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Dissertation Abstract

Report no.	(Course-based) No. 1021	Name	Florian Joël François GERARD-MERCIER
Dissertation title	THE FUNCTIONAL SPECIFICITY OF INTRINSIC CONNECTIVITY IN SENSORY NEOCORTEX, A BUILDING BLOCK FOR PROBABILISTIC INFERENCES ABOUT OUR ENVIRONMENT? (感覚野における機能的に特化した局所神経結合は環境に関する確率的推理のための機能構築の単位であるか？)		

Abstract

Cortical circuits encode sensory stimuli through the fine spatiotemporal coordination of firing across neuronal ensembles, and also produce spontaneous population patterns perseverating in the absence of sensory drive. Population activity thus reflects the interplay between the sensory drive (if any) and the reverberation in the cortical architecture. This intrinsic neural architecture can be seen as a built-in model of the expected environment that helps forming the probabilistic inferences about the sensory input that are necessary for behavior and survival.

Population activity is often characterized experimentally by the distribution of multineuron "words" (binary firing vectors). The observed match between spontaneous and evoked word distributions has been interpreted as the result of learning a probabilistic model of the sensory world. We analyzed multineuron word distributions in sensory cortex of anesthetized rats and cats, and, in contrast to previous work, found that they are dominated by fluctuations in population firing rate. We also reproduced these experimental results in simulated networks with fixed (non-plastic) random connectivity. Investigating the role of functionally specific connectivity thus requires focusing on intracortical processing of sensory-driven events rather than internally generated "cortical songs".

In the primary visual cortex of higher mammals (e.g. cat, ferret, non-human primate, humans) but not in rodents, long-range intrinsic "horizontal" connections are organized in a highly specific and reproducible pattern: they anatomically link distant cortical columns of similar preferred orientation. However, their functional role remains controversial. Given their anatomy, one hypothesis has been that they are the neural substrate for some of the Gestalt laws of perception for both contour and motion path integration. We used intracellular techniques to read out the synaptic echoes of visual perception from the fluctuations of the subthreshold membrane potential, and to reconstruct at any point in time the functional impact of the effective connectivity afferent to the recorded cell. Using both static and apparent motion stimulation paradigms, we investigated the subthreshold visual responses in the non-spiking "silent" surround of the receptive fields of cat V1 neurons.

Our results lead to two major findings. First, synaptic responses to static stimuli exhibited a coherent organization, reflecting the grouping bias of the "perceptual association field" for collinear contours. Second, using apparent motion stimuli at saccadic speeds, the in-phase summation of the horizontal and feedforward inputs often evoked facilitatory non-linear interactions, reflecting a related human bias in global motion detection. We conclude that the synaptic integration field of V1 neurons depends on the spatiotemporal features of the visual flow and can extract both local (feature) and global (motion) information, even in the absence of attentional processes. Our data support the concept of a "dynamic neural association field", whose spatial anisotropy passively adapts to retinal flow changes in order to always extract optimally the relevant features from natural sensory inputs.