Optogenetic Control of Texture Perception in the Visual Cortex

- **Supervisors:** Prof. Andrea Benucci
- **Studentship Funding:**
  - **Name:** SBBS Studentship
  - **Funder:** School of Biological and Behavioural Sciences (SBBS) at QMUL
- **Application Deadline:** 23:59PM on 2nd February 2025
- **Expected Start Date:** 22nd April 2024 (April 2025 Entry)

Project Overview

Applications are open for a 3-Year funded PhD Studentship in the School of Biological and Behavioural Sciences (SBBS) at Queen Mary University of London.

Perceiving the visual world is made possible by a cluster of areas in the lateral cortex called the ventral visual stream. According to a well-established model [1], these areas form a hierarchical processing stream, where early regions encode basic stimulus features, while later regions respond to more complex stimuli such as objects and faces. This model has advanced our ability to decode neural activity but falls short in explaining how neural activations translate into visual perception—specifically, how information is "encoded" within neural circuits.

This PhD studentship aims to address this issue using a causal approach to identify the spatiotemporal optogenetic perturbations of the neuronal dynamics that enable the perception of naturalistic visual stimuli. The project will use the mouse as a model organism and employ holography-based two-photon optogenetics [2] to activate neuronal ensembles in ventral-stream cortical areas. The project will take the following steps:

1. Train mice in a visual-texture discrimination task, with task difficulty adjusted by parametrically controlling texture statistics [3].
2. Manipulate texture perception by optogenetically activating cortical ensembles in mid-level visual areas during the task.
3. Examine the causal establishment of texture selectivity from early to mid-level ventral stream areas and assess the impact of perceptual learning on related neural representations.

Achieving these objectives will provide a mechanistic and causal understanding of the perceptual processes underlying natural vision, paving the way for methods to manipulate perception through external perturbation of cortical circuits. This could lead to advancements in brain-machine interfaces and cortical prosthetic devices for both engineering and medical applications.

Find out more about the School of Biological and Behavioural Sciences on our website.

Keywords: Visual perception, Visual cortex, Optogenetics, Optical imaging, Decision making

Research Environment

The School of Biological and Behavioural Sciences at Queen Mary is one of the UK's elite research centres, according to the 2021 Research Excellence Framework (REF). We offer a multi-disciplinary research environment and have approximately 180 PhD students working on projects in the

biological and psychological sciences. Our students have access to a variety of research facilities supported by experienced staff, as well as a range of student support services.

Prof. Benucci's lab studies the neural substrate of visual processing and vision-based decision making. To this end, his team aims to define a research framework capable of linking neural architectures to the underlying computations. This is achieved via the integration of experimental methods for all-optical dissection of neuronal circuits with large-scale dynamical network models based on artificial neural networks (ANNs). Computations in biological networks arise from connectivity principles among neurons, much like artificial neural networks perform computations. Thus, ANNs represent an effective modeling framework for the unification of computational, algorithmic, and implementation levels of analysis.

Find out more about the laboratory of Prof. Benucci's at www.benuccilab.net and about the School of Biological and Behavioural Sciences on our website here.

Entry Requirements & Criteria

We are looking for candidates to have or expecting to receive a first or upper-second class honours degree in an area relevant to the project such as Psychology, Cognitive Sciences and Neuroscience, Biology, Economics, Physics, Mathematics, Statistics, Computer Sciences or Engineering. A Master's degree is desirable but not essential.

- Candidates should also have some research experience, ideally with practical experience in neural recordings (ePhys, optical imaging).
- Knowledge and prior experience with computer coding, computational modelling, statistical testing and academic writing are essential.
- Knowledge and prior experience with behavioural data collection, particularly linked to behavioural training of rodents, would be highly advantageous.

Find out more about our entry requirements here.

Applicants from outside of the UK are required to provide evidence of their English language ability. Details can be found on our English Language requirements page.

Funding

The studentship is funded by Queen Mary University of London. It will cover home tuition fees, and provide an annual tax-free maintenance allowance for 3 years at the UKRI rate (£21,237 in 2024/25).

To classify for Home Fees, this typically means the candidate will have unrestricted access on how long they can remain in the UK (i.e. are a British National, have settled, or pre-settled status, have indefinite leave to remain etc.)

International students will need to cover the difference in fees between the home and overseas basic rate from external sources. Further details can be found on our PhD Tuition Fees page.

Funding and eligibility queries can be sent to the sbbs-pgadmissions@qmul.ac.uk

How to Apply

Formal applications must be submitted through our online form by the **stated deadline** for consideration.

Applicants are required to submit the following documents:

- Your CV
- Personal Statement
- References
- Copies of academic transcripts and degree certificates

Find out more about our application process on our SBBS website.

Informal enquiries about the project can be sent to **Andrea Benucci** AT **a.benucci@qmul.ac.uk**

Admissions-related queries can be sent to sbbs-pgadmissions@qmul.ac.uk.

Apply Online

The School of Biological and Behavioural Sciences is committed to promoting diversity in science; we have been awarded an Athena Swan Silver Award. We positively welcome applications from underrepresented groups.

http://hr.qmul.ac.uk/equality/
https://www.qmul.ac.uk/sbbs/about-us/athenaswan/

References

1. Ungerleider LM, Mishkin M. Two cortical visual systems. In: Ingle DJ, Goodale MA, Mansfield RJW, editors. Analysis of Visual Behavior. Cambridge: MIT Press; 1982.

2. Papagiakoumou E, Ronzitti E, Emiliani V. Scanless two-photon excitation with temporal focusing. Nature Methods. Nature Research; 2020. pp. 571–581. doi:10.1038/s41592-020-0795

3. Bolaños F, Orlandi JG, Aoki R, Jagadeesh A V., Gardner JL, Benucci A. Efficient coding of natural images in the mouse visual cortex. Nat Commun. 2024;15: 1–17. doi:10.1038/s41467-024-45919-3