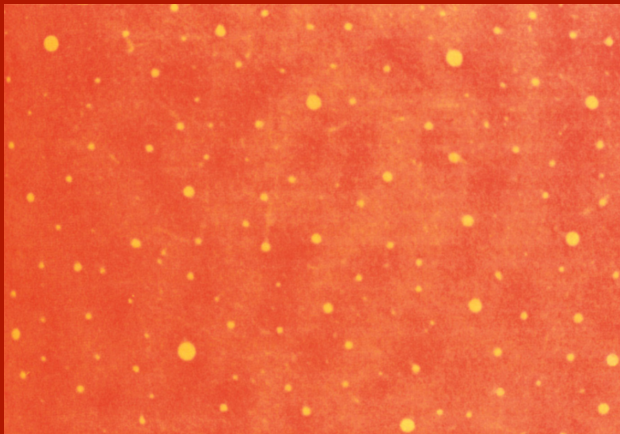
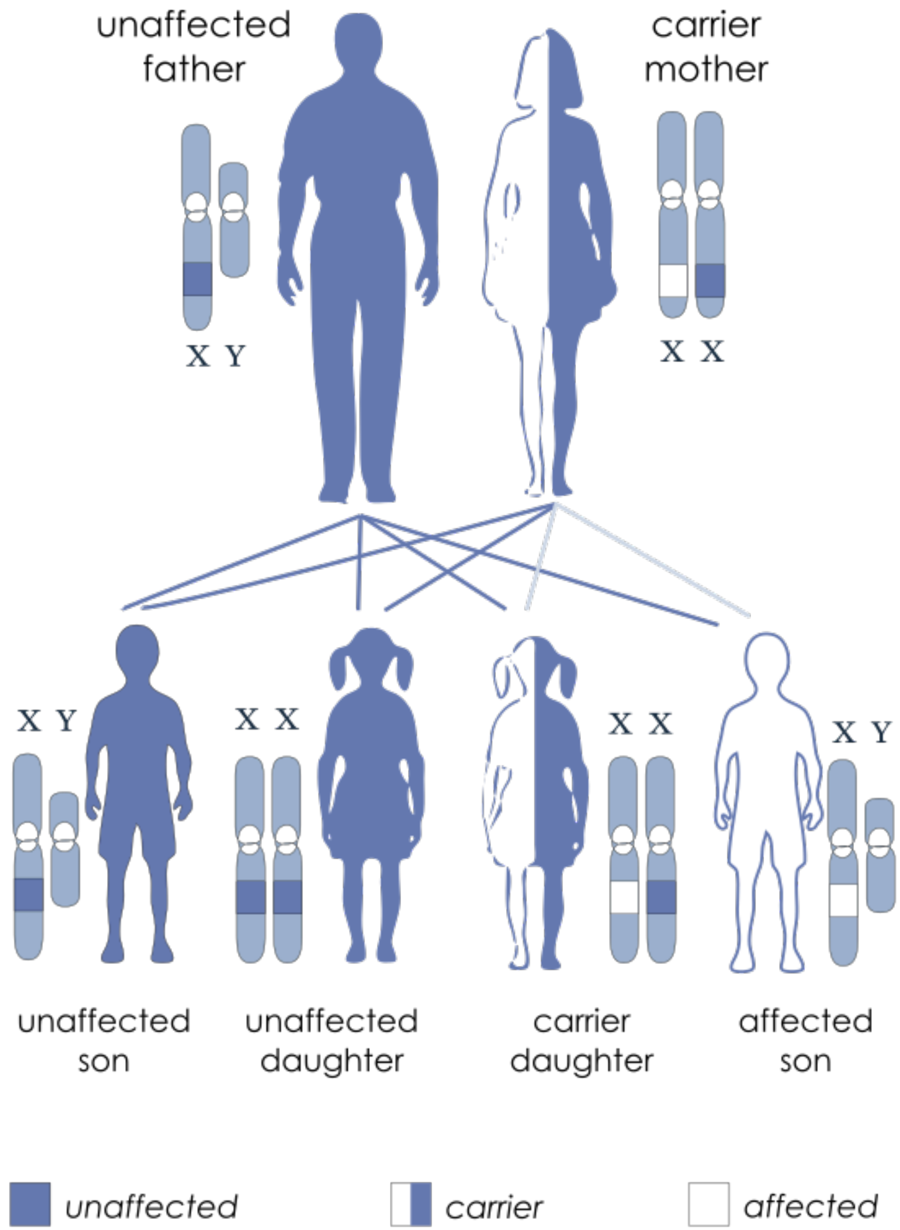


Spatial Vision: From Spots to Stripes

ELL788: Date: 01-09-2016
Computational Perception and Cognition
Instructor: TKG

X-linked recessive inheritance

Color Blindness

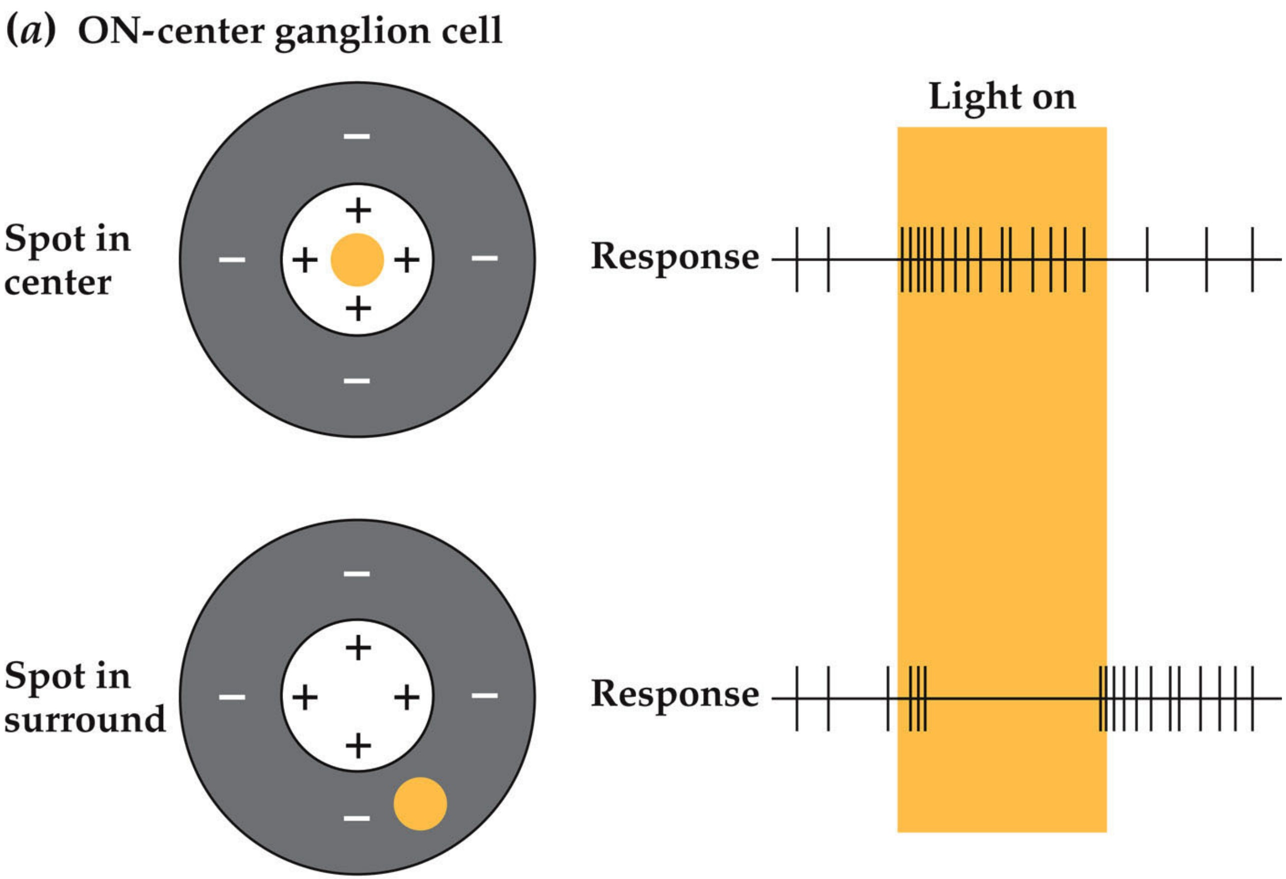


Response properties of ganglion cells

Stephen W. Kuffler
1913-1980

- Kuffler mapped out the receptive fields of individual retinal ganglion cells in the cat and found two kinds of cells
- ON-center ganglion cells
- OFF-center ganglion cells

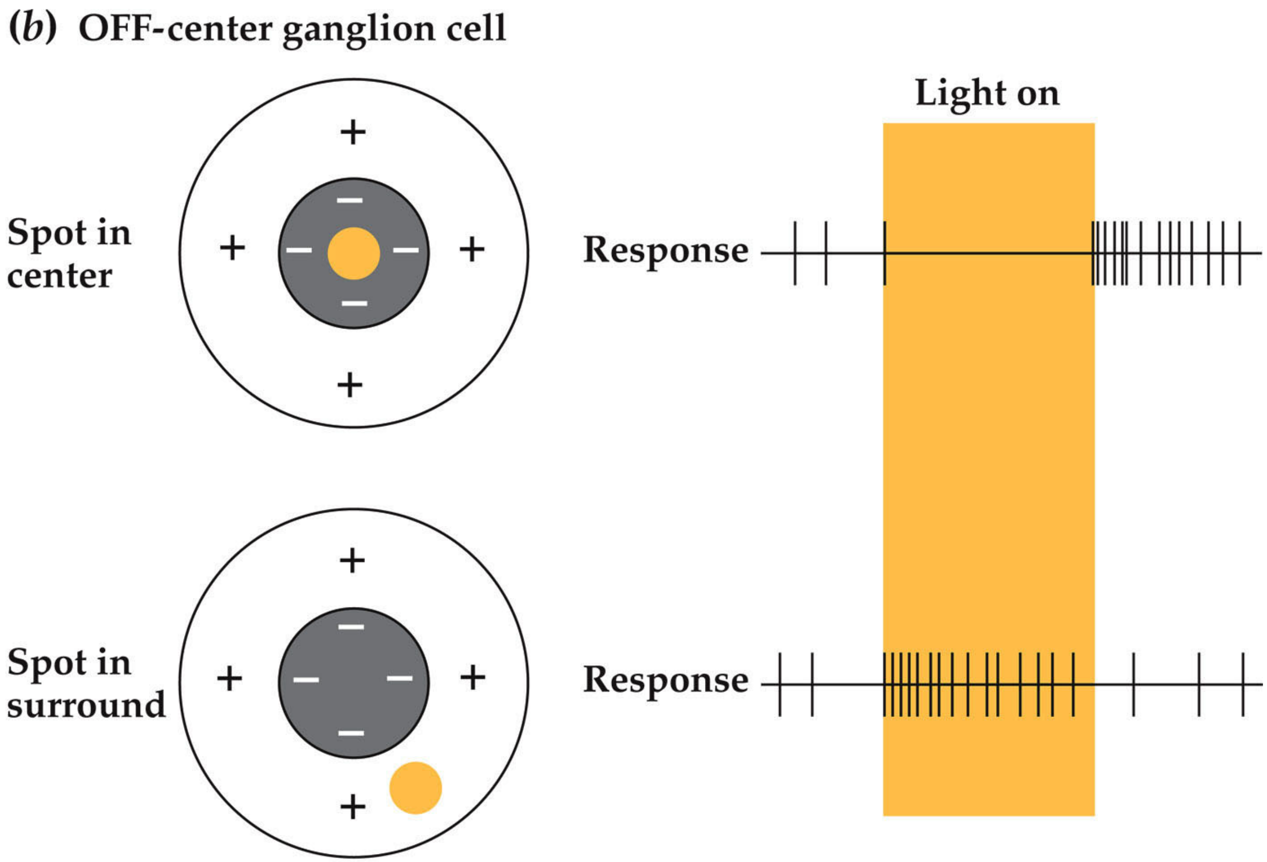
Retinal ganglion cell receptive fields (Part 1)



SENSATION & PERCEPTION 3e, Figure 2.14 (Part 1)

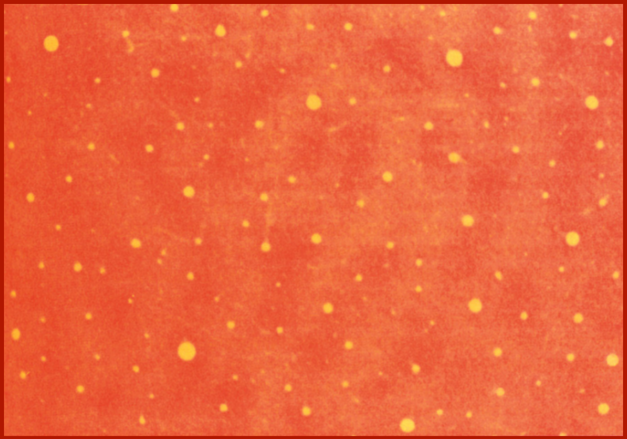
Excited by light falling on center, inhibited by light falling surround

Retinal ganglion cell receptive fields (Part 2)



SENSATION & PERCEPTION 3e, Figure 2.14 (Part 2)

Inhibited by light falling on center, excited by light falling on surround

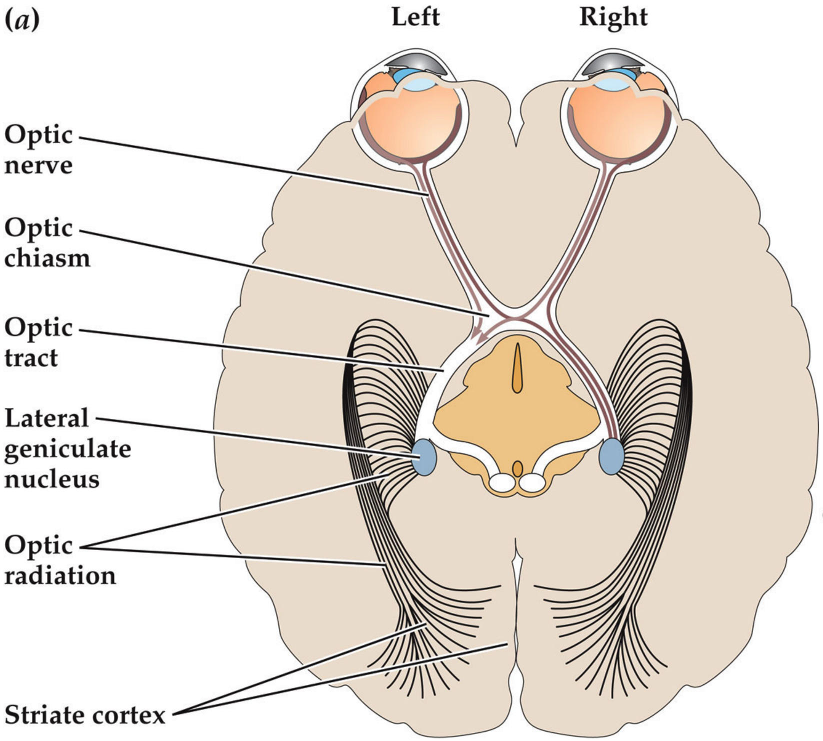


Spatial Vision: From Spots to Stripes

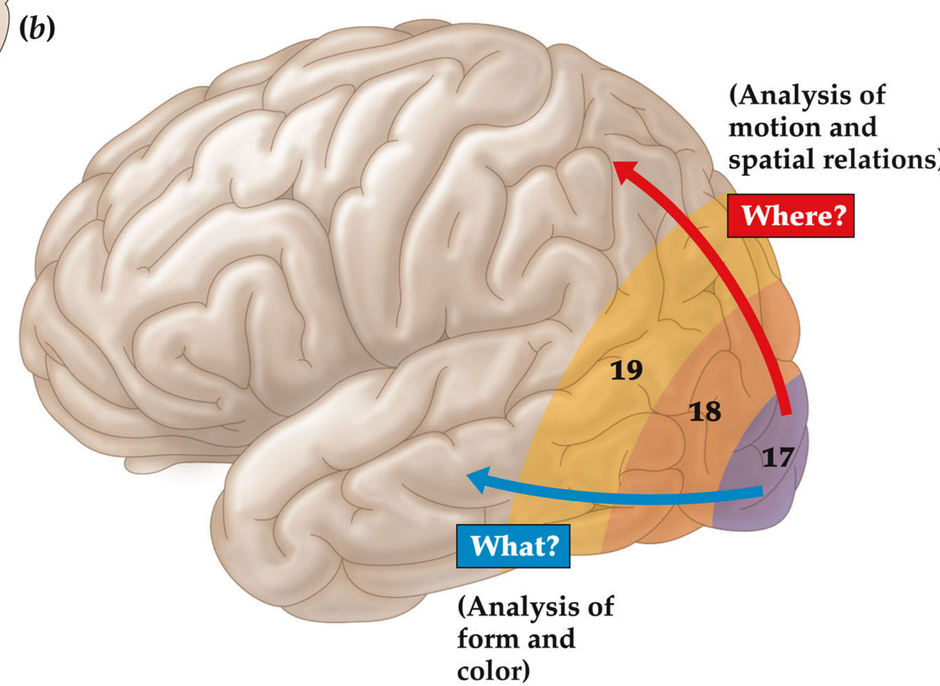
ELL788: Lecture 2&3, Date: 17-03-2016

Computational Perception and Cognition

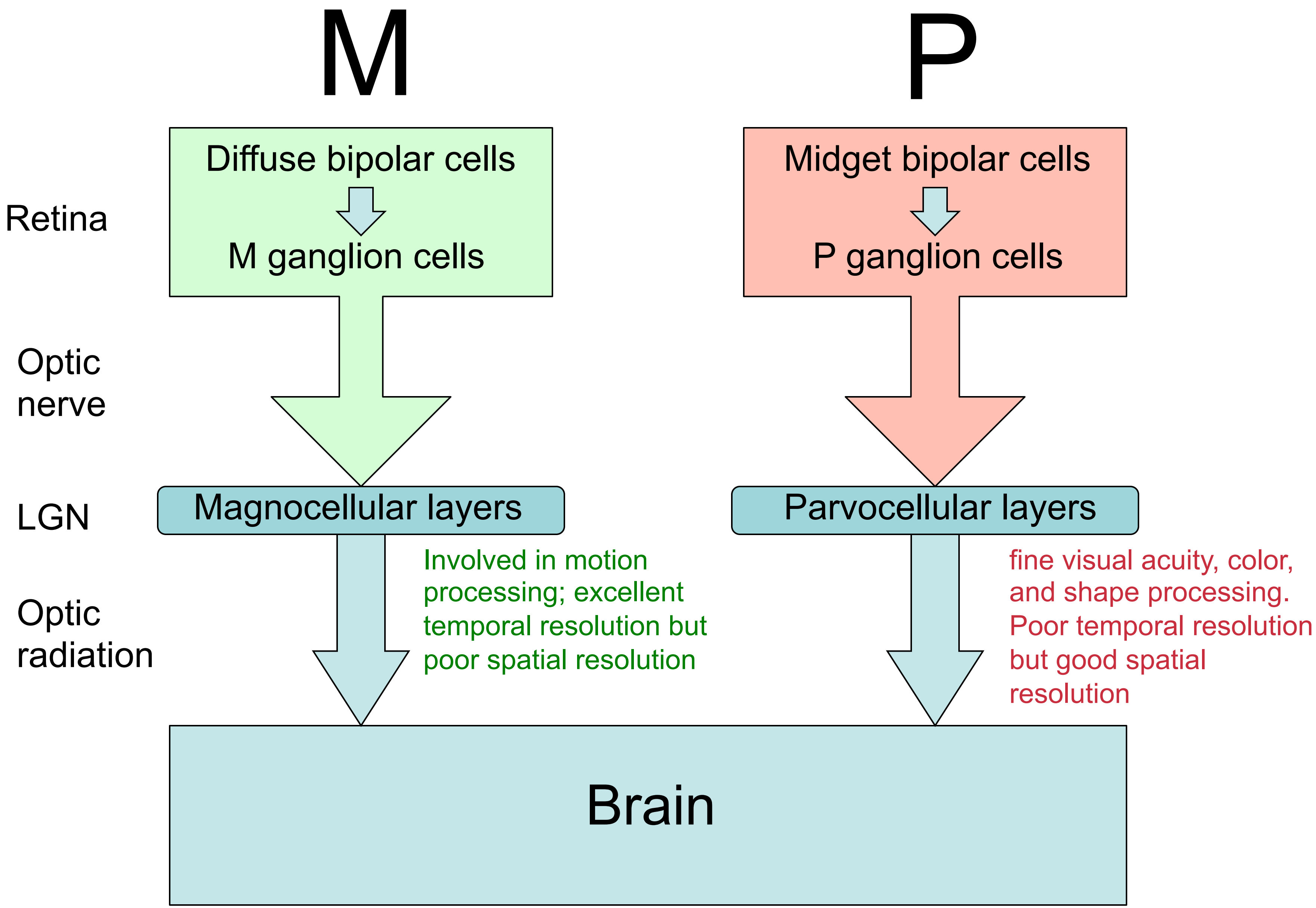
Instructor: TKG



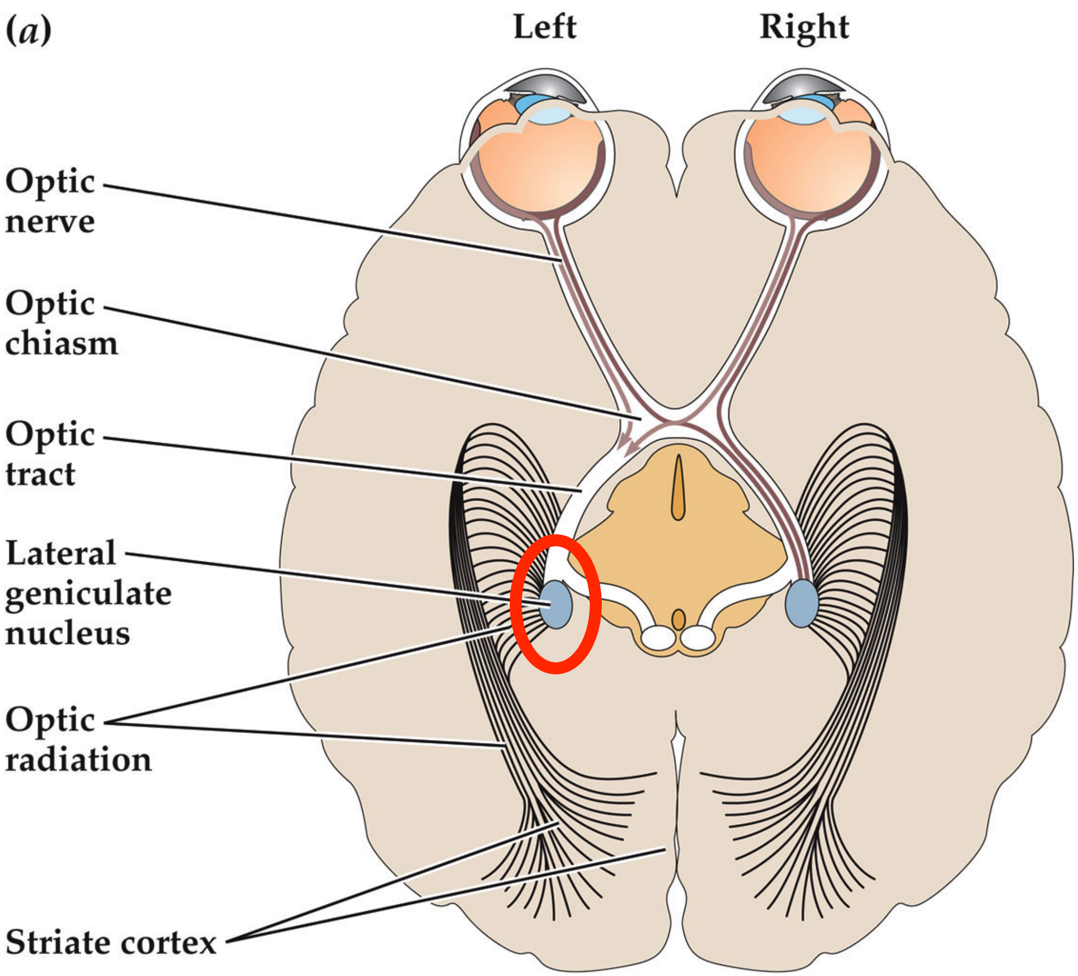
SENSATION & PERCEPTION 3e, Figure 3.1 (Part 1)



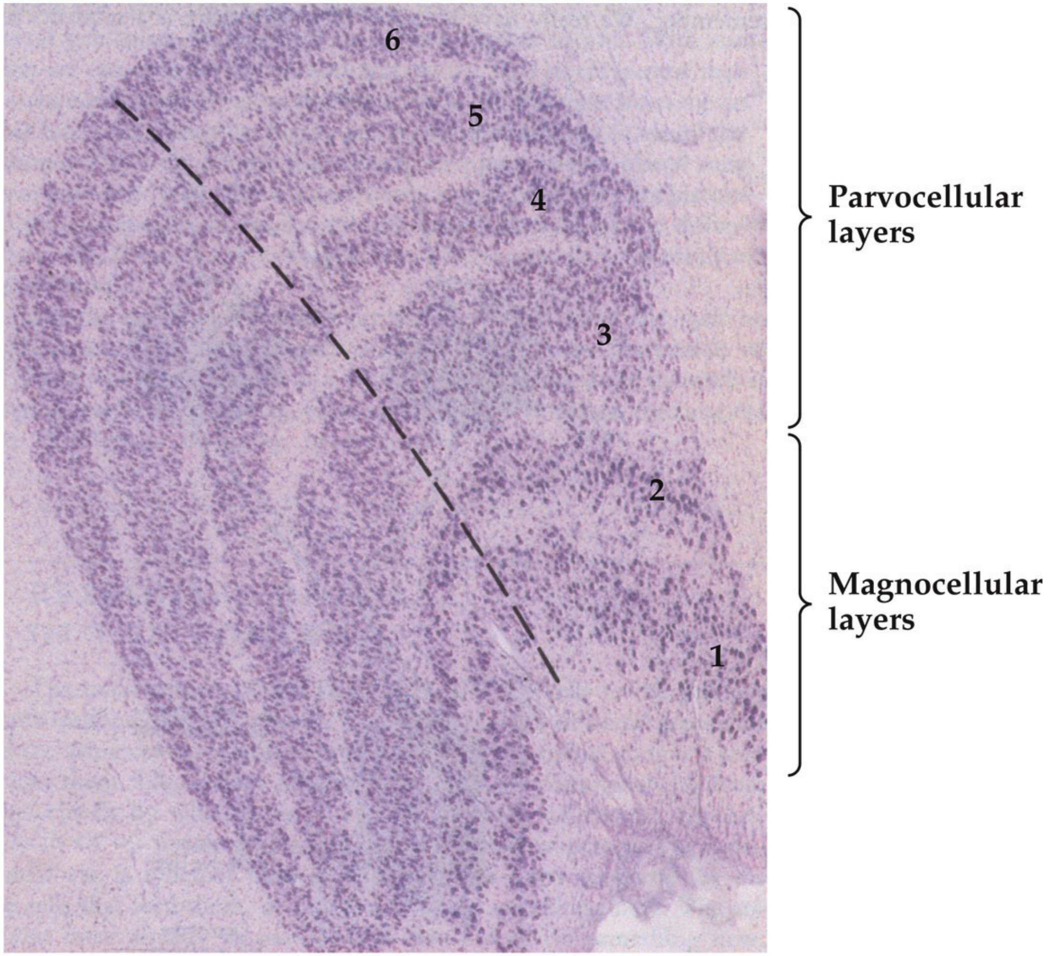
M and P pathways:



Cortical visual pathways

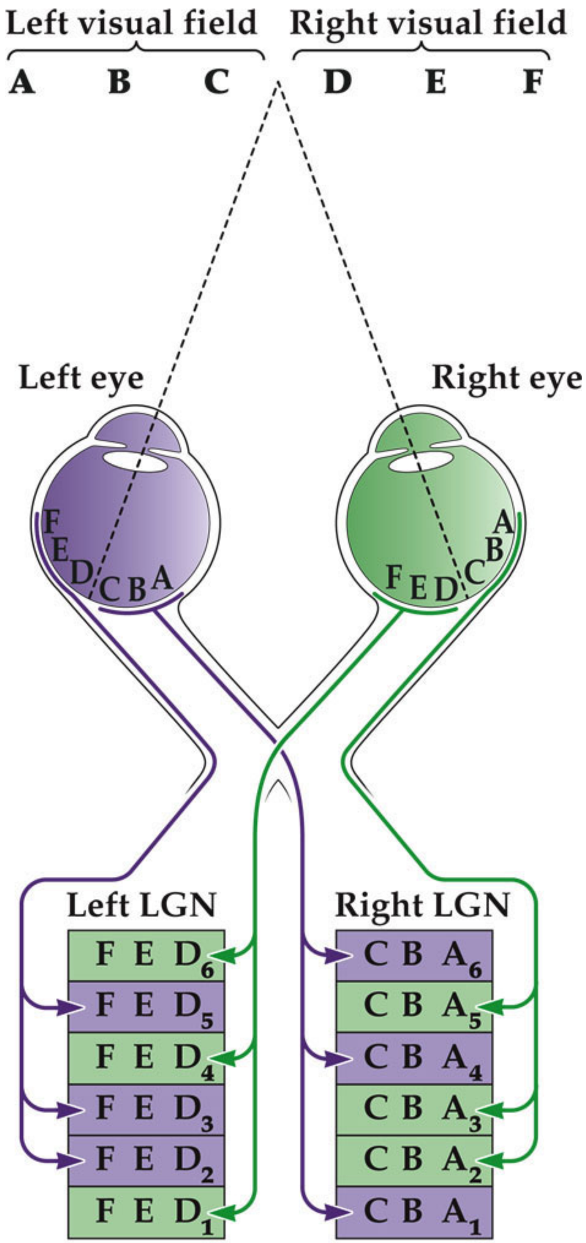


SENSATION & PERCEPTION 3e, Figure 3.1 (Part 1)



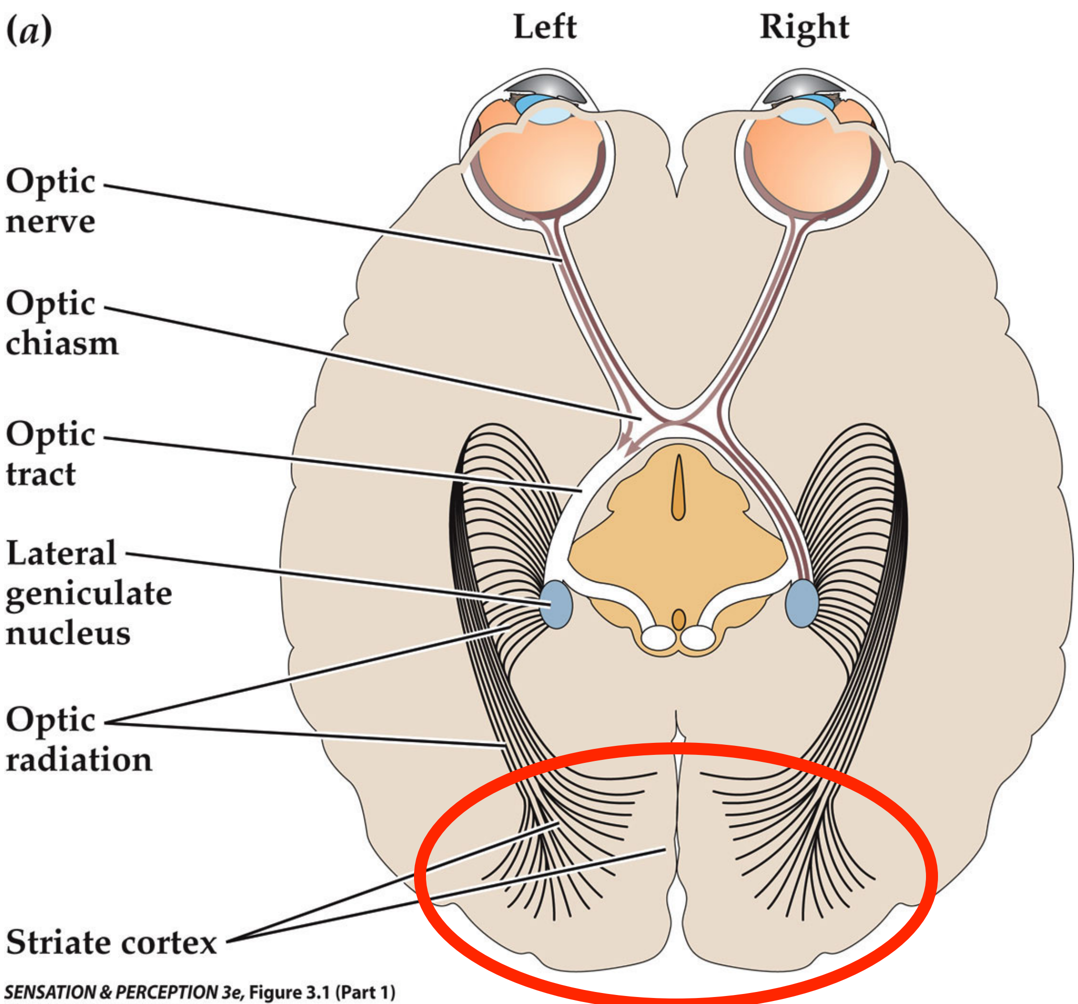
The LGN is partly a relay station and partly a location for high-level influences on inputs from the eyes

Input from the right visual field is mapped in an orderly fashion onto the different layers of the left LGN, and input from the left visual field is mapped to the right LGN



Ipsilateral: Referring to the same side of the body

Contralateral: Referring to the opposite side of the body



SENSATION & PERCEPTION 3e, Figure 3.1 (Part 1)

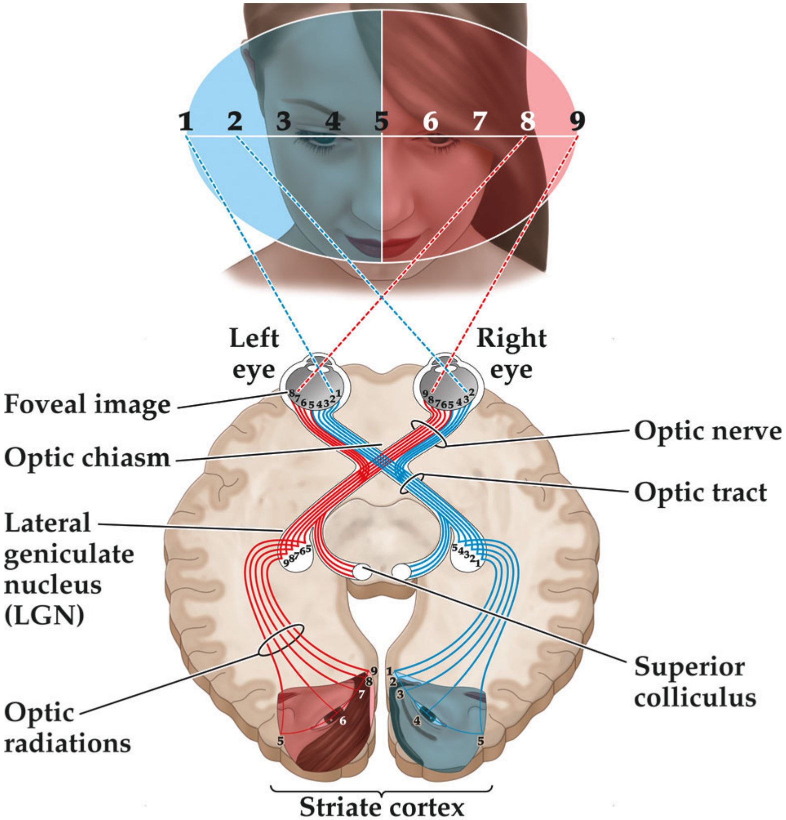
200 million cells!

Striate Cortex

- Striate cortex: Also known as primary visual cortex, area 17, or V1
- A major transformation of visual information takes place in striate cortex
  - Circular receptive fields found in retina and LGN are replaced with elongated “stripe” receptive fields in cortex

Striate Cortex (primary visual cortex, area 17, or V1)

- Two important features of striate cortex:
  - Topographical mapping
  - Cortical magnification:



SENSATION & PERCEPTION 3e, Figure 3.14

Striate Cortex

Visual acuity declines in an orderly fashion with eccentricity—distance from the fovea due to increased retinal pooling and cortical bias towards fovea

This can lead to *visual crowding*: the deleterious effect of clutter on peripheral object detection

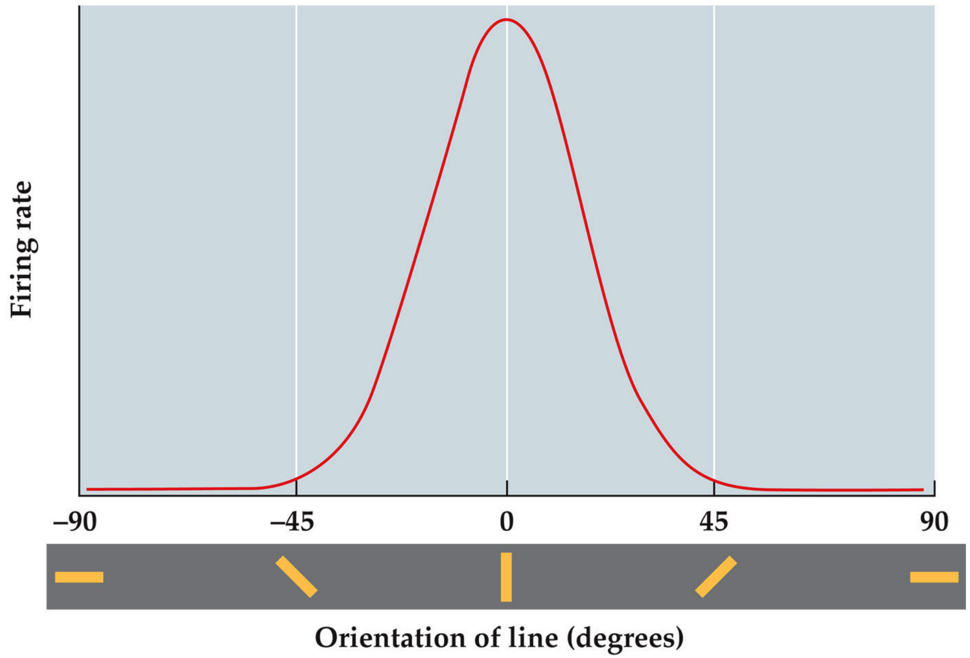
- Stimuli that can be seen in isolation in peripheral vision become hard to discern when other stimuli are nearby

Visual crowding

(*a*) (*b*)

Receptive Fields in Striate Cortex

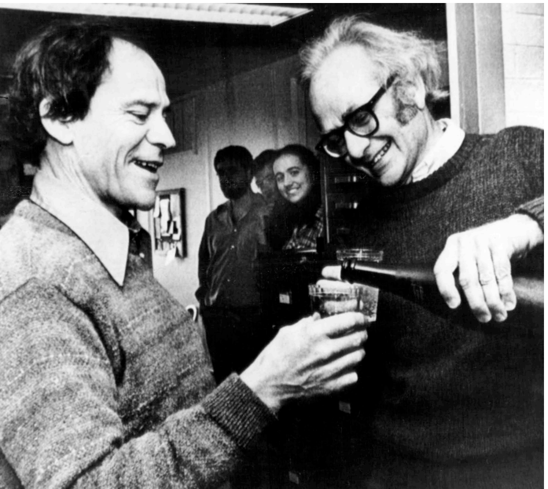
- Cells in striate cortex respond best to bars of light rather than to spots of light
- Orientation tuning:
  - Tendency of neurons in striate cortex to respond most to bars of certain orientations

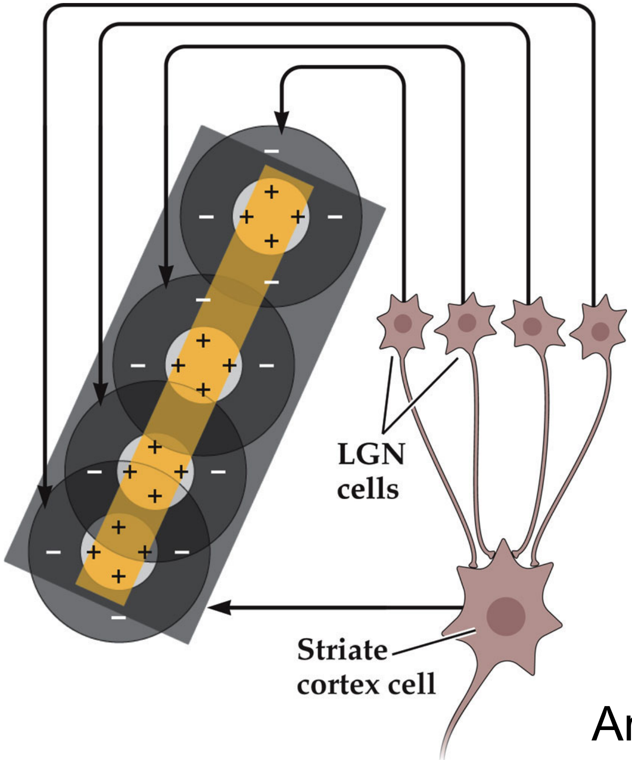


SENSATION & PERCEPTION 3e, Figure 3.18

Striate Cortex

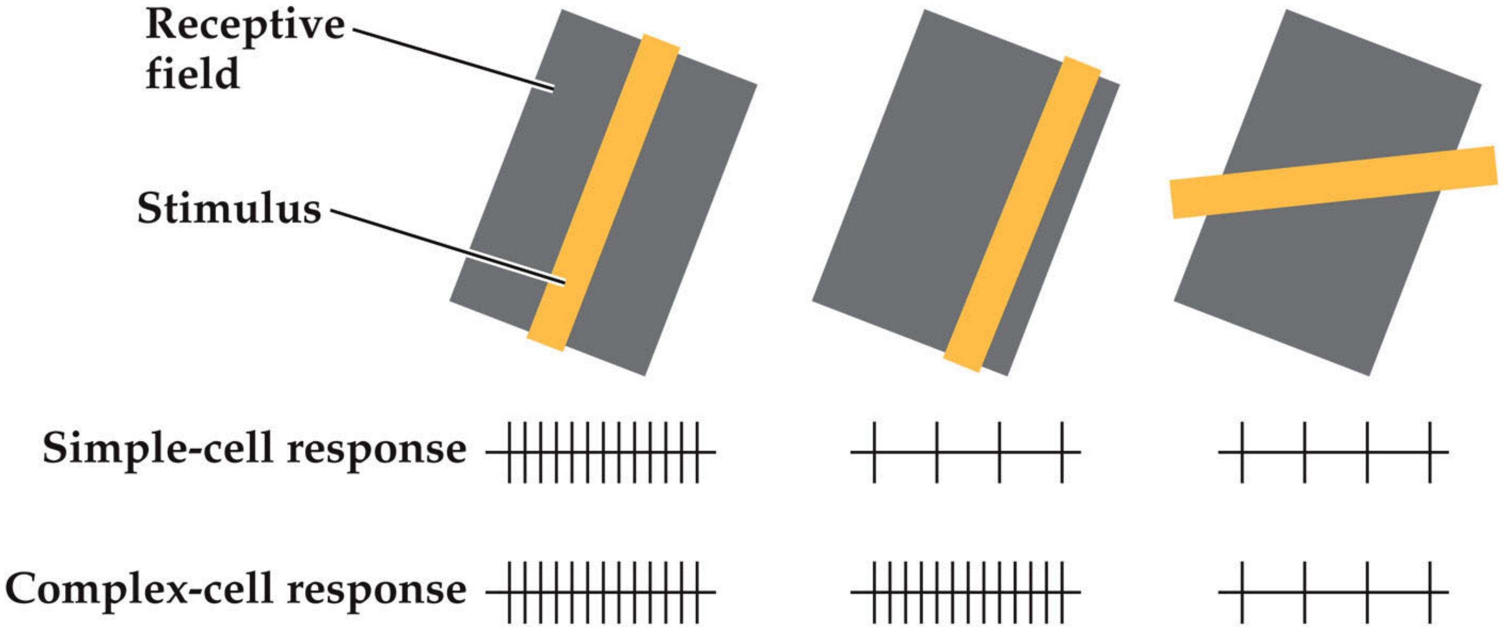
- How are the circular receptive fields in the LGN transformed into the elongated receptive fields in striate cortex?
  - Hubel and Wiesel's suggestion:





An orientation tuned cell may be a 'simple' cell or a 'complex' cell

A simple cell and a complex cell might both be tuned to the same orientation and stripe width, but will respond different



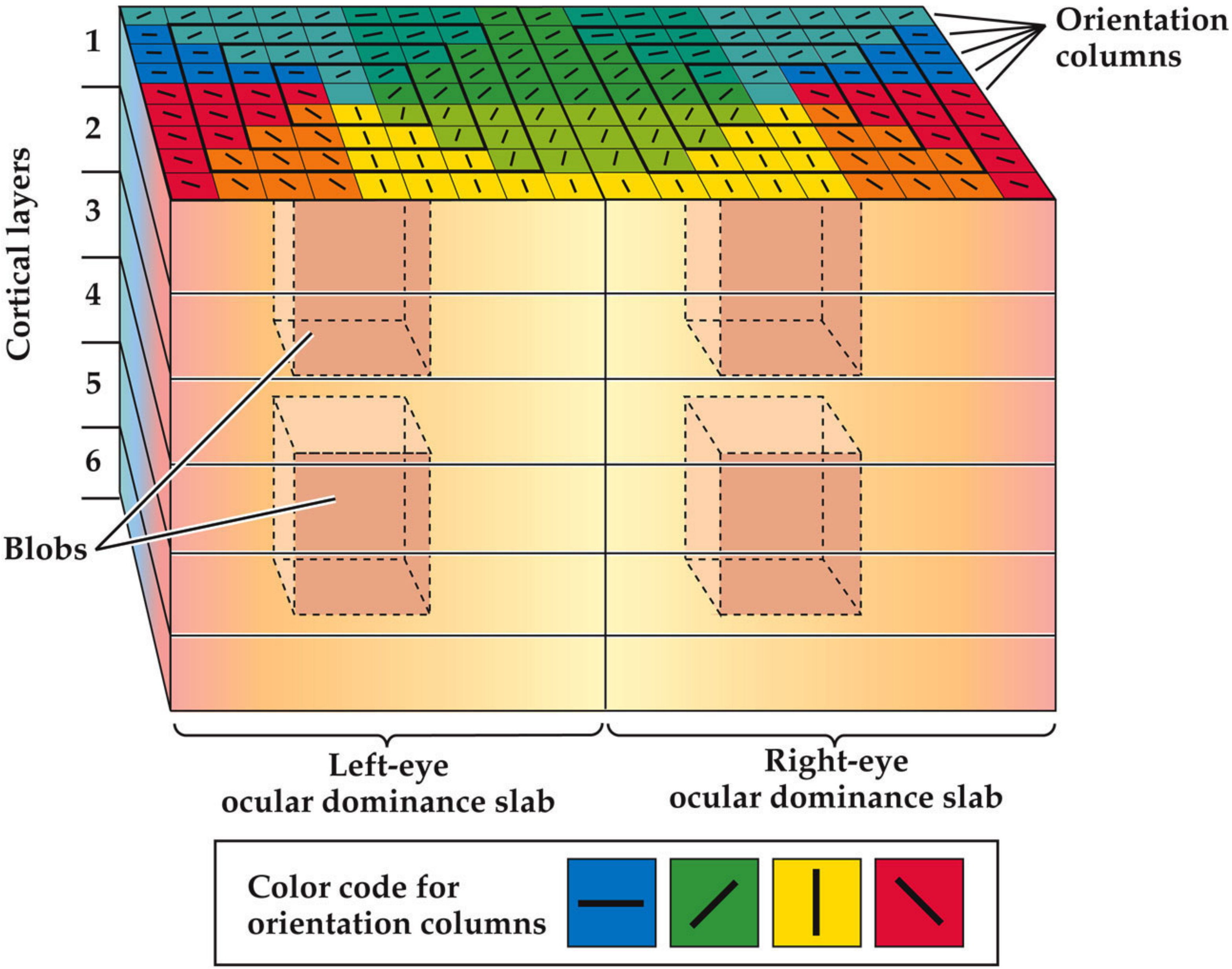
Cells with the same orientation are clustered in vertical columns.

Striate Cortex: The first site of binocular fusion

- Each LGN cell responds to one eye or the other, never to both
- Each striate cortex cell can respond to input from both eyes with some preference for one or the other

A full complement of cells to analyze, for a given region of the visual field, all orientations and input from both eyes constitutes a ‘hypercolumn’. Each hypercolumn is about 1mm across.

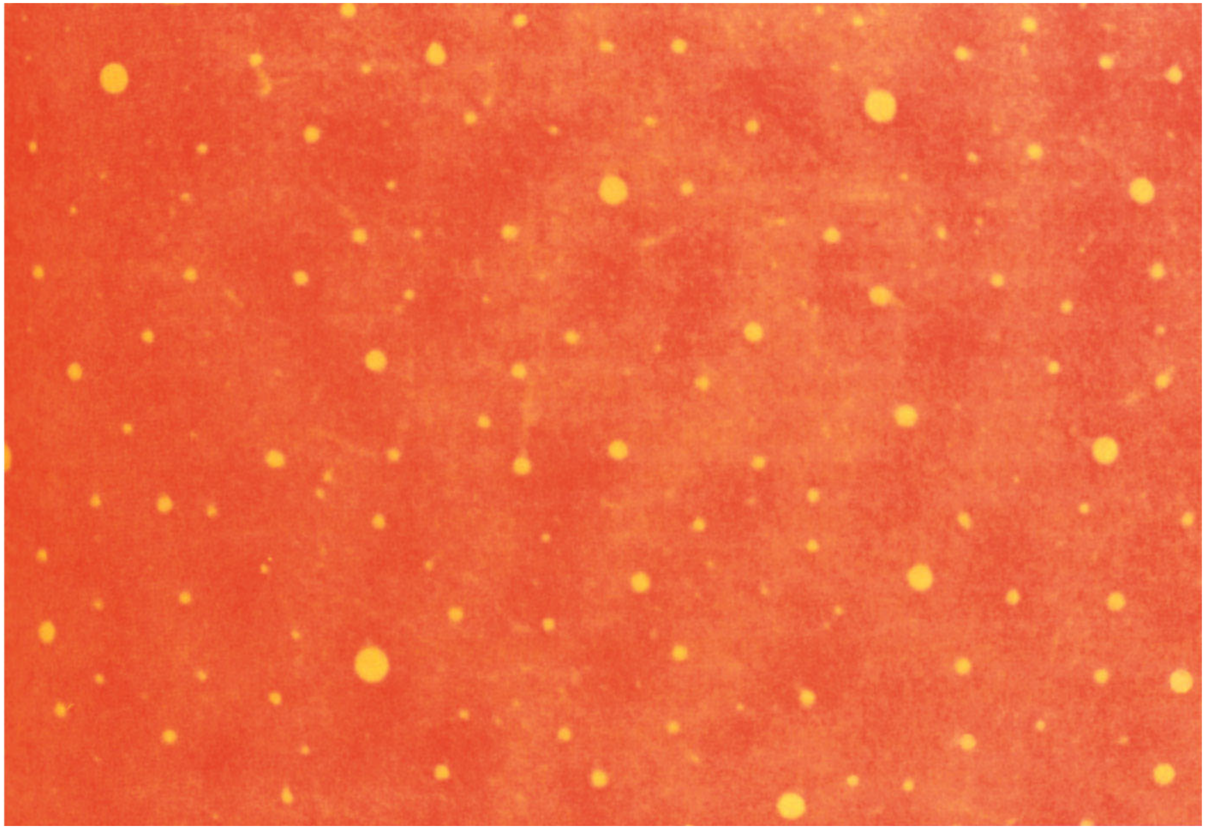
This model of a hypercolumn shows two ocular dominance columns and many orientation columns, and illustrates the locations of the CO blobs



SENSATION & PERCEPTION 3e, Figure 3.25

Blobs within Hypercolumns

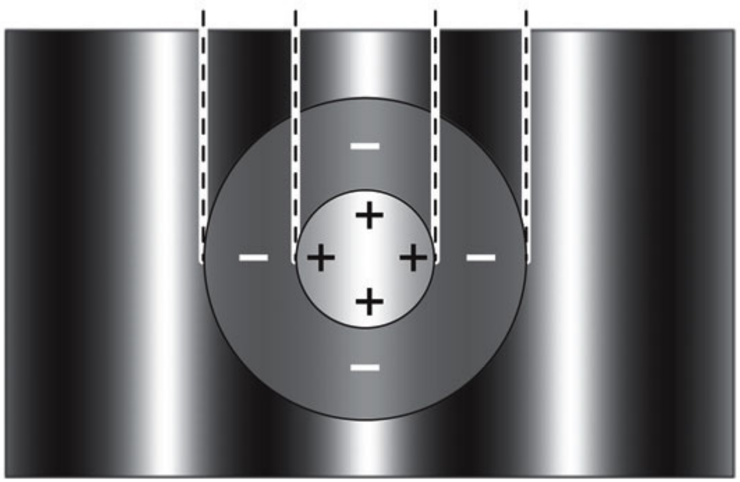
- Regular array of “CO blobs” in systematic columnar arrangement (discovered by using cytochrome oxidase staining technique)



Selective Adaptation: The Psychologist's Electrode

- To be covered in recitation

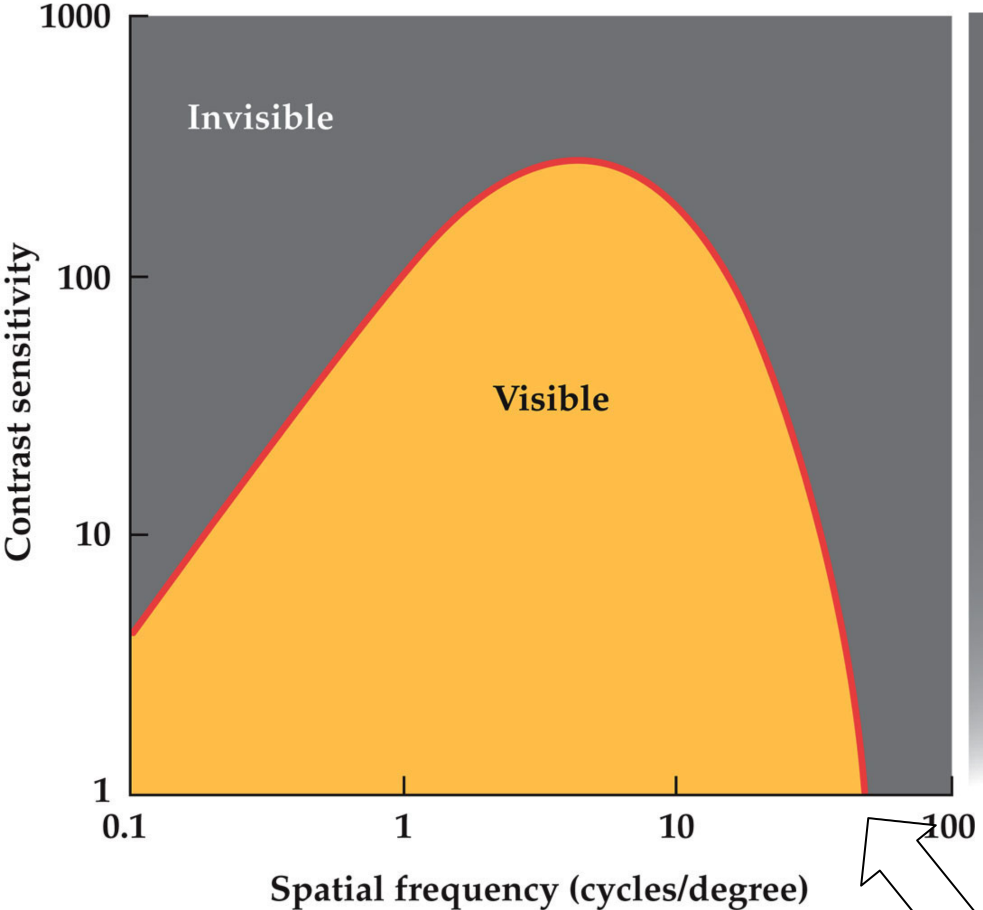
A consequence of receptive field structure: Visual acuity

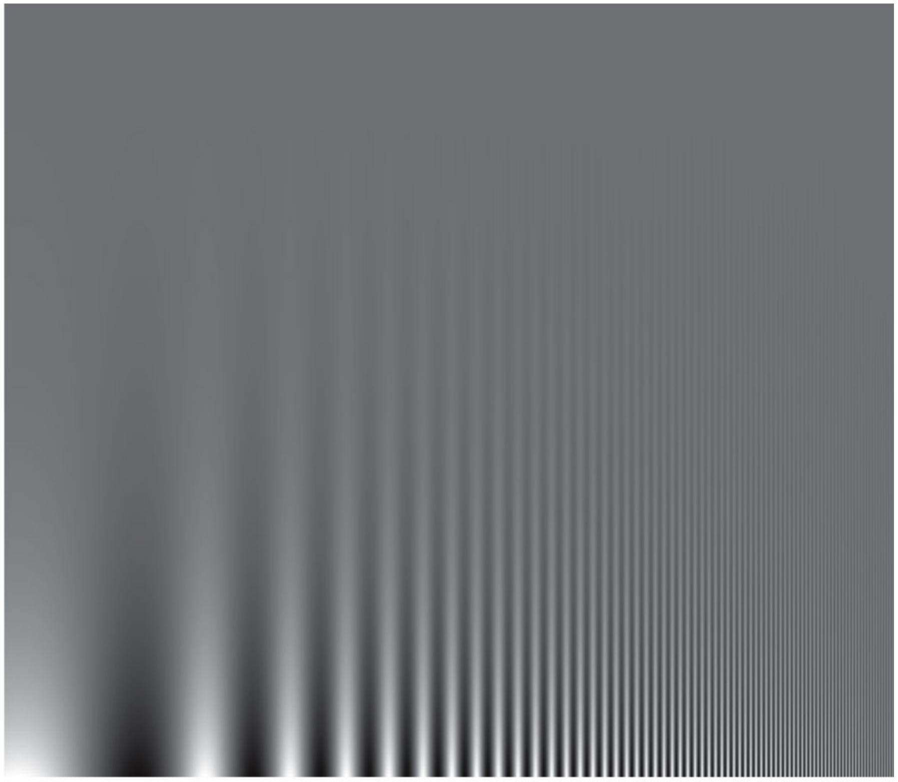


The retinal and cortical receptive fields are tuned to specific spatial frequencies

Together, these rfs define our ability to perceive gratings of different spatial frequencies. The overall sensitivity plot is referred to as a contrast sensitivity function.

The contrast sensitivity function (red line): our window of visibility

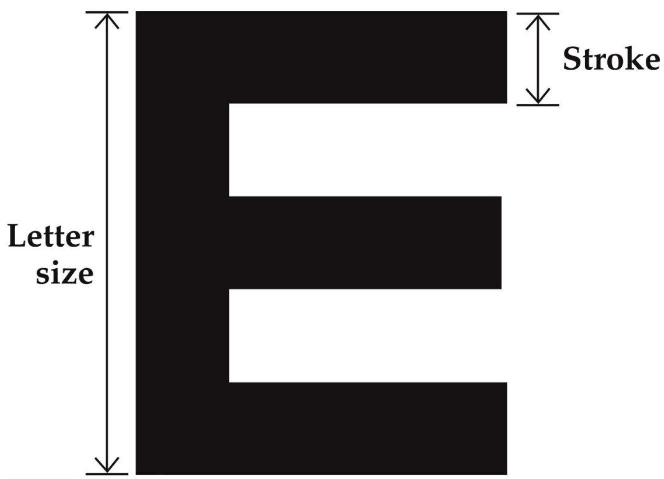




Highest resolvable spatial frequency at maximum contrast

Tests of Visual Acuity

- The Snellen E test
  - Herman Snellen invented this method for measuriing visual acuity in 1862
  - Notice that the strokes on the E form a small grating pattern



SENSATION & PERCEPTION 3e, Figure 3.5
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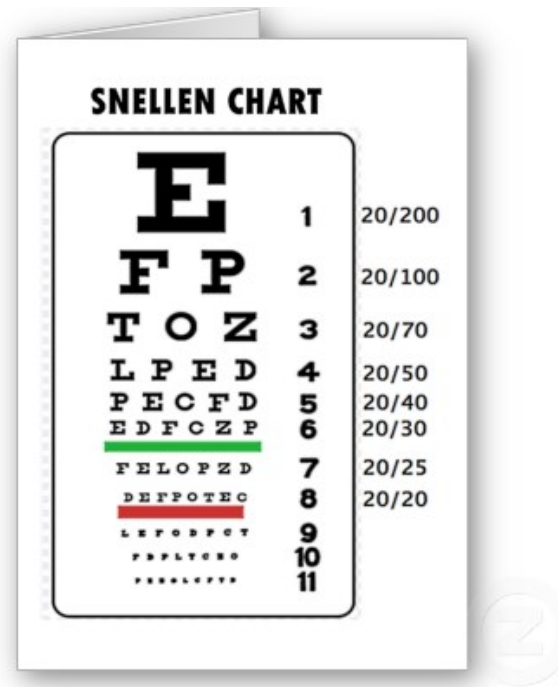
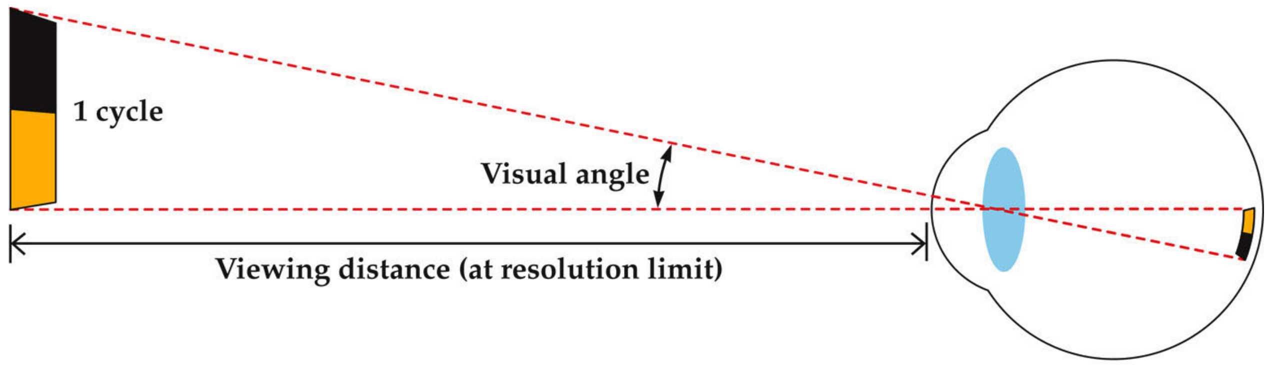


Specifying Visual Acuity

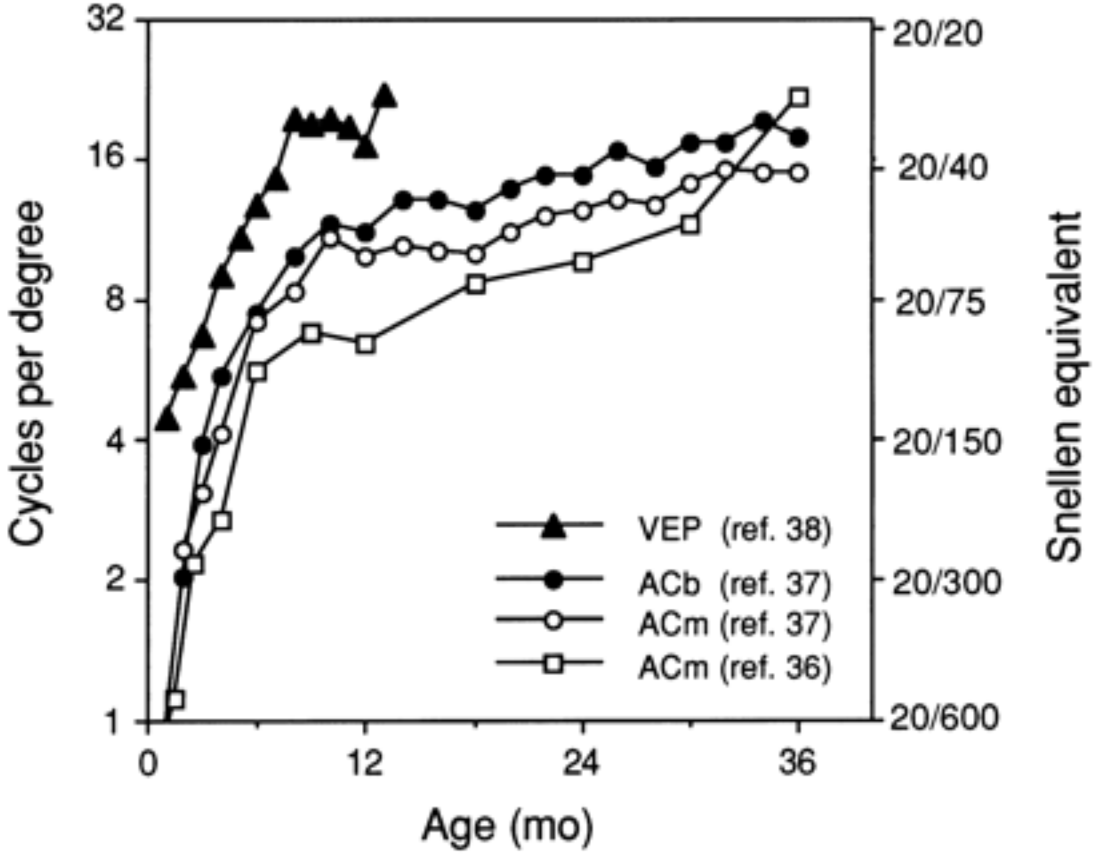
Eye doctors use distance to characterize visual acuity, as in “20/20 vision”

Your distance/normal vision distance

- Vision scientists: Spatial frequency of finest resolvable grating; Number of cycles per degree



The Development of Spatial Vision



The Development of Spatial Vision

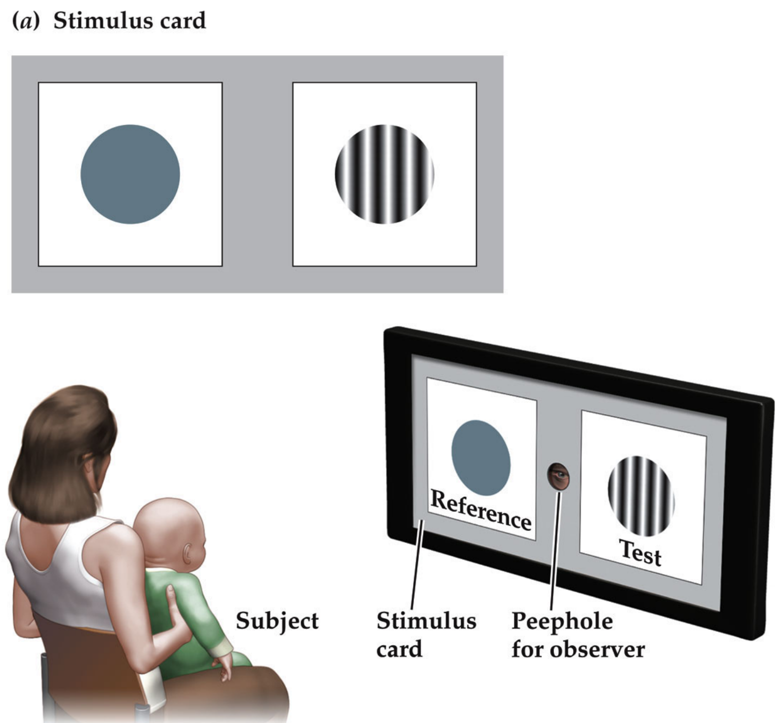
- Young children are not very sensitive to high spatial frequencies
  - Visual system is still developing
    - Cones and rods are still developing and taking final shape
    - Retinal ganglion cells are still migrating and growing connections with the fovea
    - The fovea itself has not fully developed until about 4 years of age

How can we study the vision of infants who can’t yet speak?

Video

The Development of Spatial Vision

- How can we study the vision of infants who can't yet speak?
  - Infants prefer to look at more complex stimuli
  - The forced-choice preferential-looking paradigm

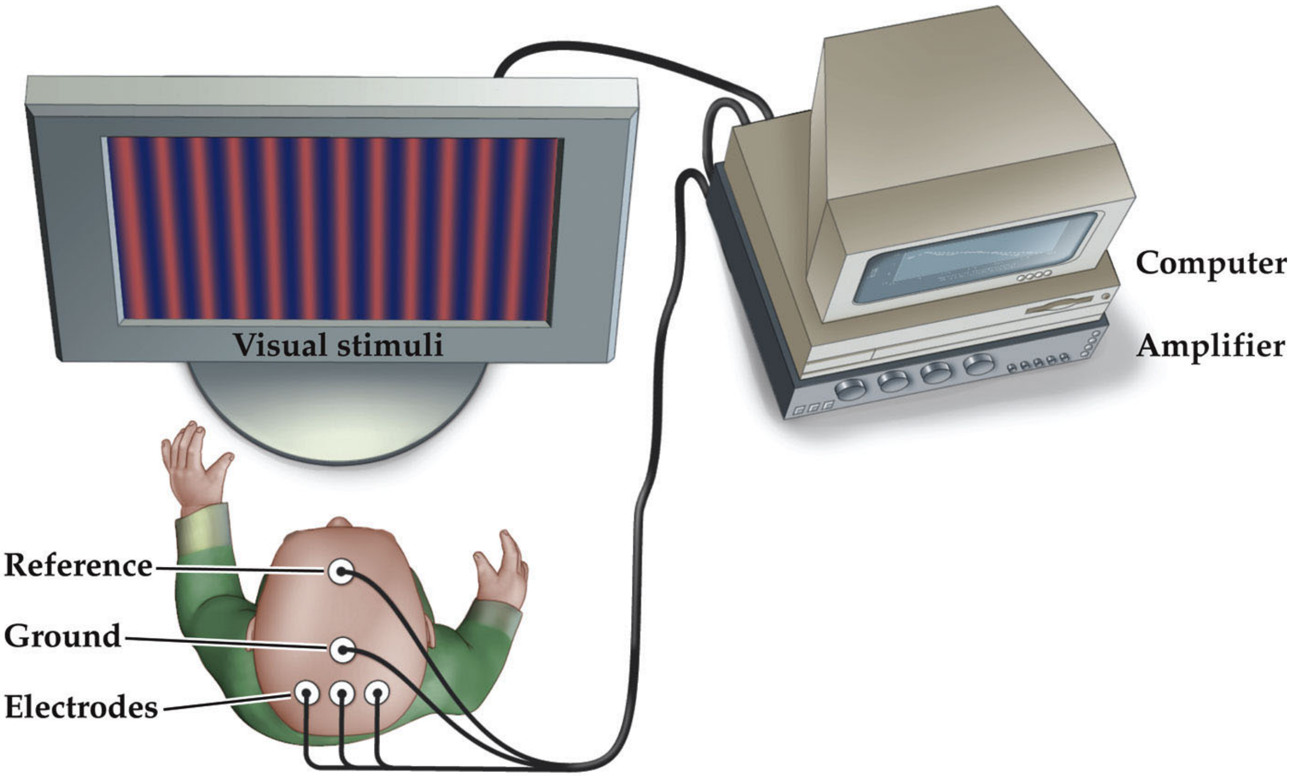


SENSATION & PERCEPTION 3e, Figure 3.34 (Part 1)

Visual evoked potentials

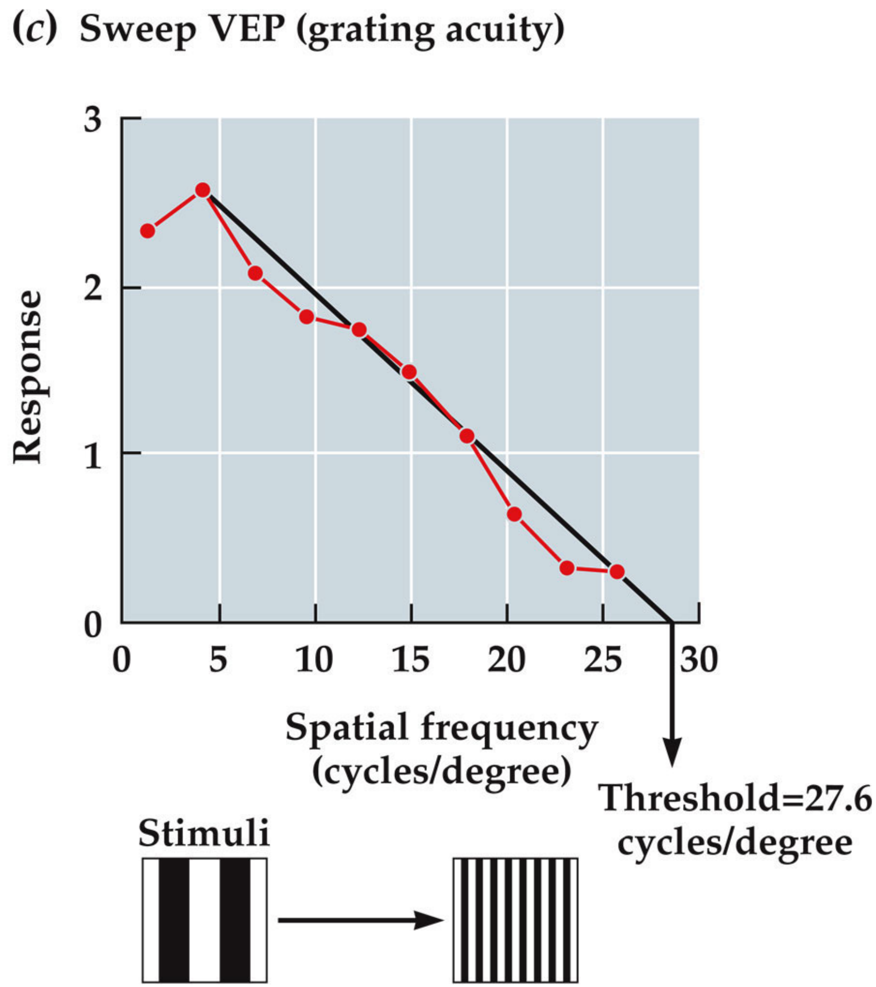
VEPs are electrical signals from the brain that are evoked by visual stimuli

(*b*)



SENSATION & PERCEPTION 3e, Figure 3.34 (Part 2)

Assessing vision in infants (Part 3)



SENSATION & PERCEPTION 3e, Figure 3.34 (Part 3)

The Girl Who Almost Couldn't See Stripes

- Story of Jane: Abnormal early visual experience resulting in possibly permanent consequences
- Monocular vision from deprivation can cause massive changes in cortical physiology, resulting in devastating and permanent loss of spatial vision
- Cataracts and strabismus can lead to serious problems, but early detection and care can prevent such problems!

Amblyopia