Researchers link a rabbit retina to a chip in vitro

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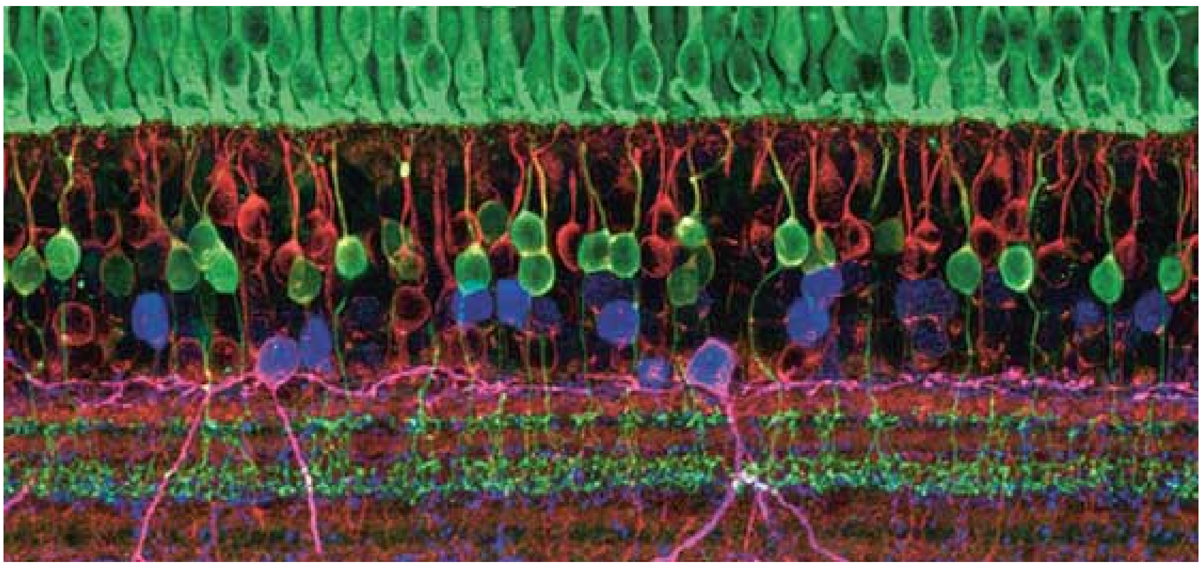

Credit: Swiss National Science Foundation

Nystagmus is a genetically transmitted disease that causes an uncontrolled, back-and-forth twitching of the eyeball. Roughly one in every 1,500 men suffer from it. But before now, we did not know that this twitching is caused by retinal neurones making miscalculations when converting visual stimuli into electrical signals.

How does the brain – to which the retina also belongs – understand what information is contained in a stimulus? Until now, it was known that neurones answer stimuli by firing off salvos of electrical signals that are transmitted via synapses to other nerve cells. The information about the stimulus is actually contained in the number of impulses and in the time intervals between them. But just how these codes are read and written is still a subject of debate among neuroscientists.

Useful noise

Felix Franke from the Bioengineering Laboratory of ETH Zurich has come one step closer to understanding this process – at least as far as the retina is concerned. In a recently published study in the specialist journal *Neuron*, Franke's team investigates whether it is more useful for the brain to 'hear' a whole orchestra of neurones at the same time, or only individual nerve cells. They found that if the brain hears them all, then it can learn more about the stimulus that caused the impulses – such as a picture that the eye has just seen.

In their experiment, Franke's team linked the retinas of rabbits, laid out flat, with a computer chip containing 11,000 densely packed electrodes. They then moved a bright bar past the retinas. The neuroscientists were able to record the signals in the photoreceptors as data, via the electrodes.

The problem is that the nerve cells often answer differently to the same stimulus, which makes it difficult to form conclusions about the original stimulus. Franke explains this so-called 'signal noise' by using a dice metaphor: "If the stimulus is the number three, then one neurone will perhaps give us a two, and the neurone next to it a four. If we take the average of them both, the answer is correct. Viewed individually, each answer would be incorrect". The 'orchestra' is thus more precise than individual neurones.

This has been confirmed by the neuroscientist Felipe Gerhard, who completed his doctorate at EPFL and is currently involved in research at

Brown University in Providence, USA. The experiments with the rabbit retinas help him to process patterns in this signal noise, enabling him to recognise visual stimuli better. These findings should be a solid basis for future research on the neural code.

But this random signal noise in the brain can sometimes also hinder communication between neurones, says Gerhard: "Evolution has found ways of dealing with this noise, and even of using it". It's especially useful for creative thinking, he maintains.

Prostheses with a tactile sense

Franke believes that these findings might in future be employed for therapeutic purposes. "If we can understand how neural networks function, then we can also better understand the diseases that are connected with them". Such as the nystagmus mentioned above.

Franke was involved in a study published in early 2016 that for the first-ever time found a connection between nystagmus in a human eye and a malformation of the retina in mice. It was the first time, says Franke, that a neural calculation was recognised as a factor in a human disease.

At Brown University, Gerhard also sees the possibility of therapeutic applications – such as prostheses controlled by thoughts. Arm prostheses could possibly even 'write' in the neural network of the brain and thereby recreate a sense of touch.

Currently, Gerhard is working with epilepsy patients measuring and analysing their neural activity during epileptic fits. Here, too, patterns in the signal noise play a role: "This could allow us to predict epileptic fits. As soon as the fit begins, we could attempt to stimulate these neurones actively, and thereby suppress the abnormal pattern."

More information: Felix Franke et al. Structures of Neural Correlation and How They Favor Coding, *Neuron* (2016). DOI: 10.1016/j.neuron.2015.12.037

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