Envisioning the Reward: Neuronal circuits for goal-directed learning

Reporting

Project Information

SweetVision

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Project website

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Coordinated by
THE UNIVERSITY OF EDINBURGH
United Kingdom

Periodic Reporting for period 2 - SweetVision (Envisioning the Reward: Neuronal circuits for goal-directed learning)

Reporting period: 2022-03-01 to 2023-08-31

Summary of the context and overall objectives of the project

Our ability to learn relies on the potential of neuronal circuits to change through experience. The overall theme of this project is to understand how sensory cortical circuits are modified by experience and learning. Recent results have shown that learning the association of a visual stimulus with a reward modifies neuronal responses in primary visual cortex (V1). However, the cellular mechanisms underlying these experience-dependent changes remain largely unknown. Computational and

experimental studies suggest that feedback pathways are crucial for adapting sensory processing by task demands, together with local interneurons that gate feedback through dendritic inhibition. I will test the hypothesis that feedback projections from higher level areas selectively enhance task-relevant information in the primary visual cortex.
The project proposes to apply state-of-the-art methods (in vivo 2D and 3D imaging in awake behaving mice, placed in virtual reality) to the investigation of a fundamental but still unresolved problem: how does practice modify the neural circuits for sensory processing to optimize performance? The recent development of imaging methods in awake behaving mice has revealed the impact of non-sensory inputs into neuronal activity in primary sensory areas. However, the nature of these contextual inputs and the mechanisms underlying their integration with sensory inputs remain unknown.
The originality of the project stems from the comparison between different types of visual experience and the investigation of mechanisms at multiple scales: the subcellular, cellular and network functional changes underlying passive and active visual experience. These results will reveal new functional pathways between brain areas, identifying which type of inputs are received by V1 neurons during goal-directed learning and revealing which type of output is sent from V1 to other brain areas. This rich data set will also reveal functional changes in subtypes of neurons that have so far not been characterized. By revealing the inputs, the local circuits computation and the output of V1 neurons during passive viewing and active learning, I will be able to propose a unifying model that captures the dynamics of the visual learning process.

Work performed from the beginning of the project to the end of the period covered by the report and main results achieved so far

Report 24/03/2022
The beginning of the project has been affected by the Covid-19 pandemic since the lab facilities were not accessible for several months between December 2020 and March 2021.
I took this time to write and publish a review on the topic of the project:
Tom Flossmann, Nathalie Rochefort, Spatial navigation signals in rodent visual cortex. Current Opinion in Neurobiology, Volume 67, Pages 163-173, 2021.
This article has so far been cited 10 times in less than a year.

Experimental part:
- Acquisition of the first data set of 2-photon imaging of V1 and ACC activity during goal-directed behaviour
- Establishment of multi-sites probes electrophysiological recordings (Neuropixels) in awake mice during goal-directed behaviour. Learning and developing the analysis pipeline of recorded activity. First data set collected and being analysed

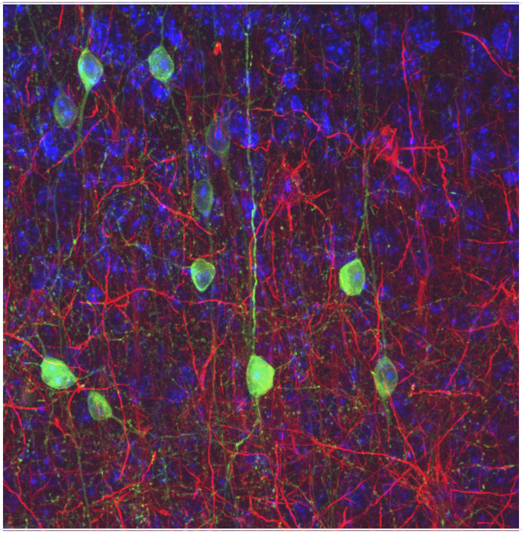
Collaborations:
In parallel to the experimental part, I have pursued a collaboration with computational neuroscientist Dr Arno Onken on the application of statistical methods for the analysis of large datatsets of neuronal activity in awake behaving animals.
This collaboration has resulted in the recent publication of a joint article with contribution from both

labs: (members of Rochefort lab in italic):
N. Kudryashova, T. Amvrosiadis, N. Dupuy, N. Rochefort, A. Onken, Parametric Copula-GP model for analyzing multidimensional neuronal and behavioral relationships, Plos Computational Biology, January 28, 2022, https://doi.org/10.1371/journal.pcbi.1009799
Collaboration with Physicist Dr Tomas Cizmar (fiber endoscopy) is on hold due to the Covid-19 pandemic. Our joint article has been cited 126 times since publication (2018).

Public engagements:
Invited speaker at the BioSoc and Girl Up Edinburgh's 'Women in Biology and Medicine' seminar, March 9, 2022; panel member
Chair of the fundraising event ‘A Statue for Elsie Inglis’; “An Afternoon with Prof Linda Bauld OBE and Kate Murray- Browne chaired by Dr Nathalie Rochefort”, March 2022
Invited speaker to ‘Starting and Developing your own lab’ seminar, more than 100 participants (june 2021)

Progress beyond the state of the art and expected potential impact (including the socio-economic impact and the wider societal implications of the project so far)

Altogether, the results of this project will reveal how experience durably affects neuronal population coding and plasticity in the adult visual cortex. Knowing how cortical responses are strengthened by experience will suggest possible strategies to promote functional recovery, for example to increase the impact of perceptual learning for the recovery of visual function after stroke or after traumatic brain injury. Early discoveries about perceptual learning have already played an important role in developing rehabilitation approaches following visual impairment. Finally, atypical sensory selection in schizophrenia and autism has been linked to differences in feedback processing as well as in inhibitory neurons activity, specifically PV- and SST- positive interneurons. Results from this project will be used to probe differences in sensory processing in animal models of these diseases, with the ultimate goal of identifying drug targets that could be of therapeutic value in these disorders.



excitation-and-inhibition-in-the-visual-cortex.gif

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