

Visual Neuroscience: Vision as an example of neural processing

Intro Psychology
Georgia Tech
Instructor: Dr. Bruce Walker

Today

- Visual pathway
- Neural representations
- Computation and parsing the visual scene

Neuroscience

- Understanding the neural structures, pathways, and mechanisms helps us understand perception, thinking, responding, living
- The brain is exceedingly complex, but...
- There are regularities and patterns of organization
- The visual system is well-studied, and quite accessible to our "tools" (which were?...)
- Can use the visual system as a model for the other systems, and for the total integration of the brain

Neuroscience

- This is a science
- It involved hypotheses, testing, experiments
- It involves doubt, probabilities, and statistics, but...
- We do understand some components very well

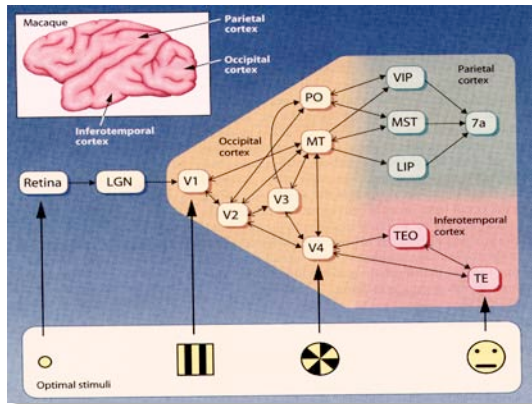
Visual Neuroscience

- Visual system is not entirely understood but
 - Nice convergence of information about neural structures and computational properties
 - Excellent case study of how we can understand a complex perceptual and cognitive system on multiple levels

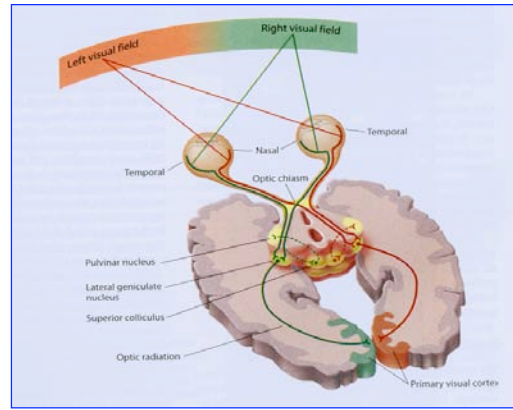
Vision as example of brain-style computations

- Good solid information about neural structures in visual cortex
- Good understanding of neural computations
- Basic principles seem to extend to other areas

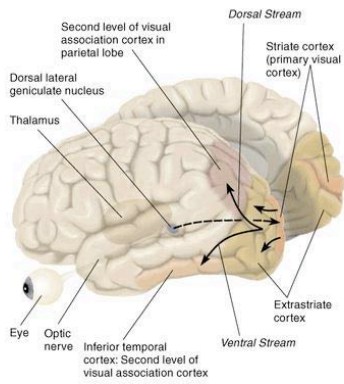
Visual Areas



Flow of Visual Information



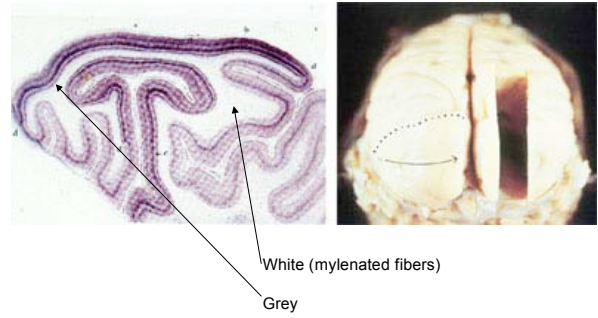
► The Human Visual System



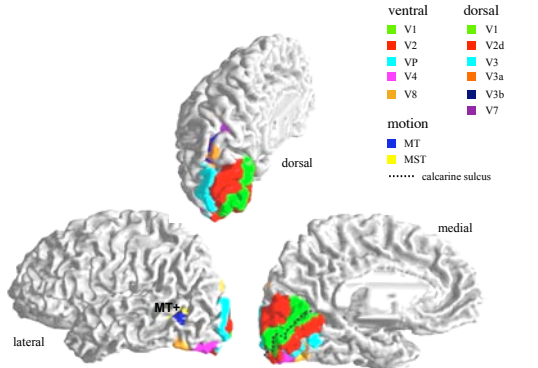
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White and Grey Matter

Slice through Monkey Primary Visual Cortex

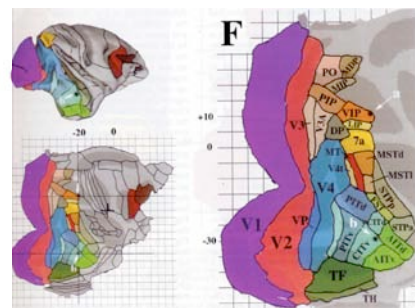


Multiple Visual Areas in Cortex



Brewer A & Wandell B

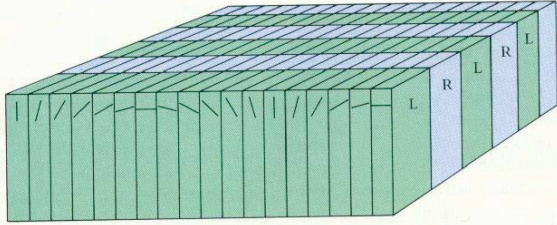
Visual Areas in Monkey Cortex



Van Essen et al. Vision Research 2001

Neural Representations

- Topographic
 - Similar things represented nearby on cortex

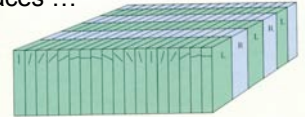


Hierarchical Organization

Simple representations – lines of some orientation

More complex representations – intersections, T junctions

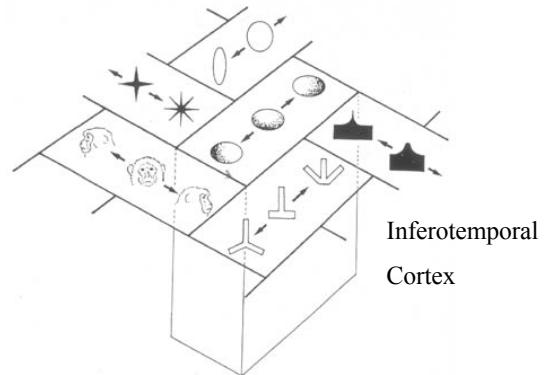
Still more complex – surfaces ...



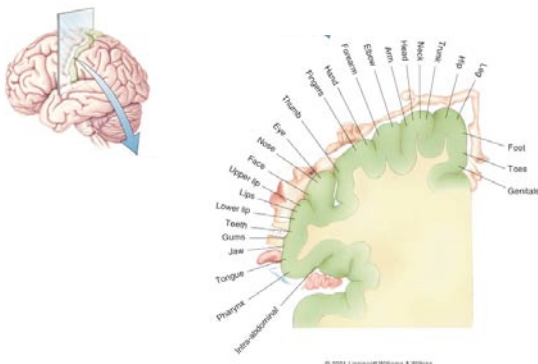
Neural Representations

- Topographic
 - Similar things represented nearby on cortex
 - Location
 - Retinotopic (vision)
 - Tonotopic maps (frequencies)
 - Objects (based on visual properties)
 - Memories - probably but limited evidence?
 - Emotions - no idea

Neural Representations



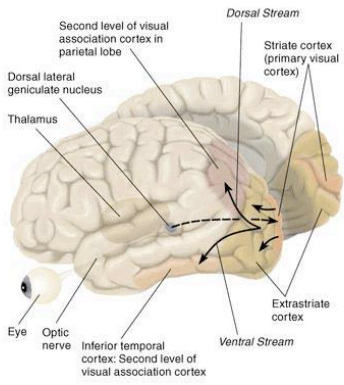
Somatosensory Map



Neural Representations

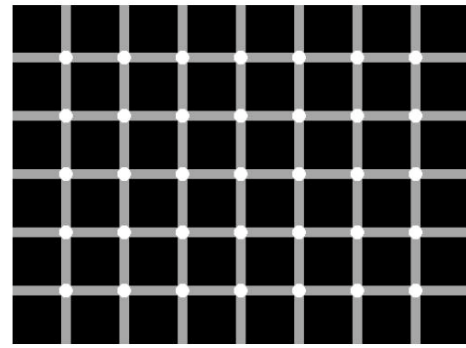
- Topographic
 - Similar things represented nearby on cortex
- Division of labor
 - Modalities are processed separately (vision, audition, memory, etc)
 - Vision: location and identity

► The Human Visual System

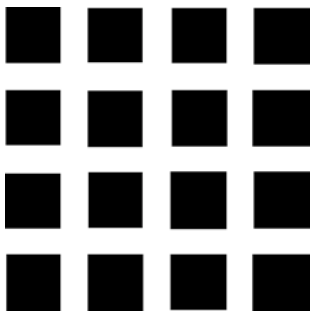


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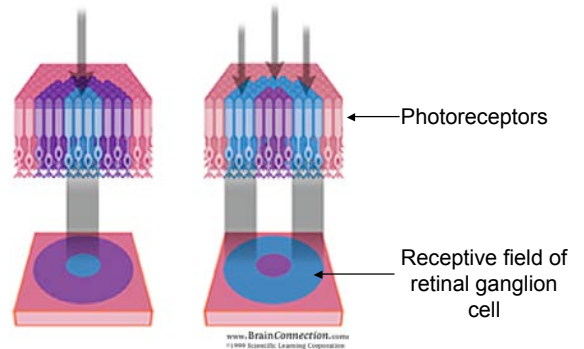
Count white and black dots



Hermann Grid

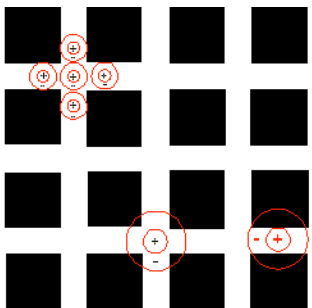


Center-Surround Opponency



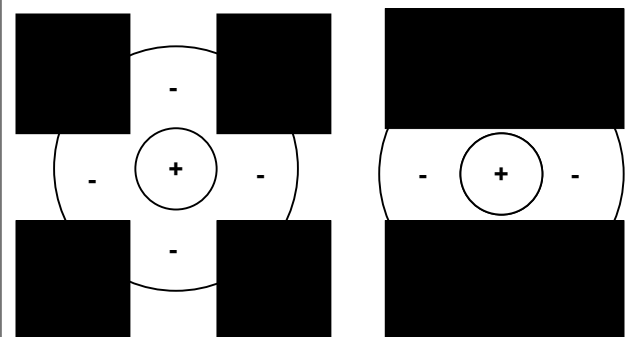
Hermann Grid

foveal representation →

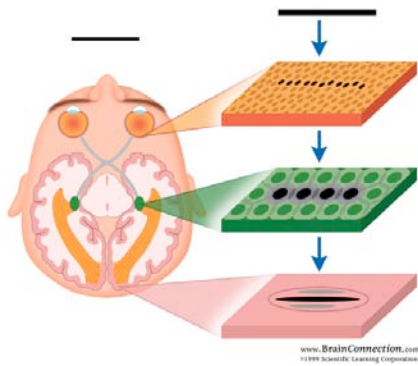


← extra-foveal representation

Hermann Grid

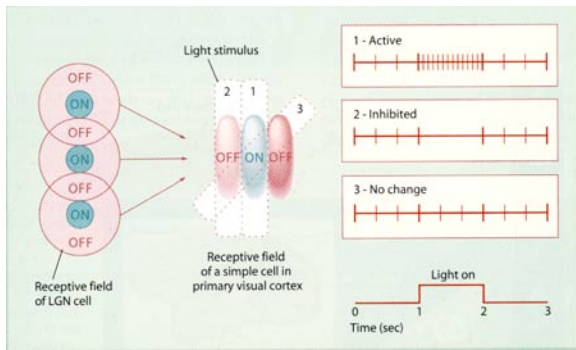


Line Detection

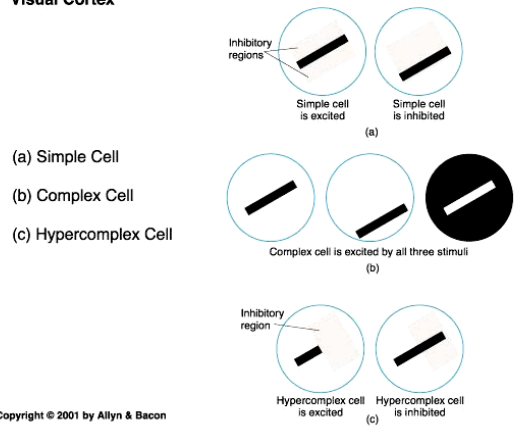


Hubel & Weisel QT movie

Hubel & Wiesel



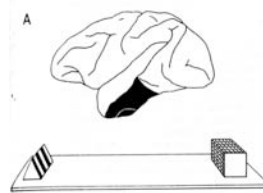
► Response Characteristics of Neurons to Orientation in the Primary Visual Cortex



Further into the visual system

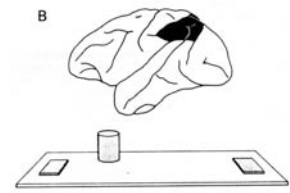
“What” and “Where” visual pathways

Mishkin & Ungerleider, 1982



“what”

Lesions in IT cortex produce deficits in shape discrimination tasks
Gross et al, 1973, Mishkin 1982

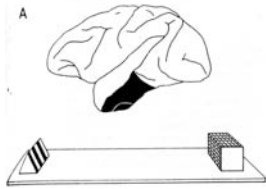


“where”

Lesions in parietal cortex produce deficits in landmark task
(Pohl et al. 1973)

“What” ventral visual pathway

Mishkin & Ungerleider, 1982



“what”

In humans lesions in occipital-temporal areas produce **visual agnosia**: an impairment of object recognition that is not attributable to general loss in intelligence or elementary visual perceptual losses such as brightness, acuity depth & color

Lesions in IT cortex produce deficits in shape discrimination tasks
Gross et al, 1973, Mishkin 1982

“Where” dorsal visual pathway

Pohl et al. 1973; Mishkin & Ungerleider, 1982

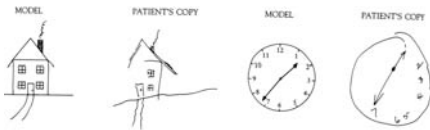


“where”

Lesions in parietal cortex produce deficits in landmark task

Spatial Attention and the Parietal Lobe: Neglect Patients

Unilateral neglect: patients with lesions to the parietal lobe fail to notice things in the visual field opposite (contralateral) to their injury.



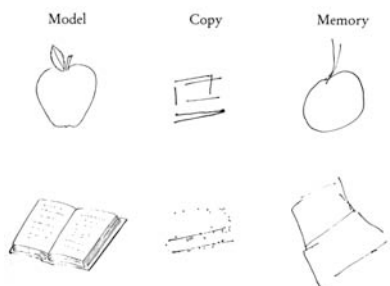
Seems consistent with the possibility that some aspect of “where system” is damaged.

Object Vision and Actions: two cortical pathways

Goodale and Milner (1991)

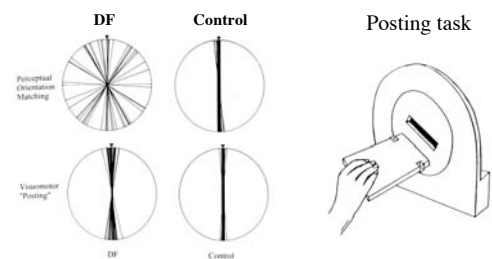
- **Ventral Stream- perception**
 - Object shape, color, texture
 - Awareness?
- **Dorsal Stream - action**
 - Grasping and reaching towards objects
 - Representation of object form in addition to information about objects' location & size

Patient DF: no form visual perception



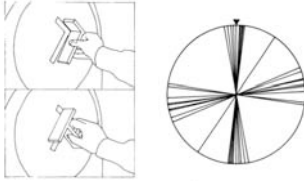
- Cannot identify line drawings of common objects
- Cannot copy line drawings
- Can draw from memory as long as she doesn't lift hand from paper

Patient DF: acting without perceiving



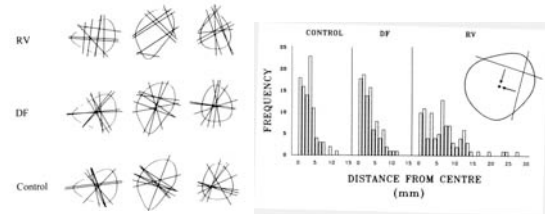
Perceptual matching task: performs poorly
Posting task: performs well, begins to rotate card in the correct direction when movement begins

DF: limitations to acting without perceiving



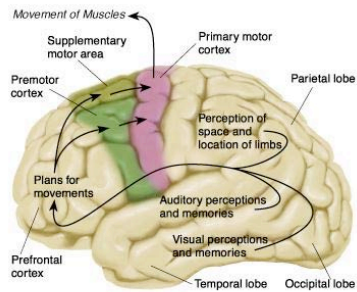
“T” task: DF was able to grasp the object at the correct point but half the times made a 90° mistake in orienting the object toward the slot.

Patients VR and RV: visu-motor deficits but spared perceptual abilities



Object ataxia: unable to use visual information to reach out and grasp objects. At the same time have no difficulty in recognizing or describing objects in the impaired visual field.

► Cortical Control of Movement



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Upcoming

- Sleep
- Motivation & Learning
- Sensation & Perception