Connectionist hypothesis about an ontogenetic development of conceptually-driven cortical anisotropy

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Introduction

In the mammalian visual cortex, there are cortical cells tuned to different orientations of visual stimuli. It was shown that the number of cells coding for orientations changes with the coded orientation and that cells responding to vertical and horizontal are more numerous (Mansfield, 1974). This orientation coding anisotropy toward an over-representation of the cardinal orientations was interpreted as an adaptation of the visual system to the greater amount of horizontal and vertical information in our visual environment. In fact some studies showed that the statistics of natural image power spectra show that vertical and horizontal orientations are most present in our visual environment (Van der Schaaf & Van Hateren, 1996). With the present study we tend to measure the influence of the statistics of the visual environment and, in a parallel way, want to see if higher level processes can play a role in visual cortical adaptation. In other words: Is the stimuli that drive the development of the visual cortex or is the cognitive demand from high level cortical areas?

Method

We used 72 images belonging to six semantic classes : beach, city, forest, indoor scene, mountain and villages. Images are 256 gray-level with a Hanning window to avoid an over-representation of the cardinal orientations (due to image edges) in the spectral domain. Thereafter, we applied a bank of fifty-six Gabor filters corresponding to seven spatial frequency bands and eight orientations, with respect to biological data (De Valois & De Valois, 1988). Each image is then described by its local energy in the 56 Gabor filters; This provides a 56-dimension vector per image that was normalized for each orientation channel independently. Then, we used a back-propagation neural network whose aim was to classify these vectors (Dailey & Cottrell, 1999; Dailey, Cottrell, Padgett & Ralph, 2002; Mermillod, Guyader & Chauvin, 2005).

Results

Our study is complementary to the analysis of the statistics of the power spectra of natural images. It consisted of testing independently each cortical orientation channel, after a normalization process which gives the same amount of energy in each orientation. By means of a connectionist classifier, we showed better categorization rates for cardinal compared to other orientation channels. So, not only the natural images have more energy in the cardinal orientations but even with an equal energy in each orientation, a neural model perform a categorization task better with these particular information. These results suggest that the structure of the striate cortex might evolve to be adapted to the statistics of the natural environment but also to the cognitive demand of a neural system.

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