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Research News Release

New laser method reveals high-density information storage in the brain

Using a new method of infrared-guided laser stimulation, researchers at the Max Planck Institute of Psychiatry in Munich/Germany have discovered that information can be stored in the brain with very high spatial density on the surface of every single neuron (Science 1 October 1999).

The new method was developed by Hans-Ulrich Dodt from the Max Planck Institute of Psychiatry. In the past, he had developed a method to visualize nerve cells in the depth of small pieces of rat brain. To achieve this, Dodt used a microscope and infrared light instead of normal light. In his new method, so-called "infrared-guided laser stimulation", he coupled now a highly precise UV-laser with his infrared microscope aiming with the laser beam at neurons to be investigated. The method allows the stimulation of selected target points on single neurons with a spatial precision of 10 µm.

A solution was added to the brain slices which contained neurotransmitter in a special chemical form, which becomes only active if the so called ‚caged neurotransmitter' is illuminated by the UV-laser. Then, the neurotransmitter was set free from its ‚cage' at the point at which the laser aims. Thus, it has become possible for scientists to do the same in the laboratory what a synapse does in the brain, but now exactly at the point and time when the scientist wants it. As this is something that neuroscientists all over the world always wanted, the method of "infrared-guided laser stimulation" will probably be very quickly taken up by many other laboratories.

A research team (H.-U. Dodt, M. Eder, A. Frick, W. Zieglgänsberger) at the Max Planck Institute for Psychiatry applied the new method to investigate the so-called "long-term depression" (LTD), a very important molecular mechanism in the brain. Actually, mechanisms like long-term depression and long-term potentiation (LTP) are regarded by many researchers as the basis for memory formation in the brain. It has been controversially debated how precise the underlying modifications of the neuronal membrane can be and where these modifications take place. The Max Planck researchers have discovered that these modifications are spatially highly restricted. Thus, information can probably be stored with very high density on the surface of neurons. During the experiments, it became apparent that a modification of the "receptor", the postsynaptic neuron, is all what is needed to understand the mechanism of long-term depression. Therefore, modifications of the amount of neurotransmitter that is released during LTD can be neglected.

As the UV-laser stimulation allowed the release of the neurotransmitter glutamate from an inactive form of caged glutamate in a very small region on the neuron, the researchers could investigate how big the region on the neuron was that experienced LTD. They found that this

region was not bigger than the resolution of their method, i.e. only a few Micrometer. Thus, even single synapses may undergo long-term depression and each single synapse could be used to store information separately from its neighbour. One could compare this possibility for information storage in the brain with the "high densitiy information storage" on a CD-ROM.

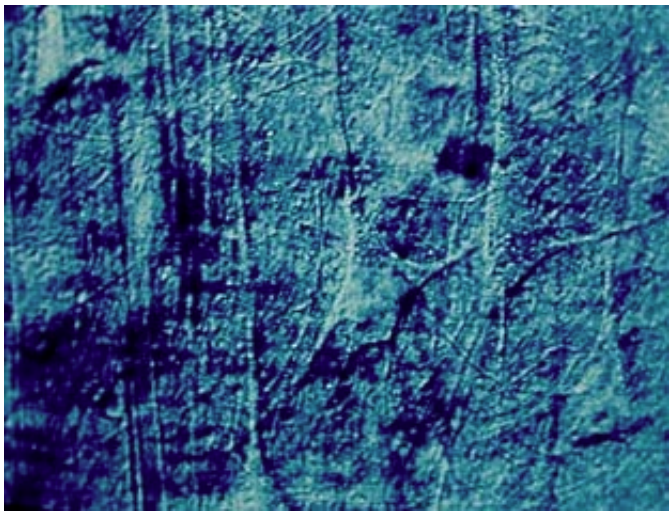

Figure 1:
Pyramidal neurons in the network of the neocortex visualized with infrared videomicroscopy in rat brain slices.

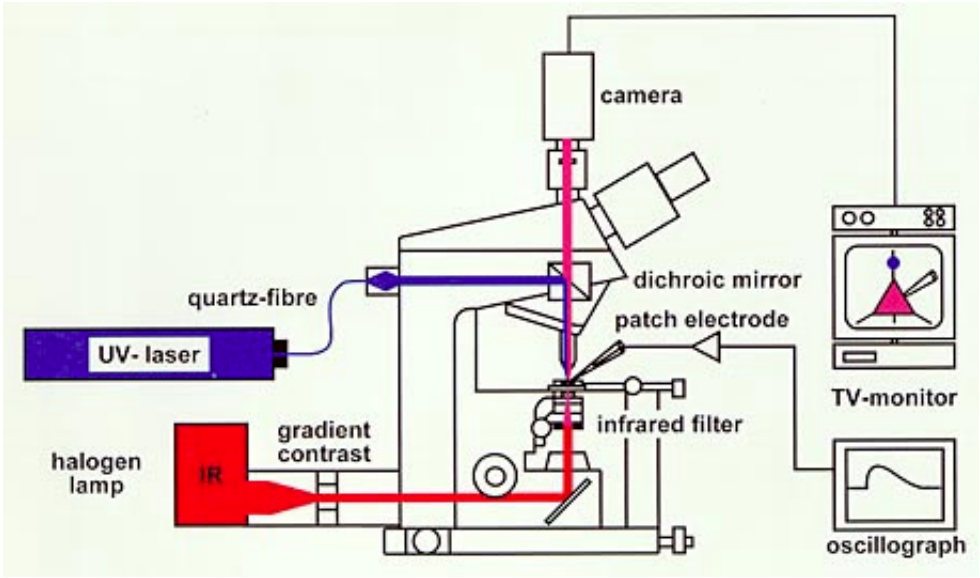

Figure 2:
Experimental set-up used for infrared-guided laser stimulation. Neurons in the brain slice were visualized by illumination with infrared light and the gradient contrast system. At the same time, light pulses of an UV-laser were fed via a quartz fibre into the microscope and directed by a dichroic mirror onto the recorded neuron. Both the slice chamber and the microscope could be positioned in x-y remote controls. The laser spot of an optical diameter of 1 µm formed by the objective (60X, 0.9 N.A., Olympus) in the specimen plane was made visible before the experiment by a fluorescent paper, and its position marked on the TV monitor. By positioning of the neuron to be stimulated on this point, the laser stimulation could be precisely guided by visual control.

Published: 30-09-99
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