Adaptation and information transmission in fly motion detection

By sompolinsky
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By sompolinsky January 21, 2011


Abstract:

In this work, we studied the adaptation of H1, a motion-sensitive neuron in the fly visual system, to the variance of randomly fluctuating velocity stimuli. We ask two questions. 1) Which components of the motion detection system undergo genuine adaptational changes in response to the variance of the fluctuating velocity signal? 2) What are the consequences of this adaptation for the information processing capabilities of the neuron? To address these questions, we characterized the adaptation of H1 by estimating the changes in the parameters of an associated Reichardt motion detection model under various stimulus conditions. The strongest stimulus dependence was exhibited by the temporal kernel of the motion detector and was parametrized by changes in the model's high-pass time constant \( \tau_{H} \). This time constant shortened considerably with increasing velocity fluctuations. We showed that this adaptive process contributes significantly to the shortening of the velocity response time-course but not to velocity gain control. To assess the contribution of time-constant adaptation to information transmission, we compared the information rates generated by our adaptive model motion detector with model simulations in which \( \tau_{H} \) was held fixed at its unadapted value for all stimulus conditions. We found that for intermediate stimulus conditions, fixing \( \tau_{H} \) at its unadapted value led to higher information rates, suggesting that time-constant adaptation does not optimize total information rates about velocity trajectories. We also found that, over the wide range of stimulus conditions tested here, H1 information rates are dependent on the amplitude of velocity fluctuations.

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