Object vision
(Chapter 4, part II)

Lecture 9

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Sensation & Perception
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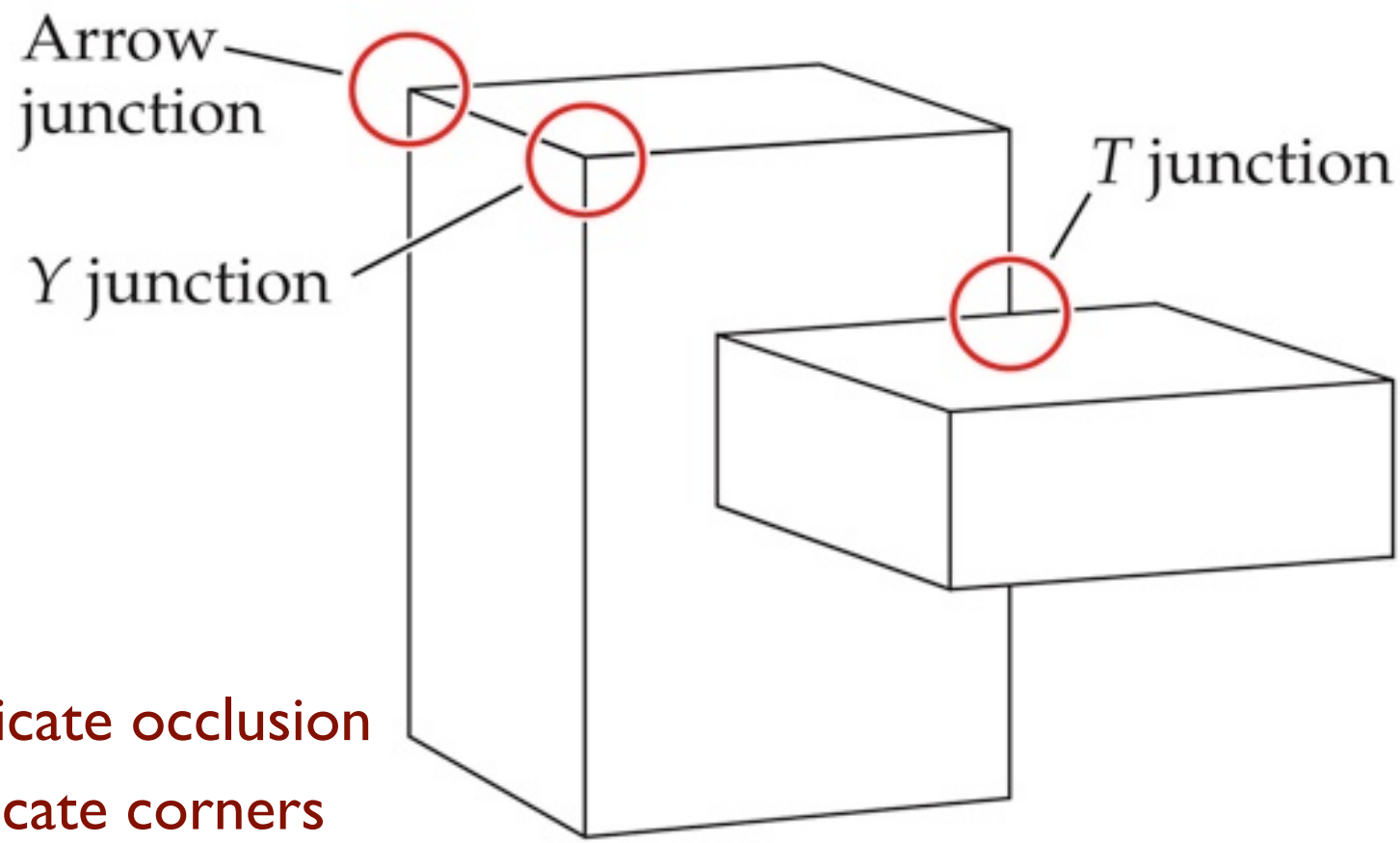
Nonaccidental feature: features that do not depend on the exact (or accidental) viewing position of the observer



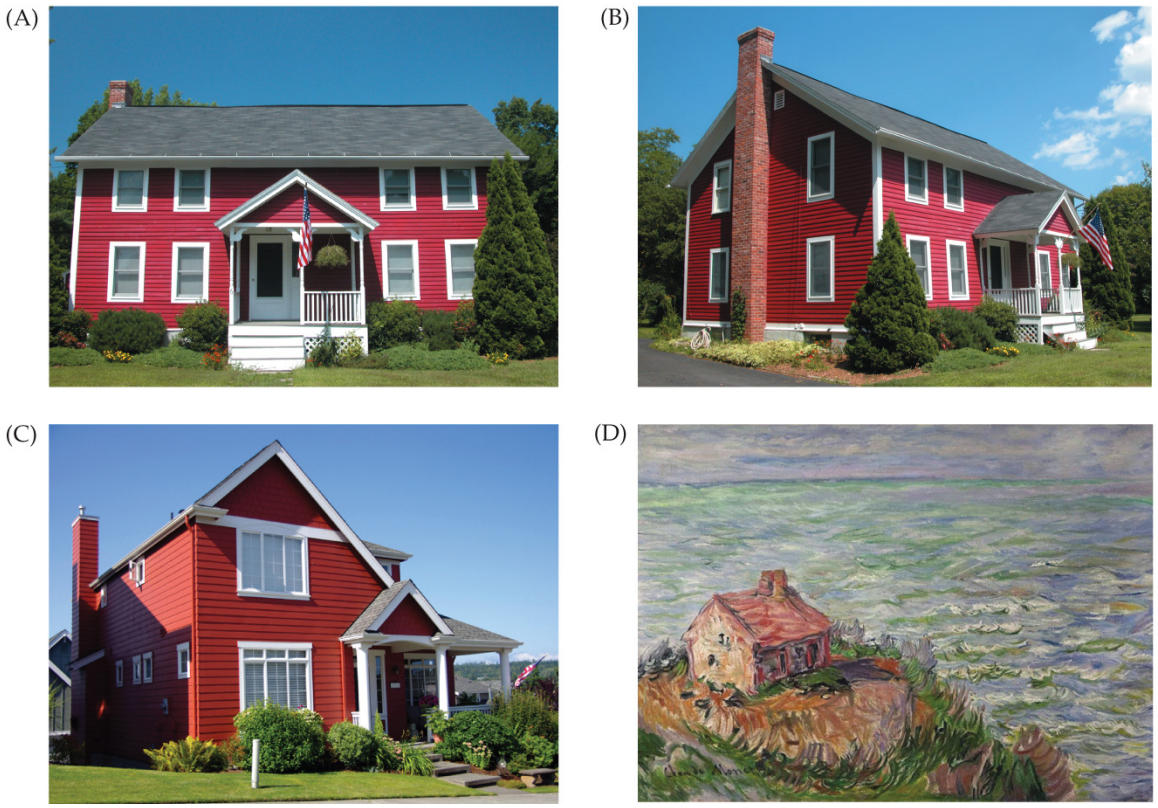
***T* junctions**: indicate occlusion

***Y* junctions**: indicate corners facing the observer

Arrow Junctions: corners facing away from observer

- these feature are still present if object is shifted, scaled or rotated by a small amount

viewpoint invariance: the idea that we should be able to recognize an object from any viewpoint.



Problems with view-invariant theories:

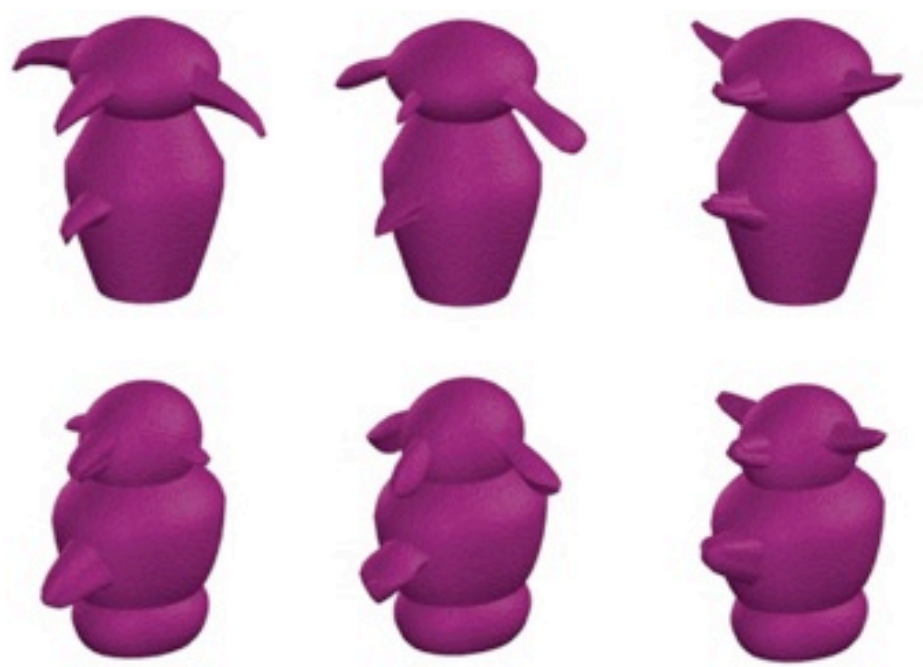
Object recognition = not completely viewpoint-invariant!

Viewpoint *does* affect object recognition

"greebles"

mental rotations study
(Gauthier & Tarr 1997)

- The farther an object is rotated away from a learned view, the longer it takes to recognize



Face Recognition

Face Recognition: not entirely viewpoint-invariant!

viewpoint invariance (take-away):

- object recognition is *somewhat* but not entirely viewpoint invariant
- observers *do* seem to store certain preferred views of objects.

Makes sense from an evolutionary standpoint:

We generate representations that are as invariant as we need them to be for practical applications

Object Recognition

Could a single neuron be responsible for recognizing your grandmother?

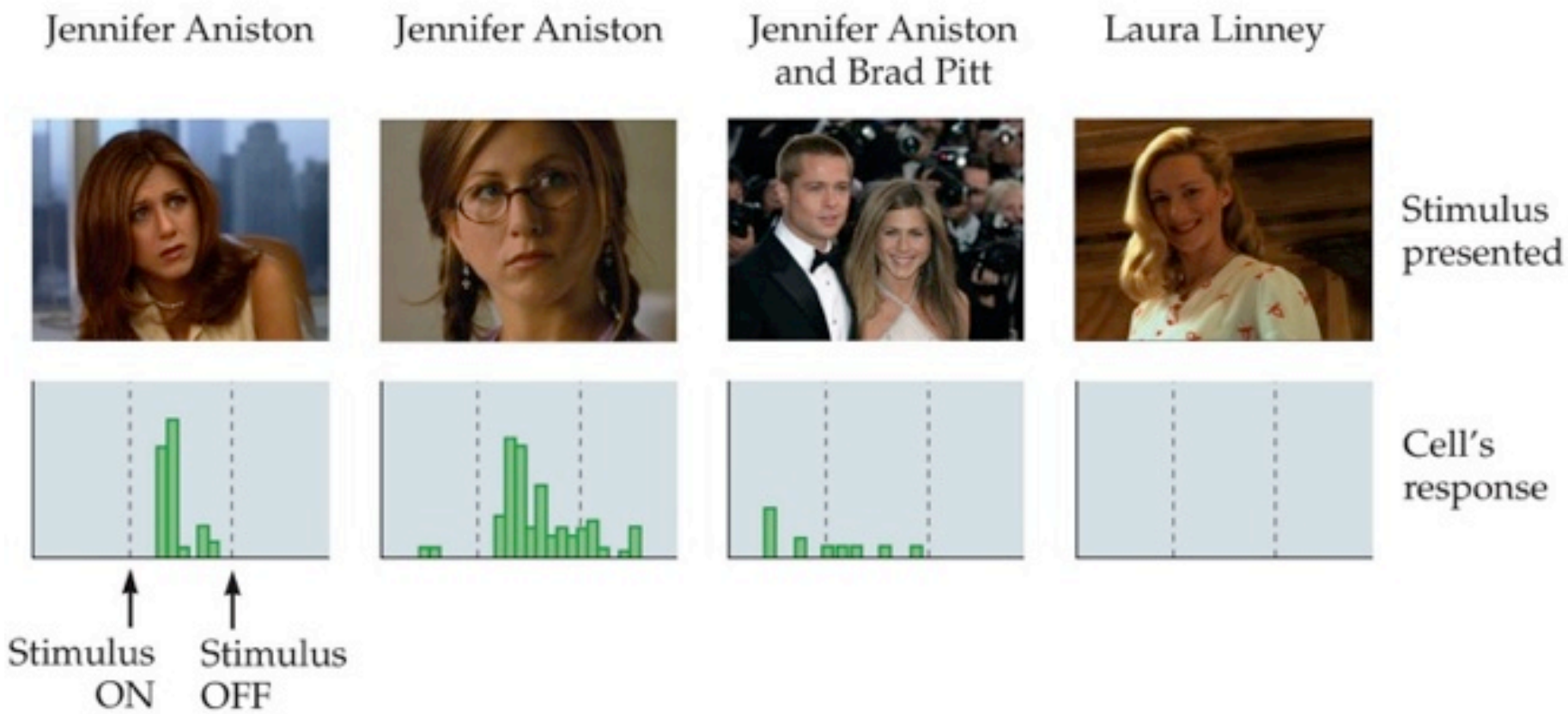
"Grandmother cell" - idea of a single neuron responsible for representing some complex object (eg, your granny)

- long considered "idea that could never work"
- how could you have a different neuron for every possible object you know how to recognize?
- what if that neuron died? Could you still recognize your grandmother?

“Jennifer Anniston neuron”

Quiroga et al 2005 (single-cell recordings in humans!)

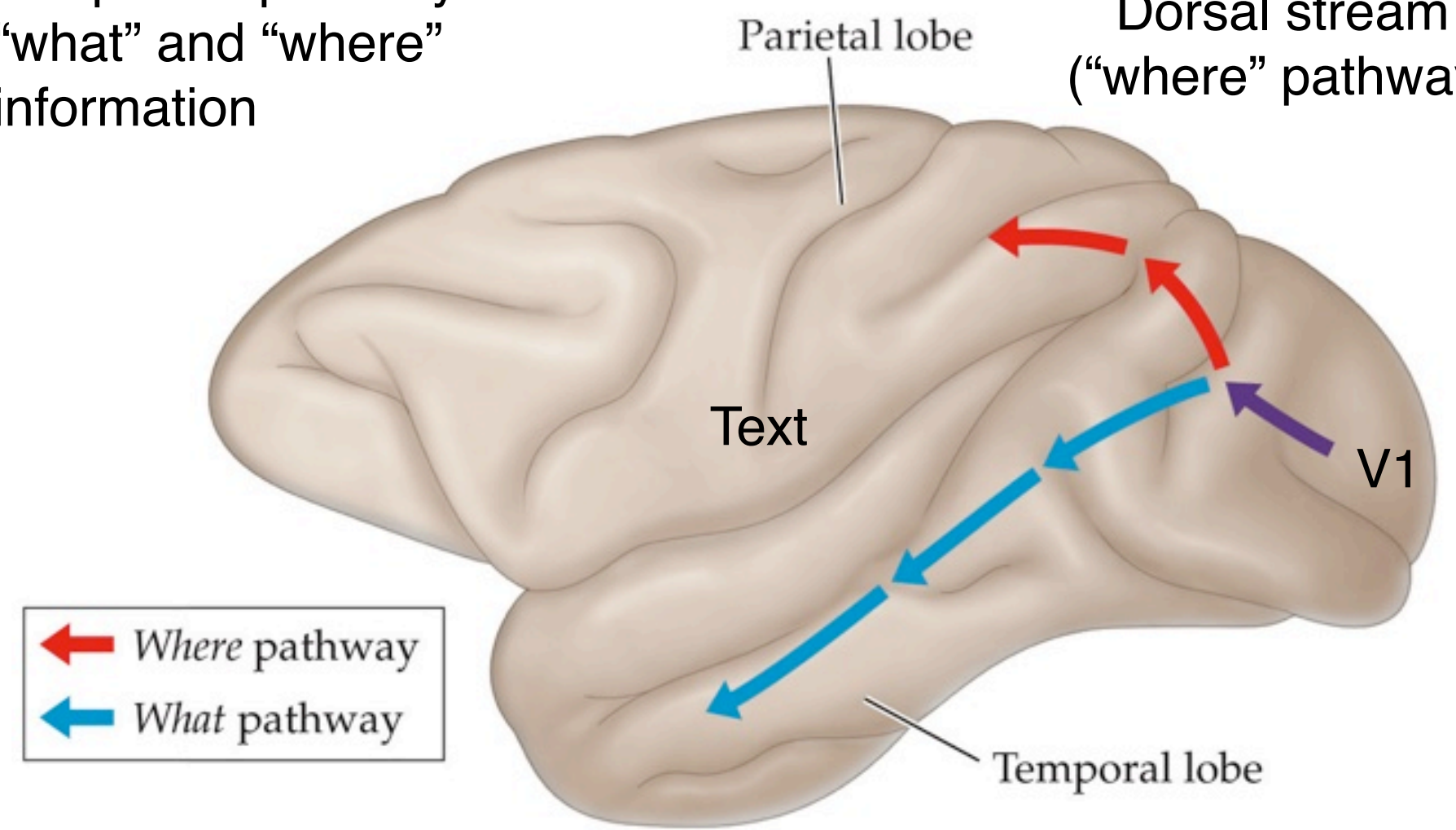
Inferotemporal (IT) cortex
- high selectivity to people / things, independent of viewpoint



Two facts that constrain any models of object recognition in the visual system

1. Visual processing divided into two cortical streams:

• Separate pathways for "what" and "where" information



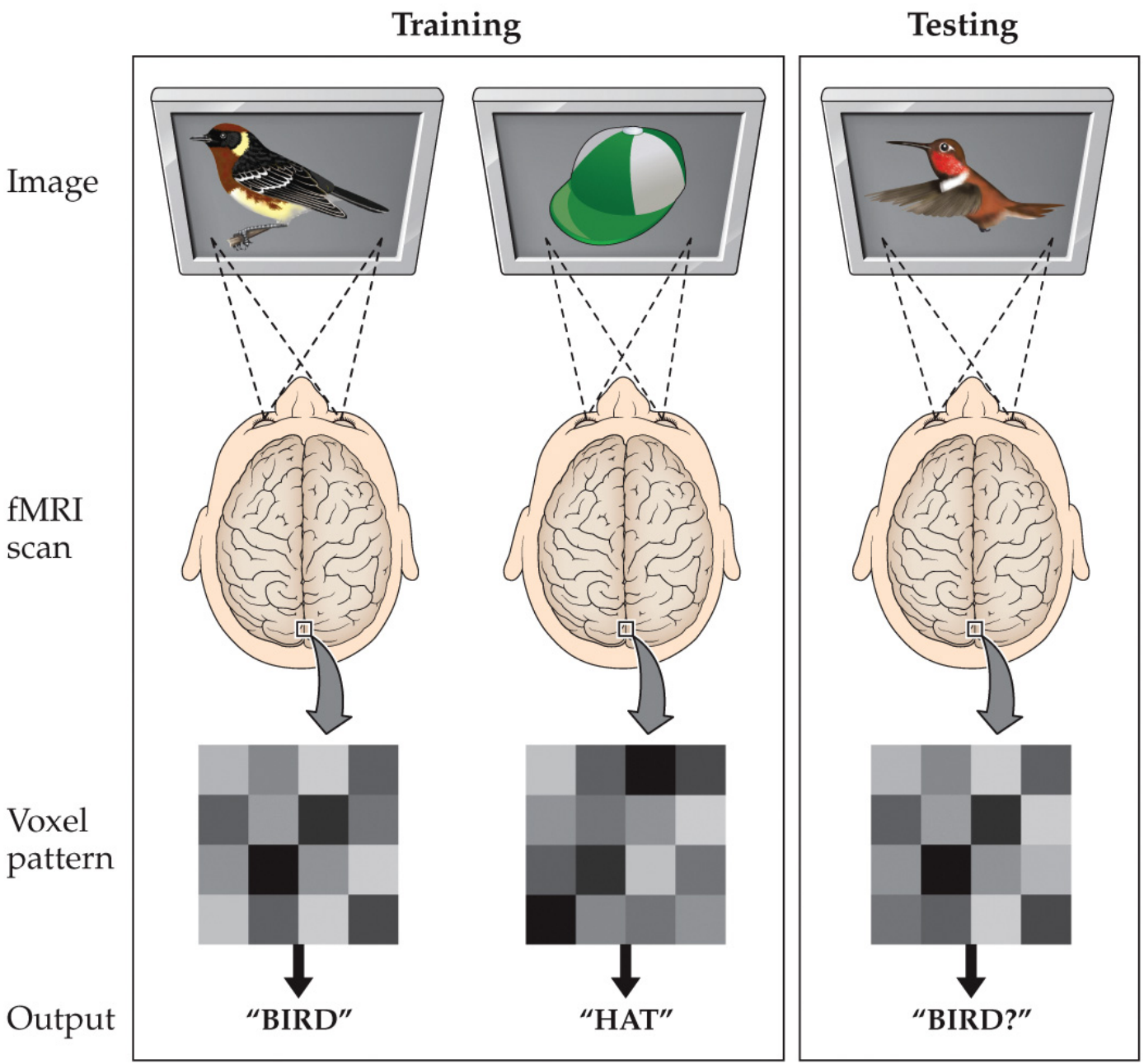
Ventral stream ("what" pathway)

Identifying brain regions associated with object recognition:

Functional imaging (fMRI) decoding method:

- train a computer to identify images using functional images of brain activity.
- Then examine which brain areas allow for objects to be decoded most accurately

fMRI decoding method:



Some areas of human cortex are specialized to process certain types of stimuli.

- **Parahippocampal place area (PPA):** responds preferentially to places, such as pictures of houses.
- **Fusiform face area (FFA):** responds to faces more than other objects.
- **Extrastriate body area (EBA):** perception of body parts.

2. Object recognition is *fast.* (100-200 ms)
Suggests operation of a feed-forward process.

(5 frames /s)

Feed-forward process: computation carried out one neural step after another, without need for feedback from a later stage

(Still debated, but it's agreed there's not much time for feedback).

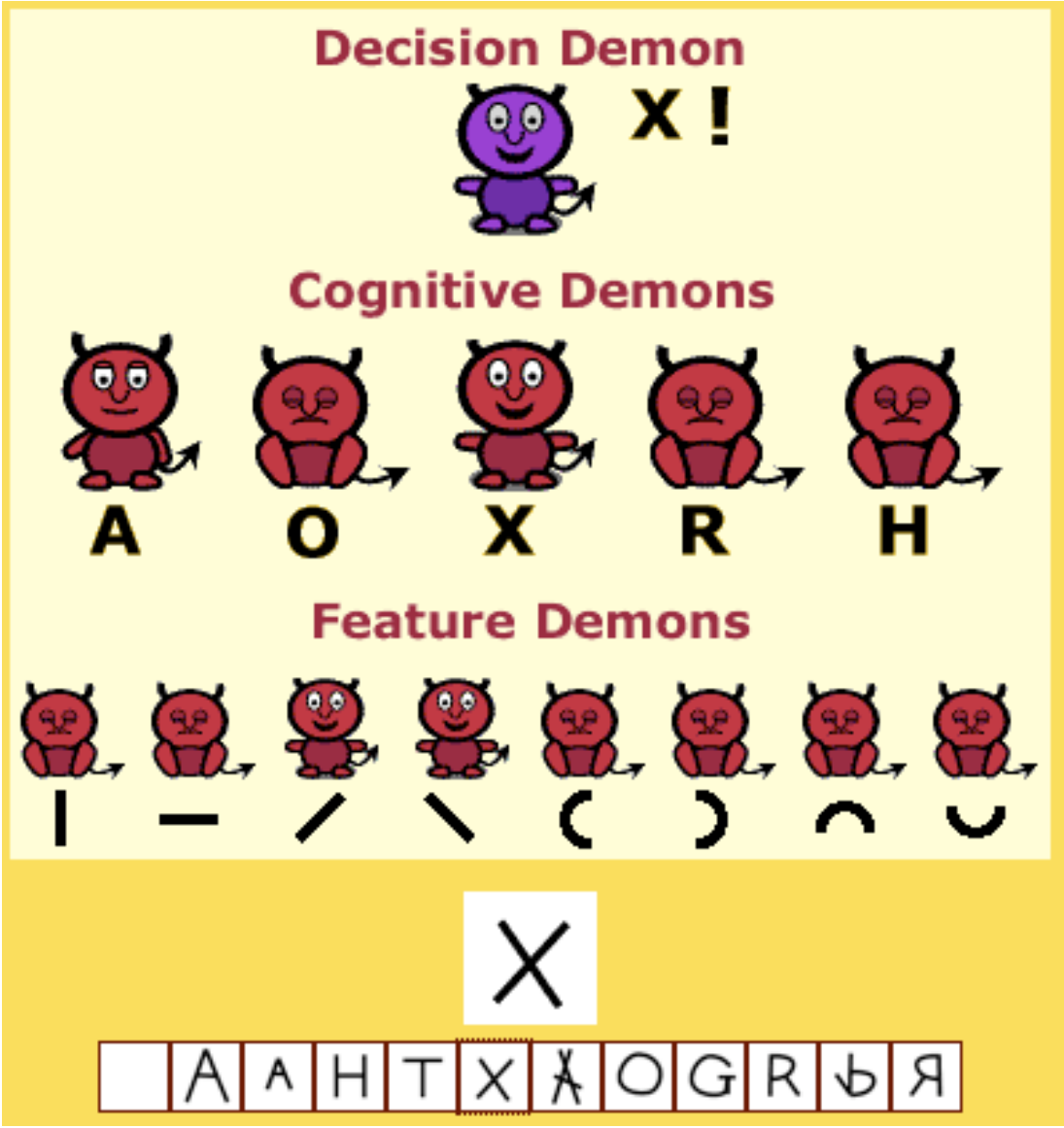
Models of Object Recognition

pandemonium model

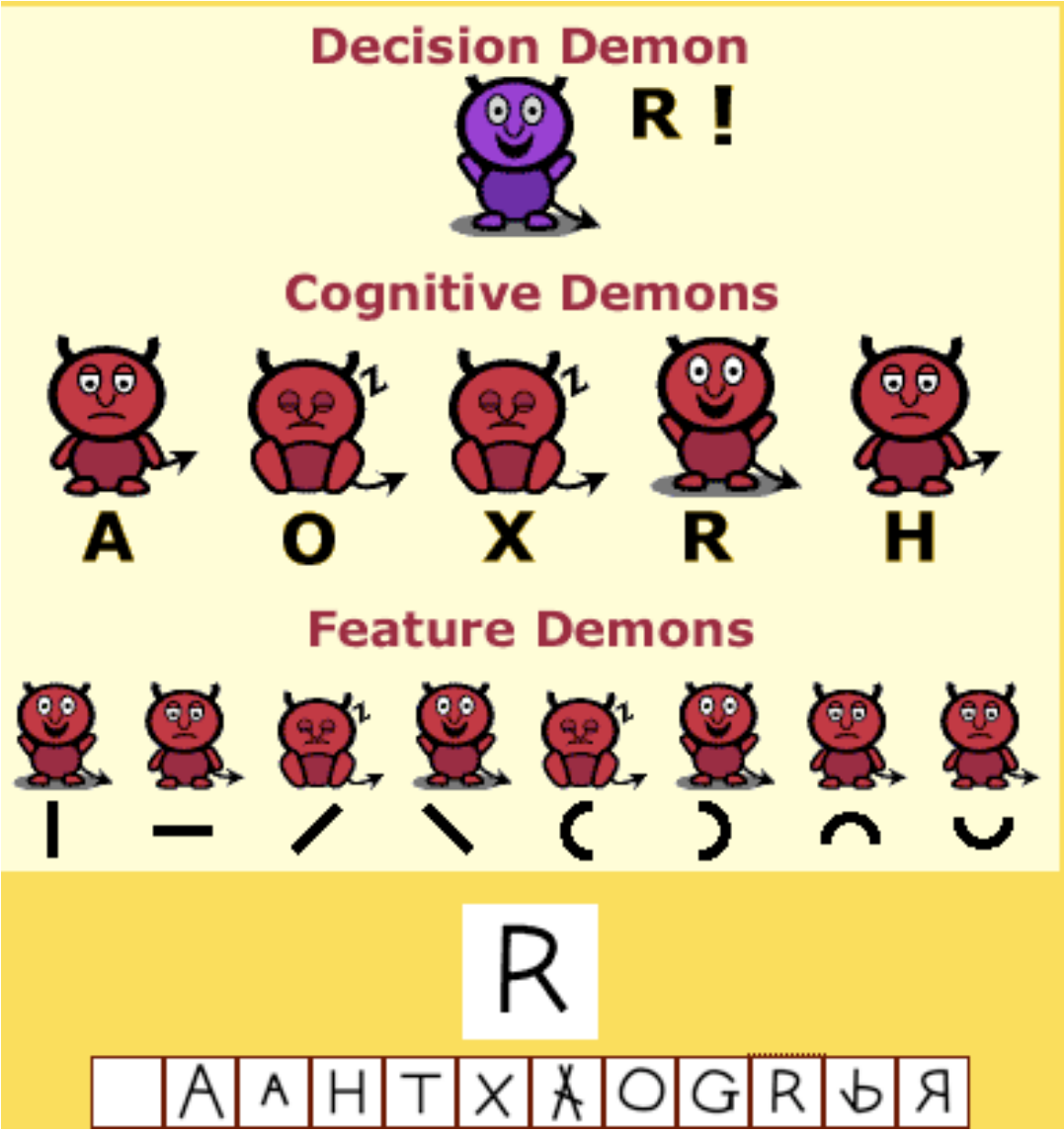
- Oliver Selfridge's (1959) simple model of letter recognition
- Perceptual committee made up of "demons"
  - Demons loosely represent neurons
  - Each level is a different brain area
- Pandemonium simulation:

https://oup-arc.com/access/content/sensation-and-perception-5e-student-resources/sensation-and-perception-5e-activity-4-5?previousFilter=tag_chapter-04

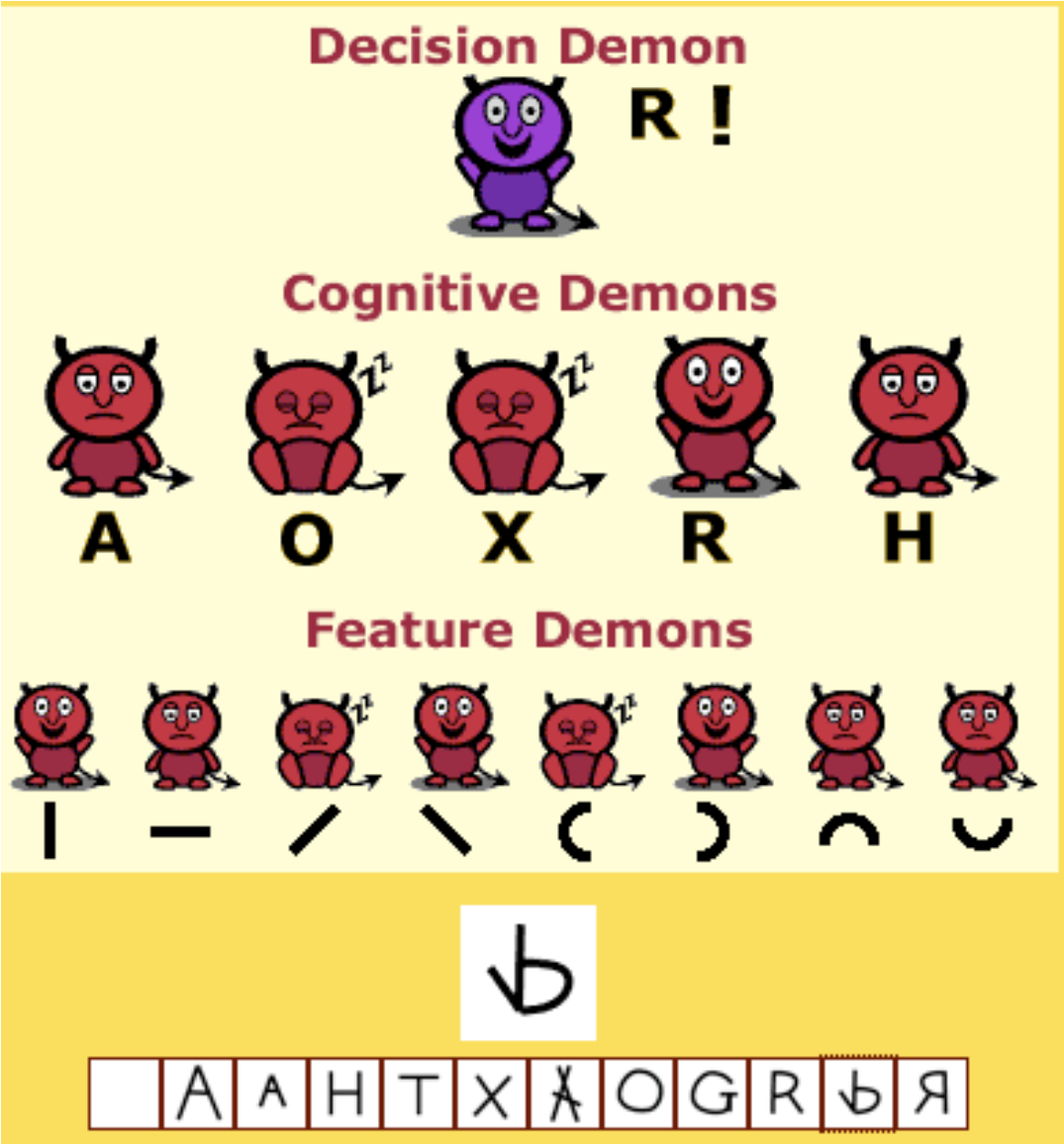
Models of Object Recognition



Models of Object Recognition



Models of Object Recognition



Models of Object Recognition

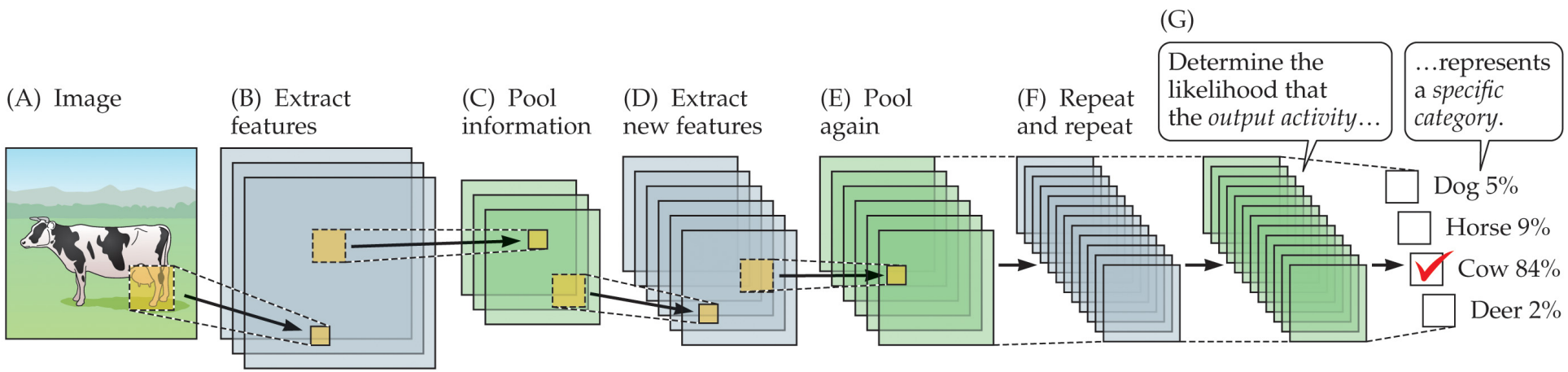
- Hierarchical "constructive" models of perception:
- Explicit description of how parts are combined to form representation of a whole

Metaphor: "committees" forming consensus from a group of specialized members

• perception results from the consensus that emerges

modern version: deep neural networks

Last 10-20 years: rapid progress in “deep learning” methods for object recognition & scene understanding



Captioned by Human and by Google's image-captioning program

Human: "A group of men playing Frisbee in the park."
Computer model: "A group of young people playing a game of Frisbee."

http://www.nytimes.com/2014/11/18/science/researchers-announce-breakthrough-in-content-recognition-software.html

Captioned by Human and by Google's image-captioning program

Human: "Three different types of pizza on top of a stove."
Computer: "A pizza sitting on top of a pan on top of a stove."

Captioned by Human and by Google's image-captioning program

Human: "Elephants of mixed ages standing in a muddy landscape."
Computer: "A herd of elephants walking across a dry grass field."

Captioned by Human and by Google's image-captioning program

Human: "A green monster kite soaring in a sunny sky."
Computer: "A man flying through the air while riding a snowboard."

Summary (Chapter 4)

- middle vision
- gestalt rules (grouping, figure-ground)
- illusory contour
- accidental viewpoint
- non-accidental feature
- viewpoint invariance
- what (ventral) /where (dorsal) pathways
- decoding methods
- pandemonium model
- deep neural network models