Spatially inhomogeneous processing of visual motion by *Drosophila*

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Over 50 years ago Bernard Hassenstein and Werner Reichardt carried out a series of elegant experiments on the optomotor reactions of the beetle *Clorophanus*, and produced a computational model for insect motion detection that has demonstrated remarkable explanatory power for a large range of behavioral and electrophysiological results [1]. Despite the success of this model, there remain several aspects of visually-guided behaviors that cannot be explained by a simple application of an array of Hassenstein-Reichardt (HR) elementary motion detections (EMDs) driving an optomotor response. I will present the results of some recent experiments that aim to unify the predictions of optomotor reactions of tethered flying insects with the more elaborate visual processing that is often suggested by free-flight behavioral experiments.

The experiments consist of rapidly interleaved presentations of pattern motion at different temporal frequencies presented to restricted frontal and lateral eye regions of a tethered *Drosophila* flying in a flight simulator. The results suggest that the direction and magnitude of the turning response is dependent on the location, speed, and direction of the motion stimulus (as had been previously shown [2]). A novel finding is that the responses show a temporal frequency tuning that is not constant across the eye. One suggestion is that the sides of the Drosophila eye are tuned for longer integration of visual motion. Speculations about the computational utility of these responses will be presented. The result that identical motion stimuli presented to different parts of the eye elicit strikingly different amplitude turning responses is surprising and not at all predicted by the optics of the *Drosophila* compound eye [3] (which unlike the eyes of many other flying insects does not contain substantial spatial heterogeneity such as an acute, high resolution zone). The most parsimonious interpretation of these results is that the turning behavior is controlled by a system fed by two non-overlapping arrays of HR EMDs that contain motion detectors with two different time constants.

These results corroborate earlier findings showing that a centering-like turning behavior is primarily elicited by motion processed by the lateral regions of the eye [4], a feature common to the well-studied centering response of honeybees [5]. Taken together, these results suggest that differential tuning of motion detection is a sensible strategy for visually-guided navigation, and may allow flies to overcome some of the limitations of seeing the world through an array of HR motion detectors. Finally, I will present the results of related experiments on turning responses that assess the ability of *Drosophila* to discriminate bilaterally asymmetric motion stimuli.

References

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