FUNCTIONAL ORGANIZATION OF CORTICAL MAPS FOR OCULAR DOMINANCE AND LIGHT-DARK POLARITY IN PRIMARY VISUAL CORTEX

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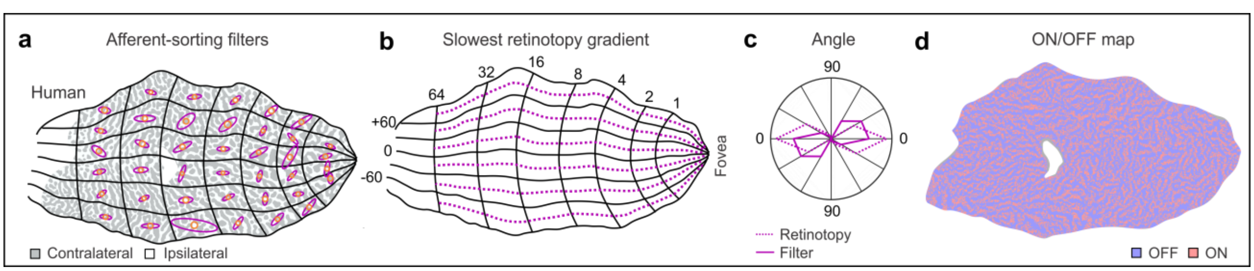
Thalamic afferents are arranged in primary visual cortex based on retinal stimulus position (retinotopic map) and eye input (ocular dominance). For reasons that remain unclear, the patterns of ocular dominance are very diverse across species and can vary even within the same individual animal. Here, we developed an image processing algorithm to quantify the morphology of ocular dominance stripes more accurately than in the past and shed new light on the development of ocular dominance maps. The algorithm starts by selecting, counting and measuring all individual stripes within a published ocular dominance map (e.g. stripe width, length, and orientation). It then divides each published map into patches representing different retinotopic sectors of the cortical map and finds the best match for each patch in a database of simulated ocular dominance patches. The database is generated with a family of afferent sorting filters (multivariate-normal-distributions) that sort thalamic afferents. By systematically varying four parameters of the filters, we generated ocular dominance patches that resembled very closely those found in nature. We then assigned a different filter to each cortical retinotopic patch (Figure 1a) and calculated the angle of the slowest retinotopy gradient (largest magnification factor) within each patch (Figure 1b). The angles of the slowest retinotopic gradient and afferent sorting filter were tightly matched across different sectors of the retinotopic map in the human (Figure 1c), macaque and cat. Based on these results, we propose a developmental model of visual cortical topography that sorts different types of thalamic afferents based on retinotopy. Because cortical domains for eye input and ON-OFF contrast polarity run across orthogonal cortical axis, our model also allow us to simulate an ON-OFF map (Figure 1d). In this eye/polarity grid, thalamic afferents are sorted by eye input across the axis of slowest retinotopic gradient to maximize the binocular retinotopic match and by ON-OFF polarity across the axis of fastest retinotopic gradient to generate the ON-OFF retinotopic mismatch needed to process stimulus orientation.



Keywords: Primary Visual Cortex, Ocular Dominance map, ON/OFF map, eye/polarity grid, Image Processing.