Motor and Premotor Cortex

Hierarchical organization of the motor cortex

Motor unit = Motor neuron + innervated muscle fibers (cells)
**Proprioception**

Muscle spindles: muscle length innervated by Ia afferents & γ motor neurons.

Golgi tendon organ: muscle tension innervated by Ib afferents.
Somatotopy in the primary motor cortex

Cortical mechanisms of reaching

Effects of practice in 2-D reaching movements
Basic vector algebra

- Addition
- Scaling (multiplication)

Coding of Movement Direction - Population Vector

Movement - Population vector
1. Mind Control Monkey
2. Brain Gate
Kinematics: position, velocity, acceleration
Kinetics (dynamics): force, torque

Newton’s second law: $F = ma$
Torque = $F \cdot d$ (moment arm) = $I \alpha$
$I$ (moment of inertia) = $\Sigma m \cdot r$

Movement vs. Force

No load (baseline)

Opposing load (315°)

Assisting load (135°)

Load-sensitive cells in the primary motor cortex
Load-insensitive cells in the primary motor cortex

Posterior parietal cortex (area 5): kinematics

Set-related (preparatory) activity in the premotor cortex & planning

Conditional motor learning task

Learning-dependent activity in the premotor cortex

(Kalaska et al., 1990)

(Mitz et al., 1991)
Mirror neuron system in the premotor cortex

SMA: connects the motor cortex to the limbic system.

Effects of SMA lesion

1. Voluntary initiation of movements
   SMA: self-paced
   PMC: stimulus-triggered

2. Bimanual coordination

3. Movement sequencing

SMA lesion produces deficit in movement sequencing.
Triggered vs. self-paced movements: primary motor cortex (Okano and Tanji, 1987)

Bimanual coordination in SMA

Movement sequence task (Mushiake et al., 1991)
Simultaneous planning of multiple movements in SMA

Sequence-dependent activity in SMA
Pre-SMA: updating motor plans

(Shima et al., 1996)