

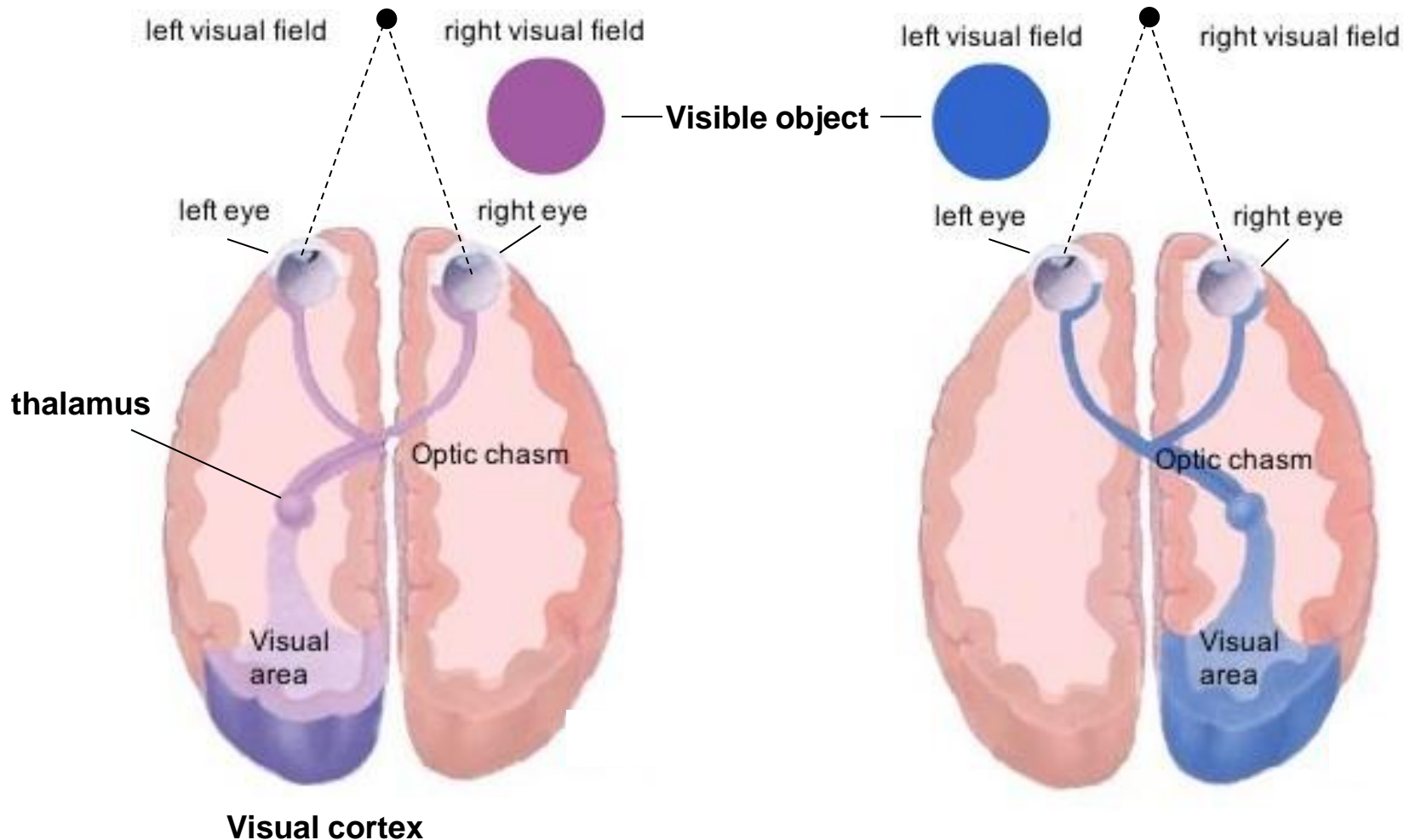
JHU BME 580.422 System Bioengineering II

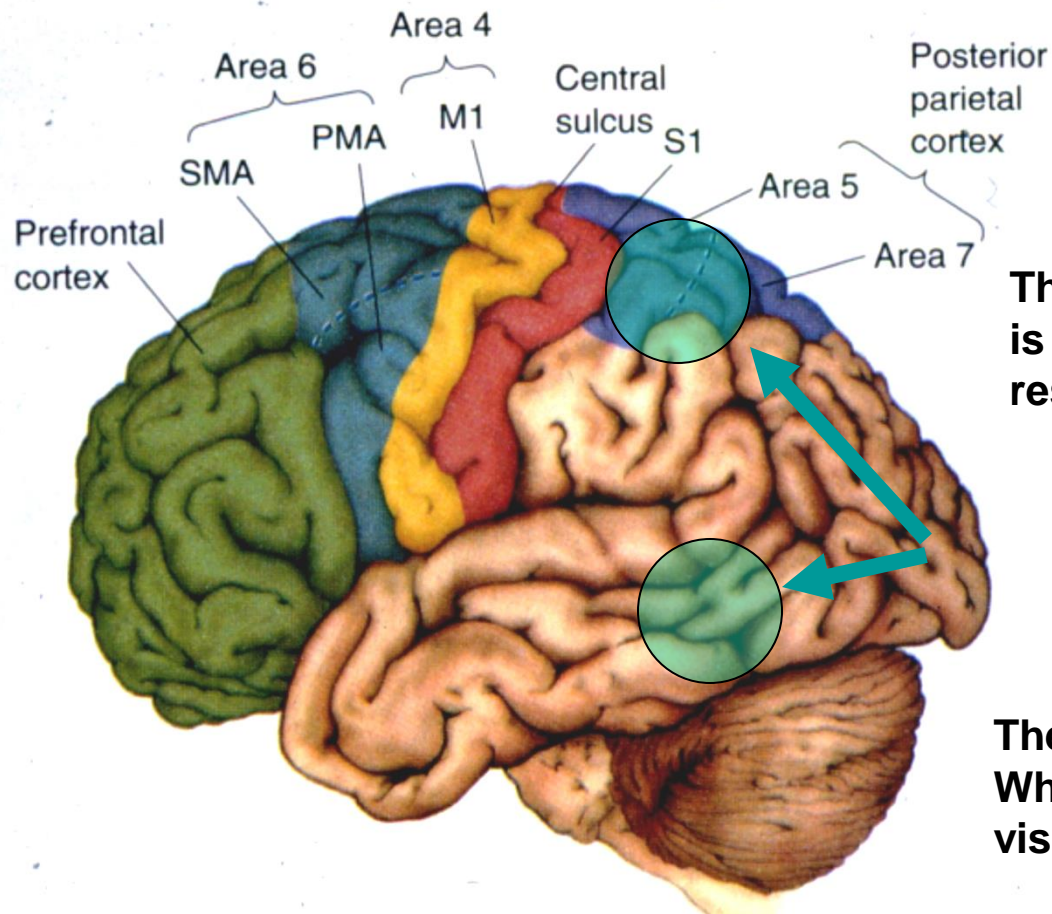
Going from vision to action: posterior parietal cortex

Descending tracts from the brain to the spinal cord

Reza Shadmehr

Objects to the right of fixation fall on the left hemi-retina, and are processed by the left visual cortex.

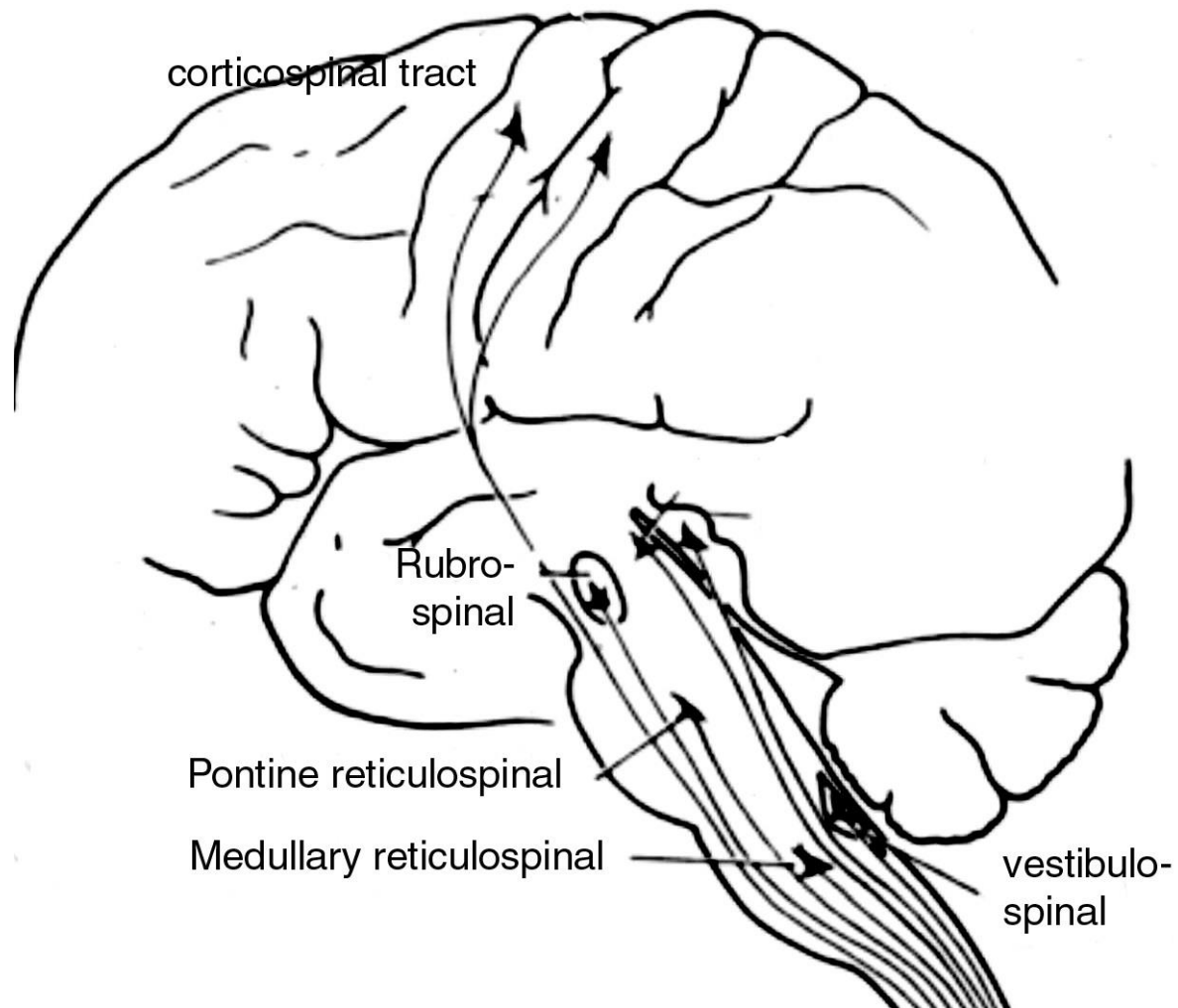




The dorsal visual stream: Where is the location of this object with respect to my body?

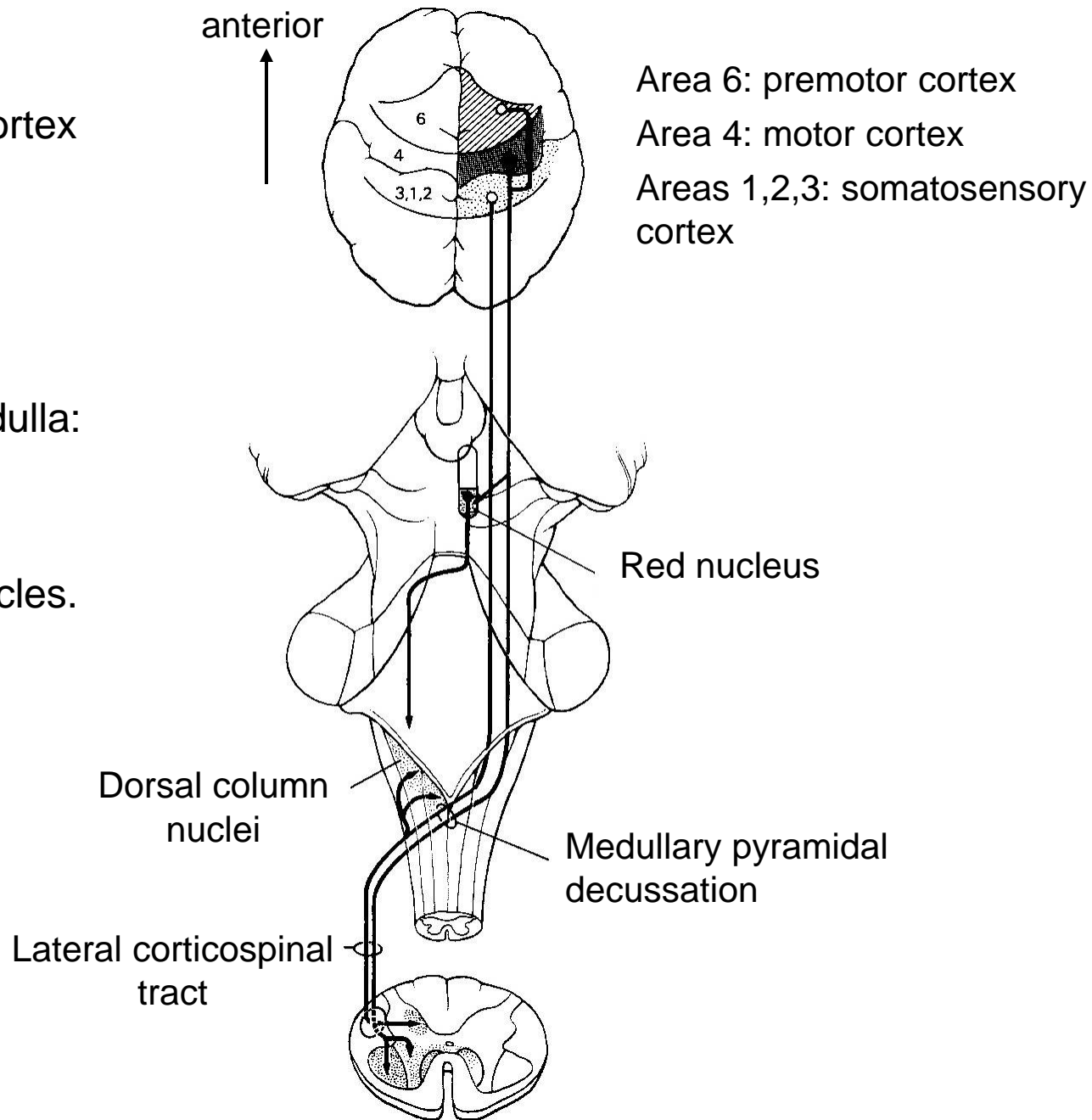
The ventral visual stream: What is this object in my visual field?

Descending tracts: send information from the brain to the spinal cord.



Corticospinal tract

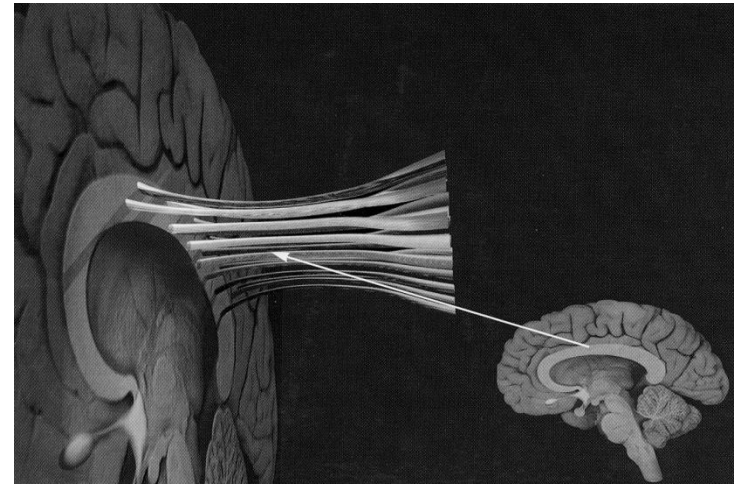
- Origin: primary motor cortex (30%), Premotor (30%), somatosensory (30%)
- About 1 million fibers in humans.
- 90% cross at lower medulla: Right motor cortical areas control the left side of the body, specially distal muscles.
- 10% do not cross
- All are excitatory
- Small diameter, slow conducting fibers



Split brain patients

A small number of individuals have had their corpus callosum sectioned to relieve intractable epilepsy.

In these individuals, information in the right visual field only goes to the left hemisphere.



The two hemispheres: alien hand

The period soon after the surgery, the split brain patient found that it often took her hours to get dressed in the morning because while her right hand would reach out and select an item to wear, her left hand would grab something else. She had trouble making the left hand follow her will.

The clothes selected by this woman's left hand were usually more colorful and flamboyant than those the woman hand "consciously" intended to wear.

While one patient was holding a favorite book in his left hand, the right hemisphere (which controls the left hand but cannot read) orders the left hand to put down the book.

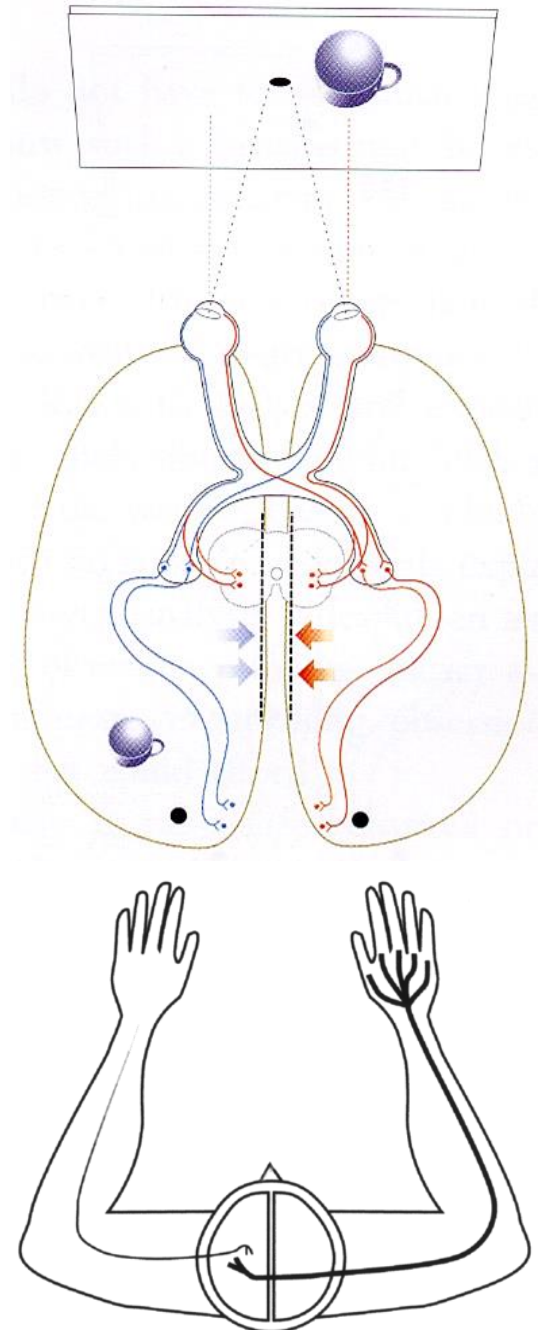
Left hemisphere has strong control over the contralateral arm and hand

Left hemisphere some control over the ipsilateral proximal arm muscle

Left hemisphere very little control over the ipsilateral hand muscle

Split brain patient studies:

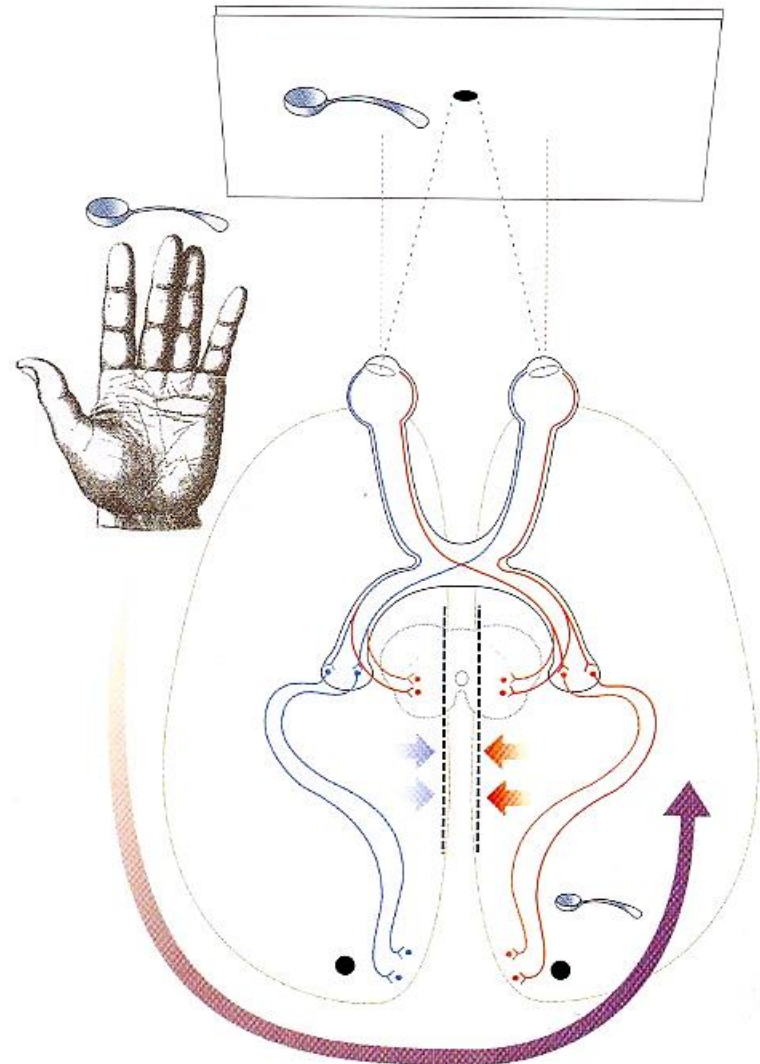
1. **Left hemisphere has good control over the left proximal arm muscles:** Subject is shown a cup in the right visual field. Information arrives in the left hemisphere. She is asked what she sees, and she answers “a cup”. She is asked to reach with the left arm towards the cup. She can reach with left arm normally.
2. **Left hemisphere has very poor control over the left finger muscles:** Subject is shown a hand posture in the right visual field and asked to copy it with the left hand. She cannot do so. Correct responses are seen for only the very basic gestures like making a fist.



The two hemispheres: language center is usually in the left hemisphere

Now a picture of a spoon is shown to the left of the dot. The picture goes to the right hemisphere. She is asked what she saw, and she says “nothing”. She says this because in nearly everyone, the language centers are in the left hemisphere. Because the left hemisphere has not been given the visual information, it says that it has seen nothing.

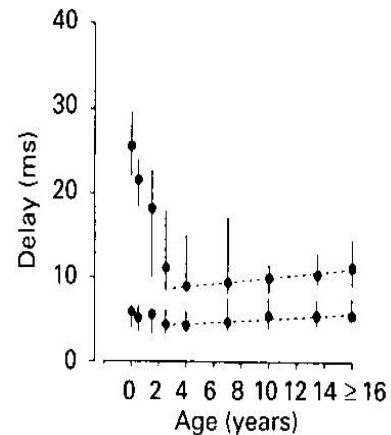
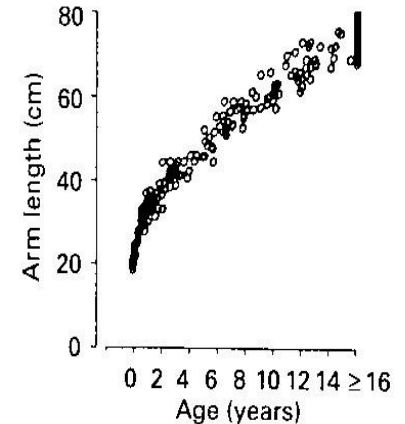
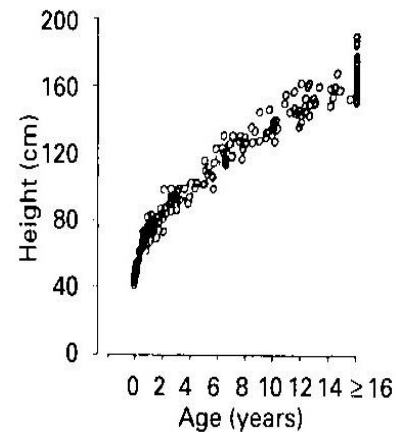
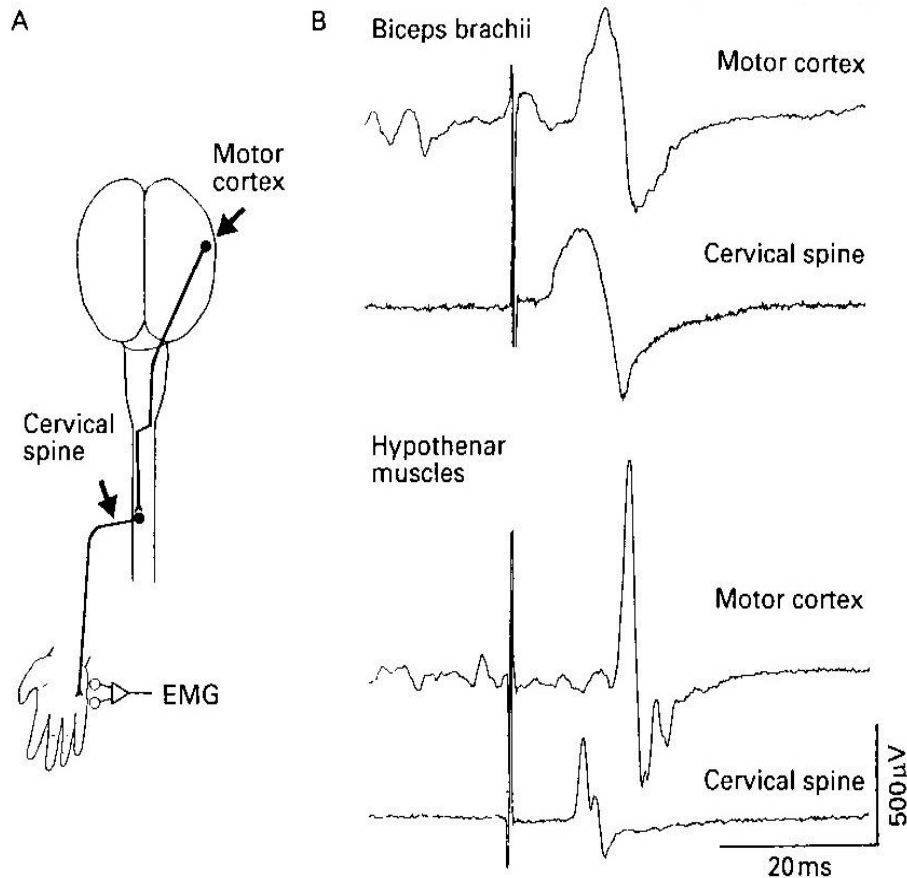
However, when N.G. is asked to reach under a table with her left hand and select, by touch only, from among a group of concealed items the one that was the same as the one she had just seen, she picks a spoon. While she is holding the spoon under the table, she is asked what she is holding, she says “a pencil”. (R.W. Sperry 1968, American Psychologist 23:723-733)



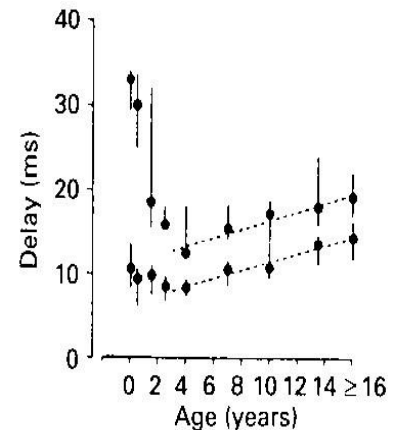
Examination of the corticospinal tract

Stimulation is used to activate the motor cortex, and cervical spine.

Evoked EMG at biceps and hand muscle is recorded.



Delay to biceps



Delay to hand

Reticulospinal tracts

Large fiber axons.

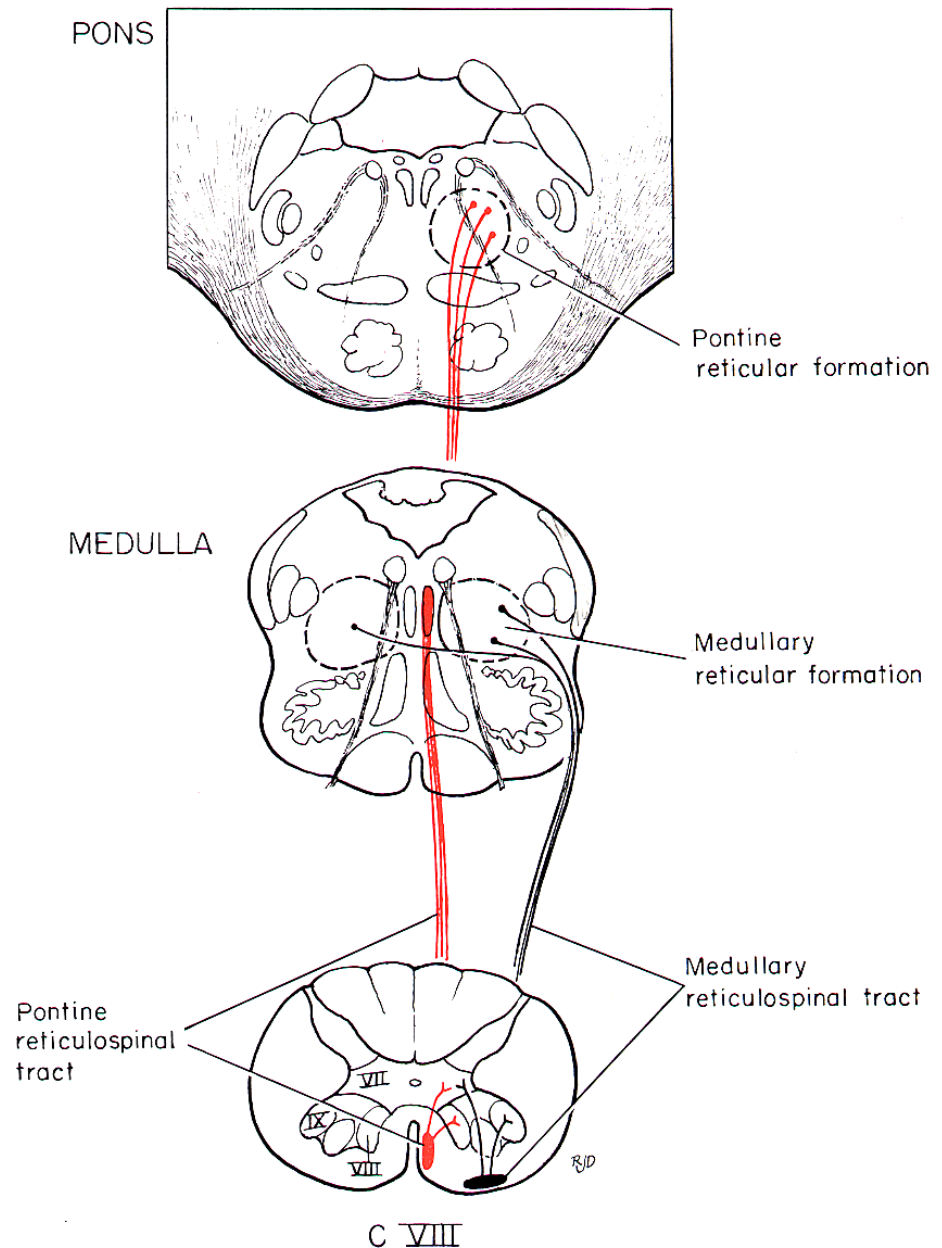
Control of posture and balance, acting on anti-gravity muscles.

Pontine reticulospinal tract

Excitatory synapses on leg extensors and arm flexors.

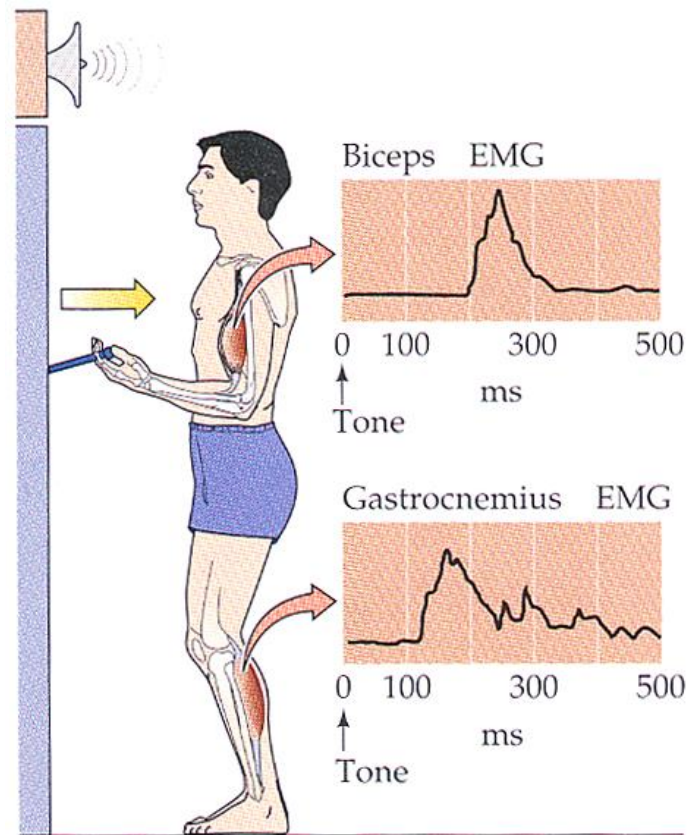
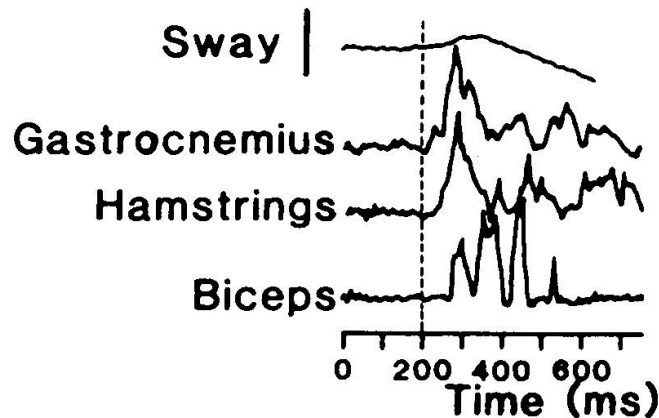
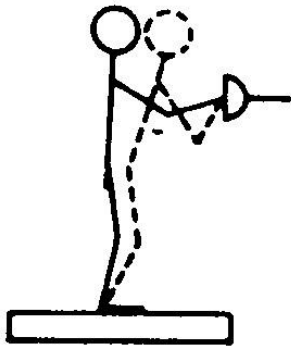
Medullary reticulospinal tract

Inhibitory synapses. Action is to reduce muscle tone for nearly all muscles of the upper and lower limbs.



Voluntary movements of our arm can have postural consequences.

The brain **predicts postural consequences of planned movements** and acts to prevent loss of balance.



Example of action of the pontine reticulospinal tract

Bell sounds to initiate the lift.
Biceps is activated after gastrocnemius.

Summary

Visual objects to the right of fixation are processed predominately by the left visual cortex. However, because of the corpus callosum, this information is shared with the contralateral cerebral hemisphere.

The corticospinal tract brings the output of the premotor cortex, primary motor cortex, and the somatosensory cortex. The corticospinal tract in the left brain controls the right arm, and the tract in the right brain controls the left arm.

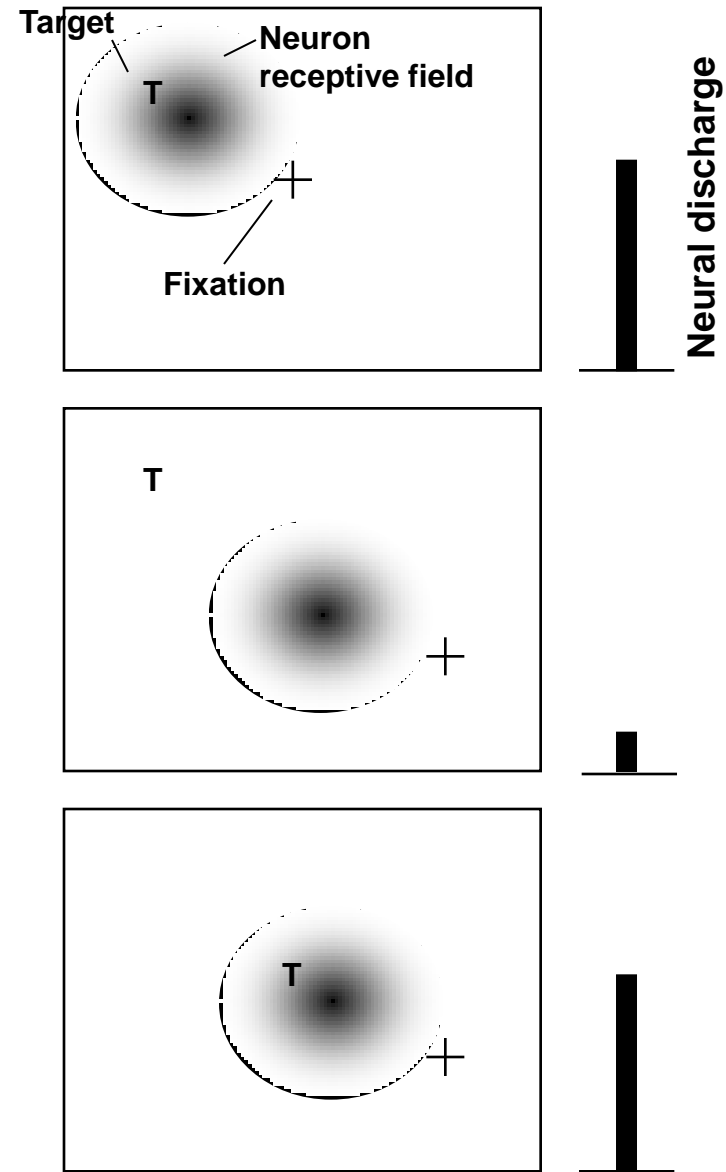
The function of the corticospinal tract is to control limb movements, particularly movements of the fingers.

In the brainstem we have two important motor centers: pontine reticular nucleus and medullary reticular nucleus. These centers sent their output to the spinal cord via the pontine and medullary reticulospinal tracts.

The function of the pontine center is to maintain our balance and posture.

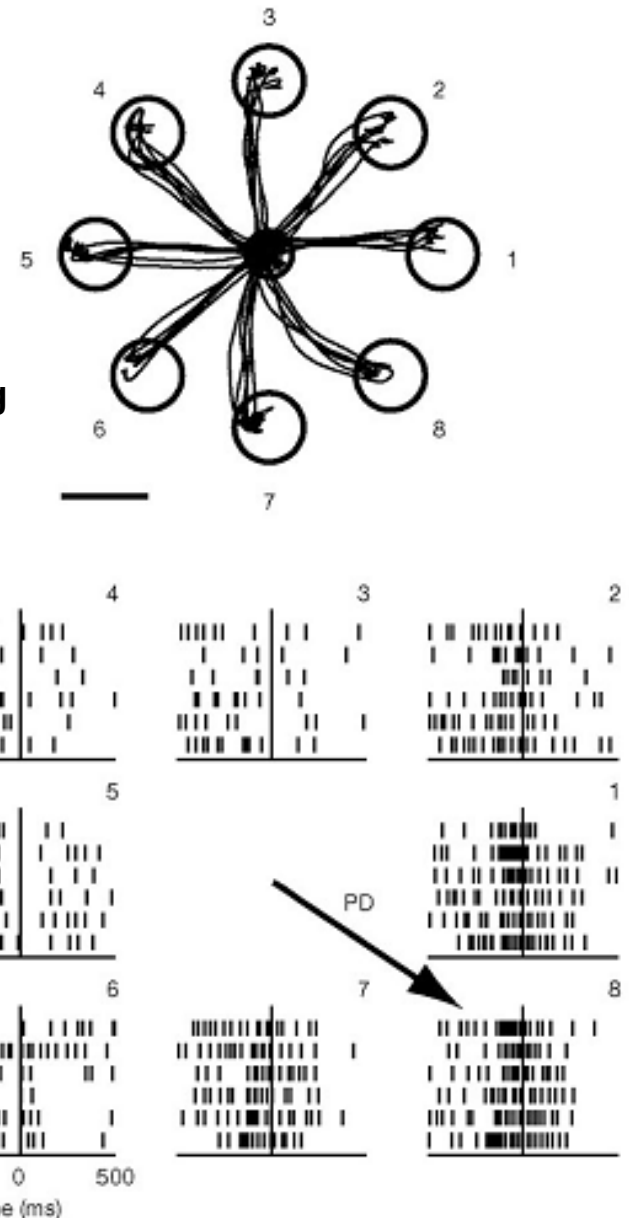
The function of the medullary center is to inhibit muscles, particularly during rest and sleep.

Cells in the visual cortex have a “fixation-centered” receptive field

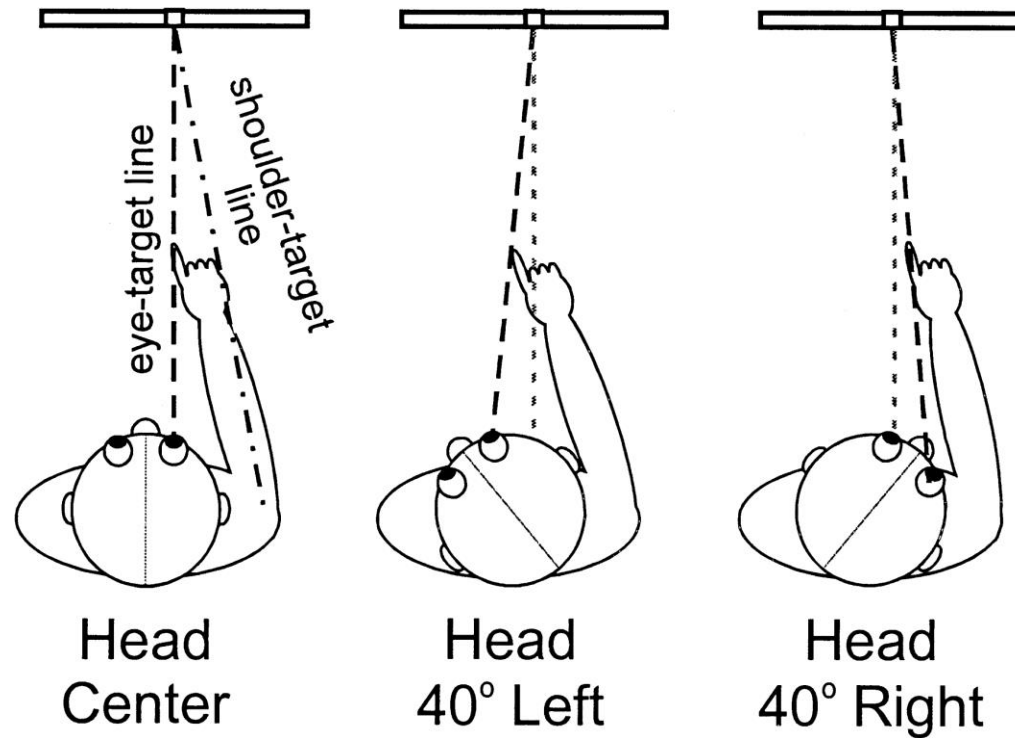


Cells in the motor cortex encode direction of limb movement and forces

Hand trajectory during reaching



When you point to a target, you align your finger with the retinal location of the target

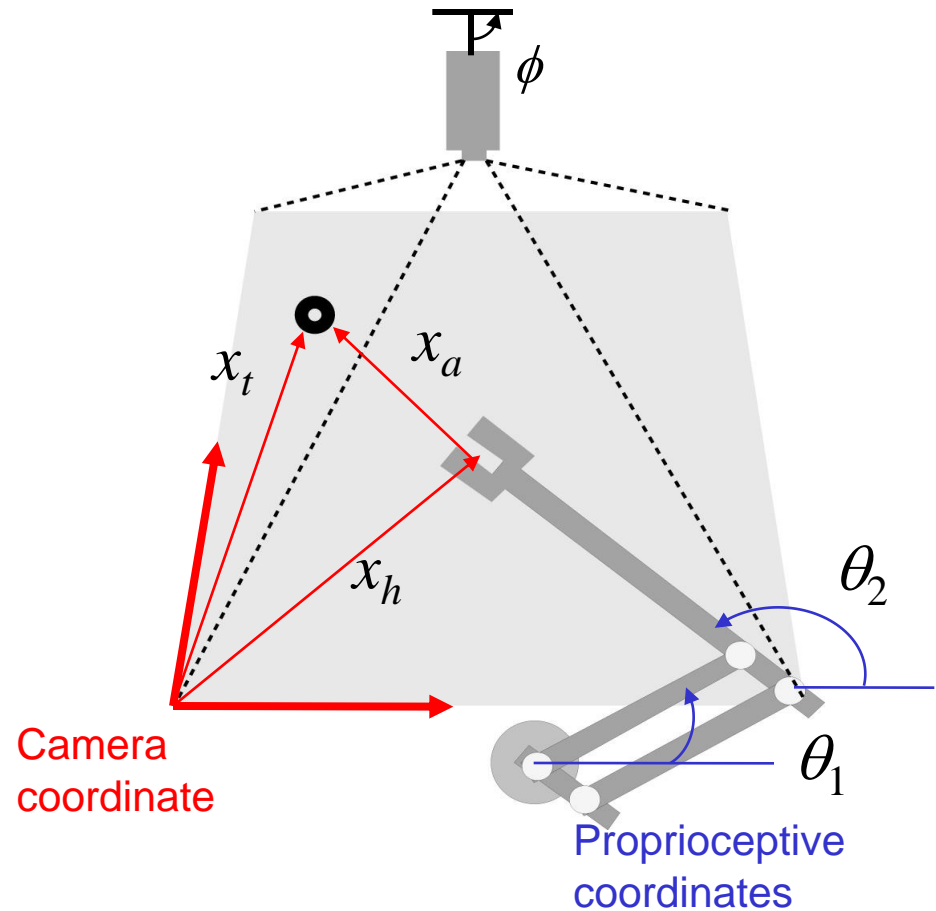


The problem of reaching:

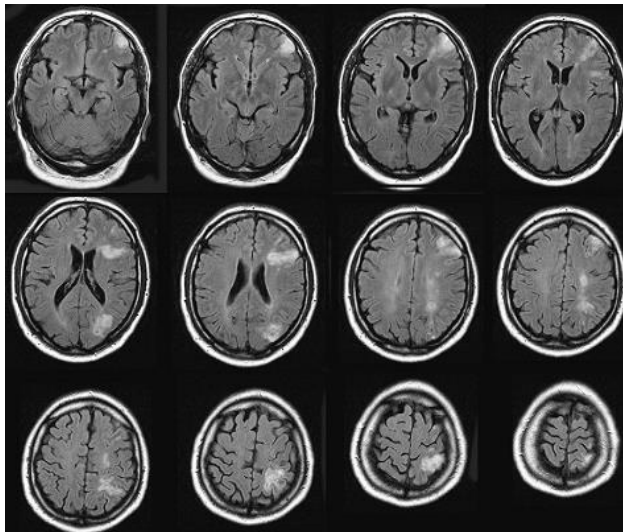
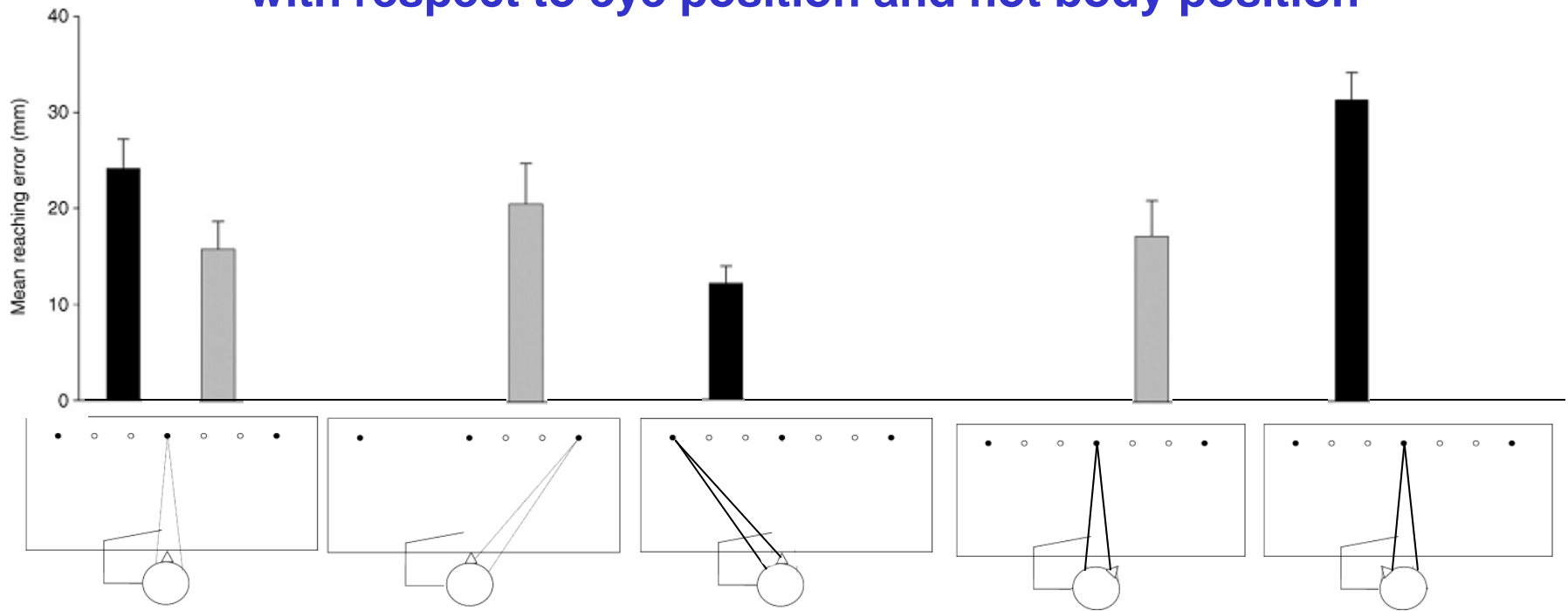
Where is the target of grasp?
(integration of visual information
on the retina with proprioceptive
information from eye and
head/neck muscles)

Where is the gripper? (alignment
of proprioception with vision)

What are the task's requirements
(rewards and costs)?



Reaching errors in parietal lobe damage suggest a coding of space with respect to eye position and not body position



56 year old right handed male who suffered an infarct in the right hemisphere, frontal and parietal areas.

**Difference vector
(target location with respect
to hand)**

**Premotor
cortex**

**Fixation-centered
location
of hand**

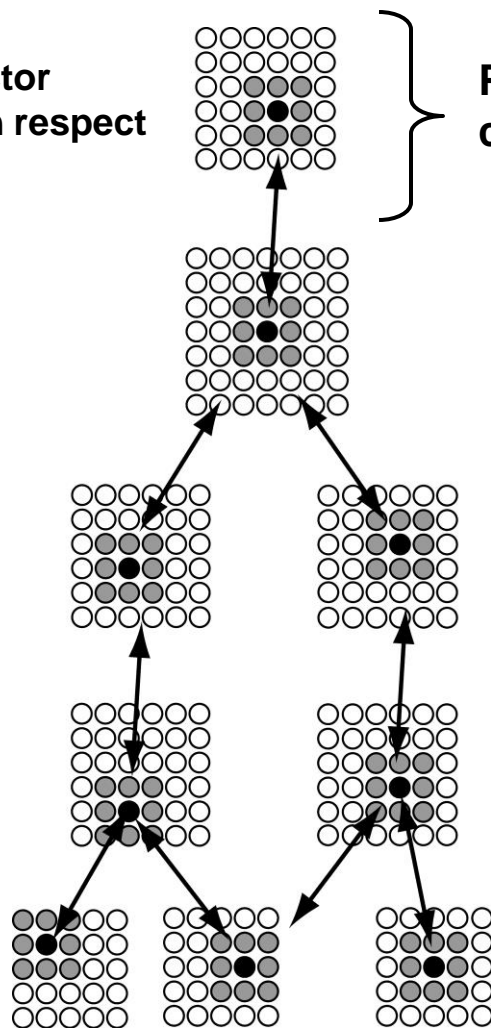
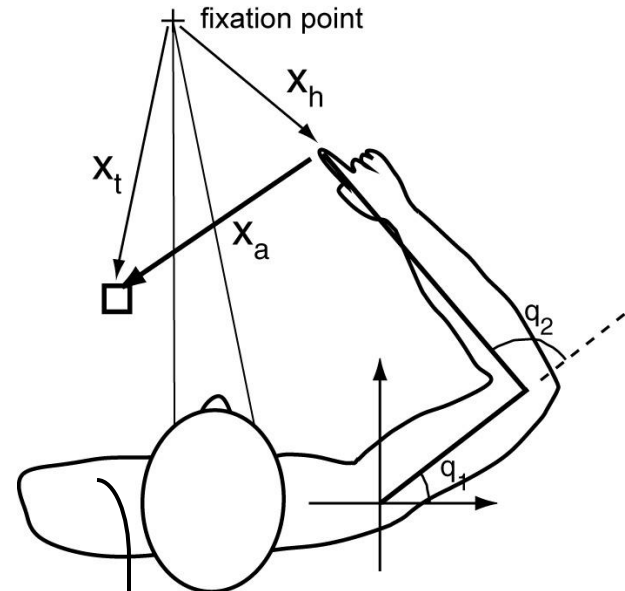
**Fixation-centered
position
of target**

**Post. Parietal
Cortex**

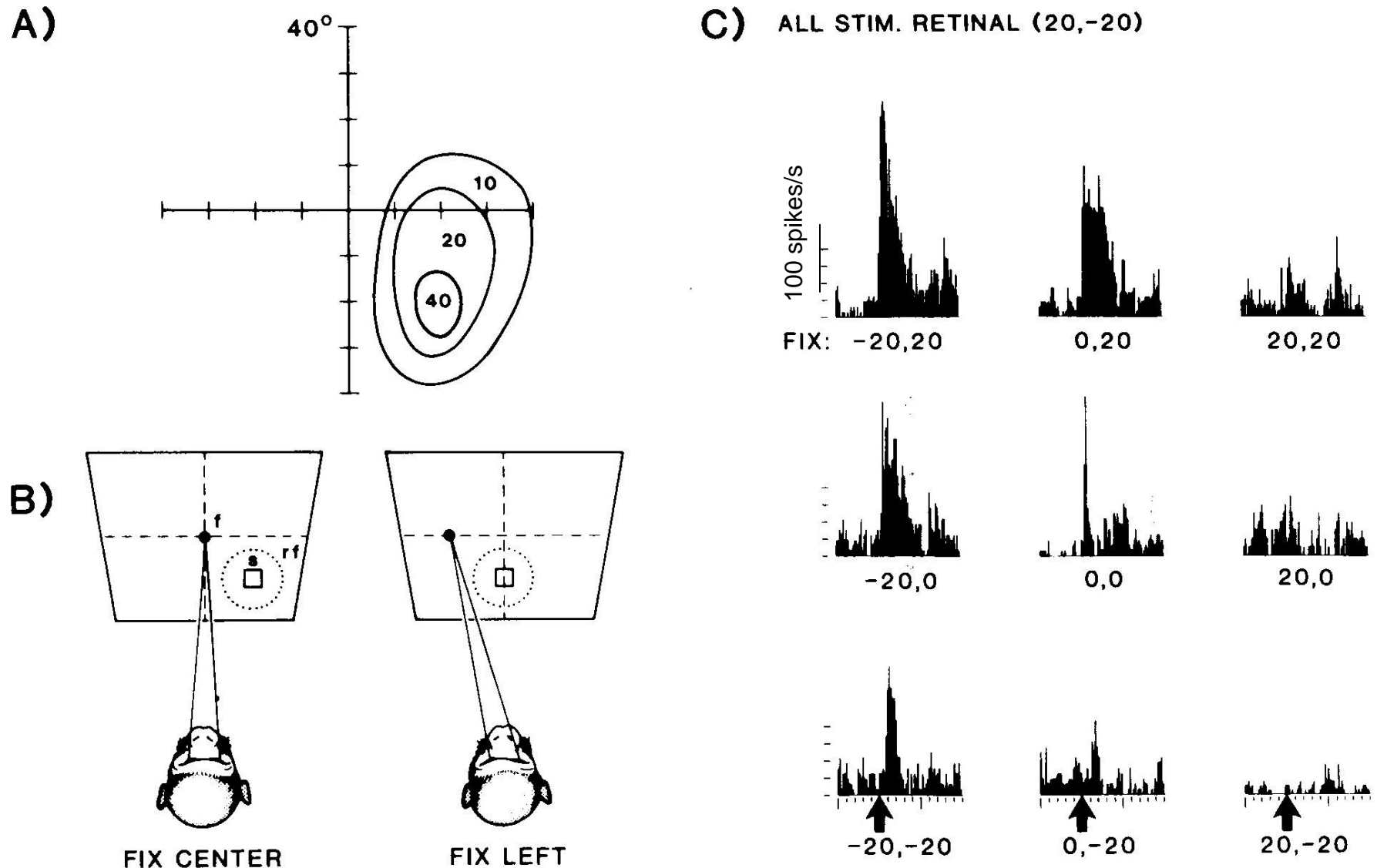
**Arm configuration in
proprioceptive coordinates**

**Eye and head orientation in
proprioceptive coordinates**

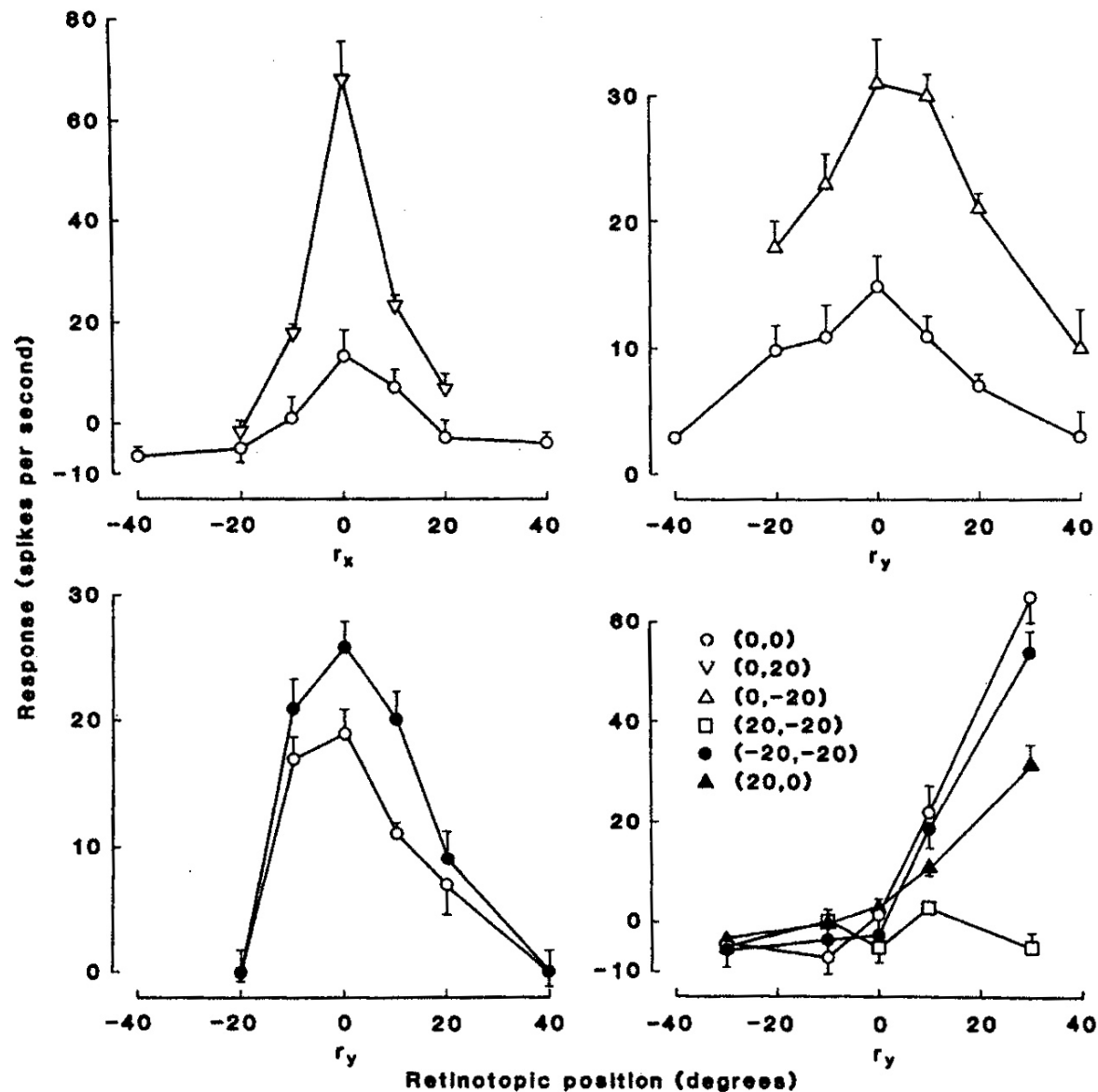
Target on the retina



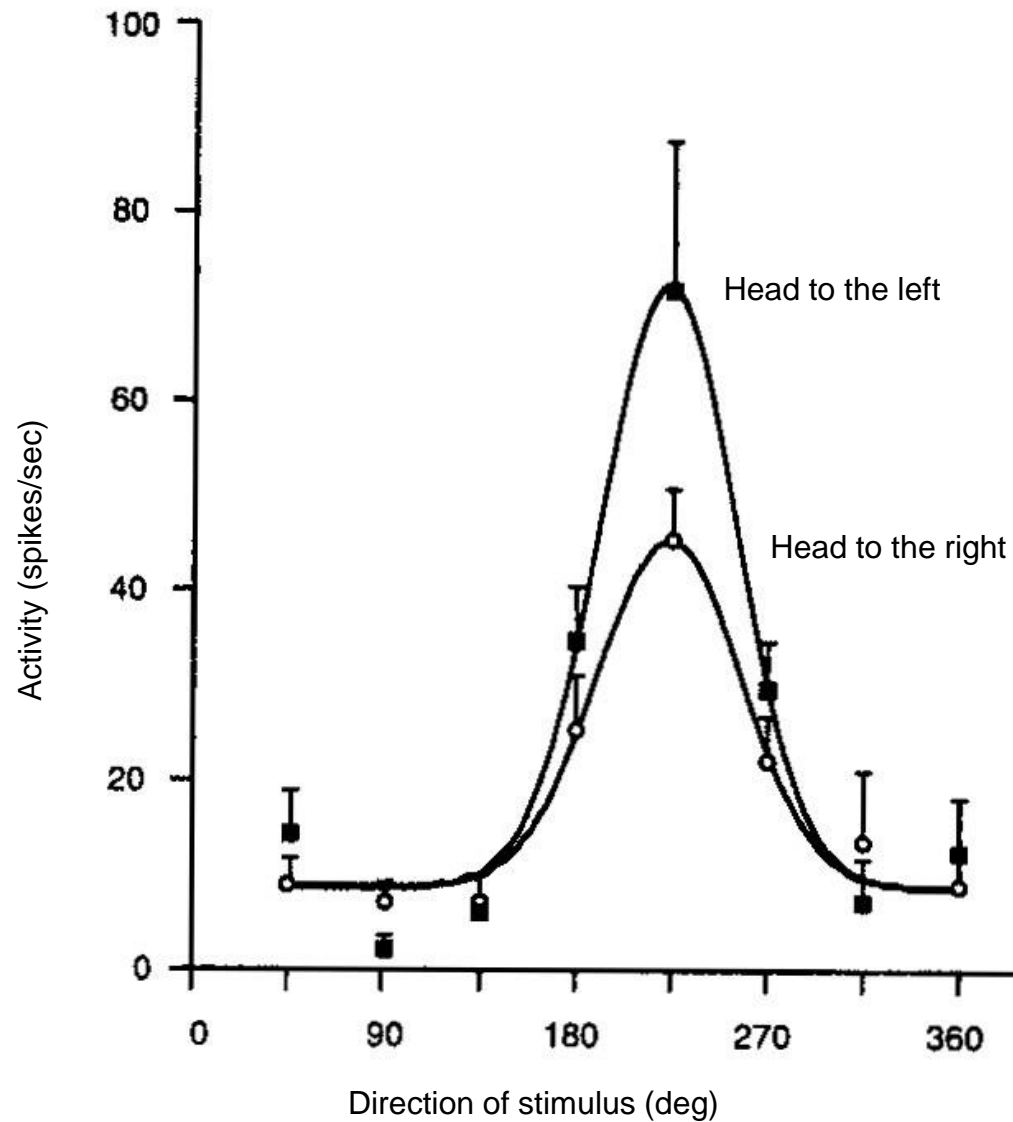
Neurons in the PPC encode both image location and eye position



As eye position changes, the gain of the discharge on the receptive field changes

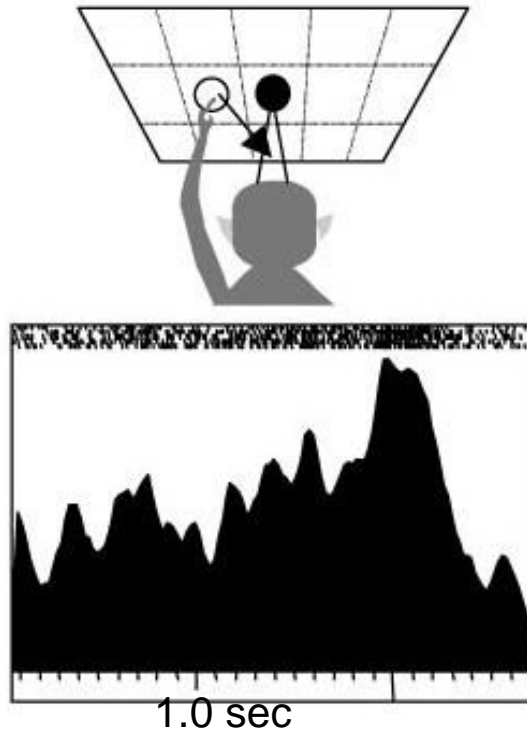


PPC neurons are also sensitive to head position

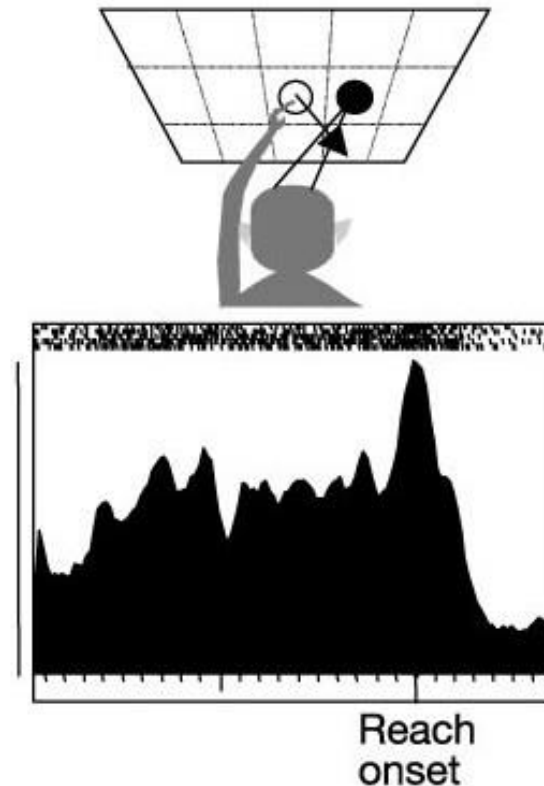


Posterior parietal cortex neurons code for hand and target position in fixation-centered coordinates

Condition 1



Condition 2



Despite the fact that both hand position and target position changed from condition 1 to 2, in fixation centered coordinates the position of the target with respect to fixation and position of hand with respect to fixation did not change. As a result, cell discharge did not change.

Summary

Target location and hand position are computed by posterior parietal cortex cells in terms of vectors with respect to fixation point. These visual cues are represented with neurons that have receptive fields.

Proprioceptive information from the arm, head, and eyes are used to estimate hand position with respect to fixation.

Proprioceptive information from the head and eyes are combined with information about retinal location of the target to estimate target position with respect to fixation.

Posterior parietal cortex neurons combine visual and proprioceptive information as a gain field. In a gain field, neuronal response has a receptive field (usually a Gaussian) that is multiplicatively affected by a linear function that encodes proprioceptive information about location of the eyes or head.