

## S20. Correspondence between contrast and LGN input rate

To a specific contrast  $C$  of the stimulus corresponds a value of the firing rate  $R_{LGN}$  of the input Poisson processes representing sensory-evoked thalamocortical inputs. The LGN input rate to a cell at coordinate  $\vartheta$ , for a stimulus of orientation  $\vartheta_{stim}$  and contrast  $C$ , is given by:

$$R_{LGN}(\vartheta, \vartheta_{stim}, C) = R_0 + [R_1(C)(1 - \epsilon + \epsilon \cos 2(\vartheta - \vartheta_{stim}))]_+$$

Here we discuss the rationale for our choice of the parameters  $R_0$  and  $R_1(C)$ . The response rate of a single LGN cell to a stimulus of contrast  $C$  can be parametrized by the following relation:

$$r(C) = r_0 + r_1 \log_{10}(1 + C)$$

where the contrast varies in the range  $C = 0 \div 100\%$  [Ref i, Ref ii]. Each neuron in the upper layer is assumed to receive inputs from  $N_{cells}$  LGN cells, each one establishing  $N_{syn}$  AMPA synapses on the target cell. In absence of a visual stimulus ( $C = 0\%$ ) the total LGN input rate  $R_0$  to a cell in the upper layer at any angular position  $\vartheta$  is given by:

$$R_{LGN}(\vartheta, \vartheta_{stim}, 0\%) = R_0 = N_{cells}r_0$$

When the stimulus orientation  $\vartheta_{stim}$  corresponding to the cell angular coordinate and when  $C = 100\%$ , the cell receives the maximum possible input from LGN, given by:

$$R_{LGN}(\vartheta_{stim}, \vartheta_{stim}, 100\%) = R_0 + R_1 \simeq N_{cells}(r_0 + 2r_1)$$

When specific values for  $r_0$ ,  $r_1$ ,  $N_{syn}$  and  $N_{cells}$  are set, the two previous equations allow us to derive  $R_0$  and  $R_1(C)$ . The peak conductance  $g_{LGN}$  is then selected according to the following formula:

$$g_{LGN} = N_{syn} g_{AMPA}$$

where  $g_{AMPA}$  corresponds to the strength of an individual AMPA recurrent connection. This peak conductance is divided by a factor 2 for LGN inputs toward the lower layer.

The exact correspondence between  $C$  and  $R_{LGN}$  for the contrast values used in our simulations is presented in Table S21 (small-variance noise regime, see main paper) and in Table S22 (large-variance noise regime, see Figures S15, S16 and S17).

## References

- [Ref i] Chino YM, Kaplan E (1988) Abnormal orientation bias of LGN neurons in strabismic cats. *Invest Ophthalmol Vis Sci* 29:644–648.
- [Ref ii] Somers DC, Nelson SB, Sur M (1995) An emergent model of orientation selectivity in cat visual cortical simple cells. *J. Neurosci.* 15:5448–5465.