
On the effects on cortical spontaneous activity of the symmetries of the network of pinwheels in visual area V1.

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Abstract

We consider the problem of describing mathematically the spontaneous activity of V1 by combining several important experimental observations including 1) the organization of the visual cortex into a spatially periodic network of hypercolumns structured around pinwheels, 2) the difference between short-range and long-range intra-cortical connections, the first ones being rather isotropic and producing naturally doubly-periodic patterns by Turing mechanisms, the second one being patchy and 3) the fact that the Turing patterns spontaneously produced by the short-range connections and the network of pinwheels have similar periods. By analyzing the Preferred Orientation (PO) map, we are able to classify all possible singular points of the PO maps (the pinwheels) as having symmetries described by a small subset of the wallpaper groups. We then propose a description of the spontaneous activity of V1 using a classical voltage-based neural field model that features isotropic short-range connectivities modulated by non-isotropic long-range connectivities. A key observation is that, with only short-range connections and because the problem has full translational invariance in this case, a spontaneous doubly-periodic pattern generates a 2-torus in a suitable functional space which persists as a flow-invariant manifold under small perturbations, hence when turning on the long-range connections.

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