Cerebral Cortex 2

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Methods for investigating the cerebral cortex

- Structural imaging
  - CT
  - MRI
- Functional imaging
  - PET
  - fMRI
- Advantages/disadvantages to each method

Brain imaging

- How can we understand the biological basis of cognitive and emotional functions?
- Use lab animals for invasive experiments (electrophysiology, tract-tracing, etc)
- Clinical studies of patients with cognitive disorders
- Structural imaging
- Functional imaging
  - Noninvasive methods used to observe areas of the human brain

Structural imaging

Detailed 3D (but static) anatomical images of the brain in a living human. Can examine the relationship between structural variance and function, including lesions.

- CT (X-ray computerized tomography)
- MRI (Magnetic resonance imaging)
- DTI (Diffusion tensor imaging)

Structural imaging: CT (X-ray computerized tomography)

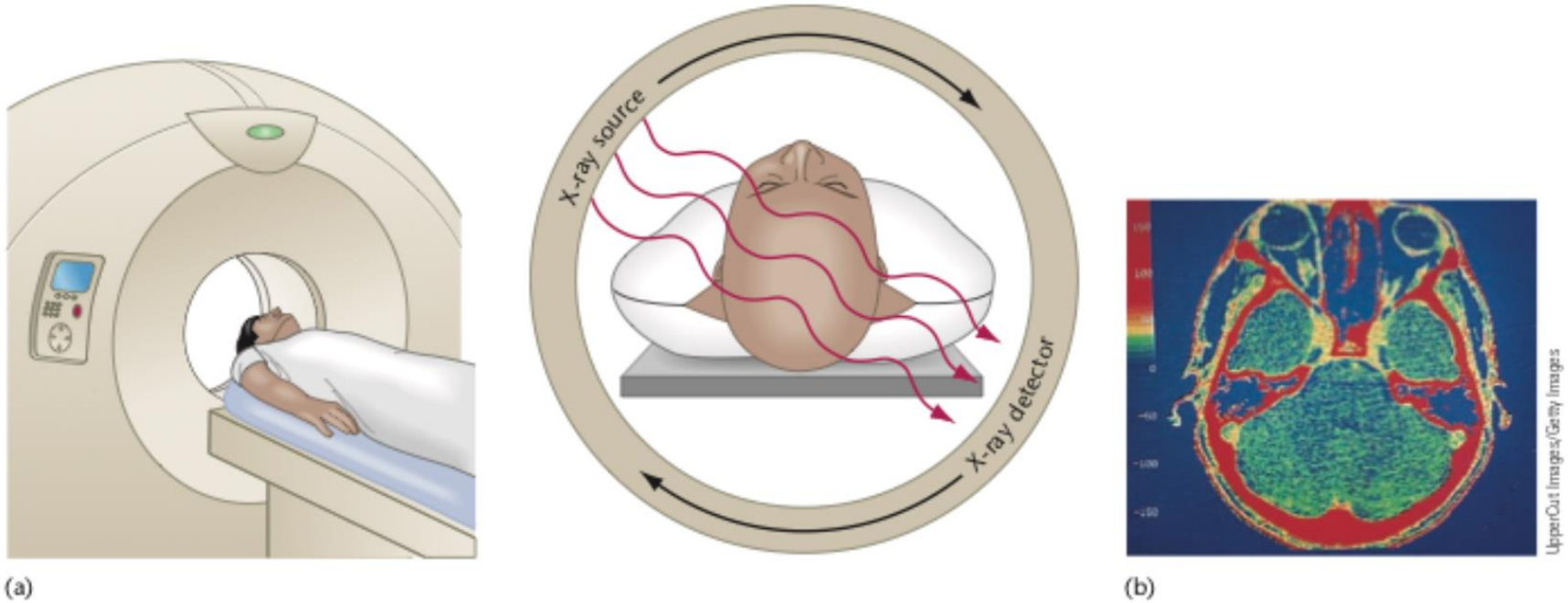
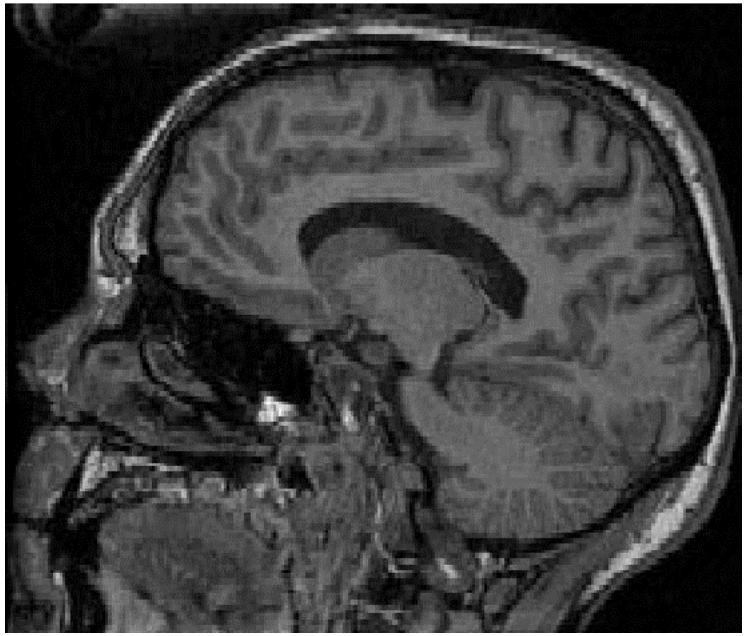


Figure 4.29 CT scanner
(a) A person's head is placed into the device and then a rapidly rotating source sends x-rays through the head while detectors on the opposite side make photographs. A computer then constructs an image of the brain. **(b)** A view of a normal human brain generated by computerized axial tomography (CT scanning).

Biological Psychology, Kalat

Structural imaging: MRI (magnetic resonance imaging)

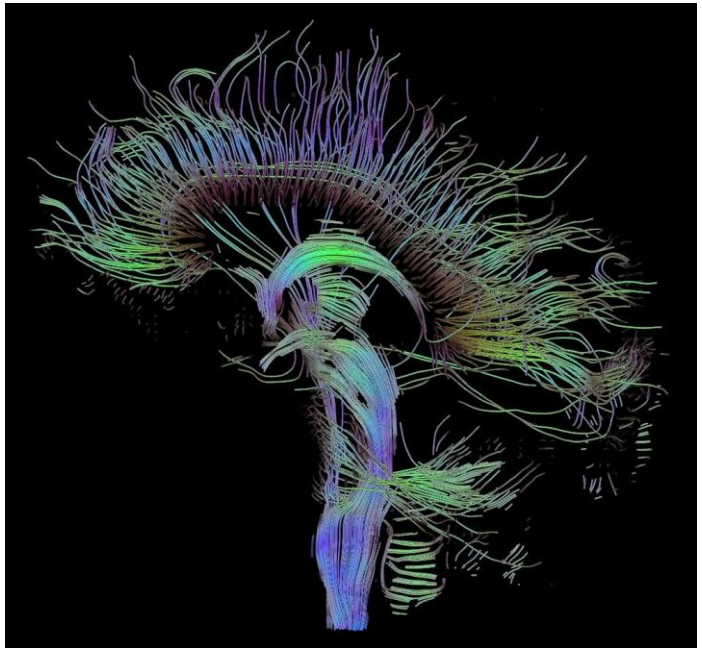
- Uses very strong magnetic fields to generate images
- Can see fine details of sulci and gyri in the cortex

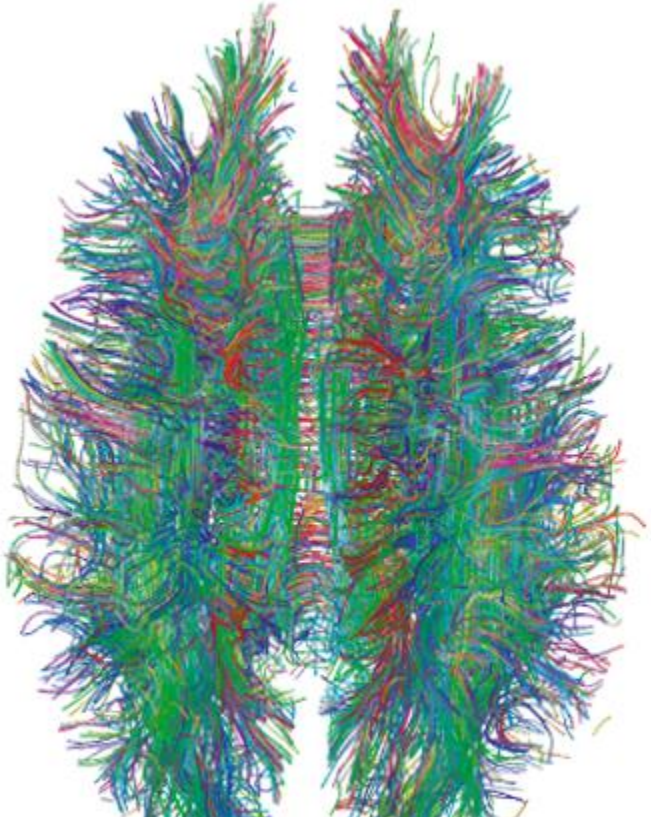


Visualization and Query Tool for a Human Brain Database LARS FORSBERG

Structural imaging: DTI (diffusion tensor imaging)

- Technically a particular type of MRI, in which specific sequences are used that take advantage of diffusion of water molecules along white matter in the brain
- Specifically used to look at white matter.





Structural imaging: comparison across methods

- MRI offers much higher resolution than CT
- CT has less distortion (important for guiding neurosurgeries)
- Tissue variation is typically clearer on an MRI

- In reality, CT scans are more likely to be used medically, whereas MRIs are more common in research settings

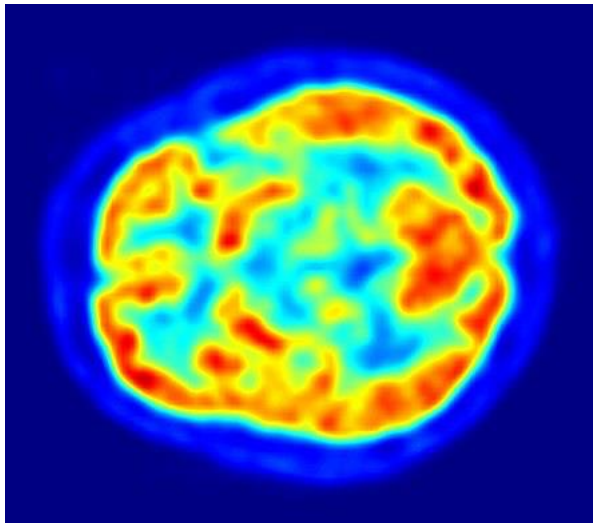
Functional imaging

Detailed 3D images of the brain in a living human, with the added benefit of being able to examine which brain regions are more active in response to particular conditions.

- PET
- fMRI

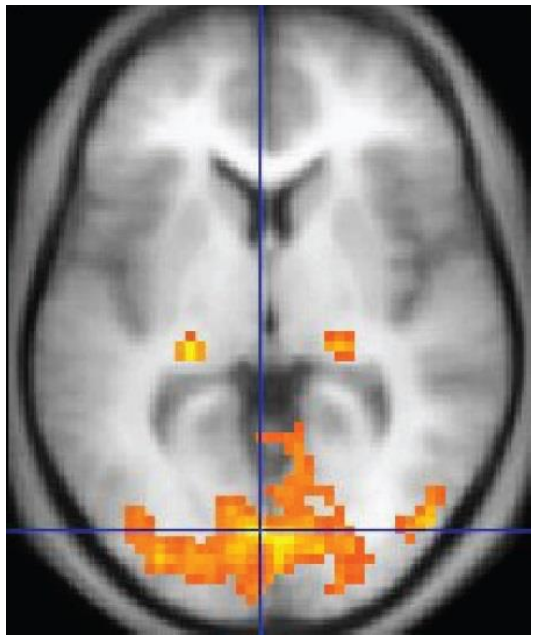
Functional imaging: PET (positron emission tomography)

- A radioactive tracer is given before the scan, and will build up in areas of higher chemical activity
- One such tracer (fluorodeoxyglucose) will build up in areas where brain cells are more active (consuming more glucose)
- Others may bind to particular receptors, transporters, etc



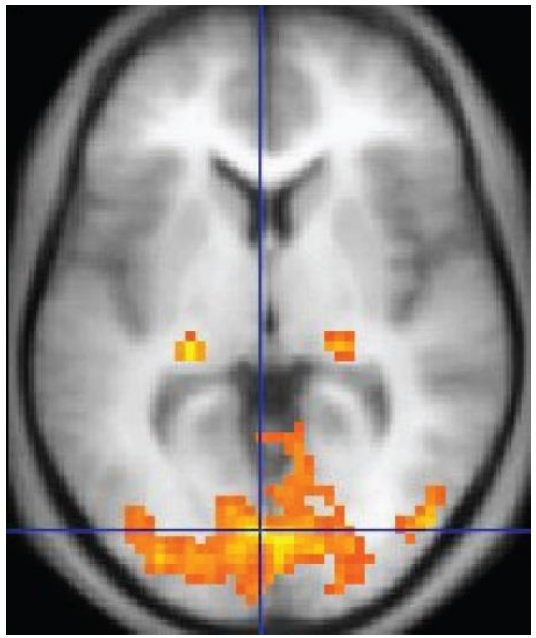
Functional imaging: fMRI functional magnetic resonance imaging

- Takes advantage of the fact that changes in blood flow are associated with neural activity
- Measures the BOLD (blood-oxygenation level dependent) signal, technically does not measure neural activity, but BOLD correlates highly with neural activity.



Functional imaging: fMRI functional magnetic resonance imaging

- BOLD changes over the course of seconds, so you can have people perform different trial types or different tasks and compare which regions are more active



Structural imaging: comparison across methods

- fMRI offers a much faster temporal resolution than PET. PET takes a “snapshot” of what occurred following the injection of the radiotracer. fMRI measures the BOLD signal as it fluctuates continuously during task performance.
- PET also requires an injection of a radiotracer.
- Because of this, fMRI is now far more commonly used in research settings.

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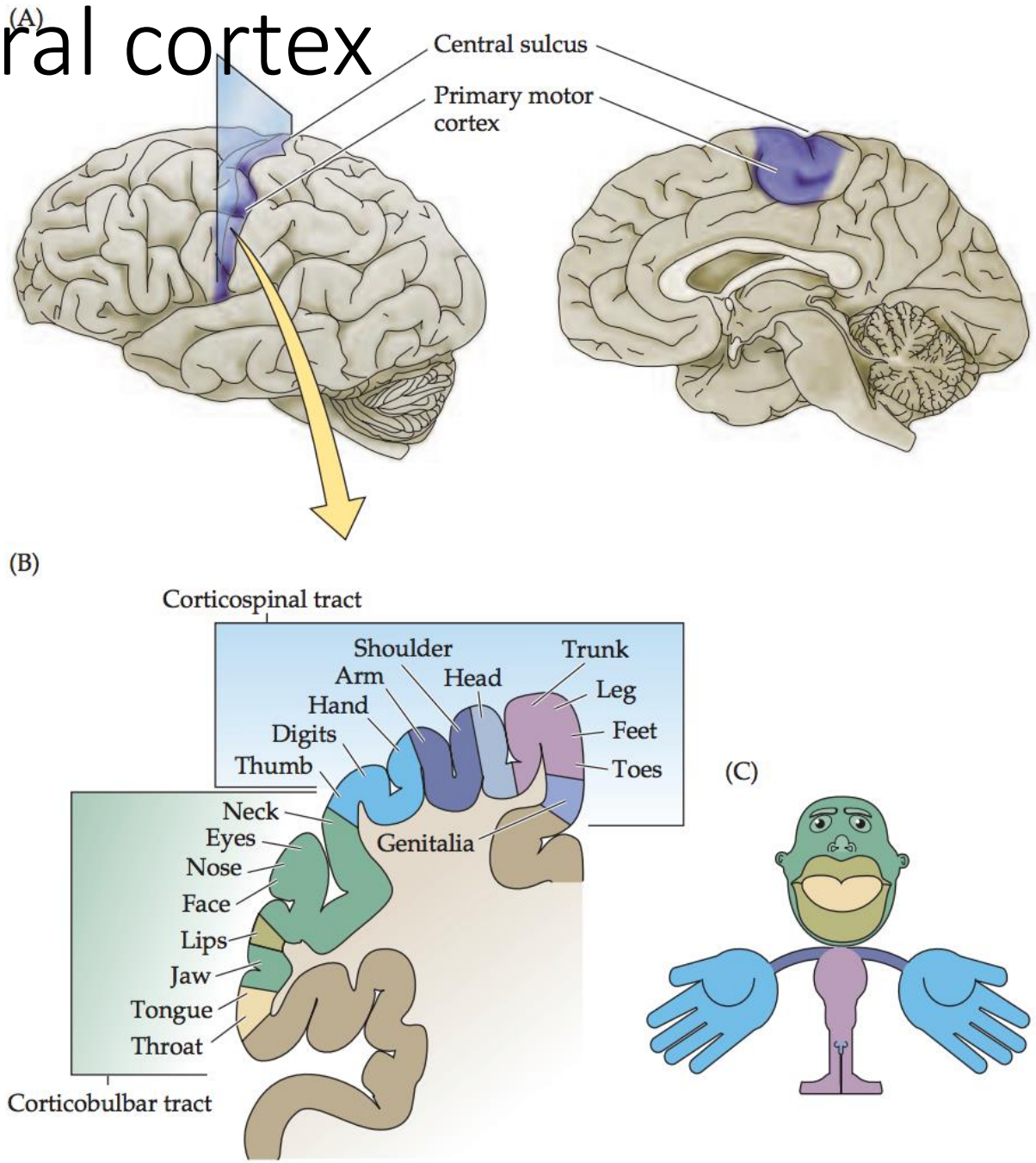
Functions of the Cerebral Cortex: Sensorimotor cortices

- Maps in primary motor cortex
- Maps in primary visual cortex
- Maps in primary auditory cortex

Maps in the cerebral cortex

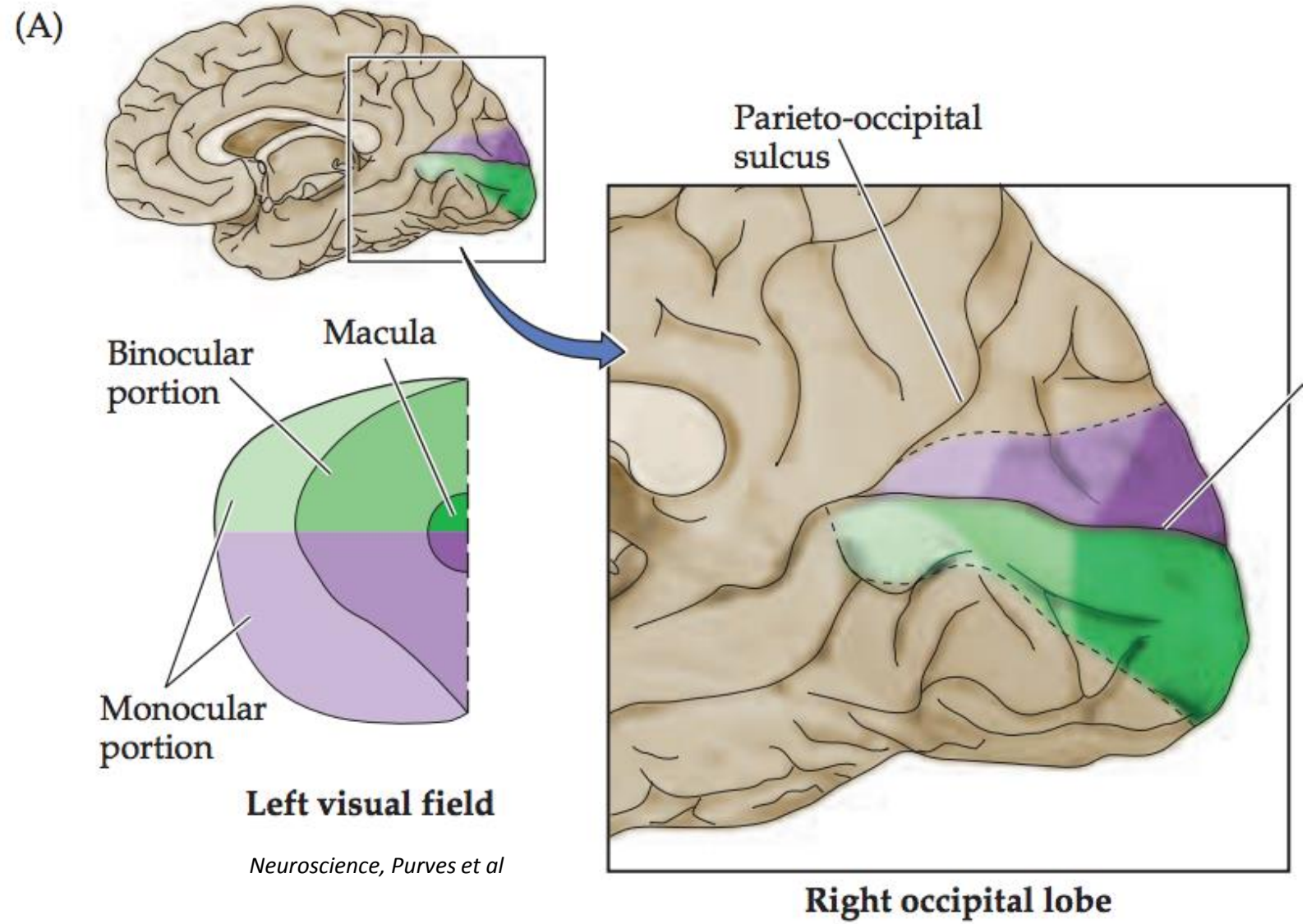
- …of the body musculature in the primary motor cortex



Neuroscience, Purves et al

Maps in the cerebral cortex

- …of the visual field in the primary visual cortex



Neuroscience, Purves et al

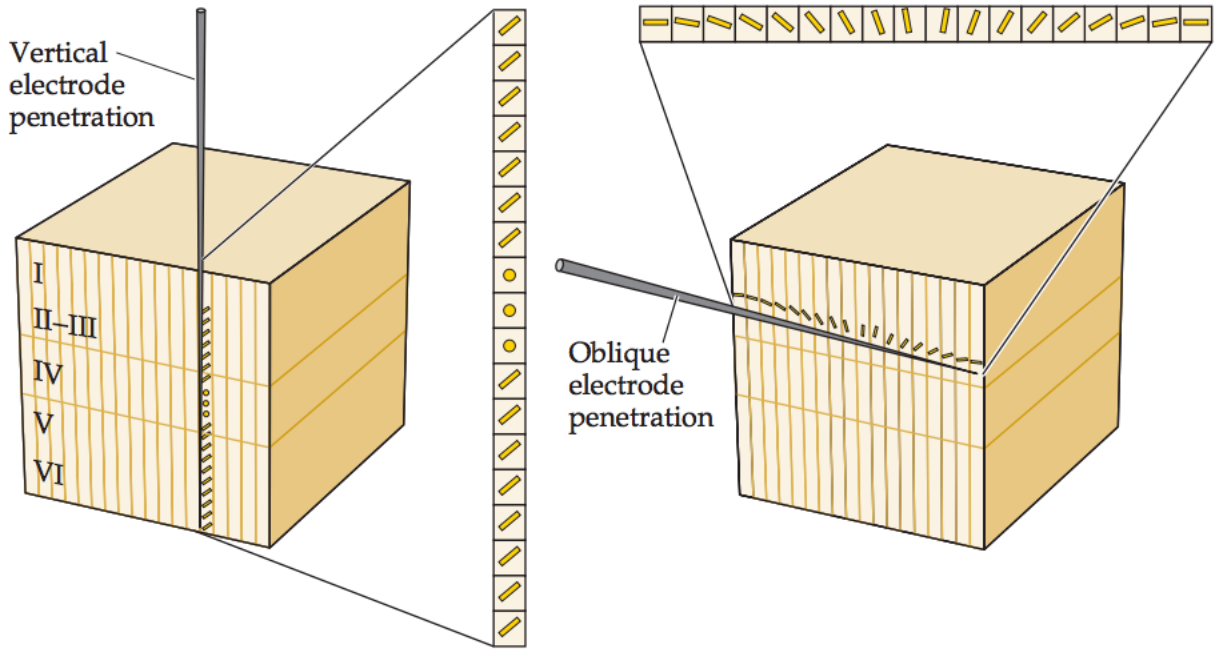
Maps in the cerebral cortex

- …of orientation

in the

primary visual

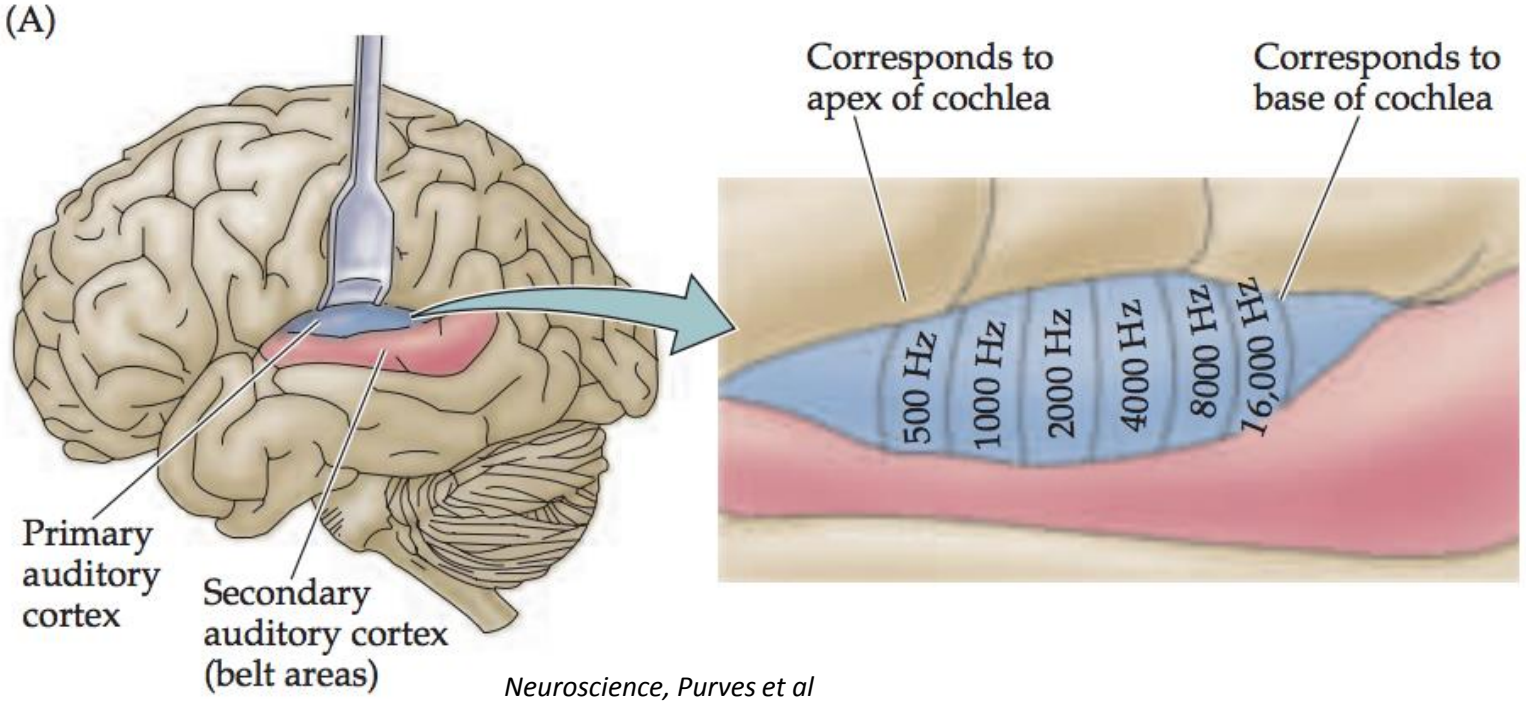
cortex



Neuroscience, Purves et al

Maps in the cerebral cortex

- …of sound frequency in the primary auditory cortex



Neuroscience, Purves et al

Functions of the Cerebral Cortex: Sensorimotor cortices

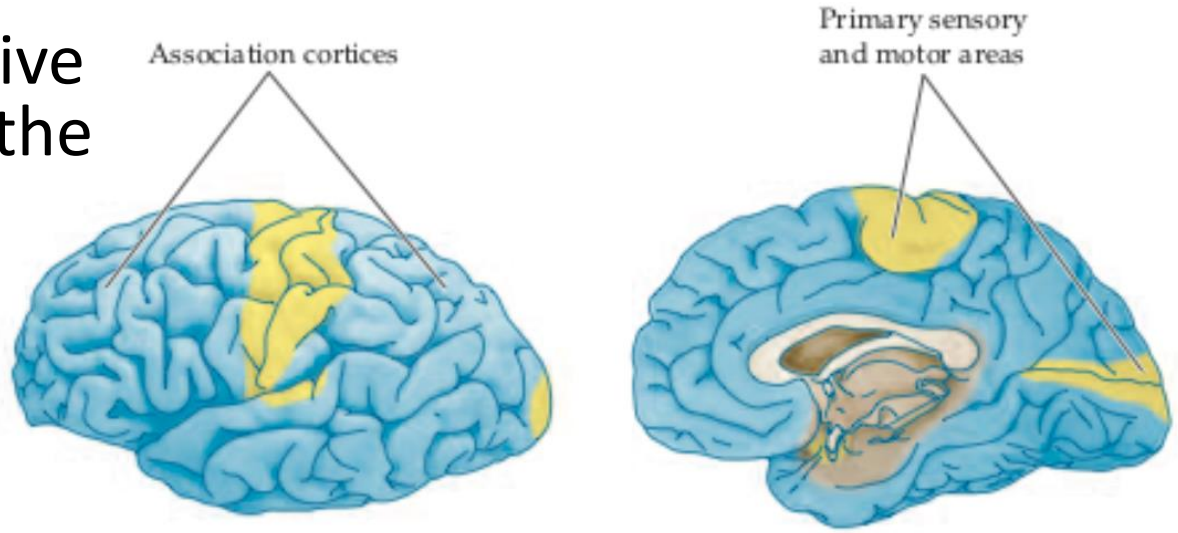
- Maps in primary motor cortex
- Maps in primary visual cortex
- Maps in primary auditory cortex

Functions of the Cerebral Cortex: Association cortices

- What are association areas?
- What is modularity?
- Parietal association cortex
- Temporal association cortex
- Frontal association cortex

What are association areas?

- Parts of the cortex that neither receive direct sensory information through the major sensory pathways or motor thalamic nuclei

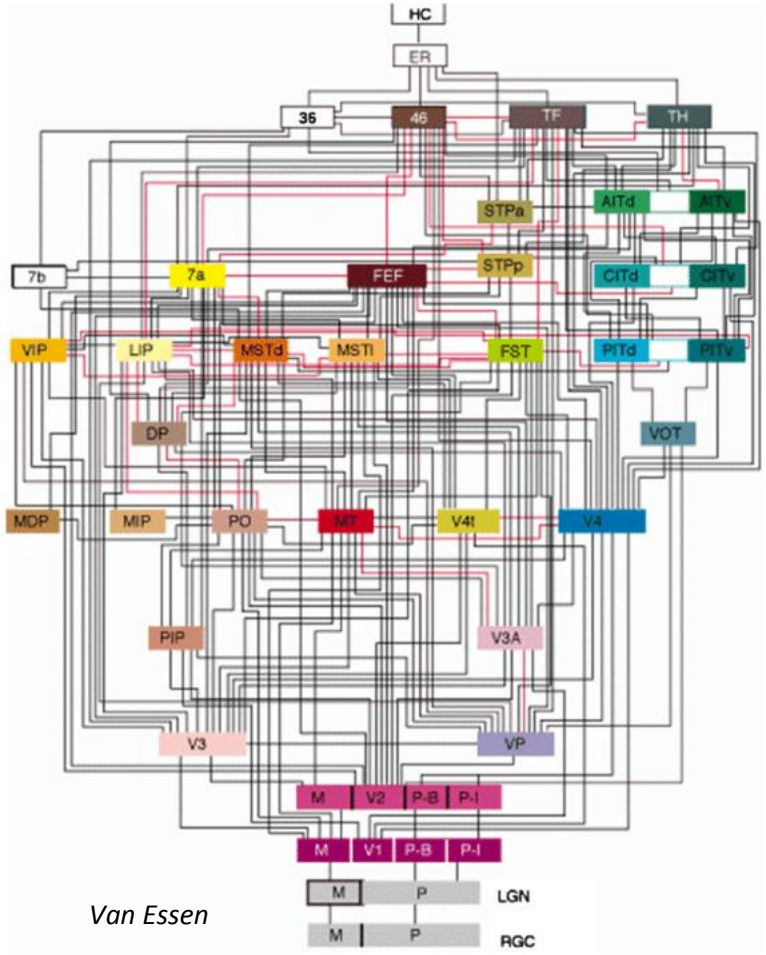


Neuroscience, Purves et al

- Unimodal: Located adjacent to or near their primary sensorimotor cortical areas, processes one type of sensorimotor information
- Multimodal: can process many types of information, in complex ways

What are association areas?

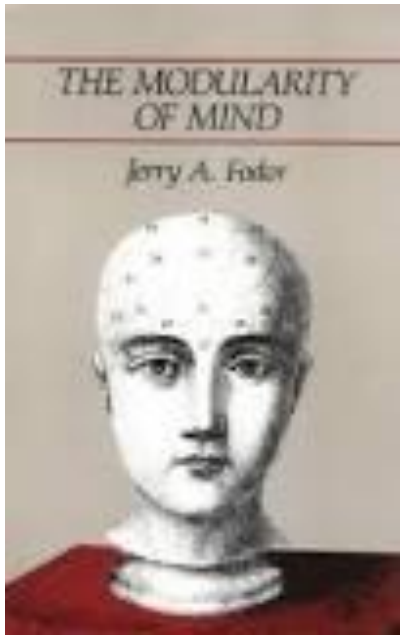
- Association cortices often have extensive connections with sensory, motor, and other association regions. Also connect to subcortical structures
- Integrate information and perform higher mental function
- Occupy a much larger fraction of the total brain in humans vs other animals



Van Essen

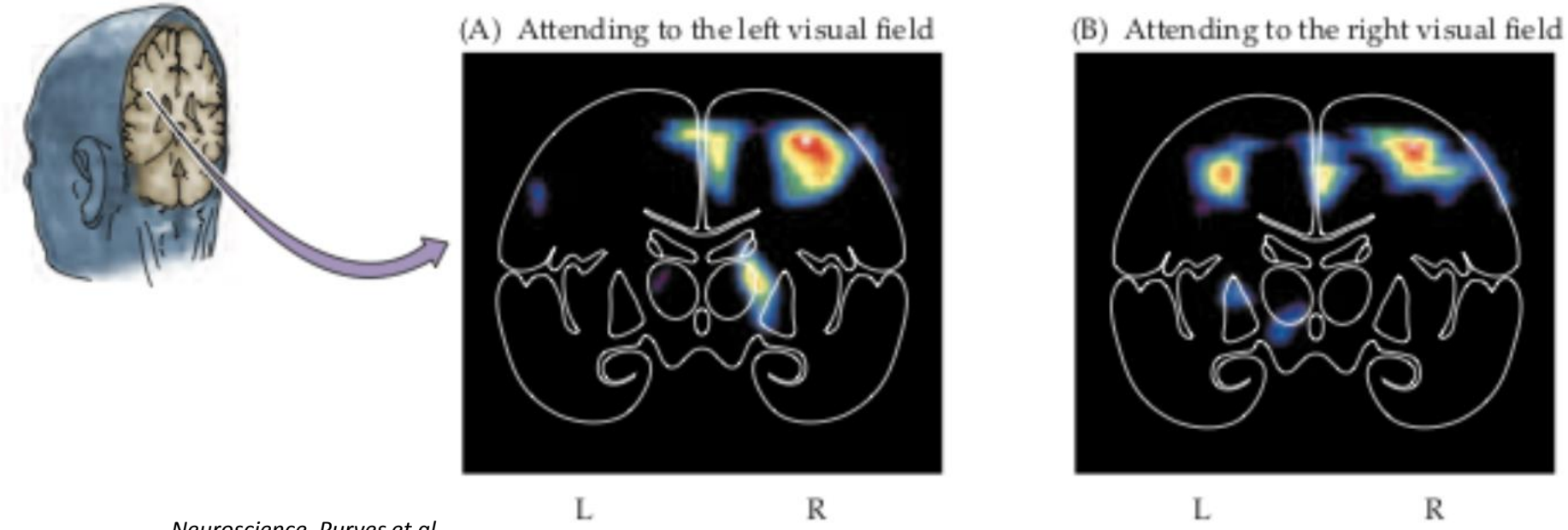
Modularity

- The concept of “modularity” in neuroscience/psychology posits that particular brain areas are highly specialized for specific functions
- This is obviously true of primary sensorimotor cortical areas, but what about higher cognitive functions in association areas?



Examples: Parietal association cortex

- Important for visual attention
- PET and fMRI studies suggest that both the right and the left parietal cortices respond to stimuli in the right visual field, but only the right parietal cortex responds to stimuli in the left visual field



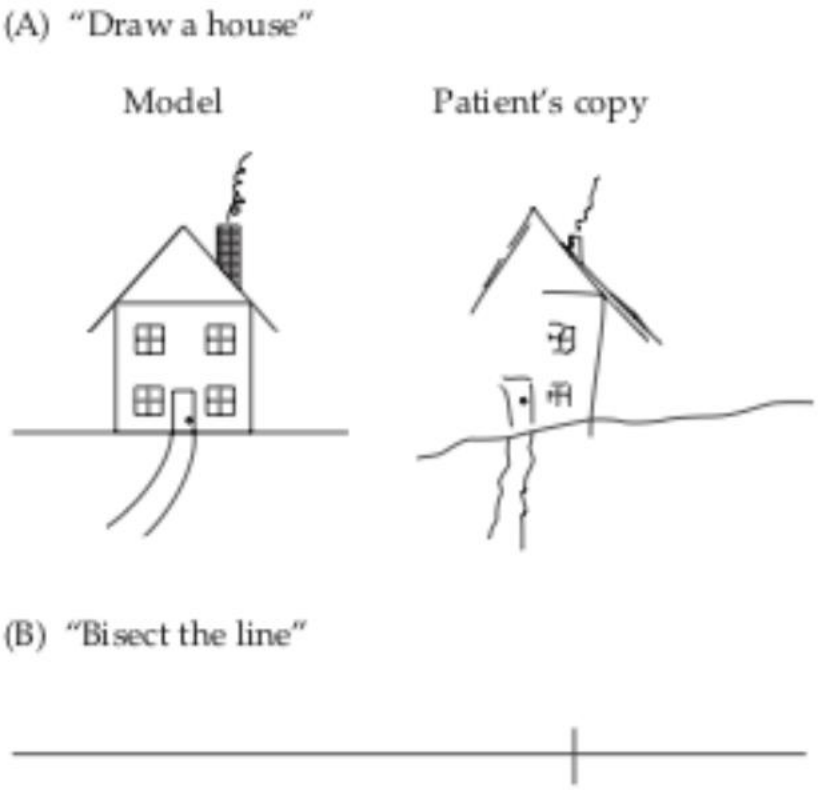
Neuroscience, Purves et al

Examples: Parietal association cortex

- This means that damage to the right parietal cortex will be particularly impactful, since there's no "extra" representation of the left visual field

Patients with damage to the right parietal cortex have trouble attending to the left visual field

This phenomenon is known as parietal neglect



Examples: Parietal association cortex

- Video: https://www.youtube.com/watch?v=d4FhZs-m7hA

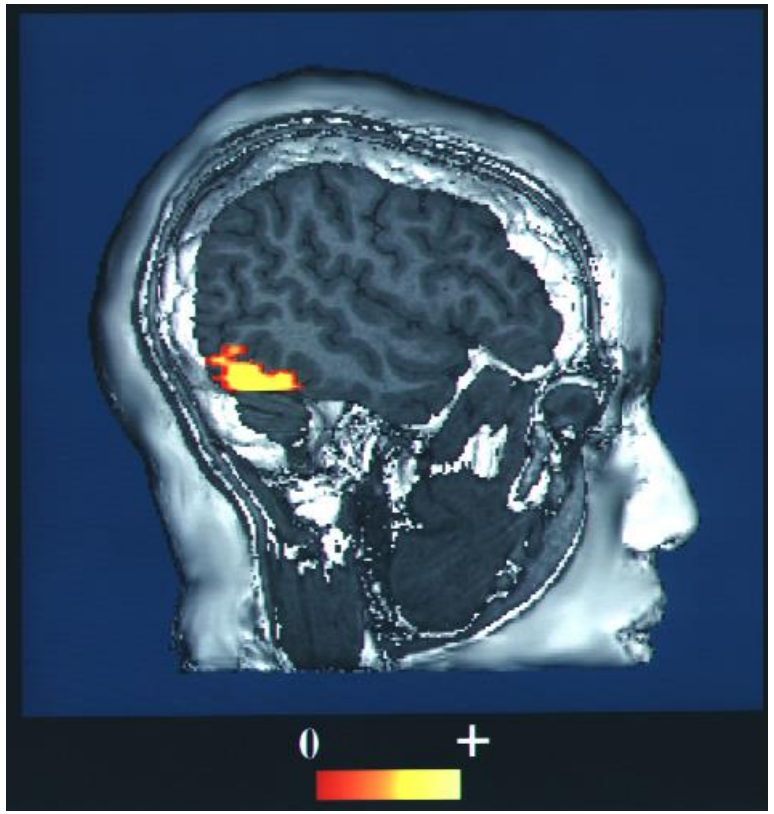
Examples: Temporal association cortex

- Temporal association cortex processes high-level features of objects, faces, and places
- Lesions cause agnosias: difficulty recognizing and/or naming things

Examples: Temporal association cortex

- The fusiform face area is one of the strongest examples of modularity in the association cortex.

A particular part of the brain is much more active when someone views faces than when they view almost anything else



Examples: Frontal association cortex

- Damage to the frontal lobe is often interpreted as a problem with the patient's "character"
- Diverse functions found in different areas of the frontal lobe, including planning, decision-making, abstract though, representation of self, and so on
- Phineas Gage is the classic example

Functions of the Cerebral Cortex: Association cortices

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- Parietal association cortex
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