Researchers develop a computer model to explain how nerve cell connections form in the visual cortex

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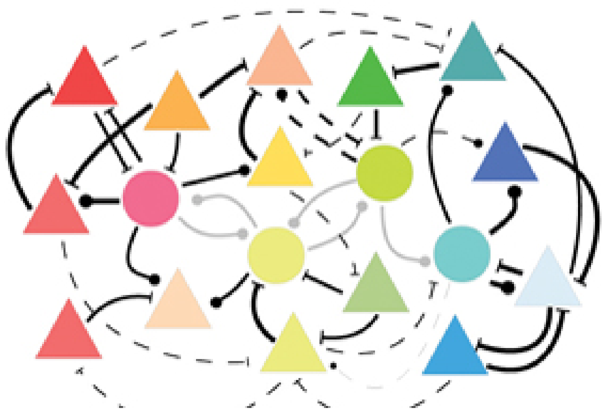

When newborn babies open their eyes for the first time, they already possess nerve cells specialized in particular stimuli in the visual cortex of their brains - but these nerve cells are not systematically linked with each other. How do neural networks that react in a particular way to particular features of a stimulus develop over the course of time? In order to better understand the steps of this development and explain the complicated processes of reorganization they involve, an international team of researchers has now developed a computer model that precisely simulates the biological processes. The results of the study by Prof. Dr. Stefan Rotter, Bernstein Center Freiburg (BCF) and Cluster of

Excellence BrainLinks-BrainTools of the University of Freiburg, conducted in cooperation with Dr. Claudia Clopath from the Imperial College London, England, have now been published in the journals *PLOS Computational Biology* and *PLOS ONE.*

"Our model enabled us to achieve a meaningful combination of typical features of biological neural networks in animals and humans in a computer simulation for the first time ever," reports the neuroscientist Dr. Sadra Sadeh from the BCF. "The networks harness the principle of feedback to make nerve cells in the visual system into efficient detectors of features. In addition, they can precisely coordinate the points of contact between the cells - the synapses - in learning processes." It is difficult to combine these two properties in computer models, because it can easily lead to an explosion of activity in the network - similar to an epileptic fit. To keep the activity in the network stable, the researchers integrated inhibitory synapses into the learning process, which control the excitation in the network.

Researchers can now use the computer model to simulate various developmental processes in the brain's visual cortex. Among other things, it will allow them to determine how connections between the nerve cells change the first time they receive stimuli from both eyes after birth. Such processes play a role in early-childhood visual disorders like congenital strabismus (squinting). "In the long term, the model could even enable us to develop better strategies for treating such illnesses," says Rotter.

But why do the neural networks change their structures in the course of visual experience if nerve cells are already specialized in particular stimuli at the moment the eyes first open? The team found an answer to this question in a parallel study. "In a simulation directly comparing inexperienced and fully developed nerve cell networks, we were able to demonstrate that fully developed networks further strengthen components of a stimulus that carry more information by preferring connections of neurons with the same function," explains Rotter. Therefore, while newborns do indeed have the capacity to process all stimuli when they first open their eyes, their perception is greatly improved through the fine tuning of the nerve cell connections.

More information: "Emergence of functional specificity in balanced networks with synaptic plasticity." *PLOS Computational Biology* DOI: 10.1371/journal.pcbi.1004307

"Processing of feature selectivity in cortical networks with specific connectivity." *PLOS ONE* DOI: 10.1371/journal.pone.0127547

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