Mapping Spatial Frequency Preferences in the Human Visual Cortex

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Abstract

Neurons in primate visual cortex are tuned for spatial frequency, and this tuning depends on eccentricity. Several studies have examined this dependency using fMRI (Henriksson et al. 2008; Sasaki et al. 2001; D'Souza et al. 2016), but they report preferred spatial frequencies (tuning curve peaks) at a given eccentricity in V1 that differ by one to two octaves, perhaps due to differences in stimuli or analysis methodology. Here, we systematically map this dependency using a population receptive field analysis of fMRI responses to a novel set of stimuli. The stimuli are constructed as mixtures of circular and radial gratings (pure circular, pure radial, or spirals). For any local region of the visual field, these stimuli cover a broad range of spatial frequencies and orientations, and the local spatial frequency of all stimuli varies inversely with eccentricity. We then used an unsupervised denoising algorithm (GLMdenoise; Kay et al. 2013) to estimate the response amplitude of each voxel to each stimulus, and combine these data with subjects' retinotopic maps (Benson et al. 2014; Dumoulin and Wandell 2008) to determine the relationship between the eccentricity of a voxel's population receptive field and its spatial frequency tuning at several orientations. We show that over a range of eccentricities from two to eight degrees, the preferred spatial frequency varies as the inverse of the eccentricity. Given that population receptive fields grow approximately linearly with eccentricity, these results are broadly consistent with a simple scaling rule, whereby peak spatial frequency tuning is inversely proportional to both population receptive field size and to eccentricity.