

How Thoughts Arise

Scientists of the BCCN Freiburg fathom the fundamental components of memory and thought

What makes up a thought? First of all, it is a firework of neuronal activity, produced by neurons, the building blocks of the brain, which encode and transmit information in the form of electrical impulses. Brain scientists hope to explain, for example, how a goal keeper uses his arms and legs, and his intuition to block a penalty by the opponent. But not always when we think or remember is there a direct input from the environment. A team of scientists at the Bernstein Center for Computational Neuroscience of the University of Freiburg, led by **Stefan Rotter** from the Institute for Frontier Areas in Psychology and Mental Health, found with the aid of elaborate computer simulations, that very large neuronal networks can, under certain conditions, show sustained activity even without external input. The researchers hypothesize that it is this sustained activity that provides the fundamental components of memory and thought. Their study has been published in the January edition of the scientific journal 'Neural Computation'.

Neurons receive inputs from other cells that can be either 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. But a number of experiments show that neurons behave in a more complex way, if intense input impinges on them within a short period of time. This is due to the fact that the biophysical properties of the cells temporarily undergo a dramatic change under these circumstances.

In their doctoral theses, **Arvind Kumar** and **Sven Schrader** have simulated large neuronal networks that, for the first time, take this neuronal feature into account. Especially in the neocortex, neurons are intensely interconnected, i.e. they receive many input signals that can modify the integration of subsequent signals. Taking the special features of such highly interconnected networks into account yields simulations that are in excellent agreement with recordings from

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biological nerve cells in the intact brain. The new virtual network thus reflects reality better than previous models.

A special feature in which Rotter's and 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 literally 'fall asleep' within short time,' says Rotter. This finding obtained in artificial systems allows to draw conclusions about the function of the real brain – after all, for thinking or remembering no external input seems to be necessary.

'But it does not suffice that the brain is just active', adds Rotter. 'The activity pattern must somehow be connected to a meaning.' When we remember, our brain has to make associations and has to produce meaningful behavior. How meaningful patterns arise in the ocean of neuronal network activity will be subject of new investigations by Rotter and his colleagues at the Bernstein Center. Their network model now provides a promising starting point for this.

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