Excitation and inhibition remain balanced, even when the brain undergoes reorganization

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Every second, the brain's nerve cells exchange many billions of synaptic impulses. Two kinds of synapses ensure that this flow of data is regulated: Excitatory synapses relay information from one cell to the next, while inhibitory synapses restrict the flow of information. Scientists at the Max Planck Institute of Neurobiology in Martinsried could now show, in cooperation with colleagues from the Ruhr University of Bochum, that excitatory and inhibitory synapses remain balanced – even if the brain undergoes reorganization. Following a small retinal lesion, the nerve cells in the mouse brain responsible for this particular region no longer received (excitatory) information. As a result, the cells reduced the number of their inhibitory synapses by 30% in the space of just one day. This down-regulated balance between excitation and inhibition could indicate to the nerve cells that it is time for them to reconfigure to partially compensate for the loss of information.

Nerve cells are "information addicts". To process and store new information or to optimize already existing ways of processing it, minute appendages emerge continually from their surface and grow towards neighboring cells. At the end of these appendages, a synapse can develop via which the two nerve cells can then exchange information. Scientists at the Max Planck Institute of Neurobiology in Martinsried and the Ruhr University of Bochum were already able to show how quickly such nerve cells can reorganize themselves even in the adult brain, so that they are constantly able to process information: After a small retinal lesion, the nerve cells responsible for processing information from this area were "out of work". However, during the weeks to follow, the neurobiologists observed that these nerve cells increased the number of appendages sent towards their neighbouring cells. The cells that had been temporarily redundant were thus reconnecting themselves and could take on new tasks within the processing network.

However, optimal processing in the brain depends not only on the circulation of information but also on the direct inhibition of the flow of information at given points. What actually happens to these so-called inhibitory synapses when conditions change in the brain? Since this area has hardly received any detailed scientific attention, the team of scientists set out to examine the fate of these synapses in the nerve cells that receive no information on account of the small retinal lesion.

"One possible outcome was that inhibitory synapses remained, maybe to inhibit these cells which would otherwise pass on no, or only meaningless, information", explains Tara Keck, whose study has just been published in the scientific journal *Neuron*. However, the neurobiologists discovered that precisely the opposite was the case. They showed that those cells which had been rendered redundant reduced the number of their inhibitory synapses by about one third within one day. Such was the extent of this downsizing that the imbalance in the flow of information, brought about by the loss of the excitatory signals from the retina, was quashed. "The exciting thing about this result is the insight that the brain appears to be constantly seeking to maintain the balance between excitation and inhibition", Keck relates.

The scientists already have a theory as to the importance of this lower level of the established balance. "The decimation of the inhibitory synapses may act as a signal to neighbouring cells by advertising: Nerve cells seeking work. Please get in touch", reflects Mark Hübener, the head of the study. The scientists now hope to establish whether this is indeed the case and whether more inhibitory synapses are produced to regain the original balance once the rewiring with other cells is complete.

More information: Tara Keck, Volker Scheuss, R. Irene Jacobsen, Corette J. Wierenga, Ulf T. Eysel, Tobias Bonhoeffer, Mark Hübener Loss of sensory input causes rapid structural changes of inhibitory neurons in adult mouse visual cortex, *Neuron*, online publication, September 8 2011

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