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Phase-of-firing information coding in laminar cortical architecture

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We applied recently developed information theory methods [1,2] to the analysis of cortical responses in a large-scale computational model of cat primary visual cortex [3]. These methods quantify the information conveyed by spikes and by local field potentials (LFPs) in a very general way, without ad hoc assumptions about precisely which stimulus features (orientation, direction, etc.) drive the neuronal response. The phase-of-firing information is the extra information obtained by labeling spikes with the value of the LFP phase [2]. In order to gain insight into the information-processing properties of laminar cortical microcircuits, we calculated the spike count information conveyed by firing rates and the phase-of-firing information conveyed by LFPs for each layer of primary visual cortex.

We found that there is substantially more information in the phase code compared with the spike rate alone for low LFP frequencies (< 30 Hz). Figure 1 shows that the information gain for the phase code may reach 80 % in Layer 2/3, while in Layer 4 it reaches only 40 %, compared to the spike count code. These data support the hypothesis that the thalamo-cortical layers, which receive direct sensory input, may rely more on spikes to convey the information, while the cortico-cortical layers with strong recurrent connectivity may use the phase code and LFP signals for information coding.

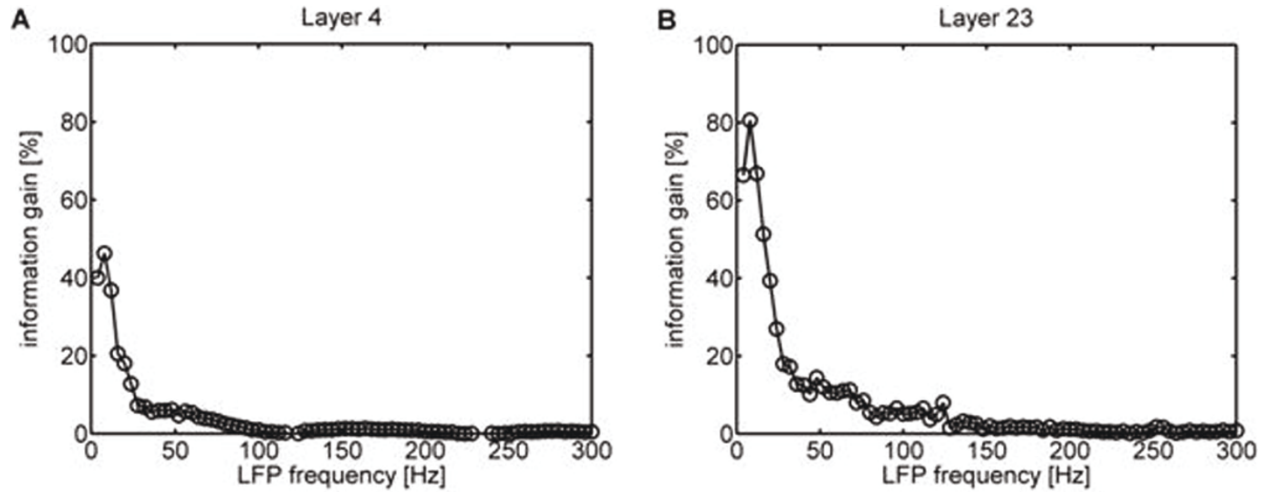

Figure 1 The phase-of-firing information as function of the considered LFP frequency (computed up to 300 Hz). The circles denote the information gain by the phase-of-firing code compared to the spike count code for Layer 4 (A) and for Layer 2/3 (B).

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