EE 791: Lecture 4

February 8, 2018

Central and peripheral Motor Function

Spinal Sensory and Motor Connections

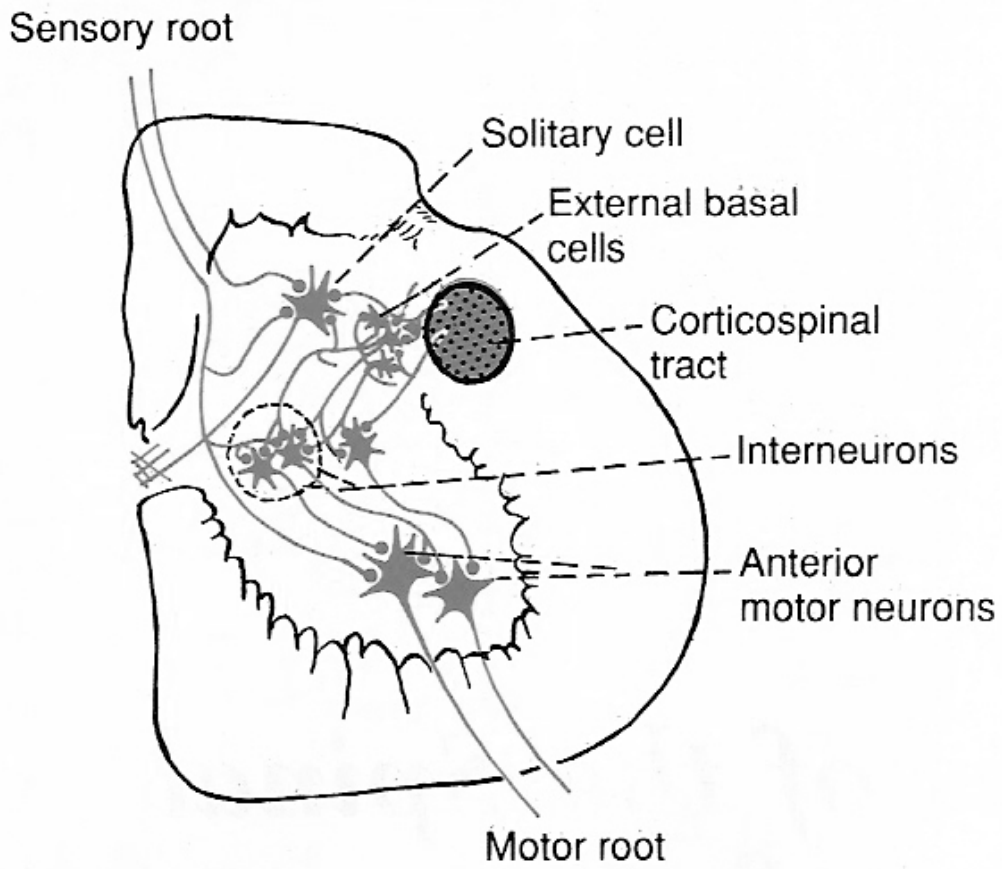


Figure 54–1. Connections of the sensory fibers and corticospinal fibers with the interneurons and anterior motor neurons of the spinal cord.

Neurons in Spinal Cord

- Grey matter includes cell bodies involved in integration of cord reflexes and motor function
- Largest are α motor neurons whose axons exit ventral region (avg 14 μm) connect to muscle fibres
- Half as many γ motor neurons whose axons (avg 5 μm) end on intrafusal muscle fibres in muscle spindles
- Interneurons (30 times as many as motor neurons) small highly excitable and inhibitory
- Inhibitory Renshaw cells

Muscle Spindles

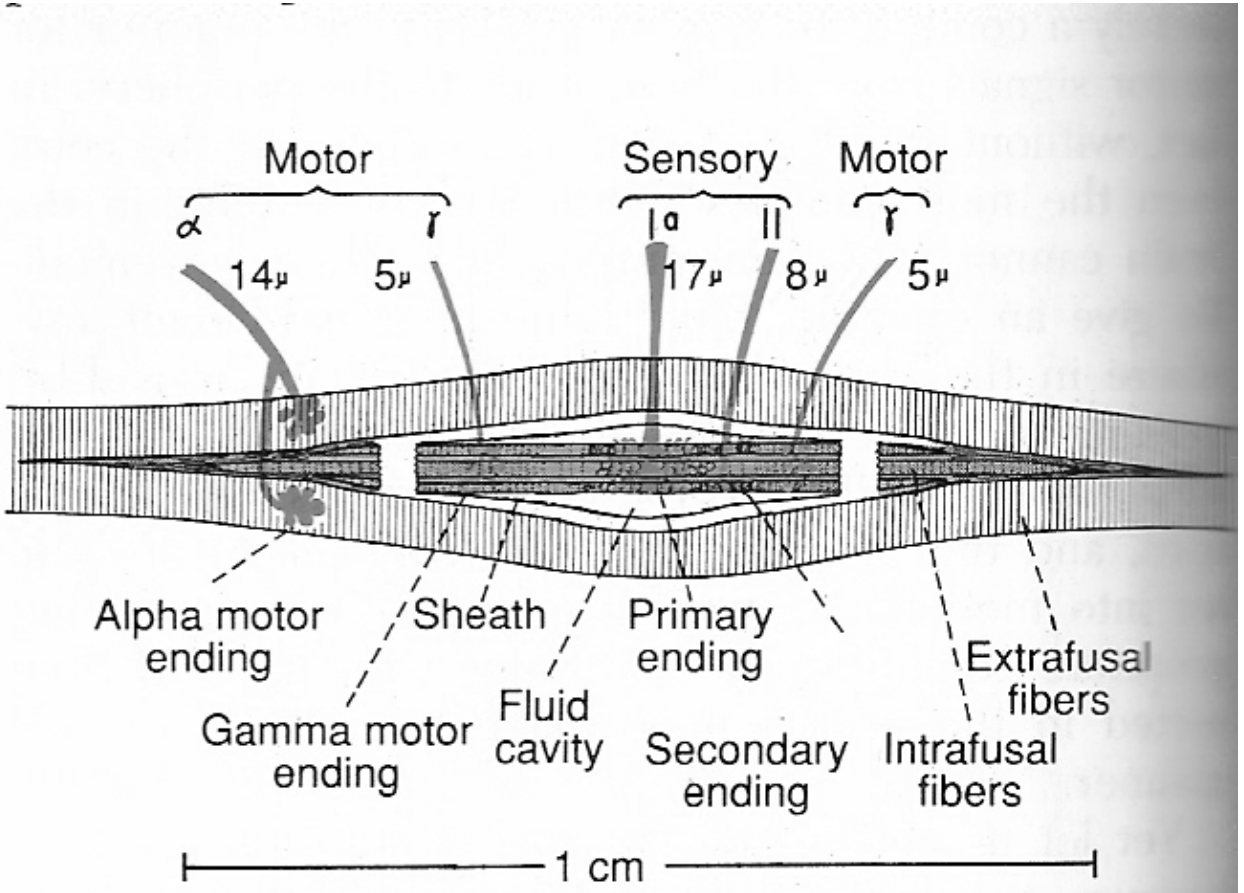
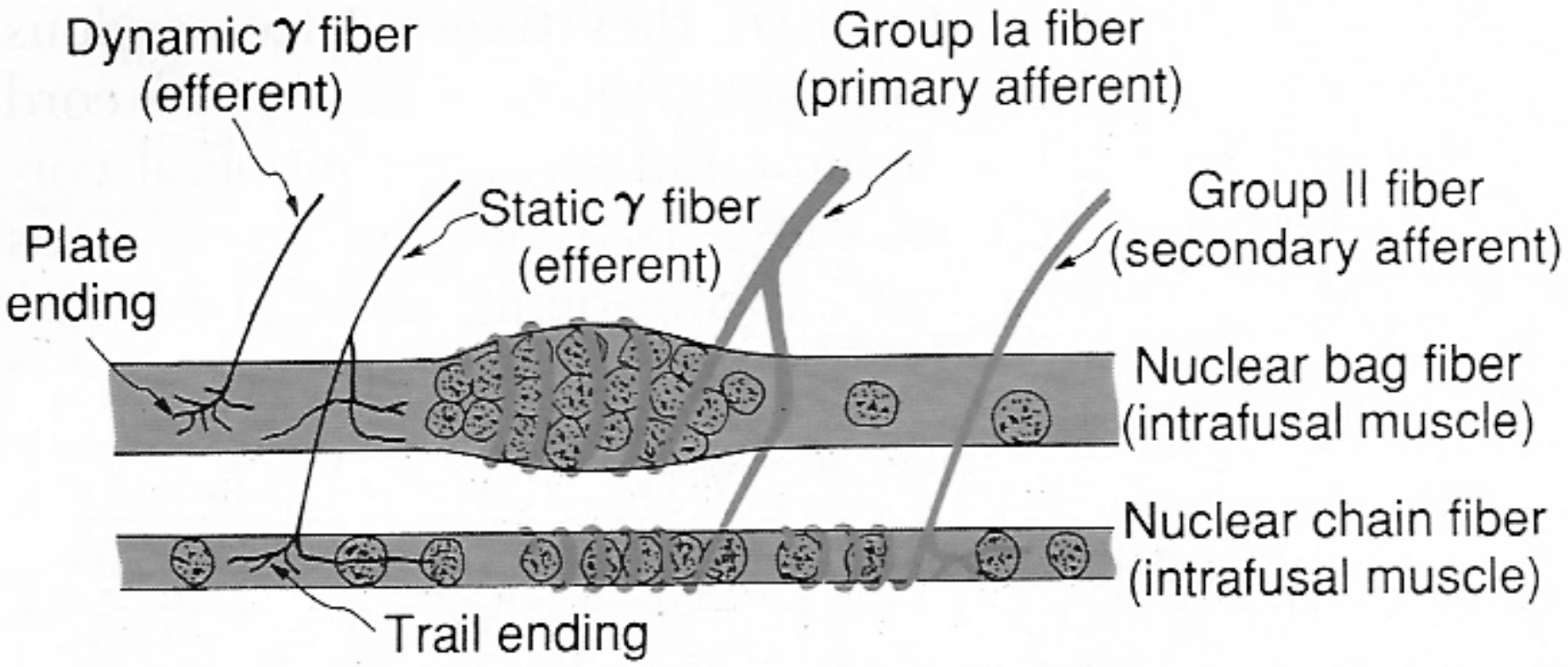


Figure 54–2. Muscle spindle, showing its relation to the large extrafusal skeletal muscle fibers. Note also both the motor and the sensory innervation of the muscle spindle and the extrafusal large muscle fibers.

Centre Section of Intrafusal Fibres



Muscle Spindles (cont'd)

- Physiological sensors or transducers
- 3 – 10 mm long in belly of muscle
- No actin or myosin in middle section of intrafusal fibres
- 1 – 3 nuclear bag fibres in each spindle
- 3 – 9 nuclear chain fibres
- Innervated by Ia (17 μm 70 -120 m/sec) and II (8 μm slower vel.)

Movement Response

- Static Response to slow stretch primary and secondary endings increase firing rate (min)
- Dynamic Response primary endings increase firing rate to stretch velocity
- γ firing maintains intrafusal stretch and can be used to control responses (increase gain)

Golgi Tendon Organs

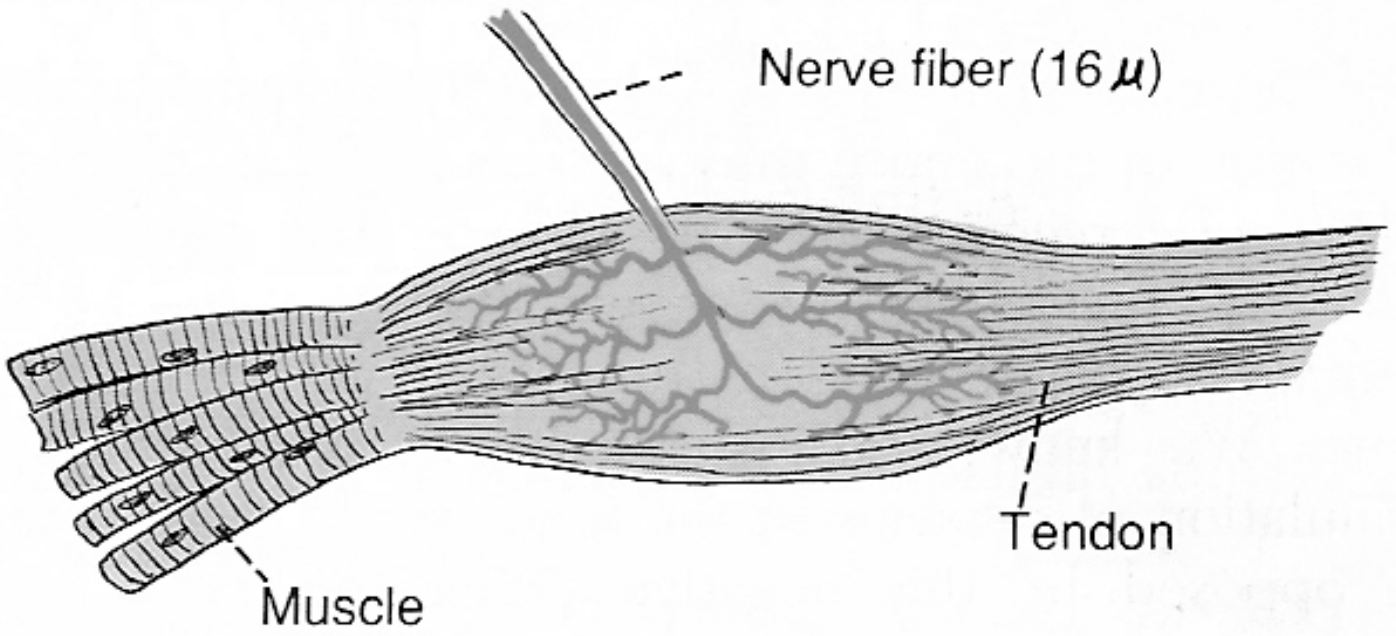


Figure 54–7. Golgi tendon organ.

Golgi Tendon Organs (cont'd)

- Innervated by IB fibres, 16 μm connected to inhibitory interneurons and up to brain
- Can provide force or tension feedback but primarily inhibitory

Simple Reflex Arc

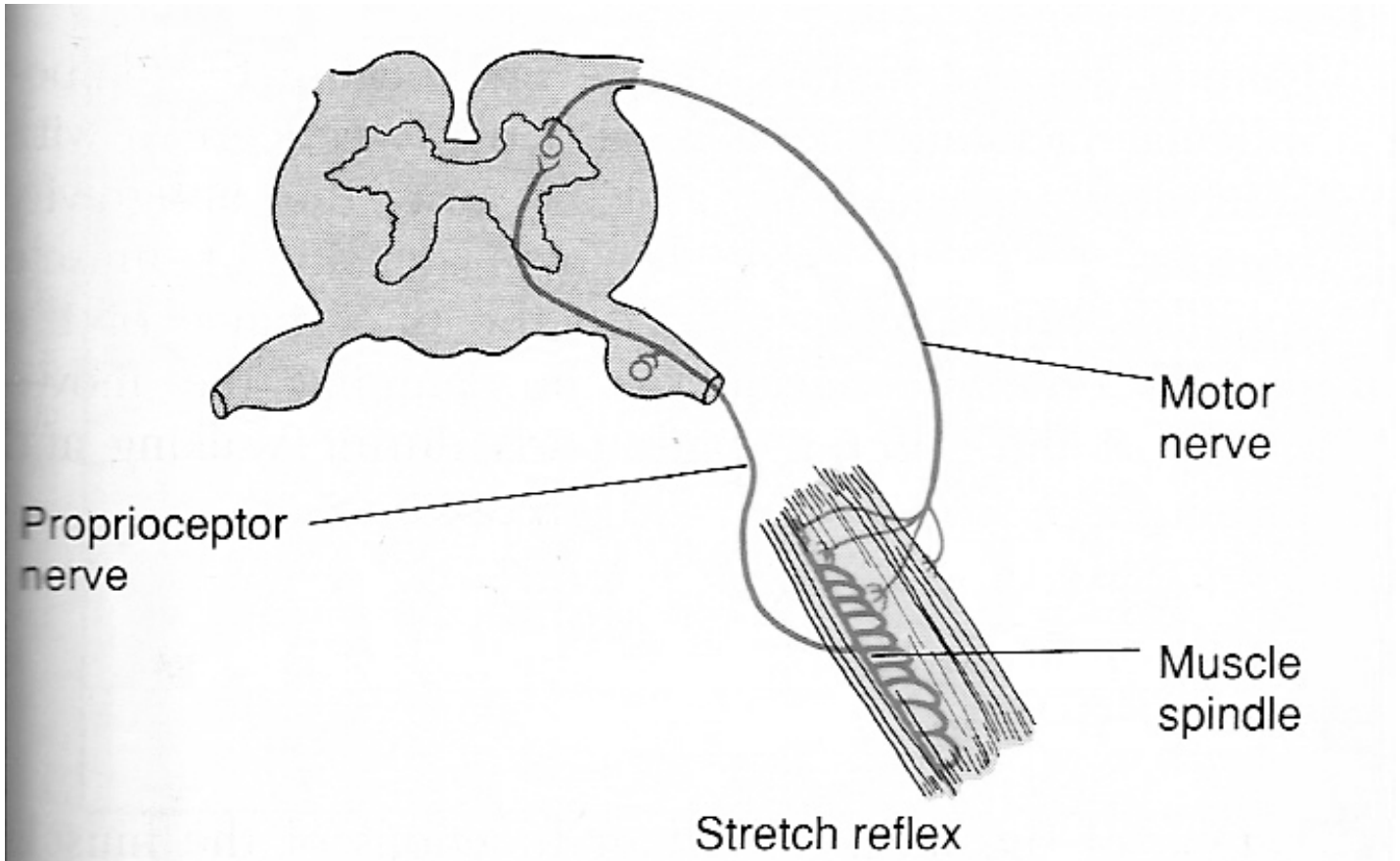


Figure 54–4. Neuronal circuit of the stretch reflex.

Motor Axis

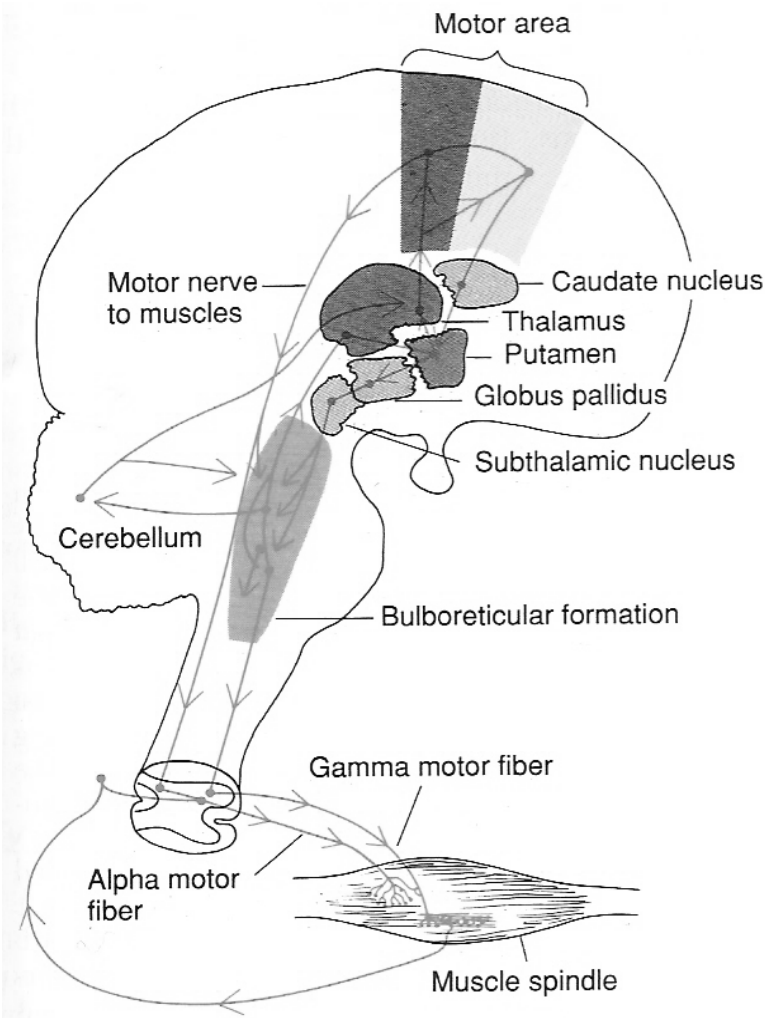


Figure 45–3. Motor axis of the nervous system.

Somatic Sensory Cortex

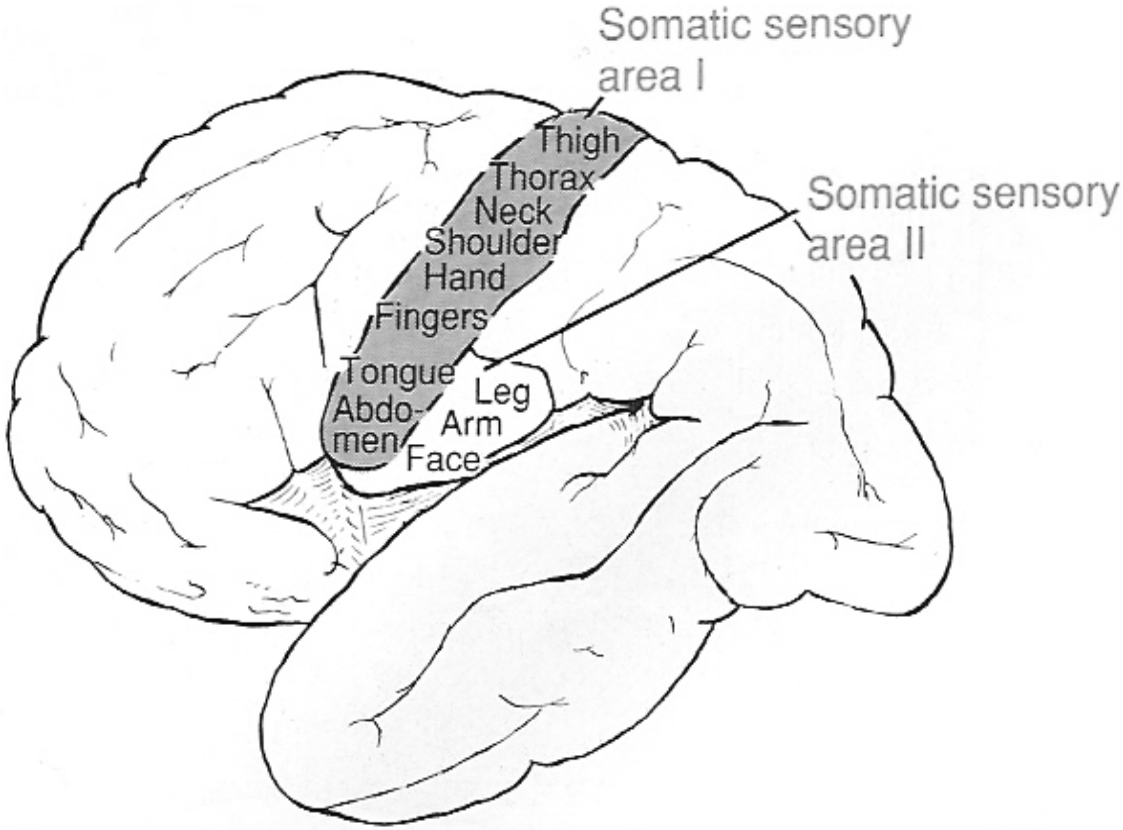


Figure 47–6. Two somatic sensory cortical areas, somatic sensory areas I and II.

Motor and Sensory Cortex

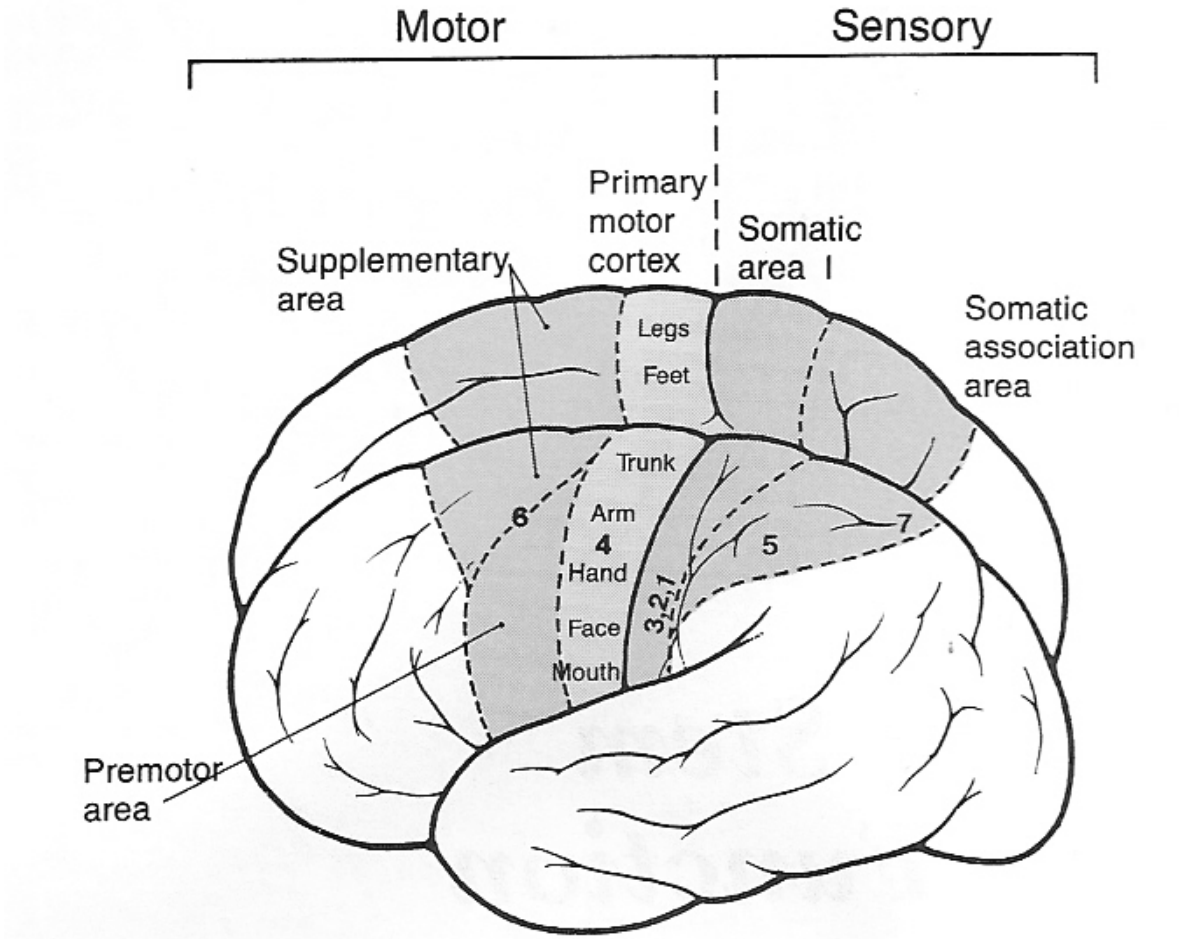


Figure 55–1. Motor and somatosensory functional areas of the cerebral cortex.

Motor Cortex Control (EE 791 5-9)

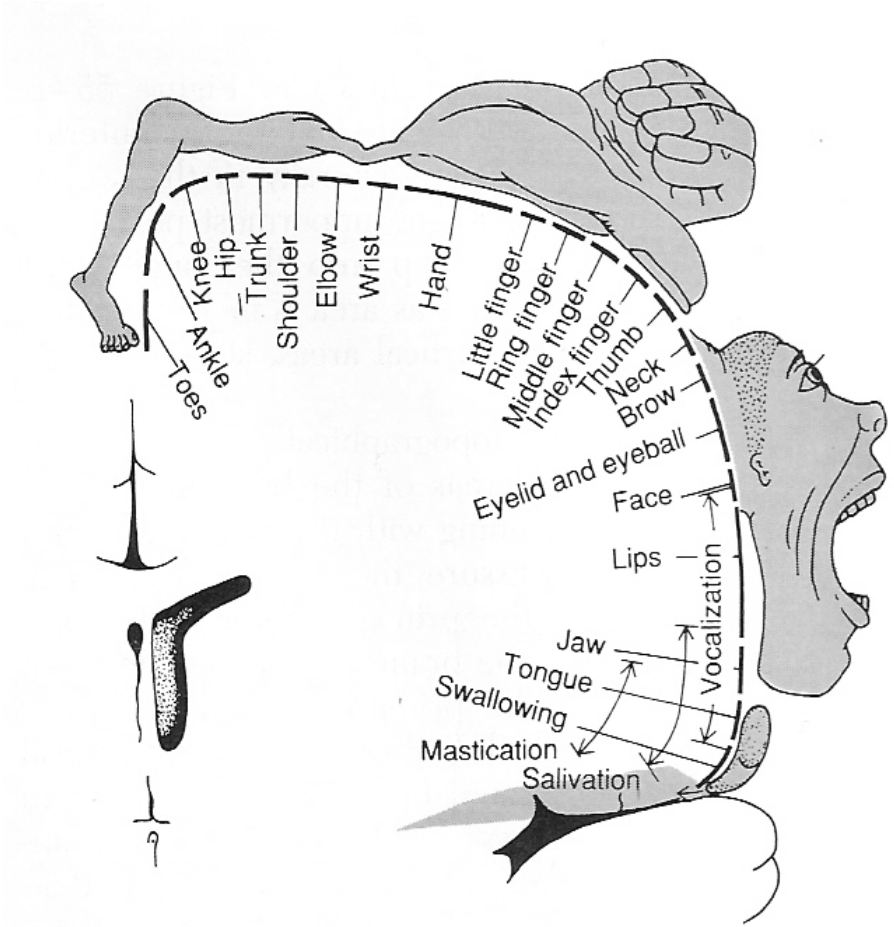


Figure 55–2. Degree of representation of the different muscles of the body in the motor cortex. (From Penfield and Rasmussen: The Cerebral Cortex of Man: A Clinical Study of Localization of Function. New York, Macmillan Co., 1968.)

Muscle Control Areas

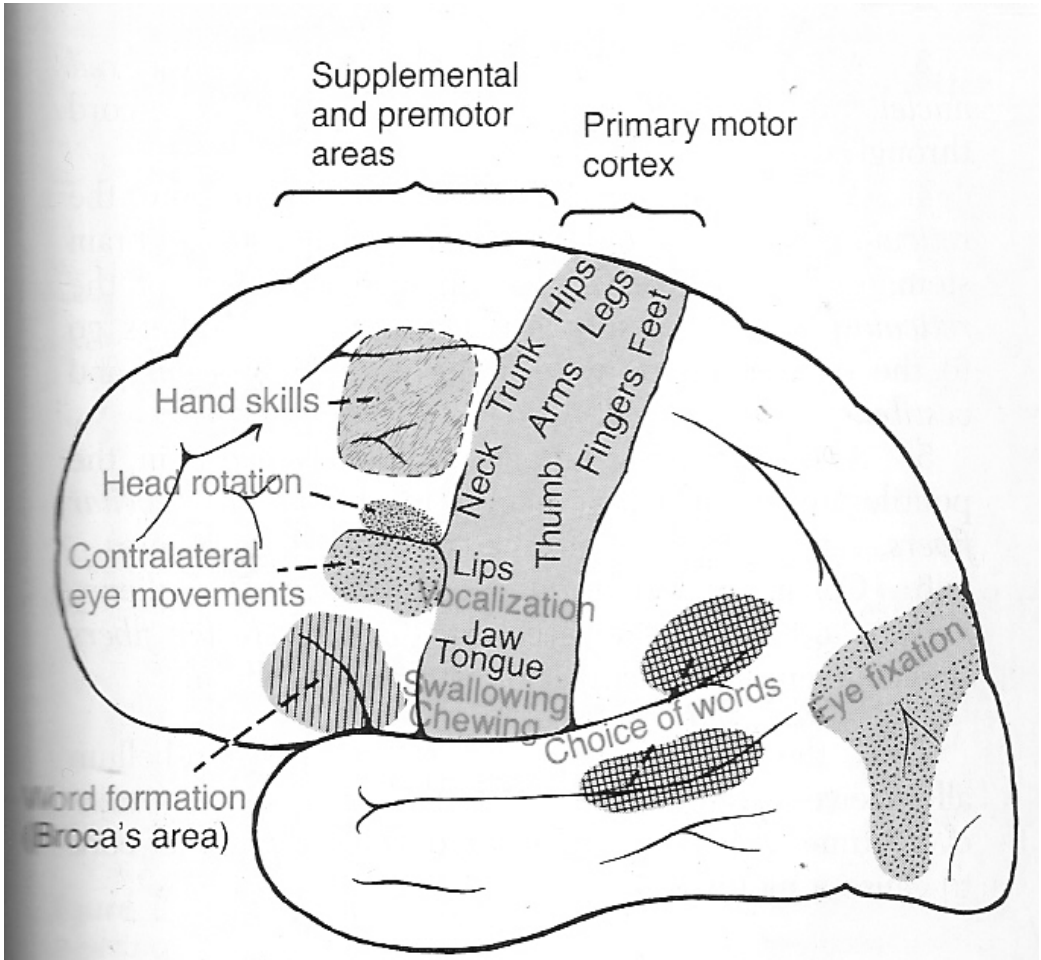


Figure 55–3. Representation of the different muscles of the body in the motor cortex and location of other cortical areas responsible for specific types of motor movements.

Pyramidal Tract (EE 791 5-11)

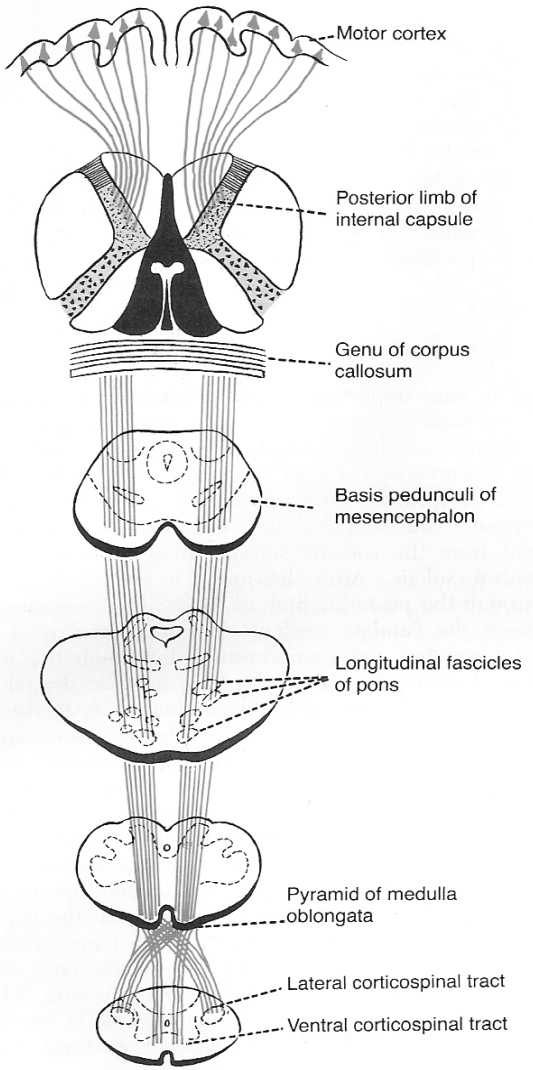


Figure 55–4. Pyramidal tract. (Modified from Ranson and Clark: Anatomy of the Nervous System. Philadelphia, W. B. Saunders Co., 1959.)

Anterior Motor Neuron Control

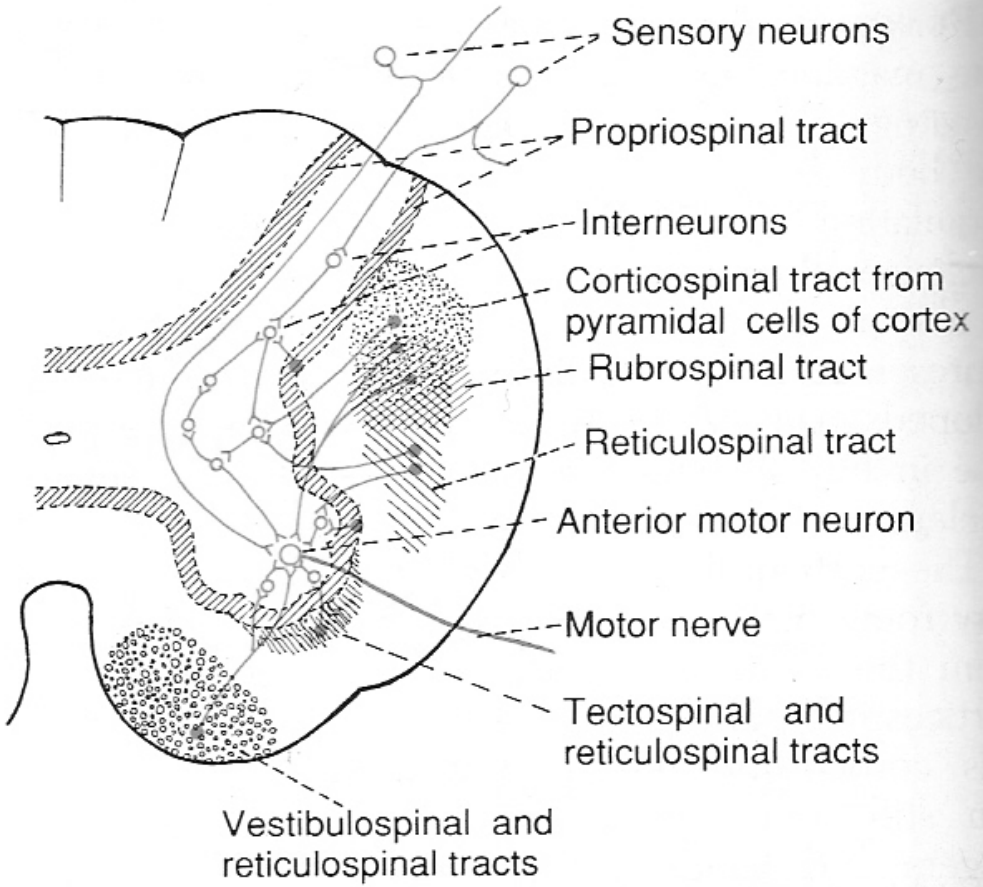
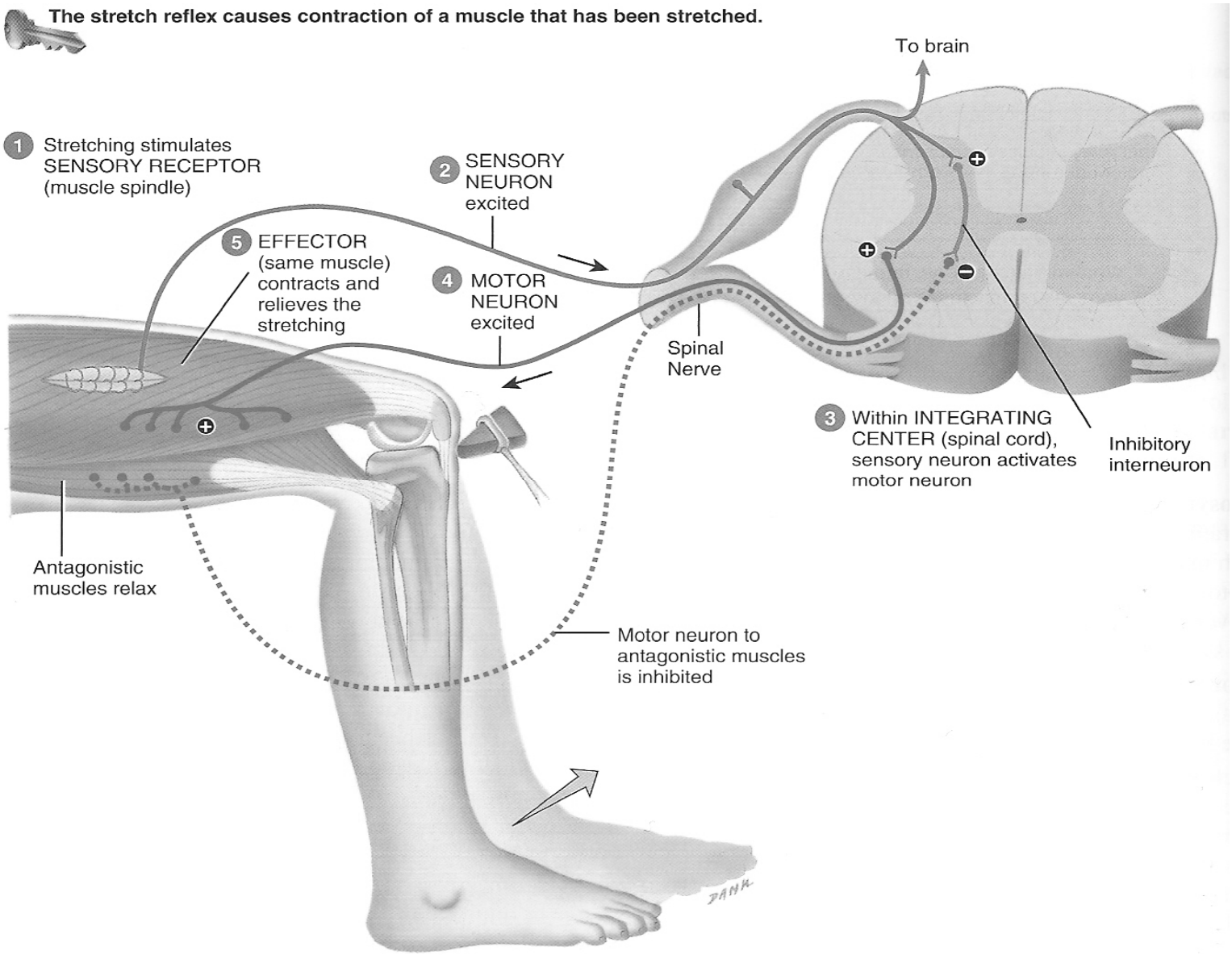


Figure 55–6. Convergence of all the different motor pathways on the anterior motor neurons.

Stretch Reflex (EE 791 5-13)



Flexor Response

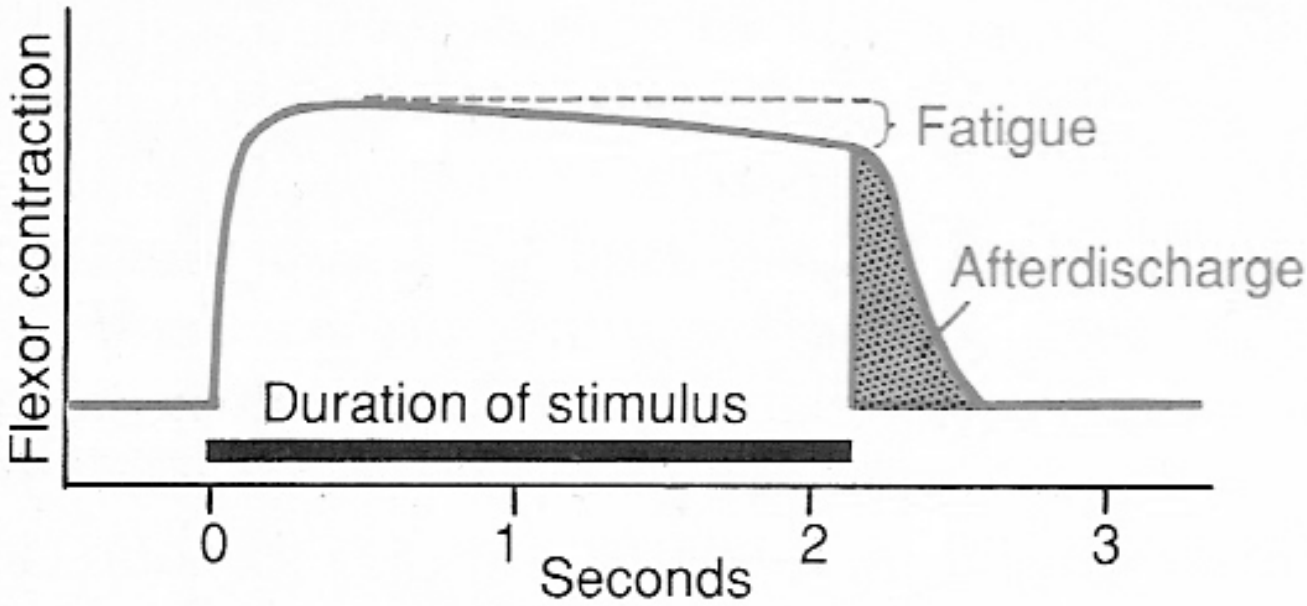
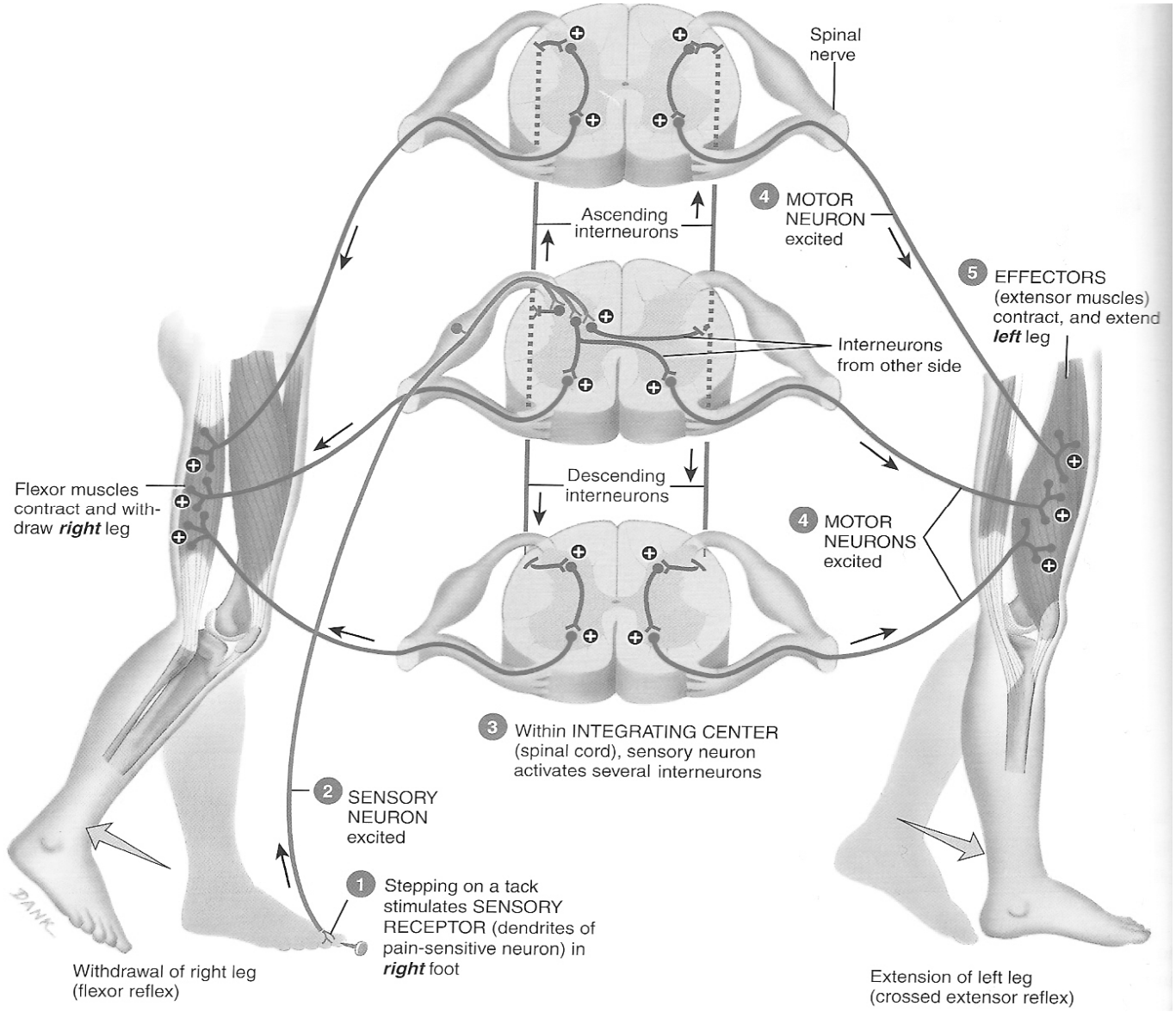


Figure 54–9. Myogram of the flexor reflex, showing rapid onset of the reflex, an interval of fatigue, and, finally, after-discharge after the stimulus is over.

Spinal Cord Muscle Control



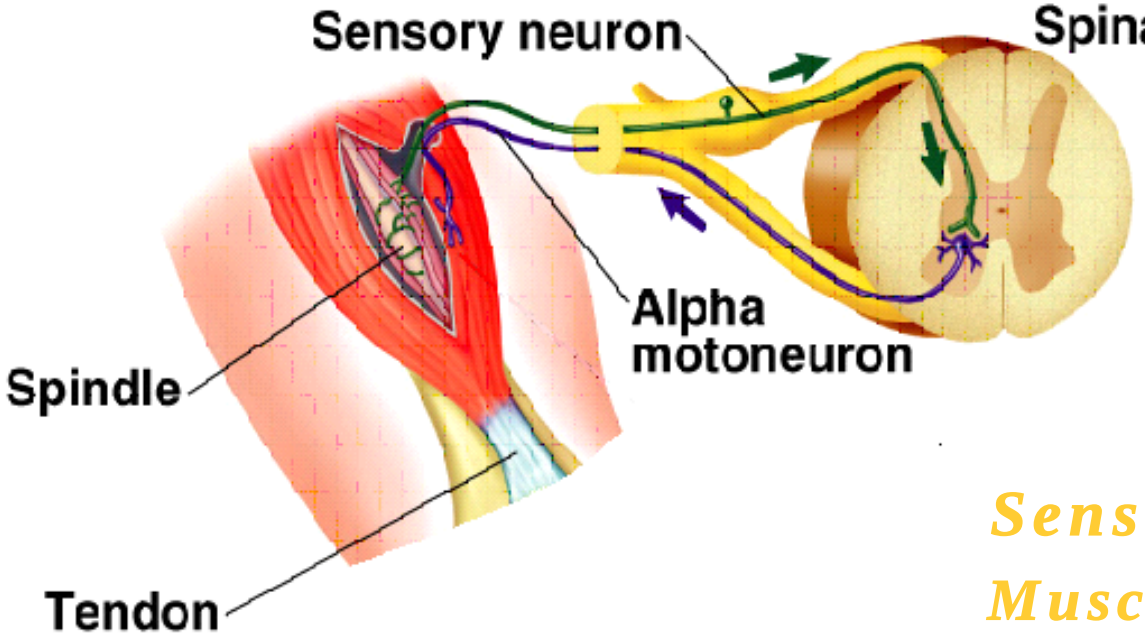
MODULATION OF THE IA INPUT: MOTONEURONE OUTPUT RELATIONSHIP OF HUMAN FLEXOR CARPI RADIALIS DURING MUSCLE CONTRACTION

Winnie Fu*, Hubert De Bruin*, Alan McComas**

Departments of Electrical and Computer Engineering*, and Medicine**

McMaster University

Introduction to Reflex Pathway



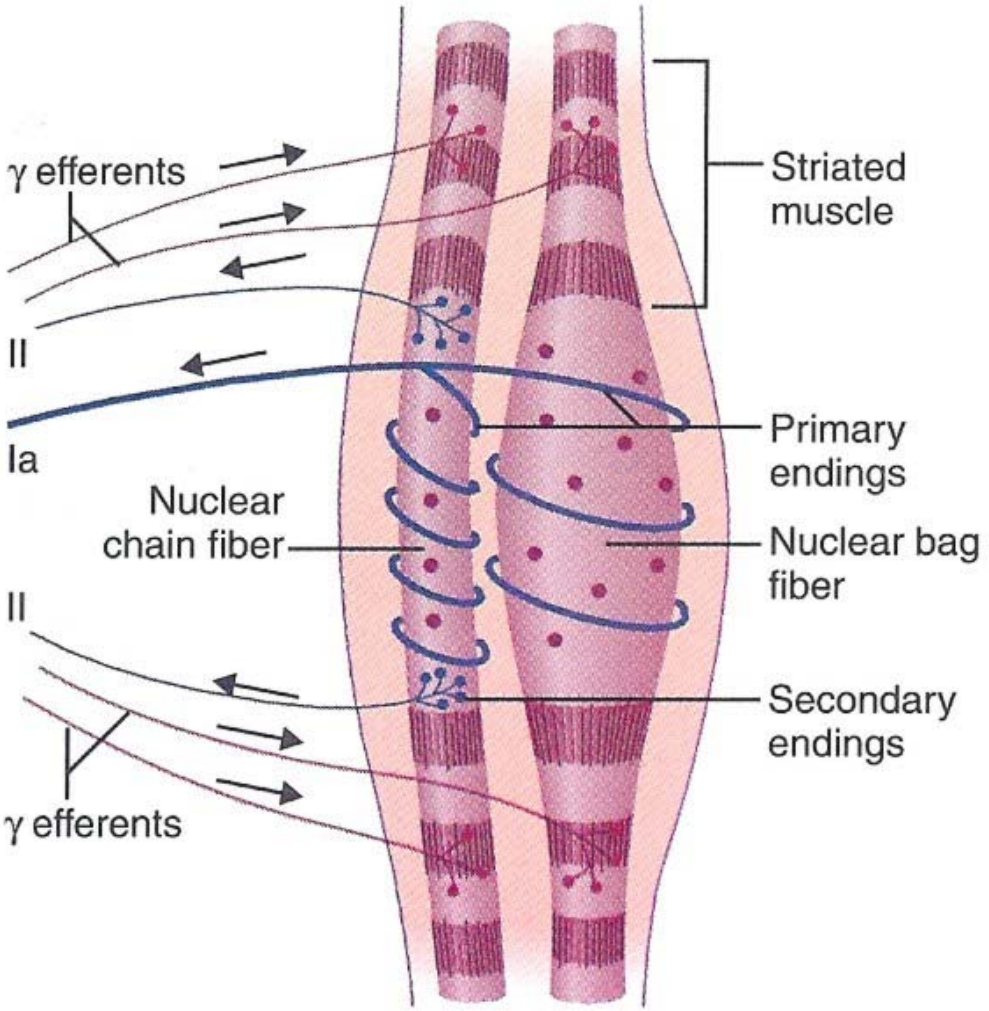
Sensory In- Motor Out

Muscle stretch produces muscle contraction

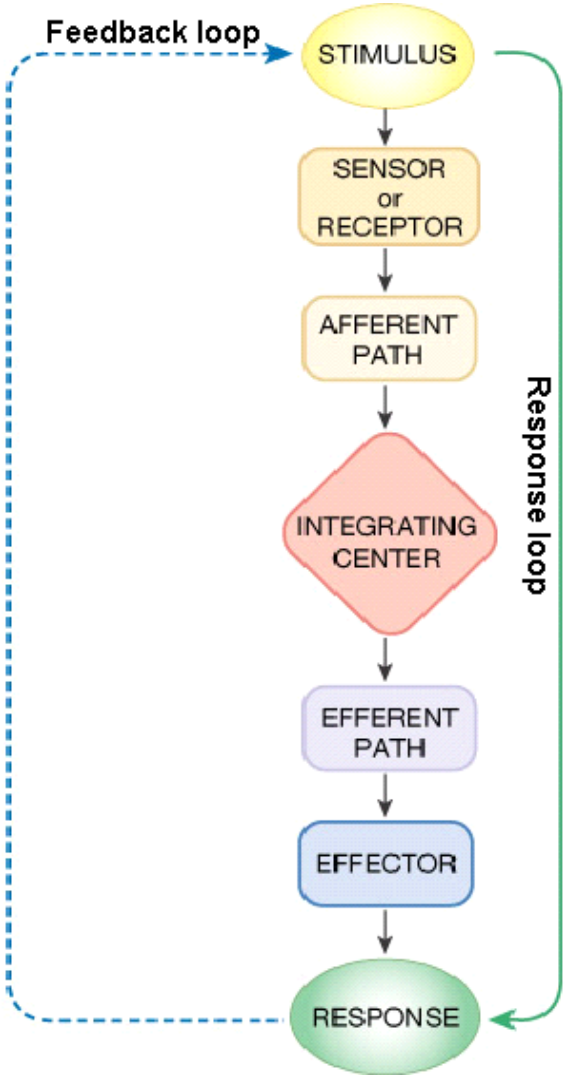
- Sensory organ: **spindle apparatus**
  - Sensory organ detects: **stretch**
- Effector: **motor units**
- Functions of reflex: **prevent muscle damage and maintain muscle length**
- Mechanism: **negative feedback**

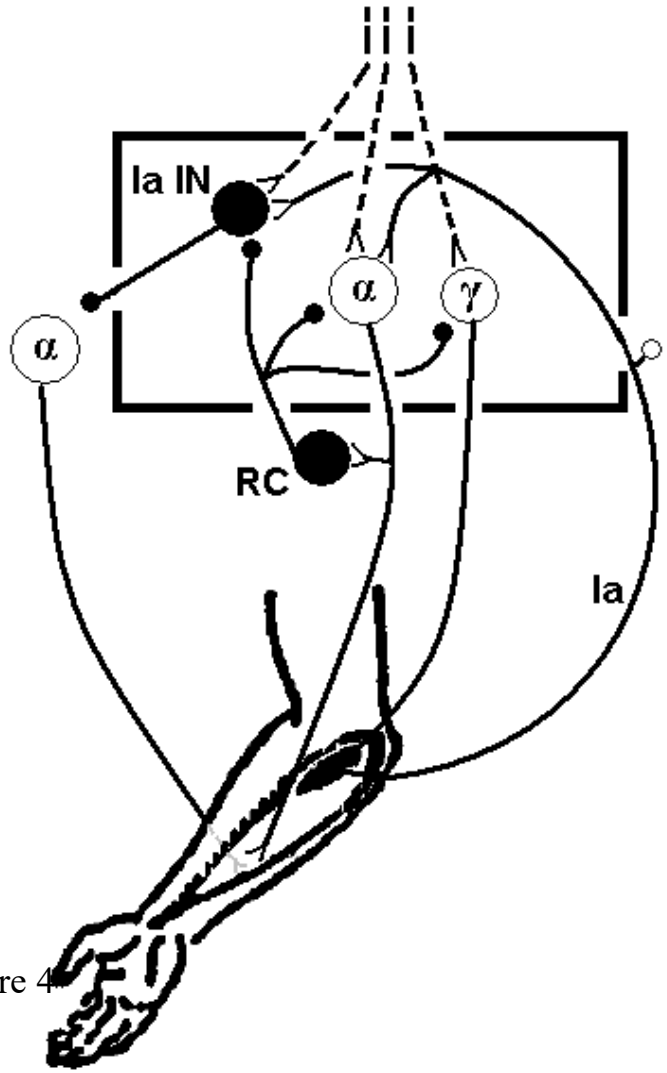
Muscle Spindle

- Sensory Organ
  - Ia and II nerve fibres
- Intrinsic Muscle Fibre
  - Gamma nerve fibres



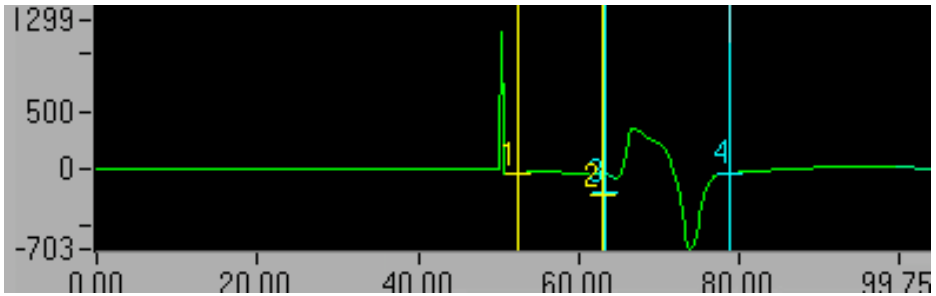
Neural Control of Flexor Carpi Radialis Muscle

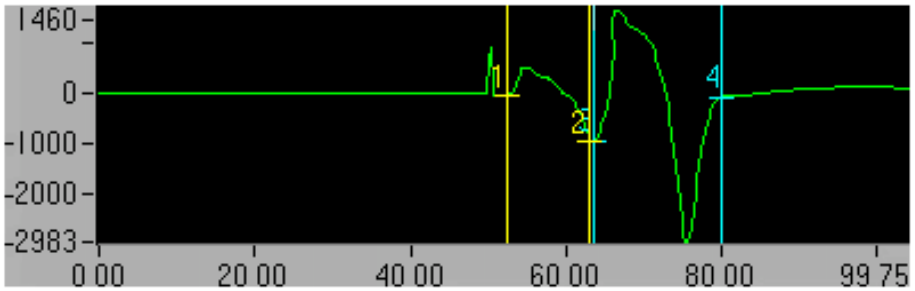


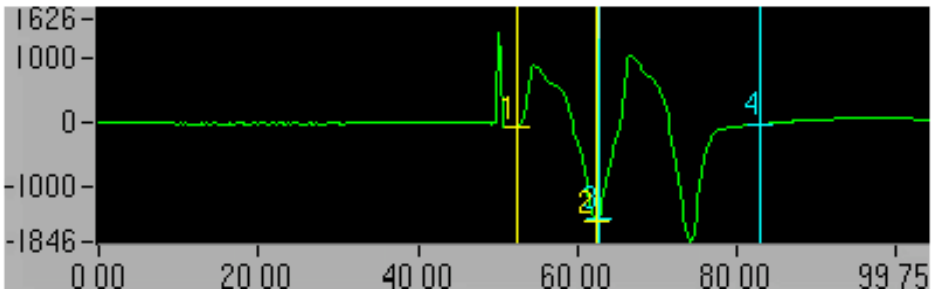


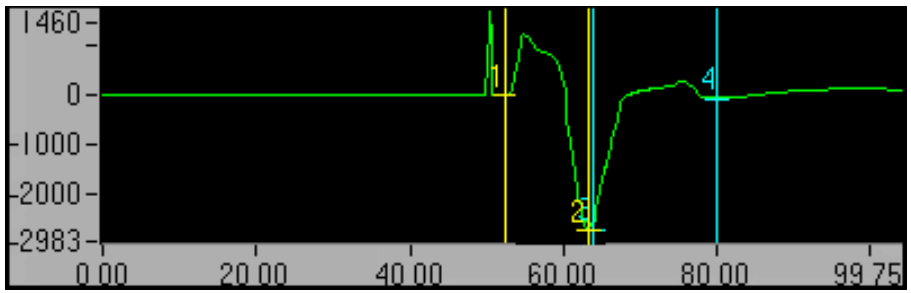
Results

- **Reflex threshold:** H reflex appears
- **Motor threshold:** M-wave appears with increase in reflex amplitude
- **Further increase in stimulus intensity:** M-wave increases while H reflex decreases





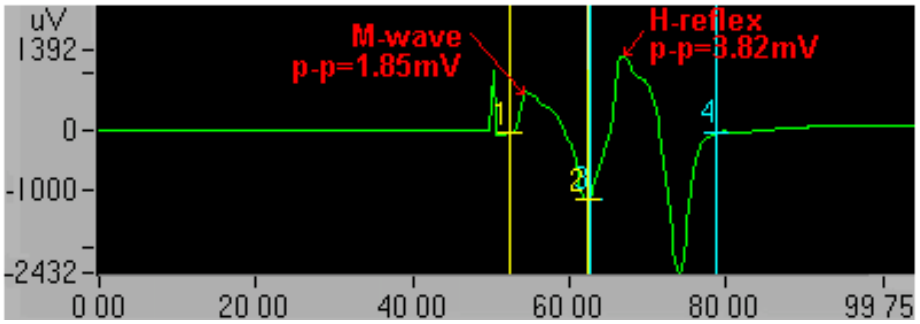




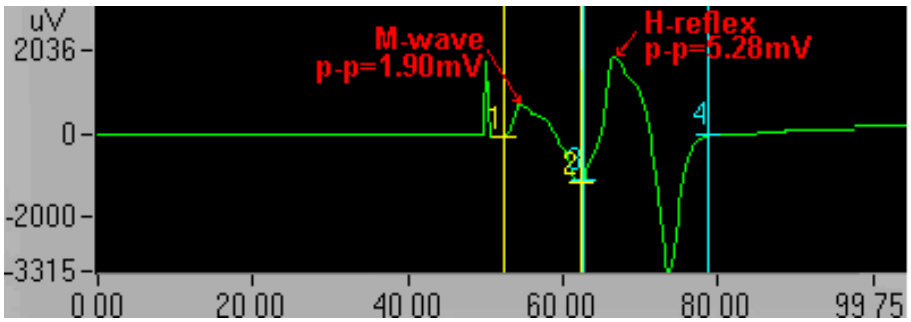
Results

Recordings displayed on front panel in Labview

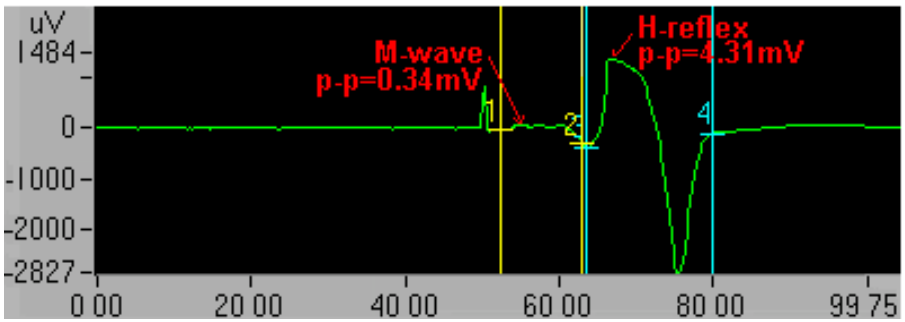
Relaxation



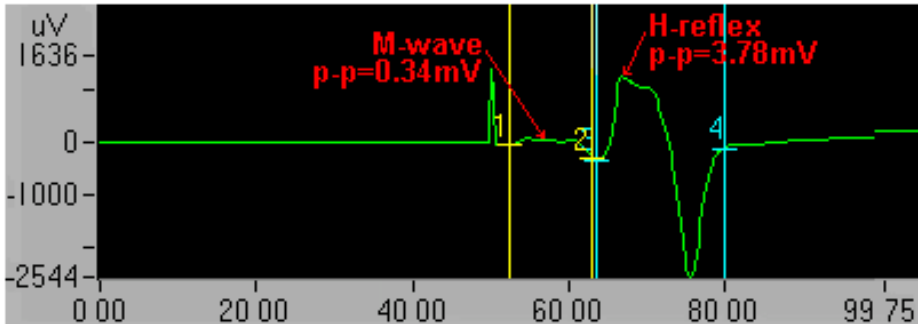
Wrist flexion



Relaxation

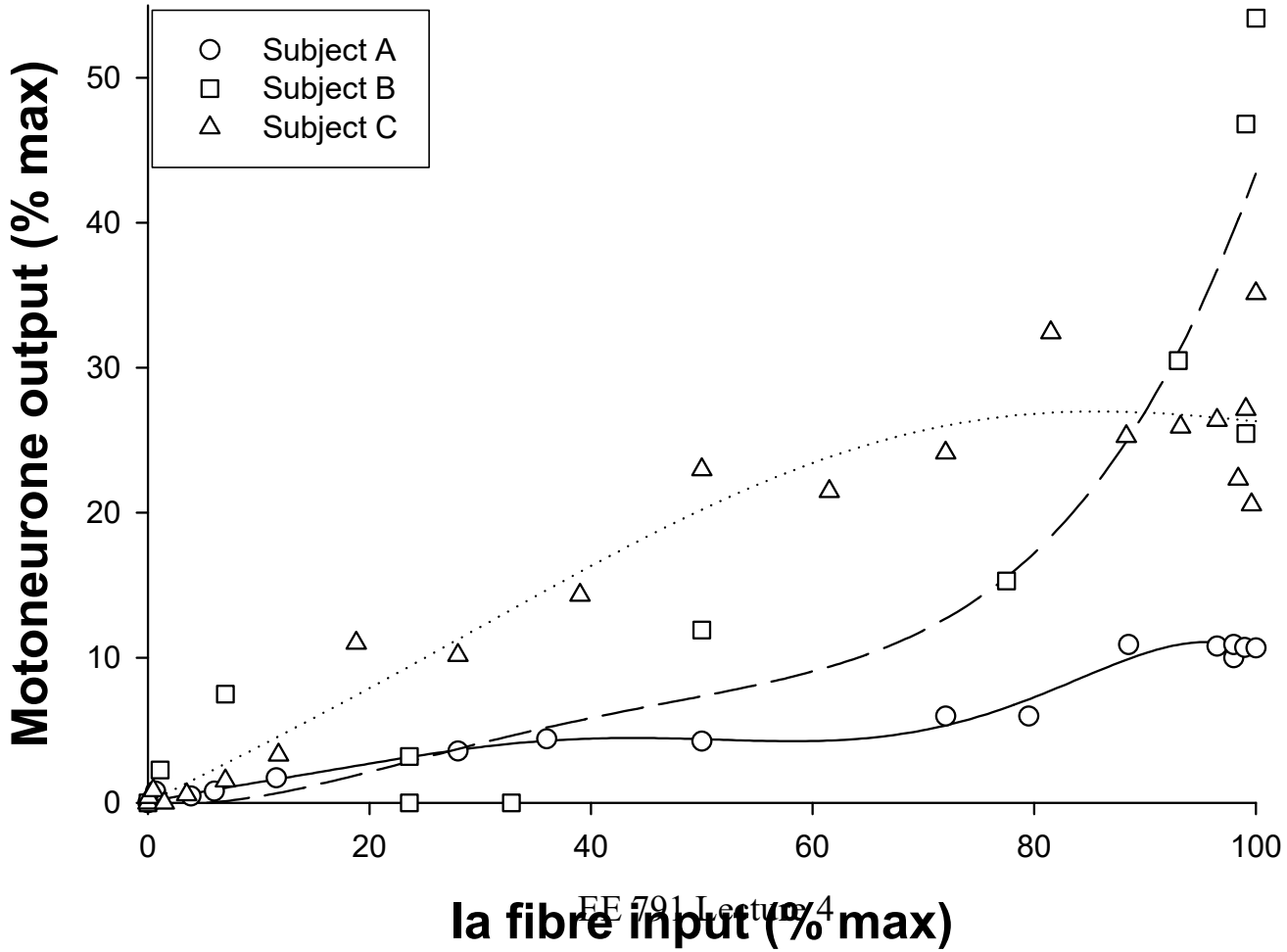


Wrist extension



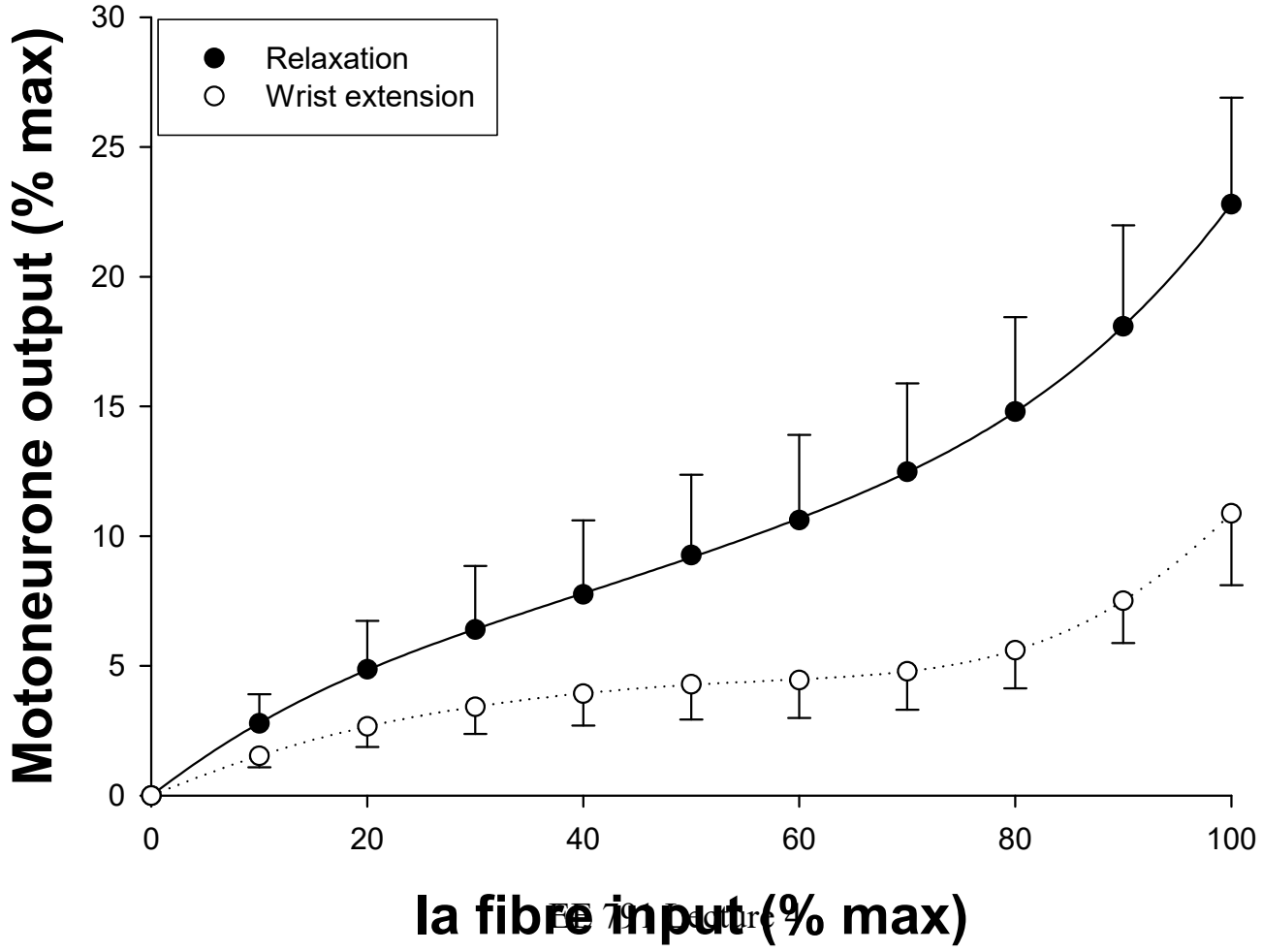
Input: Output Relationship in Relaxation

Inter-subject variability in form of input: output relationship



Wrist Extension

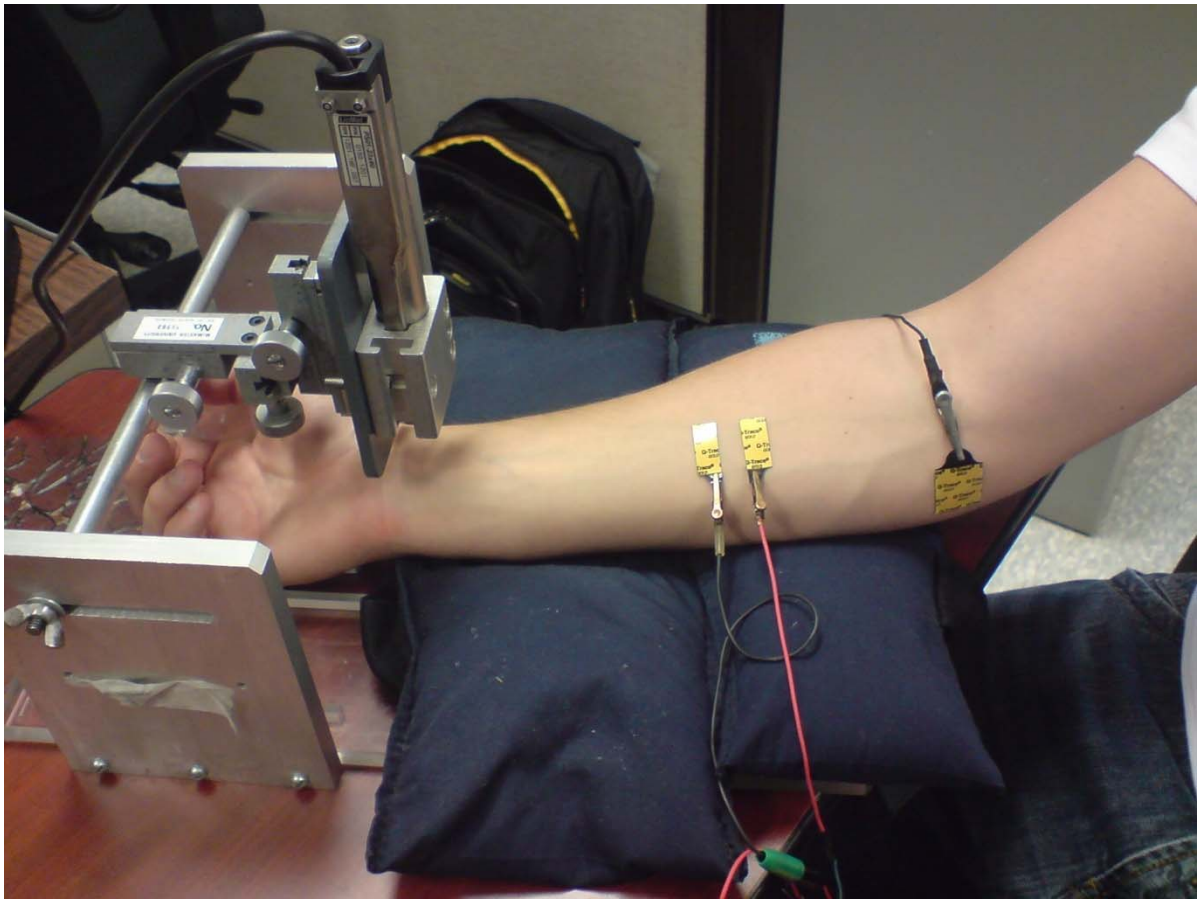
Mean data (n=8) obtained in relaxation and wrist extension



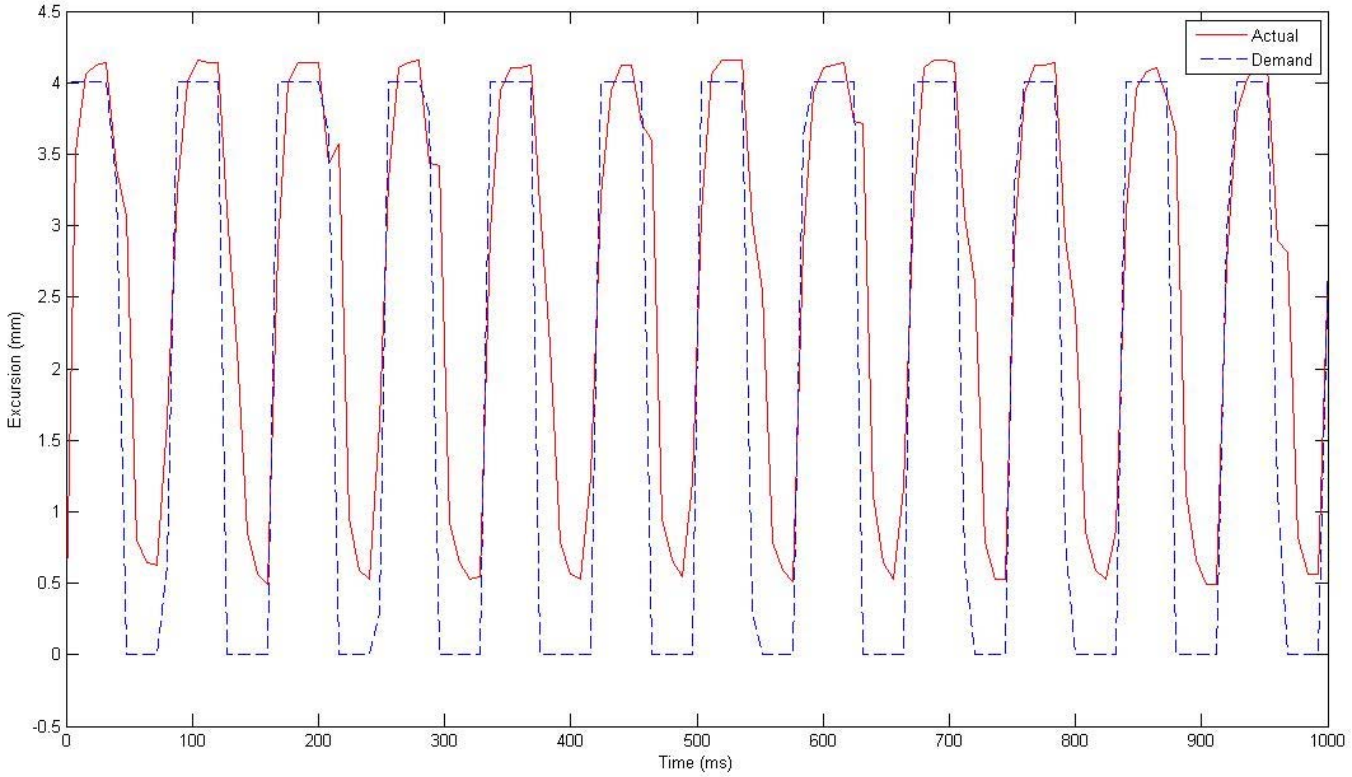
Mechanism involved in modulation of relationship during muscle contraction

- Activation of wrist flexor muscle:
  - depression of presynaptic inhibition to activate spinal reflexes
- Activation of wrist extensor muscle:
  - presynaptic inhibitory feedback to prevent activation of reflexes
- Steeply-rising segment at high-threshold end of mean curve in wrist extension:
  - breakdown of presynaptic mechanism

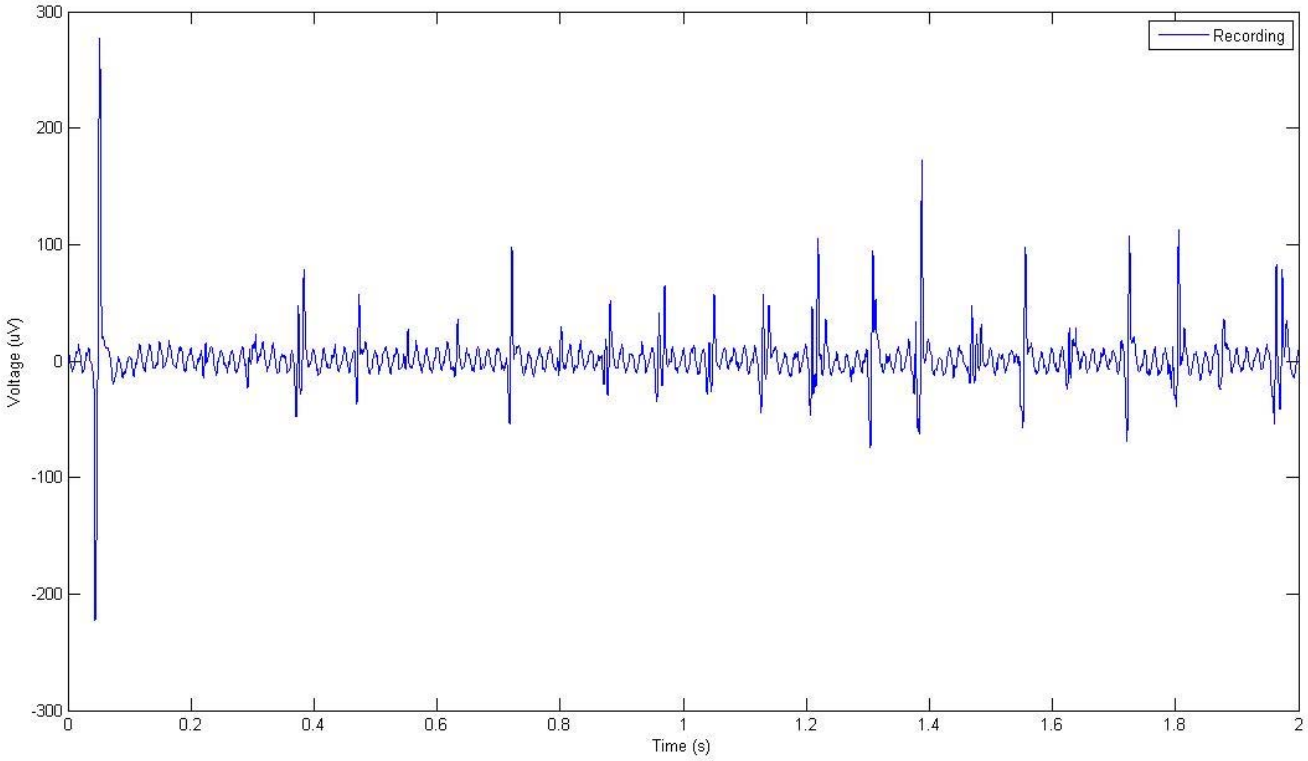
Reflex Study using Sinusoidal Tendon Drive



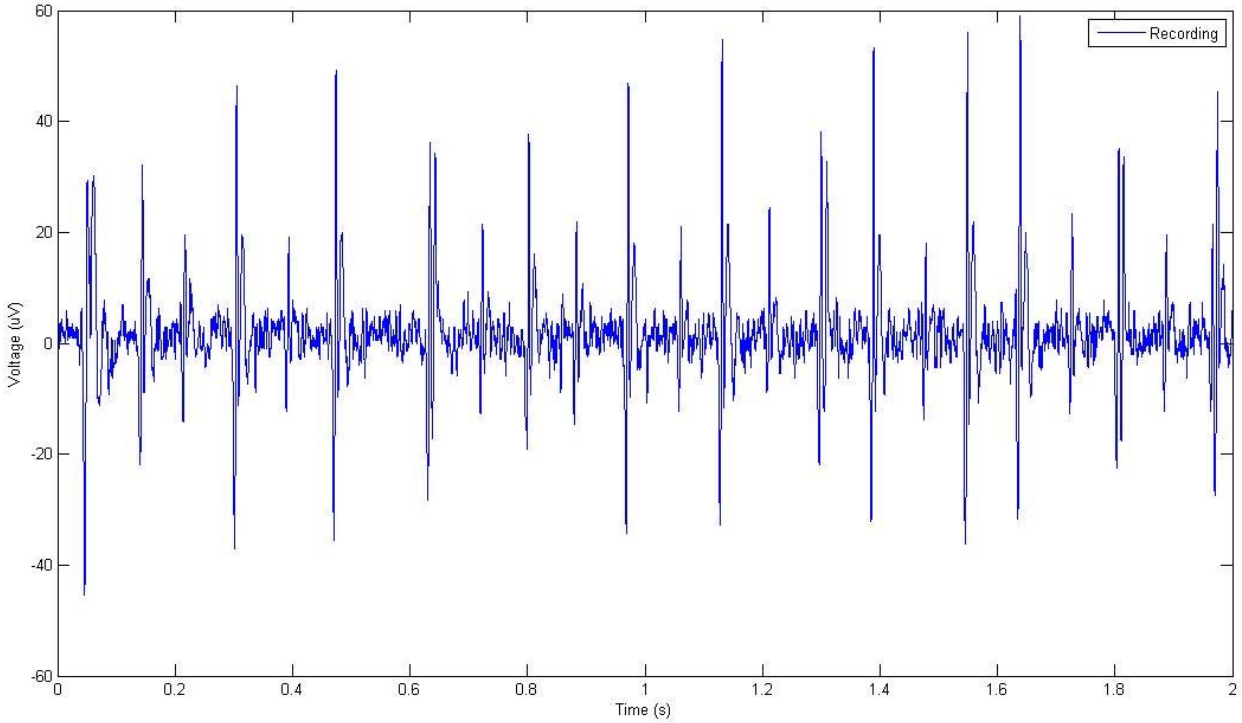
12 Hz Pseudo-Sinusoid Motor Drive



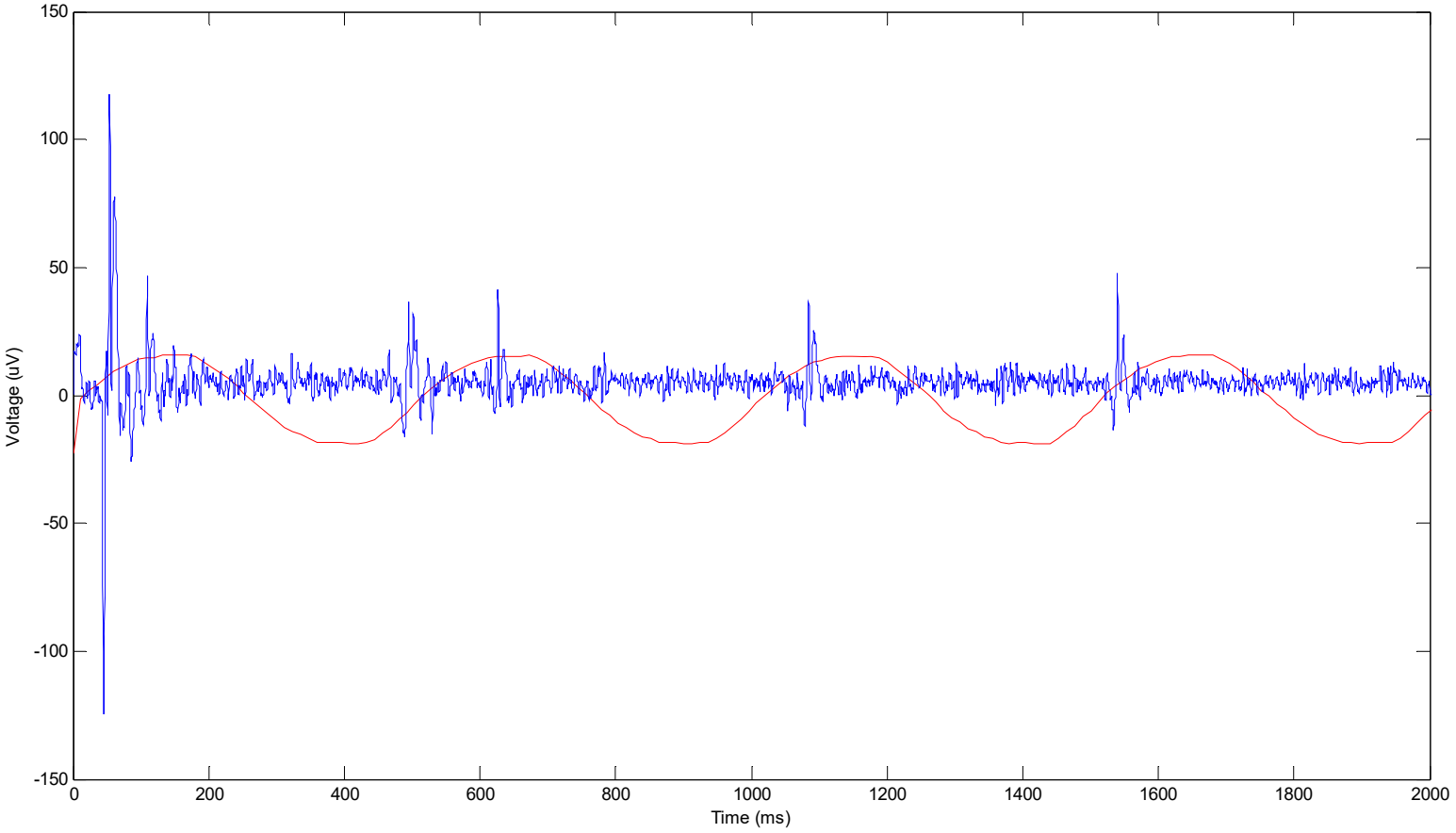
Raw EMG Results
12 Hz Drive



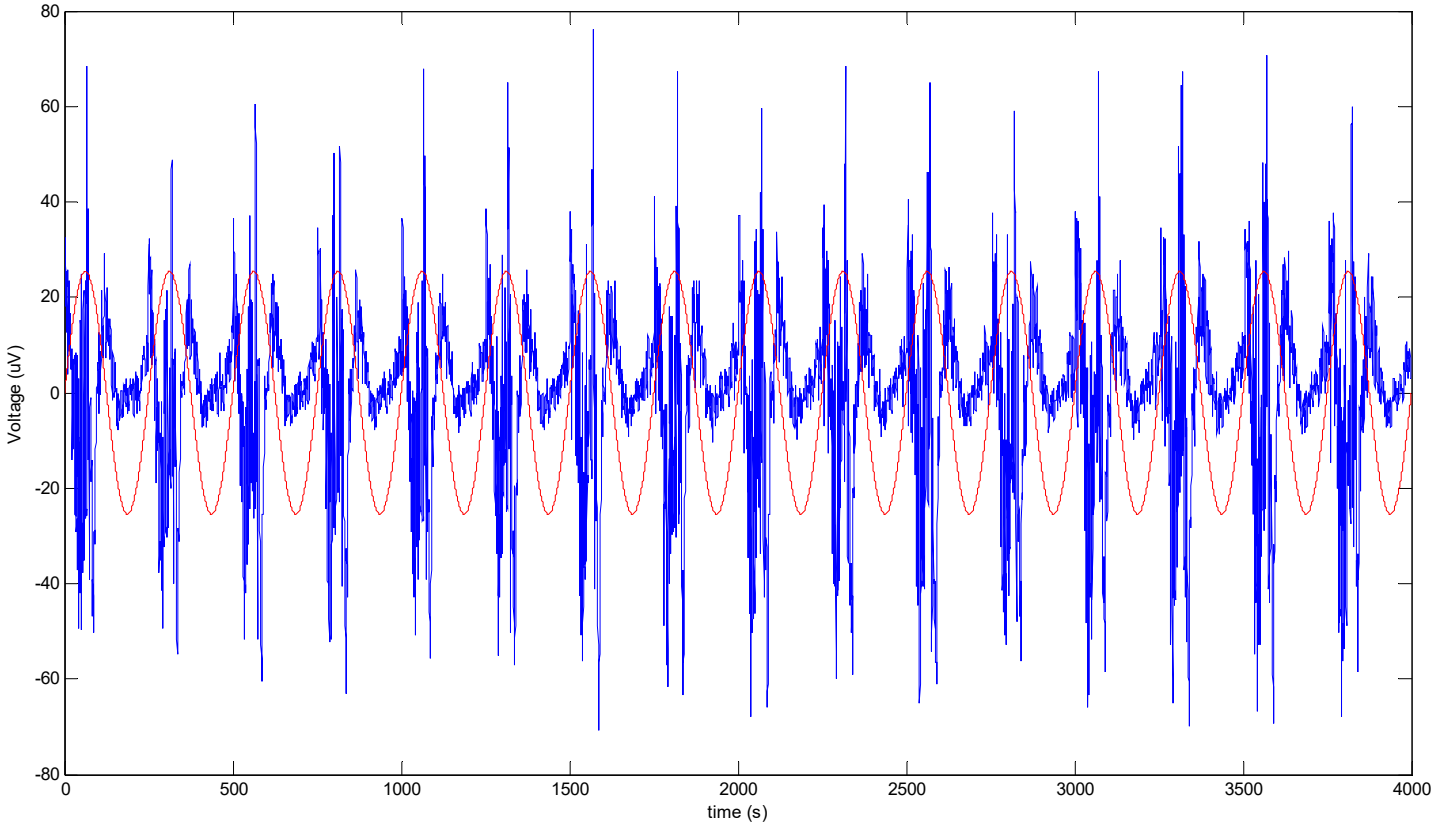
Filtered 12 Hz Results



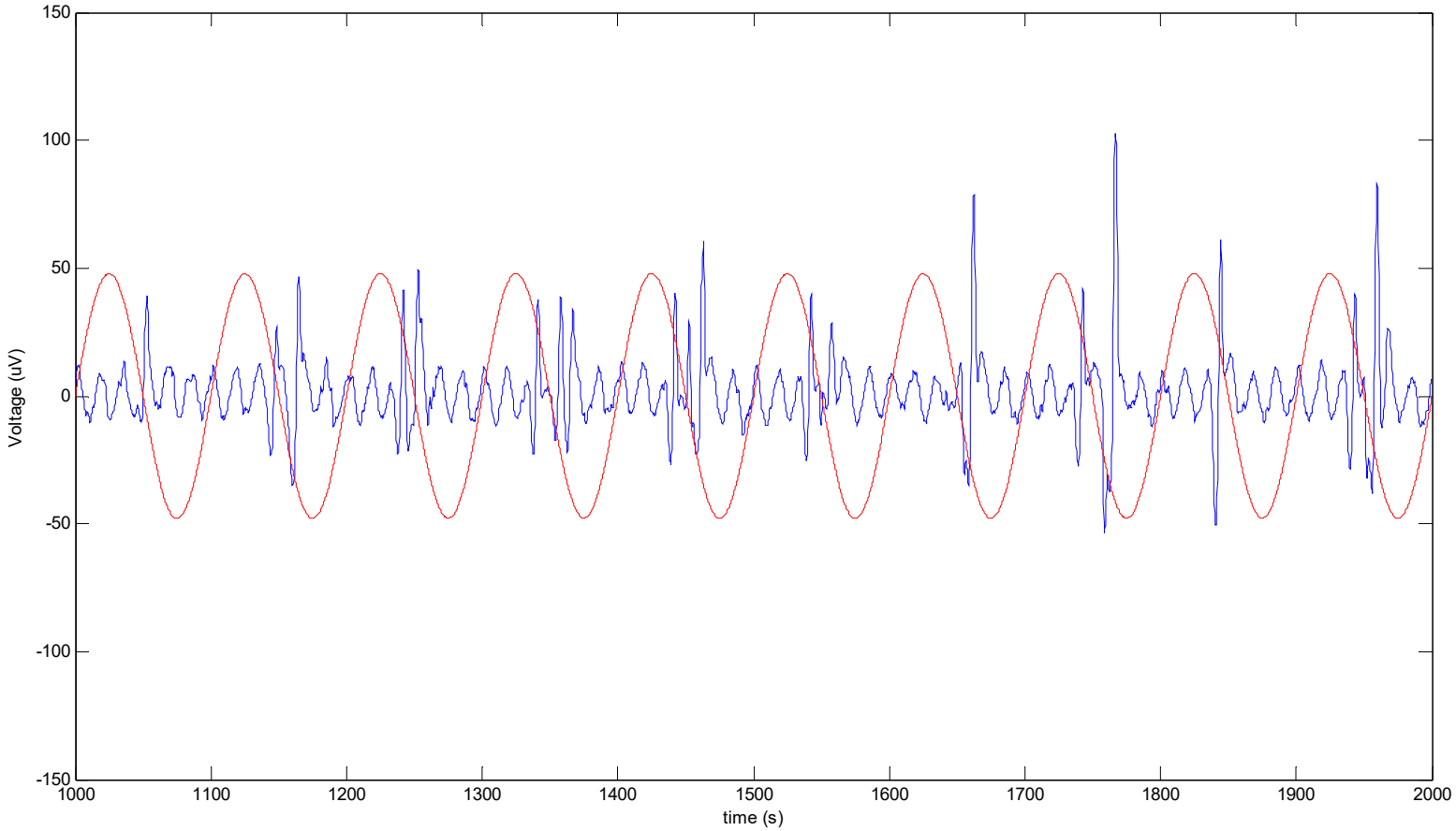
2 Hz Response



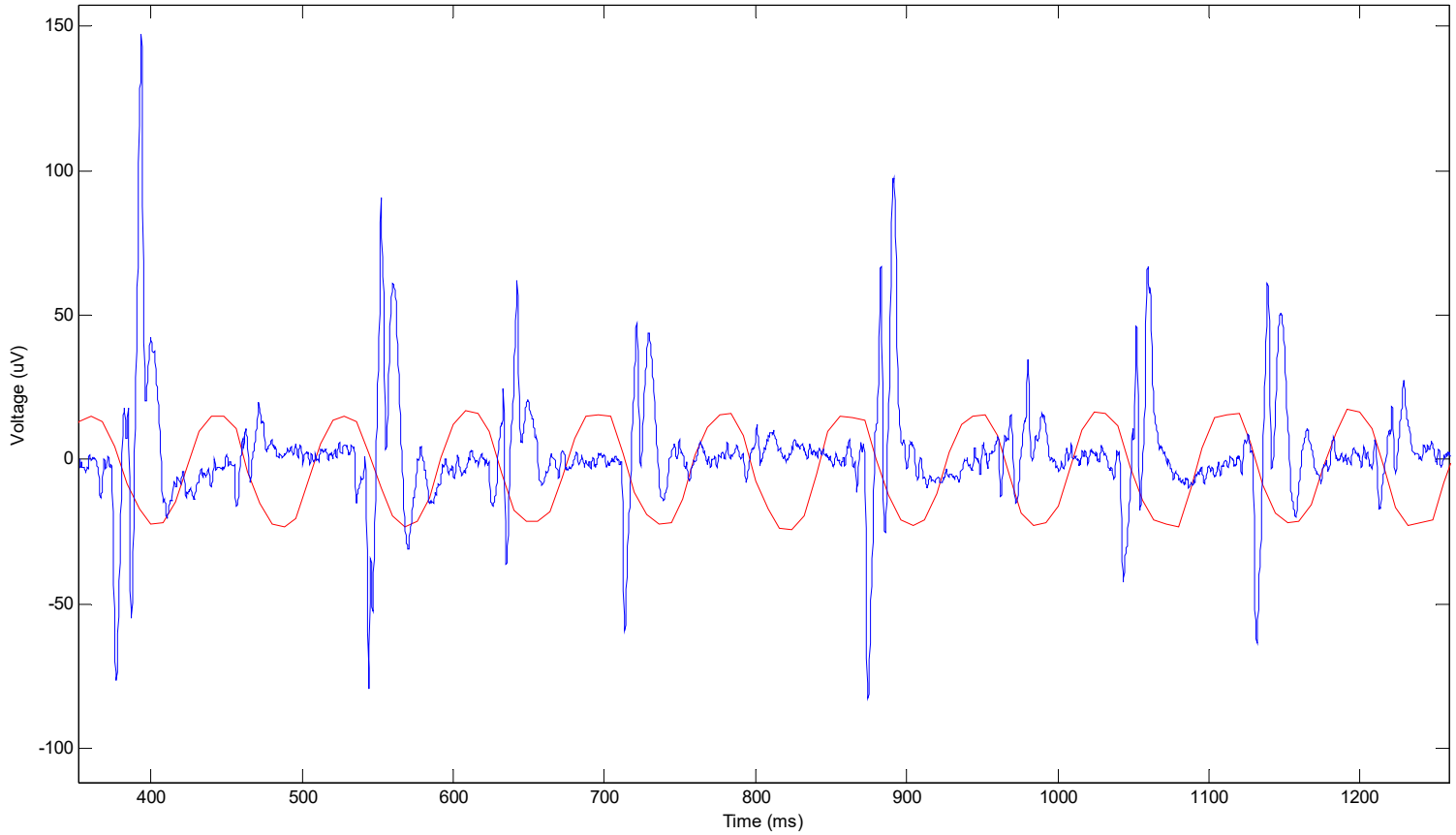
4 Hz Response



10 Hz Response



12 Hz Detail


150
100
50
0
-50
-100
Voltage (uV)
400
500
600
700
800
900
1000
1100
1200
Time (ms)