When neurons have less to say, they speak up

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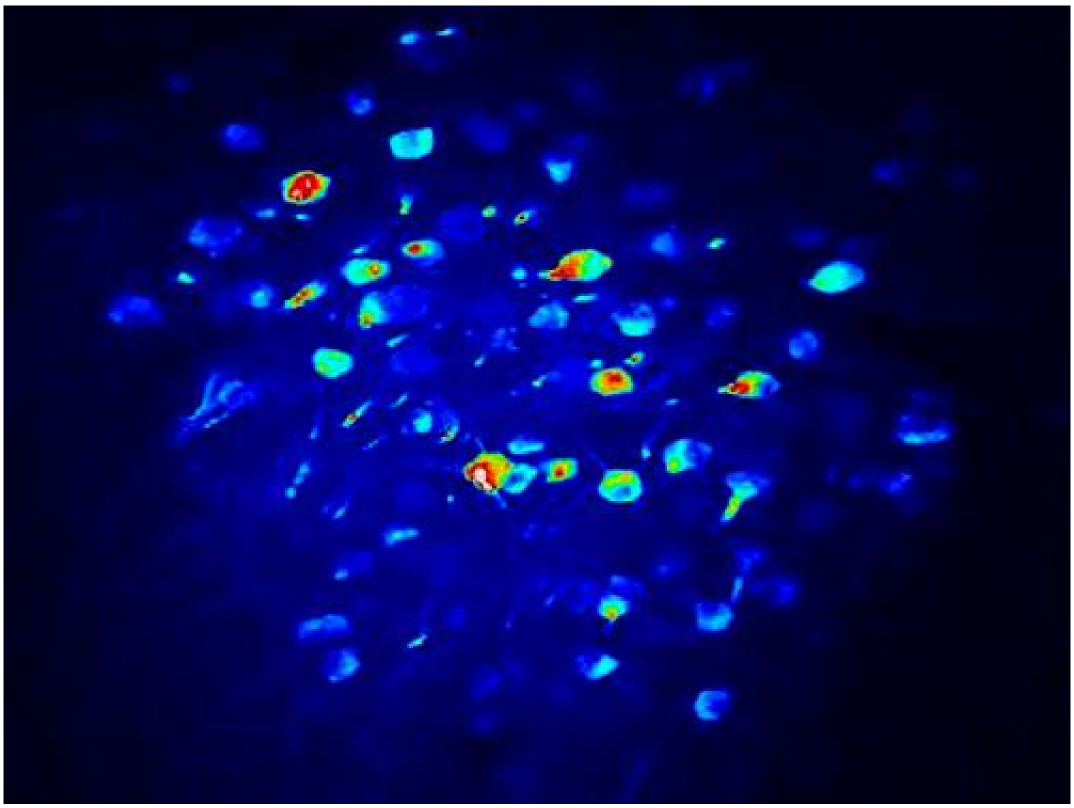

Even when neurons in the visual cortex are cut off from their main source of information, within 48 hours their activity returns to a level similar to that prior to the disruption. Under the microscope the currently active cells light up thanks to the addition of a calcium indicator. Credit: Credit: MPI of Neurobiology/Hübener

The brain is an extremely adaptable organ – but it is also quite conservative. That's in short, what scientists from the Max Planck Institute of Neurobiology in Martinsried and their colleagues from the

Friedrich Miescher Institute in Basel and the Ruhr-Universität Bochum were now able to show. The researchers found that neurons in the brain regulate their own activity in such a way that the overall activity level in the network remains as constant as possible. This remains true even in the event of major changes: After the complete loss of information from a sensory organ, for example, the almost silenced neurons re-establish levels of activity similar to their previous ones after only 48 hours. The mean activity level thus achieved is a basic prerequisite for a healthy brain and the formation of new connections between neurons – an essential capacity for regeneration following injury to the brain or a sensory organ, for example.

Neurons communicate using electrical signals. They transmit these signals to neighbouring cells via special contact points known as synapses . When new information needs processing, the nerve cells can develop new synaptic contacts with their neighbouring cells or strengthen existing synapses. To be able to forget, these processes can also be reversed. The brain is consequently in a constant state of reorganisation, yet individual neurons need to be prevented from becoming either too active or too inactive. The aim is to keep the level of activity constant, as the long-term overexcitement of neurons can result in damage to the brain.

Too little activity is not good either. "The cells can only re-establish connections with their neighbours when they are 'awake', so to speak, that is when they display a minimum level of activity", explains Mark Hübener, head of the recently published study. The international team of researchers succeeded in demonstrating for the first time that the brain is able to compensate even massive changes in neuronal activity within a period of two days, and can return to an activity level similar to that before the change.

Up to now, only cell cultures gave an indication of this astonishing ability of the brain. It was also unclear as to how neurons could control their own activity in relation to the activity of the entire network. Now, the scientists have made significant progress towards finding an answer to this question. In their study, they examined the visual cortex of mice that recently went blind. As expected, but never previously demonstrated, the activity of the neurons in this area of the brain did not fall to zero but to half of the original value. "That alone was an amazing finding, as it shows the extent to which the visual cortex also processes information from other areas of the brain," explains Tobias Bonhoeffer, who investigates processes in the visual cortex with his department at the Max Planck Institute of Neurobiology for many years. "However, things became really exciting when we continued to observe the area over the following hours and days."

The scientists were able to witness "live" through the microscope how the neurons in the visual cortex became active again. After just a few hours, they could clearly observe how the contact points between the affected neurons and their neighbouring cells increased in size. When synapses get bigger, they also become stronger and signals are transmitted faster and more effectively. As a result of this synaptic upscaling, the activity of the affected network returned to its starting value after a period of between 24 and 48 hours. "To put it simply, due to the absence of visual input, the cells had less to say – but when they did say something, they said it with particular emphasis," explains Mark Hübener.

Due to the simultaneous strengthening of all of the synapses of the affected neurons, major reductions in the neuronal activity can be normalised again with surprising speed. The relatively stable activity level thereby achieved is an essential prerequisite for maintaining a healthy, adaptable brain.

More information: Tara Keck, Georg B. Keller, R. Irene Jacobsen, Ulf T. Eysel, Tobias Bonhoeffer, Mark Hübener, Synaptic scaling and

homeostatic plasticity in the mouse visual cortex in vivo, *Neuron*, 16 October 2013

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