

Lecture 05 – Brightness and Luminance

Today's Learning Objectives:

1. Define luminance, brightness, and lightness.
2. Describe how visual adaptation works.
3. Describe lateral inhibition and how it changes the way we see.
4. Describe how Mach banding effect affects gray-scale plots.
5. Explain how the Cornsweet effect can be used to enhance edges.
6. List the types of shading and when each should be used to enhance aspects of a visualization.

Defining Terms

- **Luminance:** measured amount of light coming from some region of space (unit: candelas per square meter).

Measured

- **Brightness:** aka “relative luminance,” perceived amount of light coming from a source.

- **Lightness:** perceived reflectance of a surface.

**Perceived
ONLY**

***Brightness* and *Lightness* are a construct of our visual perception.**

Brightness illusions

- We have no concept of luminance and it has little to do with the colors we perceive. We can only perceive “relative luminance.”



- What colors are the text and background of the timer?
- What color is the board?

➡ **Adaptation and Contrast**

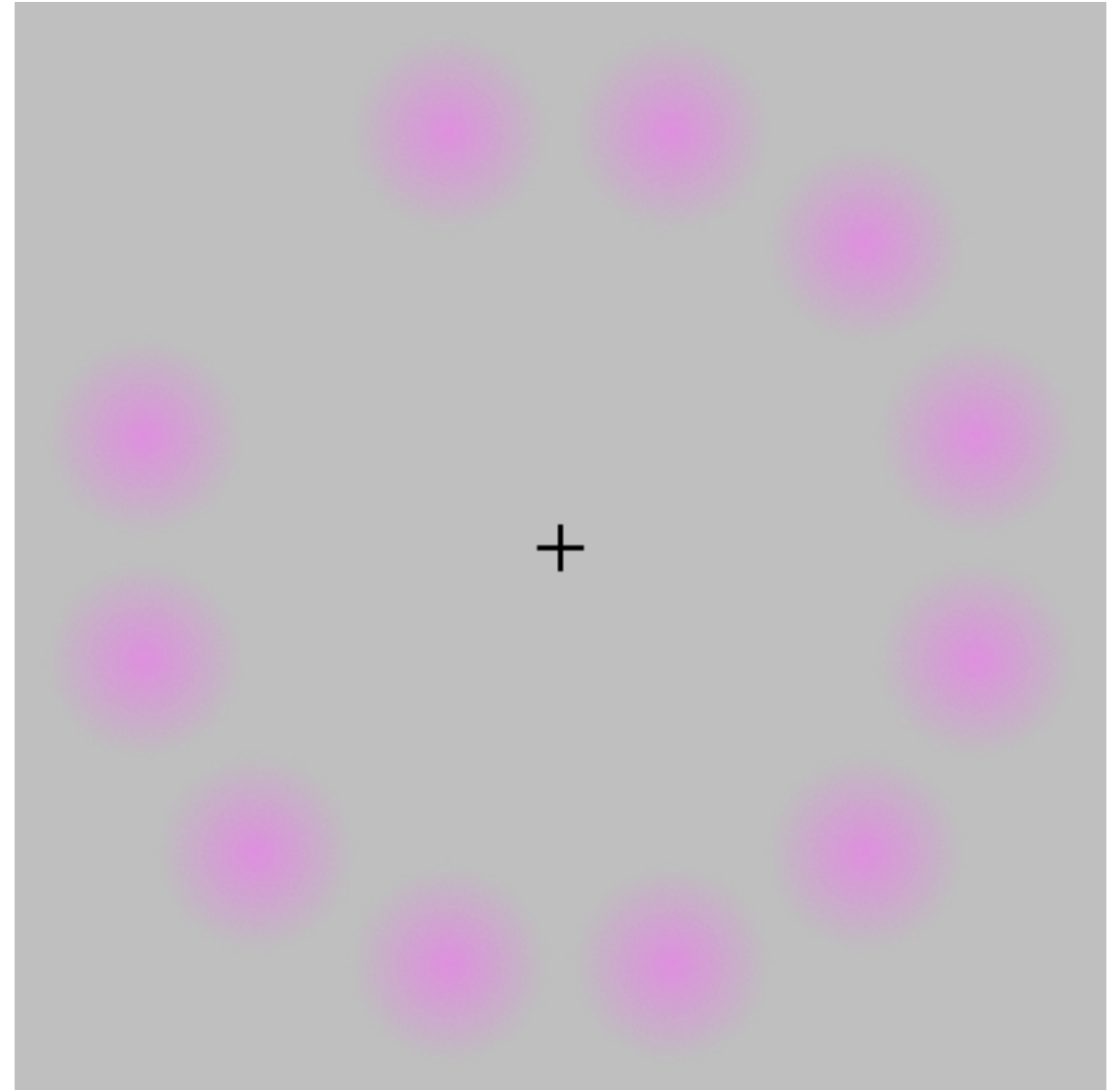


- What color is the dress?

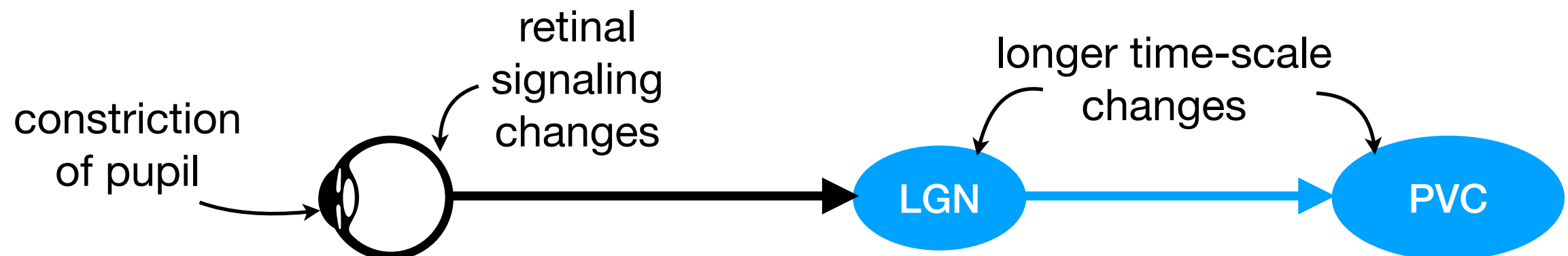
Visual Adaptation

- **Visual adaptation:** aka “visual plasticity,” changes that visual perception undergoes as the result of normalizing a signal.
 - Global process
 - VERY fast
 - Extremely powerful!
Eye is sensitive over **9 orders of magnitude**
 - Happens at a variety of levels of processing

“Lilac Chaser”

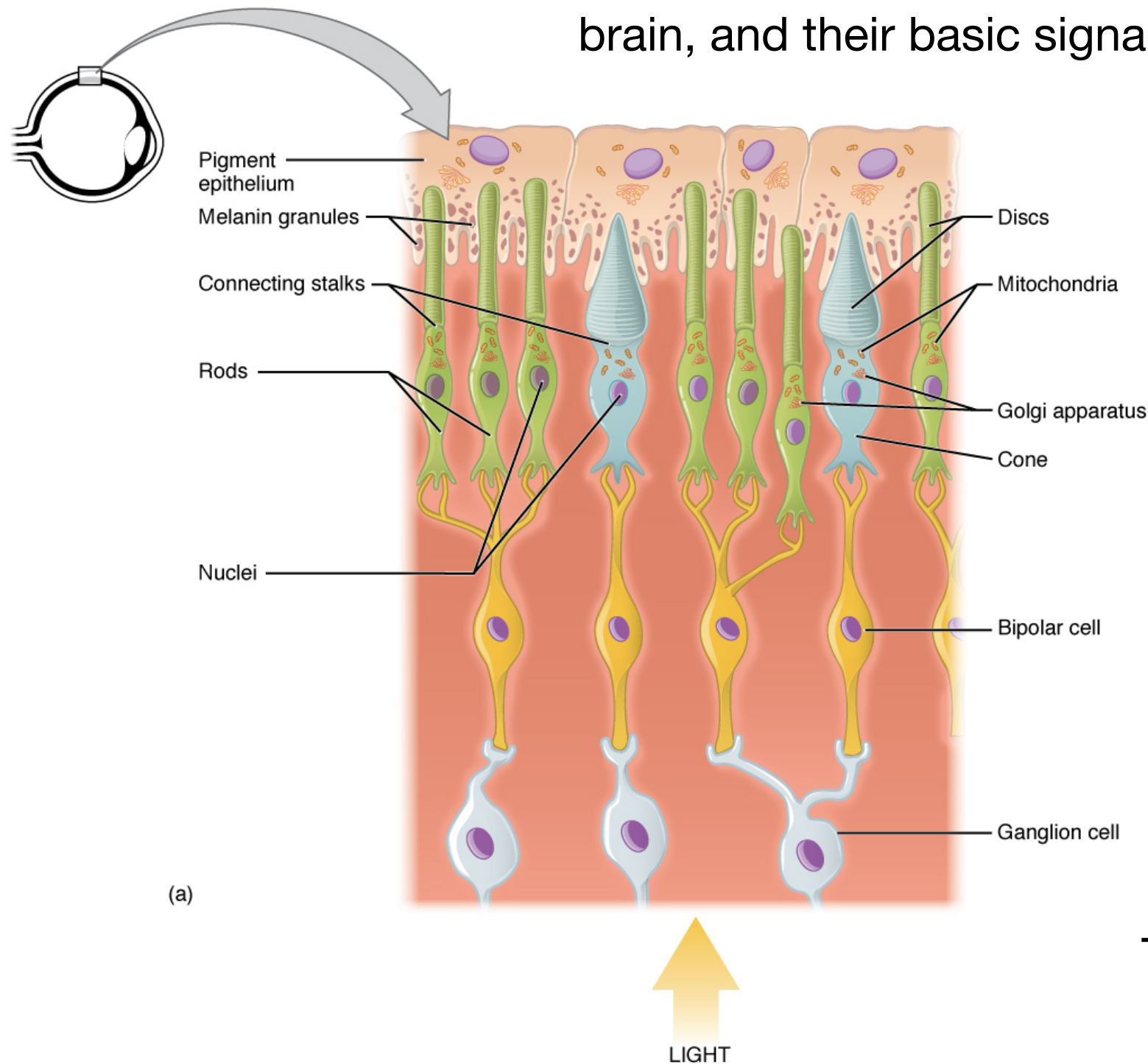


https://en.wikipedia.org/wiki/Visual_adaptation

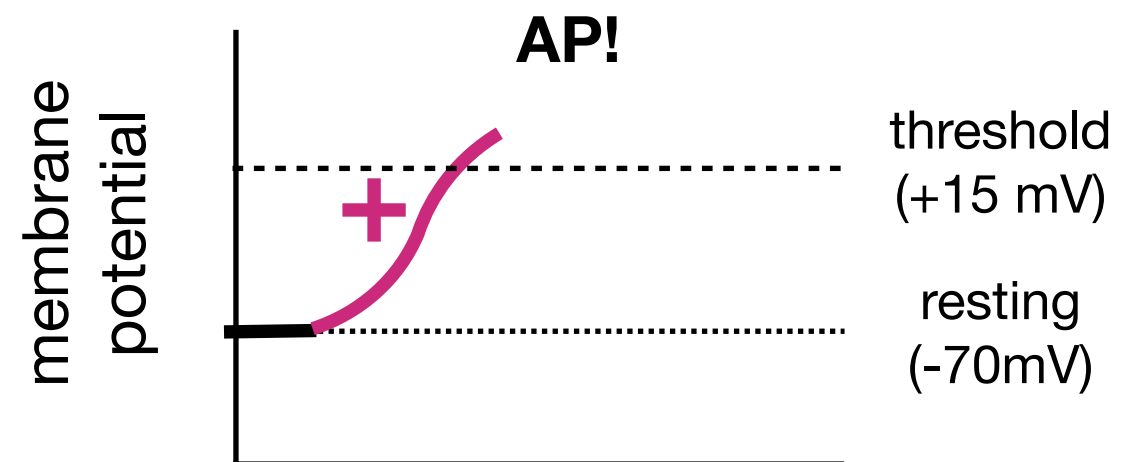


How Contrast Works

- Neurons are the basic unit of processing of the brain, and their basic signal is an action potential.



- Action potentials depolarize a cell's membrane, transmit an electrical signal.
- Photosensory cells convert light to electrical signals.
- Can be two types: **excitatory** or **inhibitory**.

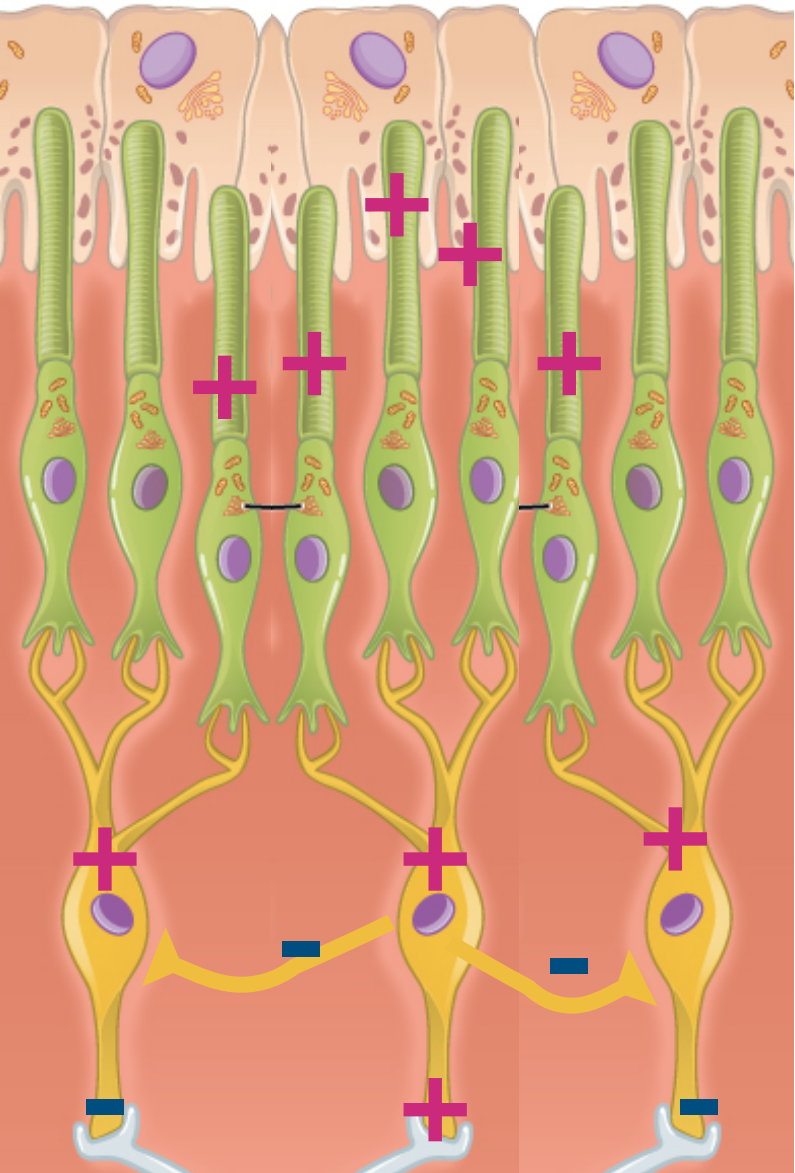


How Contrast Works

Light pattern



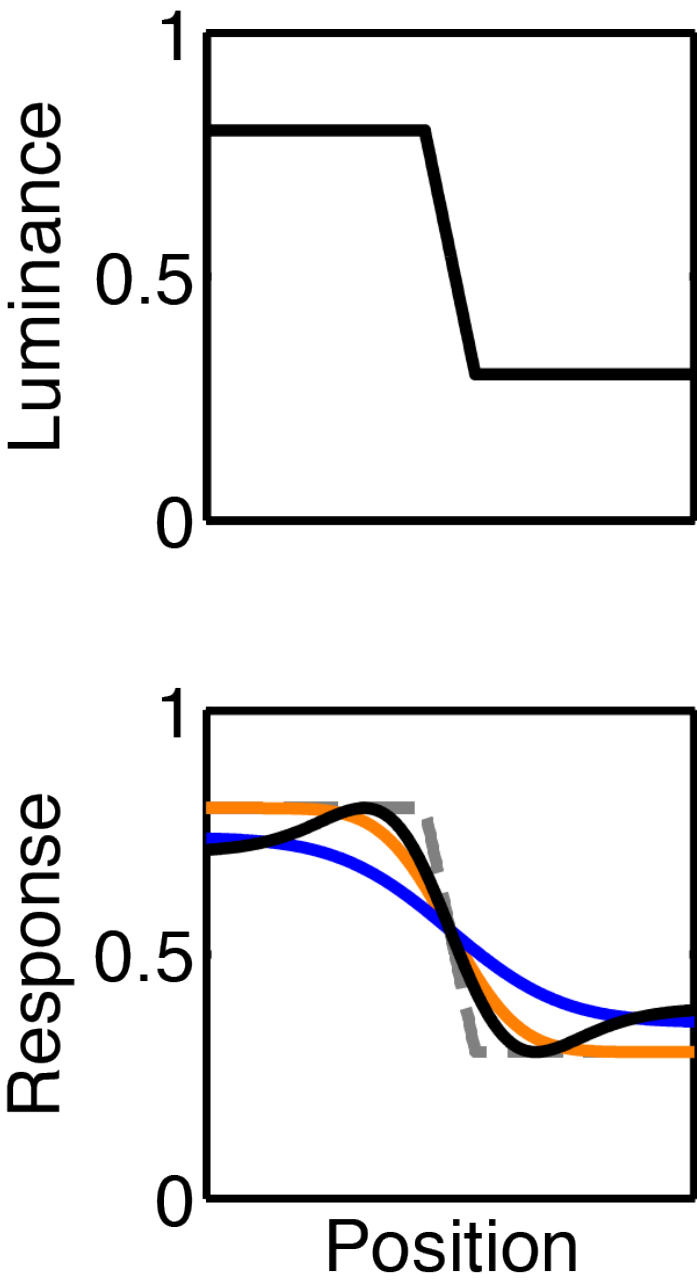
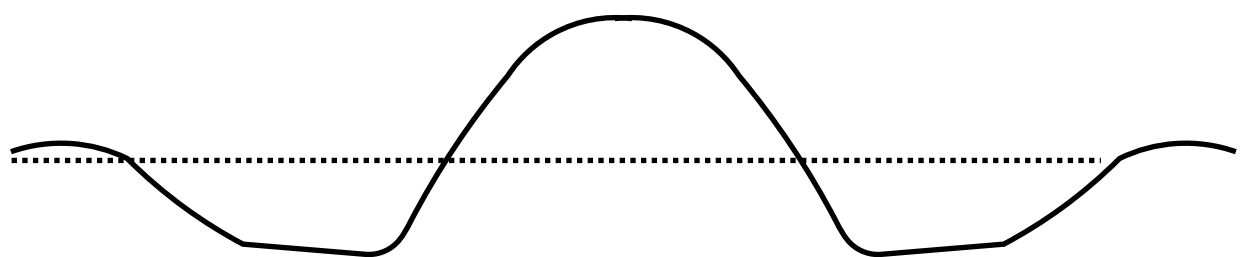
Rod cells



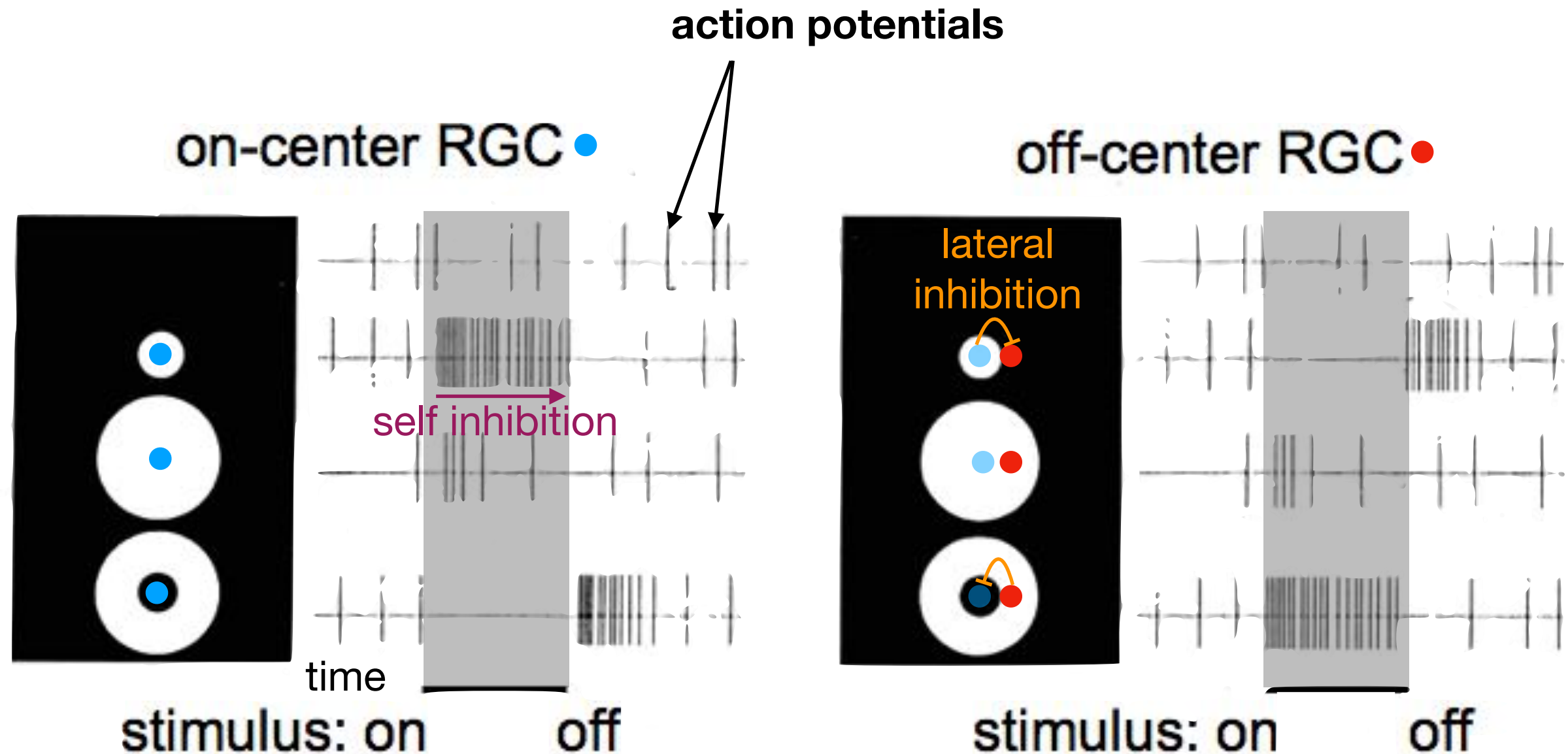
Biopolar cells

Response

resting



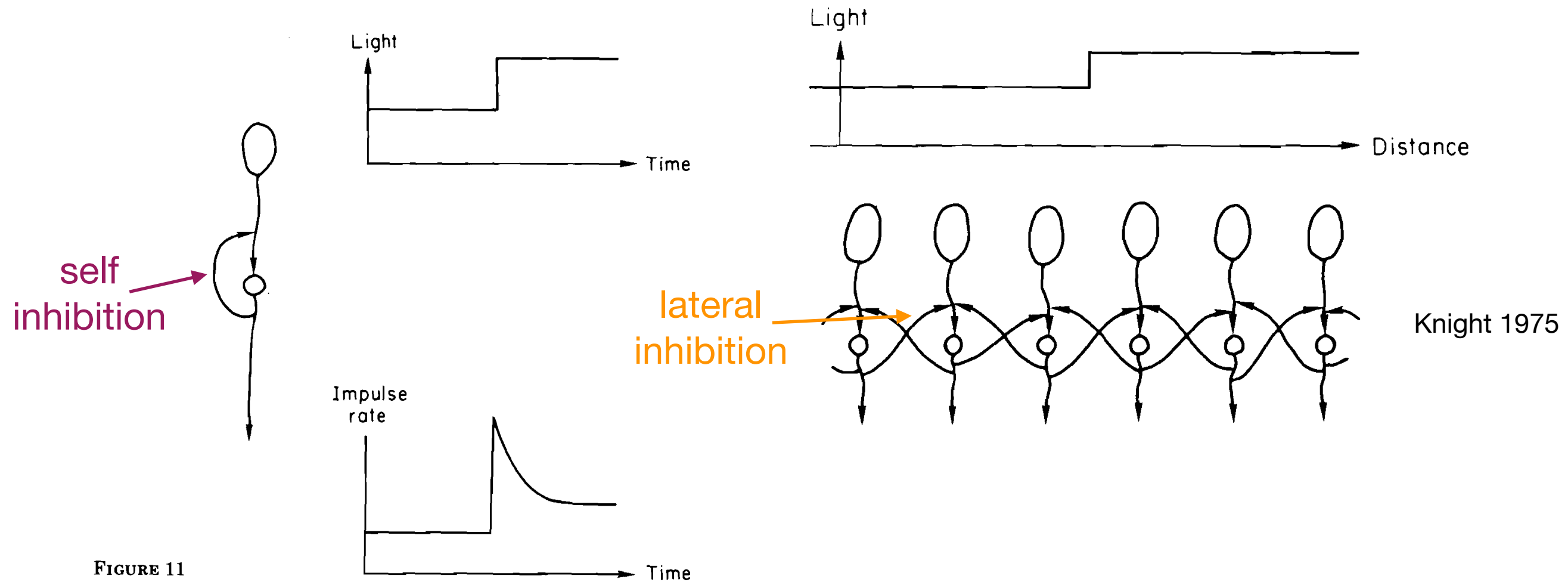
How Contrast Works



- Retinal ganglion cells (RGC) respond strongest to light near edges of dark.
 - Light sensing cells inhibit themselves (self inhibition)
 - Light sensing cells inhibit their neighbors (lateral inhibition)

How Contrast Works

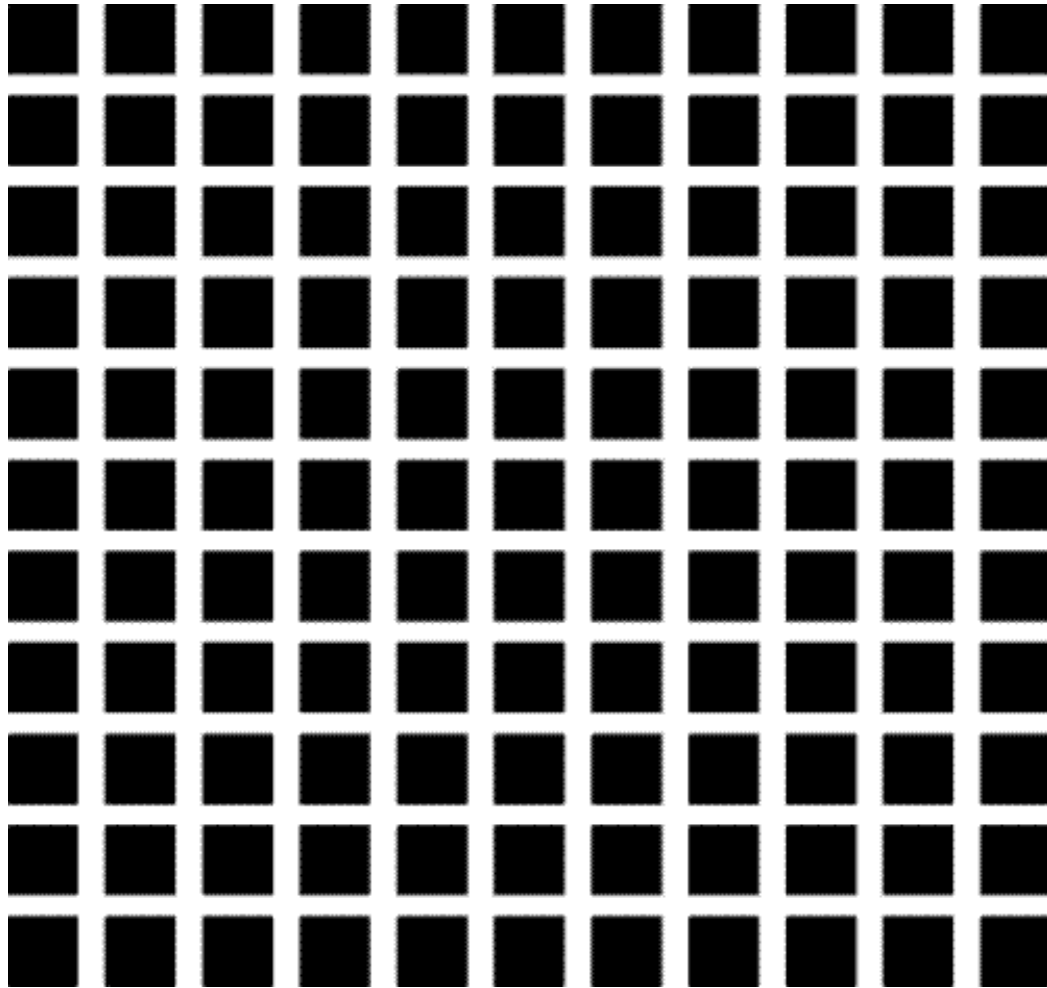
- **Self inhibition** and **lateral inhibition** cause Mach banding



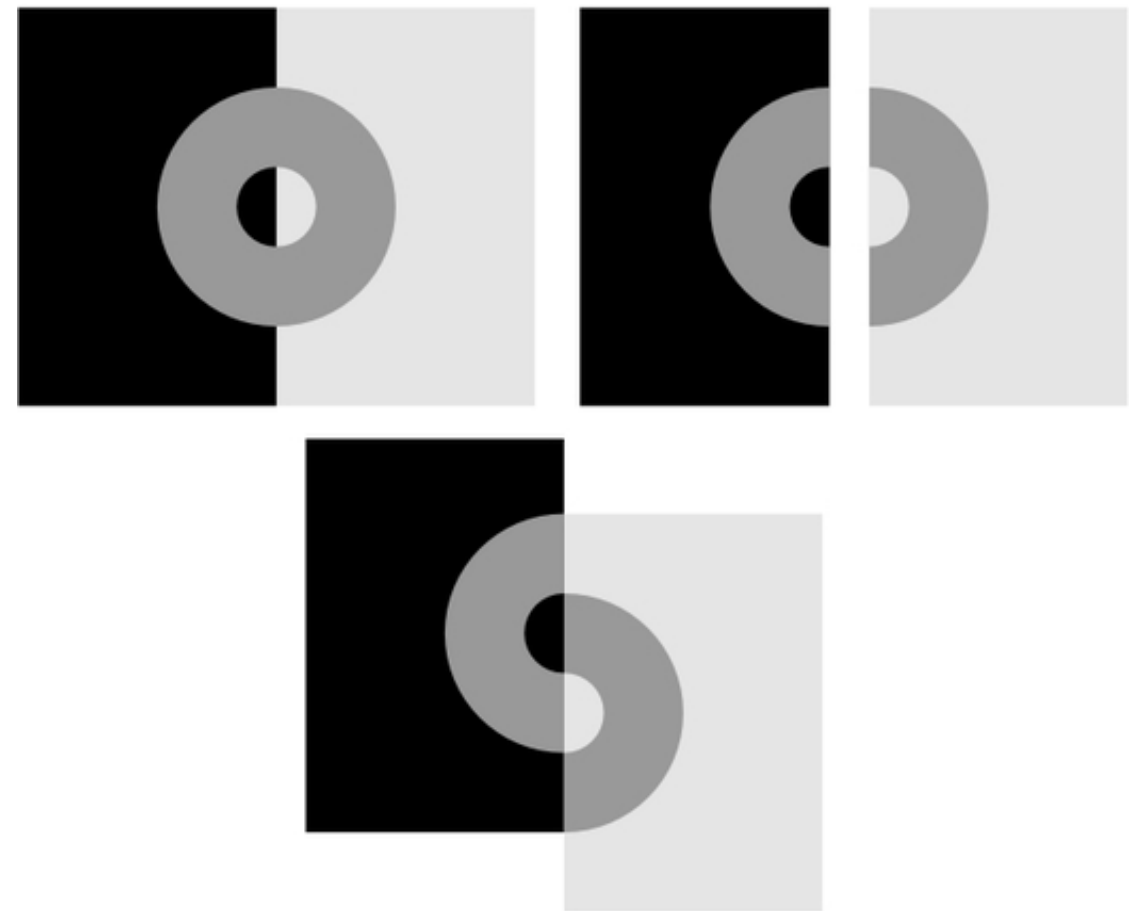
**Chevreul Illusion or
"Mach banding"**



Herman Grid Illusion



Koffka Ring Illusion



Simultaneous brightness-contrast illusion



Chevreul Illusion or “Mach banding”



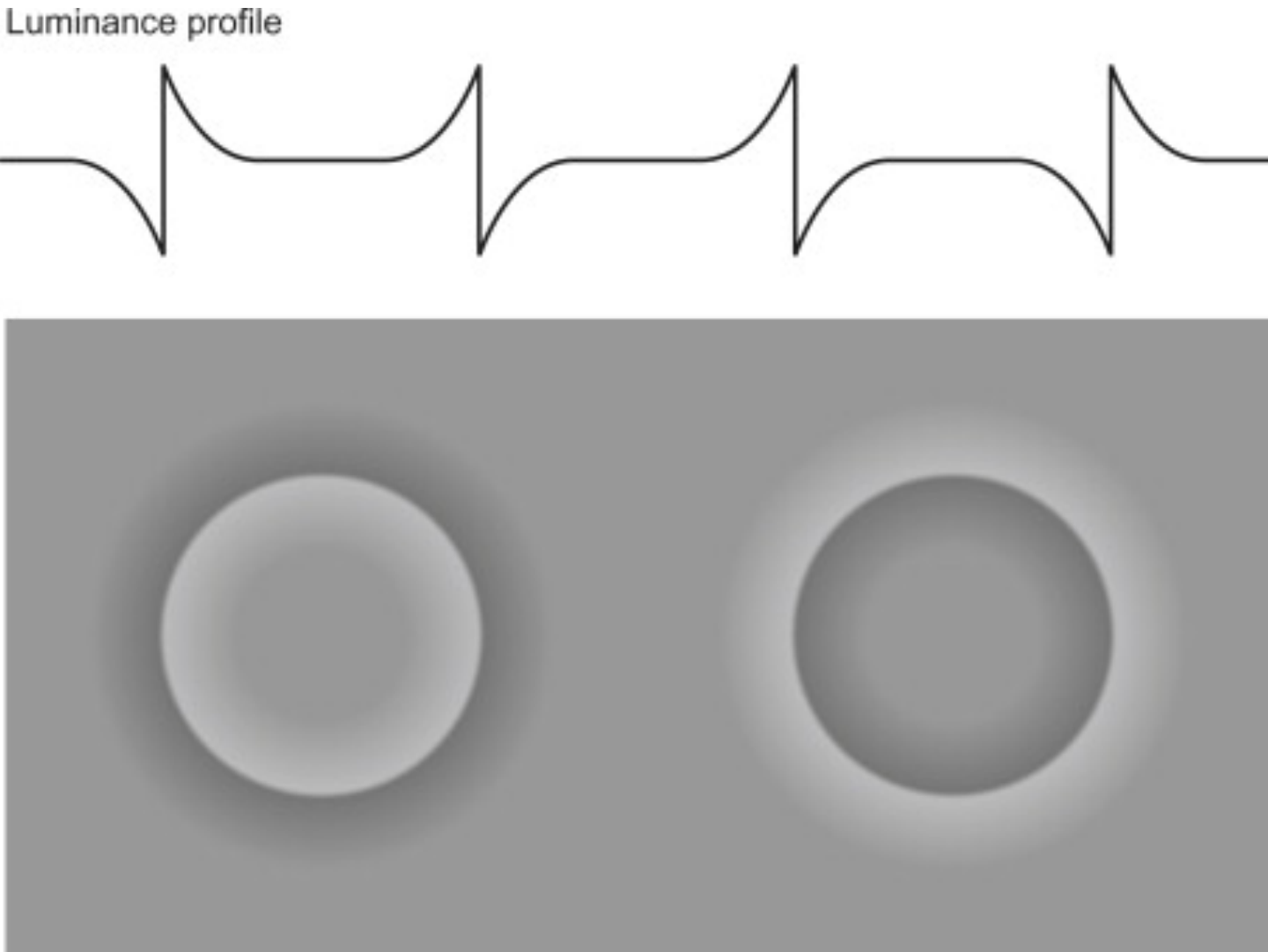
... looks just like a grayscale key bar.

Mach banding artifacts

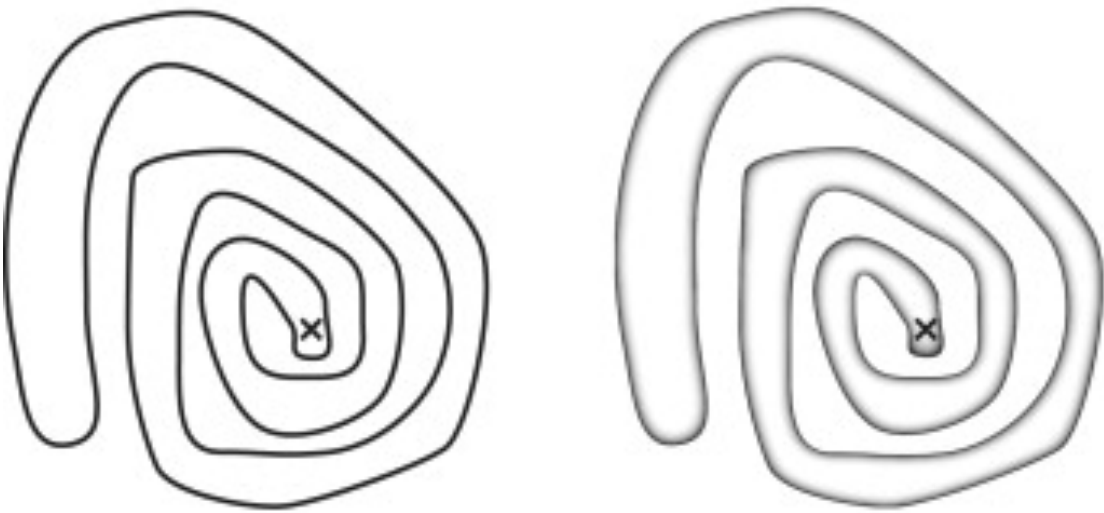


Edge Enhancement

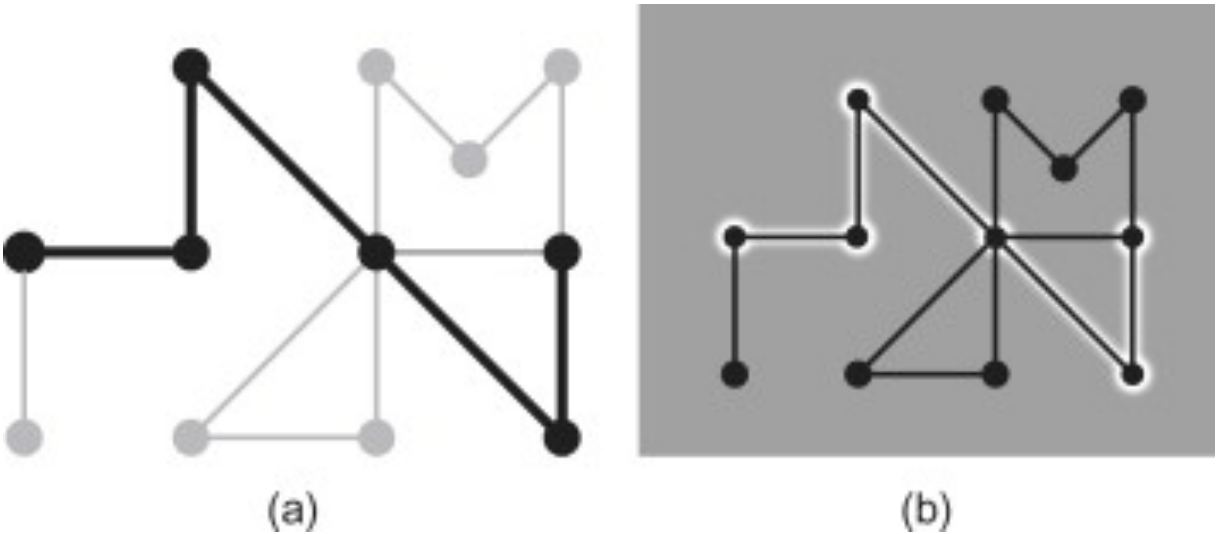
Cornsweet effect



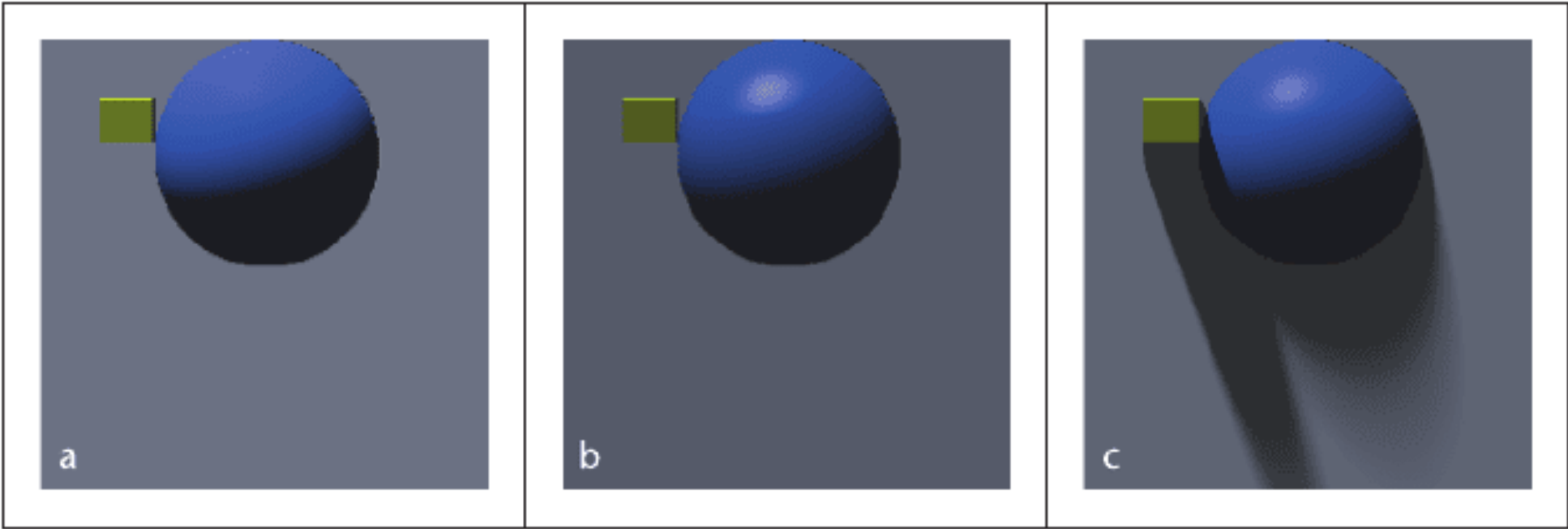
Cornsweet contours



Reducing background contrast



Shading Objects



Lambertian shading

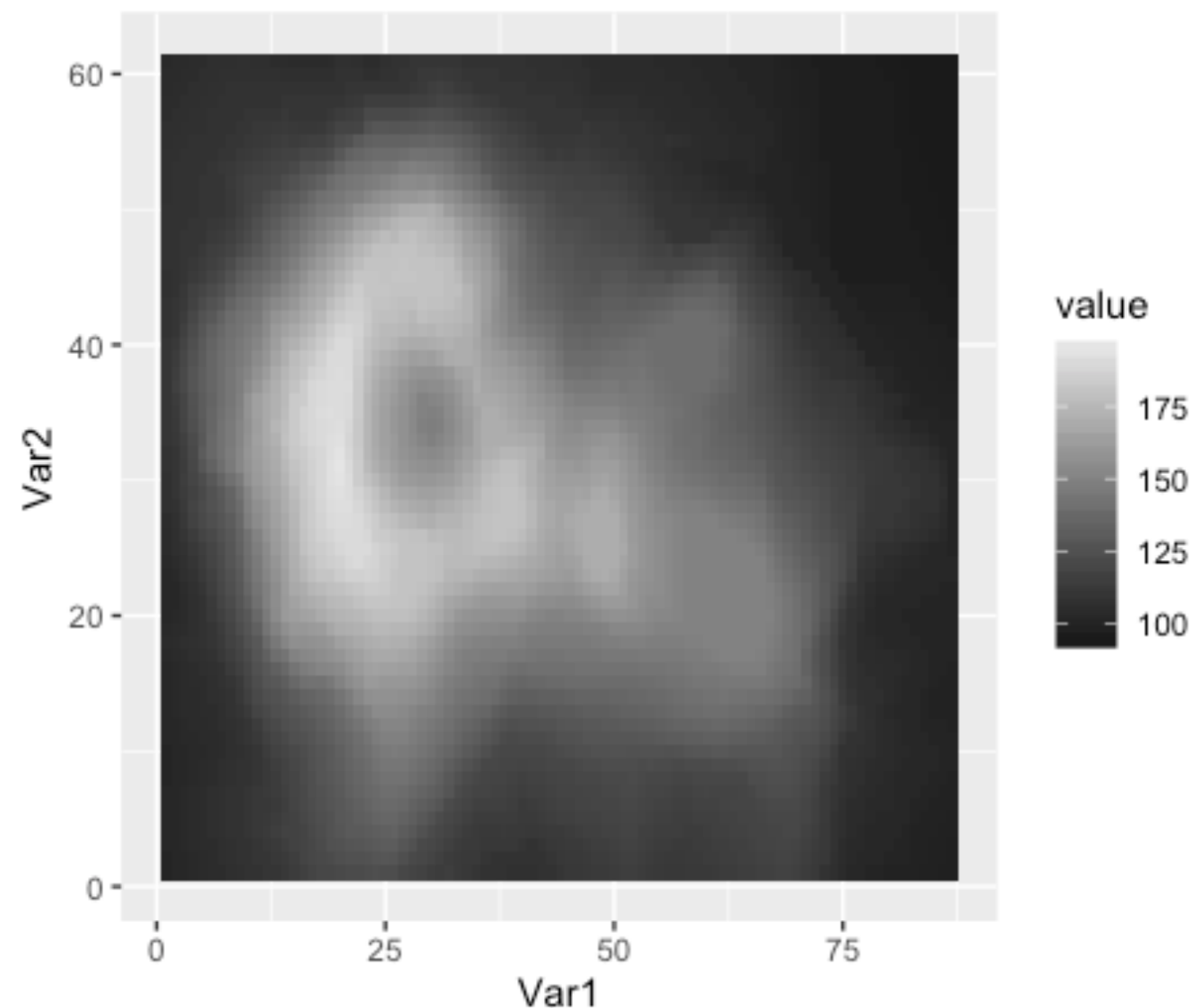
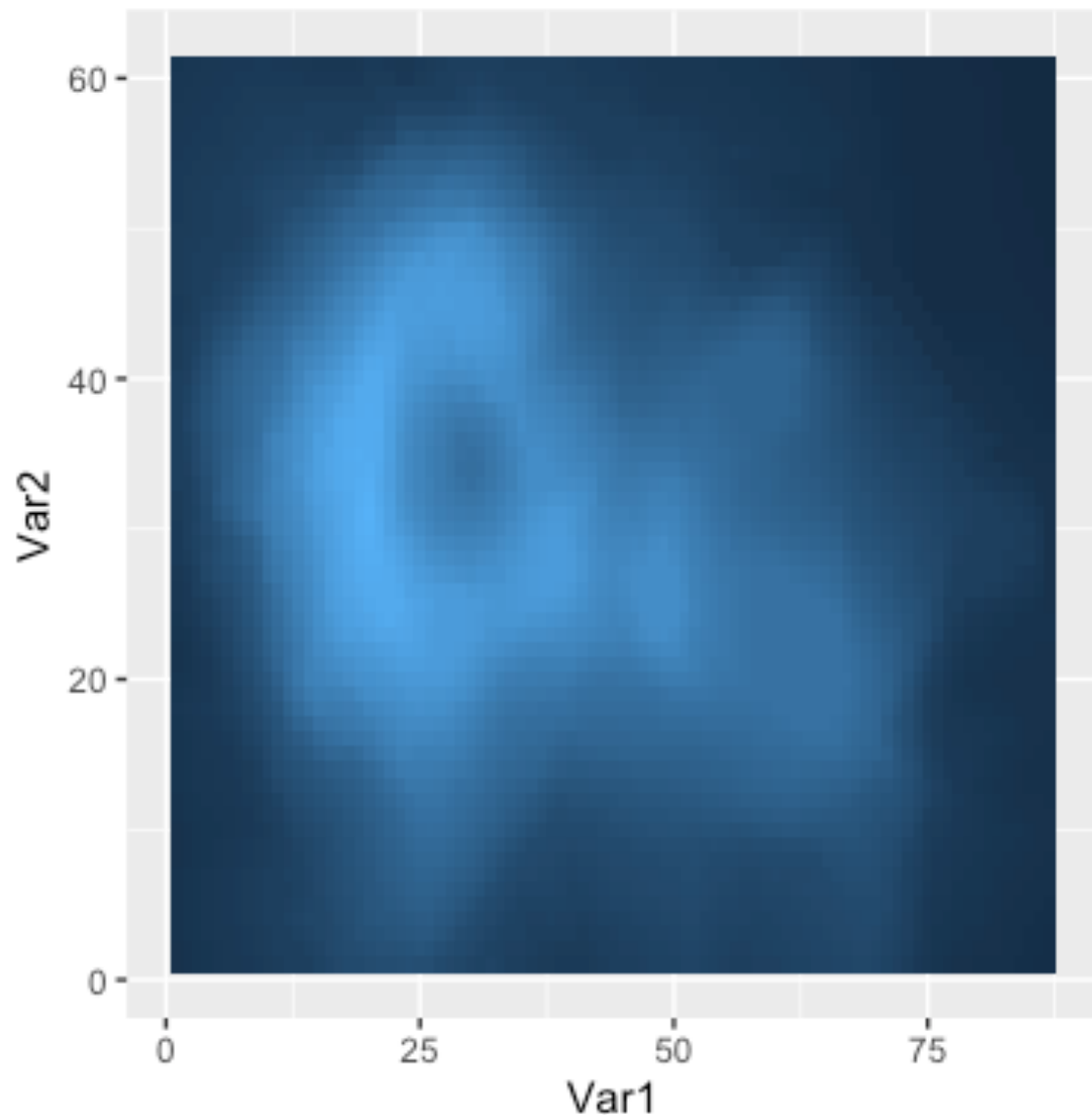
**Lambertian shading
w/ specular and
ambient shading**

**Lambertian w/
specular, ambient,
and cast shadows**

Group work:

Use `geom_tile()` in `ggplot2` to create two graphs of volcano: one with the default color scale and one with a gray scale that ranges from `gray10` to `gray90`.

Compare the two images. Where are the highest values (and what do you estimate them to be)? Do you see any Mach Banding in either image?



References:

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