Inherent anatomic features of V1 leads to dynamical separation of neurons behaviour

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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. The main framework accounting for this sensorimotor integration is the **predictive coding**, which suggest that an internal representation of the world lies in the neocortex circuitry[1]. This representation, which is used to make predictions about incoming sensory input, is continuously updated using the sensed information from our surroundings. Even though the structural rules underlying this functional properties of cortical circuits are poorly understood, recent research has shed light on the computational roles played by the different neural populations[2]. Of particular interest is in this context the computational role of top-down (TD) inputs[1], which are transmitted to lower cortical areas such as the primary visual cortex (V1), during the processing of bottom-up (BU) sensory inputs. The theoretical framework suggests that the V1 circuitry is able to compute the difference between both inputs, generating prediction errors.

This findings represent a Copernican turn in the interpretation of the top-down inputs. Instead of providing sparse representations of sensory inputs, a more modern interpretation arises in the context of Reinforcement Learning models for brain learning. It should summarize all information from the present and past, including sensory experiences and internal goals, which is potentially relevant for choosing the right action in order to achieve the desired goals. This new interpretation of the **predictive coding** is at the heart of recent reviews and experimental studies [3] [5]. In addition, other experimental studies suggest that BU and TD inputs are integrated individually, without any sensorimotor expectation[6].

Therefore, understanding how the genetically encoded structure of canonical microcircuits in the neocortex implements brain computation and learning is an important open research question. The answer to this tangled question can be better elucidated from the implementation and analysis of computational models of canonical microcircuits. In this sense, the Allen Institute has developed a model for a microcircuit of area V1 in mouse that builds on a huge body of experimental work. The model is substantially more reliable than any previous model and includes the preprocessing of visual information in the thalamic lateral geniculate nucleus (LGN) [4] (see Figure 1). Hence, the detailed study of sensory input effects on the model should represent an starting point in order to shed light on these open questions.

[1]Signals originated at higher order cortical areas involving actions and behavioural information.

In this work we perform extensive numerical simulations of the model introduced by the Allen Institute to analyse the effect that different visual stimuli have on the L2/3 layer excitatory neurons, which are the main candidates to behave as *prediction error neurons*. In particular, these neurons exhibit a dynamical separation in their response to perturbations of the visual flow, similarly to the behaviour of prediction error neurons (see Figure 1). Thus, we study the main factors leading to this effect, ranging from the role played by inhibitory neurons to the particular effect of visual flow features.

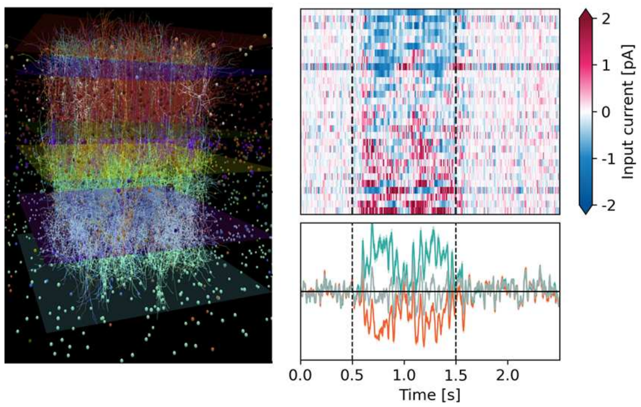

Fig. 1. Left: Visual representation of a fraction of the V1 model neurons. Right: Heatmap of average current responses for a sample of L2/3 excitatory neurons with different behaviours.

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