BIOLOGICAL CYBERNETICS

A Mature Brain Does Not Adapt

To what extent are nerve cells in the cortex able to reorganize themselves to compensate for damage following a stroke or other defects? From experiments with macaques, neurobiologists at the Max Planck Institute for Biological Cybernetics in Tübingen have now discovered that no reorganization of nerve cells in the primary visual cortex takes place after damage to the retina. This result contradicts previous concepts that primary sensory systems in the brain cortex retain plasticity and can compensate for damage up to adulthood.

During its development, the brain can adapt well to defects. For example, children who have lost the left brain hemisphere early on regain control of movements on the right side of the body – the side normally controlled by the left side of the brain. Similarly, children develop normal speech abilities by using the right side of the brain. However, the more the brain matures, the more it loses this plasticity.

Max Planck researchers based in Tübingen have now investigated the visual system and its link to the brain. Previously, it was believed that nerve cell circuits in the visual cortex – the area of the brain where optical stimuli are processed – retained plasticity into adulthood: here, the neuronal circuitry should be able to be continuously modified by experience. This adaptive capacity of neuronal networks in the brain is important for learning early on, and later should be able to cope with repairs, for instance after a stroke.

Based on this, rehabilitation regimes always aim to stimulate brain plasticity as much as possible, in the hope of restoring lost functions by reactivating functionally disrupted but morphologically intact brain regions or by using alternative structures. However, it remains unclear whether all the structures in the brain are capable of such regenerative rebuilding to the same extent, and just which mechanisms are important for this.

Using functional magnetic resonance imaging on macaques, a team led by Nikos Logothetis at the Max Planck Institute for Biological Cybernetics has now discovered that the primary upper brain area VI, where the visual stimuli converge, does not respond to retinal lesions. In other words, it cannot compensate for the damage.

Functional magnetic resonance imaging has made it possible to measure changes in blood flow, which are associated with neuronal activity. In area VI, the outside world is depicted in such a way that every point in the external field of vision corresponds to one point in cortex VI. Using this technique, activity maps can be created that depict the organization of the visual field in VI in 3-D resolution – and these maps are very similar in monkeys and humans.

What the neurobiologists found was that these "topographical maps" in the brain of adult macaques showed no plasticity. After shutting down part of the retina, they looked for changes in the topography of area VI. "We saw that even seven and a half months after the retinal lesion, region VI had not recovered its original responsivity," says Logothetis. "Our data show that VI in adult macaques possesses only limited potential for reorganization."

In addition, the experiments of the Tübingen neurobiologists show that functional magnetic resonance allows for the observation of the organization of cortical structures over a longer time period – and that this technique is also optimally suited for precise observations of the brain organization in neurological patients. Further investigations are now turning to determining whether and to what extent regeneration processes can be stimulated in adult visual cortexes. ●

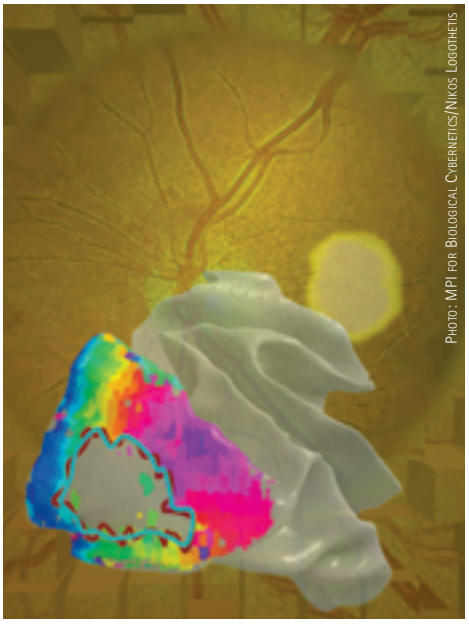

PHOTO: MPI FOR BIOLOGICAL CYBERNETICS/NIKOS LOGOTHETIS

The image in the foreground shows the primary visual cortex VI. On the outside right, in red, is the fovea, the point of clearest vision on the retina. The pale blue area corresponds to the VI retinal lesion projection zone at various times (day 0 and 4 months after the lesion). The borderline around this region has remained almost unchanged.

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