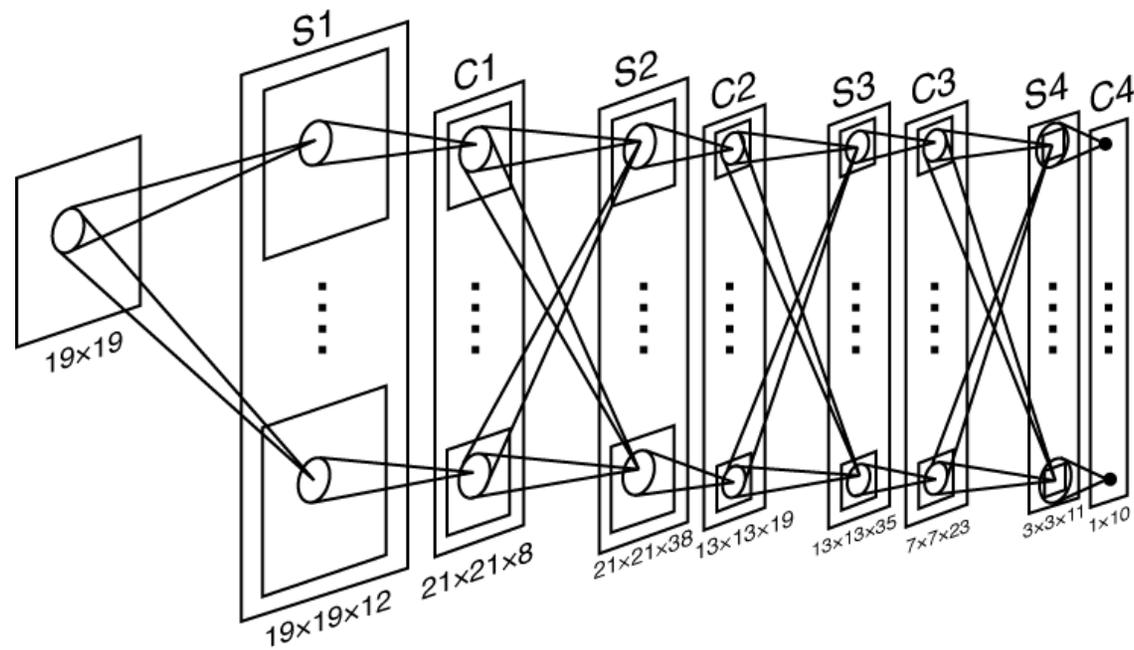


# Hierarchical perceptron model of vision

Sebastian Seung

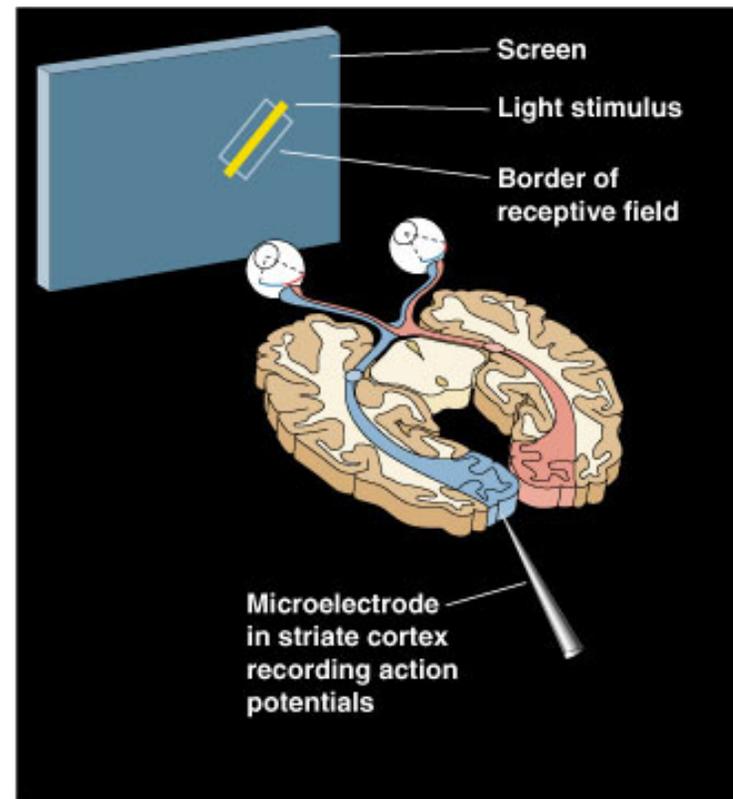
# Neocognitron



Fukushima (1980)

# Visual neurophysiology

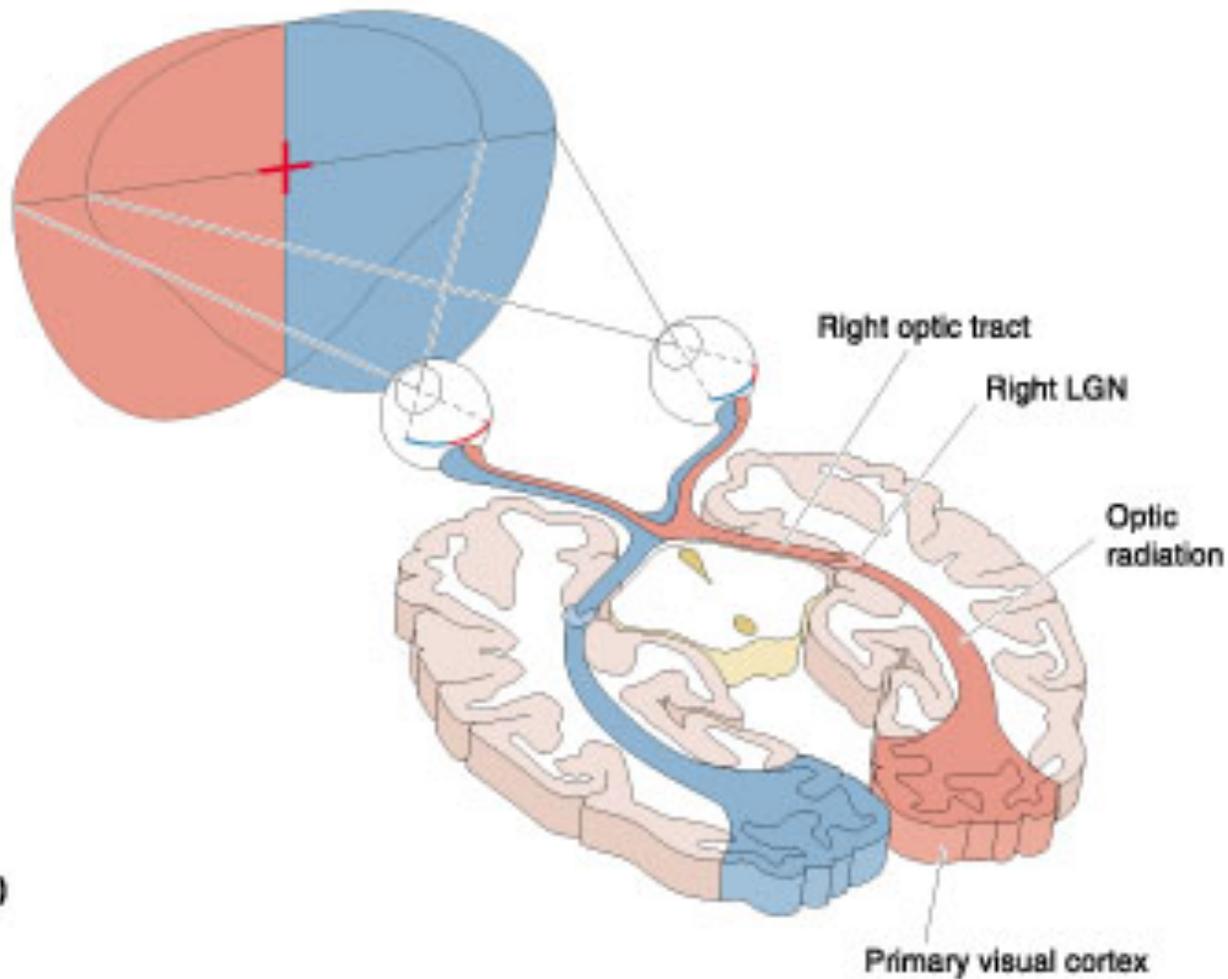
- anesthetized cat
- video: visual stimulus seen by cat
- audio: extracellular recording



(a)

# Retina → LGN → V1

(a)



(b)

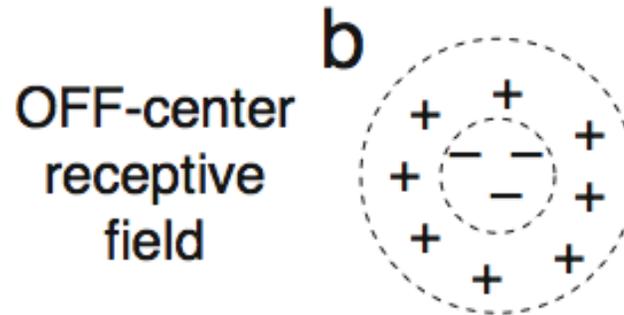
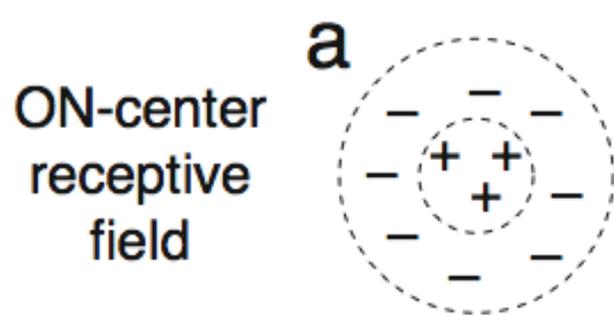
# Receptive field (functional definition)

- The area of retina (or of visual space) in which a stimulus can cause changes in the activity of a neuron.
- The “preferred stimulus” is that which causes the most increase in rate of action potential firing.

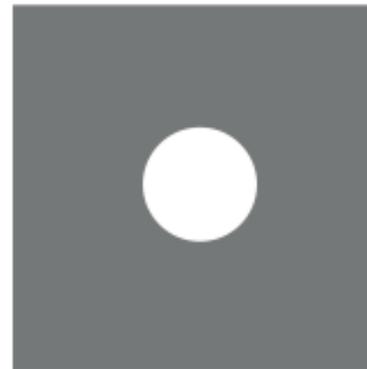
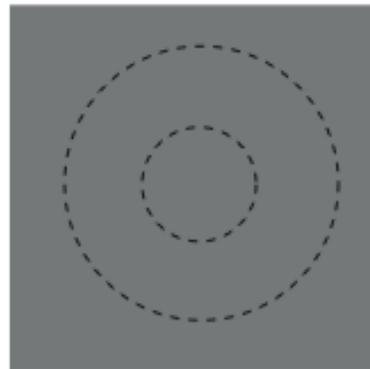
# Retinal ganglion cells

- Output cells of the retina
- Send a million axons in the optic nerve
- Background rate of spiking
- Rate of spiking is modulated up or down by visual stimulation

# Center-surround antagonism



visual stimulus on retina



spiking response of ON-center cell



# ON center



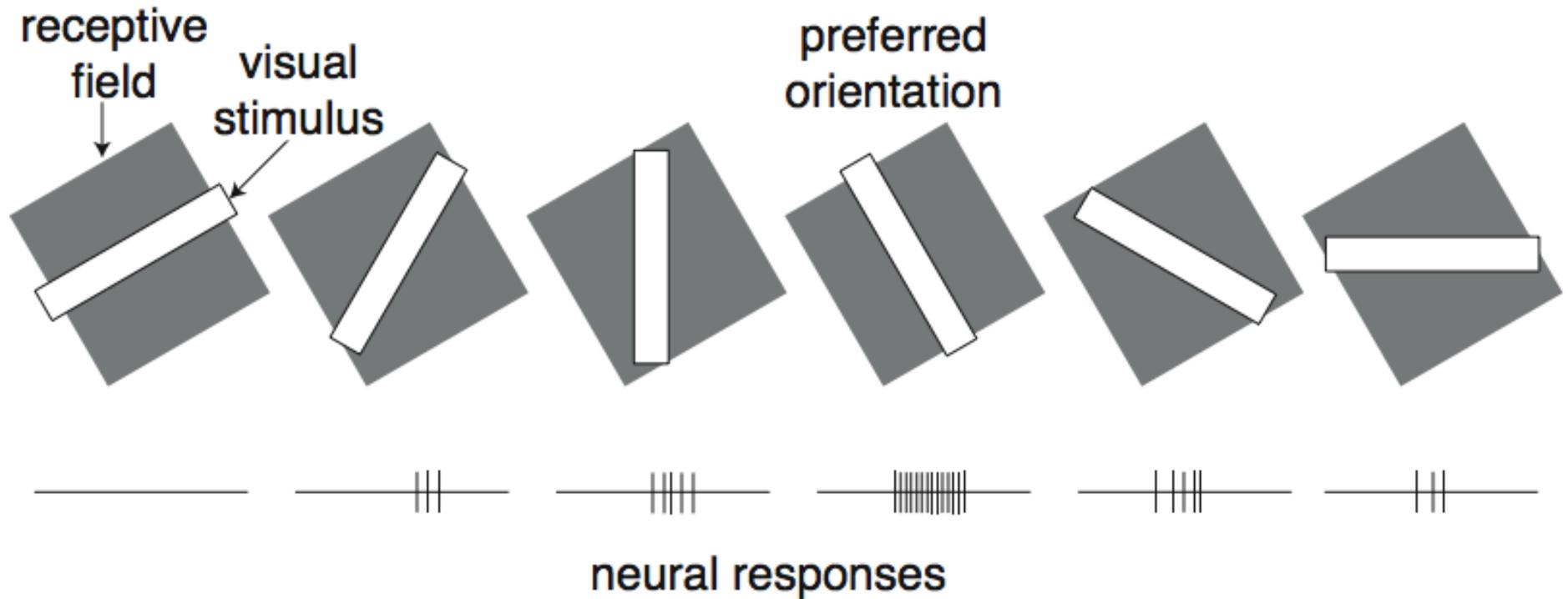
# OFF surround



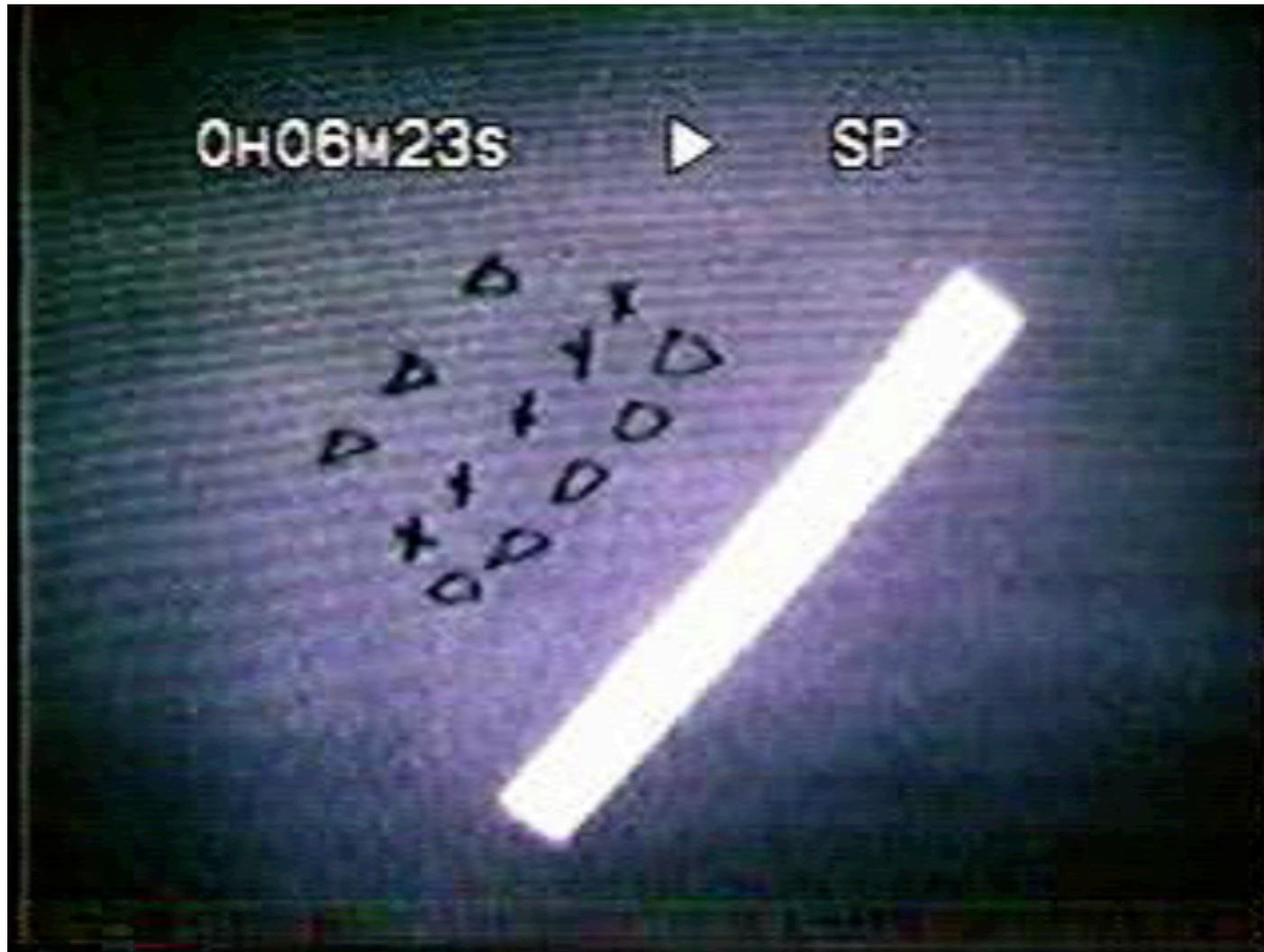
# Rotationally symmetric



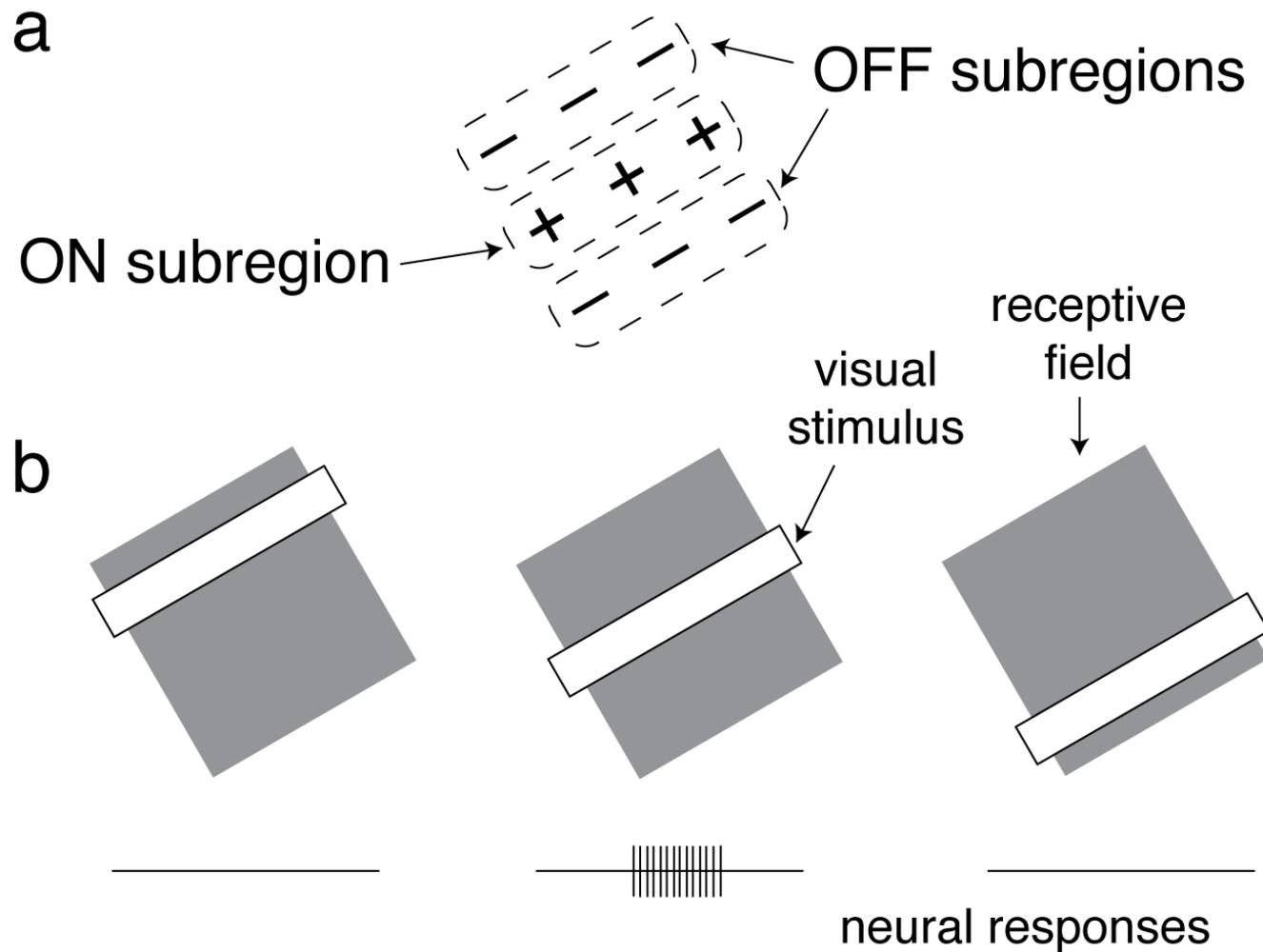
# Orientation selectivity



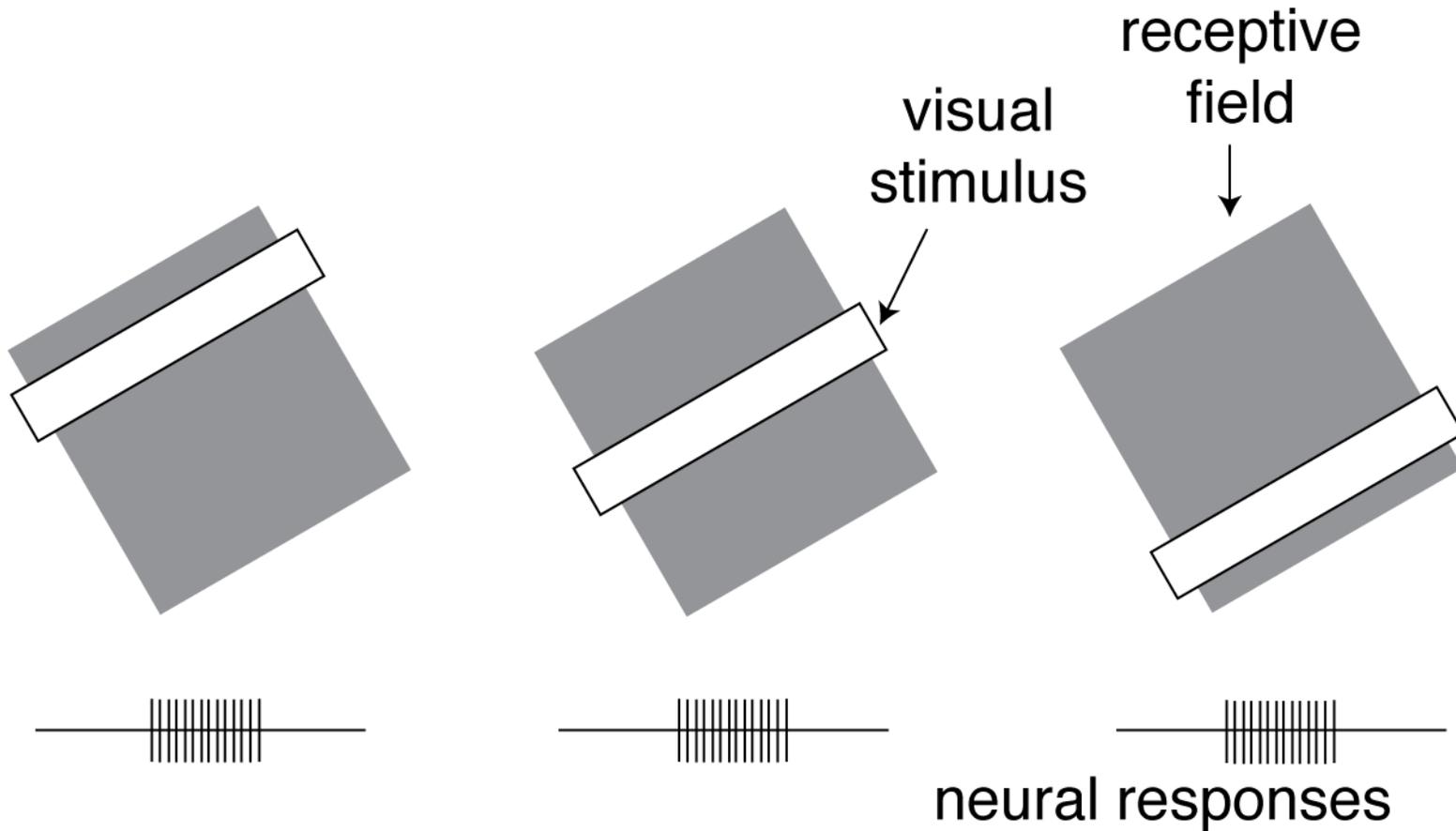
# Simple cell recording



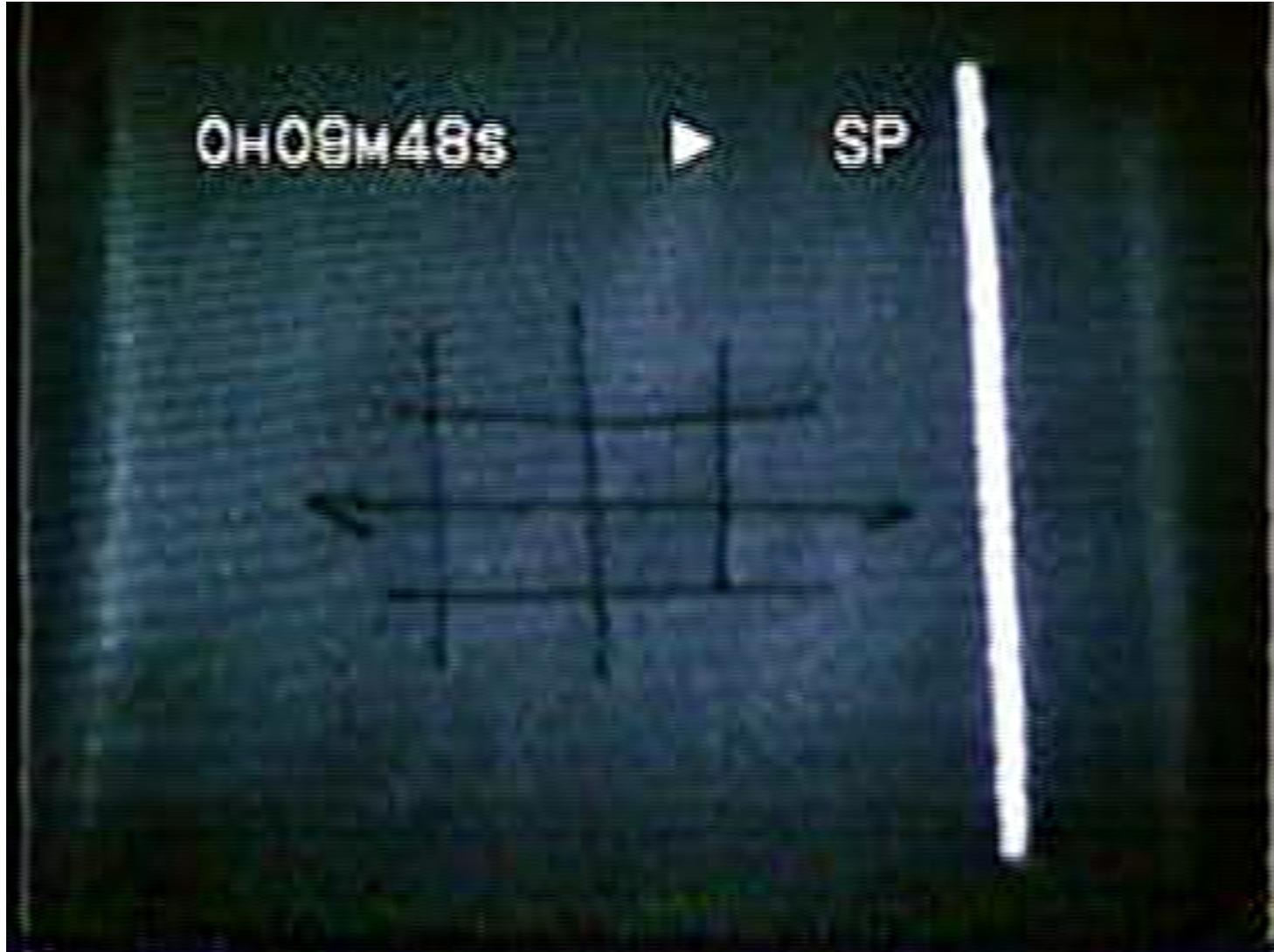
# Position selectivity: simple cells



# Position invariance: complex cells



# Complex cell recording

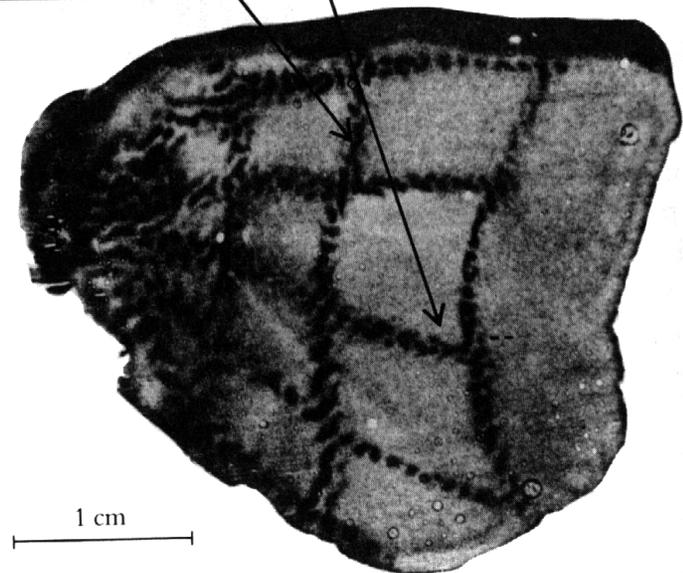
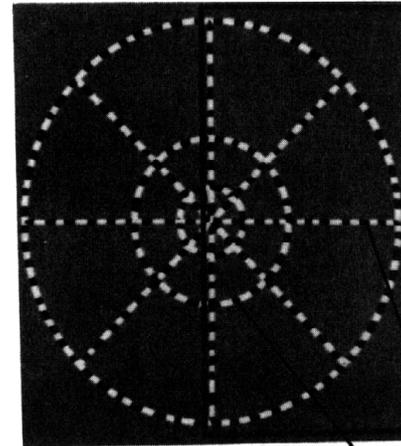


# Choose the best answer

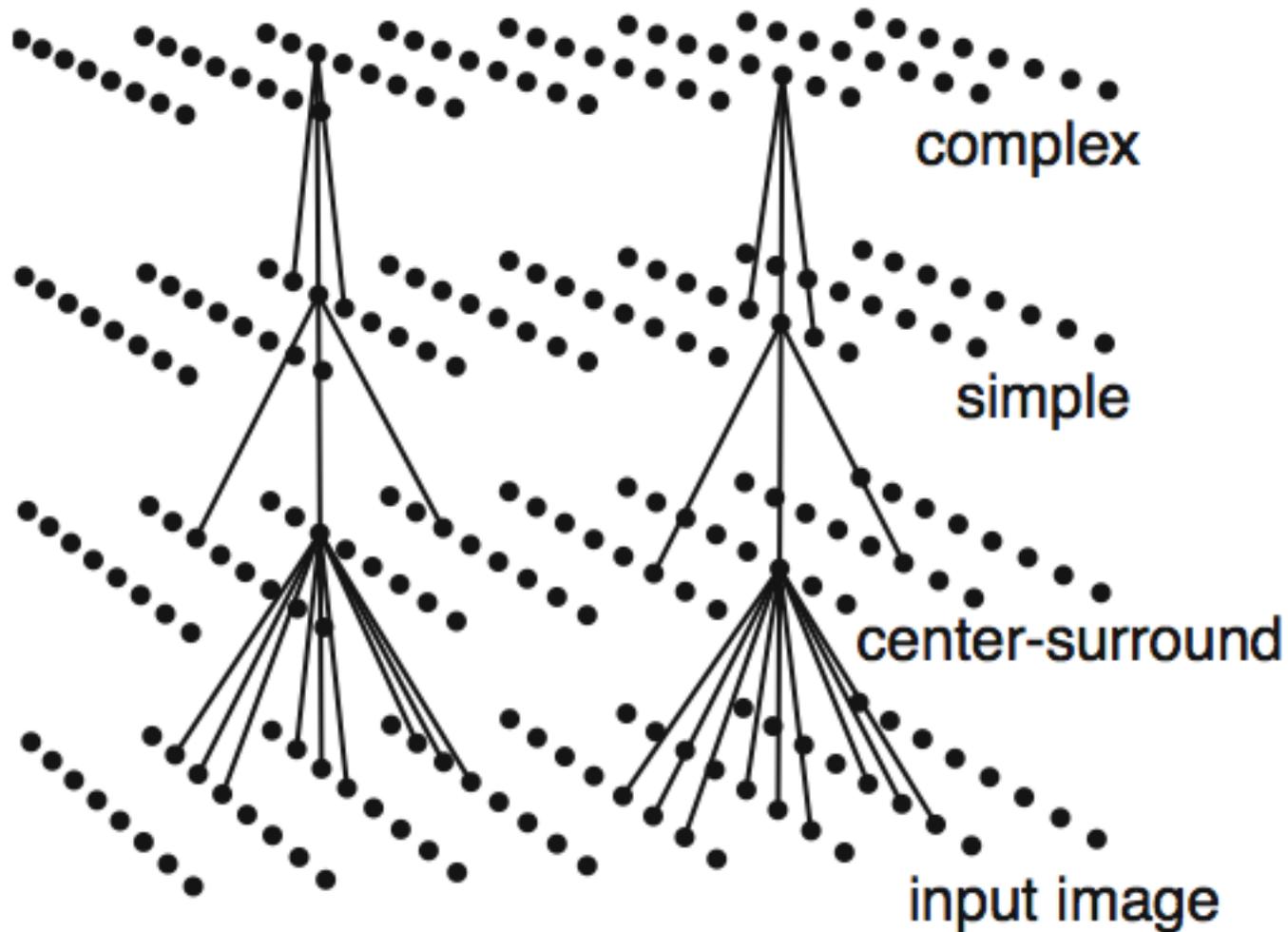
- A. structural RF < functional RF
- B. structural RF > functional RF
- C. The structural RF determines the preferred stimulus
- D. A and C
- E. B and C

# Feature maps in the brain

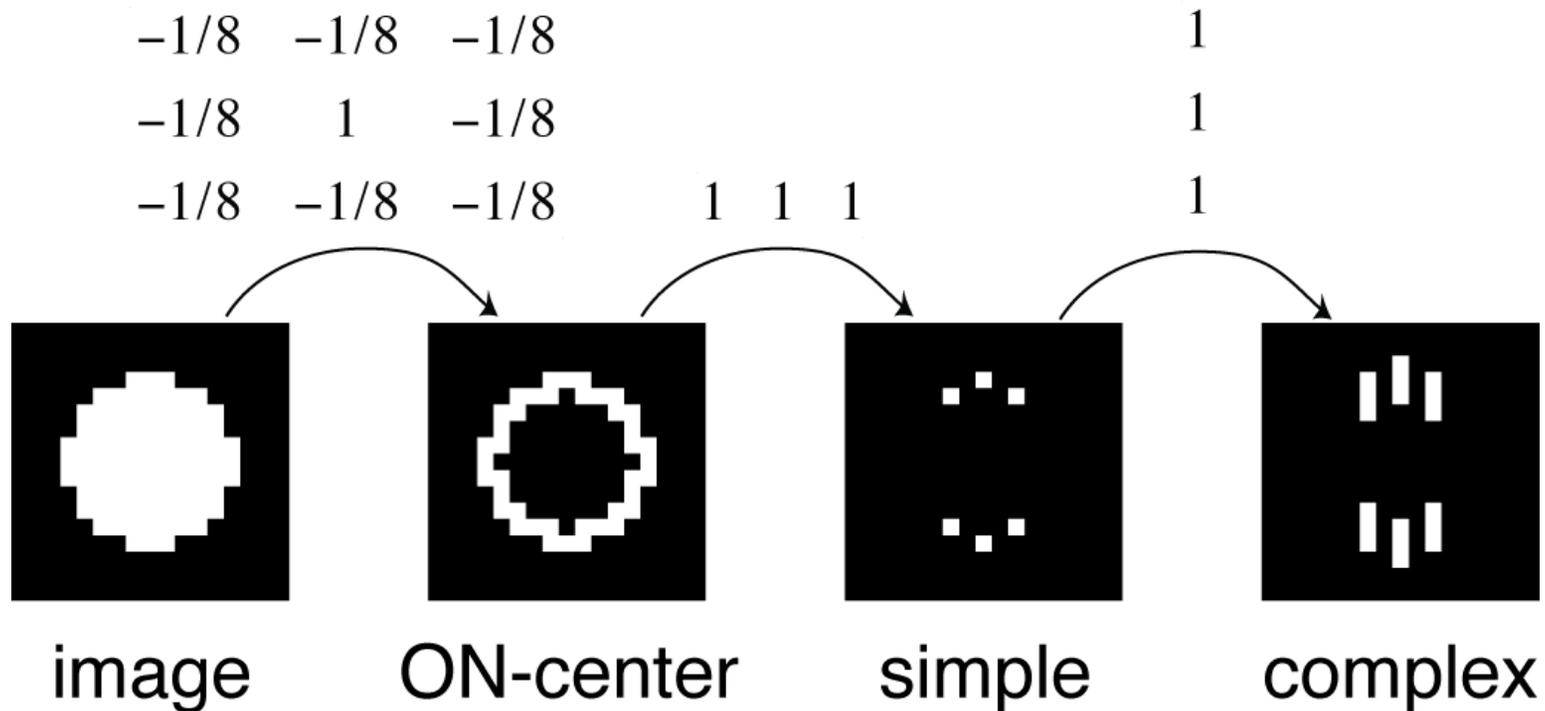
- Neighboring cells typically have neighboring receptive fields in visual space.
- But the features are mixed together.



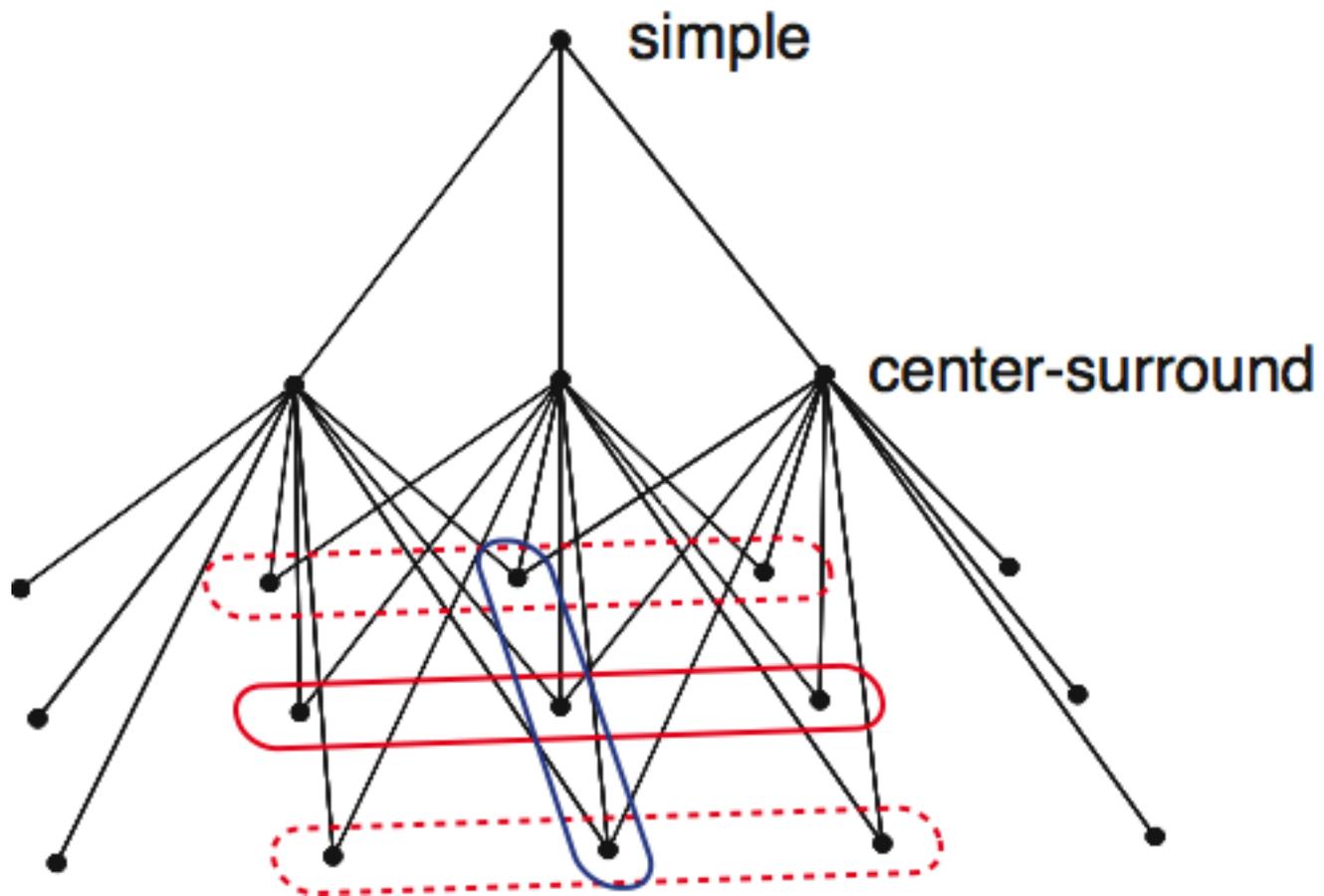
# Multilayer perceptron model



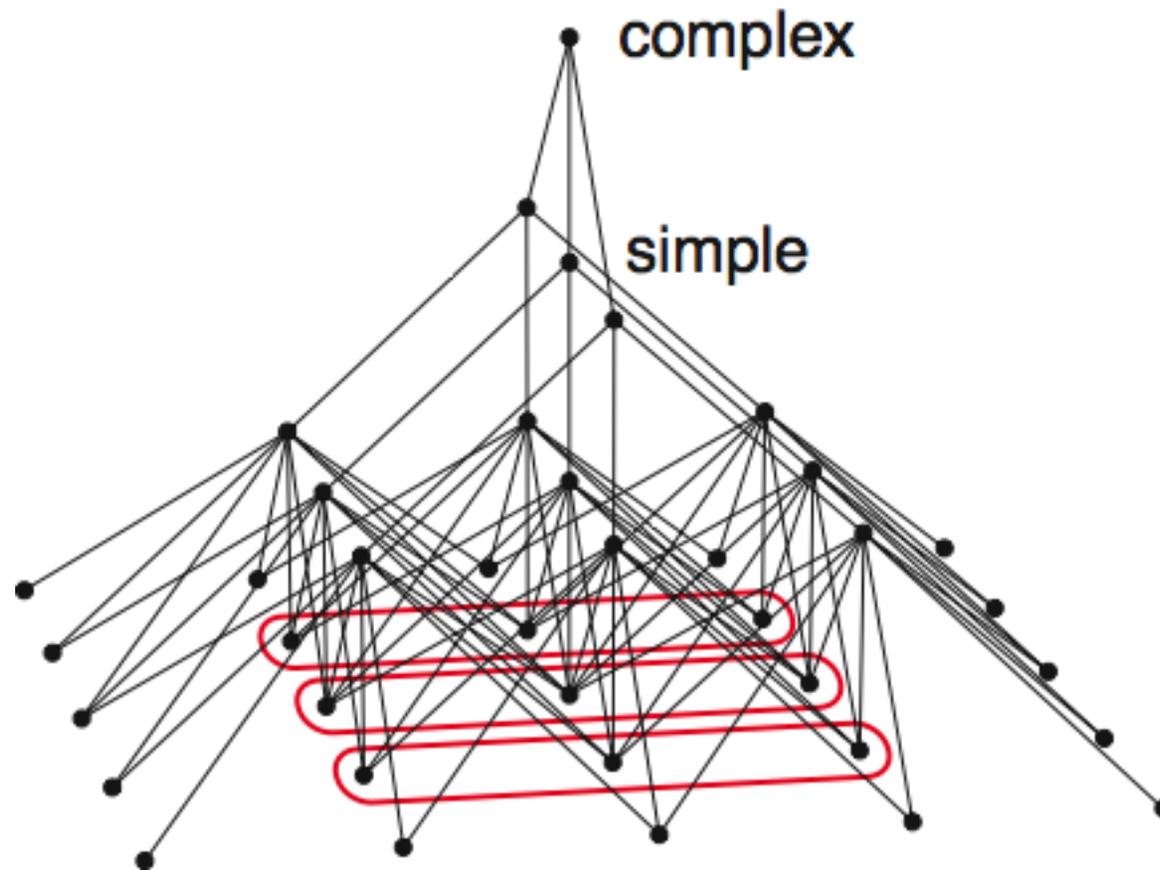
# Center-surround, simple, complex cells



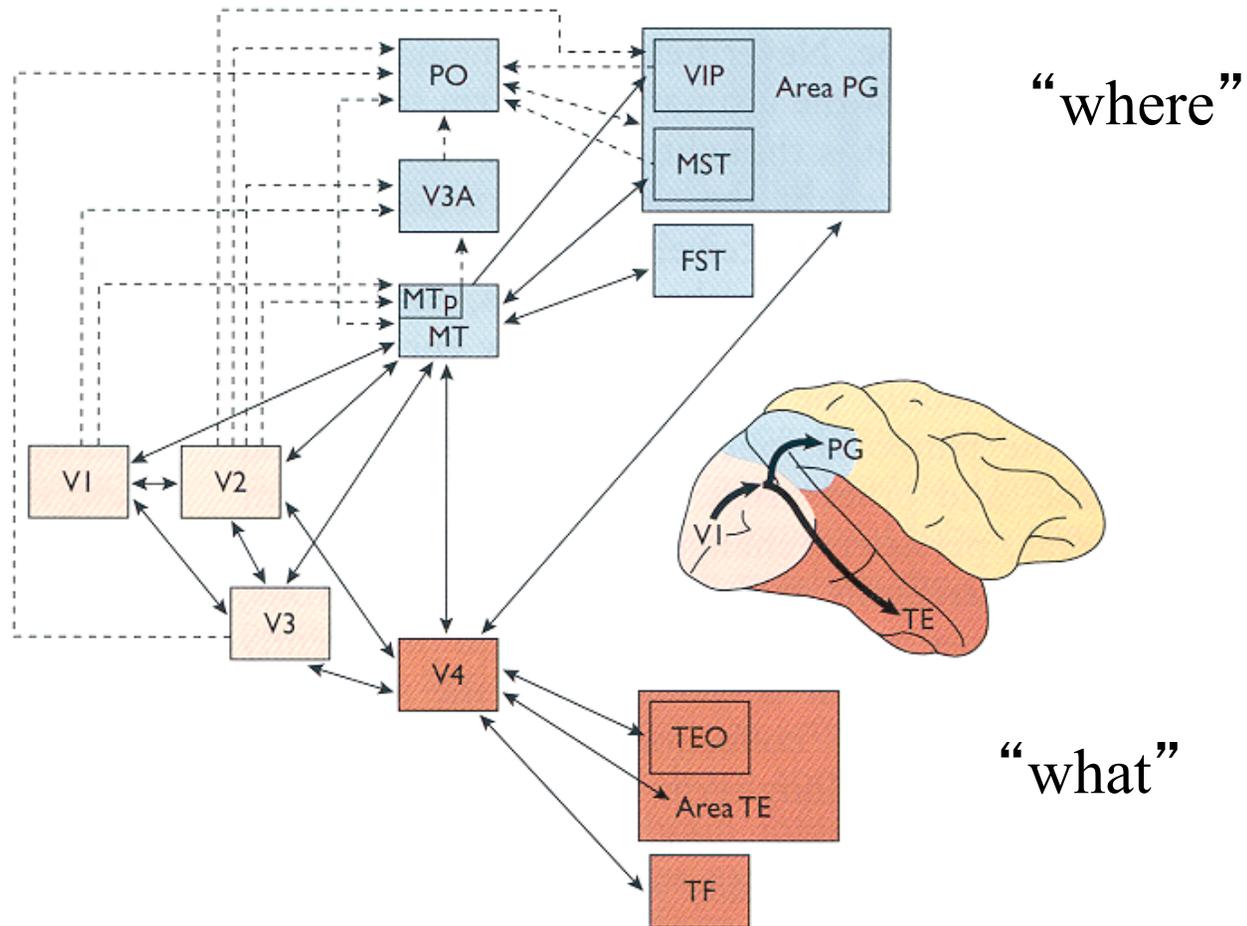
# Simple cell connectivity



# Complex cell connectivity



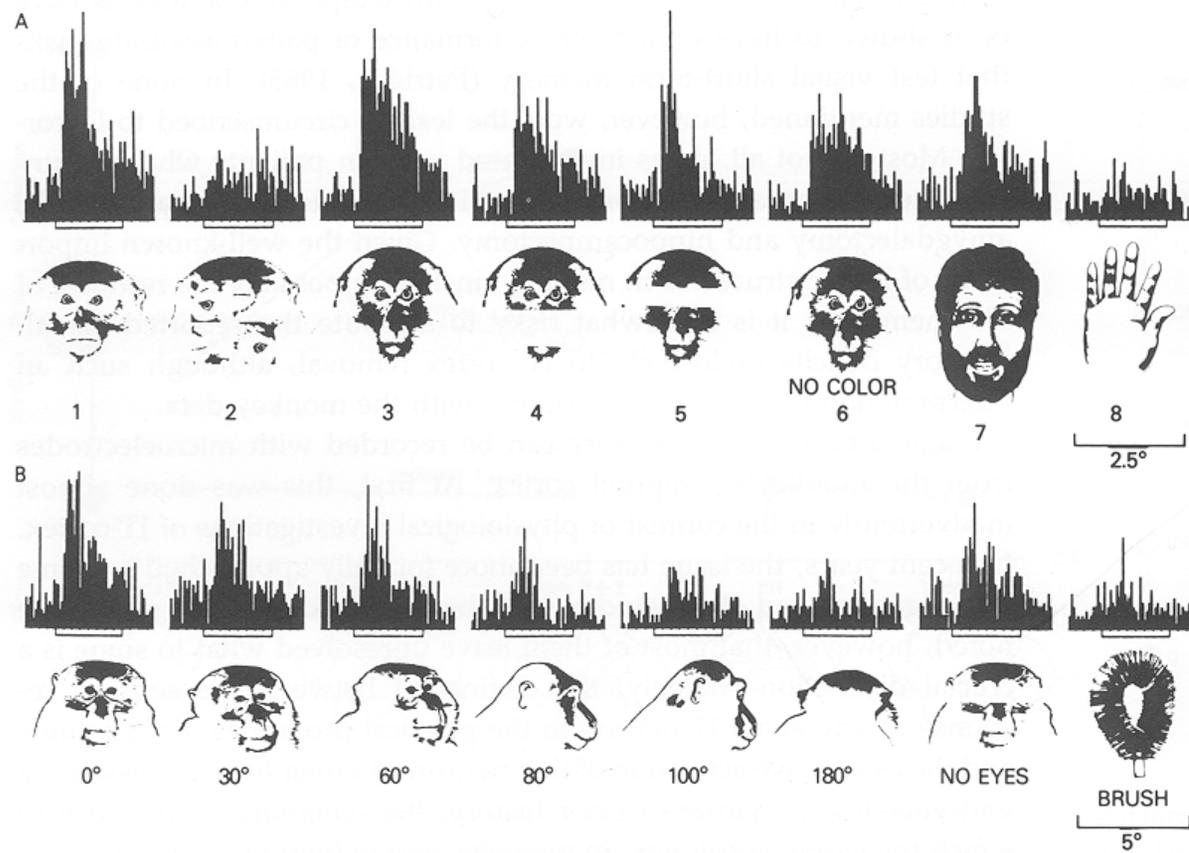
# Dorsal and ventral streams



# Inferotemporal cortex

- neuropsychology
  - IT lesions cause agnosia (“psychic blindness”)
  - monkeys and humans
- neurophysiology
  - neurons are selective to complex features
  - high degree of spatial invariance

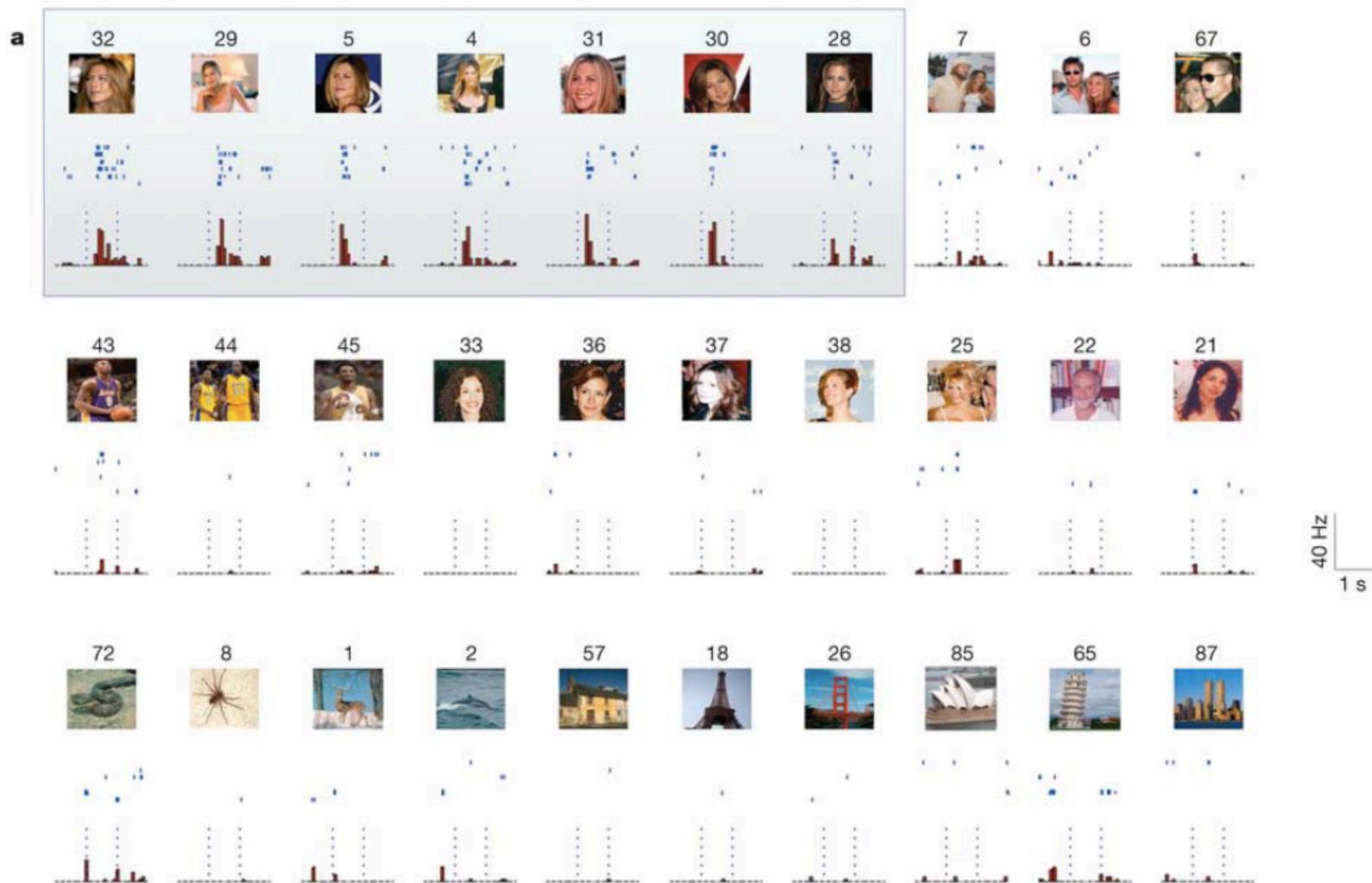
# “Face cells”



# Human neurophysiology

- Medial temporal lobe
  - hippocampus, amygdala, entorhinal cortex, parahippocampal gyrus
- Stimuli
  - famous persons, buildings, animals, objects
- Quiroga, Reddy, Kreiman, Koch, and Fried. *Nature* 435:1102 (2005).

# Jennifer Aniston neuron



# Selectivity and invariance

- Selectivity
  - Only 14% of neurons responded.
  - Responses to 3% of the pictures.
- Invariance
  - different views
  - pencil sketches
  - letter strings

# Selectivity and invariance in V1

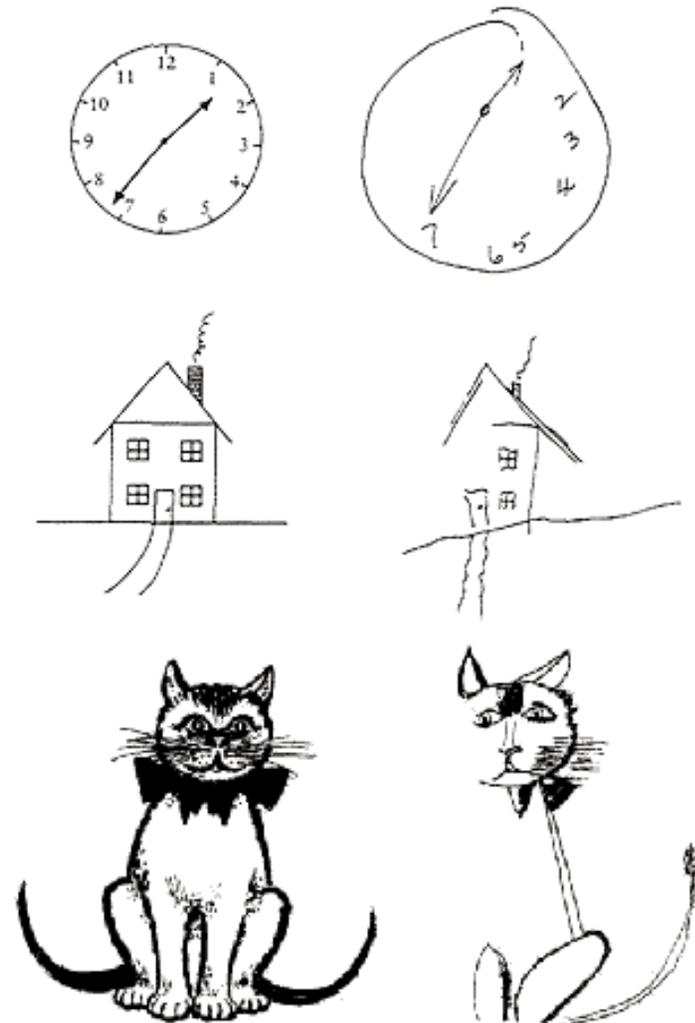
- Simple cells
  - selective to stimulus orientation
  - conjunction
- Complex cells
  - invariant to stimulus location
  - disjunction

# Hierarchical perceptron model

extrapolation of simple-complex  
cell archetype to many layers

# Hemispatial neglect

- Most commonly on left side, caused by damage to right posterior parietal cortex



# Posterior parietal cortex

- Multimodal association area
- “Vision for action”
- Neuropsychology
  - Lesions cause apraxia, hemineglect
- Neurophysiology
  - Coordinate transformations