Receptive fields

PSY 200

Greg Francis

Lecture 06

How do you recognize your grandmother?

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Action potential

- With enough excitatory input, a cell produces an action potential that sends a signal down its axon to other cells
  - But a single action potential has little effect
- If the input stays present, the cell produces another, and another,…
  - A rapid series of action potentials can influence other cells
- The *number* of action potentials in a certain length of time determines the *firing rate* of the cell

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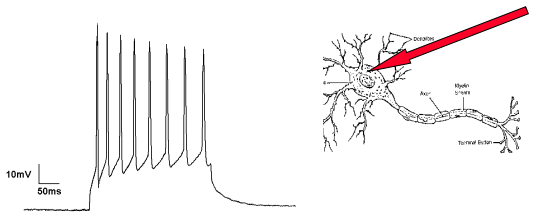
Firing rate

- 8 spikes (action potentials) during 300 ms
  - Firing rate of 27 Hz (27 spikes per second)



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Specificity

- Two key questions in cognitive neuroscience are
  - What stimulus (or stimuli) makes a given cell fire at a strong rate?
    - » something red?
    - » a pen?
    - » your grandmother?
  - What does it mean when a given cell fires strongly?
    - » You are thinking of something?
    - » Seeing something?
    - » Remembering something?

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Receptive field

- The set of stimuli that reliably *changes* a cell's firing rate.
- A stimulus could *excite* the cell
  - above normal firing rate
- Or *inhibit* the cell
  - below normal firing rate

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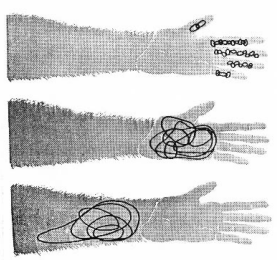
Receptive field

- Receptive fields are very useful for studies of spatial perception
- Touch involves sensitivity to pressure on skin
- The loops indicate the regions where a single neuron responds to pressure



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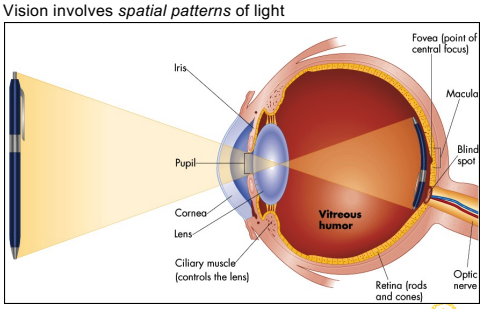
Receptive field

- Receptive fields are very useful for studies of visual perception
- Vision involves *spatial patterns* of light



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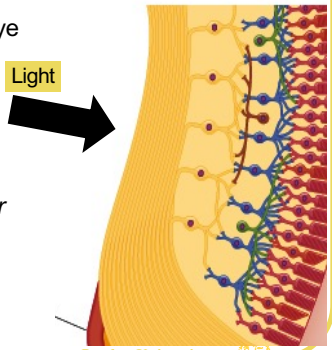
Receptors

- The back of the eye contains tightly packed sensors called rods and cones that detect light *at a particular location*



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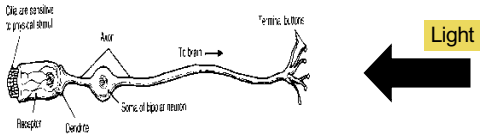
Receptors

- Light sensors (rods and cones) respond to light at a *particular location* in the back of the eye
  - produces a neural response



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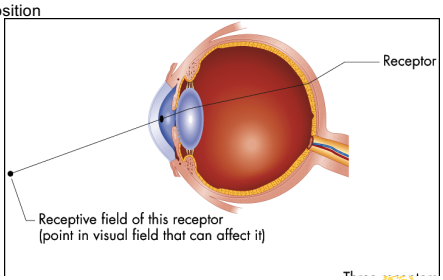
Receptors

- A receptor has a simple receptive field
  - it responds to light of the right wavelength (color) and the right position



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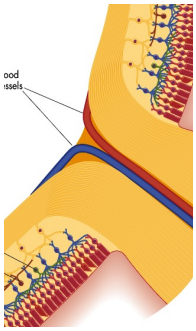
Blind spot

- Where nerves leave the back of the eye, there are no light receptors
  - light that hits this spot is not visible



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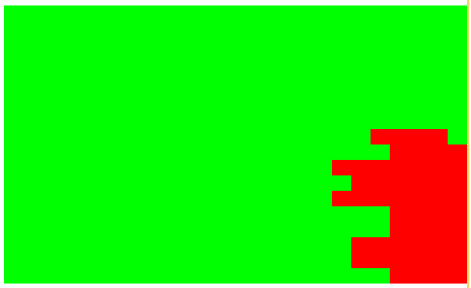
11

Blind spot

- In CogLab you mapped your blind spot
- my data looks like this



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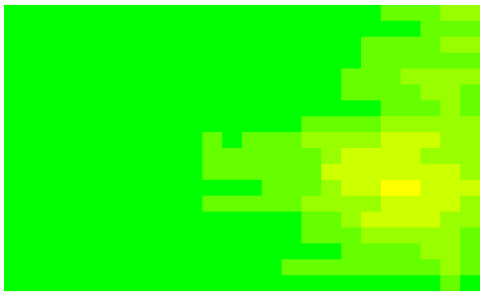
Blind spot

- Here's the average data for the whole class
- 111 participants



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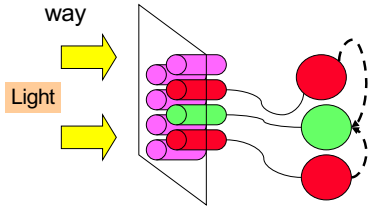
13

Network

- Light receptors do not just pass information to the brain
- Neurons are hooked together in an inhibitory way



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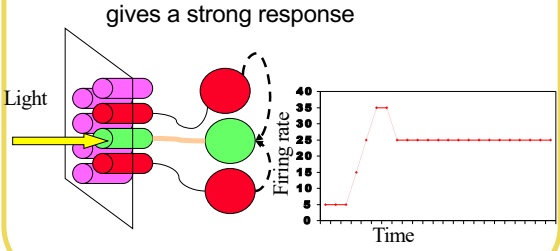
Evidence of inhibition

- Stimulation of a center region alone gives a strong response



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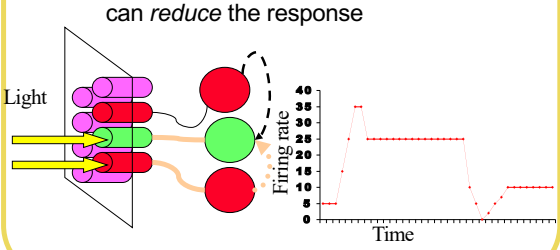
Evidence of inhibition

- *Adding* light to a surrounding region can *reduce* the response



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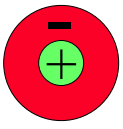
16

Receptive field

- The receptive field of this cell includes any place on the retina where light excites the cell *and* any place where light inhibits the cell
- On-center, off-surround



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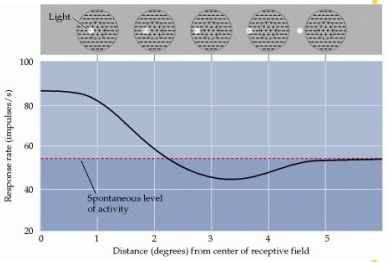
17

Spatial responses

- The spatial pattern of excitation (center) and inhibition (surround) means the cell is sensitive to the location of a small spot of light



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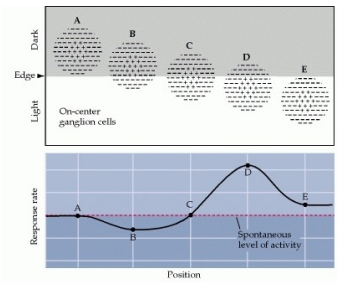
18

Spatial responses

- You have many different such cells with receptive fields that are centered at different locations
- They respond differently to an edge



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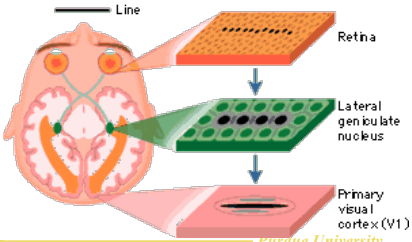
19

Simple cells

- On-center, off-surround cells send action potentials to simple cells in parts of visual cortex, which have *oriented* receptive fields



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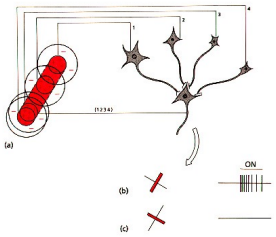
Simple cells

- On-center, off-surround cells send action potentials to simple cells in parts of visual cortex, which have *oriented* receptive fields



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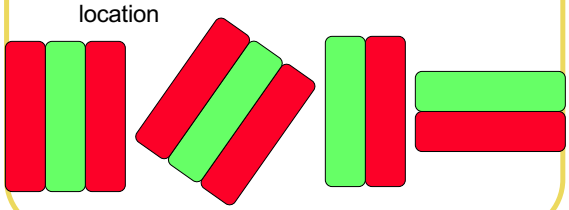
21

Simple cells

- Simple cells come in a variety of types, but all are sensitive to *bars* or *edges* of a preferred orientation at a particular location



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22

Information processing

- For simple cells, an image like this

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Information processing

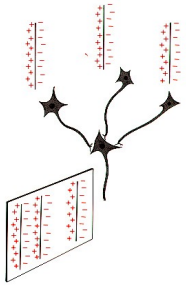
- For simple cells, an image like this
  - is coded something like this

Strong responses at edges!

24

Complex cells

- Many simple cells feed into a *complex* cell, which is insensitive to direction of *contrast* and responds to an oriented bar in many different places



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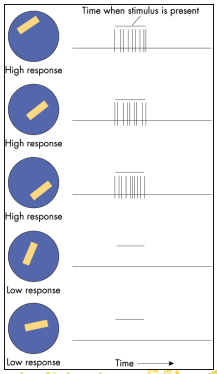
Complex cells

- Many simple cells feed into a *complex* cell, which is insensitive to direction of *contrast* and responds to an oriented bar in many different places
  - Often these cells are also sensitive to directions of *motion*



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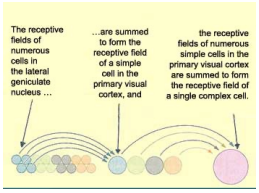
Receptive field hierarchy

- Receptive fields inherit some properties from "lower-level" cells
- But they also gain new selectivity by interacting with each other (and across levels)



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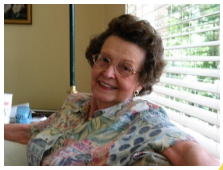
27

Higher order cells

- Complex cells feed into hypercomplex cells, which are sensitive to some types of *curves* and visual *forms*
- Receptive fields seem to get ever more complex
- What does this mean?
- Is there a grandmother cell?



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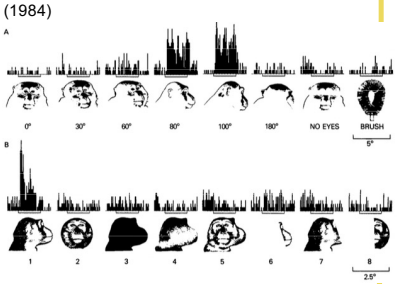
28

Receptive field

- In the inferior temporal cortex of monkeys
  - Desmione et al. (1984)
- some cells appear to have receptive fields that respond to monkey faces, in profile



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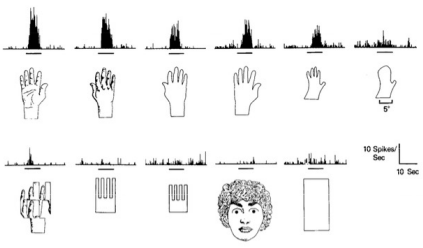
Receptive field

- In the inferior temporal cortex of monkeys
  - Desmione et al. (1984)
- Other cells appear to have receptive fields that respond to hands



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Grandmother cells?

- It *could* be that a single cell has a receptive field selectively tuned to respond to the image of your grandmother
  - but it is unlikely
  - not enough cells
  - cell death
- Receptive fields become less useful as we search for neural representations of non-sensory concepts
  - What is the receptive field of a neuron that codes "love" or "trust"?

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Conclusions

- Receptive fields
  - any stimulus that affects a cell's firing rate
  - excitatory
  - inhibitory
- Very useful for studies of the visual nervous system
- Lots of issues left unresolved

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Next time

- Networks of neurons
- Connections between cells
- Feedback – resonance

- *Seeing things that are not there.*

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