Nature Reviews Neuroscience | AOP, published online 29 August 2013; doi:10.1038/nrn3590

VISUAL SYSTEM

Mapping motion detection

Understanding how insects perceive visual motion has puzzled researchers for decades. In flies, the retina's light-sensing photoreceptors cannot detect the direction of movement, but downstream tangential neurons in the lobula plate are directionally selective. There is evidence that L1 and L2 interneurons in the fly's lamina relay motion information from photoreceptor cells to the lobula plate via T4 and T5 interneurons, but the precise mechanism that creates directional discrimination is poorly understood. Now, two studies in *Nature* shed light on this issue by identifying further key intermediary interneurons in the circuitry and functionally characterizing the properties of the T4 and T5 cells.

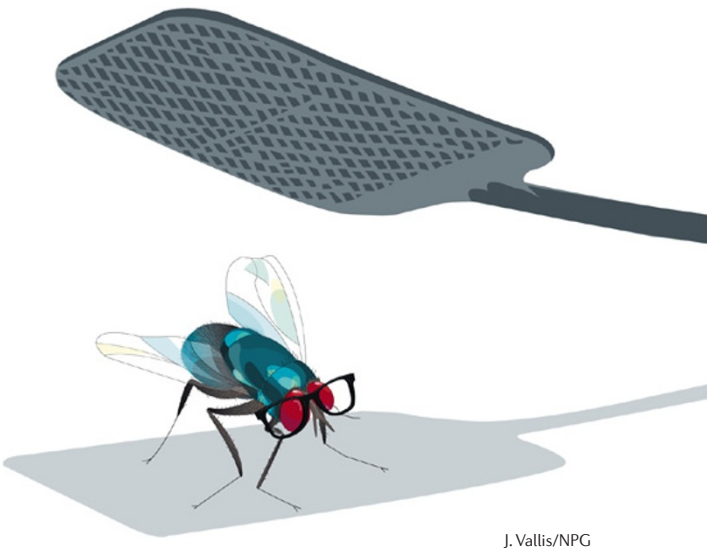
Owing to their small size, the visual processing properties of T4 and T5 interneurons were largely unknown. By expressing the calcium indicator GCaMP5 in T4 and T5 cells, Maisak *et al.* were able to optically record the cells' responses while flies were presented with gratings moving in one out of four cardinal directions (front to back, back to front, upwards and downwards). They identified four subpopulations of T4 and T5 interneurons that responded specifically to one of the four cardinal directions. As was expected, they found that the arborizations of each subset terminate in a distinct layer of the lobula plate. In an attempt to determine the differences between the information conveyed by T4 and T5 cells, instead of gratings, the authors used moving edges with positive (ON) or negative (OFF) contrast polarity as visual stimuli. T4 cells selectively responded to moving ON edges, whereas T5 cells responded to OFF edges. Blocking the output of either T4 or T5 cells with tetanus toxin strongly reduced the flies' responses to moving ON and OFF edges, respectively. These phenotypes are similar to those obtained when the output of L1 and L2 cells is blocked, indicating that T4 and T5 are the main conveyors of contrast polarity-segregated motion information to the lobula plate.

In a separate study, Takemura *et al.* used serial electron microscopy followed by a semi-automated reconstruction pipeline to assemble a connectome (8,637 chemical synapses among 379 neurons) of the fly's optic medulla. By matching reconstructed neurons to examples from light microscopy, the authors were able to assign neurons to cell types. Moreover, by identifying pre- and postsynaptic sites and assigning them to their respective parent cells, they were able to reveal the connections between the reconstructed neurons. Their detailed three-dimensional map suggests that L1-innervated Mi1 and Tm3 cells, which report on narrowly separated points in visual space, convey the information necessary for motion detection to T4 cells. They were able to demonstrate that the displacement between the visual points reported on by Mi1 and Tm3 cells innervating the same T4 cell correspond to the directional preference of that T4 cell (determined by the layer in the lobula plate in which its arborizations terminate). This study is a clear example of how, by identifying neuronal circuits, the 'connectomic' approach can provide unique insights into neuronal computations. Given the parallels with studies in vertebrate retinas, in which four subtypes of ON–OFF directionally selective ganglion cells have been described, it will be interesting to see how these findings will contribute to our understanding of motion detection in higher organisms.

Monica Hoyos Flight

> "T4 and T5 are the main conveyors of contrast polarity-segregated motion information to the lobula plate"

ORIGINAL RESEARCH PAPERS Maisak, M. S. *et al.* A directional tuning map of *Drosophila* elementary motion detectors. *Nature* **500**, 212–216 (2013) | Takemura, S.-y. *et al.* A visual motion detection circuit suggested by *Drosophila* connectomics. *Nature* **500**, 175–181 (2013)



J. Vallis/NPG