Feedforward and Feedback Signaling in Drosophila Vision

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When reading a book, our eyes move briskly from one word to another, resetting the retinal image a few times a second; yet, we perceive the book's page as stable. Our brains accomplish this remarkable feat by filtering out visual input during fast eye movements, and somehow stitching together images collected at different fixation points. Across animals and modalities, sensory processing does not merely involve a feedforward transduction of sensory stimuli but includes an interplay of the feedforward and feedback (or top-down) signaling. Using whole-cell patch clamping, calcium imaging, and massive behavioral genetics experiments in tethered, flying Drosophila, we studied feedforward visual circuits involved in various visual behaviors, such as optomotor stabilization, bar fixation, spot avoidance, and loom avoidance. Then, we studied how these multiple visual pathways, acting simultaneously on the wing motor system, are orchestrated by a feedback signaling, called an efference copy. Based on these experimental results, we built an integrative model that closely predicts how a flying fruit fly steers its wings in response to different visual patterns, as an outcome of the feedforward and feedback signaling. The experimental and modeling studies together suggest that the feedback signaling is necessary for the animal to respond selectively to multiple visual objects that could otherwise interfere with each other.

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