Brightness induction by contextual influences in V1: a neurodynamical account

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Abstract

Brightness induction is the modulation of the perceived intensity of an area by the luminance of surrounding areas and reveals fundamental properties of neural organization in the visual system. Several phenomenological models have been proposed that successfully account for psychophysical data (Pessoa et al. 1995, Blakeslee and McCourt 2004, Barkan et al. 2008, Otazu et al. 2008). Neurophysiological evidence suggests that brightness information is explicitly represented in V1 and neuronal response modulations have been observed following luminance changes outside their receptive fields (Rossi and Paradiso, 1999).

In this work we investigate possible neural mechanisms that offer a plausible explanation for such effects. To this end, we consider the model by Z.Li (1999) which is based on biological data and focuses on the part of V1 responsible for contextual influences, namely, layer 2–3 pyramidal cells, interneurons, and horizontal intracortical connections. This model has proven to account for phenomena such as contour detection and preattentive segmentation, which share with brightness induction the relevant effect of contextual influences. In our model, the input to the network is derived from a complete multiscale and multiorientation wavelet decomposition which makes it possible to recover an image reflecting the perceived intensity. The proposed model successfully accounts for well known pyschophysical effects (among them: the White's and modified White's effects, the Todorović, Chevreul, achromatic ring patterns, and grating induction effects).

Our work suggests that intra-cortical interactions in the primary visual cortex could partially explain perceptual brightness induction effects and reveals how a common general architecture may account for several different fundamental processes emerging early in the visual pathway.

Keywords: Brightness induction, primary visual cortex, horizontal intracortical connections.

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