A neurophysiologically plausible population-code model for human contrast discrimination

Robbe L. T. Goris¹, Felix A. Wichmann²,³ and G. Bruce Henning⁴

email: Robbe.Goris@psy.kuleuven.be

1. Laboratory of Experimental Psychology, K.U.Leuven, Leuven, Belgium
2. Technische Universität Berlin, FG Modellierung Kognitiver Prozesse, Berlin, Germany
3. Bernstein Center for Computational Neuroscience, Berlin, Germany

All current models of spatial vision postulate an initial spatial frequency- and orientation-selective filtering stage. The multi-dimensional stimulus selectivity of cortical neurons makes V1 a likely substrate for these channels.

Contrast sensitivity

Spatial frequency

Contrast response functions without noise, in broadband noise and in notched noise – the notching being 2 octaves wide and centred on the signal frequency. a. Simulated results for a unit optimally tuned to the signal frequency. b. Approximation of these results in the model. c. Approximation for a unit not sensitive to the signal frequency.

Model Characteristics

1. Weight assignment depends on unit selectivity and stimulus contrast

2. Contrast discrimination: effects of response pooling

3. Larger pools, correlated noise

4. Effects of (filtered) noise

5. Weighting profiles in noise

Conclusions

- In a network consisting of units whose contrast response functions resemble those of cortical cells, response-based weighted summation produces contrast discrimination data that resemble several aspects of psychophysical observations. The pedestal effect in this model arises because of information combination across units, level-dependent noise and a stimulus-independent base firing rate.

- These findings suggest that in processing even low-contrast sinusoidal gratings, the visual system may combine information across neurons tuned to different spatial frequencies and orientations.

References