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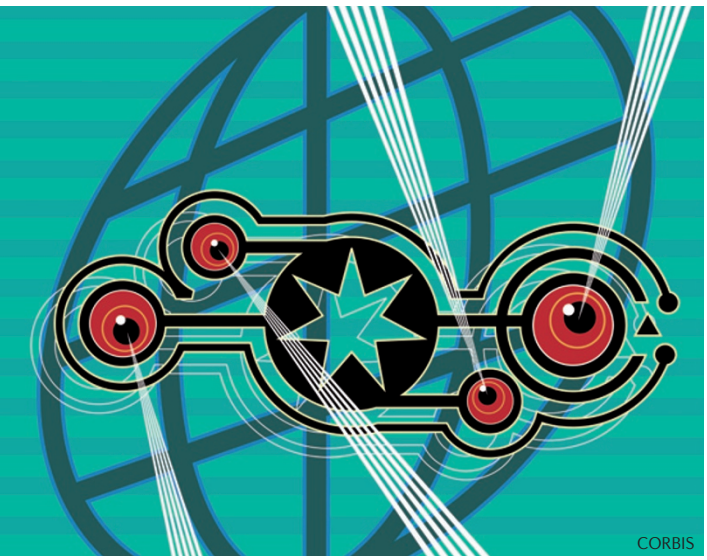
ASTROCYTES

More than meets the eye


CORBIS

Astrocytes are no longer seen as cells that merely provide structural support to neurons. Instead, it has become clear that they have a more active role, interacting with neurons by responding to and releasing neurotransmitters. Schummers and colleagues now show that astrocytes in the primary visual cortex (V1) respond to visual stimuli, and that they are key intermediaries in coupling neural activation to changes in blood flow.

The authors loaded V1 cells of anaesthetized ferrets with a fluorescent Ca^{2+} indicator and measured cellular activity using two-photon Ca^{2+} imaging. Surprisingly, not only neurons but also astrocytes responded to visual stimuli consisting of drifting black and white bars, although the astrocytes responded 2–4 seconds later than the neurons.

V1 neurons respond to a stimulus only if it appears in a restricted part of space (the neuron's receptive field), and they respond most strongly to stimuli that have a particular orientation and spatial frequency (the sparseness of the bars). Astrocytes seemed to resemble V1 neurons in this respect: each astrocyte had a spatially restricted receptive field that overlapped with that of a neighbouring V1 neuron. Furthermore, each displayed an orientation- and spatial-frequency tuning that was strikingly similar to, and in fact sharper than, that of the nearby V1 neuron.

Neurons are not distributed randomly across the V1, they are organized in two-dimensional 'maps' that contain clusters of neurons with similar stimulus-feature preferences. The authors found that astrocytes were clustered in the same way, resulting in astrocyte orientation maps that were organized around pinwheel centres that overlapped precisely with those of neuronal maps.

Orientation maps can be visualized using functional brain imaging and other optical imaging methods that measure blood-flow changes as a proxy for neural activity. As astrocytes are thought to have a role in coupling neuronal signals to vascular dilation, the authors wondered whether activated V1 astrocytes contribute to haemodynamic regulation in the V1. They showed that blocking astrocyte activity with a glutamate transporter antagonist greatly decreased the orientation-mapping signal, indicating that optical imaging of orientation maps is dependent on the activation of astrocytes by V1 neurons.

These findings provide further evidence for astrocytes' complex role in the nervous system. Rather than functioning in a broad network, V1 astrocytes respond to visual stimuli largely individually and in close contact with nearby neurons. Moreover, astrocytes seem to provide the link between neuronal activation and the haemodynamic signals that are measured in, for example, functional MRI studies.

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ORIGINAL RESEARCH PAPER Schummers, J., Yu, H. & Sur, M. Tuned responses of astrocytes and their influence on hemodynamic signals in the visual cortex. *Science* **320**, 1638–1643 (2008)
FURTHER READING Kerr, J. N. D. & Denk, W. Imaging *in vivo*: watching the brain in action. *Nature Rev. Neurosci.* **9**, 195–205 (2008)