Retinal Ganglion Cells

- Retinal ganglion cells represent the output of the retina; exhibit several important properties that are characteristic of many visual neurons
  - All-or-none responses
- Remember basic anatomy of a neuron:
  - cell body ("soma")
  - dendrites (which receive inputs from other cells)
  - the axon (which sends outputs to other cells)
Receptive Fields

- Retinal ganglion cells fire action potentials in response to certain types of retinal stimulation
- The part of the retina that needs to be stimulated in order to elicit a spike is the retinal ganglion cell's receptive field
- The receptive field of a neuron can be defined, more generally, as:
  - The part of the visual world that the neuron is responsive to (that it "sees")
  - What the visual stimulus needs to be in order to elicit spikes

Most retinal ganglion cells have concentric (center-surround) receptive fields

Center-Surround Receptive Fields

- These receptive fields are divided into 2 parts (center/surround), one of which is excitatory ("ON"), the other inhibitory ("OFF")
- For an ON/OFF center/surround cell, a spot of light shown on the inside (center) of the receptive field will elicit spikes, while light falling on the outside ring (surround) will suppress (or inhibit) firing below the baseline rate
- Opposite results for an OFF/ON cell

Types of Center-Surround Cells

Hermann Grid: Perceptual consequence of these receptive fields

- When you stare at a set of dark squares separated by a grid of white lines, you will see darkness at the intersections of the lines

Hermann Grid Explained

- Note that at the intersections, there is relatively more light (white) falling on the inhibitory surround of ON/OFF receptive fields (compare to the amount of white falling on the inhibitory surround of receptive fields that are not centered over intersections)
- This relatively-larger amount of inhibition suppresses the firing of cells with receptive fields that overlie the intersections, decreasing their firing rates, and yielding the perception of darkness
Hermann Grid Explained
- Once again, it is a matter of lateral inhibition between the center and surround of the receptive field.
- Note the lower right part of the diagram. The receptive field that lies at the intersection of the white cross has more light falling on its inhibitory surround than does the receptive field that lies between the two black squares.

However, note that the darkness disappears at an intersection that you stare at directly.
Why do you think this happens?

- Receptive fields in the central fovea are much smaller than in the rest of the retina.
- This is represented in the upper left of the diagram. In the Hermann grid you probably did not see a dark area when you looked directly at the intersection of the white cross, but did see dark areas in your peripheral vision.

More re. Lateral Inhibition
- Visual neurons do not simply "pipe" the output of the retina through the visual pathways
- Instead, the activity of a given neuron is affected by the activity of nearby neurons; lateral inhibition in the retinal ganglion cells is a prime example
- When a retinal ganglion cell fires action potentials, it also inhibits the firing of nearby (lateral) ganglion cells

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Mach Bands

• Lateral inhibition performs edge (contrast) enhancement
• A perceptual example of this edge enhancement: Mach bands
• The borders between light and dark parts of the image are exaggerated and appear as extra-light and extra-dark bars
• So…your perceptual experience can be predicted by the responses of the retinal ganglion cells

Lateral inhibition….

• evident in Mach Bands
  – left part of each bar “seems” darker - right side seems lighter

Lateral Inhibition example….

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<th>d</th>
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importance of change….

• retinal bleaching will result if no “change” occurs in the visual stimulus
  – retinal bleaching is caused by the depletion of photoreactive chemicals in the rods and cones
  – involuntary eye movements insure constant change
    • constantly “sweep” image across multiple cells
    • cells have a chance to “recover”
      • small, 10-20 cones
      • trembling, 1-2 cones

Representation of the Visual Field in the Brain

• As the pattern of light reflected off objects in the world enters the eye, it is flipped upside-down
• This upside-down pattern of light is the retinal image

  • The spatial structure of the retinal image is preserved as neurons from the retina connect to the LGN, and is still preserved further along in the cortex