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Press Release

Zapping between Channels in the Retina

Investigating the biological basis of vision: Tübingen neuroscientists analyse the 'division of labour' in the retina.

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Visual information is processed long before it reaches the brain. As early as in the retina, numerous types of cells are responsible for decomposing images into their diverse components, and for feeding these to the brain on several parallel channels. Here the so-called bipolar cells play a central role, as the first retinal layer to process the output of the light-sensitive cells in the eye. Recently, Tübingen neuroscientists have studied the functional organisation of bipolar cells in detail, publishing their findings in Nature this Wednesday (doi: 10.1038/nature21394).

We ceaselessly sense our surroundings: we hear, feel, smell and taste it. Yet the dominant factor feeding our view of the world is the way we see it. How does information about our visual surroundings, projected into our eyes as patterns of light, enter our brain to create our internal representation of the world? Seeing is not as simple as assembling an image from many individual dots, like a digital photo. Our visual system processes information using many channels simultaneously, literally creating a multi-layered 'bigger picture'. The very first level of the visual system, the retina, already provides information on colour, contrast, movement, and brightness. We notice individual objects 'at a glance' because they jump out from what we see as mere background. Moving stimuli likewise command immediate attention.

For visual information to reach the brain through such parallel channels, images are pre-processed in the retina. For years, a team of scientists led by Prof. Thomas Euler (CIN – Werner Reichardt Centre for Integrative Neuroscience and Institute for Ophthalmic Research at the University of Tübingen) has been investigating the retinal 'switchboard' responsible for much of this processing. Recently, they focused on bipolar cells. Bipolar cells link the light-sensitive photoreceptor cells in the eye with retinal ganglion cells, which in turn forward the retinal output to the brain. Genetically and anatomically, 14 different types of bipolar cells have been identified. The Tübingen researchers therefore tested the hypothesis that each of these 14 cell types represents one visual channel, each with its own function. But how are these channels different from each other, and what are the mechanisms involved?

To answer this question, the scientists projected many different patterns of light onto mouse retinas. Simultaneously, they made use of a genetically encoded fluorescent protein to measure bipolar cell output. With this method, they were able to take measurements from a very large number of individual synapses (more than 13,000), and from all types of bipolar cells.

The results showed one surprising fact: when subjected to small spots of light, the 14 bipolar cell types' functions seemed very similar. Only larger stimuli covering far more than one cell's receptive field – the area where a bipolar cell collects photoreceptor inputs – generated different signals across multiple channels. Further experimentation showed that the bipolar cells' neighbours, so-called amacrine cells, are responsible for this diversification of encoded information.

Katrin Franke, who designed the study and performed the experiments, explains the findings like this: 'Instead of simply telling the brain "in my receptive field, it is currently bright/dark/green/blue", bipolar cells that receive input from amacrine cells can tell the brain more detailed information, like "it is bright here, but right next to where I am, it is dark". This level of detail allows the brain to assemble a complex layered impression including transitions, contrast, edges and movement.'
A better understanding of signal processing in the retina may be beneficial not only for basic research, but also in eye care medicine. For several years now, a retina implant for patients with degenerative eye conditions has been under development at the University of Tübingen's eye clinic. This implant makes use of bipolar cells, as these form the second layer downstream of photoreceptor cells lost to the progress of disease. Accordingly, the new study's insights promise to promote further application-oriented research in the field.

Publication: Katrin Franke, Philipp Berens, Timm Schubert, Matthias Bethge, Thomas Euler, Tom Baden: Inhibition Decorrelates Visual Feature Representations in the Inner Retina. *Nature* (in press). February 8th, 2017, doi: 10.1038/nature21394.

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Our core research areas include: integrative neuroscience, clinical imaging, translational immunology and cancer research, microbiology and infection research, biochemistry and pharmaceuticals research, the molecular biology of plants, geo-environment research, astro- and elementary particle physics, quantum physics and nanotechnology, archeology and prehistory, history, religion and culture, language and cognition, media and education research.

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The Werner Reichardt Centre for Integrative Neuroscience (CIN)

The Werner Reichardt Centre for Integrative Neuroscience (CIN) is an interdisciplinary institution at the University of Tübingen funded by the DFG's German Excellence Initiative program. Its aim is to deepen our understanding of how the brain generates functions and how brain diseases impair them, guided by the conviction that any progress in understanding can only be achieved through an integrative approach spanning multiple levels of organization.