EFFICIENT CODING WITH RAPID ADAPTATION IN THE PRIMARY VISUAL CORTEX

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Several studies have shown that the representation of visual information in the brain can be understood from principles derived from information theory. Previous theoretical studies made the implicit assumption that the neural code remains stationary on the time-scale of stimulus presentation (for example on the time scale of the fixation period between saccades). This assumption, however, may not be justified, because (i) the neural responses to flashed but otherwise static visual stimuli are time-dependent, and (ii) if one argues for an integrating, continuous readout by higher order cortical areas, application of the so-called infomax principle calls for a dynamic change of the coding strategy, because with increasing processing time the noise level decreases.

We call the idea of a rapid adaptation of the coding strategy ‘dynamic coding’. Note that the classical "ecological" hypothesis about neural adaptation states that neural codes are optimally adapted to the current sensory environment. Neural adaptation is therefore interpreted as the signature of this ongoing optimization w.r.t. changes of the set of inputs. However, information theory also predicts that the optimal code depends on the level of noise in the neural system. In the case we consider the noise level is dynamic, because the signal is averaged over time by a hypothesized read-out. Consequently, neural adaptation could also be viewed as the signature of an adaptation to changing 'internal states' (reflected by the changing noise level).

We show that a particular type of fast adaptation - the dynamic adjustment of cortical competition - leads to a better performance in terms of information transfer than a static coding strategy. Using a computational model of an orientation hypercolumn we show that spike-frequency adaptation of regular spiking neurons could serve as the underlying mechanism which suggests that it may emerge naturally under the assumption of an optimal representation of visual stimuli.