JHU BME 580.422 Systems Bioengineering II

Disorders of parietal cortex

The motor cortex

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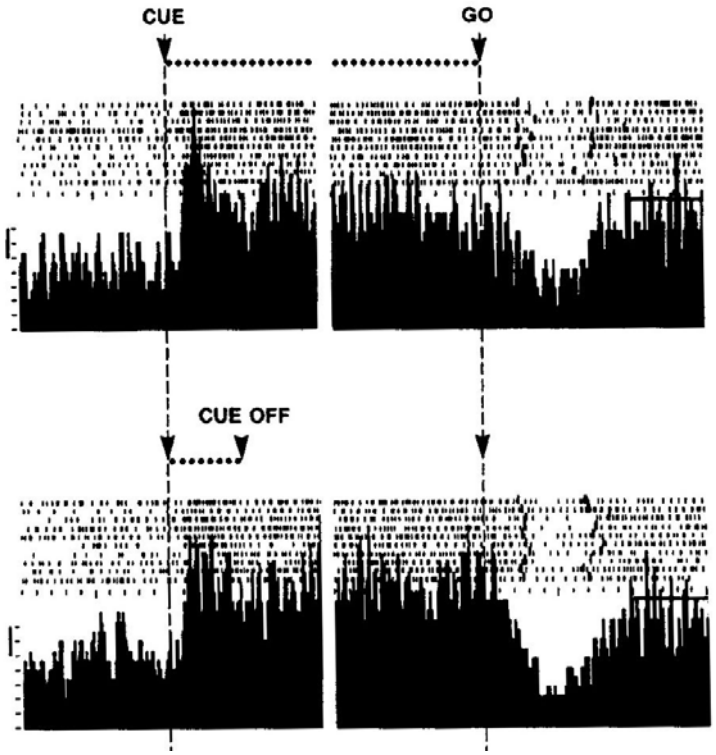
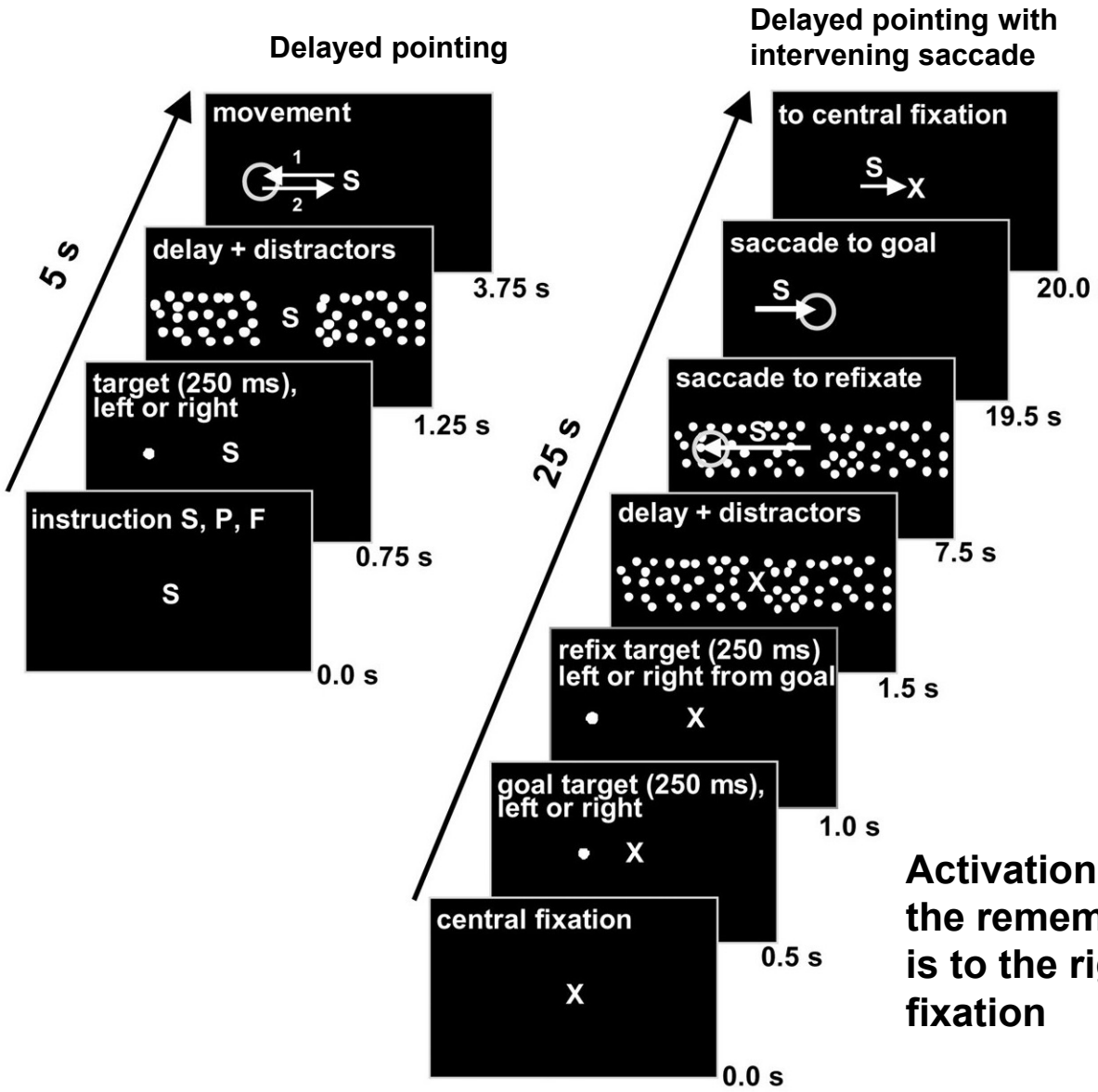
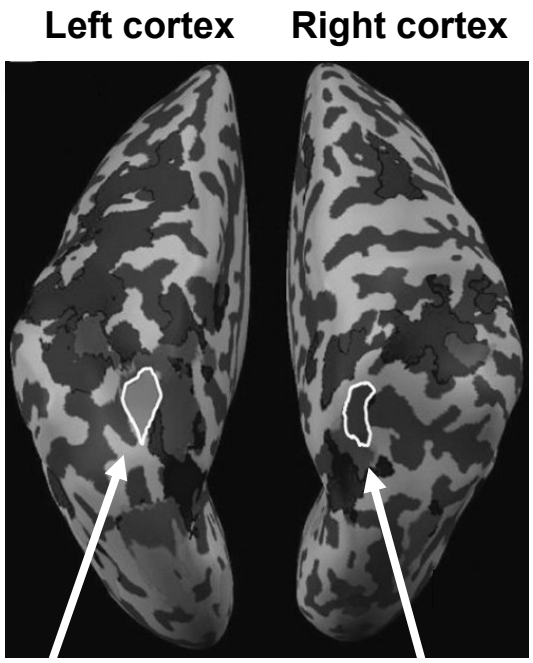
PPC neurons encode target of intended movement even after it disappears



Kalaska JF Can J Physiol Pharmacol 1996

Human PPC neurons code for target location in fixation centered coordinates



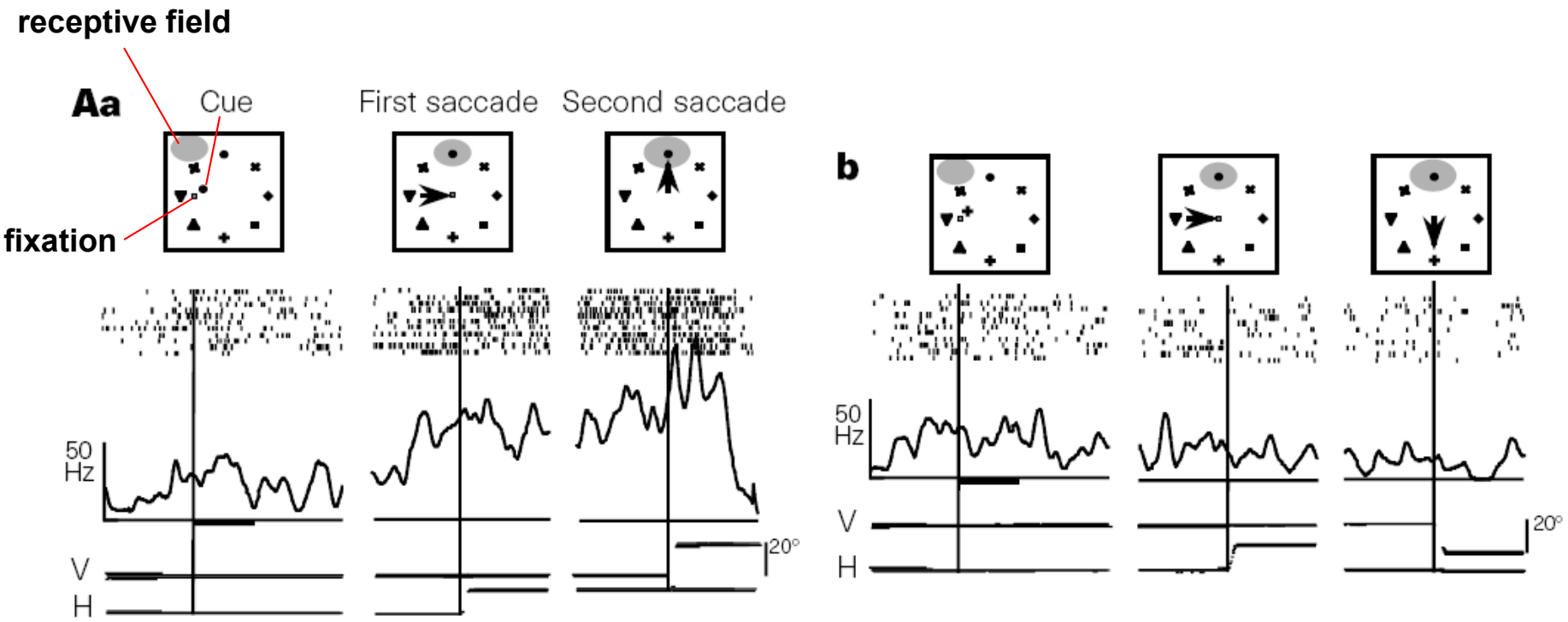


Activation area when the remembered target is to the right of fixation

…left of fixation

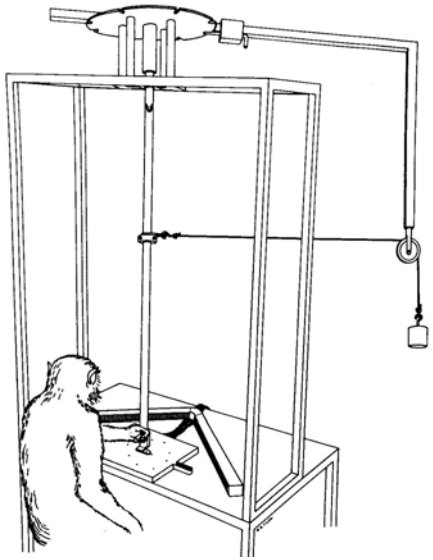
Medendorp et al. 2003

PPC neurons encode an internal value of the visual stimuli with respect to action

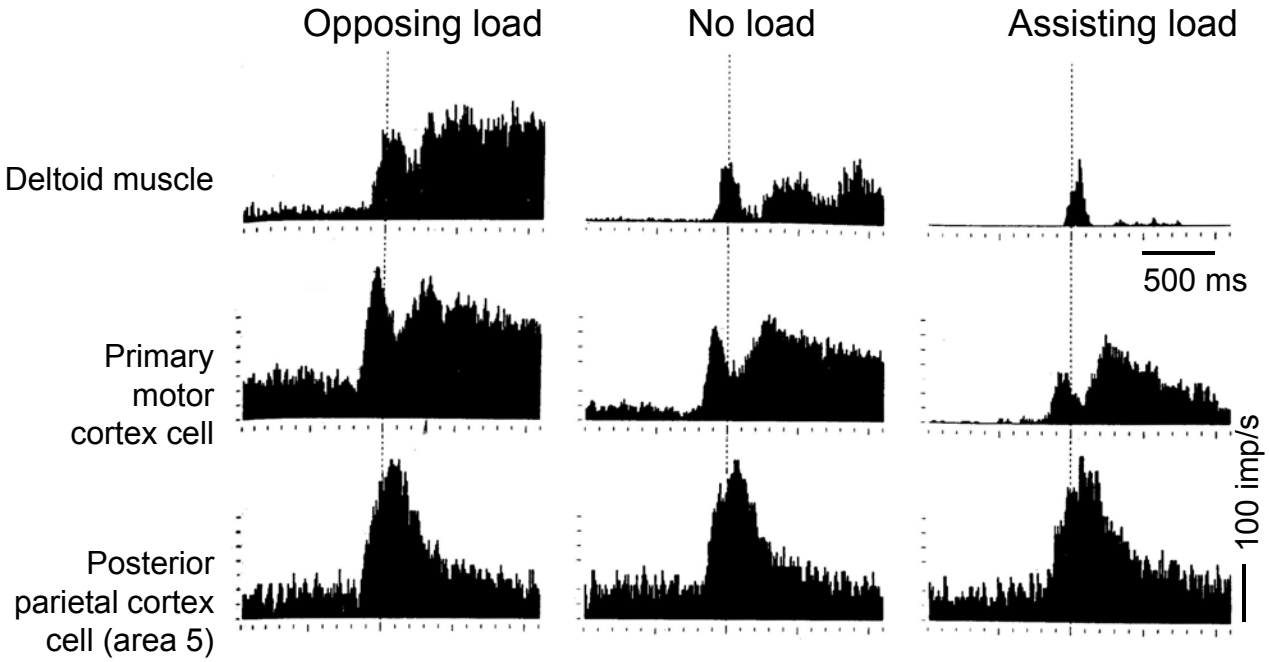


Gottlieb, Kusunoki, and Goldberg 1997

PPC neurons encode target location and not the forces necessary to reach that target

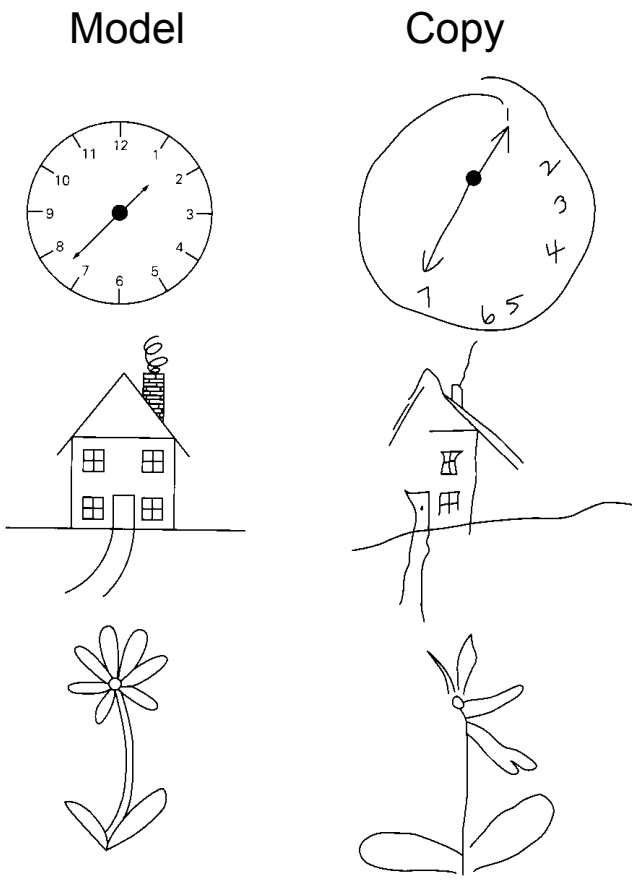


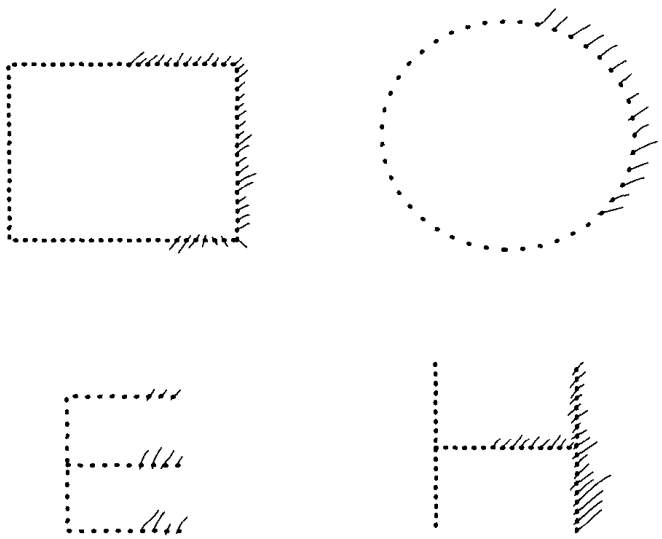
Kalaska et al. J Neurosci 1989



Kalaska JF (1988)

Patients with lesion in the right hemisphere may exhibit neglect of the left visual space





Marshall JC & Halligan PW (1995) Nature 373:521

Summary of the posterior parietal cortex

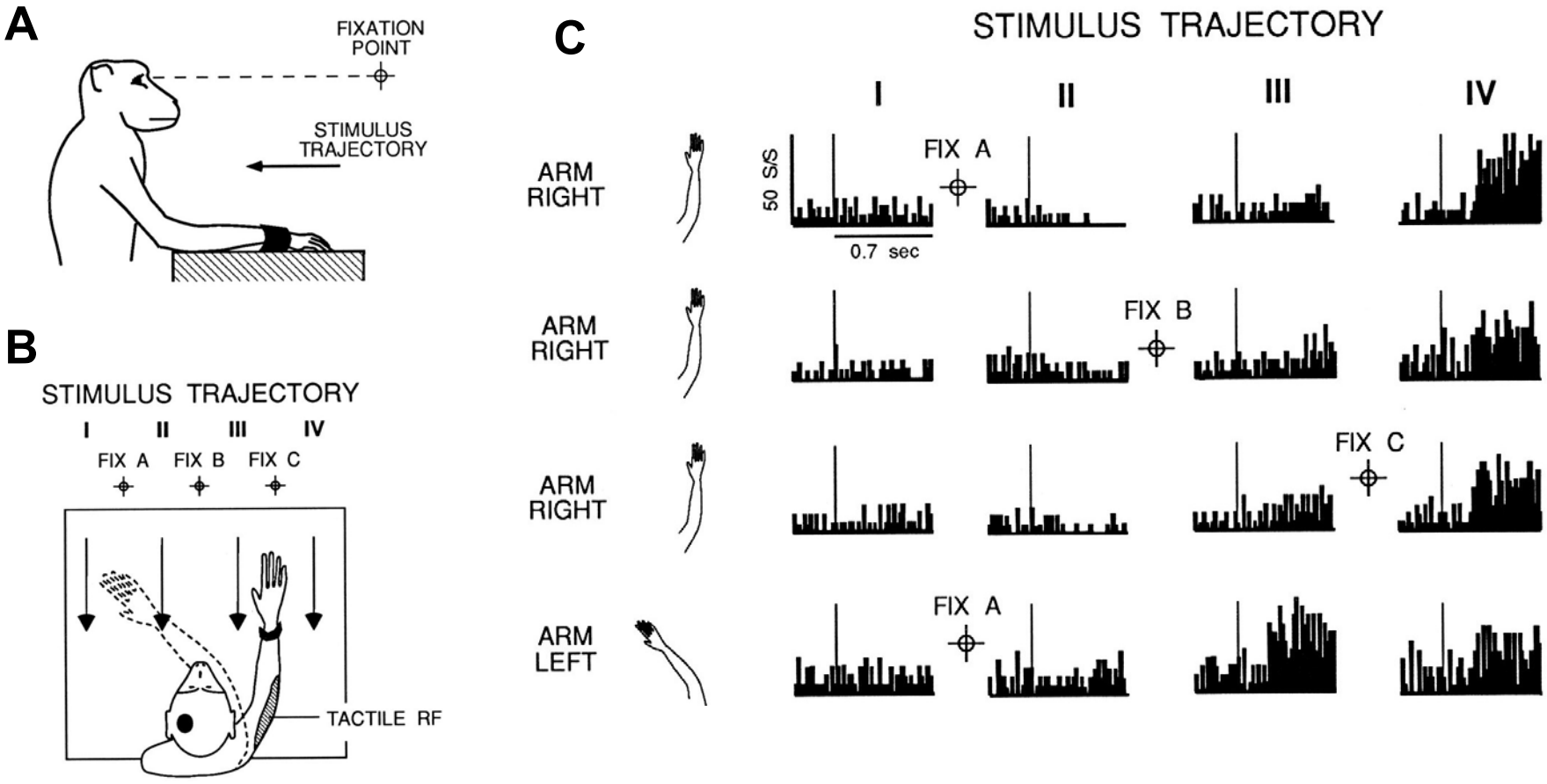
Actions are planned in fixation centered coordinates

Neurons combine proprioceptive information with visual information using a gain field.

Movements are planned in terms of goals, not in terms of detailed forces.

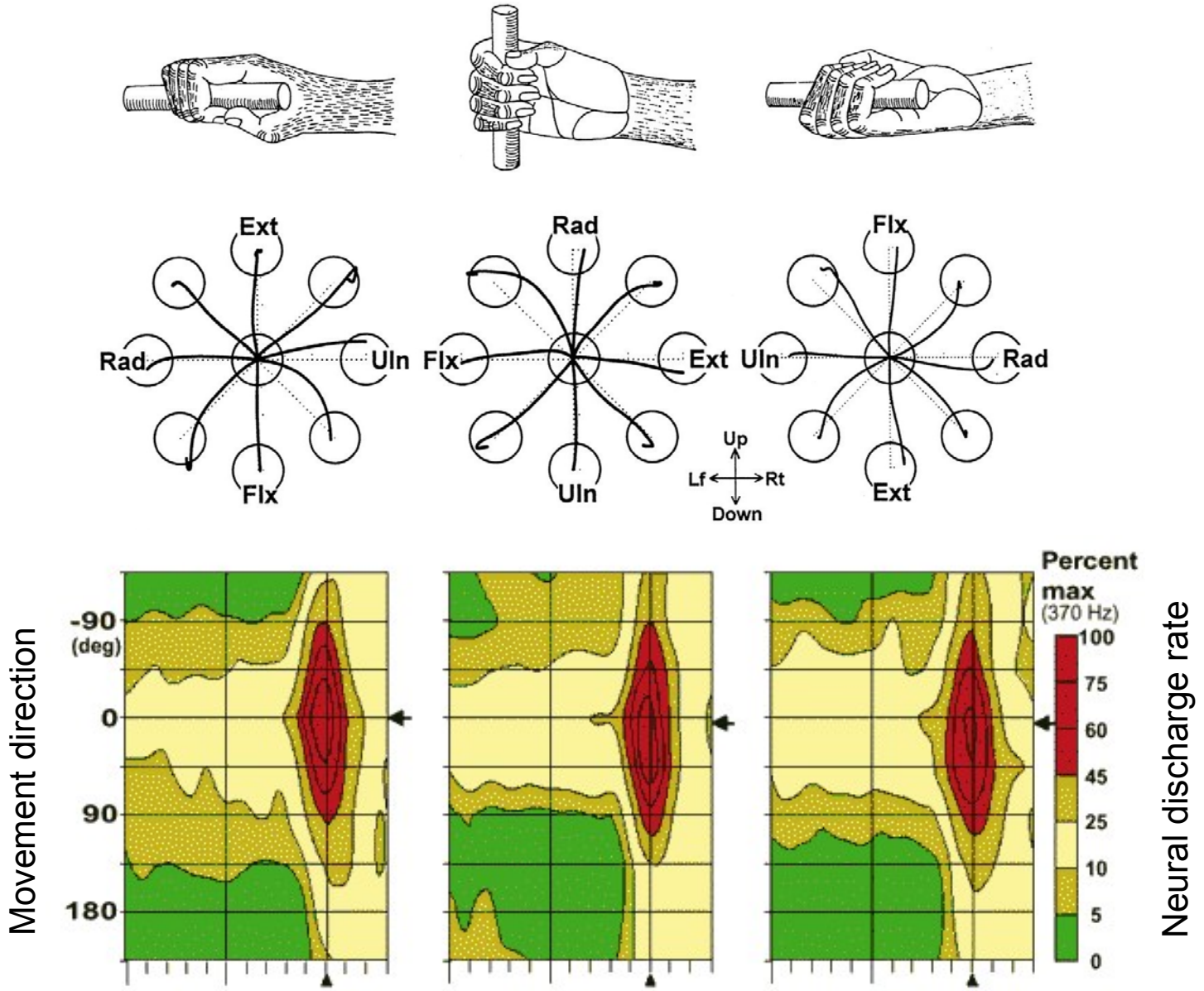
Lesion of the right parietal cortex can result in neglect.

Coding object position with respect to the arm takes place in the premotor cortex



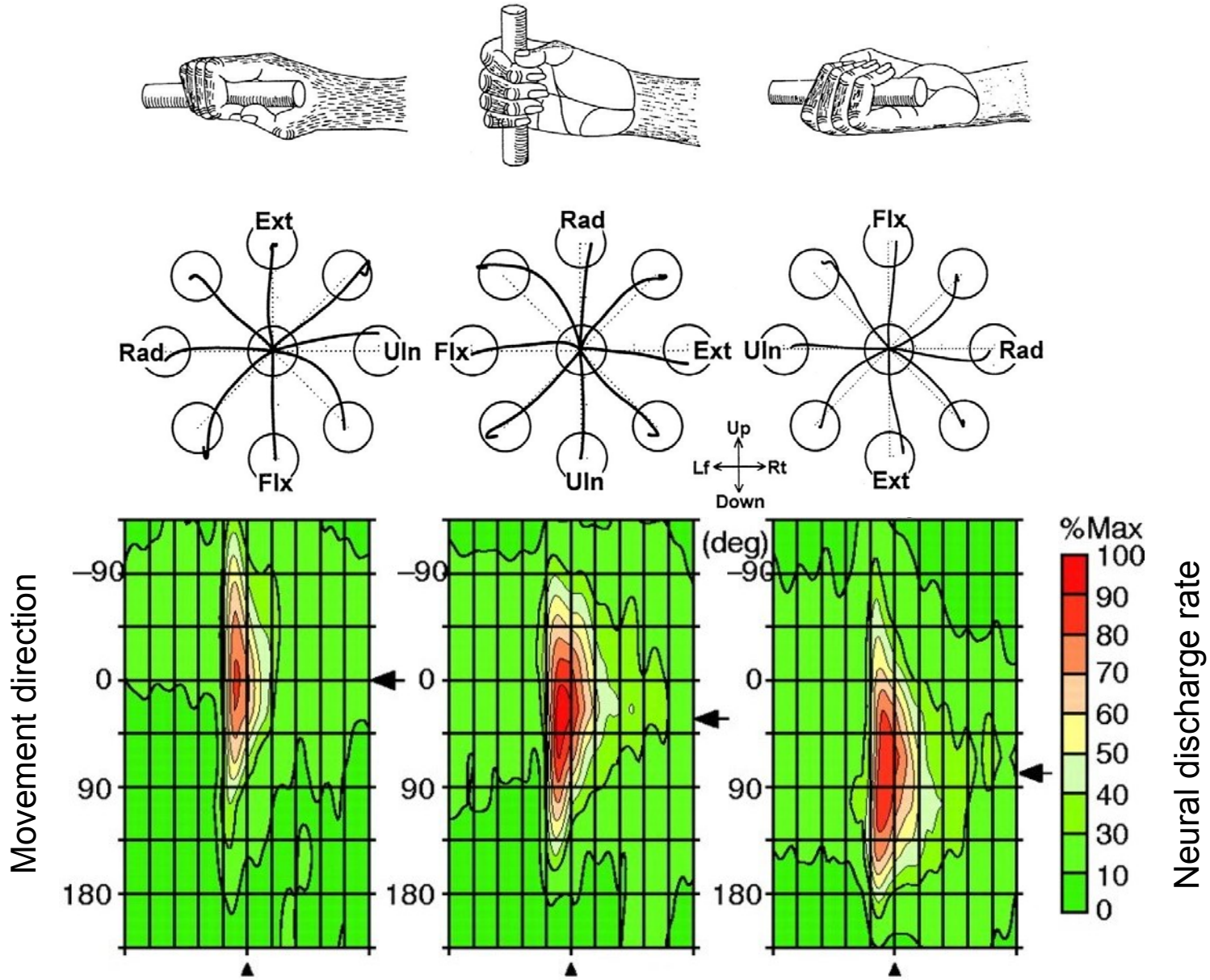
Graziano MSA et al. (1997) J Neurophysiol

In the premotor cortex, target of a reaching movement is coded with respect to the end-effector



Kakei, Hoffman & Strick Science 1999 and Nature Neurosci 2001

Neurons in the primary motor cortex are sensitive to forces that are necessary to perform a reaching movement



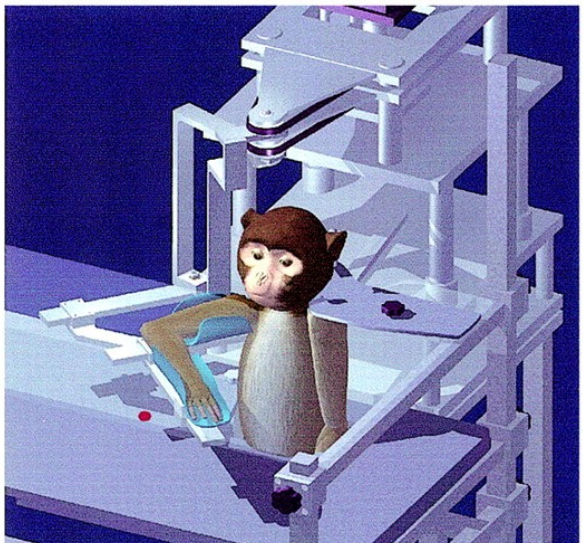
Kakei, Hoffman & Strick Science 1999 and Nature Neurosci 2001

Neuronal activity among some cells in the primary motor cortex relates to muscle forces

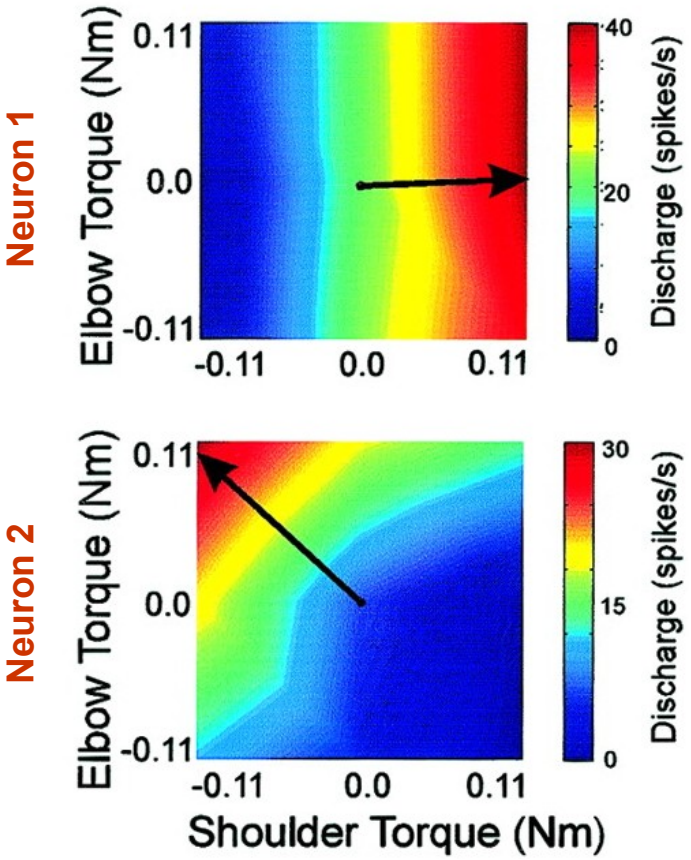
Experiment: A constant torque was applied to elbow and shoulder joints of the monkey's arm. The animal is trained to maintain constant arm position. Therefore, muscles produce activity to counter the imposed torque.

Neural activity is averaged over 2 seconds.

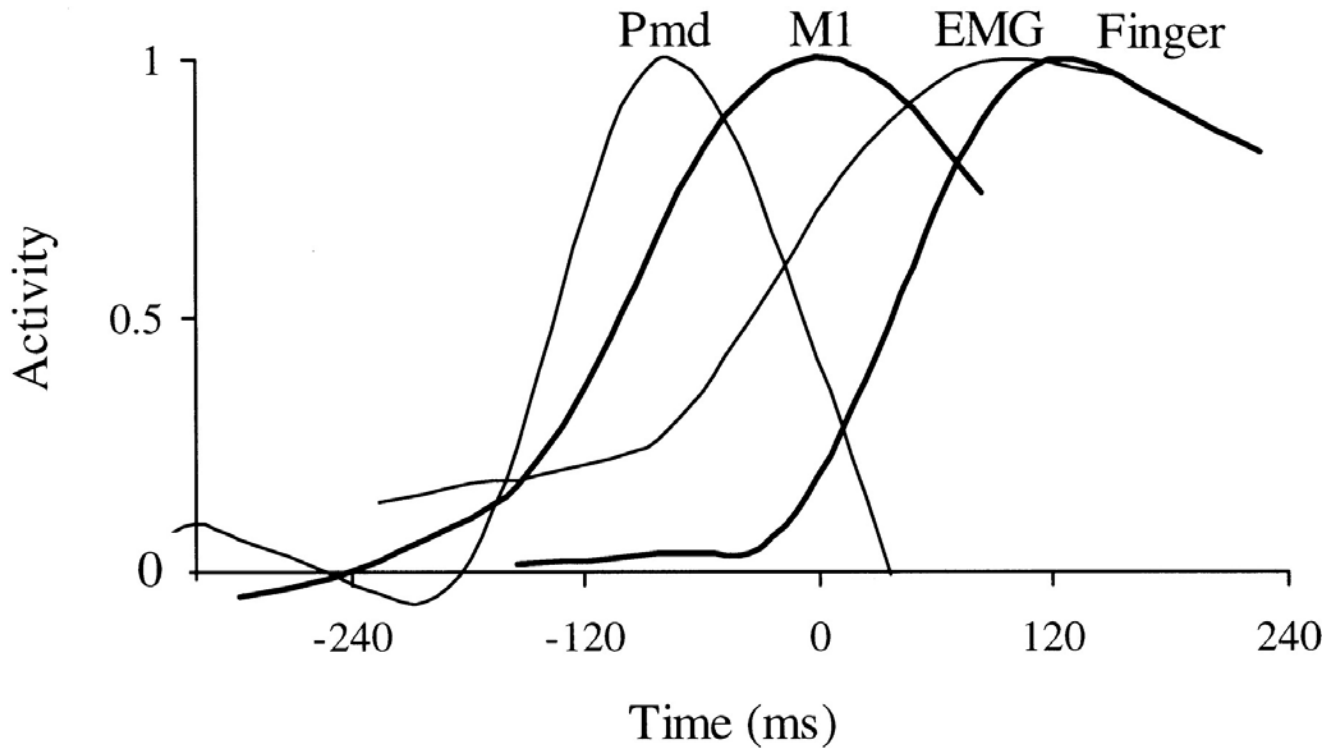
Neural activity for many cells varies with direction of torque. Different cells have different preferred directions of torque.



Cabel, Cisek & Scott J Neurophysiol 2001

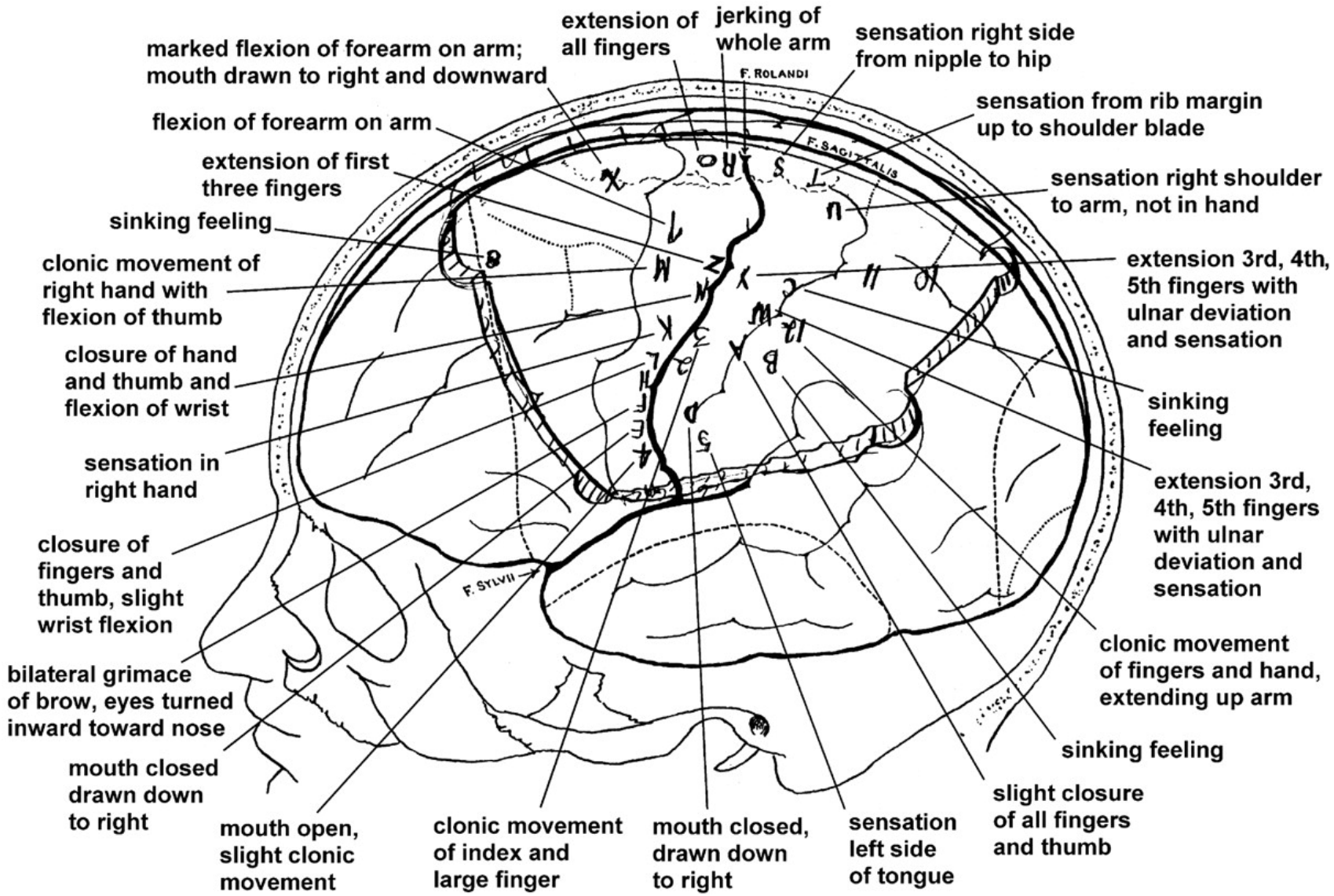


During a reaching movement, activity in premotor cortex cells precedes the activity in M1



Moran & Schwartz, J Neurophys 1999

Stimulation of cortical surface in an individual



Penfield & Rasmussen *The Cerebral Cortex of Man* (1950), Redrawn by M.H. Schieber *J Neurophysiol* 2001

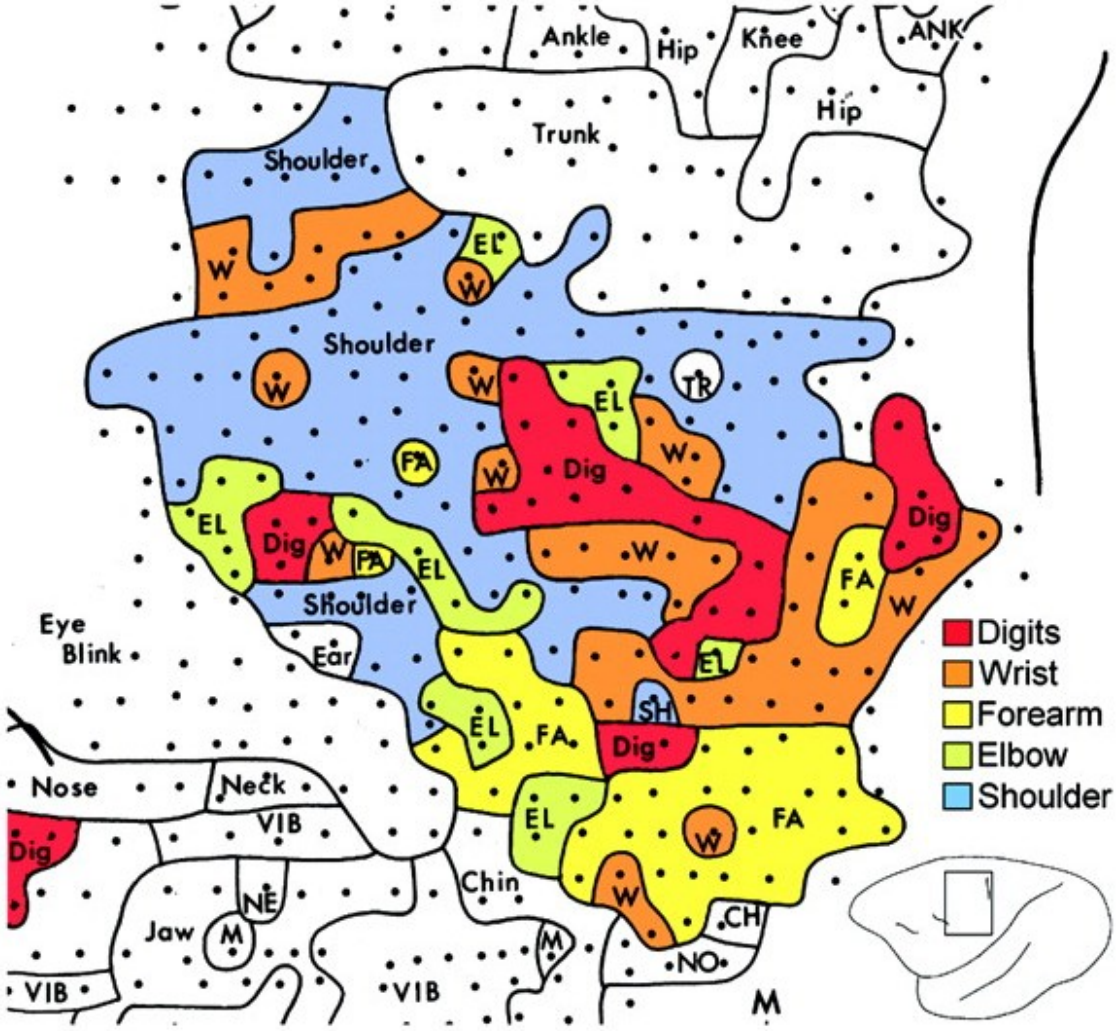
Intracortical microstimulation maps of monkey motor cortex

In anesthetized monkey, a microelectrode is positioned closed to layer V. Low current stimulation is delivered to excite ~30 pyramidal neurons.

Flick-like twitches of discrete parts of the contralateral side of the body are observed.

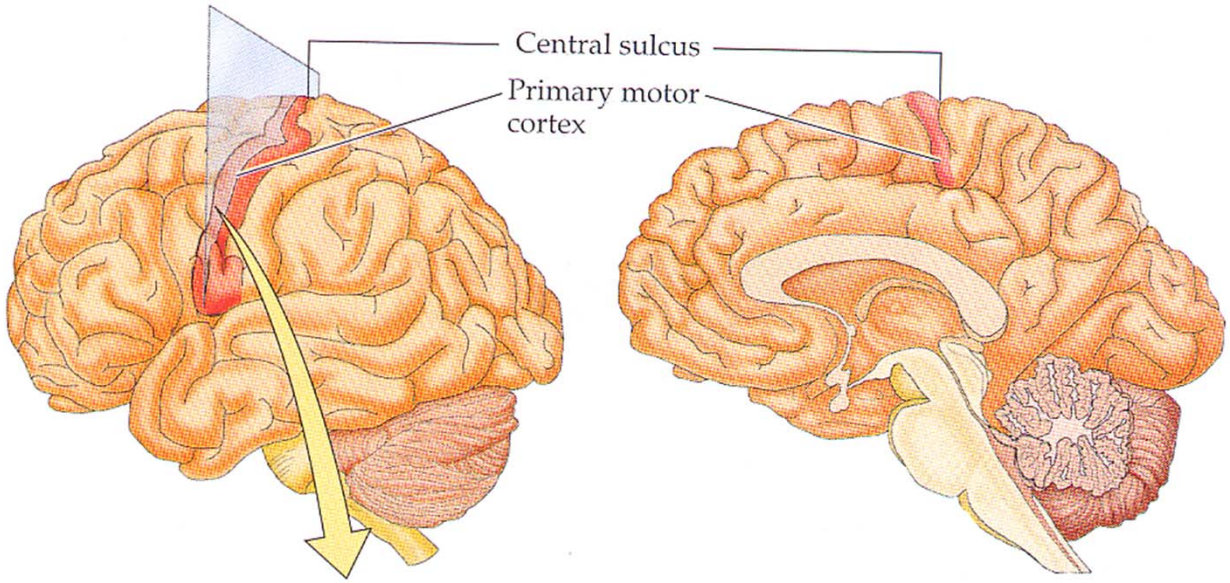
There is a general trend for somatotopy: trunk more medial, jaw more lateral.

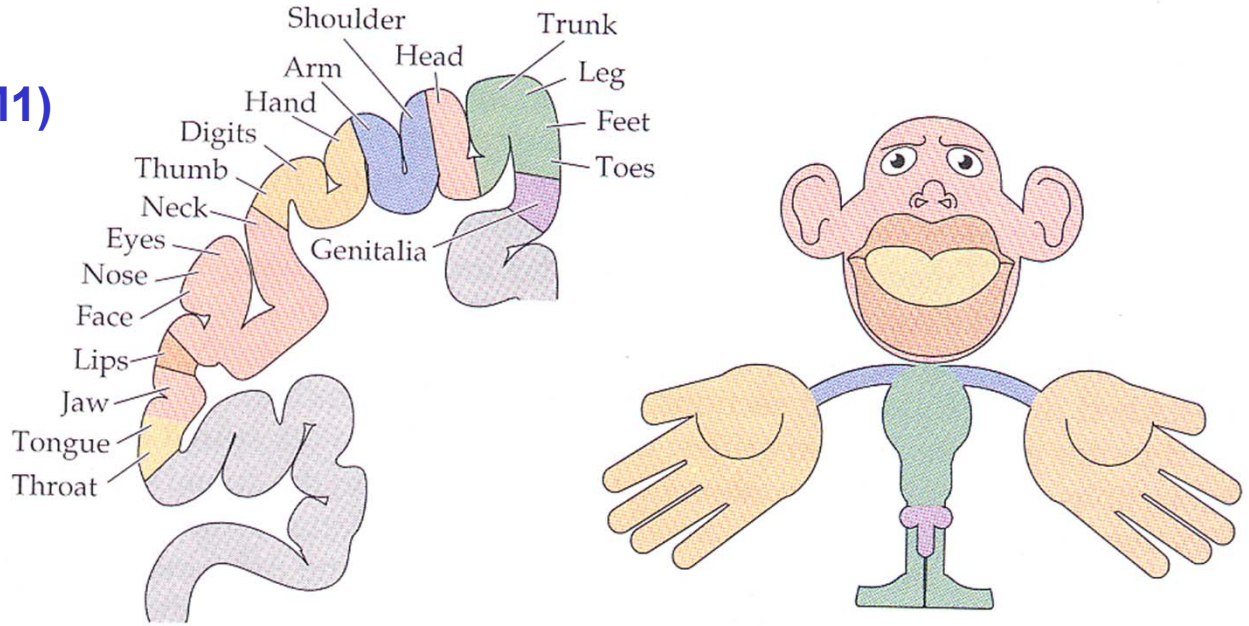
However, movement of a given body part (e.g., digits) is evoked from multiple foci.



HC Kwan et al. *J Neurophysiol* 41:1120 1978, redrawn by Shieber *J Neurophysiol* 2001.

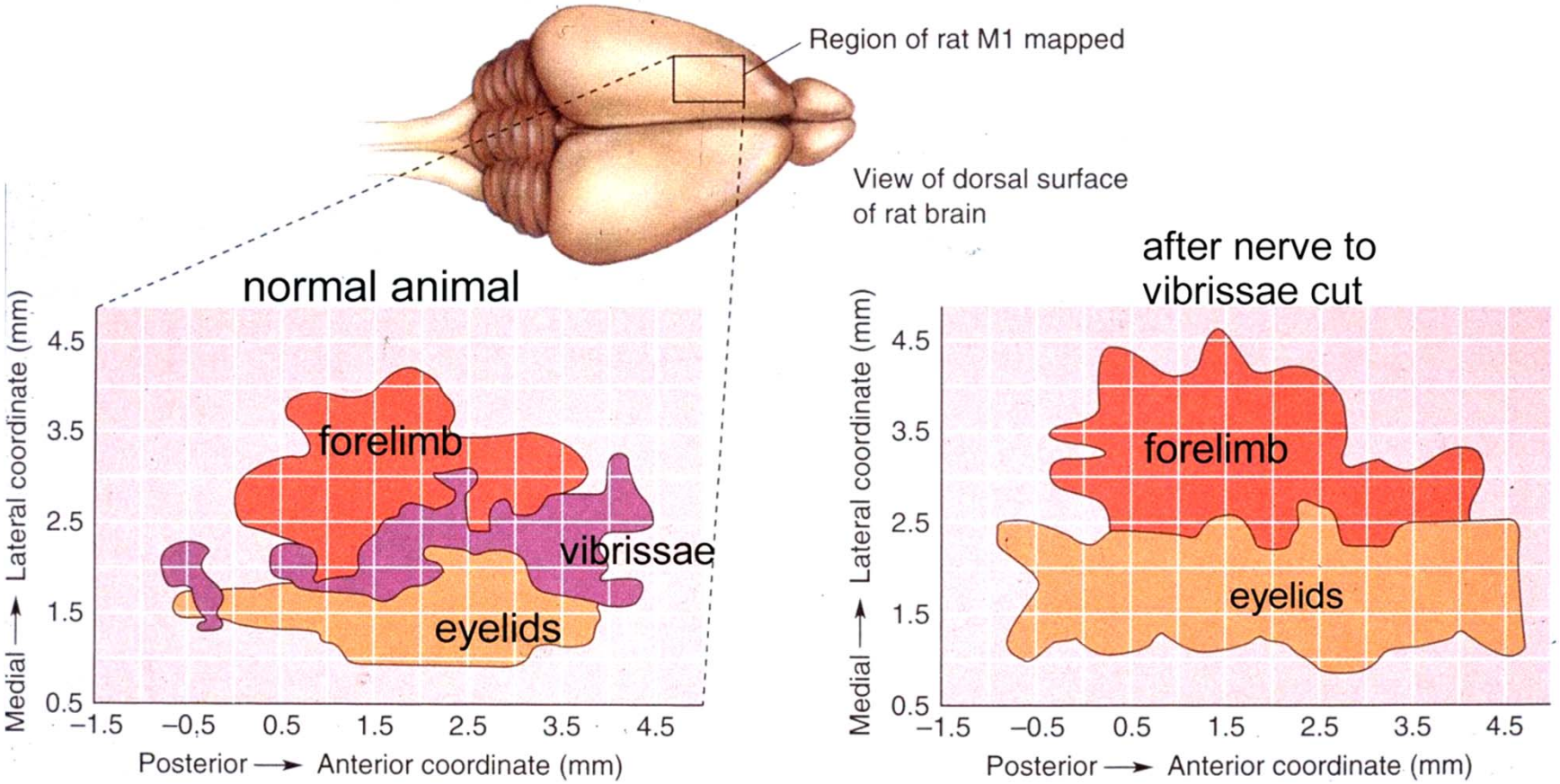
Primary motor cortex (M1)





Damage to peripheral nerves causes change in the motor map

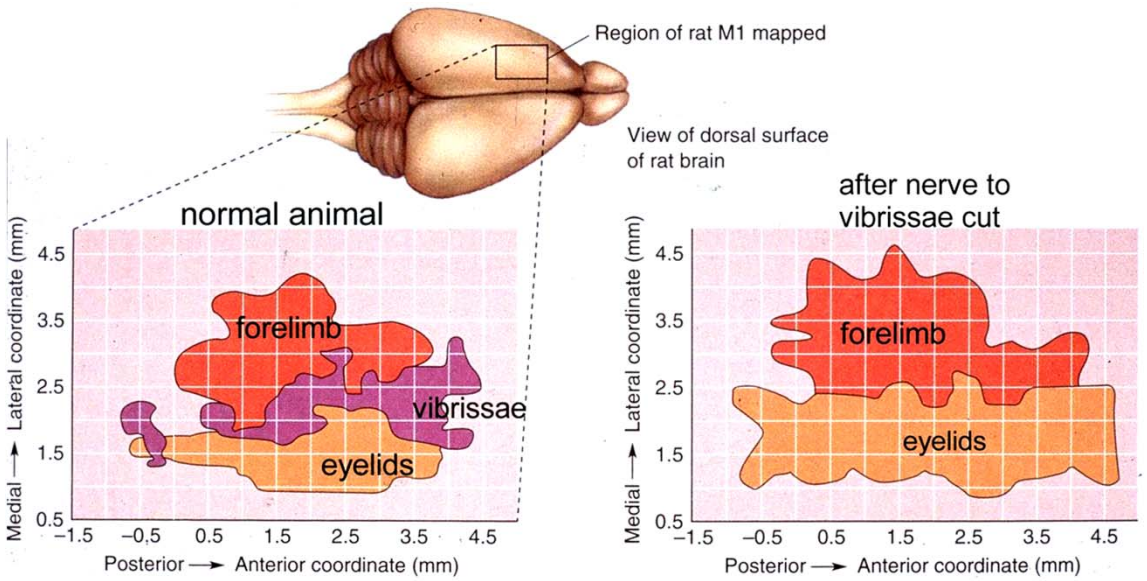
In adult rat, motor map can change a few hours after a branch of the nerve supplying motor axons to the muscle attached to whiskers (vibrissae) is cut. No sensory fibers are damaged.

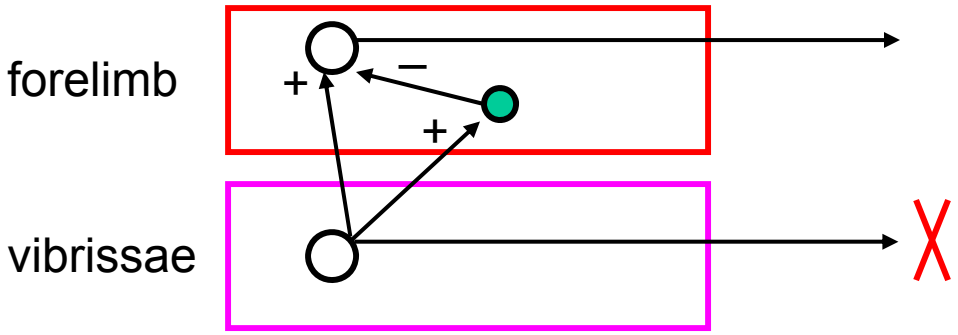


Neighboring regions of the motor cortex are connected via inhibitory interneurons.

Damage to the peripheral nerve, reduces the synaptic efficacy of the inhibitory pathway from vibrissae to the forelimb.

Stimulation in vibrissae area now causes motion of the forelimb.

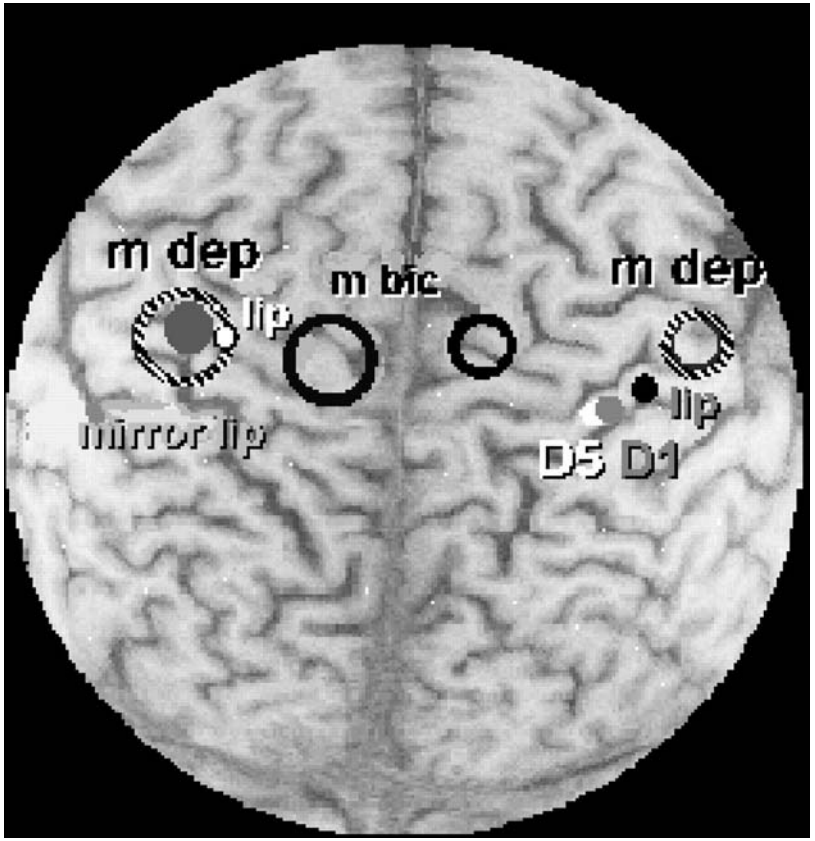




Amputation changes the motor map

This individual's **right arm** above the wrist has been amputated. The motor cortex is stimulated (via TMS) and muscle activity is recorded in biceps and depressor labii inferioris. The lip, and first and fifth digits are touched and evoked potentials are recorded from the brain.

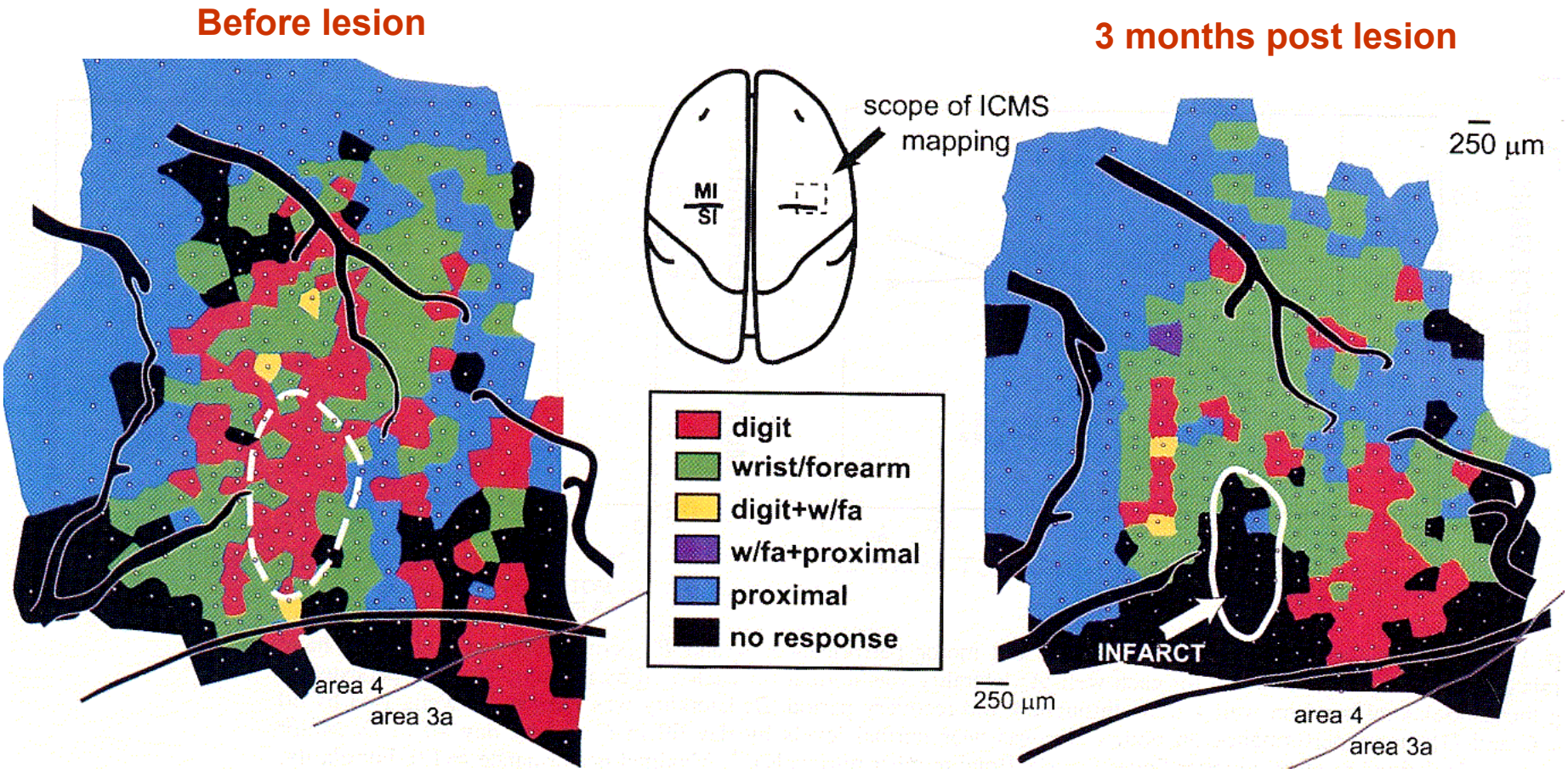
Motor representation of biceps contralateral to the stump is larger than on the side of the intact arm.



Karl A. et al. (2001) J Neurosci 21:3609

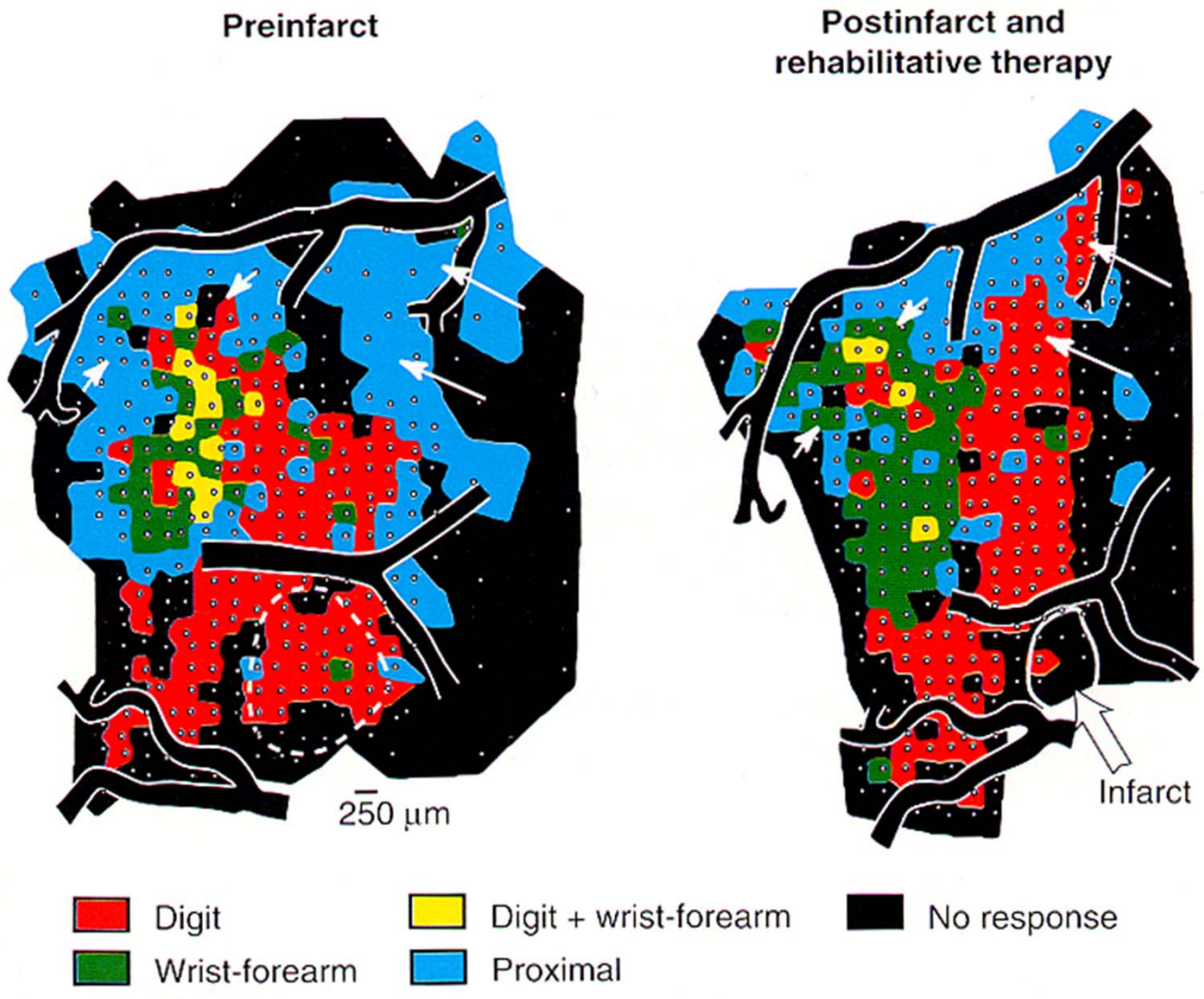
Effect of an infarct

A lesion in the monkey motor cortex destroys 21% of digit and 7% of wrist. After 3 months, the area for digits has been reduced in neighboring regions as well.



Nudo & Milliken, J Neurophys 1996

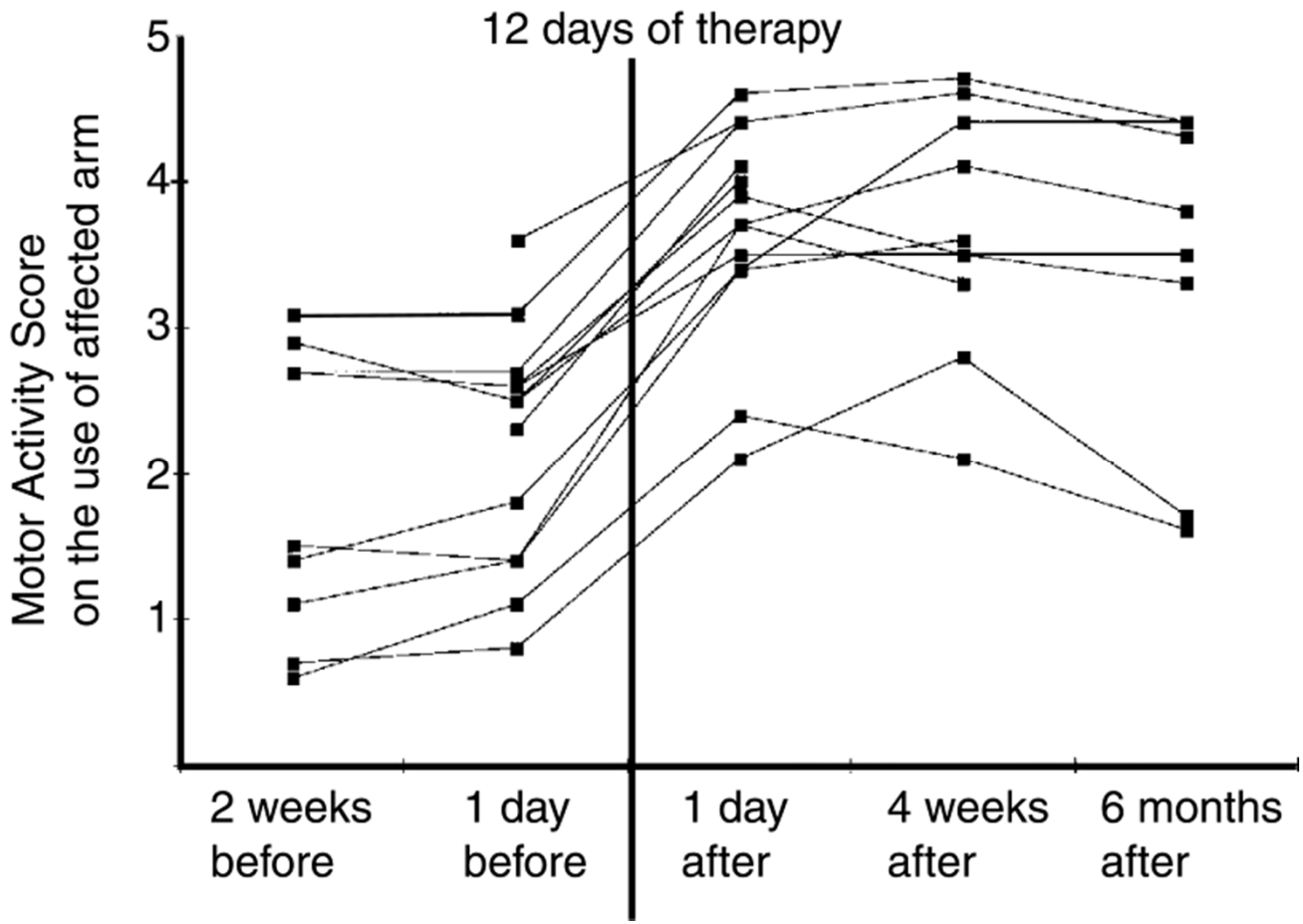
Lesion destroyed 22% of digit region. After rehabilitation, the spared digit area increased by 15%.



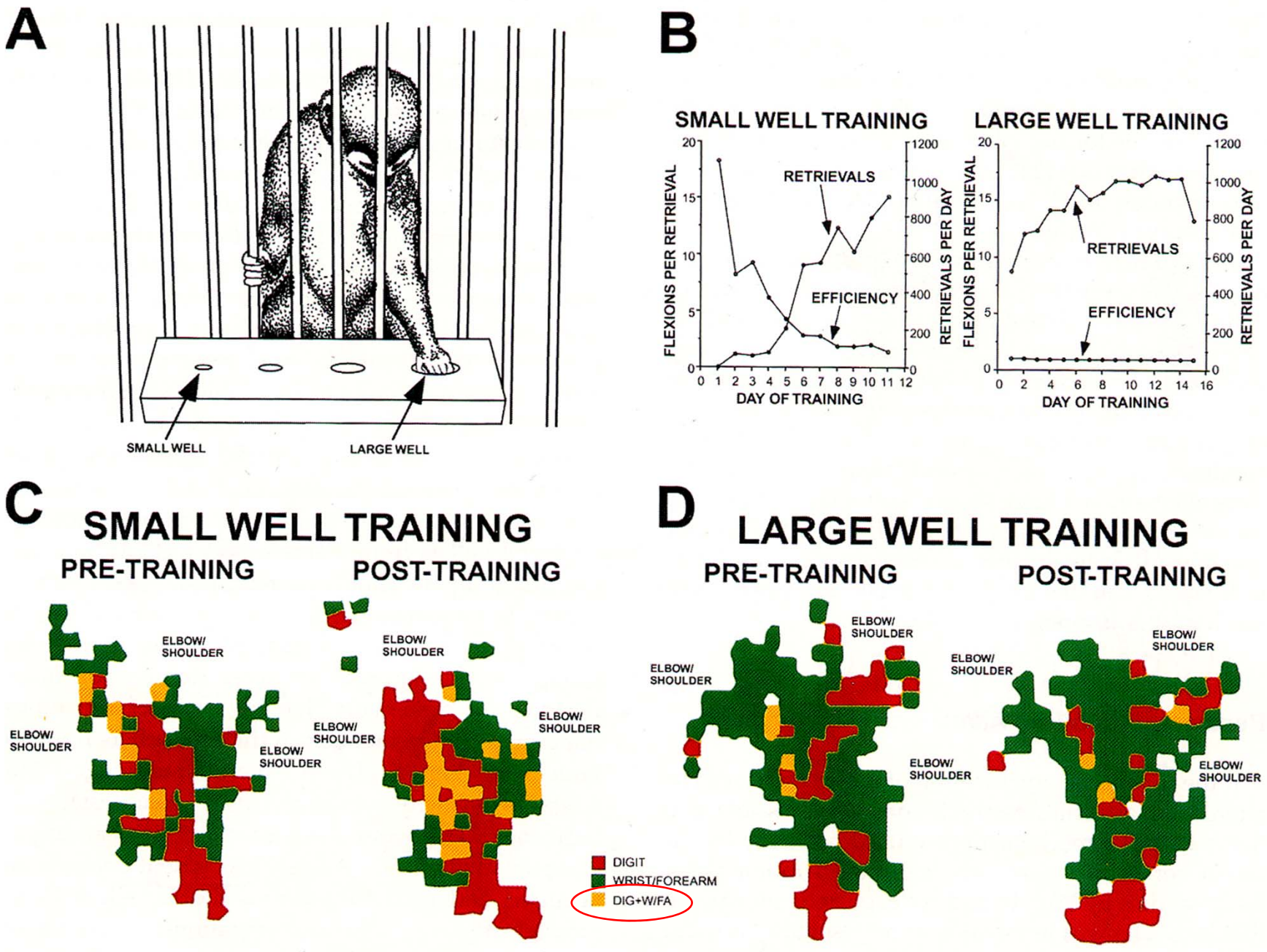
Nudo et al. *Science* 1996

Constrained motion rehabilitation

The unaffected arm is restrained for 8 hours a day, 12 days. During this period, the affected arm is trained.



Liepert, J. et al. *Stroke* 2000



Digit,wrist, and forearm

Nudo et al. *Sem Neurosci* 1997

Summary of functions

Posterior parietal cortex:

- align proprioception of arm with vision of hand
- compute hand position in eye-centered coordinates.
- compute target position in eye-centered coordinates.

Premotor cortex:

- Subtract target position with respect to hand position and code the desired movement in terms of displacement of the hand.

Primary motor cortex:

- Transform the desired movement to muscle activity patterns and send this command to the spinal cord.