Maastricht University

Project title: Mechanisms and role of axon-myelin structural plasticity in learning and information processing

Project leader: Prof. Dr. Renaud Jolivet and Dr. Michelle Moerel

Function: Professor of Neural Engineering and Computation

Collaborators: Prof. Kaylene Young, University of Tasmania
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Proposal (250 words):

Introduction: Our group and collaborators have recently discovered a new type of structural plasticity in the brain between axons – the structure through which neurons propagate electrical signals – and the myelin coverage of axons – the structure that ensures the speedy, reliable, and energetically efficient propagation of those signals. Experimental evidence suggests that this newly identified form of plasticity is important in learning, for instance for the coordination of fine motor tasks, and can be induced or modulated by external interventions such as transcranial magnetic stimulation.

Hypothesis and Objectives: This project will investigate in computational biology simulations, the biophysics underlying this new form of plasticity.

Setting and Methods: We will investigate the role of potassium channels located underneath the myelin coverage at juxtaparanodes. We will test the hypothesis that changes in the volume of the periaxonal space affect the degree of coupling between parallel myelinated axons. We will also ask how this structural plasticity can shape information flow in neural networks by simulating its effects on the propagation failure of neurons' electrical signals, and on the time course of these signals. Finally, we will investigate a possible link between this new form of structural plasticity and the metabolic coupling of axons and myelin sheaths. The project will make extensive use of MATLAB, COMSOL and NEURON packages, and will involve collaborators in Hobart, Tasmania, and Prague, Czech Republic.

Impact: The project addresses a new form of neural plasticity, and will have a profound impact on our understanding of learning in the brain, but also potentially on the design of new types of machine learning algorithms in spiking neural networks.

Requirements candidate: Highly motivated student with good English communication skills, and proactive and resolute attitude. The project requires good programming skills and an interest for the complexity and diversity of the brain's heterocellular population. The ideal candidate would have a foundation in computational neuroscience, and some computational skills, preferably in MATLAB or COMSOL. Applicants with other profiles are still welcome if the applicant can make a case for being able to catch up in programming and computational aspects. Prior participation to the Neuromatch Academy would be highly appreciated.

Keywords: Basic Research, Biological Foundations of Human Health and Diseases, Computational Biology, Neuroscience, Scientific Basis for Development of Information Technology

Top 5 selected publications:

1. Myelin and nodal plasticity modulate action potential conduction in the adult mouse brain Cullen CL, Pepper RE, Clutterbuck MT, Pitman KA, Oorschot V, Auderset L, Tang AD, Ramm G, Emery B,

Rodger J, **Jolivet RB** & Young KM *Cell Reports* 34:108641, 2021 **[JIF 9.4; quartile Q1; 15 citations Web of Science]**

2. Magnetic moments of short-lived nuclei with part-per-million accuracy: Towards novel applications of ß-detected NMR in physics, chemistry and biology Harding RD, Pallada S, Croese J, Antušek A, Baranowski M, Bissell ML, Cerato L, Dziubinska-Kühn KM, Gins W, Gustafsson FP, Javaji A, **Jolivet RB**, Kanellakopoulos A, Karg B, Kempka M, Kocman V, Kozak M, Kulesz K, Madurga Flores M, Neyens G, Pietrzyk R, Plavec J, Pomorski M, Skrzypczak A, Wagenknecht P, Wienholtz F, Wolak J, Xu Z, Zakoucky D & Kowalska M *Physical Review X* 10:041061, 2020 **[JIF 15.8; quartile Q1; 5 citations Web of Science]**

3. Pivotal role of carnosine in the modulation of brain cells activity: Multimodal mechanism of action and therapeutic potential in neurodegenerative disorders Caruso G, Caraci F & **Jolivet RB** *Progress in Neurobiology* 175:35–53, 2019 **[JIF 11.7; quartile Q1; 42 citations Web of Science]**

4. Microglial Ramification, Surveillance, and Interleukin-1β Release Are Regulated by the Two-Pore Domain K^+ Channel THIK-1 Madry C*, Kyrargyri V*, Arancibia-Cárcamo IL*, **Jolivet RB***, Kohsaka S, Bryan RM & Attwell D *Neuron* 97:299–312, 2018 **[JIF 17.2; quartile Q1; top 1% cited in Neuroscience & Behavior; 182 citations Web of Science]**

5. A Process for Digitizing and Simulating Biologically Realistic Oligocellular Mesoscale Networks Demonstrated for the Neuron-Glia-Vasculature Ensemble Coggan JS, Calì C, Keller D, Lehväslaiho H, Agus M, Boges D, Kare K, Abdellah M, Eilemann S, Holst G, Favreau C, Hadwiger M, **Jolivet RB**, Markram H, Schürmann F & Magistretti PJ *Frontiers in Neuroscience* 12:664, 2018 **[JIF 4.7; quartile Q2; 18 citations Web of Science]**