

# Nerve cells use internal amplifiers to compensate for discrepancies in optic input

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Every movement causes the environment to move past the eyes in the opposite direction. Nerve cells rely on this "optic flow" for their calculation of self-movement - against any backdrop. Image: Max Planck Institute of Neurobiology / Schorner

(PhysOrg.com) -- Generally speaking, animals and humans maintain their sense of balance in their three-dimensional environment without difficulty. In addition to the vestibular system, their navigation is often aided by the eyes. Every movement causes the environment to move past the eyes in a characteristic way. On the basis of this "optic flow", the nerve cells then calculate the organism's self-motion. Scientists at the Max Planck Institute of Neurobiology have now shown how nerve cells succeed in calculating self-motion while confronted with differing backgrounds. So far, none of the established models for optical processing were able to cope with this requirement. (*Neuron*, 26 August

2010).

In one respect, humans and flies bear a close resemblance to each other: both rely heavily on their [eyesight](#) for navigation. Despite the fact that the visual impressions are constantly changing, this navigation is exceptionally proficient. For example, if I walk past a whitewashed wall, tiny asperities pass my eyes in the opposite direction and reassure me that I am indeed moving forwards. If, on the other hand, I pass a billboard pasted with bright posters, a great variety of colours and structural changes flow past me as I move. Although the [visual information](#) is very different, my nerve cells are able to confirm in both cases that I am moving forwards at a certain pace. Something that, at first glance, appears to be rather mundane thus turns out to be a remarkable feat of our brain.

In order to understand how nerve cells process such different optical information, neurobiologists study the brains of flies. Using the fly brain as a model has some obvious advantages: Flies are experts in optical motion processing, yet their brains contain comparatively few nerve cells. This allows scientists to examine the function of every nerve cell in a network. In laboratory experiments, the flies are presented with moving striped patterns while the reactions of individual nerve cells are measured. The knowledge gained from these experiments resulted in models that serve well to show how and to which stimuli a nerve cell reacts and what information it relays to the next cells in line. However, once the patterns the flies see varied too greatly in their complexity, the models' predictions failed.

"These models considered only the input-output relationship of nerve cells, but ignored anything that happened within the cell", explains Alexander Borst, who examines optic processing in the fly brain with his department at the Max Planck Institute of Neurobiology in Martinsried. That these cell-internal activities cannot be ignored was now shown by

his PhD student, Franz Weber. Together with Christian Machens from the Ecole Normale Supérieure in Paris, Weber developed a model that not only takes the input-output function into account, but that also makes provisions for the biophysical properties of the cell.

Franz Weber presented the flies with patterns of dots with different dot densities. In the course of the experiments, he established that the [nerve cells](#) show essentially the same reaction to high and low dot densities. This is astonishing, given that a pattern with a lower number of dots provides a nerve cell with considerably less visual motion information than one with a high dot density (bringing us back to the whitewashed wall and the billboard). The cells evidently compensate for the differences in incoming information by means of an internal amplifier. With this signal enhancement in mind, the scientists devised a new model. It now provides a reliable description of the nerve cells' behaviour within the network - no matter how complex the surrounding world turns out to be.

**More information:** Franz Weber, Christian Machens, Alexander Borst, Spatio-temporal response properties of optic-flow processing neurons, *Neuron*, online publication, August 25, 2010

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