Growing brain is particularly flexible

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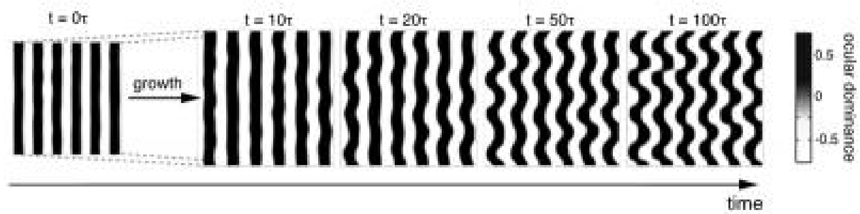

Computer simulation of the development of ocular dominance columns in a simple model with cortical growth. Black areas correspond to a preference for the left eye, white areas a preference for the right eye. The pattern is initially striped and slowly dissolves after the growth into a zigzag pattern. A similar rearrangement is also shown by experimental studies on the visual cortex of the cat. Credit: Wolfgang Keil

Science has long puzzled over why a baby's brain is particularly flexible and why it easily changes. Is it because babies have to learn a lot? A group of researchers from the Bernstein Network Computational Neuroscience, the Max Planck Institute for Dynamics and Self-Organization in Gottingen, the Schiller University in Jena and Princeton University have now put forward a new explanation: Maybe it is because the brain still has to grow.

Using a combination of experiments, mathematical models and computer simulations they showed that neuronal connections in the visual cortex of cats are restructured during the growth phase and that this restructuring can be explained by self-organisational processes. The study was headed by Matthias Kaschube, former researcher at the Max

Planck Institute for Dynamics and Self-Organization and now at Princeton University (USA). (*PNAS*, published online June 21, 2010)

The brain is continuously changing. Neuronal structures are not hard-wired, but are modified with every learning step and every experience. Certain areas of the brain of a newborn baby are particularly flexible, however. In animal experiments, the development of the visual cortex can be strongly influenced in the first months of life, for example, by different visual stimuli.

Nerve cells in the visual cortex of fully-grown animals divide up the processing of information from the eyes: Some "see" only the left eye, others only the right. Cells of right or left specialisation each lie close to one another in small groups, called columns. The researchers showed that during growth, these structures are not simply inflated - columns do not become larger but their number increases. Neither do new columns form from new nerve cells. The number of nerve cells remains almost unchanged, a large part of the growth of the visual cortex can be attributed to an increase in the number of non-neuronal cells. These changes can be explained by the fact that existing cells change their preference for the right or the left eye. In addition, another of the researchers' observations also points to such a restructuring: The arrangement of the columns changes. While the pattern initially looks stripy, these stripes dissolve in time and the pattern becomes more irregular.

"This is an enormous achievement by the brain - undertaking such a restructuring while continuing to function," says Wolfgang Keil, scientist at the Max Planck Institute for Dynamics and Self-Organization Göttingen and first author of the study. "There is no engineer behind this conducting the planning, the process must generate itself." The researchers used mathematical models and computer simulations to investigate how the brain could proceed to achieve this restructuring. On the one hand, the brain tries to keep the neighbourhood relations in the visual cortex as uniform as possible. On the other, the development of the visual cortex is determined by the visual process itself - cells which have once been stimulated more strongly by the left or right eye try to maintain this particular calling.

The researchers' model explains the formation of columns by taking both these tendencies into account. The scientists showed that when the tissue grows and the size of the columns is kept constant, the columns in the computer model change exactly as they had observed in their experimental studies on the visual cortex of the cat: The stripes dissolve into a zigzag pattern and thus become more irregular. In this way, the researchers provide a mathematical basis which realistically describes how the visual cortex could restructure during the growth phase.

More information: Wolfgang Keil, Karl-Friedrich Schmidt, Siegrid Löwel and Matthias Kaschube, Reorganization of columnar architecture in the growing visual cortex, PNAS, published online on June 21, 2010

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