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Poster presentation

Eye dominance induces pinwheel crystallization in models of visual cortical development

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Introduction

The formation of orientation preference maps during the development of the visual cortex is sensitive to visual experience and impulse activity [1]. In models for the activity dependent development of these maps orientation pinwheels initially form in large numbers but subsequently decay during continued refinement of the spatial pattern of cortical selectivities [2]. One attractive hypothesis for the developmental stabilization of orientation pinwheels states that the geometric relationships between different maps, such as the tendency of iso-orientation domains to intersect ocular dominance borders at right angles can prevent extensive orientation map rearrangement and pinwheel decay [2,3]. Here we present a analytically tractable model for the coupled development of orientation and ocular dominance maps in the visual cortex. Stationary solutions of this model and their dynamical stability are examined by weakly nonlinear analysis. We find three different basic solutions, pinwheel free orientation stripes, and rhombic and hexagonal pinwheel crystals locked to a hexagonal pattern of ipsilateral eye domains. Using amplitude equations for these patterns, we calculate the complete stability diagram of the model. In addition, we study the kinetics of pinwheel annihilation or preservation using direct numerical simulations of the model in model cortical areas encompassing several hundred orientation hypercolumns. When left and right eye representations are symmetrical, inter-map coupling per se is not capable of stabilizing pinwheels, in this model. However, when the overrepresentation of the contralateral eye exceeds a critical value intermap coupling can stabilize hexagonal or rhombic arrays of orientation pinwheels. In this regime, we find a transition from a dominance of low pinwheel density states ($4/\cos(60°)$) to high density states ($6/\cos(60°)$) with increasing strength of inter-map coupling. We find that pinwheel stabilization by inter-map coupling and contralateral eye dominance leads to the formation of perfectly repetitive crystalline geometrical arrangements of pinwheel centers. These results suggest that while inter-map coupling can prevent pinwheel annihilation it is not sufficient to explain the spatially aperiodic arrangement of pinwheel centers in the visual cortex.

References

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