Rapid synaptic adaptation increases cortical population coding accuracy

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The cellular and synaptic mechanisms underlying visual adaptation have extensively been debated during the last years (for reviews see [1,2]). However, the effect of neural adaptation on information coding is difficult to study experimentally as it requires an enormous amount of data. Furthermore, as adaptation typically reduces the firing rate (lowering information) but also reduces correlations (increasing information), its net effect is not known.

Here we present a mechanistic model for rapid visual adaptation to examine the effect of adaptation on population coding. Compared to the longer time scale for spike-frequency adaptation, short-term synaptic plasticity is likely to be responsible for the rapid adaptation occurring on the time scale of the stimulus presentation (typically hundreds of milliseconds)[3]. A standard recurrent model of V1 [4] that included short-term synaptic depression of the excitatory cortical synapses [5] reproduced post-stimulus changes at the single-neuron and population levels. After adaptation, individual neurons reduced their activity, thus saving metabolic expenses on coding a repetitive stimulus, while the population code of the neurons reproduced perceptual changes after adaptation, e.g. tilt after-effects.

Based on an analysis using Fisher information, stimulus discriminability increased for stimuli close to the adapting stimulus. These results suggest that visual adaptation is functionally advantageous from an information coding perspective and validate the "efficient neural coding hypothesis."

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References