

The Brain, Biology and Cognition (BBC)

Vision & Perception

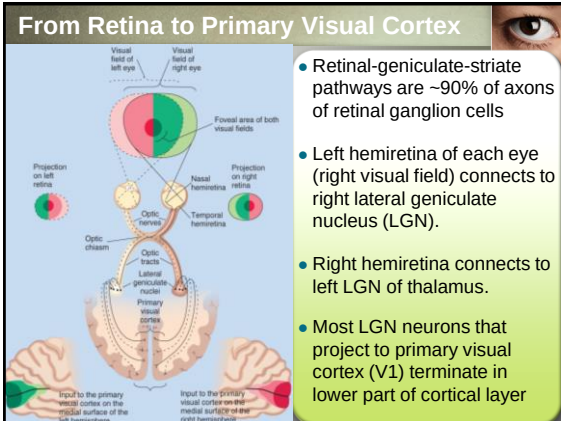
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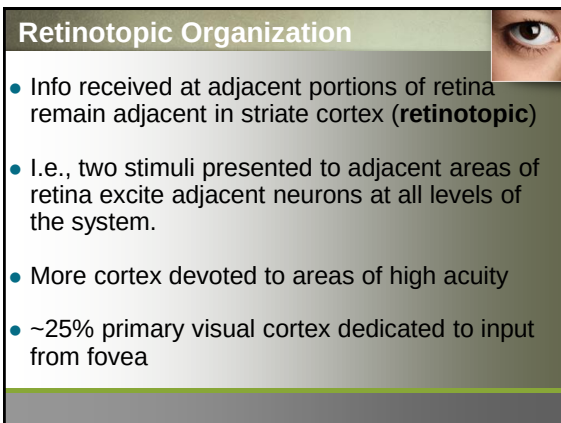
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From Retina to Primary Visual Cortex



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Retinotopic Organization



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The M and P channels of communication that flow through each LGN.

Magnocellular layers

- Big cell bodies, bottom two layers of LGN
- Particularly responsive to movement
- Input primarily from rods

M

Parvocellular layers

- Small cell bodies, top four layers of LGN
- Color, detail, and still or slow objects
- Input primarily from cones

P

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Seeing Edges

- Edges define extent and position of all objects.
- Where 2 different areas of a visual image meet.
- Perception of edge is perception of contrast between 2 adjacent areas in the visual field.
- To enhance contrasts, our visual system creates nonexistent stripes called:
 - **Mach bands**
 - Makes edges easier to see
 - Consequence of lateral inhibition

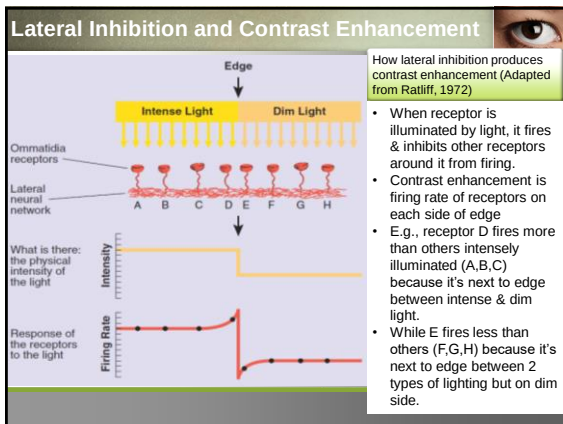
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Lateral Inhibition and Contrast Enhancement

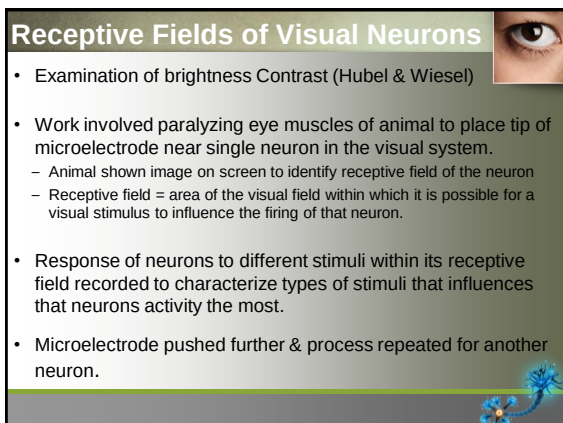
Illusory Mach bands

- Intensity graph shows what is there:
- Series of stripes of differing intensities.
- But we see brightness changing from darker to lighter.
- Next to each edge, brighter stripe looks brighter than is & darker stripe looks darker.

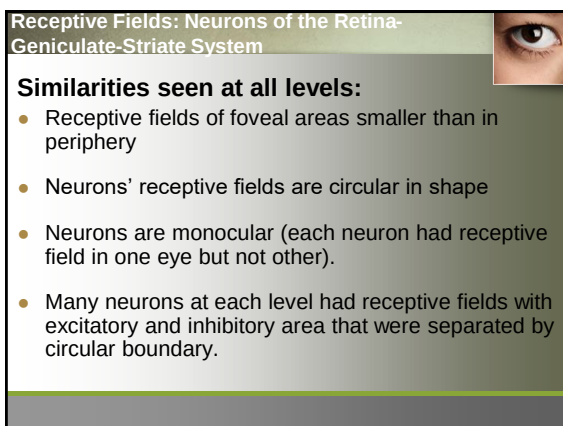
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Receptive Fields: Neurons of the Retina-Geniculate-Striate System






The most effective way of maximizing the firing of an on-center or off-center cell is to completely illuminate either the "on area" or the "off area" of its receptive field.

If both areas of a cell's receptive field are illuminated together, there is little reaction from the cell.

- Many cells have receptive fields with a center-surround organization:
 - Excitatory and inhibitory regions separated by circular boundary
- Some cells are "on-center" and some are "off-center"

The responses of an on-center cell to contrast

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Receptive Fields: Simple and Complex Cortical Cells



- In lower layer IV (4) of striate cortex, neurons with circular receptive fields (as in retinal ganglion cells and LGN) are rare.
- Most neurons in V1 are either:
 - Simple** – receptive fields are rectangular with "on" and "off" regions and respond best to bars of light,
 - Complex** – also rectangular, larger receptive fields, respond best to particular stimulus anywhere in its receptive field

Figure 6.18 in Pinel book shows an example

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Receptive Fields: Simple and Complex Cortical Cells



SIMPLE	COMPLEX
- Rectangular "On" and "off" regions, like cells in layer IV - Orientation and location sensitive - All are monocular	- Rectangular - Larger receptive fields - Do not have static "on" and "off" regions - Not location sensitive - Motion sensitive - Many are binocular

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Columnar Organization of Primary Visual Cortex



- Cells with simple receptive fields send info to cells with more complex receptive fields
- V1 neurons grouped in functional vertical columns - all cells in column have same receptive field and ocular dominance:
 - As electrode moves horizontally, dominance of columns changes through areas of left-eye dominance then right-eye dominance

See Figures 6.19 & 6.20 in Pinel

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Plasticity of Receptive Fields of Neurons in the Visual Cortex



- Plasticity is fundamental
- Studies using simple/individual stimuli (e.g., bars) do not provide full understanding of how visual system works.
- Receptive field properties must be examined within a scene because we do not see things in isolation in the world.



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Seeing Color: Component and Opponent Processing



Component theory (trichromatic theory)

Proposed by Young (1802), refined by Helmholtz (1852)

- 3 types of colour cone receptor in eye, each with different spectral sensitivity.
- Colour of stimulus encoded by ratio of activity in each.
- Evidence: any colour in visible spectrum can be matched by mixing 3 different wavelengths of light in different proportions

Opponent-process theory

Proposed by Hering (1878)

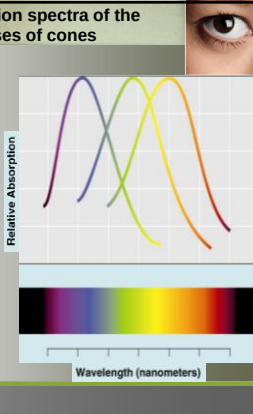
- 2 classes of cells encoding colour and another encoding brightness.
- Each encodes two complementary color perceptions.
 - One for red and green
 - Another for blue and yellow
- Accounts for color afterimages and colors that cannot appear together (reddish green or bluish yellow)

Both theories correct: coding of color by cones operates on component basis, opponent processing of color seen at all subsequent levels.

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Seeing Color

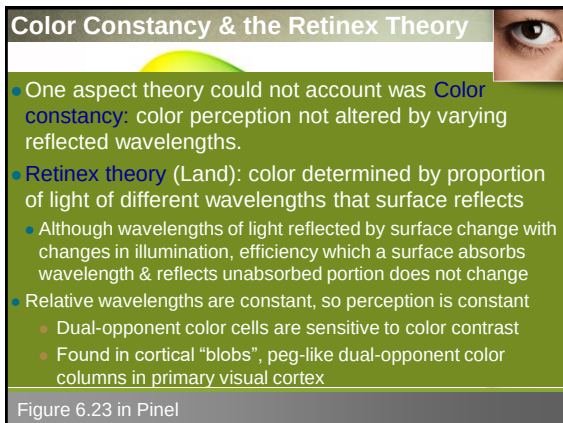
The absorption spectra of the three classes of cones



- 1960s: technique to measure absorption spectrum of photopigment contained in single cone confirmed Young's findings.
- 3 different types of cones in retina with different photopigment & own characteristic absorption spectrum.
- Diagram shows some cones more sensitive to short, medium & long wavelengths.
- 3 cones are red, green, & blue.

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Color Constancy & the Retinex Theory

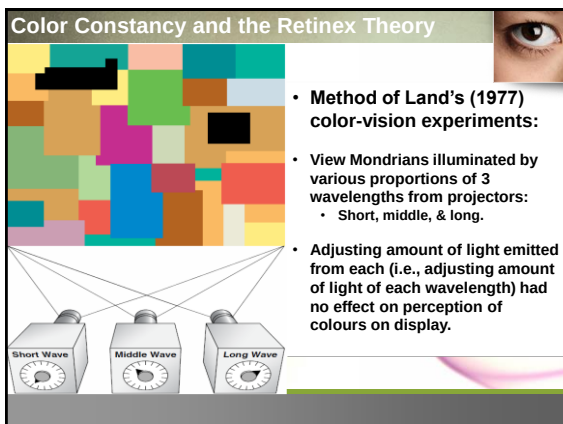


- One aspect theory could not account was **Color constancy**: color perception not altered by varying reflected wavelengths.
- Retinex theory** (Land): color determined by proportion of light of different wavelengths that surface reflects
 - Although wavelengths of light reflected by surface change with changes in illumination, efficiency which a surface absorbs wavelength & reflects unabsorbed portion does not change
- Relative wavelengths are constant, so perception is constant
 - Dual-opponent color cells are sensitive to color contrast
 - Found in cortical "blobs", peg-like dual-opponent color columns in primary visual cortex

Figure 6.23 in Pinel

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Color Constancy and the Retinex Theory



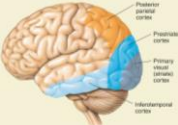
- Method of Land's (1977) color-vision experiments:**
- View Mondrians illuminated by various proportions of 3 wavelengths from projectors:
 - Short, middle, & long.
- Adjusting amount of light emitted from each (i.e., adjusting amount of light of each wavelength) had no effect on perception of colours on display.

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Cortical Mechanisms of Vision and Conscious Awareness



- Visual cortex is of 3 different types:
 1. Primary visual cortex (striate): receives input from visual relay nuclei of thalamus & located in posterior region of occipital lobe,
 2. Secondary visual cortex: receives input from primary visual cortex & located in pre-striate & inferotemporal cortex,
 3. Association cortex: receives input from secondary visual cortex & located in several parts of cerebral cortex but mainly in posterior parietal cortex.
- As information flows up visual hierarchy neurons have larger receptive fields and stimuli to which neurons respond are more specific and complex.



Visual areas of the human cerebral cortex.

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Functional Areas of Secondary and Association Visual Cortex



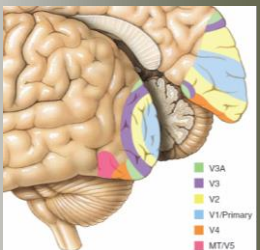
- Neurons in each area respond to different visual cues, such as color, movement, or shape
- Lesions of each area results in specific deficits
- Anatomically distinct (about 12 functionally distinct areas identified so far)
- Retinotopically organized

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Visual Functional Specialization theory



- Different cortical areas in brain are specialised for processing different visual attributes/functions (Zeki).
- V1 and V2: Early stage/initial processing of items
- V3 AND V3a: Cells respond to form (especially shape)
- V4: Cells respond to colour and some to line orientation
- V5/MT: Processes visual motion



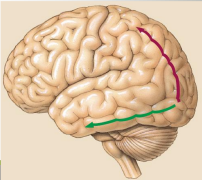
However, this leads to the binding problem(s) (Feldman)

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Dorsal and Ventral Streams



- Most visual info enters V1 via lateral geniculate nuclei
- Info from the two LGNs is received in V1 combined.
- Then separated to various functional areas of secondary & association cortex (See Horton & Sincich, 2004).



dorsal stream

ventral stream

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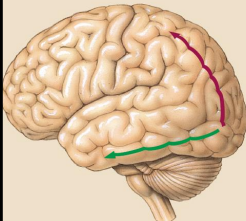
Dorsal and Ventral Streams



“Where” vs. “What” Theory – Ungerleider and Mishkin (1982)

“Control of behavior” vs. “conscious perception” theory - Goodale & Milner (1992)

Dorsal and Ventral Streams: Two Theories and What They Predict



“Where” vs. “What” Theory

Dorsal stream specializes in visual spatial perception

Ventral stream specializes in visual pattern recognition

Predicts

- Damage to dorsal stream disrupts visual spatial perception
- Damage to ventral stream disrupts visual pattern recognition

“Control of Behavior” vs. “Conscious Perception” Theory

Dorsal stream specializes in visually guided behavior

Ventral stream specializes in conscious visual perception

Predicts

- Damage to dorsal stream disrupts visually guided behavior but not conscious visual perception
- Damage to ventral stream disrupts conscious visual perception but not visually guided behavior

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