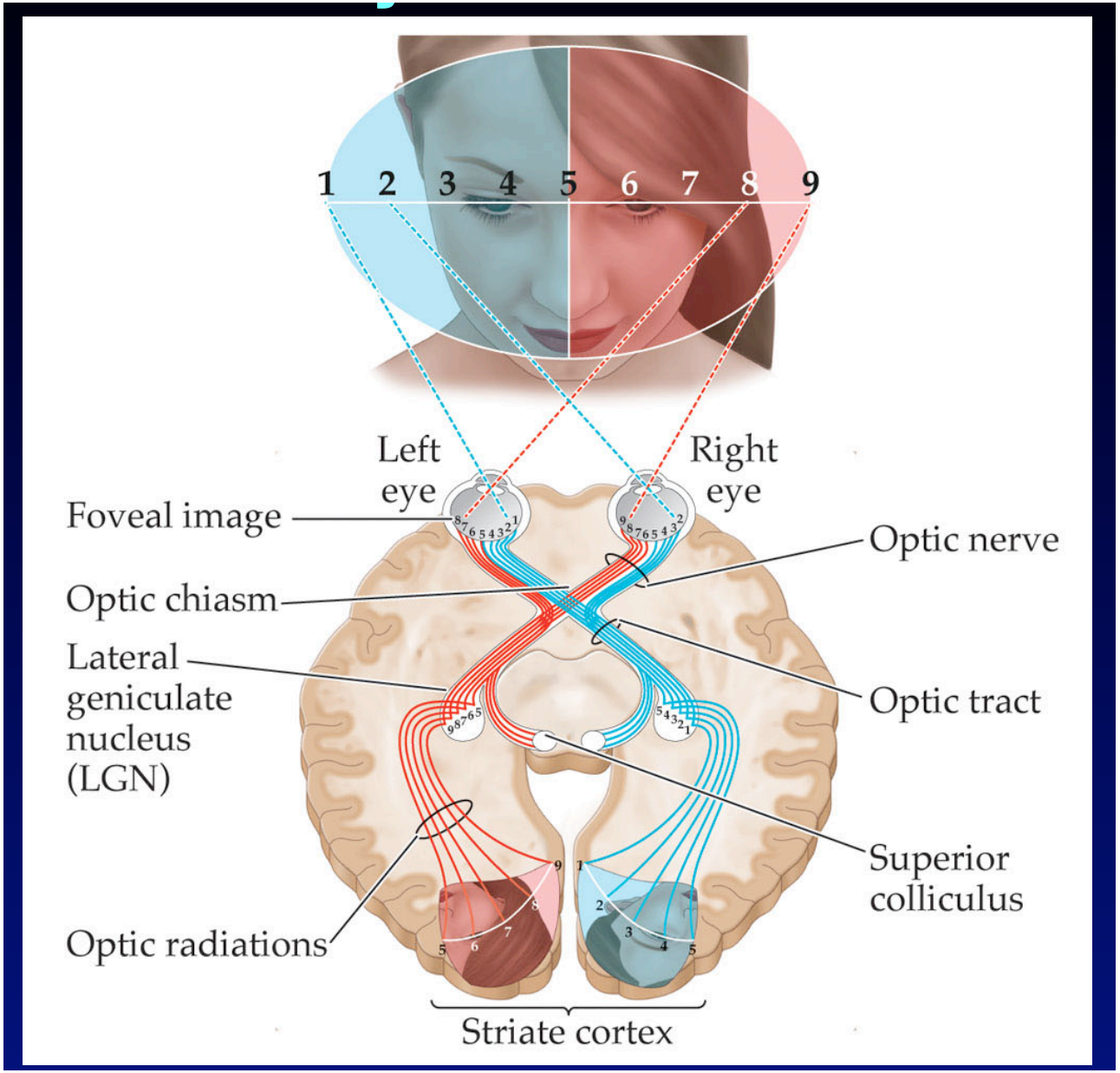
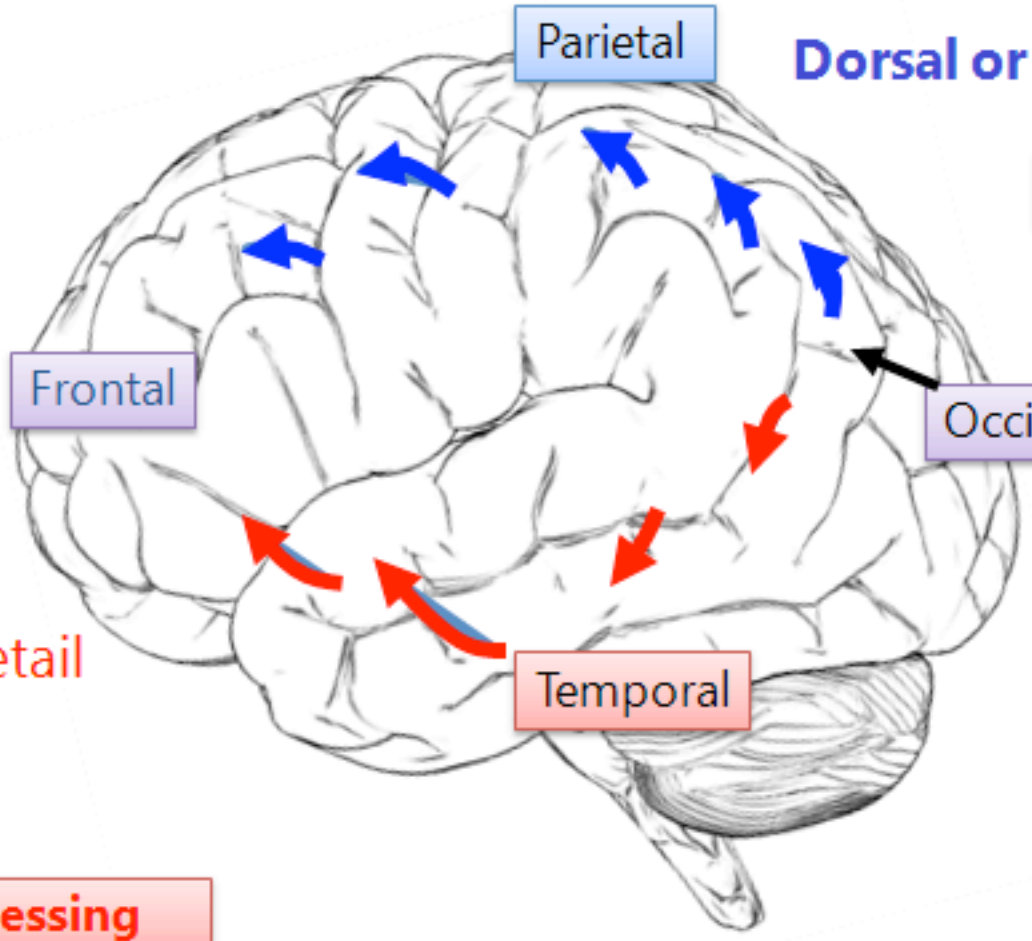

1 2 3 4 5 6 7 8 9
Left eye
Right eye
Foveal image
Optic nerve
Optic chiasm
Lateral geniculate nucleus (LGN)
Optic tract
Superior colliculus
Optic radiations
Striate cortex

Visual Streams



Dorsal or "where" stream

Spatial processing

location

movement

spatial transformations

spatial relations

Attention

color

texture

pictorial detail

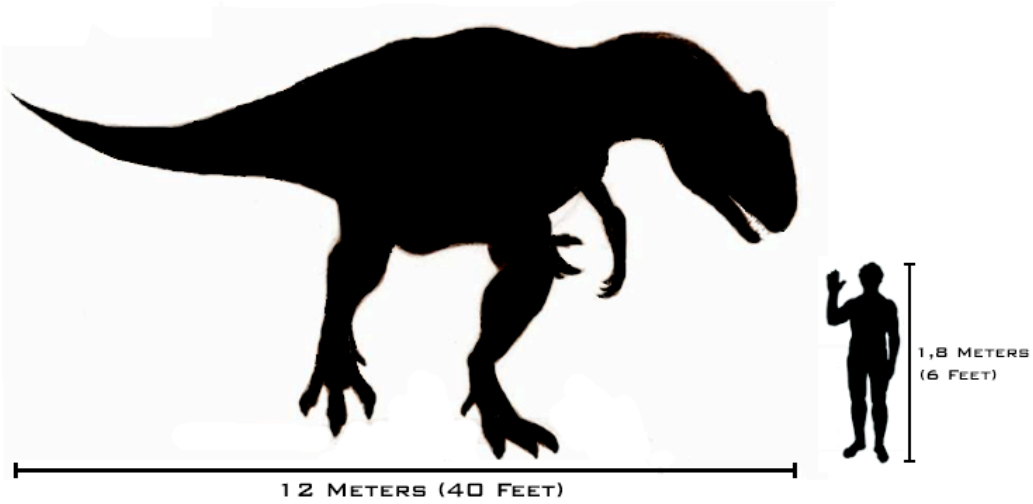
shape

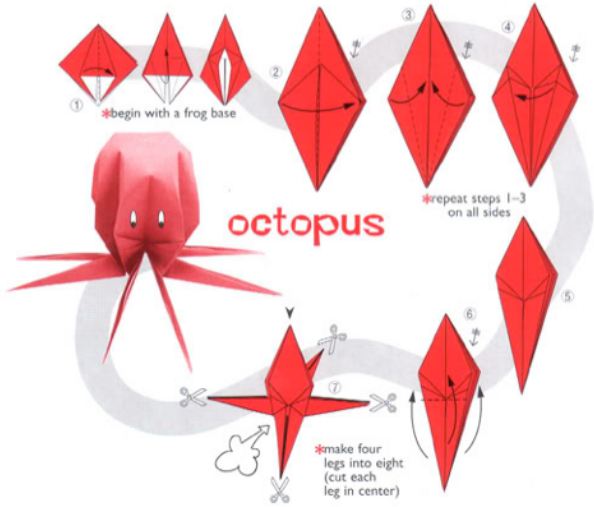
size

Object processing

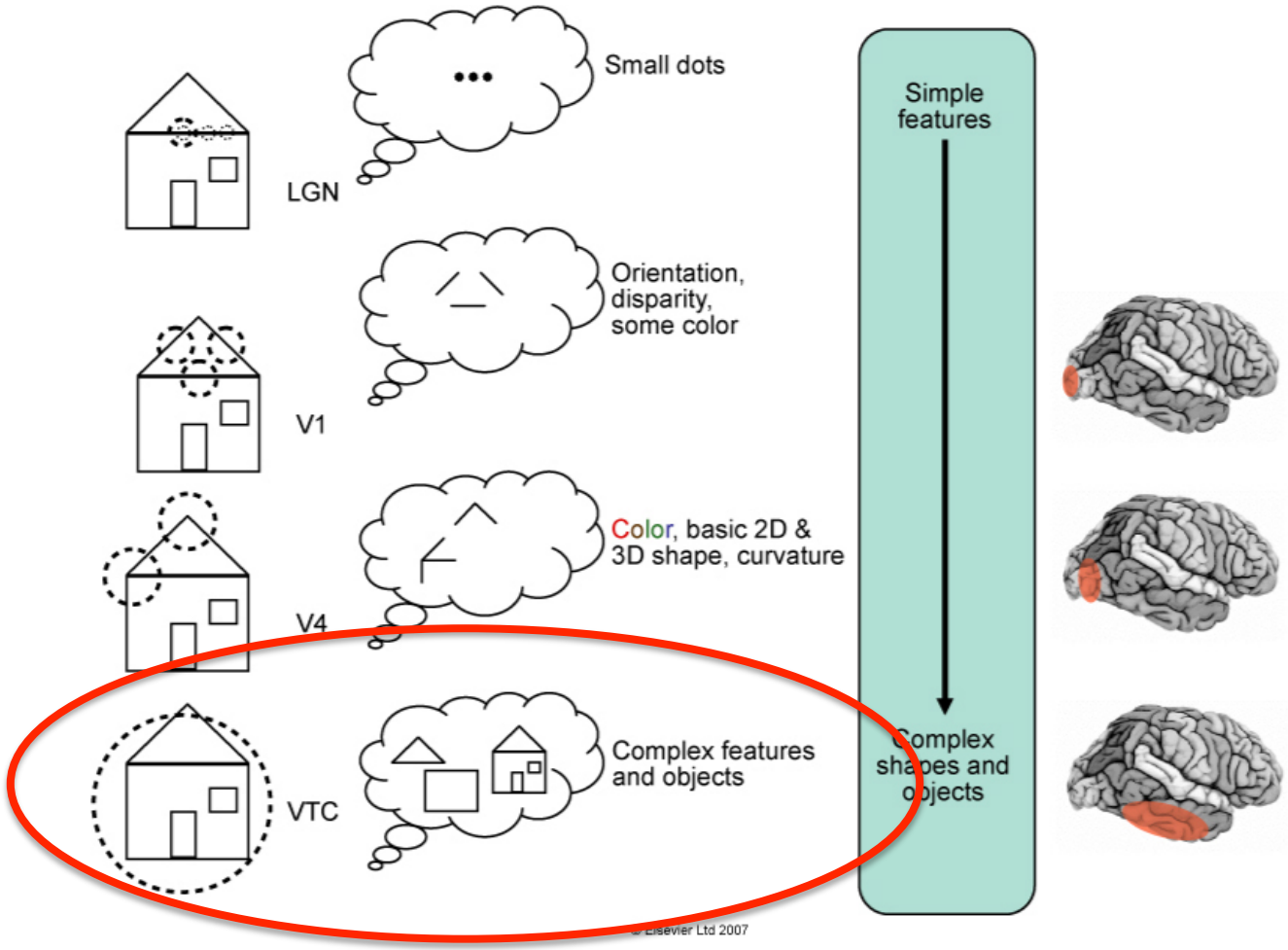
Ventral or "what" stream

Dorsal Stream: Vision beyond identification

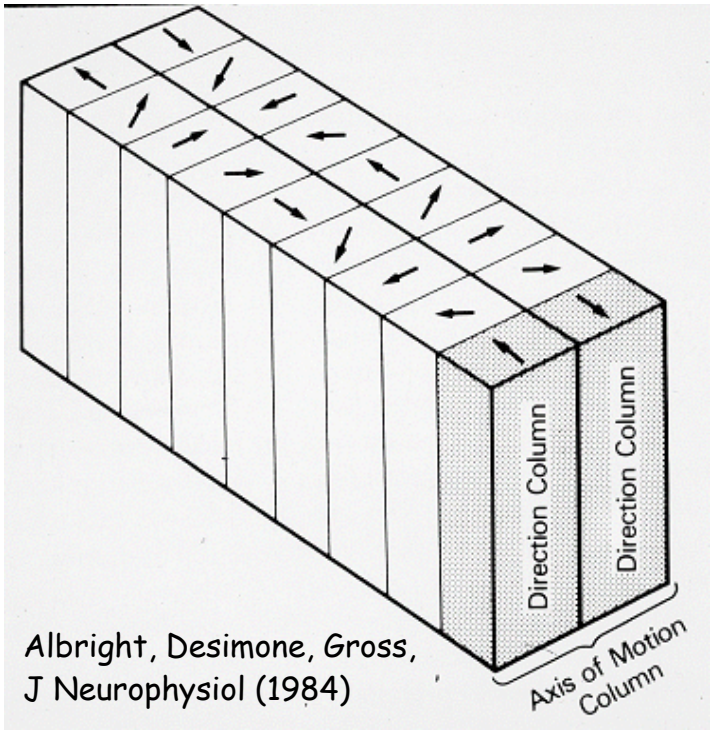




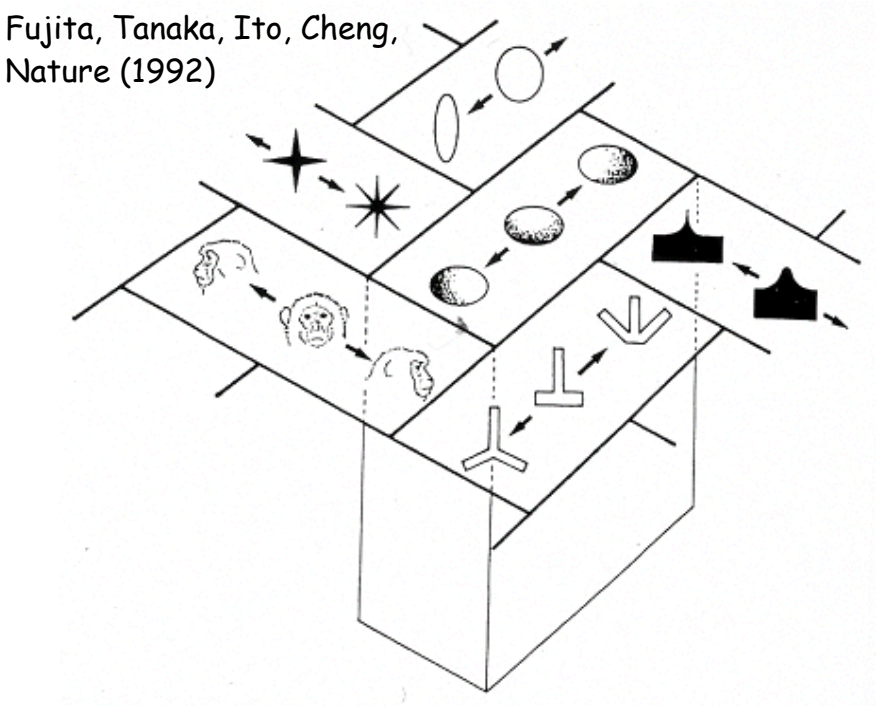
Ventral Stream: Identification
Hierarchical Organization



Columnar architecture in other visual areas

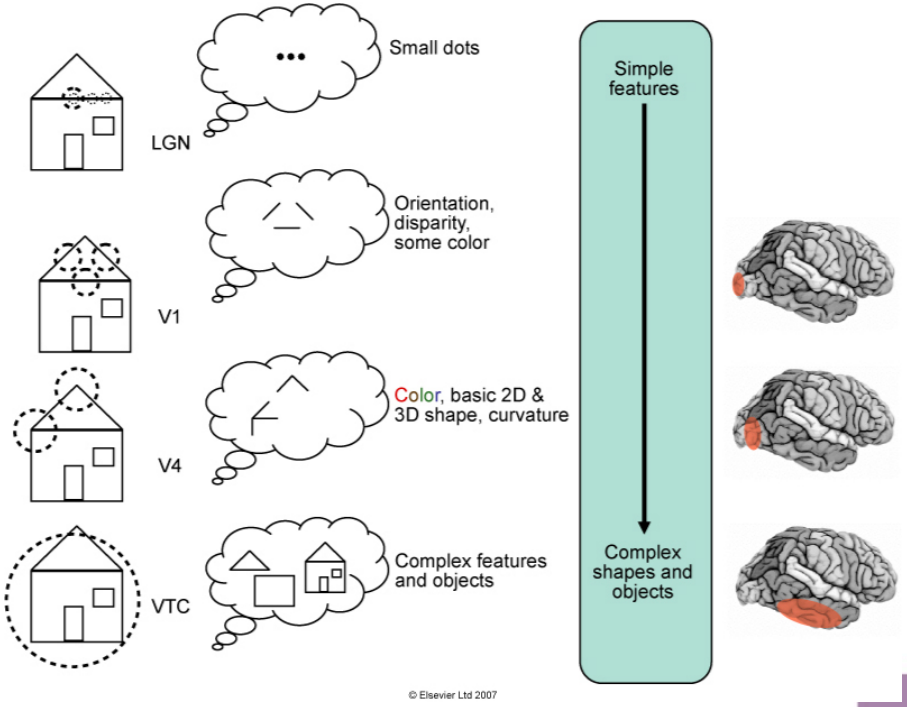


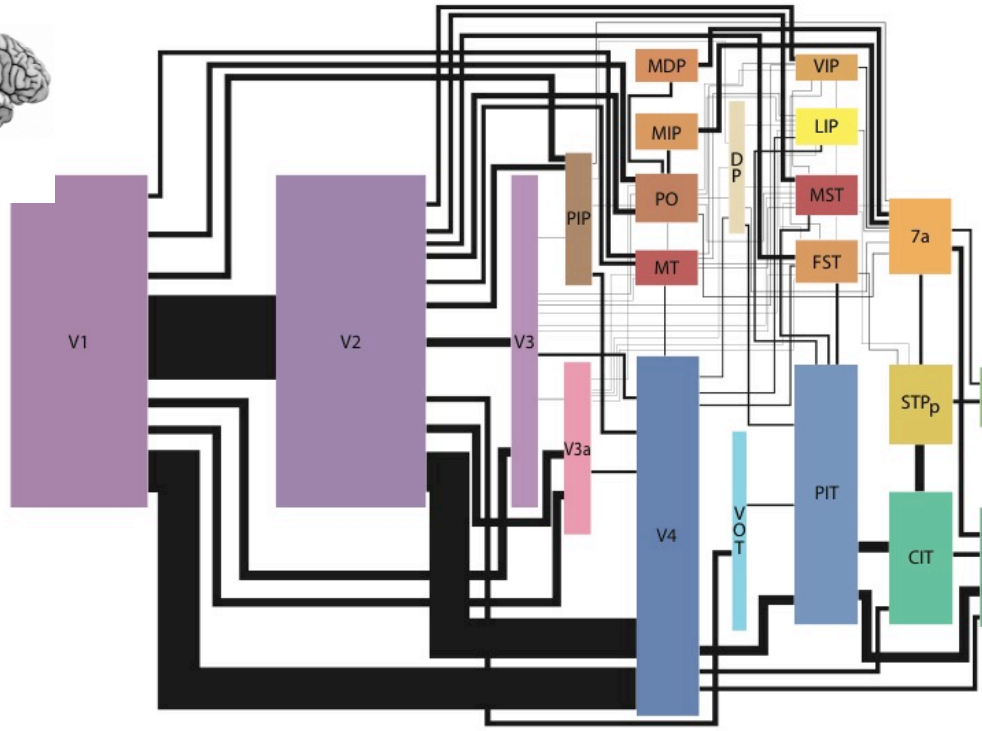
Direction columns in MT



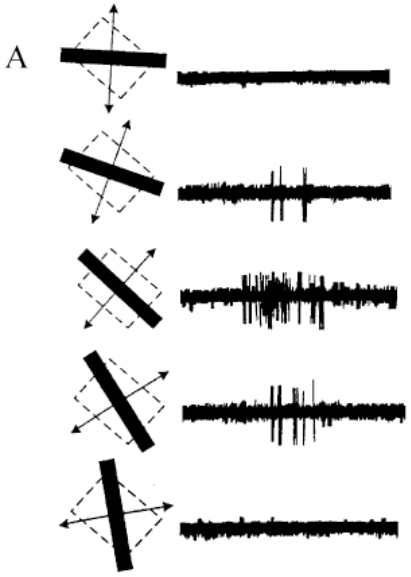
"Feature" columns in IT

Hierarchical Organization

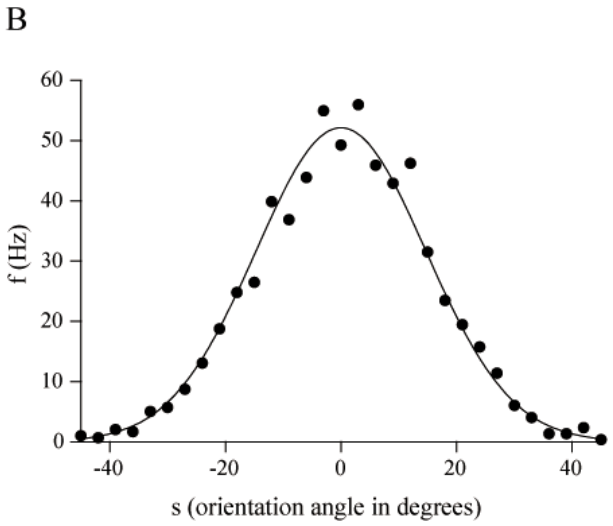




Single unit recordings in V1: Orientation selectivity

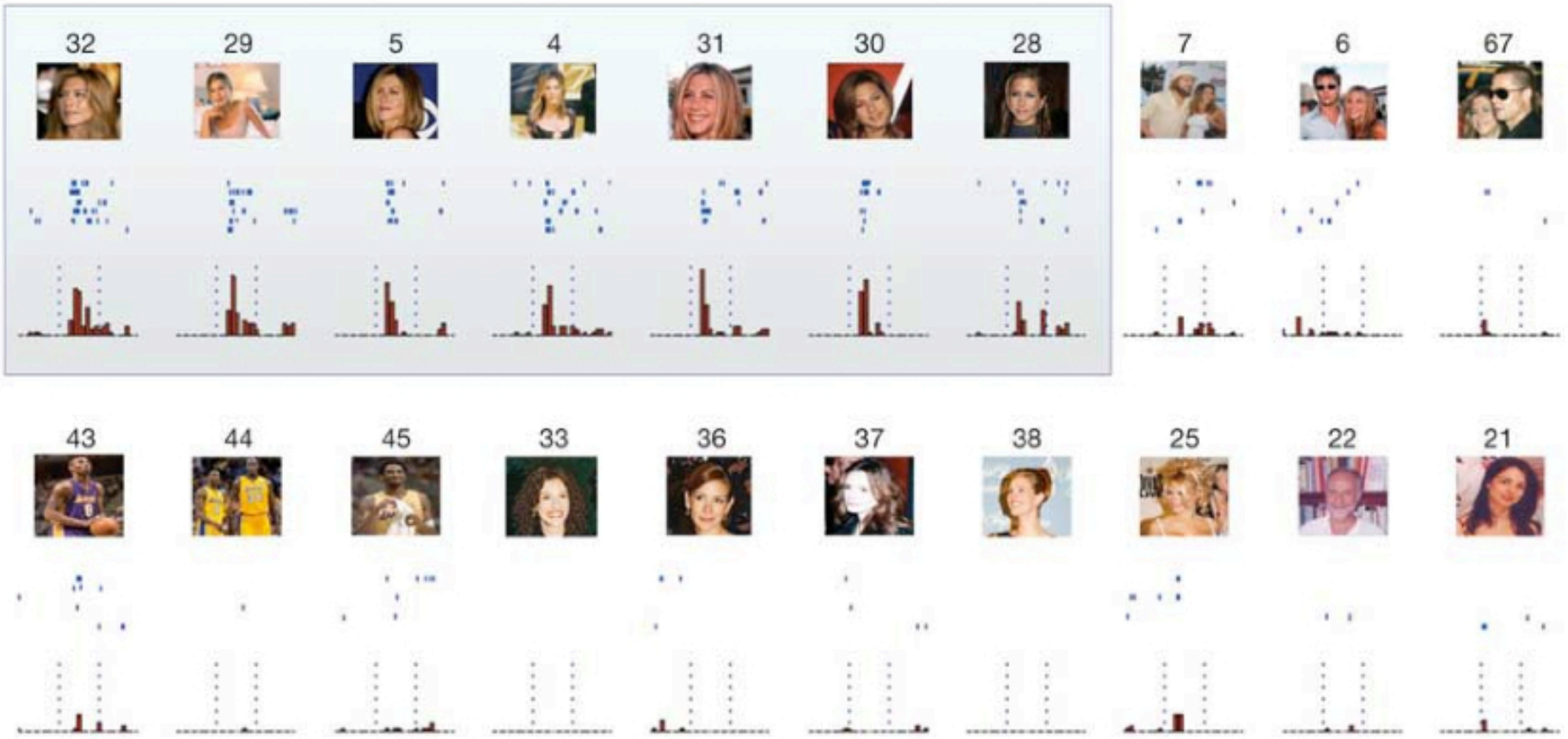


V1 data



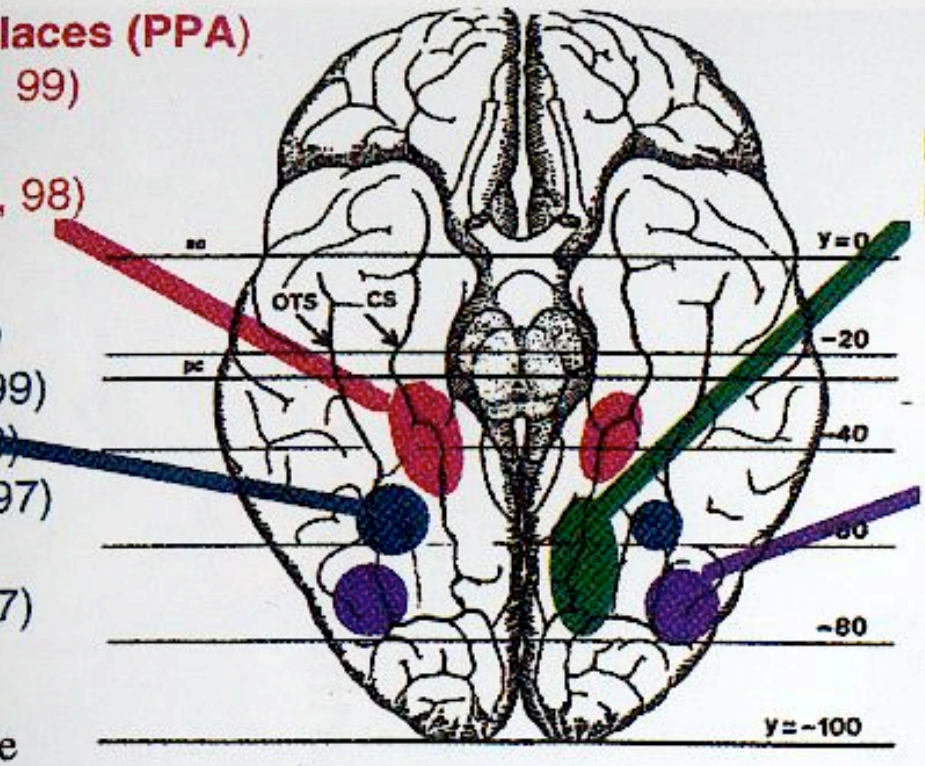
Stimulus orientation (deg)

Response selectivity: the “Jennifer Aniston cell”



Spatial Layout/Places (PPA)
Epstein et al. (98, 99)
Aguirre et al. (98)
Maguire et al. (97, 98)

Faces (FFA)
Sergent et al. (92)
Haxby et al. (94, 99)
Puce et al. (95, 96)
Kanwisher et al. (97)
Clarke et al. (96)
McCarthy et al. (97)
Halgren et al. (99)



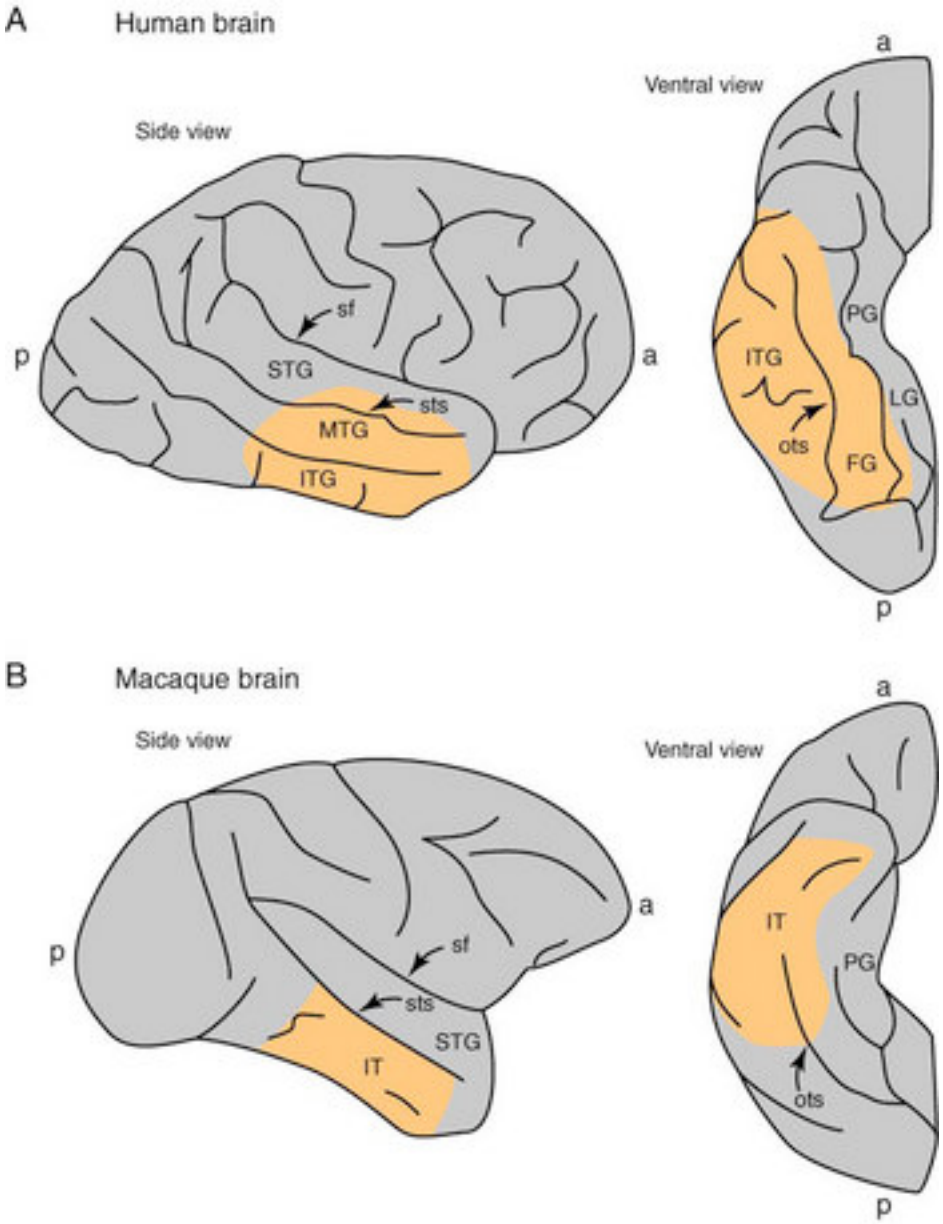
Visual Word Form?
Petersen et al. (90)
but see Howard et al.(92)
Price et al. (94)

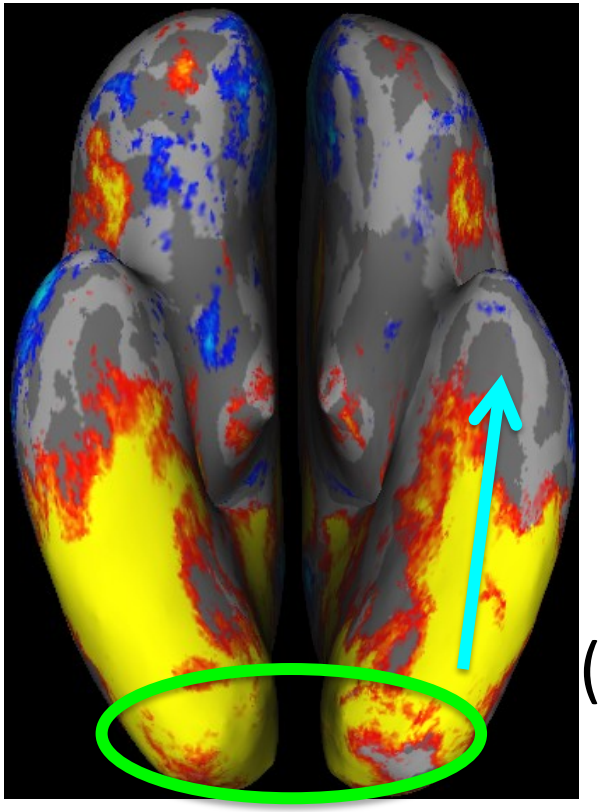
Shape Analysis?
Malach et al. (95)
Grill-Spector et al. (98, 99)
Kanwisher et al. (96)
Mendola et al. (99)

Right Hemisphere

Left Hemisphere

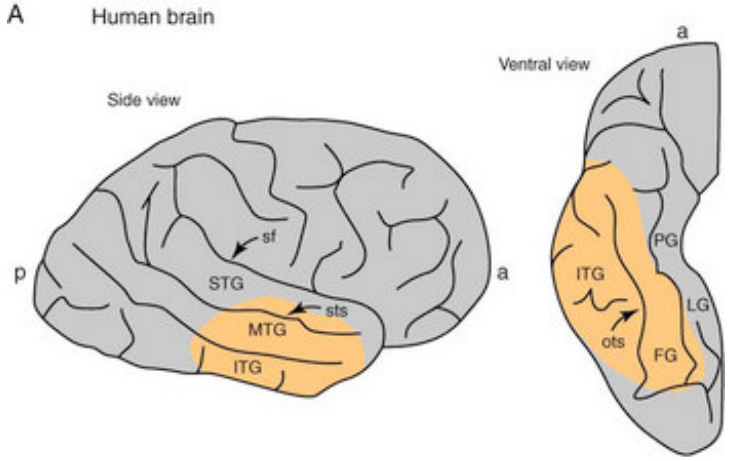
Ventral Stream

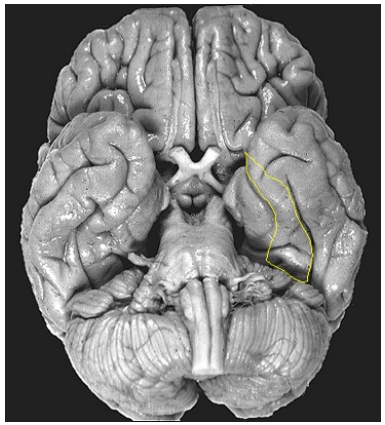


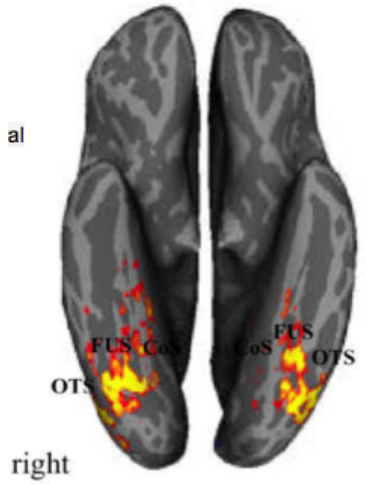


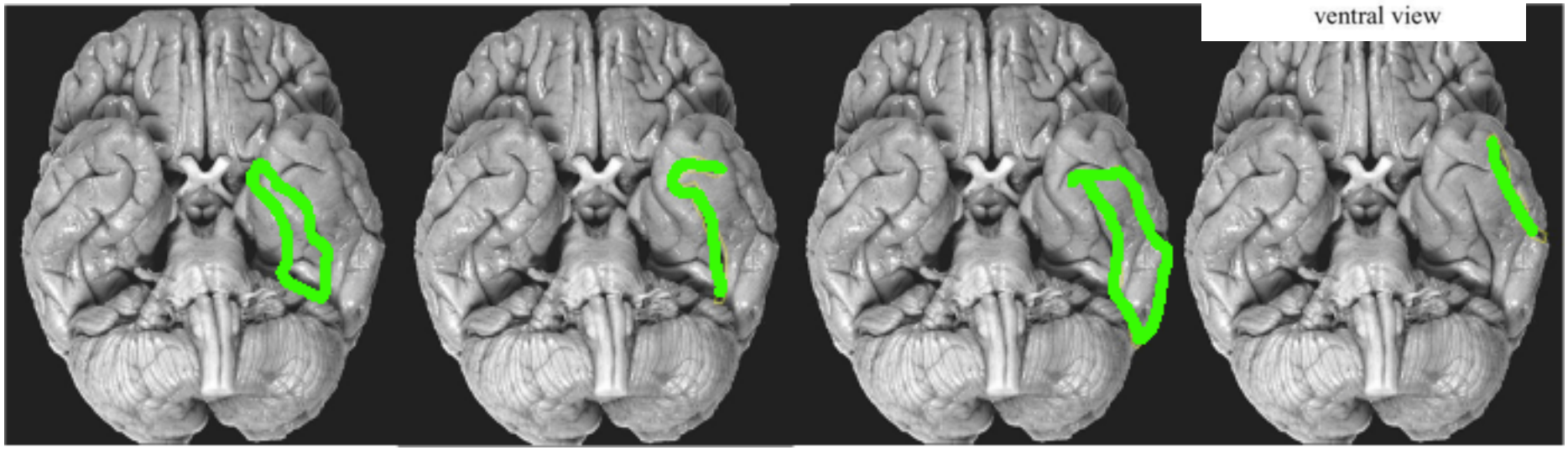
High Level (LOC, IT)

Low Level V1-V3









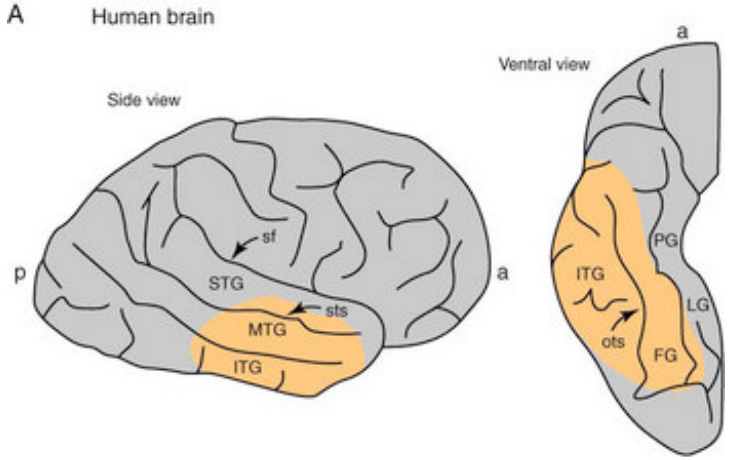
Fusiform gyrus

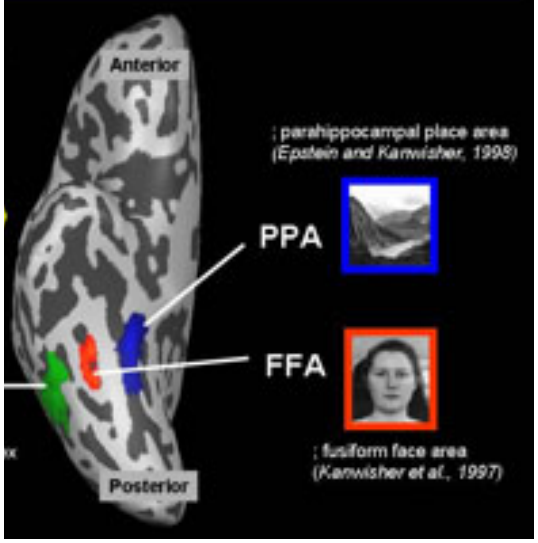
Occipitotemporal sulcus

Lateral occipitotemporal gyrus

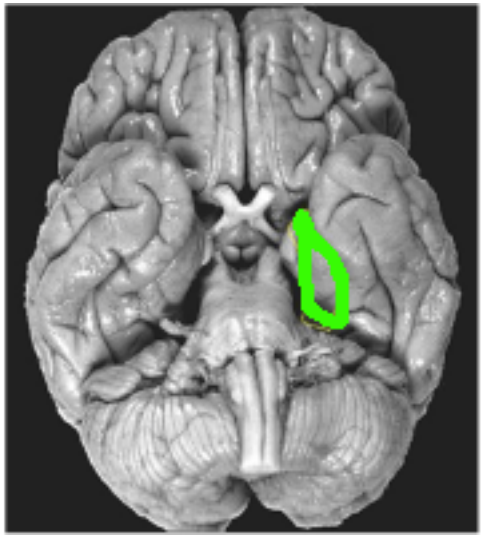
Inferior temporal sulcus

Inferior temporal cortex (IT): all of these regions; lateral occipital cortex (LOC); TE/TEO (monkey)

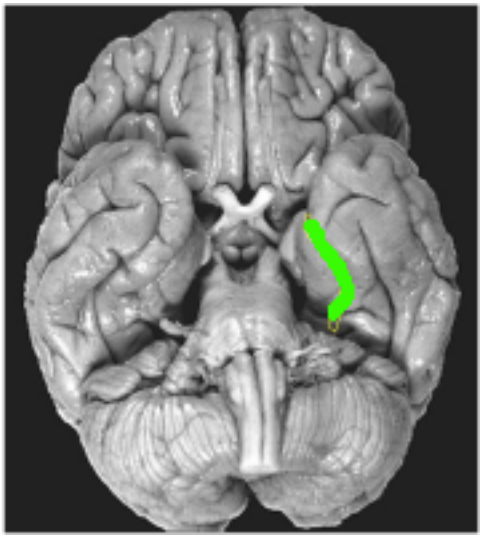




Lingual gyrus



Parahippocampal gyrus



Collateral sulcus

Medial temporal lobe; PPA; TE/TEO;TF;TH monkey

Neural Communication

"Neurons that fire together, wire together"

Hebbian Theory

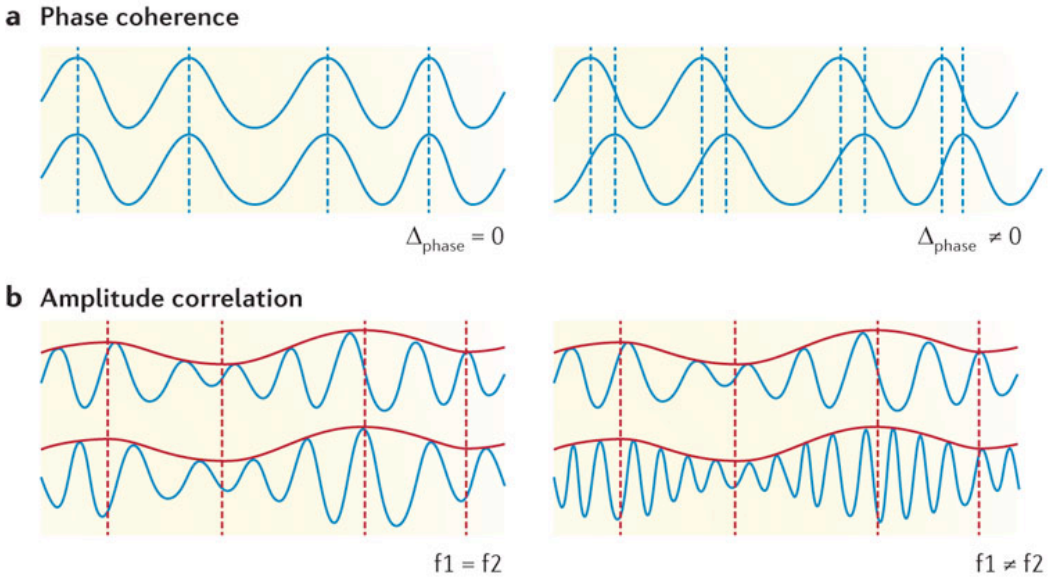
- Spatial organization
- Temporal organization

Spatial organization

- cells that are grouped together into functionally unique zones.
- Reflects functional mechanisms
- connected to other brain areas via long and short sets of pathways (axons of nerve cells)

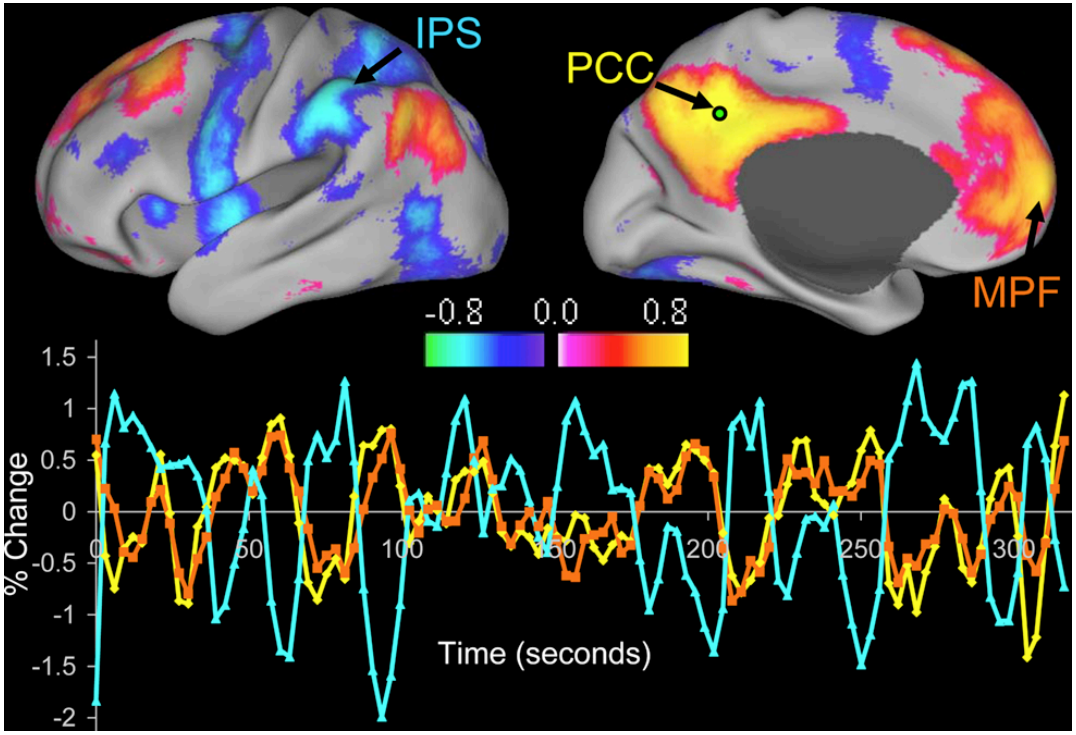
Temporal organization

- Firing rate of neurons carry meaningful information



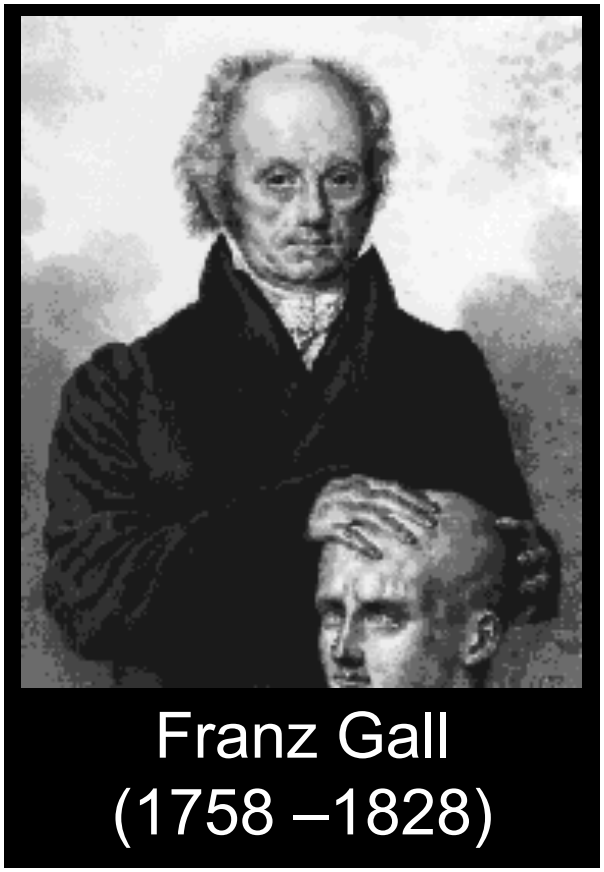
Temporal organization

- Carried through to levels of fMRI signal



Cognitive Neuroscience Methods

Franz Gall's Phrenology
1796



Franz Gall
(1758 –1828)

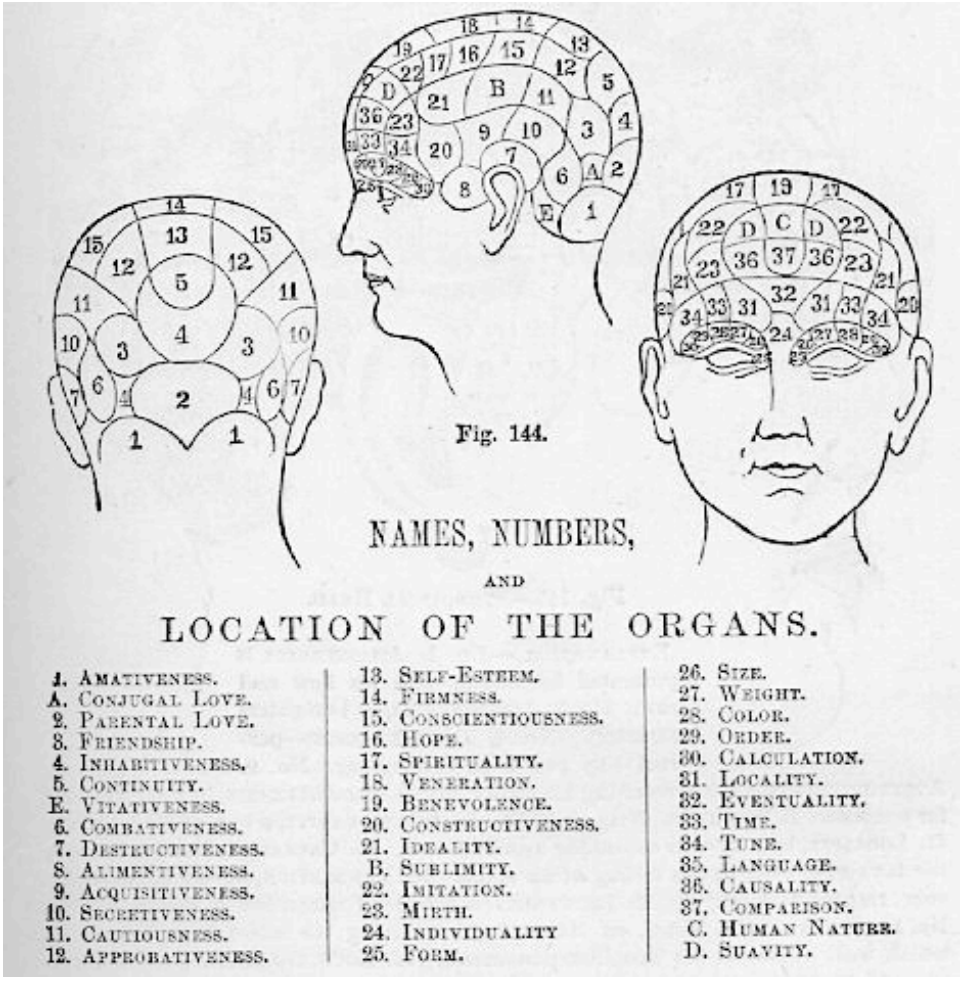


Fig. 144.

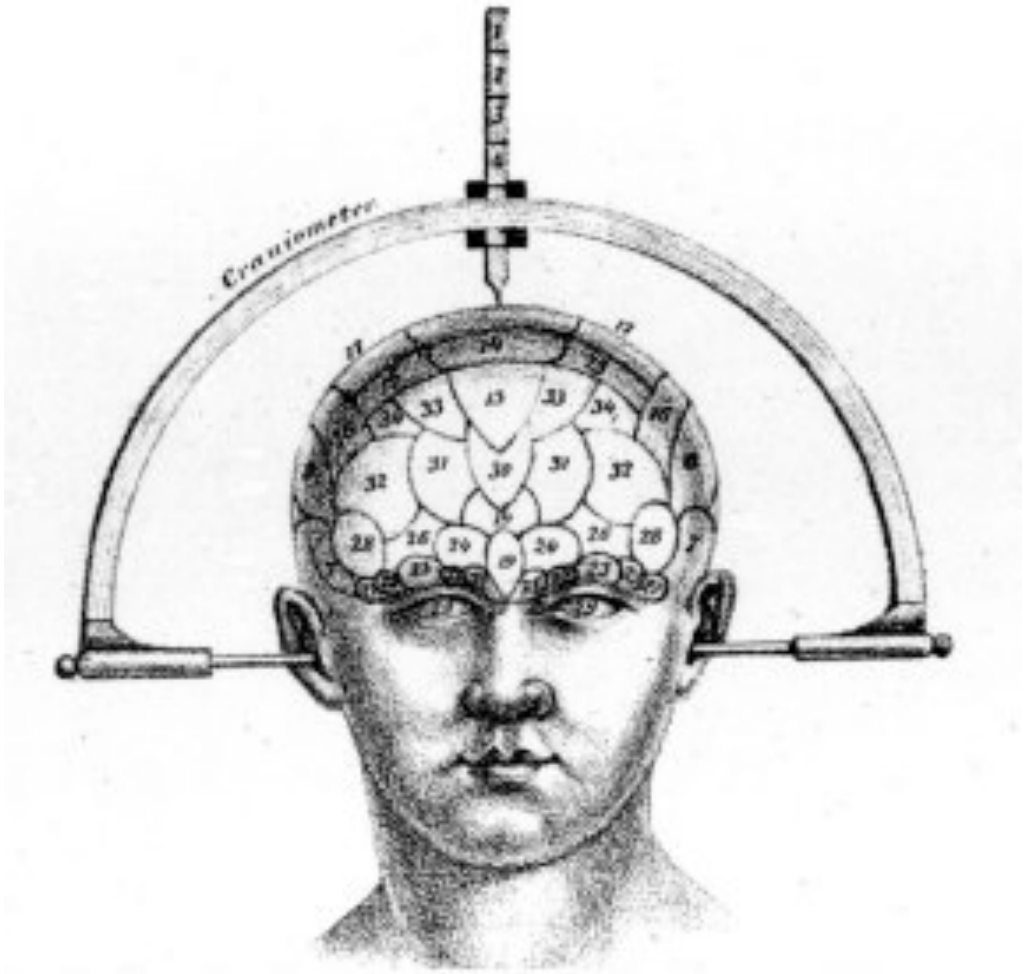
NAMES, NUMBERS,

AND

LOCATION OF THE ORGANS.

1. Amativeness.
A. Conjugal Love.
2. Parental Love.
3. Friendship.
4. Inhabitiveness.
5. Continuity.
E. Vitativeness.
6. Combativeness.
7. Destructiveness.
8. Alimentiveness.
9. Acquisitiveness.
10. Secretiveness.
11. Cautiousness.
12. Approbativeness.
13. Self-Esteem.
14. Firmness.
15. Conscientiousness.
16. Hope.
17. Spirituality.
18. Veneration.
19. Benevolence.
20. Constructiveness.
21. Ideality.
B. Sublimity.
22. Imitation.
23. Mirth.
24. Individuality
25. Form.
26. Size.
27. Weight.
28. Color.
29. Order.
30. Calculation.
31. Locality.
32. Eventuality.
33. Time.
34. Tune.
35. Language.
36. Causality.
37. Comparison.
C. Human Nature.
D. Suavity.

Franz Gall's Phrenology
1796



Wrong about:

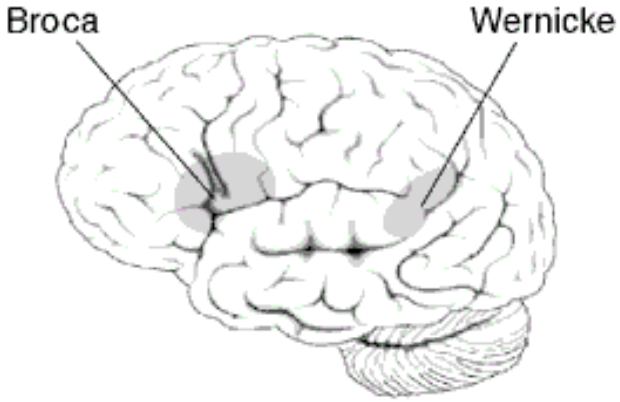
- Bumps
- traits

Right about:

- Localization

Patient Work/Brain Lesions

Broca's and Wernicke's aphasia – 1870's-ish



Visual Agnosias 1890 – Lissaeuer – Apperceptive and Associative
Studies of brain lesions really gained speed in the 1970s

Electrical Stimulation

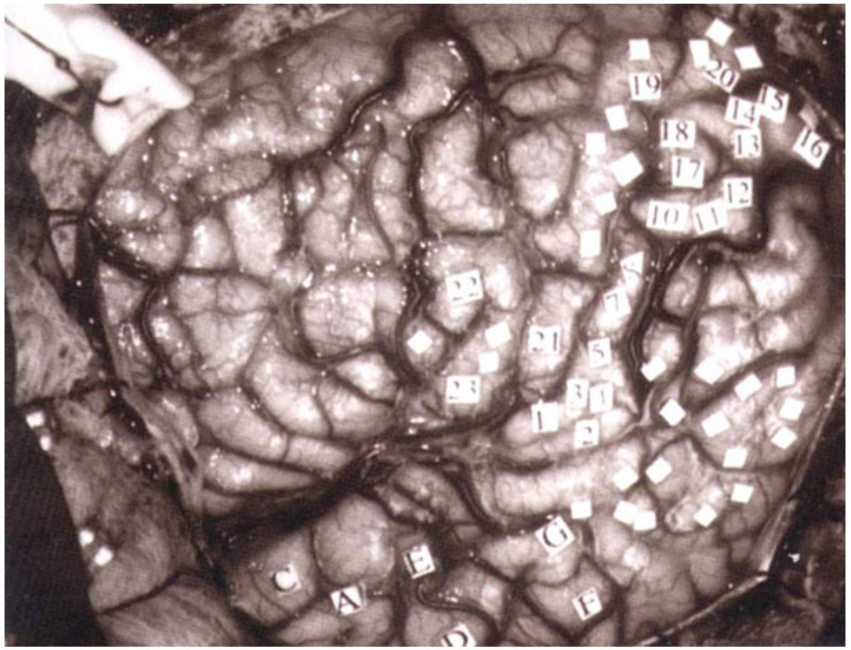


Figure 7. Human brain labeled as to cortical areas during neurosurgery. From Penfield.

Human neurosurgery

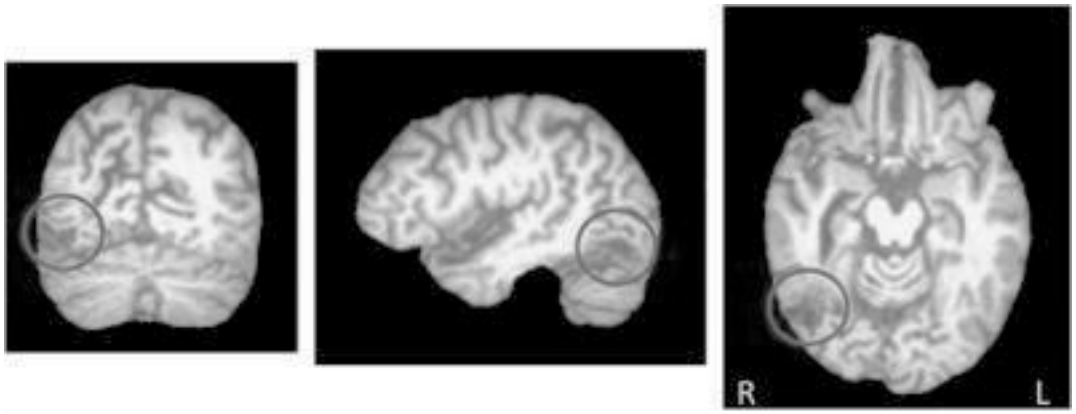
Penfield 1951

Hubel & Weisel – 1950s, 1960s, 1970s – orientation columns

Patient Work/Brain Lesions

- Visual Agnosias 1890

- Studies of brain lesions really gained speed in the 1970s
  Warrington & Colleagues



- 1980s - neurophysiology

Brain Lesions

As a result of traumas, surgery, infarcts, or diseases

<u>Main advantage:</u> causality

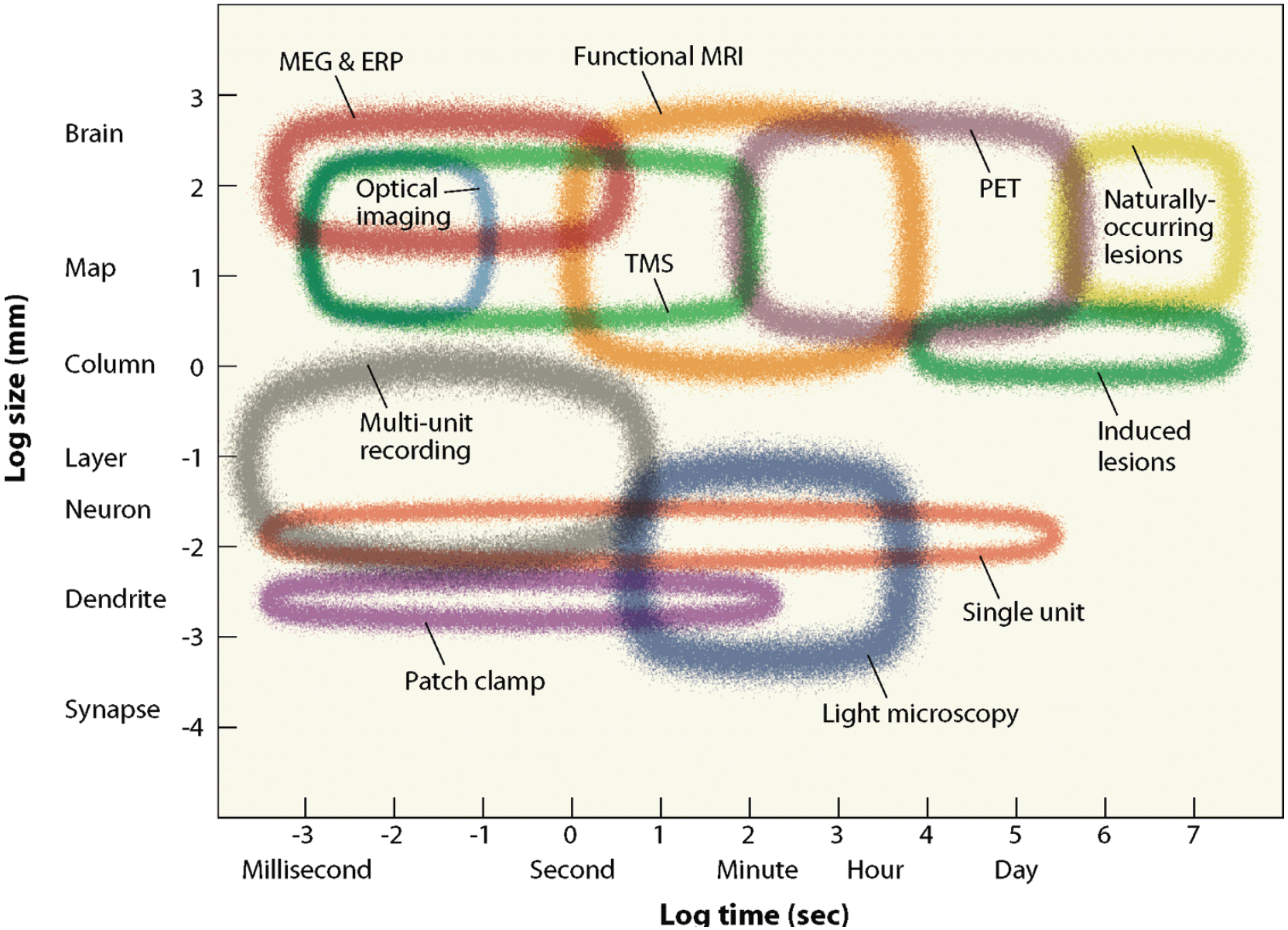
<u>Disadvantages</u>

- **Localization uncertainty** (affecting connections instead of neural center *per se*)
- **Specificity** (multiple/extensive lesions may lead to more than one deficit)
- **Plasticity** (neural reorganization complicates interpretation)
- **Rarity** (only very few cases may exist)
- **Sufficiency but not necessity**

Cognitive Neuroscience Methods

Design experiments – hypothesis driven investigations

Not one ideal technique, but several pretty good ones...



Cognitive Neuroscience Methods

Design experiments – hypothesis driven investigations

What kinds of questions can we ask?

Cognitive Neuroscience Methods (non-humans)

- Induced lesions

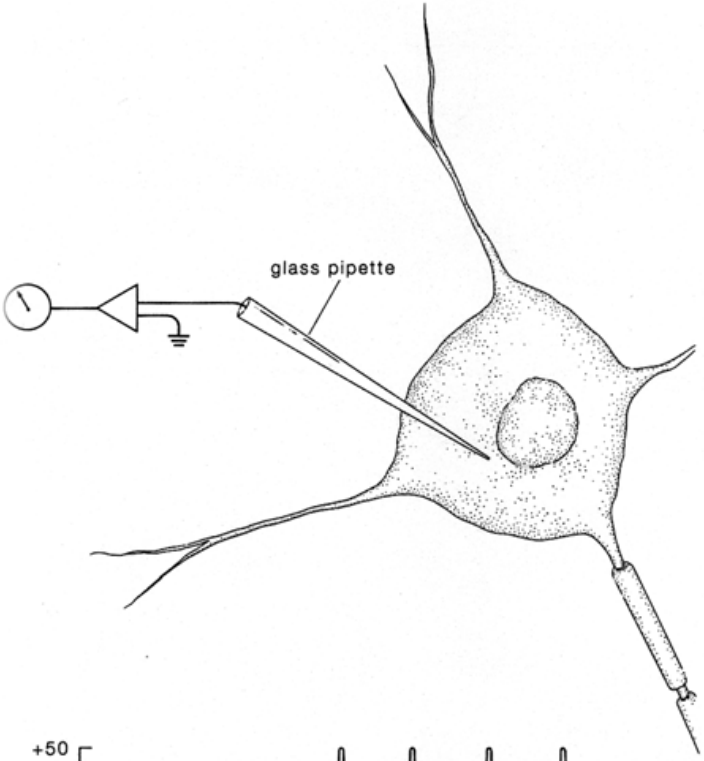
- Physiology

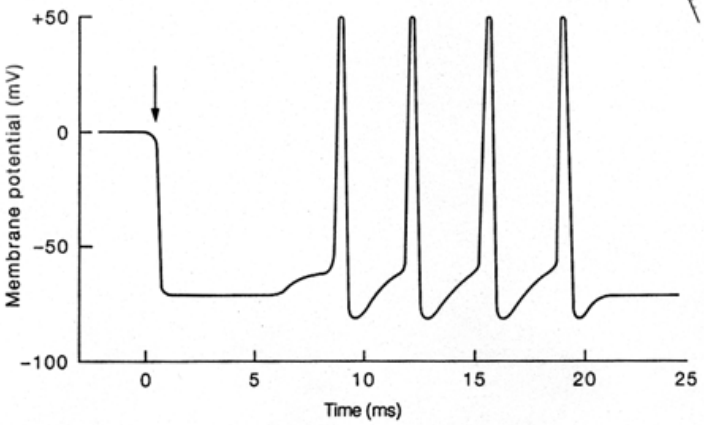
Intracellular Recording

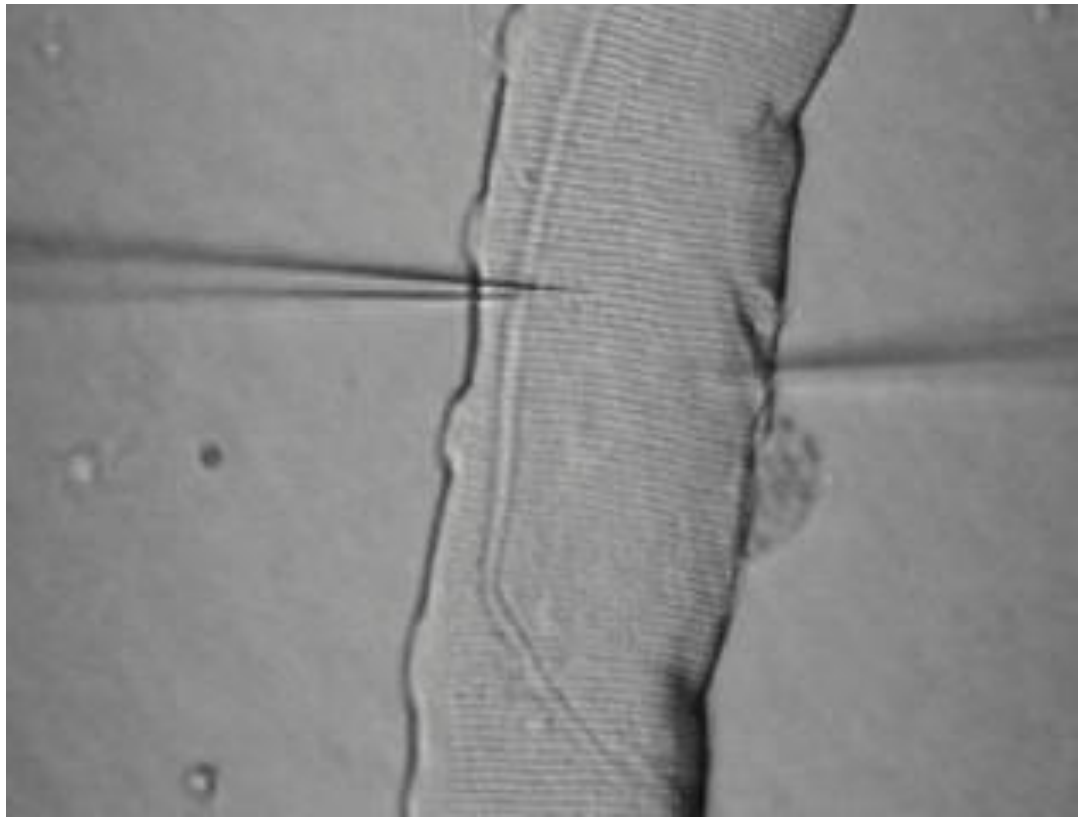
- Microelectrode
  - Glass micropipette
    - Much smaller tip (<1 micron)
    - Small enough to penetrate the cell wall

- Insert electrode inside of the neuron
- Record changes in resting potential
  - Tells you about the currents entering and exiting the neuron
  - Change voltage of the cell and see how the cell reacts

Intracellular Recording







Single Unit Recording

- Pro
  - Can record from single neurons
  - Can be done in vivo or in vitro
  - Can systematically manipulate the conditions under which the cell will respond

- Con
  - Invasive
  - Anesthesia
    - Difficult to do while animal is awake and behaving
  - Requires responses from a large number of neurons to study a system

Multi-Unit Recording

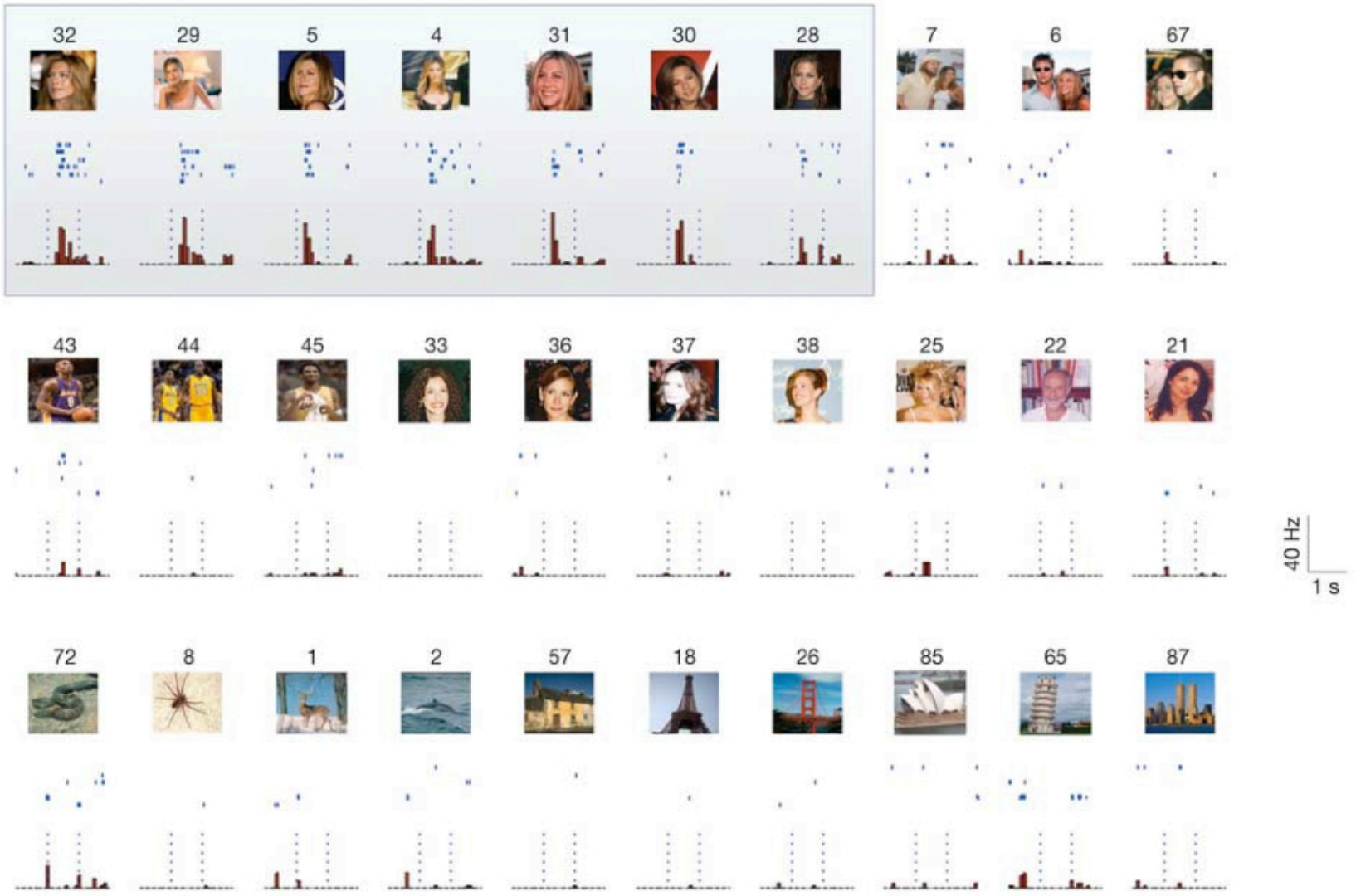
- Macro electrode
  - Larger diameter electrode is used
- Record the responses of a large number of neurons at the same time
- Local field potentials
  - Changes in the resting potential of the neurons at the dendrites
  - Dipole

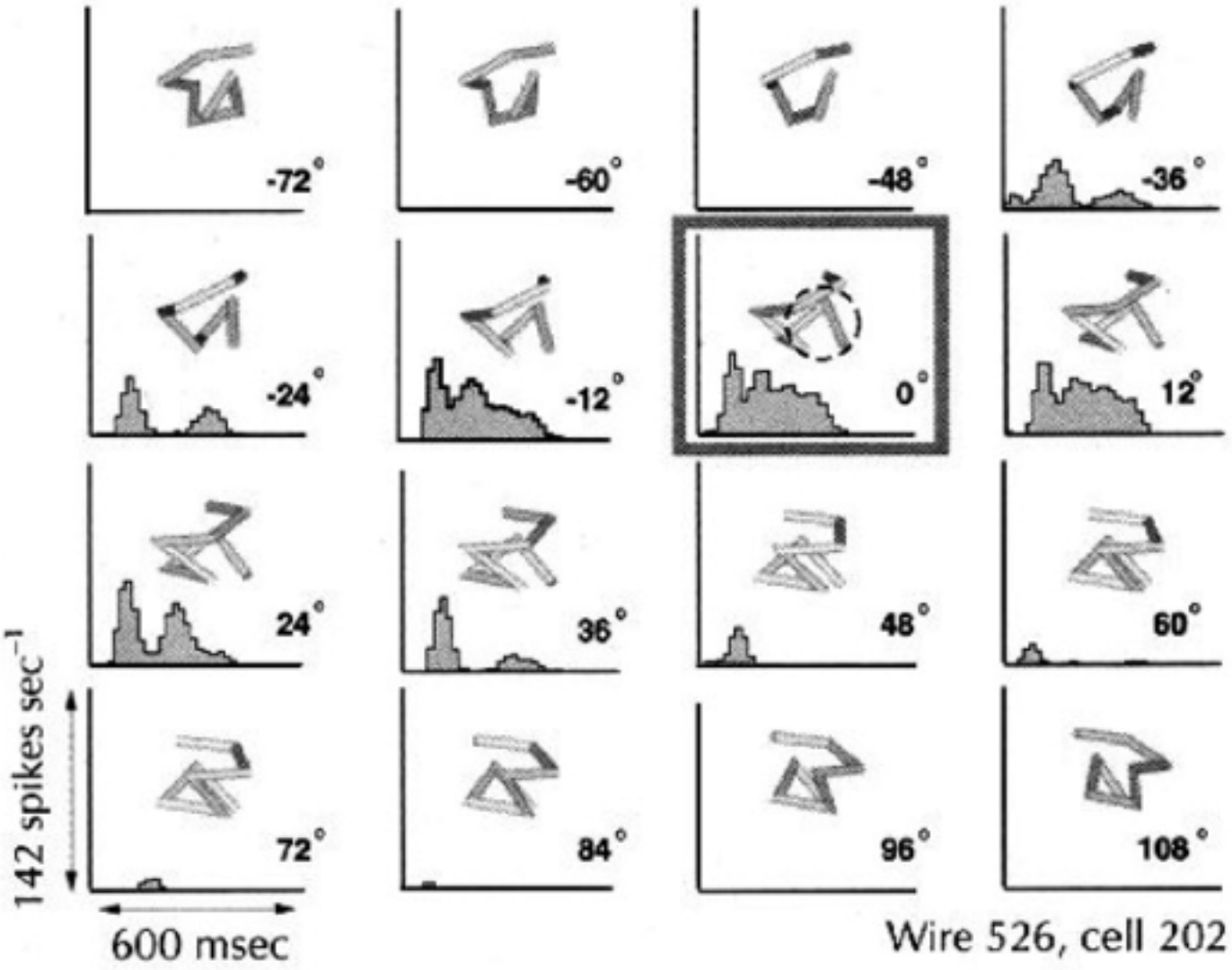
Multi Unit Recording

- Pro
  - Can record many neurons at a time
  - Not as invasive
  - Can utilize awake behaving preparations

- Con
  - Not as precise as single unit recording
  - Traces can include artifacts not related to the behavior

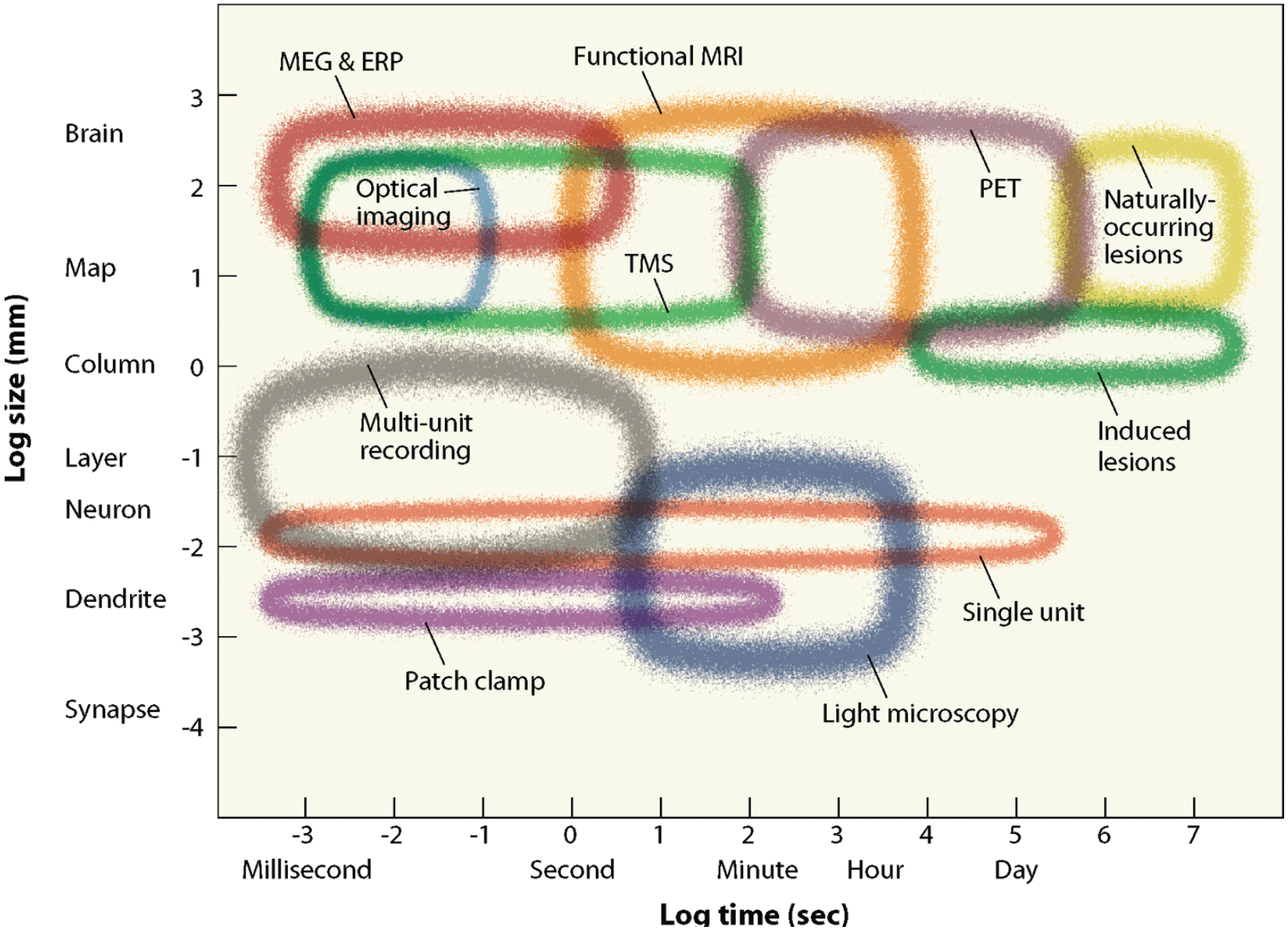
Response selectivity: the “Jennifer Aniston cell”



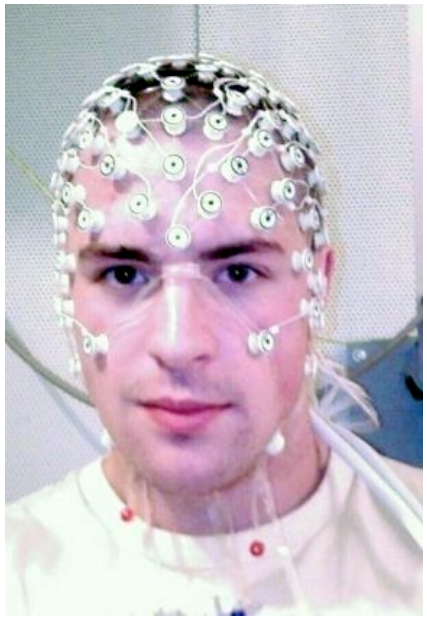


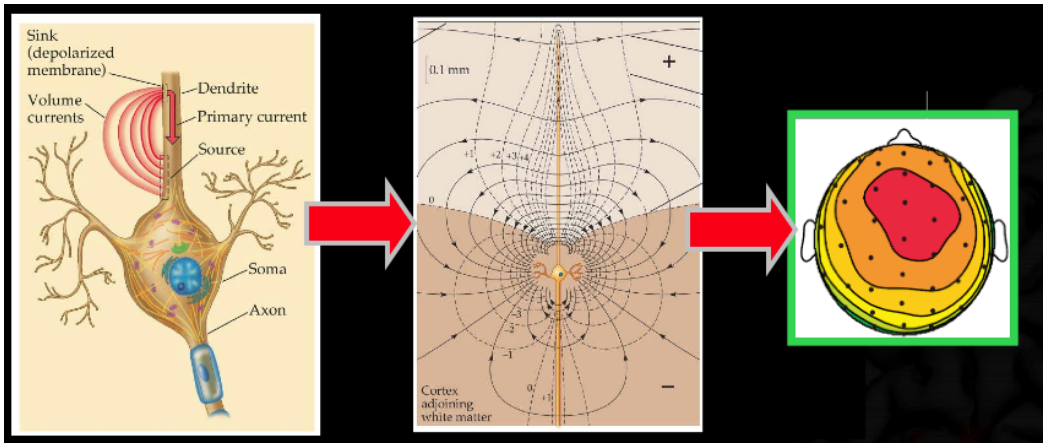
Logothetis, Pauls & Poggio, 1995

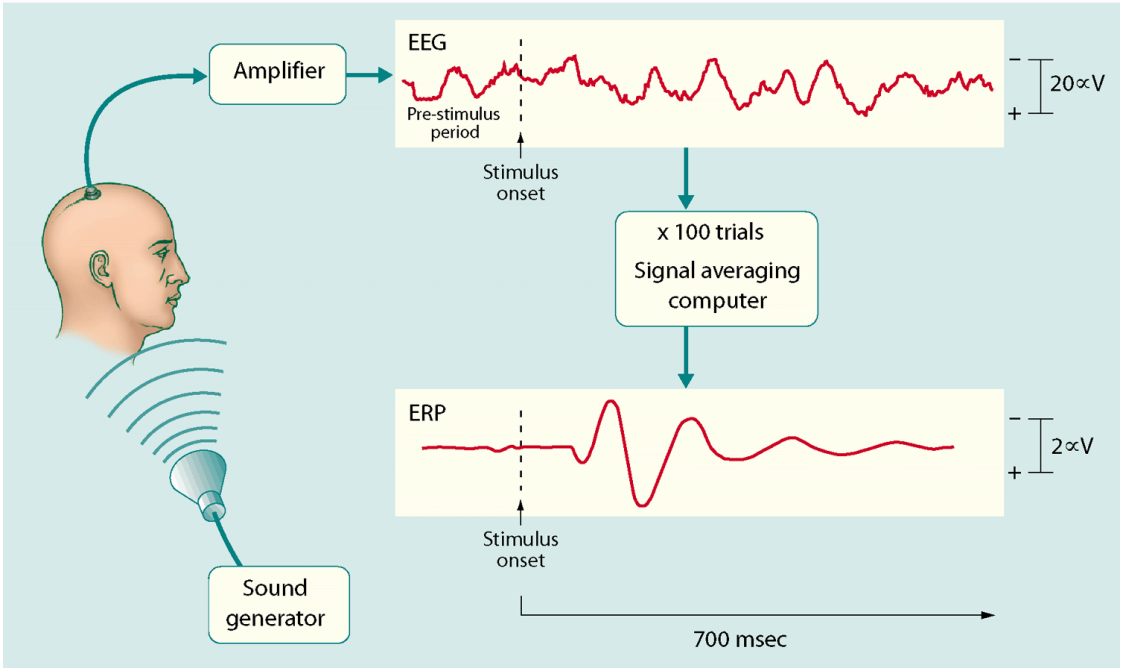
Not one ideal technique, but several pretty good ones...



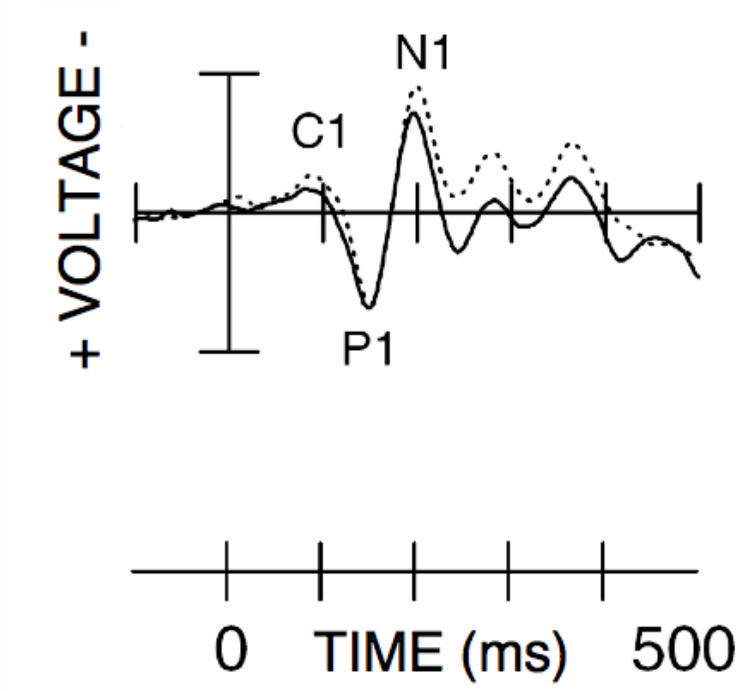
Electroencephalography (EEG/ERP)

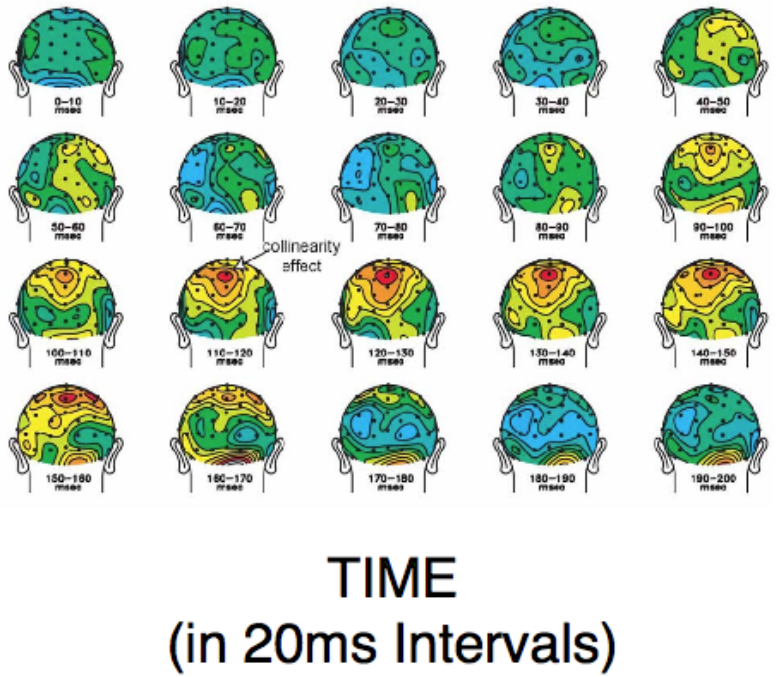






Electroencephalography (EEG/ERP)

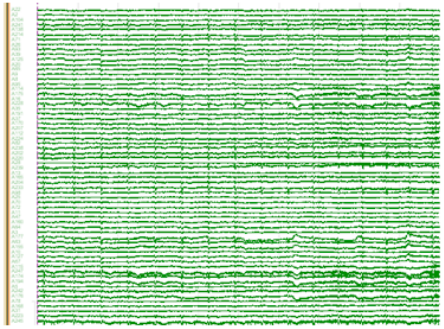


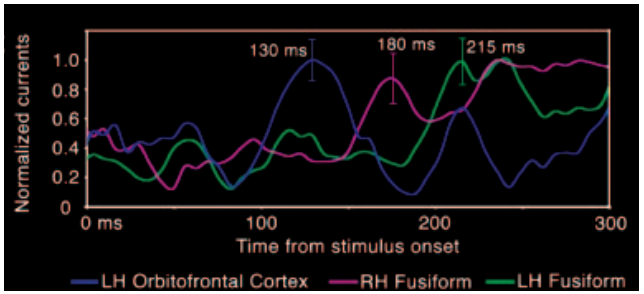


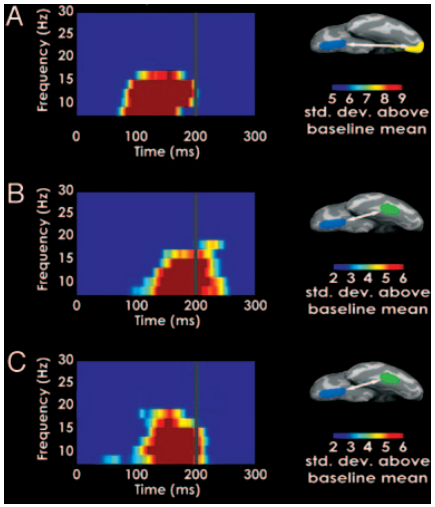
Pros:
Temporal Resolution
Direct measurement of activity

Cons:
Spatial Resolution

Magnetoencephalography (MEG)







Pros:

Temporal Resolution

Direct measurement of activity

Better spatial resolution

Cons:

Still, not great spatial resolution

Questions to ask using MEG/EEG

- Temporal questions
- Neuroimaging questions with very short inter-stimulus-intervals