Today’s plan

• Overview of motor circuits
  – Types of movements
    • Reflex, rhythmic, voluntary
  – Structures and pathways
    • Cortex, spinal cord, basal ganglia, cerebellum
  – Hierarchical and parallel processing
• Motor units and the size principle
• Spinal reflexes – simple and complex
• Central pattern generators
• Voluntary movements

Classes of movement

• Reflexes
• Rhythmic patterns
  – Central pattern generators
  – Modulation by sensory input and voluntary input
• Voluntary movements
  – Use reflex circuits and pattern generators
Simplistic hierarchical view of motor control

Higher control
“volition”

Central pattern generator

Reflex

Spinal cord organization

Dorsal horn
Lateral columns
Ventral horn

KSJ 18-3
Dorsal and ventral spinal roots

Dorsal and ventral spinal roots

The cortico-spinal tract

Descending axons from primary motor cortex to the contralateral ventral horn of the spinal cord

Midbrain
Pons
Medulla
Medulla-spinal cord jcn.
Cervical spinal cord

KSJ 18-8
Basal ganglia and cerebellar loops influence descending pathways

Motor unit

A motor neuron and all muscle fibers it innervates
Motor units within a given muscle vary in many parameters

- Motor neuron size
- Number of muscle fibers innervated
- Size of individual muscle fibers
- Force generated by fibers

- These parameters are all positively correlated!!!

Size principle

Within a given muscle:

- Large motor neurons connect to more, larger, more forceful muscle fibers

- Recruitment of motor units in a contraction is in order of smaller motor units first, and larger motor units later.
Size principle makes sense

• Smaller force increments for finer movements
• Simple mechanism: Input resistance difference in motor neurons. A given synaptic current will produce a greater voltage effect on smaller neurons (higher input resistance)

“Simple” spinal reflexes
Stretch reflex

Matthews 8-3
Muscle spindles – stretch receptors

Stretch reflex

Matthews 8-4

Matthews 8-5
Central pattern generators

- Key feature: don’t require sensory feedback to generate the pattern
- Often, but not always rhythmic
- Some innate, some learned
Example vertebrate central patterns

- Locomotion (swimming, walking, flying)
- Chewing
- Breathing
- Suckling (in mammals)

- Others? (not necessarily rhythmic)
Central pattern generators

Matthews 8-11

Central pattern generators

Matthews 8-12
Simplistic view

Higher control
"volition"

Central pattern generator

Reflex

Brain

Local circuits

Reflexes

Motor units

A more realistic view

Higher control
"volition"

Central pattern generator

Reflex

Brain

Local circuits

Reflexes

Motor units