# Introduction to Cognitive Science

(3: The turn to the brain)

*(fMRI in the next presentation)*

# Intro

- Cognitive systems as functional systems
    - Performing a function (goal?)
    - Is this different from information processing? Is it compatible with information processing?
    - We can study algorithms without thinking about the circuitry, but thinking about circuitry might help
        - Also, nature-inspired computation is a big thing right now!
    - But beware: CogSci as science takes as a fundamental assumption that cognitive processes can be studied independently of the hardware/wetware

# Should we ignore the brain?

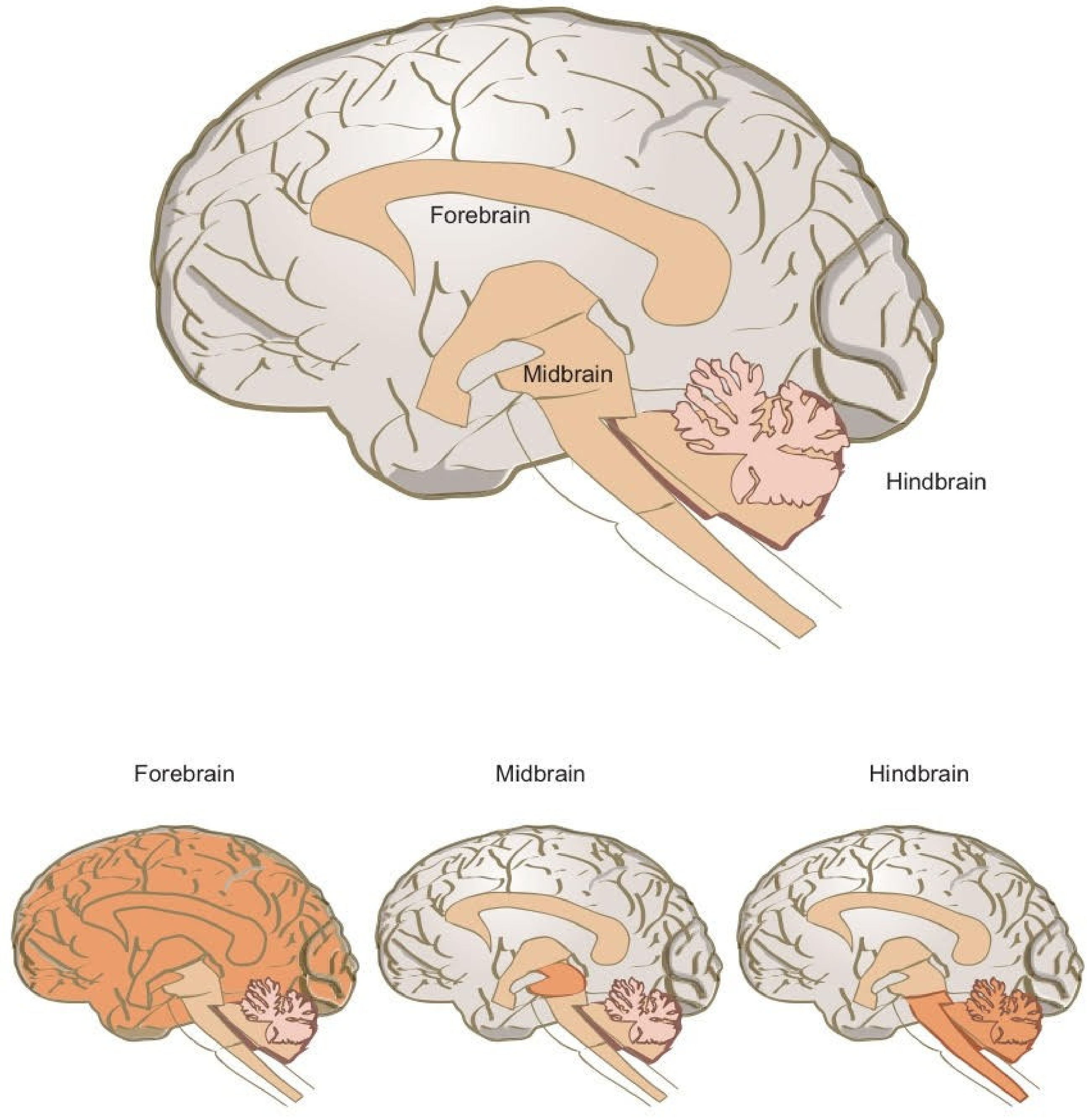
- Most CogSci think yes
  - But not in a complete sense, rather in the sense that we should not get caught in neural peculiarities which do not carry over to say crows
  - i.e. it may lead to a misleading view on cognitive processes qua *cognitive* processes
  - e.g. can we conclude all hearts have four chambers just because the human heart has?
- „There is an artificial version of every organ asides from the brain"
  - Is this true?
  - Why?

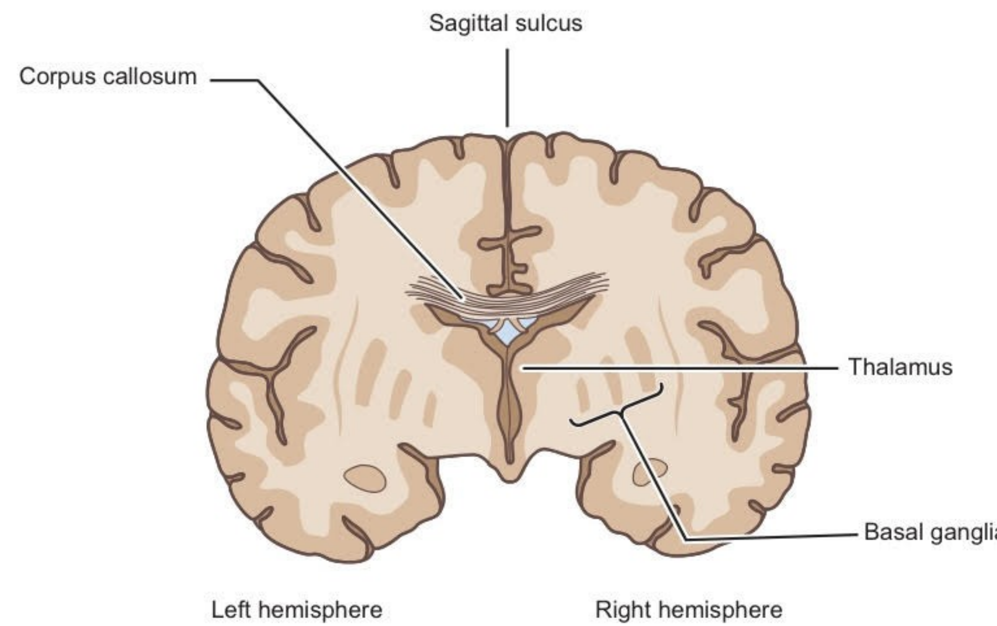
# Should we ignore the brain?

- But let us explore an idea:
  - Do brains learn how they learn because of how they are constructed?
  - If so, their construction is highly relevant

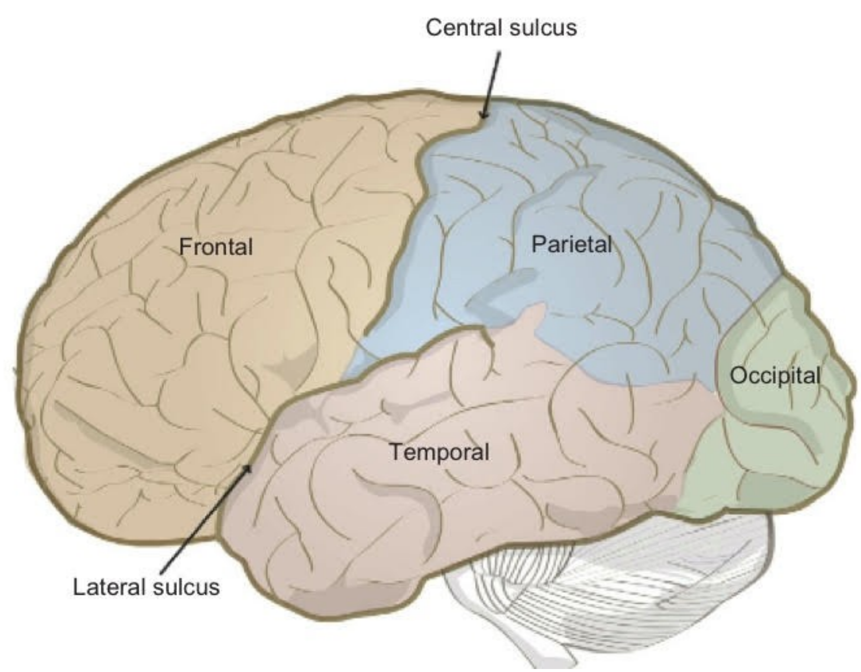
# Basic brain anatomy

- Three different parts:
  - Forebrain (hemispheres form the celebral cortex):
    - Left hemisphere (four lobes)
    - Right hemisphere (four lobes)
    - Interhemispheric fissure
  - Midbrain
  - Hindbrain


Forebrain
Midbrain
Hindbrain
Forebrain
Midbrain
Hindbrain



Sagittal sulcus
Corpus callosum
Thalamus
Basal ganglia
Left hemisphere
Right hemisphere

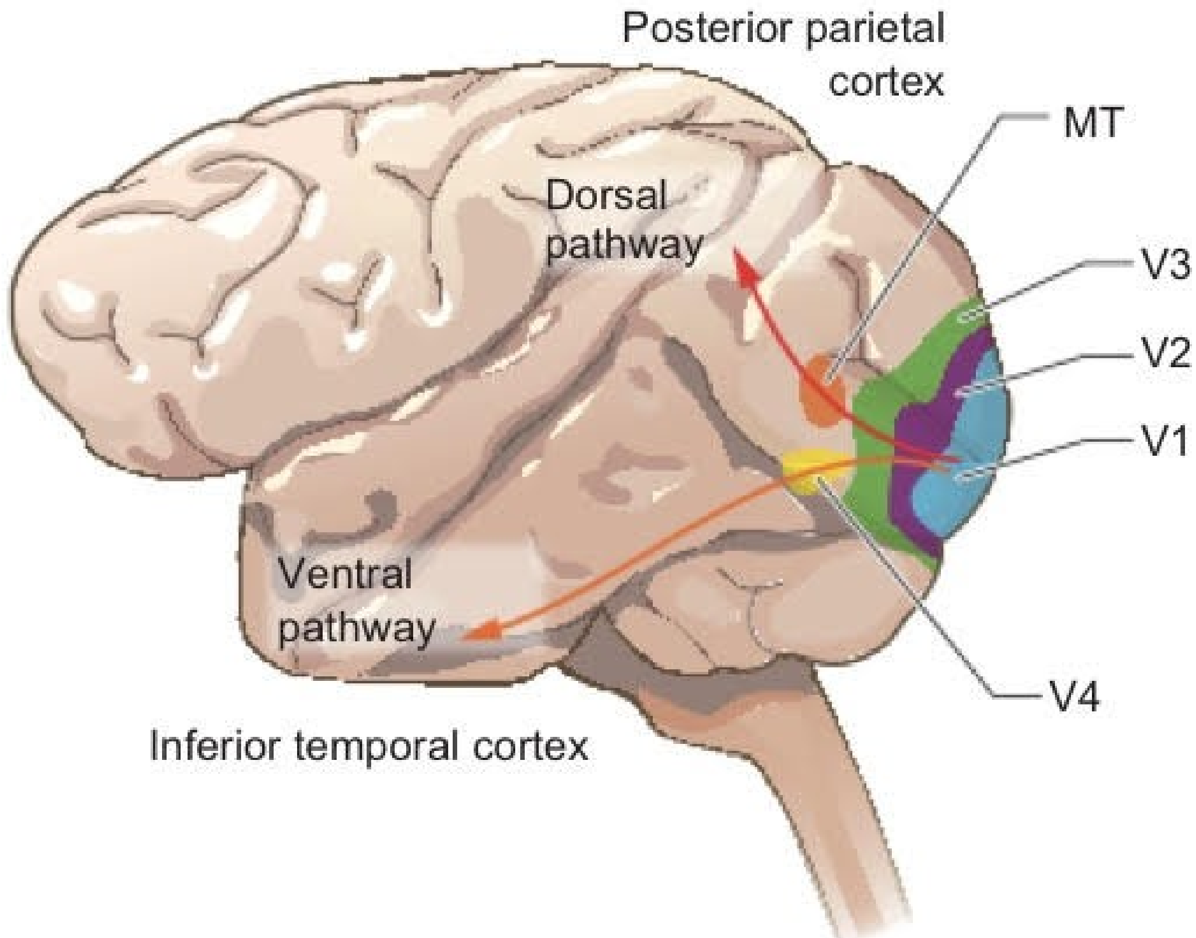
Central sulcus
Frontal
Parietal
Occipital
Temporal
Lateral sulcus

# Cerebral cortex: four lobes

| What Does Each Lobe Do? |
| --- |
| ■ Frontal lobe – reasoning, planning, parts of speech, movement, emotions, and problem solving<br>■ Parietal lobe – movement, orientation, recognition, perception of stimuli<br>■ Occipital lobe – associated with visual processing<br>■ Temporal lobe – associated with perception and recognition of auditory stimuli, memory, and speech |

# Inside lobes

- There is further organization within each lobe
  - 52 Brodmann areas
    - We are interested in Brodmann area 17, also known as:
      - the primary visual cortex or
      - the striate cortex or
      - area V1
- Contralateral organization of the brain



Posterior parietal cortex
MT
Dorsal pathway
V3
V2
V1
Ventral pathway
V4
Inferior temporal cortex

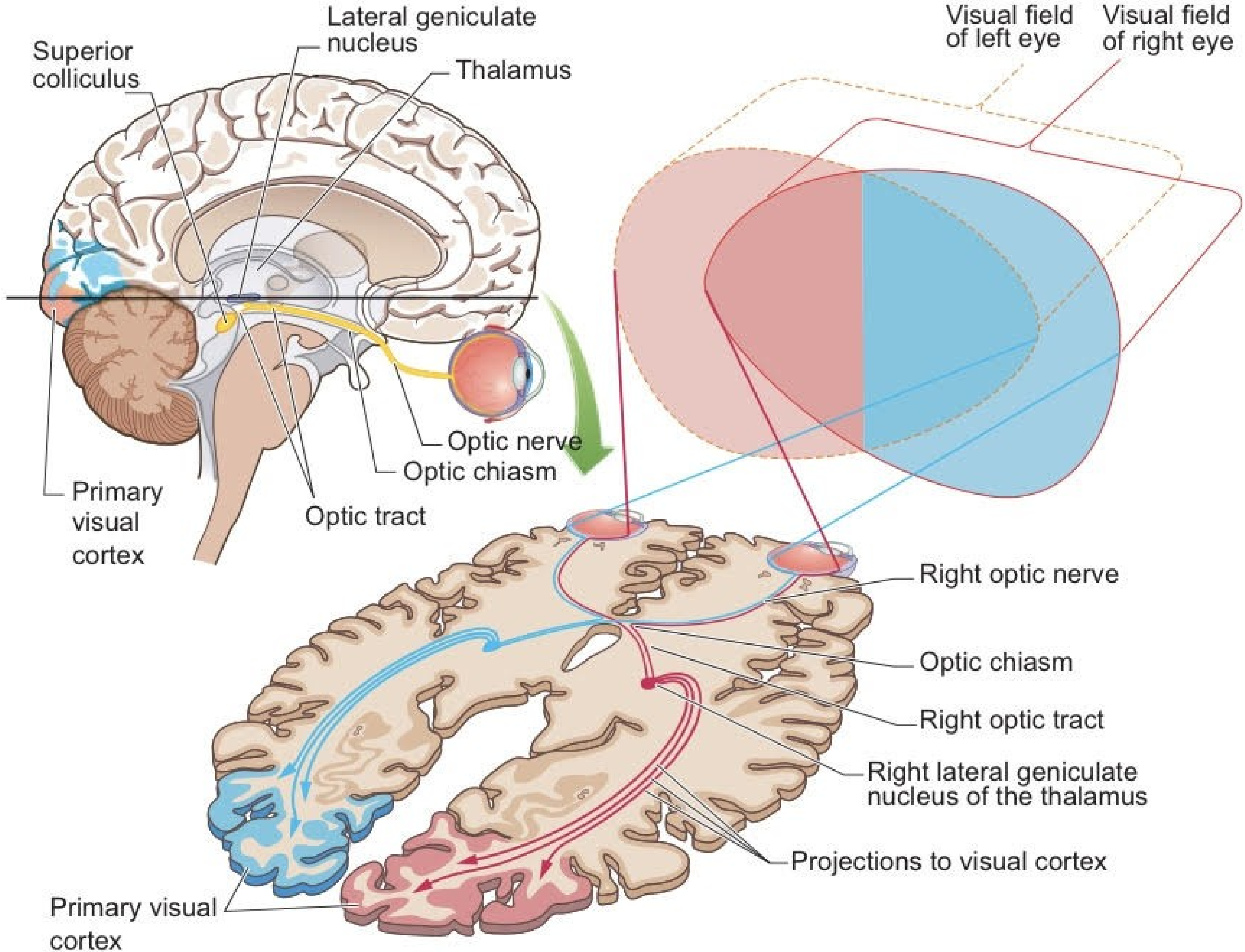



**Figure 3.4** The primary visual pathway. Note the contralateral organization, with information from the right side of space processed by the left side of the brain.

# Two visual systems hypothesis: 1982 Ungerleiden and Mishkin

- Example of a bottom-up approach to cogSci
- Theysuggested that visual information does not follow a single route to the primary visual cortex
    - Information relevant for recognizing and identifying the object follows a ventral route from the primary visual cortex (PVC) to the temporal lobe
    - Information for locating objects follows a dorsal route from the PVC to the posterior parietal lobe

# Two visual systems hypothesis: 1982 Ungerleiden and Mishkin

- How did they arrive at this conclusion?
- Studying cognitive impairments due to brain damage and performing neuroanatomical experiments on monkeys
- Back then, there was already significant evidence to suggest that patients with damage to the temporal an parietal lobes exhibit very different types of cognitive problems

# Cross-lesion disconnection experiments

- Standard experiments with a region-lesion have (another) fatal flaw: we do not know if the cognitive impairment is:
  - due to the region-lesion as such, or
  - because of the connective property of the region (i.e. because two other regions cannot communicate)
- Hence, precise surgical removal is required for a conclusive proof (major technical limitation)
- Cross-lesion disconnection experiments exploit the fact that the cerebellum is divided in two hemispheres with duplication of the primary areas

# Experiments

- Ungerleider and Mishkin hypothesized that:
  - There is a pathway from PVC to inf. temp. area
- Three stage removal:
  - ITA right
  - PVC left
  - Corpus callosum
- Location test had the most severe drop in training after the second stage (PVC) removal
- Recognition dropped only after corpus callosum removal

# Functional neuroimaging with PET
# 1988 Petersen, Fox, Posner, Mintun

- PET: Positron emisson tomography (not the same as fMRI)
- The idea behind functional neuroimaging (among which is PET):
  - Function of different brain areas by measuring blood flow
  - Subjects are injected with oxygen-15 which emits positrons and then the PET scanner tracks it.
  - Lasts for about a minute before decaying
- However, just identifying which areas have a higher bloodflow is not conclusive:
  - That is why we need to be careful on how to design an experiment around a technique
  - We need to filter out irrelevant background brain activity

# Functional neuroimaging with PET
# 1988 Petersen, Fox, Posner, Mintun

- How linguistic info is processed
- Lexical access: info-proc. Models of single word processing
- Two different models:
  - Neurology, based on studies on lesions: processing a single word uses an invariant pathway (serial)
  - CogSci, based on experiments on non-damaged brains: the brain can carry out several processes at once, no fixed route

# Functional neuroimaging with PET
# 1988 Petersen, Fox, Posner, Mintun

- Petersen et al. Designed a complex experiment to decide which model is correct
- Main idea is to organize the experimental conditions hierarchically, so that each condition uses a more advanced version of information processing
- This means looking at new brain areas that become involved
  - (Also we can positively identify which areas are never involved)

# Functional neuroimaging with PET
# 1988 Petersen, Fox, Posner, Mintun

- Baseline condition: Subjects were asked to look at a crosshair on a screen (visually attending to something which is not a word)
- Second condition: flashed a word on the screen at a rate of 40 words per min
  - Subtract the brain activation of the first from the second
- Third condition: they had to speak outloud the word
- Fourth condition: they had to say outloud an associated verb with the word on the screen

# Functional neuroimaging with PET
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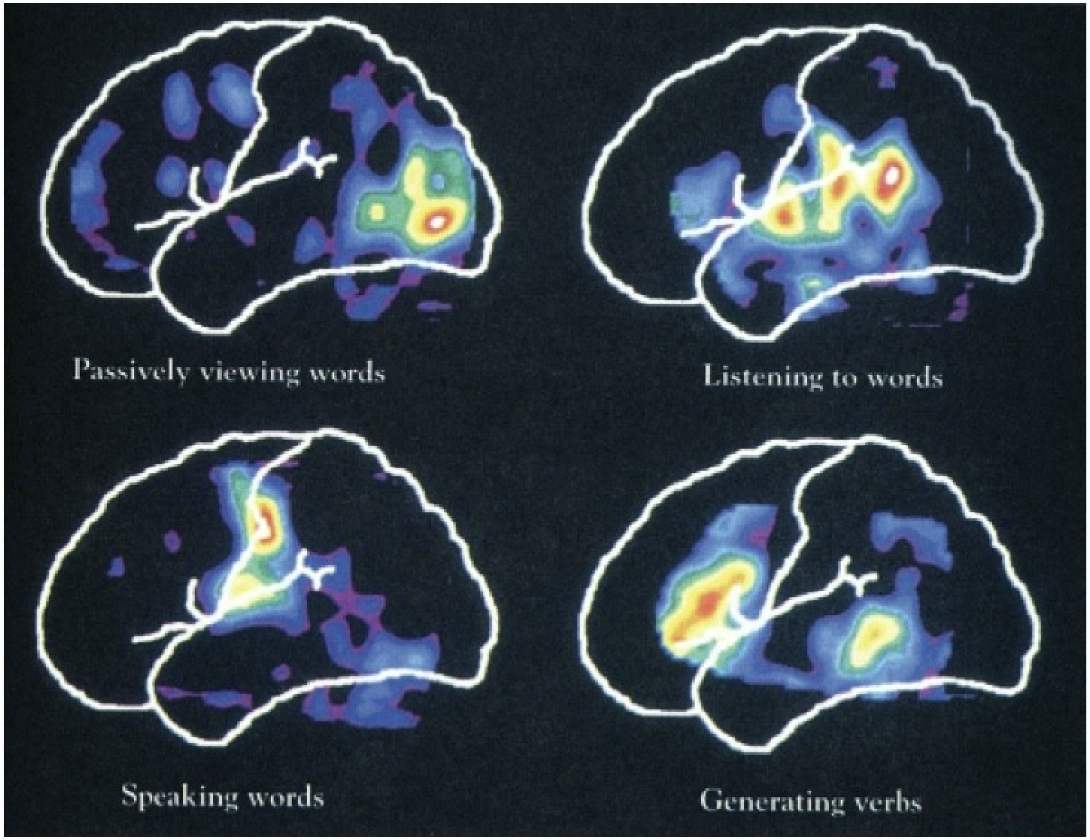


**Figure 3.9** Images showing the different areas of activation (as measured by blood flow) during the four different stages in Petersen et al.'s (1988) lexical access studies. (From Posner and Raichle 1994)

# Functional neuroimaging with PET
# 1988 Petersen, Fox, Posner, Mintun

- Results showed clear evidence against the neurological model
- Also:
  - When speaking outloud the word, there were no activations in the regions associated with auditory processing
  - Areas involved in semantic processing (4th condition) were not used in any other task

# Homework

Easy read:

- Section 3.3. of chapter 3 (pp. 76-80)