RECEPTIVE FIELDS

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**Receptive field**: PHYSIOLOGICALLY defined as the area of the sense organ which elicits a response from the neuron when stimulated.
PHYSIOLOGICALLY, THE RECEPTIVE FIELDS OF BIPOLAR CELL ARE CONCENTRIC, OPPONENT TYPE

The field’s CENTER is formed by the receptor cell(s) with which the bipolar cell make(s) direct synaptic contact.

Center Response

[Diagram of the receptive field with a center and surround, showing the depolarization of the bipolar cell in response to light.]
PHYSIOLOGICALLY, THE RECEPTIVE FIELDS OF BIPOLAR CELL ARE CONCENTRIC, OPPONENT TYPE

The field’s CENTER is formed by the receptor cell(s) with which the bipolar make(s) direct synaptic contact.

Center Response

The On bipolar cell is depolarized when light is directed on the receptor(s) that define its receptive field CENTER.
PHYSIOLOGICALLY, THE RECEPTIVE FIELDS OF BIPOLAR CELL ARE CONCENTRIC, OPPONENT TYPE

Light on the receptor cells immediately surrounding the “center” receptor produces the opposite or SURROUND response.

**Center Response**  
**Surround Response**
Physiologically, the receptive fields of bipolar cell are concentric, opponent type.

Light on the receptor cells immediately surrounding the “center” receptor produces the opposite or SURROUND response.

Center Response

Surround Response

The On bipolar cell is hyperpolarized when light is directed on the receptors that SURROUND the center receptor.
PHYSIOLOGICALLY, THE RECEPTIVE FIELDS OF BIPOLAR CELL ARE CONCENTRIC, OPPONENT TYPE

Light on the receptor cells in the center and surround of a bipolar cell receptive field produces a reduced “center-type” response.
Rod Bipolars have large receptive fields whereas Cone Bipolars have small receptive fields.

Cone Bipolars in the fovea synapse with few cones, whereas Rod Bipolars in peripheral retina synapse with many rods.
Orientation selectivity

Light bar stimulus projected on screen

Recording from visual cortex

Stimulus orientation

Stimulus presented

Time (sec)
Reverse correlation method

\[ P(\theta, \tau) = \frac{\sum \text{spikes}(\theta, \tau)}{\text{Total spikes}(\theta, \tau)} \]
Dynamics of orientation selectivity

Dragoi et al., Nature Neurosci, 2002
Simple V1 cell

Complex V1 cell
Linear V1 neurons

Non-linear V1 neurons
Receptive fields in rat auditory cortex (A1)

High-density microelectrode mapping technique (Kilgard lab)
Receptive fields in rat barrel cortex (S1)

Pictomicrograph shows the barrel field in layer IV of the rat somatosensory cortex. Each barrel receives input from one whisker. The tissue in the image has been stained with cytochrome oxidase and is 50μm thick.
Spatial firing patterns of 7 place cells recorded from the CA1 layer of a rat. The rat ran several hundred laps clockwise around an elevated triangular track, stopping in the middle of each arm to eat a small portion of food. Black dots indicate positions of the rat's head; colored dots indicate action potentials, using a different color for each cell (Skaggs et al., 1996)
Parallel streams of visual processing
Receptive fields are larger and more complex in downstream areas.


Responses (filled blue curves) of neurons relative to the baseline (mean) firing rates (red circles) are plotted in polar coordinates as a function of stimulus orientation at 19 positions arranged in hexagonal arrays in space (x and y). Gray circles, locations and the size of stimulus patches used to obtain orientation tuning. Value in spikes per second at the lower right corner of each map indicates maximum firing rate as represented by the radius of the gray circle at each location. Orientation increases counterclockwise from 0° at the 3 o'clock position on each gray circle. Results for the orientation range between 0° and 180° were repeated to complete the polar plot in full circle. Solid and dashed black circles, subregions tuned to different orientations. (a–e) Maps from V2 neurons with uniform (a) and nonuniform (b–e) RF structures. (f) Map from a V1 neuron. (g–i) Maps from V3 neurons with uniform (g) and nonuniform (h,i) RF structures.
The model was an extension of classical models of complex cells built from simple cells, consisting of a hierarchy of layers with linear ('S' units in the notation of Fukushima, performing template matching, solid lines) and non-linear operations ('C' pooling units, performing a 'MAX' operation, dashed lines). The nonlinear MAX operation—which selected the maximum of the cell's inputs and used it to drive the cell—was key to the model's properties, and differed from the basically linear summation of inputs usually assumed for complex cells. These two types of operations provided pattern specificity and invariance to translation, by pooling over afferents tuned to different positions, and to scale (not shown), by pooling over afferents tuned to different scales (Riesenhuber and Poggio, 1999).
Complex receptive field structure in inferotemporal (IT) cortex

[from C. Gross’ Lab]
