to either match the natural latency, or impose higher or lower delays. We will determine the effect of this manipulation on learning a one-dimensional BMI task, notably whether matching the natural latency results in optimal control of the actuator.