COGS 101A: Sensation and Perception

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Lecture 7:

Color (Chapter 6)

Course Information

- Class web page: http://cogsci.ucsd.edu/ desa/101a/index.html
- Professor: Virginia de Sa
  - I'm usually in Chemistry Research Building (CRB) 214 (also office in CSB 164)
  - Office Hours: Monday 5-6pm
  - email: desa at ucsd
  - Research: Perception and Learning in Humans and Machines

For your Assistance

TAS:

- Jelena Jovanovic OH: Wed 2-3pm CSB 225
- Katherine DeLong OH: Thurs noon-1pm CSB 131

IAS:

- Jennifer Becker OH: Fri 10-11am CSB 114
- Lydia Wood OH: Mon 12-1pm CSB 114

Course Goals

- To appreciate the difficulty of sensory perception
- To learn about sensory perception at several levels of analysis
- To see similarities across the sensory modalities
- To become more attuned to multi-sensory interactions

Grading Information

- 25% each for 2 midterms
- 32% comprehensive final
- 3% each for 6 lab reports - due at the end of the lab
- Bonus for participating in a psych or cogsci experiment AND writing a paragraph description of the study

You are responsible for knowing the lecture material and the assigned readings. Read the readings before class and ask questions in class.

Academic Dishonesty

The University policy is linked off the course web page.

You will all have to sign a form in section

For this class:

- Labs are done in small groups but writeups must be in your own words
- There is no collaboration on midterms and final exam

Last Lecture

Beyond V1 (extrastriate processing)

Midterms look quite good for the most part

This Class

Color vision

Why is color vision important?

Recognizing fruit on the tree (there is a good picture in your text)

Adds beauty to our lives

Allows easy distinction of many natural and artificial signals

Magno/parvo review

Magno pathway transmits information about motion and low spatial frequency

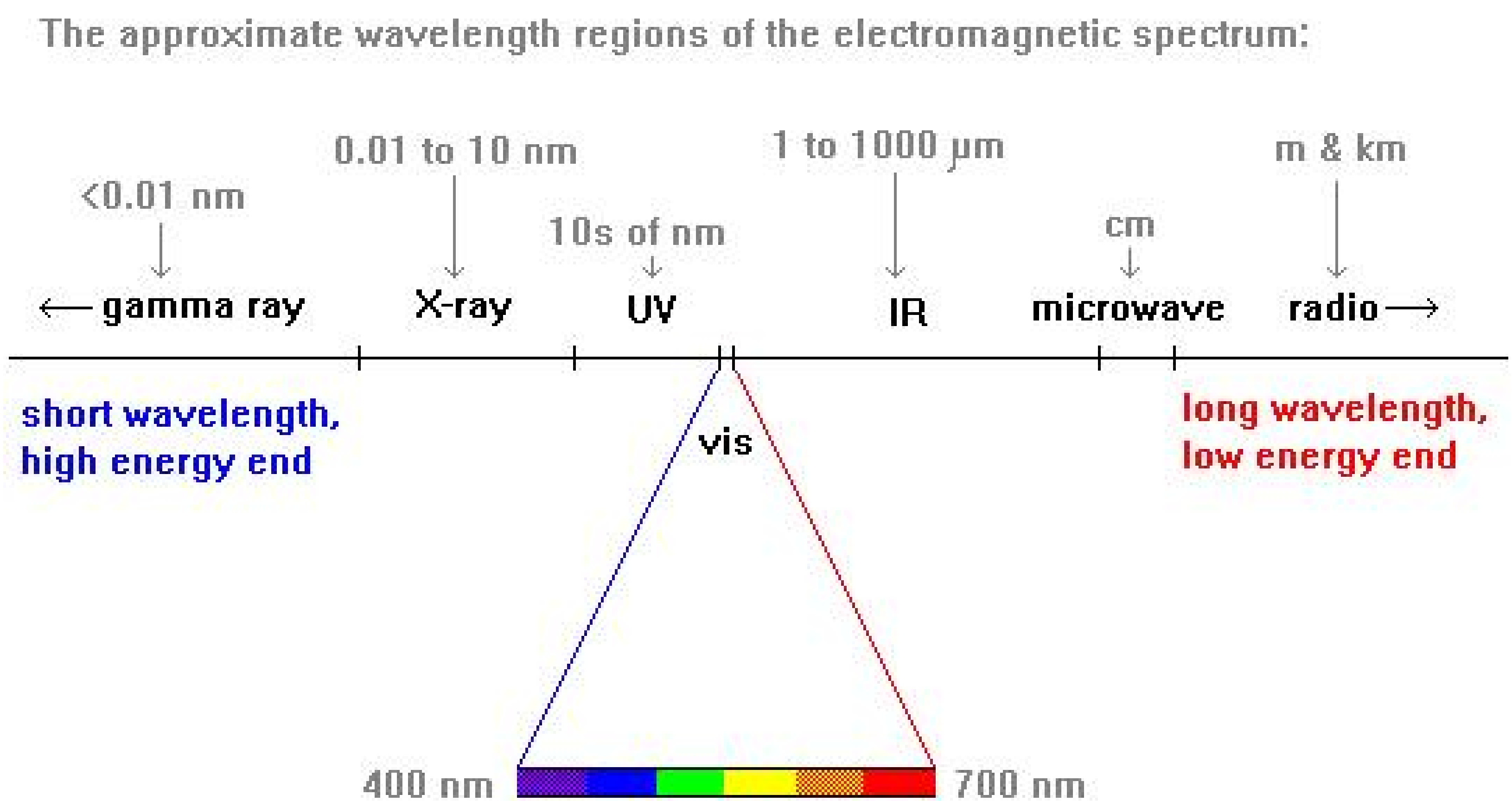
Parvo pathway transmits information about Red-green distinctions in high spatial frequency

Koniocelullar pathway more recently discovered transmits information about blue-yellow

The magno cells form the major input to the dorsal stream (parietal pathway)(where or how pathway). The parvo cells form the major input to the ventral stream (temporal pathway)(what pathway)

But there is significant crosstalk (especially to ventral stream)

Color is related to wavelength of light



Definitions

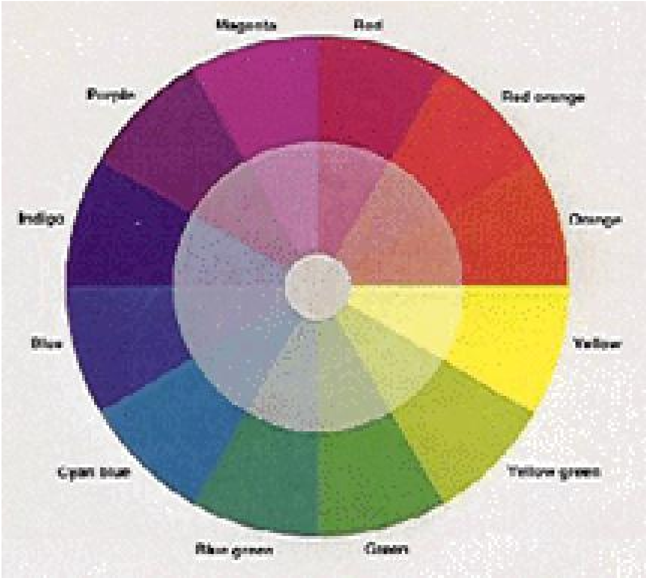
reflectance - percentage of light reflected versus wavelength (can look at a **reflectance curve**

achromatic colors - when light reflectance is flat across the spectrum (white,black,gray)

chromatic colors - when some wavelengths are reflected more than others

Green things **selectively reflect** more green light

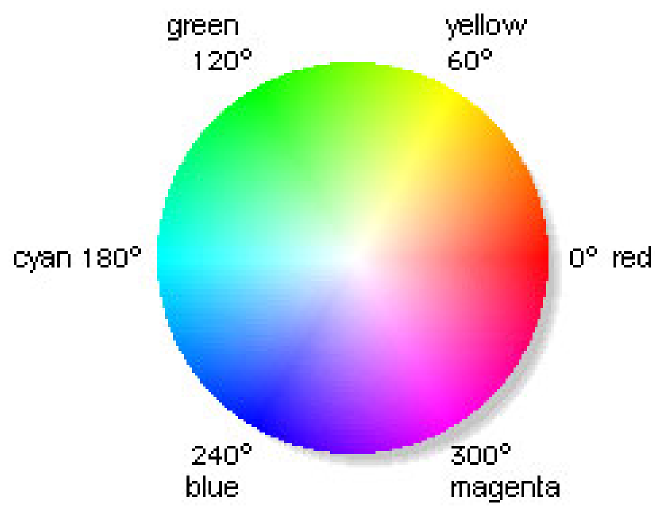
Color Circle



http://colorvisiontesting.com

Color circle shows perceptually similarity of colors (neigboring colors are perceptually similar)

Color Circle



http://www.sapdesignguild.org/resources/glossary_color/index1.html

Color circle shows perceptually similarity of colors (neigboring colors are perceptually similar)

Adding more white **desaturates** a color (the color has less **saturation** when more white is added)

How do we see color?

In the 1800's two different theories of color vision were proposed based on pschophysical evidence. Turns out both were mostly correct as verified over 70 years later physiologically.

trichromatic theory or color vision- Young-Helmholtz theory of color vision says that color vision depends on the activity in three different receptor mechanisms.

Opponent-Process Theory of Color Vision- Hering's theory of color vision says that color vision is caused by opposing responses (red vs green) and (blue vs yellow)

Aside: Additive color mixing vs Subtractive color mixing

When you add lights you add the spectrum

Paints have color because they absorb proportions of some wavelengths (more than others) and reflect the rest

When you add paints you combine the absorption spectra. This decreases the reflected light and is called subtractive color mixing.

(draw diagram on the board)

Trichromatic theory

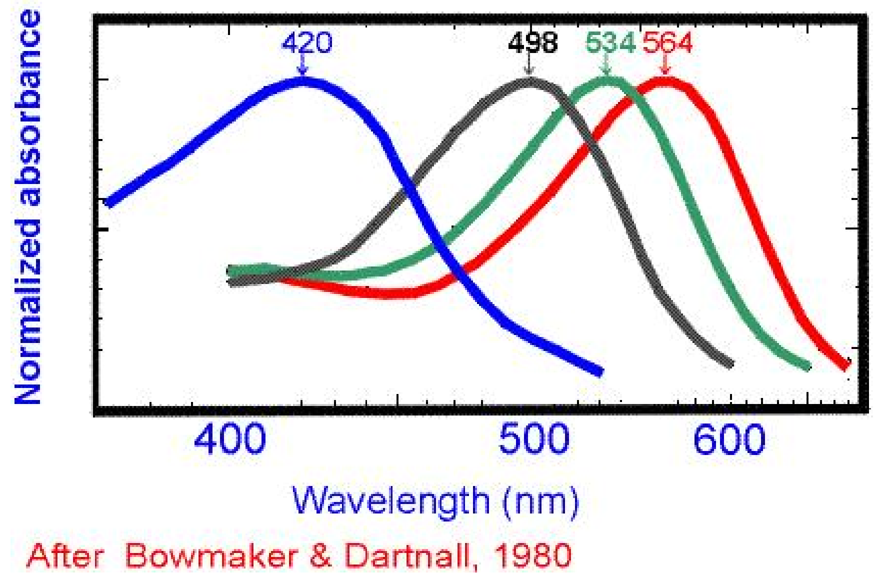
Based on **color matching experiment**: Have subjects match a light of one wavelength by varying the strengths of three lights of three other wavelengths

People with normal color vision can do the match with any 3 wavelengths (as long as you can't make any one from the other two). We will see that people with impaired color vision can match with less than 3 wavelengths.

Theory goes that there are 3 different types of detectors with different spectral sensitivies. The pattern of activity across the three types codes for the color.

Three different cone pigments

Three different cone pigments were discovered over 70 years later.



http://www.yorku.ca/eye/specsens.htm

They have been named S,M,and L cones for short/medium/ and long wavelength maximum sensitivity

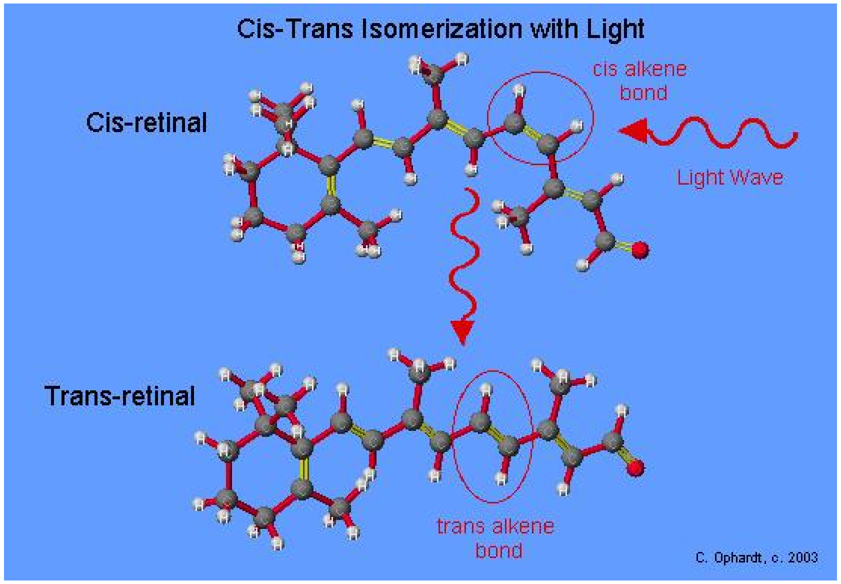
The different cones have slightly different opsins which cause them to be differentially selective absorption spectra

We can't distinguish all types of color stimuli

e.g. We can match any one wavelength with a mix of three others

color metamers – two different wavelength mixes that can't be distinguished

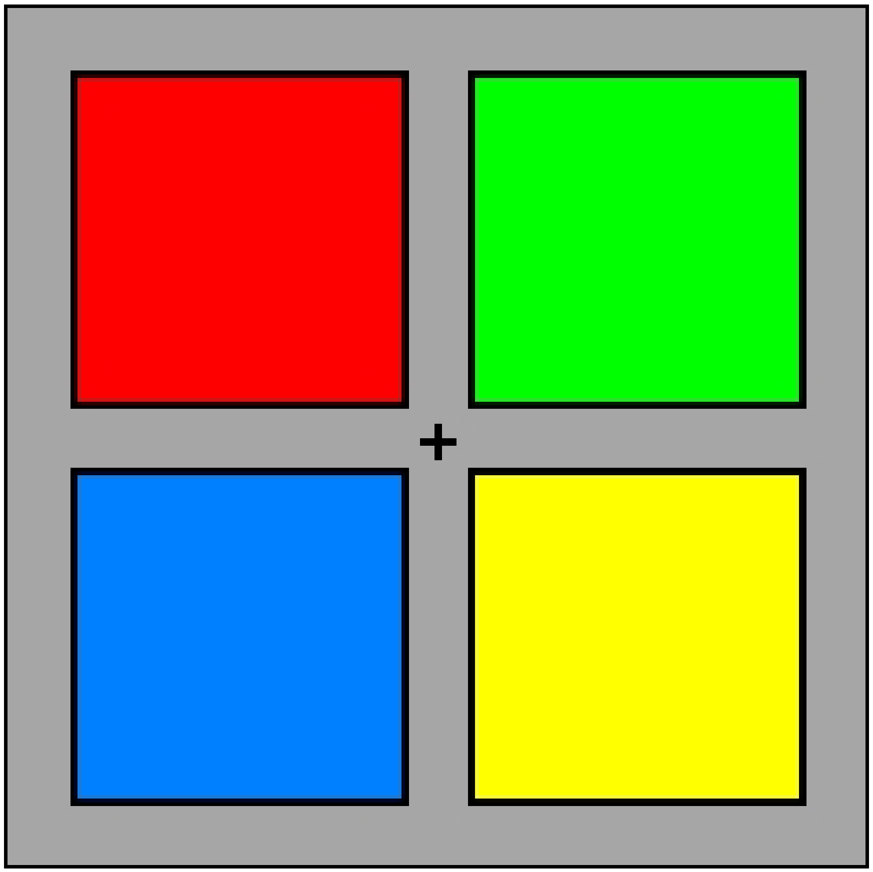
Remember the retinal is attached to opsin



http://www.elmhurst.edu/ chm/vchembook/533cistrans.html

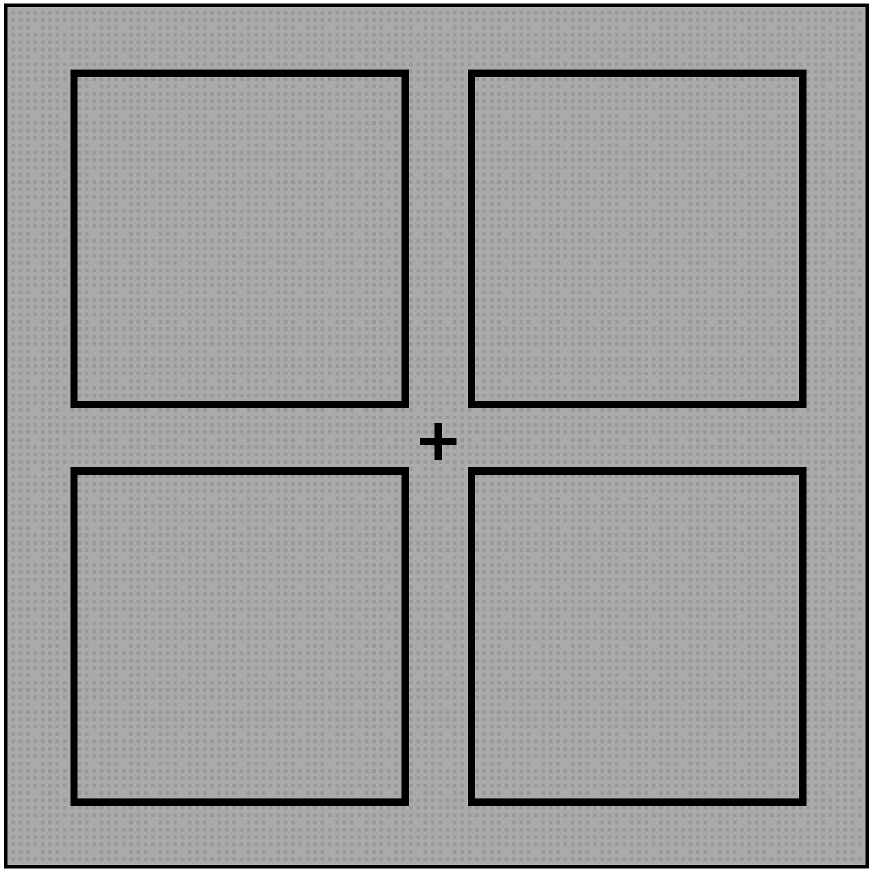
light is transduced when the retinal detaches from the opsin

Color Opponency from a simple aftereffect



http://psy.ucsd.edu/ sanstis/SAai.html

Color Opponency from a simple aftereffect



http://psy.ucsd.edu/ sanstis/SAai.html

Color Opponency from a simple aftereffect

What can you determine from observing this effect?

Color Opponency from a simple aftereffect

What can you determine from observing this effect?

Almost a full century before physiological recordings confirmed the existence of opponent color processing, Hering proposed that red and green compete to activate neurons, as do blue and yellow, and black and white.

This is a good example of how Illusions and Aftereffects can

- determine how stimuli are processed neurally (neural architecture)

Opponent Neurons

Bipolars can have opponency (e.g. excited by Red, inhibited by Green [R+G-]) (some retinal ganglion cells and LGN also have this kind of simple opponency)

Center surround cells (retinal ganglion, LGN, V1) can be

(single) opponent cells e.g. R+ center G- surround

Also find B/Y opponent cells

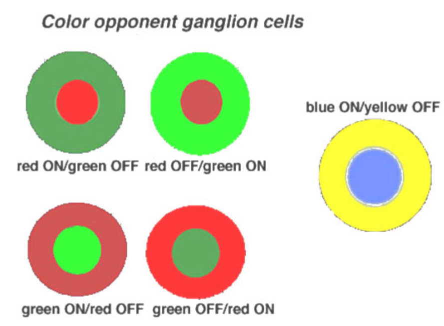


Fig. 19. Color-opponent units as recorded in monkey retina by Gouras (1968).

http://webvision.med.utah.edu/imageswv/colorop.jpeg

Color cells in V1 are found in the “blobs”

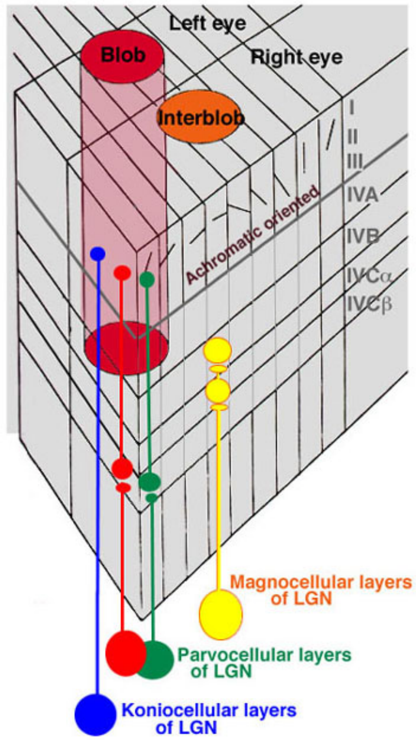


Fig. 27. Diagram of a slab of striate cortex (V1) of primate brain to show the composition of a hypercolumn. A hypercolumn consists of two ocular dominace columns (one from each eye) each containing stacks of orientation columns. A blob is a cylinder of cells running from I to IVB which receives direct input from blue/yellow cells of the koniocellular layers of the LGN, and the color-opponent red and green cells of the parvo-cellular layers of the LGN. The latter projections are secondary to the first synapses in layer IVCb. Magnocellular cells from the LGN project to layer IVCa.

http://webvision.med.utah.edu/imageswv/cortex.jpeg

Here we have the emergence of **double opponent cells** e.g. R+G- center R-G+ surround

Color vision impairments

Good color blindness site at http://colorvisiontesting.com/

Color vision impairments

Monochromat - has only rods or one kind of cone (very rare occurs in about 10 in 1 million people). Can match any wavelength by adjusting the intensity of any other.

Dichromat - has two kinds of cones. Can match any wavelength by adjusting the intensity of two others.

Anomalous trichromat-Has three cones but the M and L spectra are shifted closer together. Can match any wavelength by adjusting the intensity of three others but uses different proportions than people with “normal” color vision

Different types of Dichromatism

Protanopia - Missing the L pigment (In 1% of males and 0.02% of females)

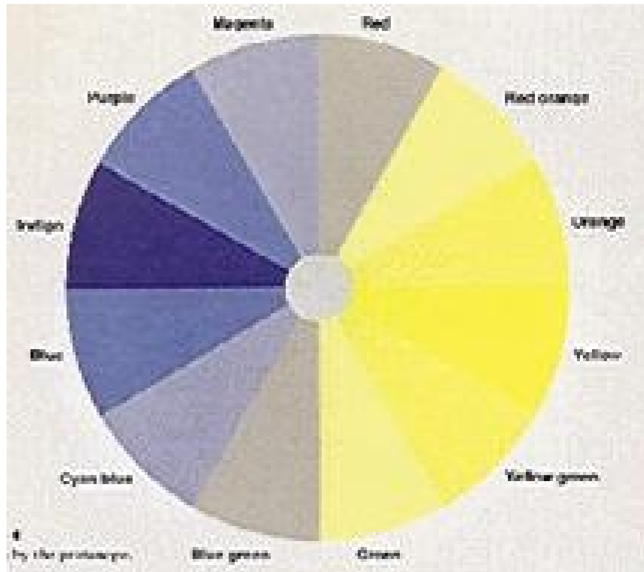
Deuteranopia- Missing the M pigment (In 1% of males and 0.01% of females)

Tritanopia- Probably missing the S pigment (In 0.002% of males and 0.001% of females)

Vision for a person with normal color vision

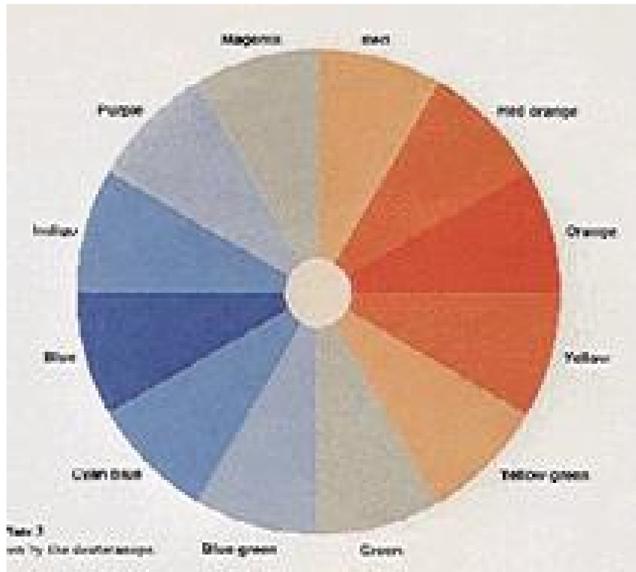
http://colorvisiontesting.com

Vision for a protanope



http://colorvisiontesting.com

Vision for a deuteranope



http://colorvisiontesting.com

See how color deficient people see

link

http://colorvisiontesting.com

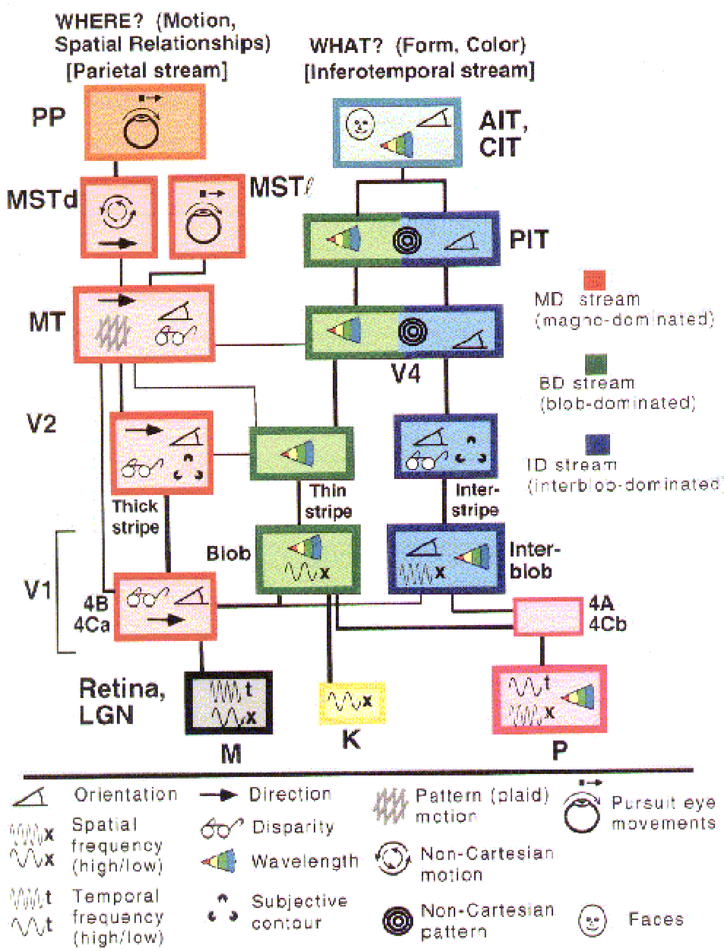
Color beyond V1

V4 has been considered the "color center" but it is likely more widespread.

color constancy - the ability to recognize the same color in very different lighting conditions where the wavelength spectra are very different

V4 starts to show "color constancy" – responses are similar to same colored item in different illuminations (where the light relected is of different wavelength composition). In V1 and earlier responses are more tied to the actual wavelengths

Parallel Pathways in Visual Cortex



[Van Essen & Gallant 1994]

The what and where pathways

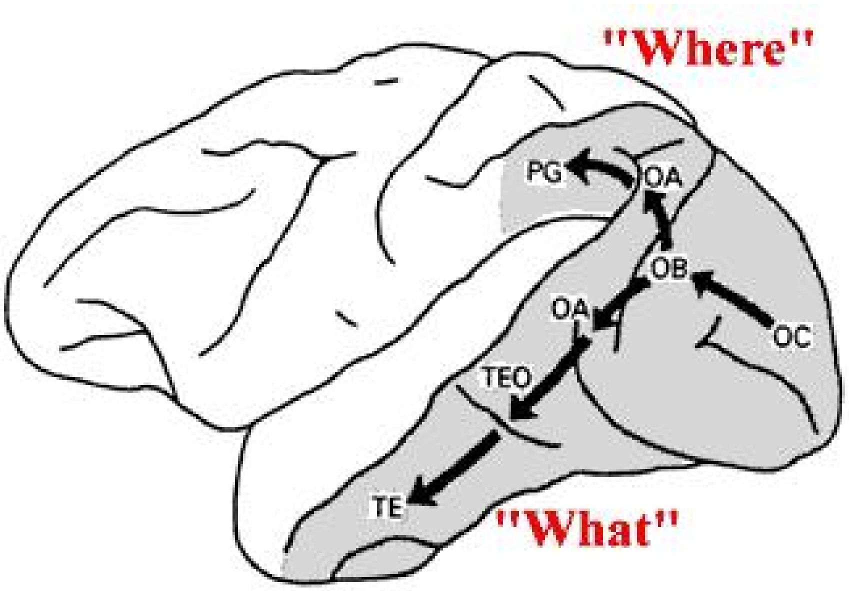


Fig. 1. *Lateral view of the left hemisphere of a rhesus monkey. The shaded area defines the cortical visual tissue in the occipital, temporal and parietal lobes. Arrows schematize two cortical visual pathways, each beginning in primary visual cortex (area OC), diverging within prestriate cortex (areas OB and OA), and then coursing either ventrally into the inferior temporal cortex (areas TEO and TE) or dorsally into the inferior parietal cortex (area PG). Both cortical visual pathways are crucial for higher visual function, the ventral pathway for object vision and the dorsal pathway for spatial vision.*

Cortical achromatopsia

cortical color blindness **(cortical achromatopsia)** occurs with damage to cortex (likely including V4) but intact cones

A great set of flash lecture notes

link to notes

http://www.med.uwo.ca/physiology/courses/sensesweb by Tutis Vilis, University of Western Ontario, Canada

Lightness Perception can be very complicated

Great Lightness perception demos)

Rolling/bouncing ball demo by Dan Kersten et. al.

Next Class

Perceiving Depth and Size (Chapter 7)