MASTER 2 Fundamental and Clinical Neurosciences

Internship proposal 2022-2023

(internship from January to June 2023)

Host laboratory:
Stem Cell & Brain Research Institute, Inserm U1208
18 Avenue du Doyen Jean Lepine, 69500 Bron
(Site of the "Hopitaux Est")

Host team :
Neurobiology of Executive Functions
https://www.sbri.fr/team/6neurobiology-executive-functions

Internship supervisors :
Charlie Wilson, CRCN, Charles.wilson@inserm.fr (Supervisor of proposed stage)
Emmanuel Procyk, DR2, Emmanuel.procyk@inserm.fr (Team leader)

Project title :
What is the neurophysiological basis of motivation and attentional effort in prefrontal cortex?

Project summary :

Motivation has a profound effect on all cognition, and on our daily life in general, and yet we currently have a weak understanding of its neural basis. For example, motivation strongly influences the neurophysiology of prefrontal cortex (PFC, Botvinick & Braver 2015), but the way motivation interacts with the other things PFC does is not well understood. Motivation drives task performance by letting us apply "attentional effort" to the things we are doing (Sarter et al 2006). Attentional effort is linked to *both* intrinsic motivation *and* specific factors of the task itself, for example how engaging and rewarding it is. It may reduce over time, for example in the "time-on-task" effect (Boksem et al 2006).

In our team we have used chronic neurophysiology in macaque monkeys, to study how attentional effort is implemented in PFC. We revealed an intriguing effect of strong and specific modulation of the beta oscillations in frontal cortex around pauses in work that monkeys make (Stoll, Wilson et al, 2016; Wilson et al 2016).

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This work is very promising, but there remains much to be done. The proposed internship project is to further investigate the mechanisms in several datasets of monkey neurophysiology. There are many potential questions to answer in this project. We will construct the detailed content of the internship together with the interested student. Possible questions to pursue are:

- How does the brain change between motivated and non-motivated states?
- How do bursts of oscillation coordinate frontal cortex functions?
- What is the effect of pauses on task performance, and can we predict pauses from brain activity?
- How does the brain integrate factors impacting motivation?
- How can we design cognitive protocols to capture and modulate attentional effort?

To ensure M2 interns experience all elements of a monkey neurophysiology project, we provide students with already-acquired data to analyze, plus the opportunity to experience the current recordings in the lab. Analysis work is the core of the internship, built around answering a specific and novel research question, but students will also gain extensive experience in the lab of how data are acquired, how the monkeys work, etc. We work hard to give a good internship experience that covers the whole process of our research, and potential candidates are encouraged to contact previous interns to discuss.

For this internship the student will be provided with lots of great data – 2 datasets of electrocorticography (ECoG) recordings in macaques, and one even larger dataset of intracortical recordings provided by collaborators. All datasets cover prefrontal and premotor cortex, and two additionally cover parietal cortex and some visual areas. The monkeys are performing learning and decision-making tasks in long sessions that tax their motivation and attentional effort (Stoll, Wilson et al, 2016; Faraut et al., 2016; Dotson et al 2018).

The student should have some knowledge of programming in R and one of Matlab or Python before the internship starts. We can offer lots of help to students who need to do this preparation between now and then - contact Charles.wilson@inserm.fr to discuss it. Close daily supervision will be provided to carefully guide the analyses, and in addition the student will be able to work with current lab members working on similar questions and already familiar with the data. The data and the analysis approaches are highly promising, and a significant amount of initial work has been completed. There is certainly the potential for a motivated student to obtain a good publication from the work in the internship.

Relevant publications from the team:

Faraut, M. C. M., Procyk, E., & Wilson, C. R. E. (2016). Learning to learn about uncertain feedback. *Learning & Memory (Cold Spring Harbor, NY)*, *23*(2), 90–98. http://doi.org/10.1101/lm.039768.115

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Stoll*, F. M., Wilson*, C. R. E., Faraut, M. C. M., Vezoli, J., Knoblauch, K., & Procyk, E. (2016). The Effects of Cognitive Control and Time on Frontal Beta Oscillations. *Cerebral Cortex (New York, NY : 1991)*, *26*, 1715–1732. http://doi.org/10.1093/cercor/bhv006

Wilson, C. R. E., Vezoli, J., Stoll, F. M., Faraut, M., & Leviel, V. (2016). Prefrontal Markers and Cognitive Performance Are Dissociated during Progressive Dopamine Lesion. *PLoS Biology*. http://doi.org/10.1371/journal.pbio.1002576.s005

Other references:

Boksem MAS, Meijman TF, Lorist MM. 2006. Mental fatigue, motivation and action monitoring. Biol Psychol. 72:123–132. https://doi.org/10.1016/j.biopsycho.2005.08.007

Botvinick, M., & Braver, T. (2015). Motivation and Cognitive Control: From Behavior to Neural Mechanism. *Annual Review of Psychology*, *66*(1), 83–113. http://doi.org/10.1146/annurev-psych-010814-015044

Dotson, N. M., Hoffman, S. J., Goodell, B., & Gray, C. M. (2018). Feature-Based Visual Short-Term Memory Is Widely Distributed and Hierarchically Organized. *Neuron*, *99*(1), 1–17. http://doi.org/10.1016/j.neuron.2018.05.026

Sarter M, Gehring WJ, Kozak R. 2006. More attention must be paid: the neurobiology of attentional effort. Brain Res Rev. 51: 145–160. https://doi.org/10.1016/j.brainresrev.2005.11.002