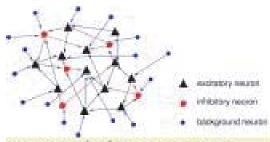
How thoughts are generated

What is a thought? First of all, it is a firework of neuronal activity produced by the neurons, the building blocks of the brain, which encode and transmit information as electrical impulses. Brain researchers are hoping to explain how, for example, a goalkeeper uses his eyes, arms and legs as well as his intuition to save a penalty. However, when we think or remember something there is not always a direct input from the environment.

A team of scientists at the Bernstein Centre for Computational Neuroscience at the University of Freiburg led by Stefan Rotter from the Freiburg Institute for Frontier Areas of Psychology and Mental Health has used complex computer simulations and found that very large neuronal networks can, under certain conditions, show sustained activity even without external input. The scientists assume that it is this sustained activity that provides the fundamental components of memory and thought. Their findings have been published in the January issue of the journal "Neural Computation".

Many signals in a short time lead to complex behaviour

Neurons receive input from other cells that can either be excitatory or inhibitory. Mathematical models of neuronal networks generally assume that nerve cells integrate the incoming signals and, as soon as a threshold is reached, elicit an electrical impulse themselves. However, numerous experimental analyses have shown that neurons behave in a more complex way if they receive intense input within a very short time. This is due to the fact that the cells' biophysical properties temporarily undergo a dramatic change under these circumstances.



Neurons behave in a very complex manner if many signals are received within a very short time. (Fig.: Rotter)

Excellent agreement between model and experiment

In their doctoral theses, Arvind Kumar and Sven Schrader simulated large neuronal networks that, for the first time ever, take this neuronal feature into account. They found that the neurons are intensely interconnected in the neocortex, i.e. they receive many input signals that can modify the integration of the subsequent signals. When these special features of such highly interconnected signals are taken into account, the resulting simulations are in excellent agreement with recordings from biological nerve cells in the intact brain. The new virtual network thus reflects reality better than previous simulations.

Network maintains activity itself

A special feature in which Rotter's and his colleagues' network differs from other models is its self-sustained activity. If the network is large enough, it suffices to trigger it once; from then on it remains active even without external input. "Networks built from simpler model neurons would 'fall asleep' within a short time," said Rotter.

Arvind Kumar, Sven Schrader, Ad Aertsen and Stefan Rotter have developed a virtual network that reflects reality better than previous models. (Photos: private)

This observation of artificial systems allows conclusions to be drawn regarding the function of our brain – after all, the brain does not always require external input for thinking or remembering.

Sensible patterns in an ocean of neuronal activity

"But it does not suffice that the brain is simply active," said Rotter adding that, "The activity pattern must somehow be connected with meaning." When we remember, our brain has to make associations and has to produce meaningful behaviour. Rotter and his colleagues at the Bernstein Centre will now investigate how meaningful patterns arise in the ocean of neuronal network activity. Their new network model has provided a promising starting point for such a study.

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