

Human Visual System

Introduction to Computer Vision

CSE 152

Lecture 3

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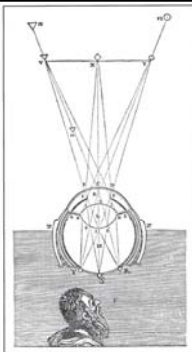
Announcements

<http://cseweb.ucsd.edu/classes/sp15/cse152-a/>

- Piazza
- Instructor office hours today
- Wait list
 - We're working to get a larger room.
 - But, if you decide that you're not going to take the class, please drop it to make room for others.

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Kepler

Kepler, 1604

Eye as an optical instrument

Image is inverted on retina

First such experiment by Scheiner, 1625

Figure 2.3 Image formation on the retina, according to Descartes. Descartes removed the eye of an ox, swapped its back to make it transparent, and then observed on it from a darkened room "not perhaps without wonder and pleasure" the inverted image of a waxe loaf (Pavani, 1907). Such an experiment was performed originally by Scheiner, first with the eyes of sheep and cows, and then, in 1625, with a human eye; the formation of an inverted retinal image was proposed by Kepler in 1604 (see (Pfebach, 1977)). (From Descartes's *La Dioptrique*, 1637.)

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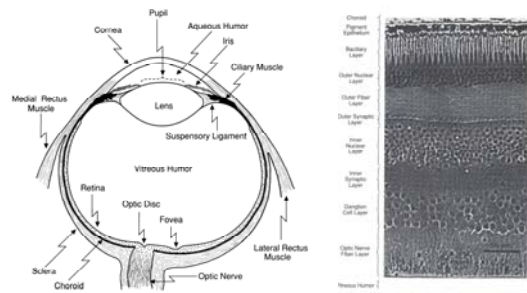
Ways to study human vision

1. Physiological
2. Phenomenological/Psychophysical
3. Cellular recordings
4. Functional MRI
5. Computational modeling

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Physiological level



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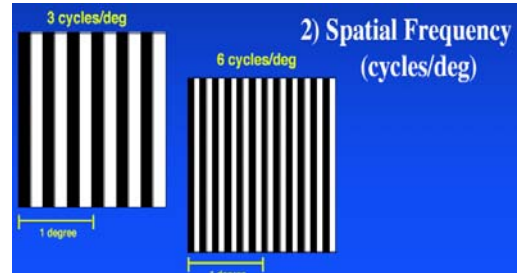
Psychophysical Testing of Subjects



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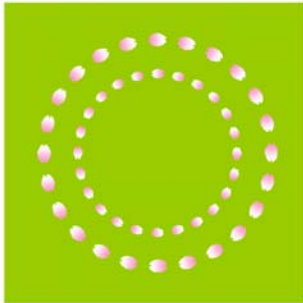
Example:
Show gratings w/ different spatial frequencies



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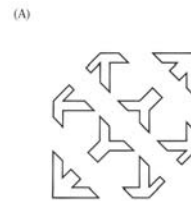
Gradients/Motion



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Perceptual Organization



Occlusion provides a different organization

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Perceptual Organization



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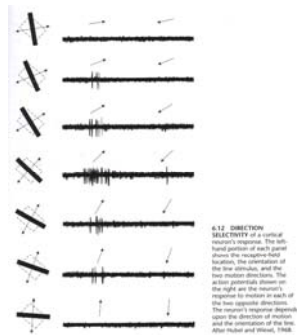
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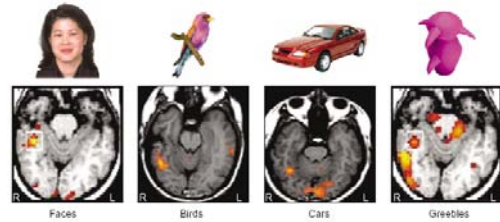
Single Cell Recordings



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fMRI



Activation in the right fusiform gyrus.
[Tarr, Cheng 2003]

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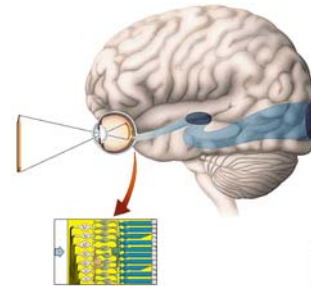
Ways to study human vision

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Computational Modeling

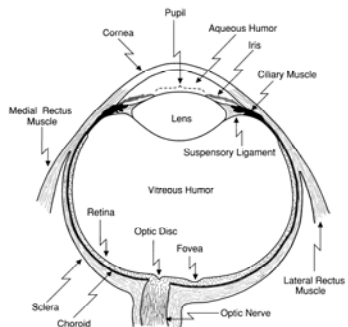


What is being computed and why?

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Structure of the eye



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The range of lighting



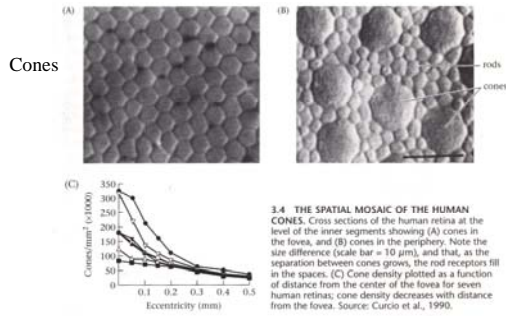
Direct sun	100'000 Lux
Sunny day	50'000 Lux
Cloudy day	5'000 Lux
Office	400 Lux
Home lighting	10 Lux
Street lamps	1 Lux
Full moon	0.1 Lux
Quarter moon	0.01 Lux
Clear moonless night	0.001 Lux
Cloudy moonless night	0.0001 Lux

Electronic imagers
Total lighting range

1 lux = 1 lumen/m²

C

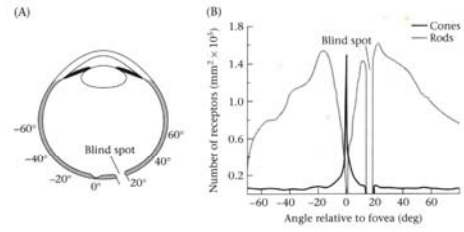
Rods and cones



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Distribution of Rods & Cones

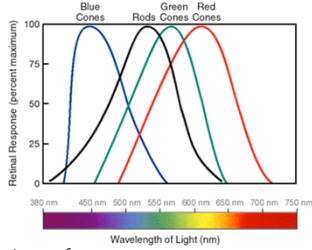


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Three types of cones: R,G,B

$$\text{Response of } k^{\text{th}} \text{ cone} = \int \rho_k(\lambda) E(\lambda) d\lambda$$



There are three types of cones

S: Short wave lengths (Blue)

M: Mid wave lengths (Green)

L: Long wave lengths (Red)

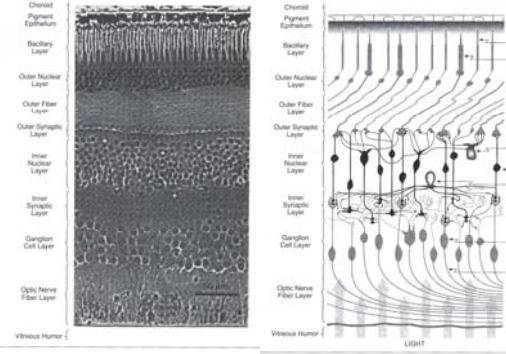
• Three attributes to a color

• Three numbers to describe a color

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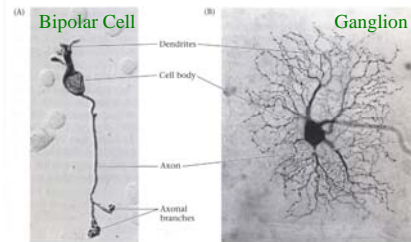
Retina edge on



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Retinal Neuron



5.2 RETINAL NEURONS have many different shapes and sizes. (A) The cell body of a bipolar cell resides in the outer nuclear layer. Its dendrites make contact with the photoreceptors and horizontal cells and its axon carries the output of the bipolar cell to the inner plexiform layer (see Figure 5.1), where it contacts the dendritic field of a ganglion cell. (B) The retinal ganglion cell bodies reside in the ganglion cell layer of the retina (see Figure 5.1). The axons of the retinal ganglion cells comprise the optic nerve. Several types of retinal ganglion cells can be distinguished based on the properties of their dendritic fields, their interconnections, and their cell bodies. The cell shown here was called a parasol cell by Stephen Polyak (1941, 1957). Sources: A from Yamashita and Wässle, 1991; B from Dacey and Petersen, 1992.

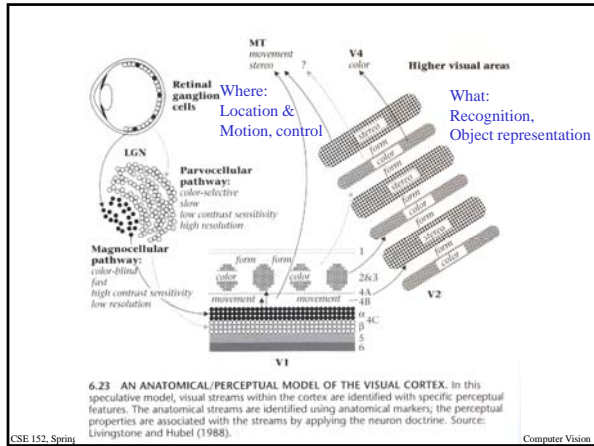
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Other Eyes

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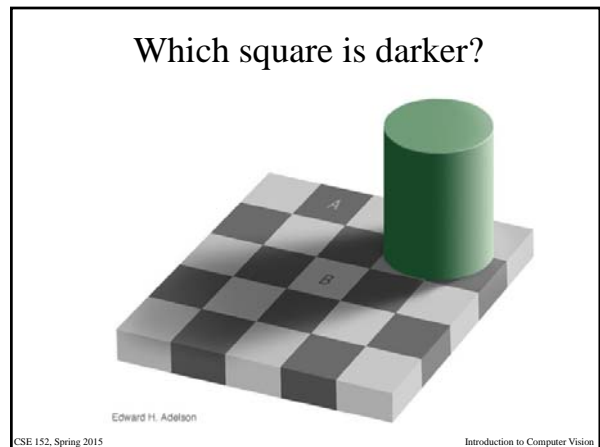
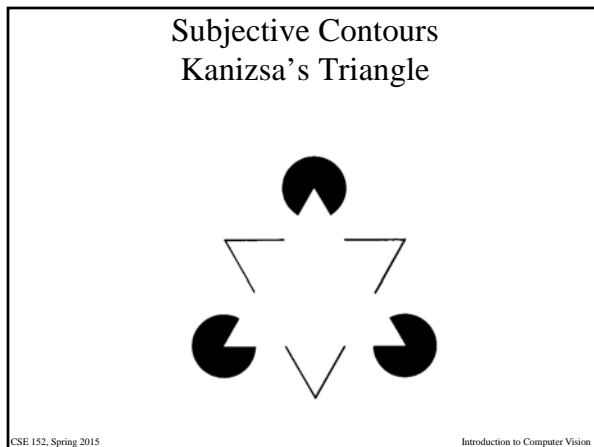
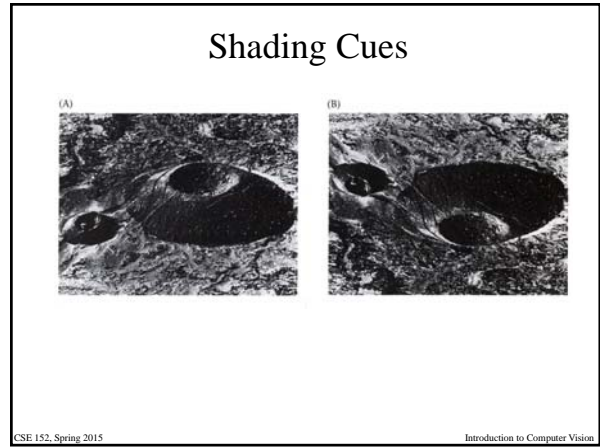


CUES

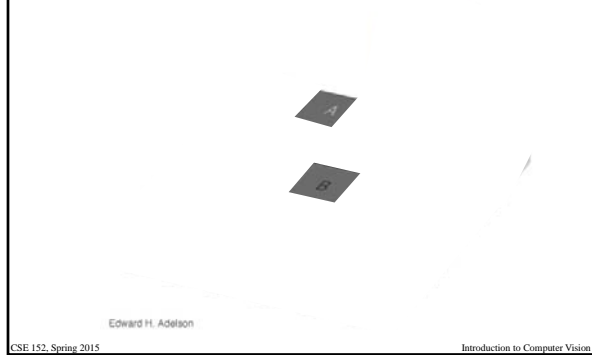
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Fixate at center
What color are the dots

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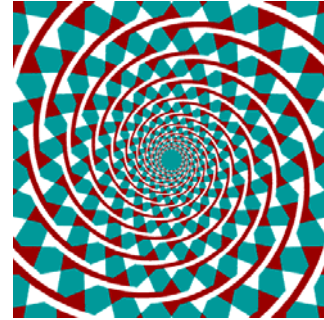
Which square is darker?



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Global vs. Local information:
Fraser's Spiral



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Context



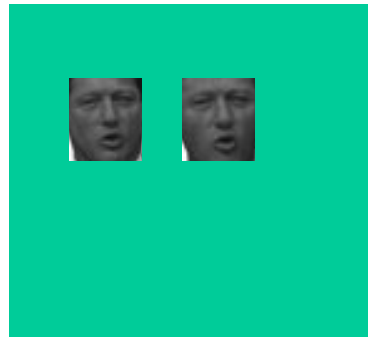
Who is taller?

Who is taller?

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Context: Whose faces do you see?



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A picture of a man



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In this shot, what is his facial expression?



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In this shot, what is his facial expression?



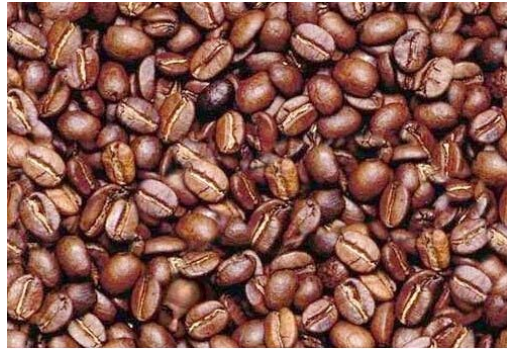
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Thatcher illusion

(g)

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Hidden Human Face



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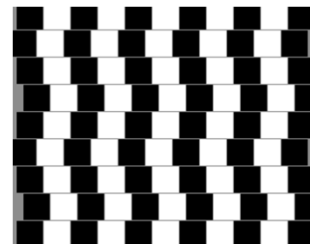
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Additional Pictures

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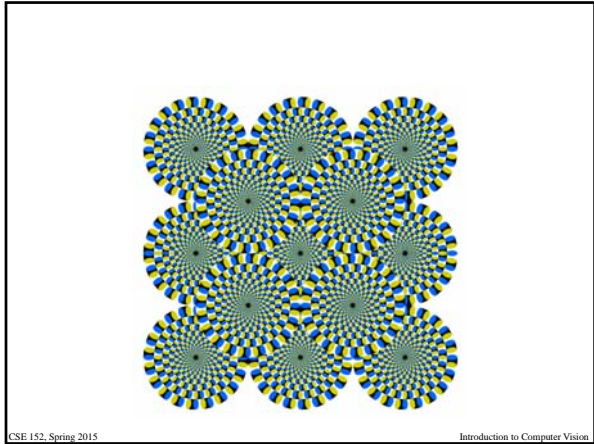
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Parallel Lines



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