Is it me or is the world moving around me?

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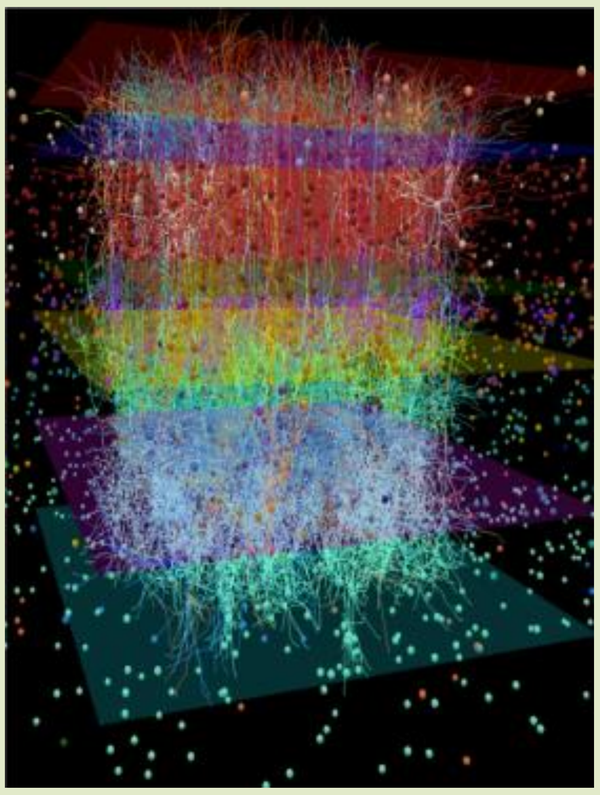
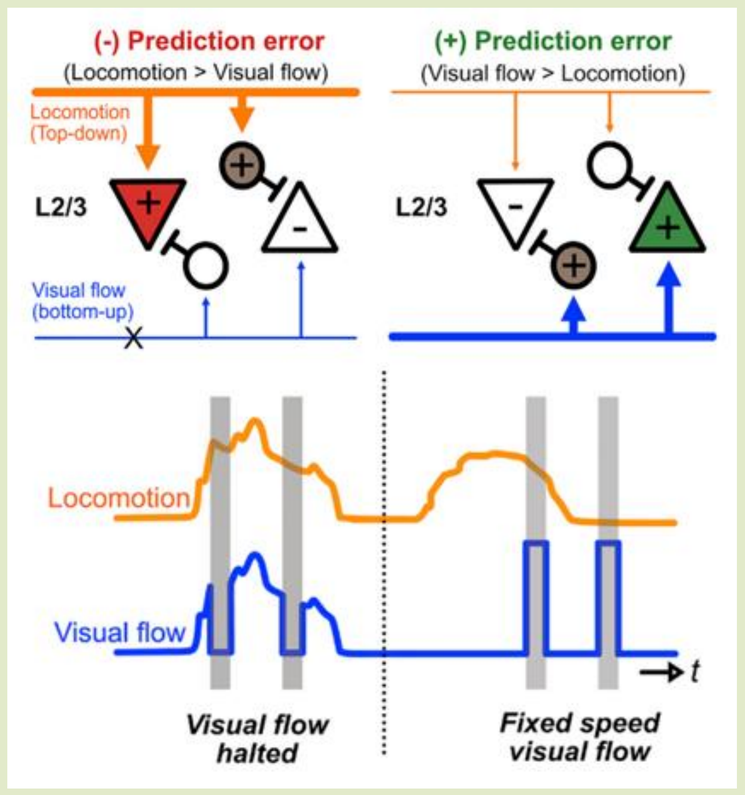


INTRODUCTION

Since we started to interact with the outside world, we have learned to distinguish whether the movement is coming from our own actions or from the movement of external objects. To distinguish between these experiences, it is necessary to factor out the sensory consequences of our actions from incoming sensory information. One framework that accounts for this way of sensorimotor integration is **predictive coding**. According to this framework, animals hold an internal representation of the world, which is used to generate predictions about incoming sensory input. These predictions constitute **top-down** inputs to sensory regions of the brain, where they are compared to **bottom-up** sensory input.

AIMS AND OBJECTIVES

- Produce a model for distributed cortical computation and learning in the primary visual cortex based on recent experimental data.
- Examine under what conditions neurons on layers 2/3 of the V1 model respond to interruptions of visual flow and understand the emergence of prediction errors.
- Develop a theory of neocortical computation that relates computational function to the experimentally found architecture and components of cortical microcircuits.

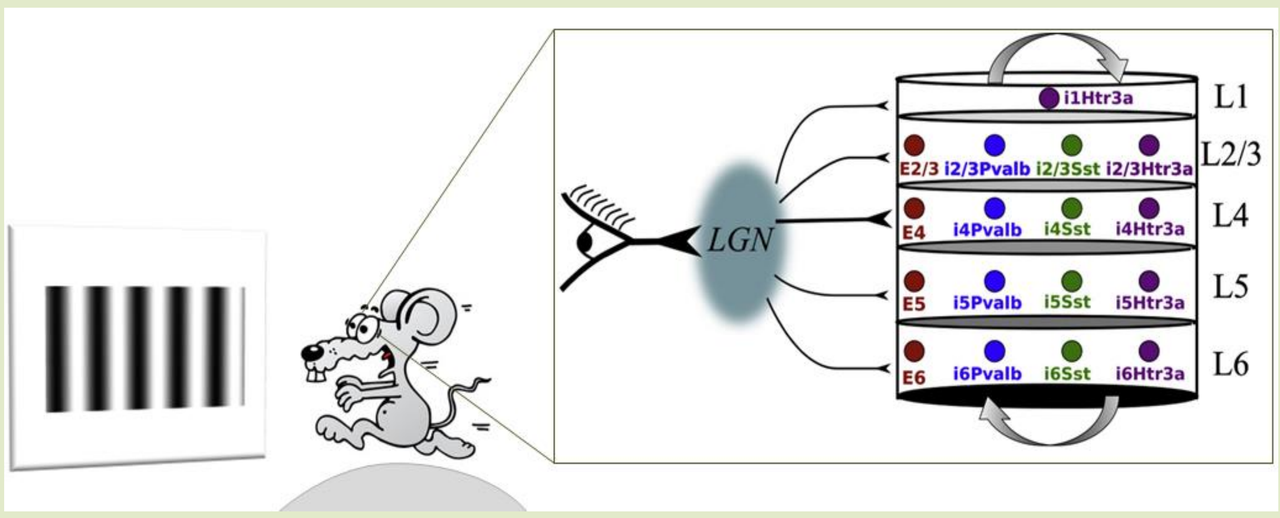


THE EXPERIMENT

Experimental data

Several experiments performed in mouse have found that layer 2/3 neurons compute a difference between top-down and bottom-up visual flow input. Particularly, most neurons respond to visuomotor mismatch with either hyperpolarization or depolarization.

In the experiment we are considering, mouse were presented 1 second visual flow stimuli, consisting of a drifting gratings movie, at random times independent of the subject movement and the responses of 32 excitatory neurons were recorded.

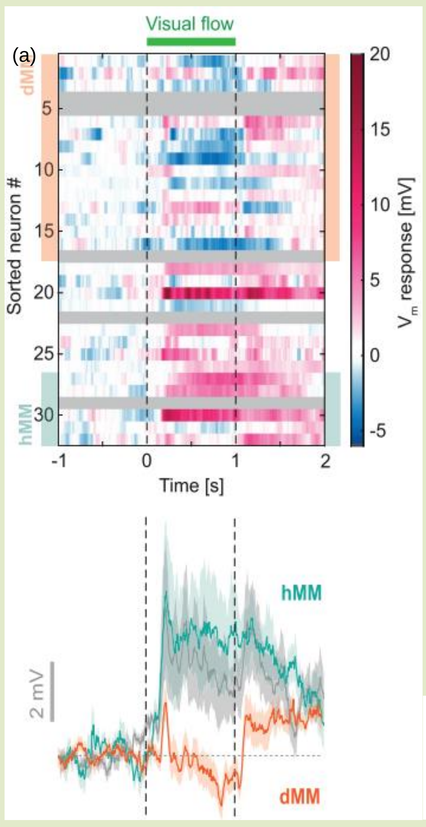


Computational model

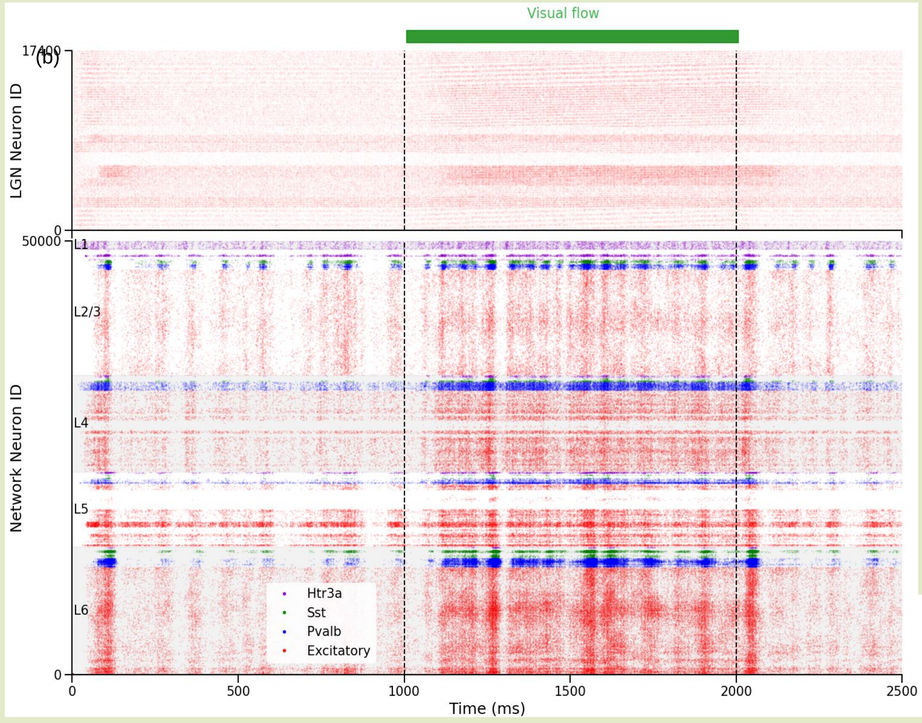
A biologically realistic model of the mouse primary visual cortex with 50,000 generalized leaky integrate-and-fire point neurons along with a model of the lateral geniculate nucleus (LGN) has been implemented computationally.

In the experiment we are considering, 1 second visual flow stimuli in the form of drifting gratings was introduced as an input to the model. The stimuli was preceded by 1 second of a gratings halt image and the responses of all the model neurons were tracked throughout the experiment.

PRELIMINARY RESULTS

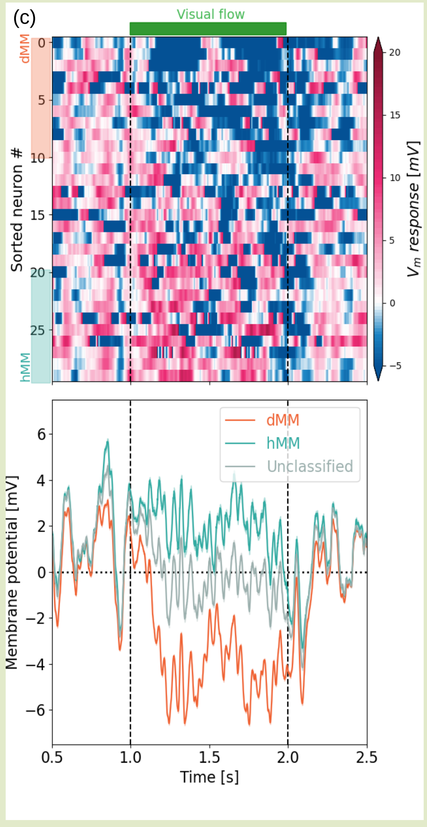


(a) Experimental results. Heatmap of the average membrane voltage response to visual flow stimuli across all L2/3 excitatory neurons and average response across the different types of neurons. Check the QR code to see the visual input presented to the mice.



(b) **Computational results.** Raster plot presenting the spikes of the model neurons to visual flow input. It can be appreciated how the neurons ignite when the gratings start to drift. Check the QR code to see the visual input presented to the model.

(c) **Computational results.** Heatmap of the average membrane voltage response to visual flow stimuli across all L2/3 excitatory neurons and average response across the different types of neurons.



DISCUSSION

- Preliminary results are quite promising as it seems that the computational model can reproduce the experimental results. This means that two well-distinguished behaviors appear when the gratings start to drift, and this pattern agrees with the theoretical basis of the predictive coding framework.
- In the same way that this separation arises when the movement started, it finishes when the movement stops, enhancing the fact that the separation arises as a response to the movement.
- Subsequent work aims at integrating a simplified model of the primary motor cortex to perform a detailed study of the computational role of top-down inputs to lower cortical areas such as the primary visual cortex.
- Finally, once the model can reproduce the available experimental data, the elucidation of the underlying learning principles of the cortical areas through the predictive coding theory turns to be the first research goal.