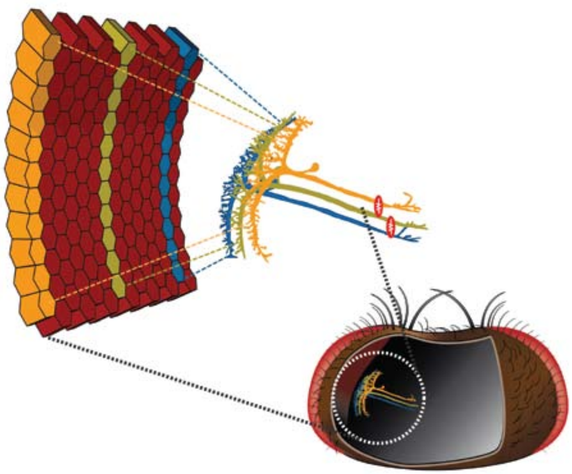
Small brain, optimal wiring

With its spherical compound eyes, the fly has an almost complete all-round view of its surrounding. It uses its visual sense to coordinate its flight. From what it sees, it can infer its own movement – whether it is, for example, heading forwards or drifting off sideways. Alexander Borst from the Max Planck Institute for Neurobiology and Bernstein Center in Munich and his colleagues Yishai Elyada und Jürgen Haag have investigated, which neuronal circuits underlie these calculations. In a recent study the scientists show that a previously unknown mechanism plays a crucial role in this context: Different parts of a single cell take on different tasks in the processing of visual motion information. The cell's input region – the part with which it receives information – only processes a very narrow part of the fly's visual field. Near the cells output, this information is set off against information coming from neighboring cells. Computer models showed that this division of labor within a single cell is especially effective for calculating the fly's movement.



When observing the acrobatic flight of a fly it becomes evident that its small brain works extremely fast. Its efficiency is based on a sophisticated wiring scheme of the neurons that deduce the fly's flight based on its visual input. If the fly heads straight ahead, it sees its surrounding pass by horizontally. When it turns around its own body axis, its visual surrounding will drift off vertically. Defined motion sensitive neurons are specialized for computing of each of these movements, respectively. So called VS cells, for example, are specialized in computing vertical movements. Each VS-cell receives input from a narrow vertical stripe of the fly's visual field.

But this is, as the scientists have now discovered, only half the truth. They used sophisticated microscopy technologies to observe the distribution of calcium within the cell – an indication of the cell's activity – while they played patterns of moving stripes to the fly. The researchers showed that, although the cell can „see" only a narrow stripe with its input regions, it gains additional information about neighboring regions through cell coupling at its output region. Computer models simulating the processing of visual information show that this division of labor between different regions within a single cell is very useful for the fly. Like this, it can calculate motion information faster and more precisely.

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Each VS nerve cell receives visual information in its input region (broad cell end) from only a narrow strip of the fly's eye. In the output region at the rear end of the cell, electrical connections (red) enable the cells to communicate with neighbouring cells.