Voluntary Movement II.

Cortical representation of movements and parameters.

Claude Ghez, M.D.

1. Primary motor cortex: how are movement parameters coded
   - Distal movements
   - CM neurons.
   - Population coding.

2. Premotor areas higher order features of movement
   - Supplementary motor area: Sequences
   - Lateral dorsal premotor area: sensorimotor transformations
   - Lateral ventral premotor area: grasping

3. Experience modifies representations
Target muscles can be identified by “spike triggered averaging”

CM neurons: divergence

CM neurons to distal muscles have small “muscle fields” (1-4 muscles)
CM neurons to proximal muscles have large (>4) “muscle fields”

Single corticospinal axons diverge to terminate in several motor nuclei

CM neurons code for force exerted
CM neurons are preferentially recruited for tasks requiring topographical precision.

Section of pyramidal tracts in monkeys produces loss of independent "individuated" digit control.

Neurons in proximal motor cortex regions are broadly tuned for direction.
Movement direction can be coded precisely by the population responses of broadly tuned neurons.

Primary motor cortex receives direct input from 5 premotor areas. These premotor areas also project to the spinal cord.

"Self initiated" voluntary movement are preceded by premotor activation: early evidence from evoked potentials.
Planning movement sequence without moving activates SMA
First neuroimaging data

<table>
<thead>
<tr>
<th>Repeated simple finger flexion</th>
<th>Repeating sequence finger-thumb apposition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor cortex</td>
<td>Sensory cortex</td>
</tr>
<tr>
<td>Supplementary motor area</td>
<td></td>
</tr>
<tr>
<td>Mental rehearsal of finger sequence</td>
<td></td>
</tr>
</tbody>
</table>

Activation of motor areas depend different on behavioral context

<table>
<thead>
<tr>
<th>Primary motor cortex</th>
<th>Lateral premotor area</th>
<th>Supplementary motor area</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st key touch</td>
<td>1st key touch</td>
<td>1st key touch</td>
</tr>
<tr>
<td>Visual cue</td>
<td>Learned sequence</td>
<td></td>
</tr>
</tbody>
</table>

Supplementary motor area neurons code movements in specific context of movement sequence.

- Cell fires with pull followed by turn but not followed by pull
- Cell fires with turn followed by pull and push but not just with pull
Separate pathways convey visual inputs to premotor areas for reaching and grasping.

Instructed delay task: coding of “preparatory set” for directed reach by dorso-lateral premotor neurons.

Neurons in ventral premotor area (PMv) code for hand configuration of grasp.
“Mirror neurons” in PMv represent types of movement independent of its actualization: motor vocabulary

Practice and learning of finger sequence can alter motor representations in primary motor cortex

Damage to local region of motor cortex induces change in representation of nearby areas
Motor practice can alter functionality and motor mapping in motor cortex.

Infarct

Preinfarct

Post infarct with rehabilitative therapy

Motor cortex

Motor cortex

No response