

Parsing visual images through concerted cortical processes

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Abstract

Visual perception is mediated by hierarchically organized and functionally specialized cortical areas, which are interconnected by layer-specific feedforward and feedback projections. The traditional point of view of visual image processing emphasizes the bottom-up process: local image components are detected in early visual cortex and global forms are subsequently assembled in higher-tier visual areas where the receptive fields of neurons become increasingly larger.

In contrast to the simplified bottom-up viewpoint, recent studies in awake behaving monkeys have shown that analyses of visual images depend on concerted processes mediated by feedforward, feedback and lateral interactions across cortical areas. The multilayered and multithreaded processing framework allows for global forms and their constituent parts to be concurrently and efficiently analyzed in the cortical loop, leading to a parallel and rapid buildup of global figural signals within specific layers in both early and higher visual areas. Moreover, through the complex cortical interactions, the neural computations in the circuitry can be flexibly adjusted according to different stimulus and behavioral context. In particular, task-dependent top-down signals mediated by feedback connections play an important role in enhancing neuronal representations of task-relevant features and suppressing irrelevant components. Furthermore, extended practicing the same discrimination or detection task, and therefore, repetitively invoking top-down influences specific to the task can induce long-term learning effects by further refining the representation and readout of task-relevant information. This adaptive processing regime could represent a general mechanism underlying perception and perceptual learning.

Two interrelated lectures will cover the contents outlined above, with the first one focusing on cortical interactions and top-down influences; and the second one on learning-induced changes.

Suggested readings

- (1) Chen, R., Wang, F., Liang, H., and Li, W. (2017). Synergistic processing of visual contours across cortical layers in V1 and V2. *Neuron* 96, 1388-1402.
- (2) Yan, Y., Rasch, M.J., Chen, M., Xiang, X., Huang, M., Wu, S., and Li, W. (2014). Perceptual training continuously refines neuronal population codes in primary visual cortex. *Nat Neurosci* 17, 1380-1387.
- (3) Li, W. (2016). Perceptual learning: Use-dependent cortical plasticity. *Annu Rev Vis Sci* 2, 109-130.