Creative Computing II

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Autumn 2010, Wednesdays:
10:00–12:00: RHB307 & 14:00–16:00: WB316
Winter 2011, TBC

Ambiguity

Image

Walter Ehrenstein (1899–1961)

Zeitschrift für Psychologie 117, 339–412 (Fig. 3, p. 369)
http://socrates.berkeley.edu/~kihlstrm/JastrowDuck.htm

Rods:

- present over all the retina (except near fovea);
- sensitive to motion;
- highly sensitive to light:
  - can detect a single *photon*;
  - except light wavelengths above 640nm (reddish).
- slow response time (c. 100ms);
- no pigments (no colour vision).

Cones:

- concentrated near fovea;
- high intensity required for stimulation;
- rapid response time;
- three different pigments:
  - peak sensitivities around 570nm, 540nm and 430nm;
  - different sensitivity curves;
  - ability to distinguish colours, by different rates or intensities of firing.

The Eye

Other eyes, flowers and evolution

Bees:

- cannot see red;
- can see ultraviolet.

Why white flowers?

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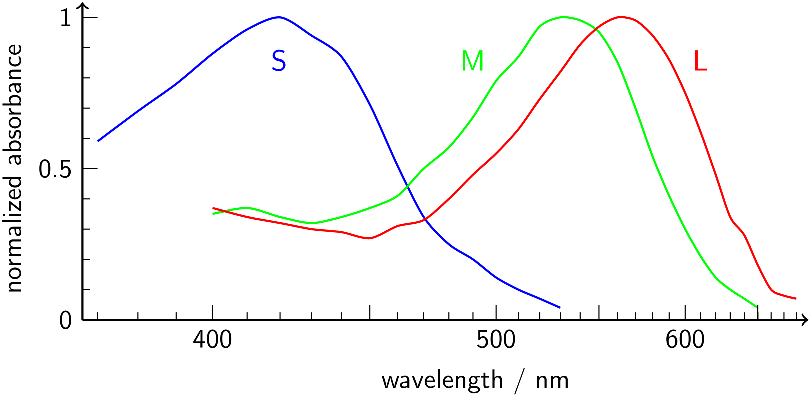
Octopods and squid:

- very similar eyes to humans;
- no blind spot (retina the right way round).

Colour Vision

Trichromatic Colour Perception



Data from Bowmaker, J. K. and H. J. Dartnall, *Visual pigments of rods and cones in a human retina*, The Journal of Physiology (1980)

Colour Vision

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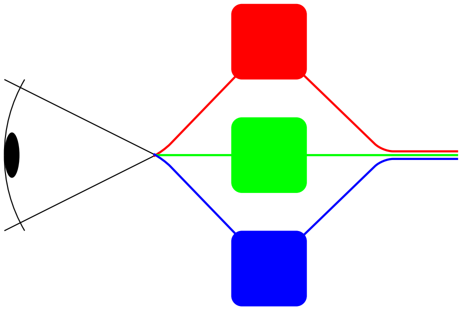
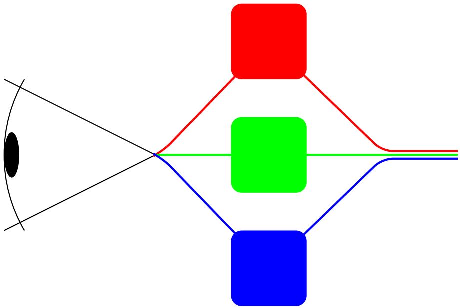


- Explains three-colour matching.

Colour Vision

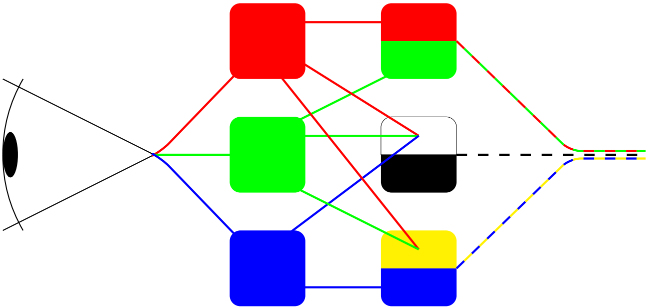
Trichromatic Colour Perception



- Explains three-colour matching.
- Problem with colour-blindness...

Colour Vision

Opponent Colour Perception



Explains:

- colour-blindness;
- psychological primary colours.

Compatible with:

- trichromatic colour perception.

Colour Vision

Grassmann's Laws

Hermann Günther Grassmann (1809–1877)

Wikimedia commons (user Dstender)
Public Domain

- Mathematician (Vector spaces, Grassmann algebras)
- Linguist (another Grassman's Law, about aspirated consonants)
- Physicist (Crystallography, mechanics, electromagnetism)

Colour Vision

Grassmann's Laws

Many different forms. One version:

- **additivity**: adding the same light to each of two equal lights produces two equal lights:
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Colour Vision

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These are *empirical* laws derived from experiment, not mathematical laws derived from axioms.

- break down in low light (when rods become important)

Grassmann's Laws imply that we can choose particular coloured lights (any colours) to act as *primaries*

- express *any* colour as weighted linear sum of primaries:
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- mixture of colours as linear additive mixture of primaries:
  - $C = xX + yY + zZ$; $C' = x'X + y'Y + z'Z$
  - $C + C' = (x + x')X + (y + y')Y + (z + z')Z$

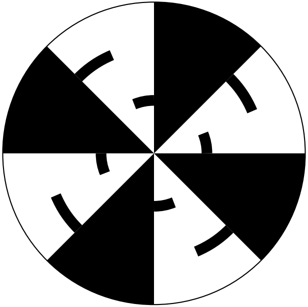
Notes:

- Basis of digital colour production;
- Only applies to lights;
- in general, you can need negative weights.

Colour Vision

Pattern-Induced Flicker Colours

Don't let the preceding material fool you into thinking that we understand colour vision!



Charles E. Benham (1860–1929)

Colour Vision

Colour Blindness

Many forms of colour blindness:

- **monochromacy** or *achromatopsia*. Two forms:
  - rod monochromacy (no cone cells)
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- **dichromacy**:
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- **anomalous trichromacy**:
  - protanomaly (mutated L pigment);
  - deuteranomaly (mutated M pigment);
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Colour Vision

Colour Blindness: Prevalence

- protanopia and deuteranopia: sex-linked;
  - also related anomalies.

Colour Vision

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- genes for red and green pigments on the X chromosome (but not the Y)
  - 5% prevalence of deuteranomaly in males;
  - 1% prevalence of protanomaly in males;
  - 1% prevalence of deuteranopia in males;
  - $< 1\%$ prevalence of colour blindness in females.

Colour Vision

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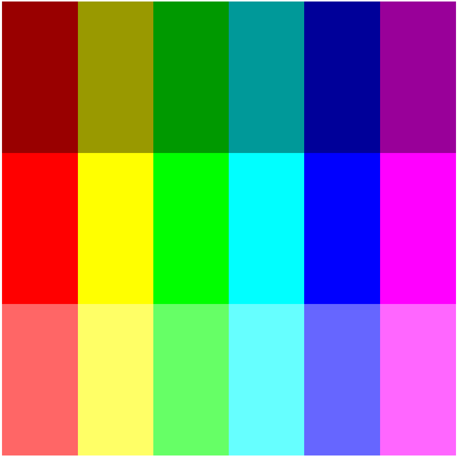
- gene for blue pigment on chromosome 7
  - low (but equal) prevalence of tritanomaly / tritanopia in males and females.

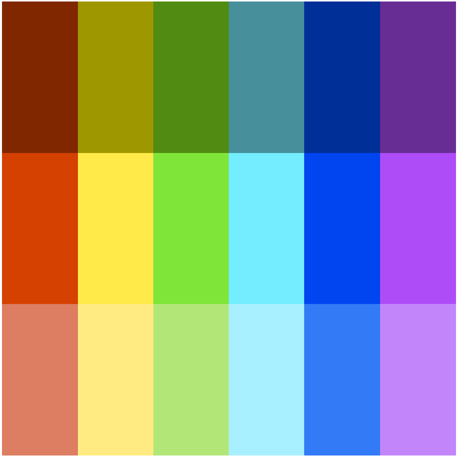
Colour Vision

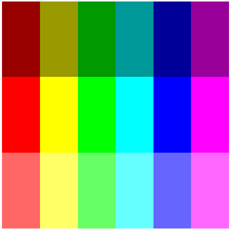
Colour Blindness: Baseline Vision



Colour Vision

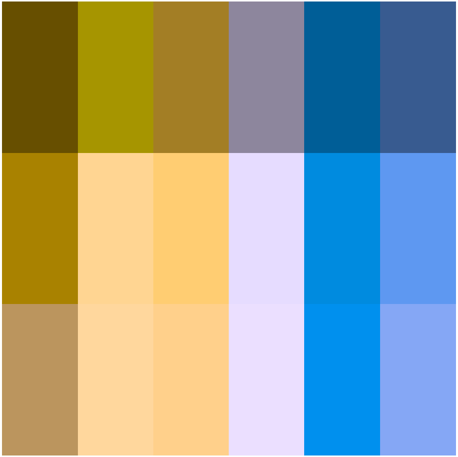
Colour Blindness: Deuteranomaly

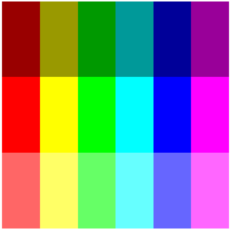




Colour Vision

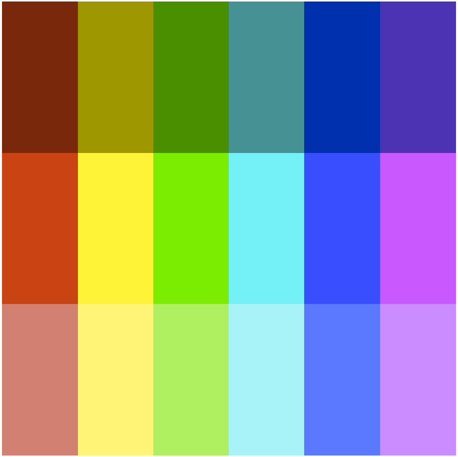
Colour Blindness: Deuteranopy

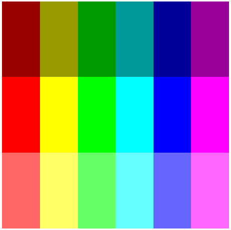




Colour Vision

Colour Blindness: Protanomaly





Colour Vision

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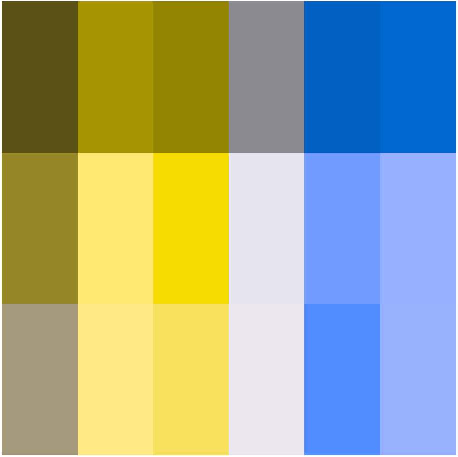
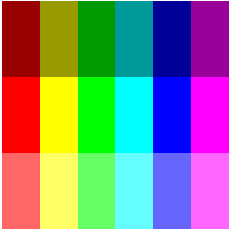
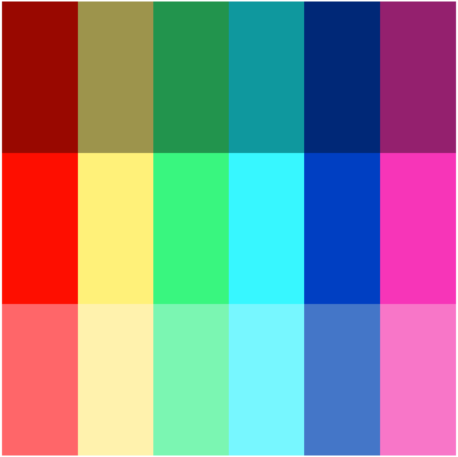
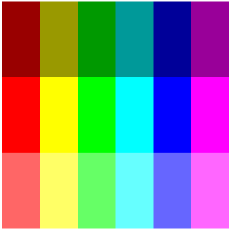




Colour Vision

Colour Blindness: Tritanomaly





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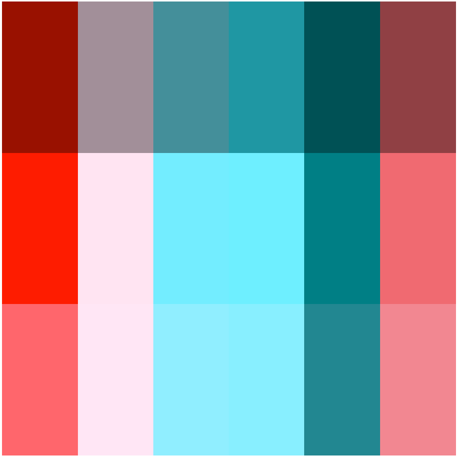
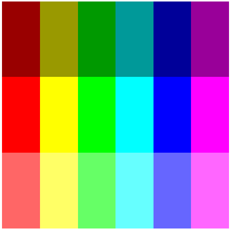
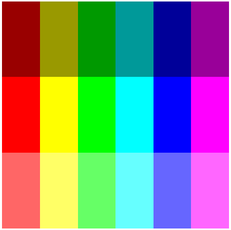




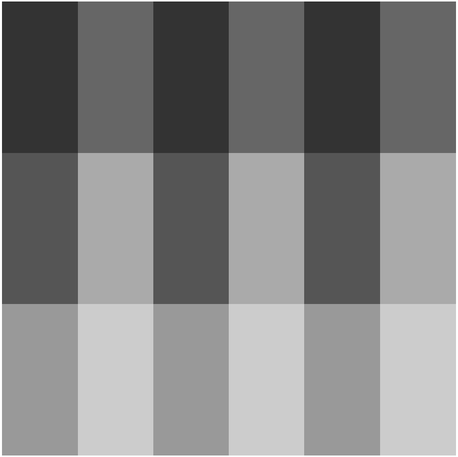
Colour Vision

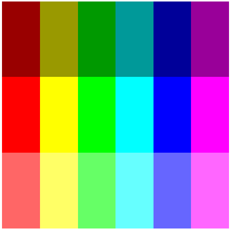
Colour Blindness: Partial monochromacy



Colour Vision

Colour Blindness: Monochromacy





Colour Vision

Other Colour Vision Disorders

- cerebral achromatopsia
    - inability to perceive colour;
    - results from damage to V4 cortical region.
- colour anomia
    - inability to name colours;
    - again from damage to visual cortex

Colour Vision

Cognitive interference and the Stroop effect

Many layers to perception. Cognitive effects can come into play.
J. Ridley Stroop (1897–1973):

- psychologist;
- professor of biblical studies

Interference in task reaction time:

- Reading Coloured Names;
- Naming Coloured Words.

[Experiment: Stroop Effect Sketch]