Lecture 2: Seeing Colour

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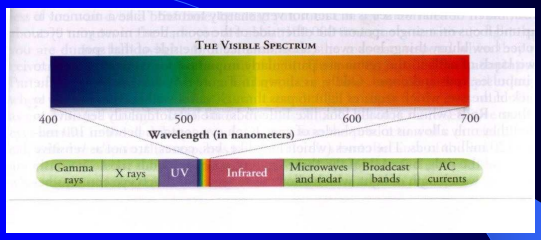
Lecture 2: Seeing Colour

- ***Reading:*** **UoA Psychology text**
  Chapter 5, Sensation and Perception: How the World Enters the Mind
  Especially pp. 134-137

Colour Vision

- Physics of light and colour
- Physiology of eye and visual pathways in the brain
- Psychological experience of colour



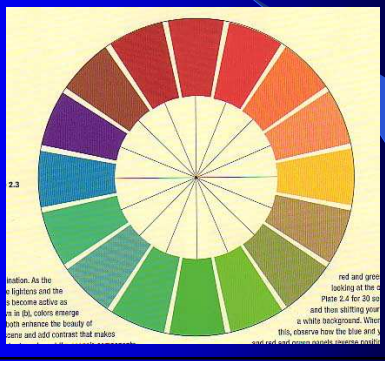
Light & other electromagnetic waves.

Wavelengths in the visible spectrum range from about 360nm to about 750nm

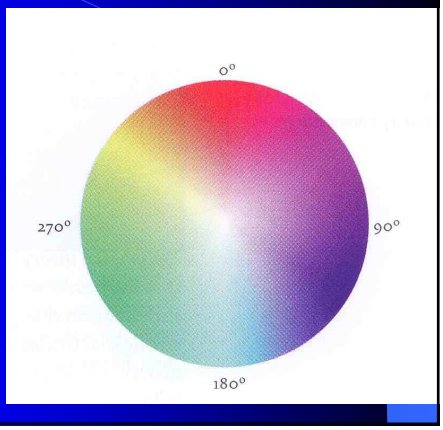
Light

Physical attribute	Psychological attribute
Wavelength	Hue
Intensity	Brightness
Spectral purity (coloured light mixed with white light)	Saturation (eg. pink is desaturated red)

Colour circle



Colour disc

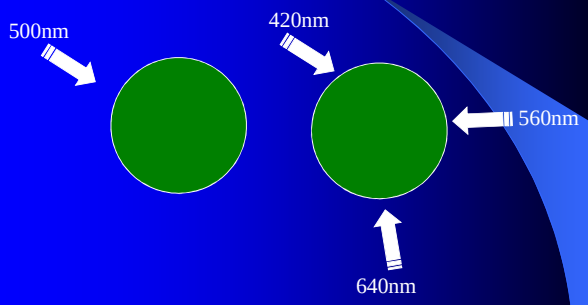


Colour spindle

Trichromatic theory of colour vision

- Thomas Young, Hermann von Helmholtz
- Colour matching experiments
  - Test field: single wavelength (monochromatic) light
  - Comparison field: three lights with different wavelengths

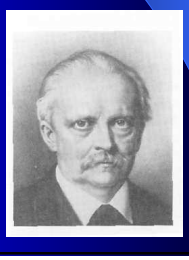
Colour matching



Trichromatic theory

- Colour experience determined by pattern of activity in three different receptor mechanisms

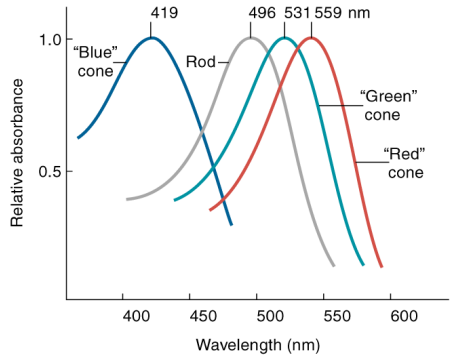
Hermann von Helmholtz



Physiology of trichromatic theory

- Three cone types
- Cone pigments & maximal absorption
  - Short (blue) 419nm
  - Middle (green) 531nm
  - Long (red) 559nm

► **Relative Absorbance of Light of Various Wavelengths by Rods and the Three Types of Cones in the Human Retina**



Source: From Dartnall, H.J.A., Bowmaker, J.K., and Mollon, J.D. Human visual pigments: Microspectrophotometric result from the eyes of seven persons. *Proceedings of the Royal Society of London, B.*, 1983, *220*, 115–130.

Cone responding and colour experience

- Pure (monochromatic) yellow light
  - Red cones – high response
  - Green cones – high response
  - Blue cones – low response
- Red light + green light
  - The same pattern
  - Red (high); Green (high); Blue (low)

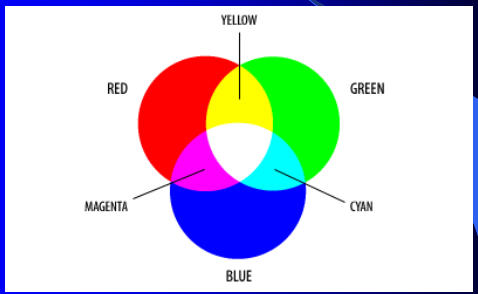
Metamers

- Perceptually identical but physically different
  - Yellow light vs. (Red + Green) Light
  - Cyan light vs. (Blue + Green) light

Cone responding and colour experience

- Patterns of activity in S, M & L cones
- About 200 hues can be discriminated
- About 500 brightness values
- About 20 values of saturation
- Therefore – well over 1 million colours can be discriminated

Colour addition



Colour addition

- Colour TV, computer monitors
- Pointillist painting

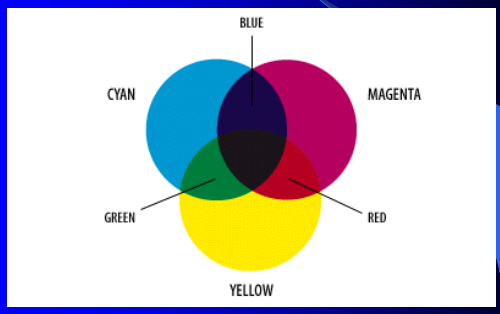
Paul Signac

Colour addition & subtraction

Colour subtraction

- Pale blue paint
  - absorbs longer wavelengths (red & yellow)
  - reflects short (blue) wavelengths & some medium (green)
- Yellow paint
  - Absorbs short (blue) & long (red) wavelengths
  - Reflects yellow + some green
- Mixture reflects green only

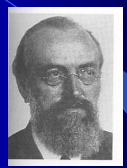
Colour subtraction



Colour subtraction

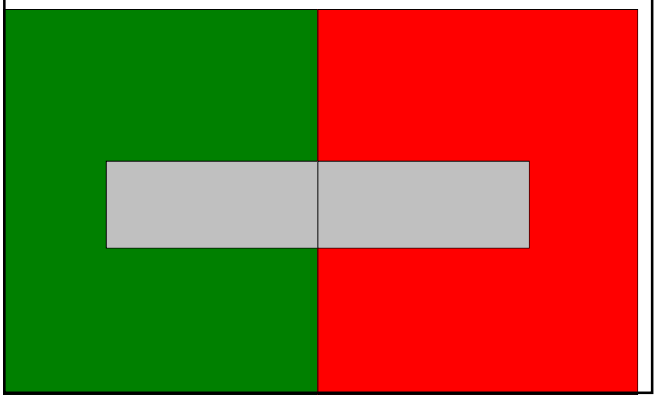
- Colour printing
- Ink-jet printers

Opponent Process Theory



- Ewald Hering (late 19C.)
- Colour vision arises from combined operation of two opposing processes
  - red – green opponency
  - blue – yellow opponency

Simultaneous contrast



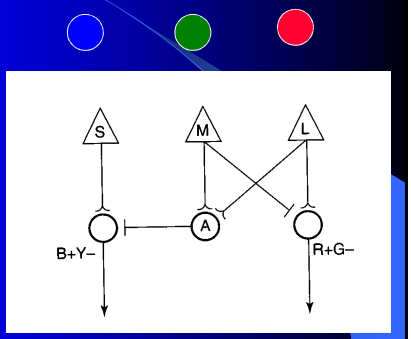
Colour blindness

- Individuals colour blind to red, also colour blind to green
- Individuals colour blind to blue also colour blind to yellow

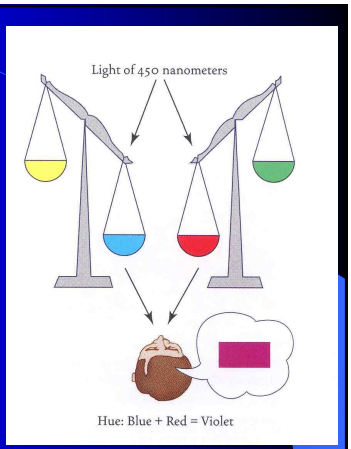
Physiology of opponent process theory

- Opponent process & trichromatic theory initially seen as competitors
- Now seen as complementary
- Observations of Helmholtz & Hering reflect physiological processing at different levels

Opponent process theory: basic wiring



Opponent process theory

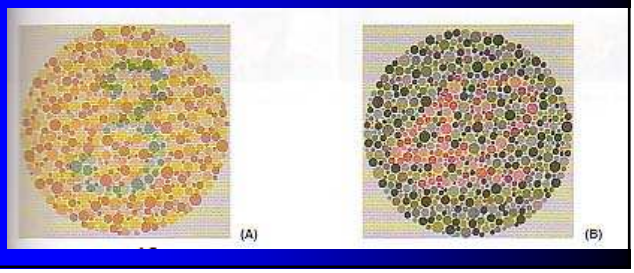


Location of colour opponent cells

- Retinal ganglion
- Lateral geniculate nucleus of thalamus
- Colour sensitive cells in striate cortex (V1)

Colour deficiency

- Often assessed via Isihara test



Colour deficiency

- Affects about 8% of males, but only 0.03% of females
- Assessed via colour mixing procedure
- Monochromats
  - Can match any wavelength by adjusting intensity of any other wavelength
  - Truly colour blind

Monochromats

- Extremely rare (1:100,000)
- Have few, or no functioning cones
- Reduced acuity
- Sensitive to glare

Dichromats

- Colour deficient, rather than colour blind
- Missing one kind of retinal pigment
  - Usually pigment for long (red) or middle (green) cones
  - Red-green colour blind
  - Blue-yellow colour blindness is extremely rare

Summing Up

- Physical attributes of light
- Trichromatic theory
  - S, M & L cones
- Opponent process theory
  - Wiring of colour opponent cells
- Neural correlates of conscious experience