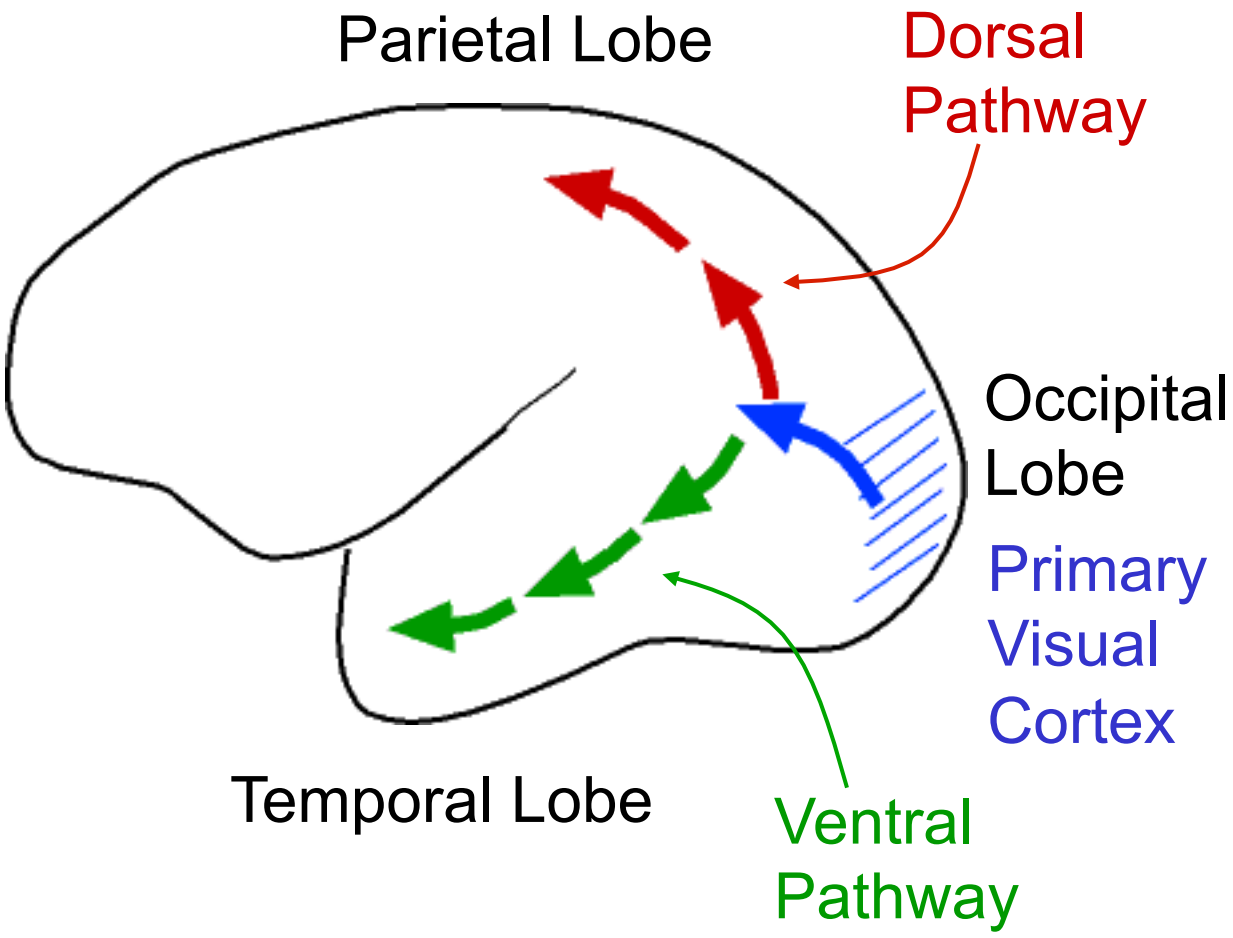
Visual Cortex

From the visual cortex, connections follow two routes. The Dorsal Pathways project to the parietal lobe. The Ventral Pathways project to the temporal lobe.



Dorsal and Ventral Pathways

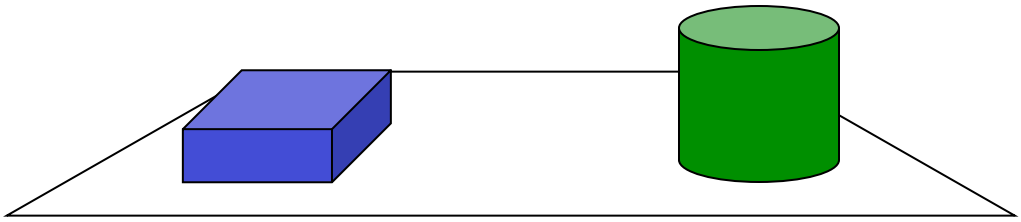
The Dorsal and Ventral pathways seem to represent different aspects of visual perception. Put another way, they represent *parallel processing* of different qualities that are part of visual perception.

In monkeys, removing the ventral pathway or the dorsal pathway cause different behavioral deficits.

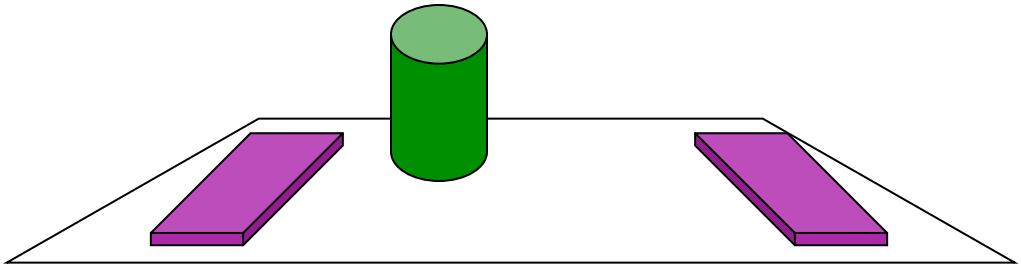
Removing parts of the ventral path (the temporal cortex) leads to problems in object discrimination.

Removing parts of the dorsal path (parietal cortex) leads to problems in location identification (landmark discrimination).

Task Examples

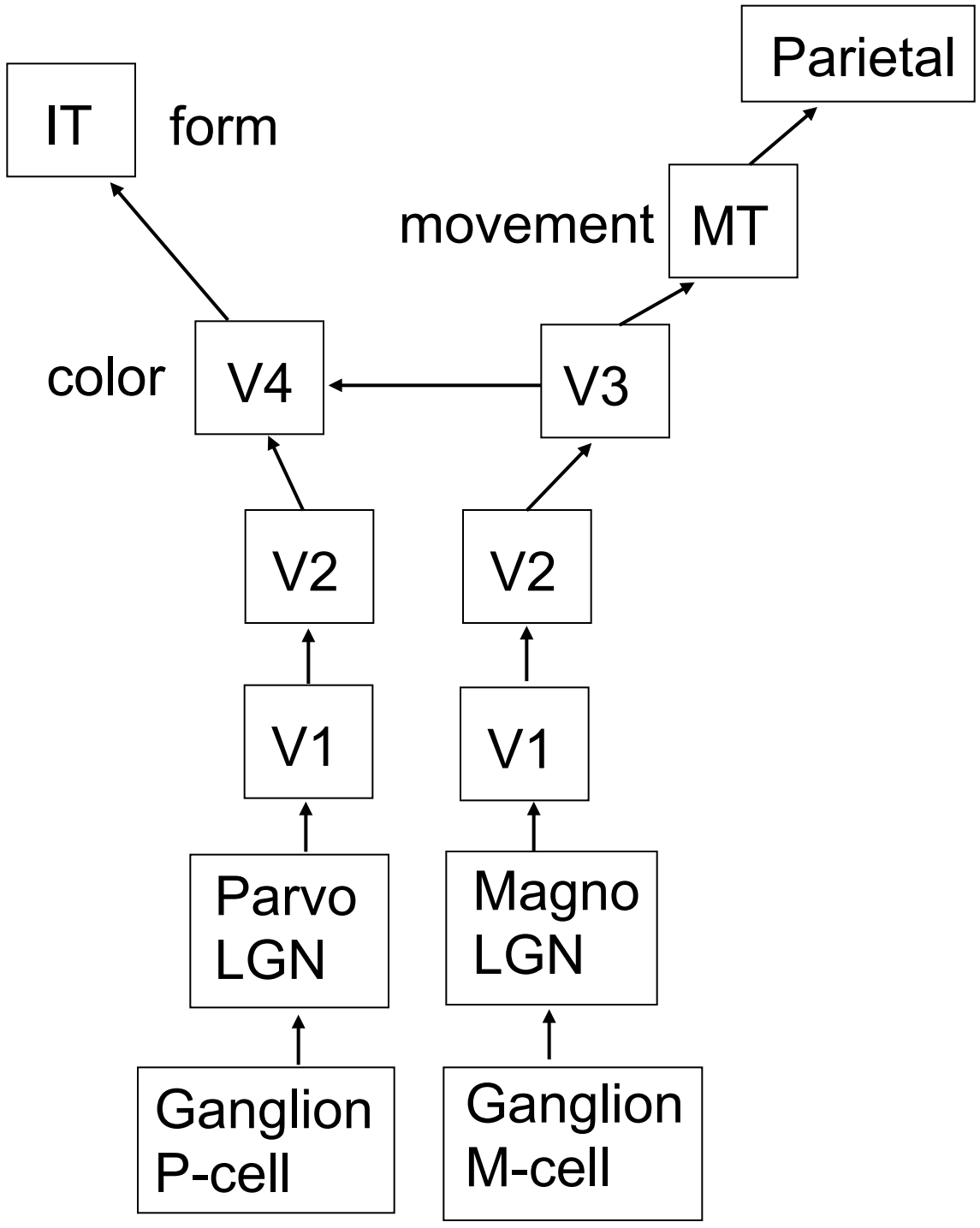


Object Discrimination



Location Discrimination

What and Where Pathways Overview



Human Data

Brain damage due to stroke, CO poisoning, and other trauma can lead to selective perceptual deficits in humans.

A single dissociation is when damage to a particular location leaves one function intact and causes a loss to another function. This means that at least two locations are involved in these two processes though they may be interdependent.

In a double dissociation, loss in one area leads to one deficit and loss in another area to a different deficit. In this case, there are different areas involved in the perceptual processes and they operate independently of one another.

Human Data 2

For example, damage to V4 in humans leads to deficits in color perception, but no loss of the perception of motion. Damage to MT leads to problems in motion perception, but no loss in color or object perception.

An individual (D.F.) with damage to IT can not recognize and label an object or draw it. However, when asked to remember such an object (imagine an apple) she can draw it accurately from memory. When asked later what the drawing is, she was unable to label it.

D.F. could not accurately indicate the orientation of a card held up to her. However, given a card, she could accurately insert it into a narrow slot.

Modularity - Area MT

Modularity means that different regions of the cortex handle different functions.

Neurons in MT are motion sensitive. Very few neurons in V4 are motion sensitive. In V4, about 60% of neurons are color (wavelength) sensitive while virtually no neurons in MT are color sensitive.

What happens to the behavior of a monkey if MT is damaged? In a normal monkey, if a display of many points has most of them in random motion but a few are moving together, the monkey can reliably detect the direction of motion. (A few means 1 to 2%). If area MT is damaged, 10 times as many points must be moving together for the monkey to detect the motion direction.

Modularity - Area IT

Neurons in area IT (Inferotemporal Cortex) respond to a range of shapes, many complex.

1. Some neurons respond regardless of the retinal location or size of the shape. That is, these cells are *size invariant* and *location invariant*.

2. Some cells respond only to a particular size or retinal location.

Neurons within a column in IT tend to respond to similar shapes.

Area IT - Faces

Some neurons in IT respond to images of faces. Some of these cells are view specific. They respond to a particular view of a face. Others are view invariant. They respond strongly regardless of the angle of view.

This shows that perception involves both highly specific attributes and general, invariant attributes. It is tempting to speculate that this underlies the ability to recognize specific details and instances but to also classify and categorize objects more abstractly.

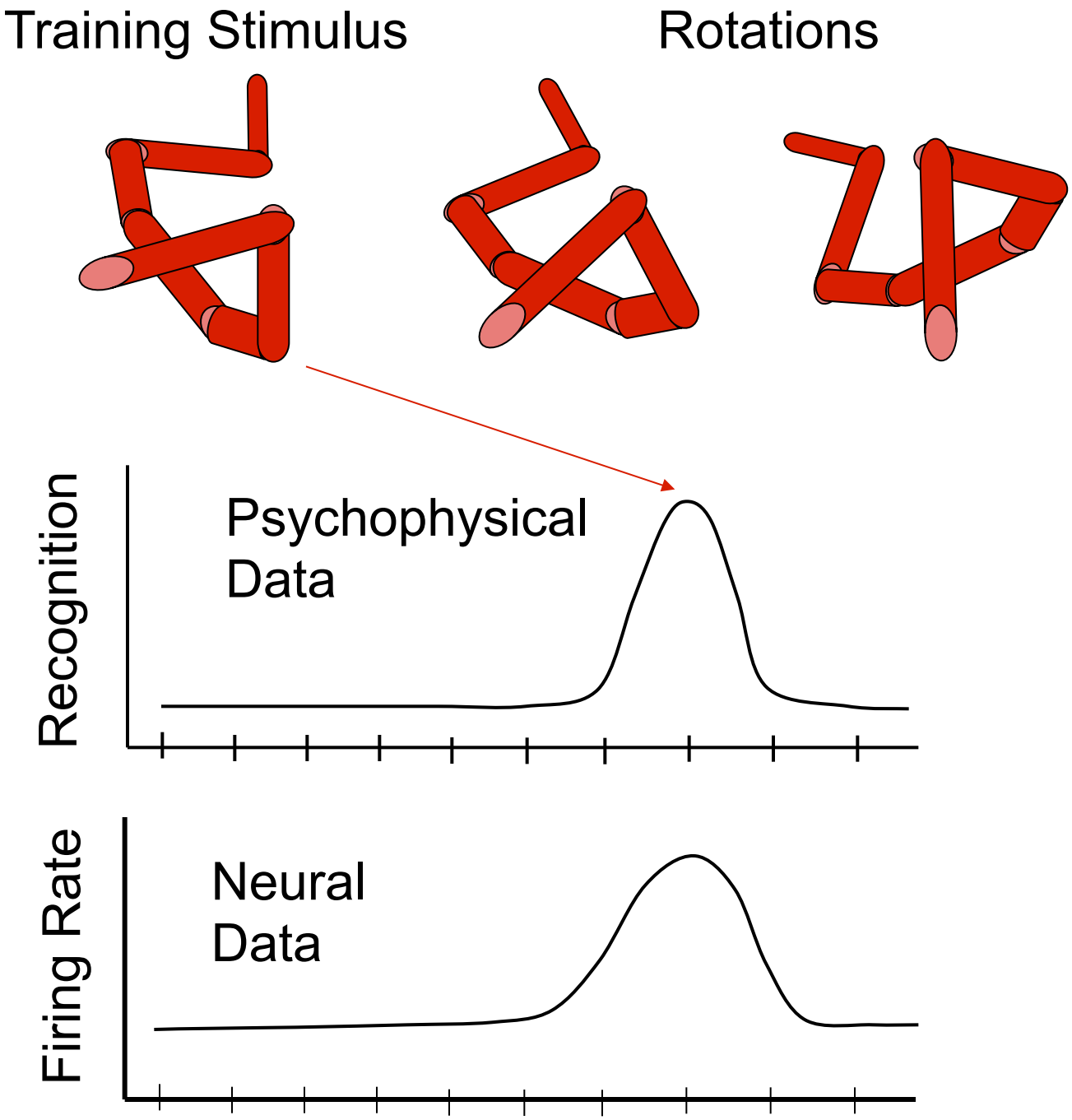
Effects of Learning

If there are neurons in IT that respond to complex patterns, how do they "acquire" this ability? Is it biologically determined? Is it learned?

If a monkey is trained to respond to a particular view of a novel object and tested with rotated views of the novel object, their performance gets gradually worse with the larger rotations.

Neurons in IT can also be found that respond to the novel object, but no neurons that respond to novel objects that the monkey has not been trained on. The neurons show a tuning curve that is similar to the monkey's behavioral data.

Effects of Learning - 2



Human Data - Part 2

An individual, D.B. had to have part of his visual cortex removed to control severe headaches.

After the operation, he had a scotoma or area of the visual field in which he could not see spots of light. For D.B., this was the lower left quadrant of the visual field.

Even though D.B. could not detect the presence of a light in this quadrant, if a test spot was flashed there and D.B. was asked to point to the location of the spot, he was quite accurate. He could also distinguish between an X and an O presented in this region even though he claimed not to have seen a letter.

Human Data - Part 2 cont.

D.B. showed evidence that visual processing was proceeding even though he was *not aware* of the identity of the stimulus. That is, other visual processes allowed him to detect the location and attributes of the objects in his scotoma.

The processing in the visual cortex seems necessary for awareness, but other areas are also involved in our perceptual abilities and “experience” of the world.

Human Data - Part 3

D.F. had a different deficit: inability to recognize objects. This is *visual agnosia*. In some cases, a person with agnosia can recognize parts of objects and describe them but is unable to put the whole object together. e.g. A carrot has a pointed end and a feathery end and may be recognized as a brush.

Prosopagnosia is the inability to recognize faces. That the ability to do this particular complex task can be lost while other forms of object recognition remain means that different aspects of recognition are mediated by different modules or combinations of modules (brain areas).

Attention and Perception

In humans, an object must be attended in order to be reliably remembered. What is the role of attention in perception? What is its effect on neural responses?

Fixation

Receptive Field

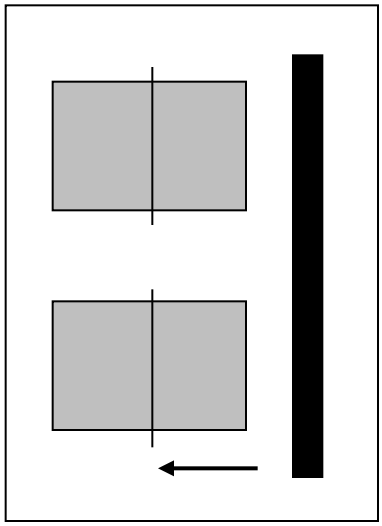
Record from neuron in Dorsal Pathway. When the object in the receptive field was irrelevant, the neuron responded weakly. When the same object was relevant, the neuron responded strongly.

The Binding Problem

Different areas of the cortex code different properties. However - our experience (perception) is of a single, unified world or object. How are the responses of different areas grouped or bound together in representing an object? This is the binding problem.

One possibility is that if cells in different regions are responding to the same object, then their firing is synchronized or phase locked.

Binding Problem - 2

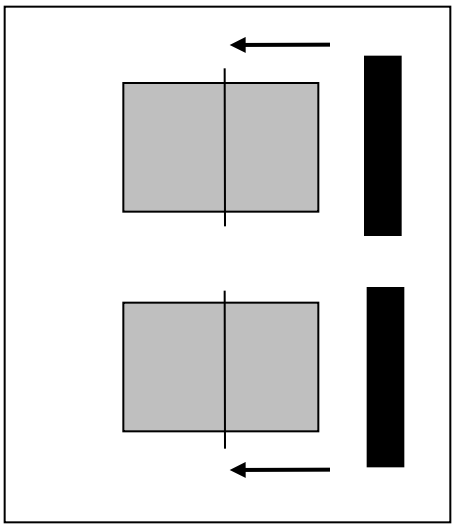


When we record from two complex cells with vertically oriented fields above one another, a single vertical bar elicits synchronized firing in the two cells.

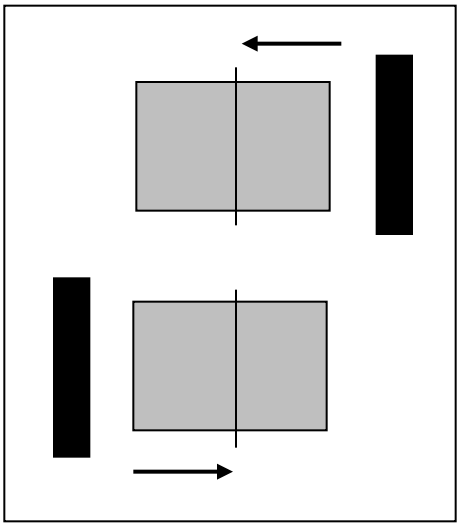
Two aligned vertical bars that move together elicit a strong, but less synchronized response from these two cells.

If the two bars do not move together, there is no synchronization.

Binding Problem - 2 cont.



Some synchronization in cell firing



No synchronization in cell firing

Higher Level Cortical Processing Summary

Different pathways process different attributes.

Some are done in a specific manner, some are invariant across transformations (location, view, size).

Attention and learning can modify the response properties of cells.

Attributes that belong to the same object may elicit synchronized firing by the neurons that code these attributes.