511-2017-10-20-action-II

Rick Gilmore

2017-10-20 13:49:15

Prelude

https://www.youtube.com/embed/L0CVoFsUhC4

Prelude

Woody Guthrie-This Land Is Your Land

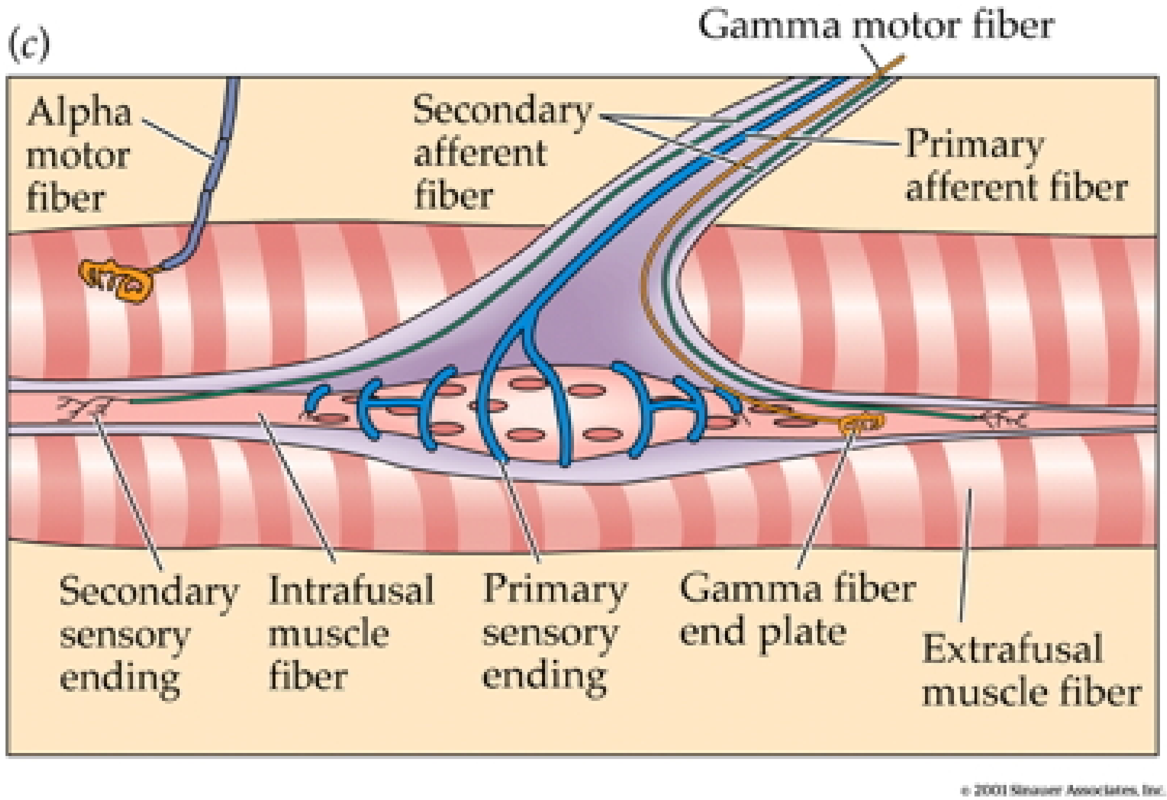
https://www.youtube.com/embed/XaI5IRuS2aE

Today's Topics

- The neuroscience of action

Muscles are sensory organs, too!

Two muscle fiber types



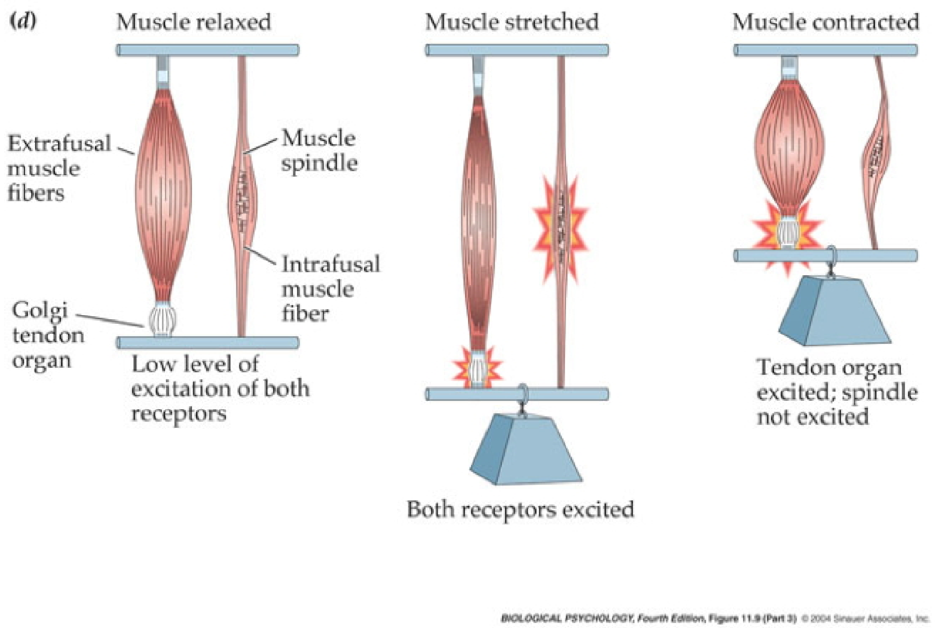
Two muscle fiber types

- Intrafusal fibers
  - Sense length/tension
  - Contain muscle spindles linked to Ia afferents
  - ennervated by gamma (γ) motor neurons
- Extrafusal fibers
  - Generate force
  - ennervated by alpha (α) motor neurons

Monosynaptic stretch (myotatic) reflex

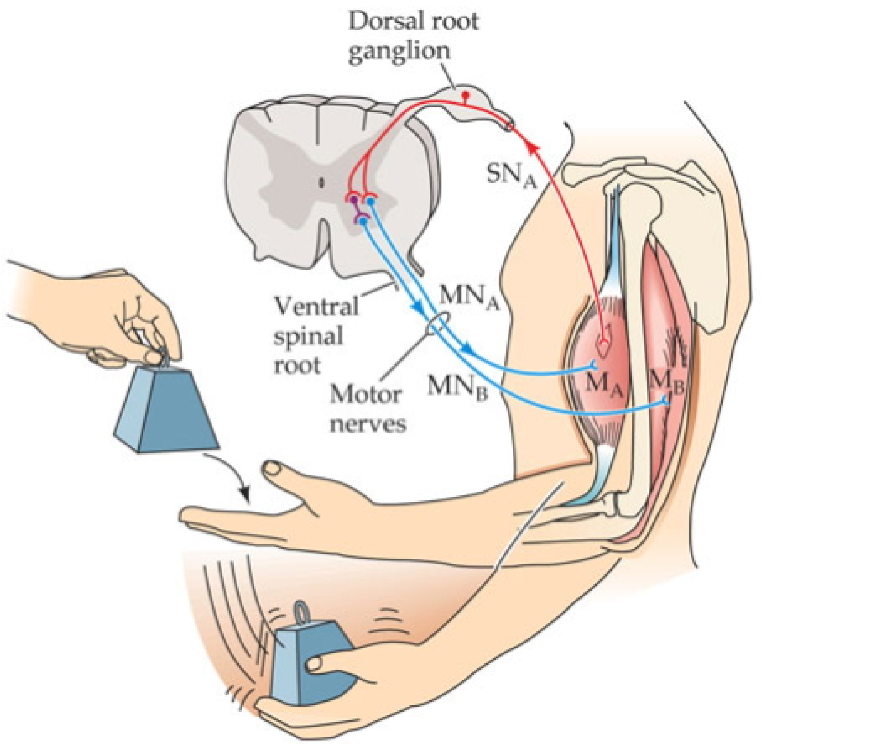
- Muscle stretched (length increases)
- Muscle spindle in intrafusal fiber activates
- Ia afferent sends signal to spinal cord
    - Activates alpha (α) motor neuron
- Muscle contracts, shortens length

Monosynaptic stetch (myotatic) reflex



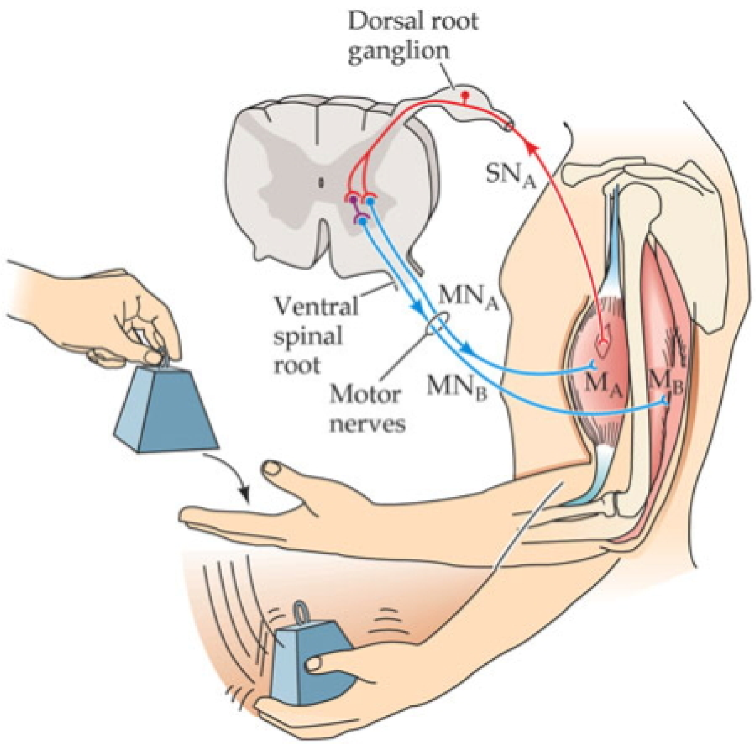
- Gamma (γ) motor neuron fires to take up intrafusal fiber slack

Monosynaptic stretch (myotatic) reflex



BIOLOGICAL PSYCHOLOGY, Fourth Edition, Figure 11.10 (Part 1) © 2004 Sinauer Associates, Inc.

Why doesn't antagonist muscle respond?



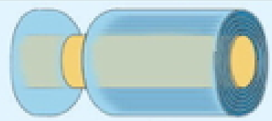
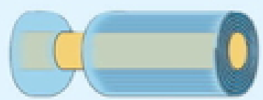
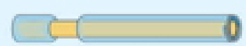
BIOLOGICAL PSYCHOLOGY, Fourth Edition, Figure 11.10 (Part 1) © 2004 Sinauer Associates, Inc.

Why doesn't antagonist muscle respond?

- Polysynaptic inhibition of antagonist muscle
- Prevents/dampens tremor

Brain gets fast(est) sensory info from spindles

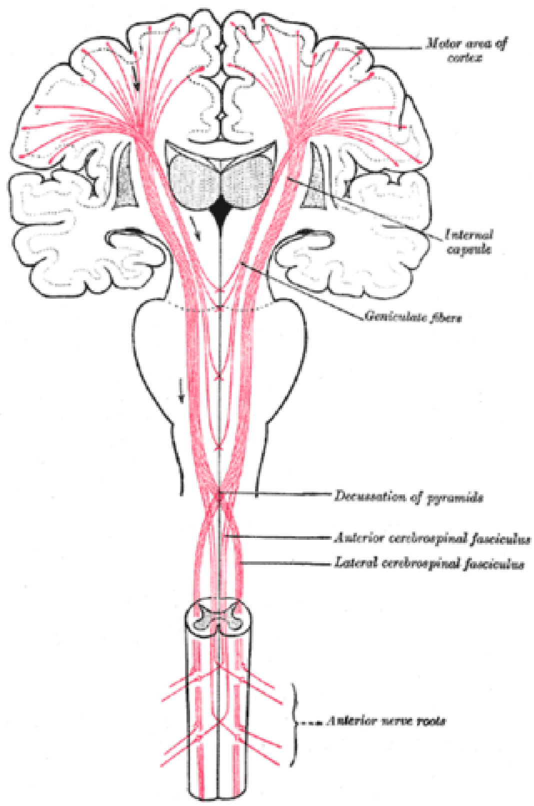
TABLE 8.2 ***Fibers That Link Receptors to the CNS***

Sensory function(s)	Receptor type(s)	Axon type	Diameter (μm)	Conduction speed (m/s)
Proprioception (see Chapter 11)	Muscle spindle	 Aα	13–20	80–120
Touch (see Figures 8.12 and 8.13)	Pacinian corpuscle, Ruffini's ending, Merkel's disc, Meissner's corpuscle	 Aβ	6–12	35–75
Pain, temperature	Free nerve endings; VRL1	 Aδ	1–5	5–30
Temperature, pain, itch	Free nerve endings; VR1, CMR1	C	0.02–1.5	0.5–2

How the brain controls the muscles

- Pyramidal tracts
  - Pyramidal cells (Cerebral Cortex Layer 5) in primary motor cortex (M1)
  - Corticobulbar (cortex -> brainstem) tract
  - Corticospinal (cortex -> spinal cord) tract
- Crossover (decussate) in medulla
  - L side of brain ennervates R side of body

Corticospinal tract

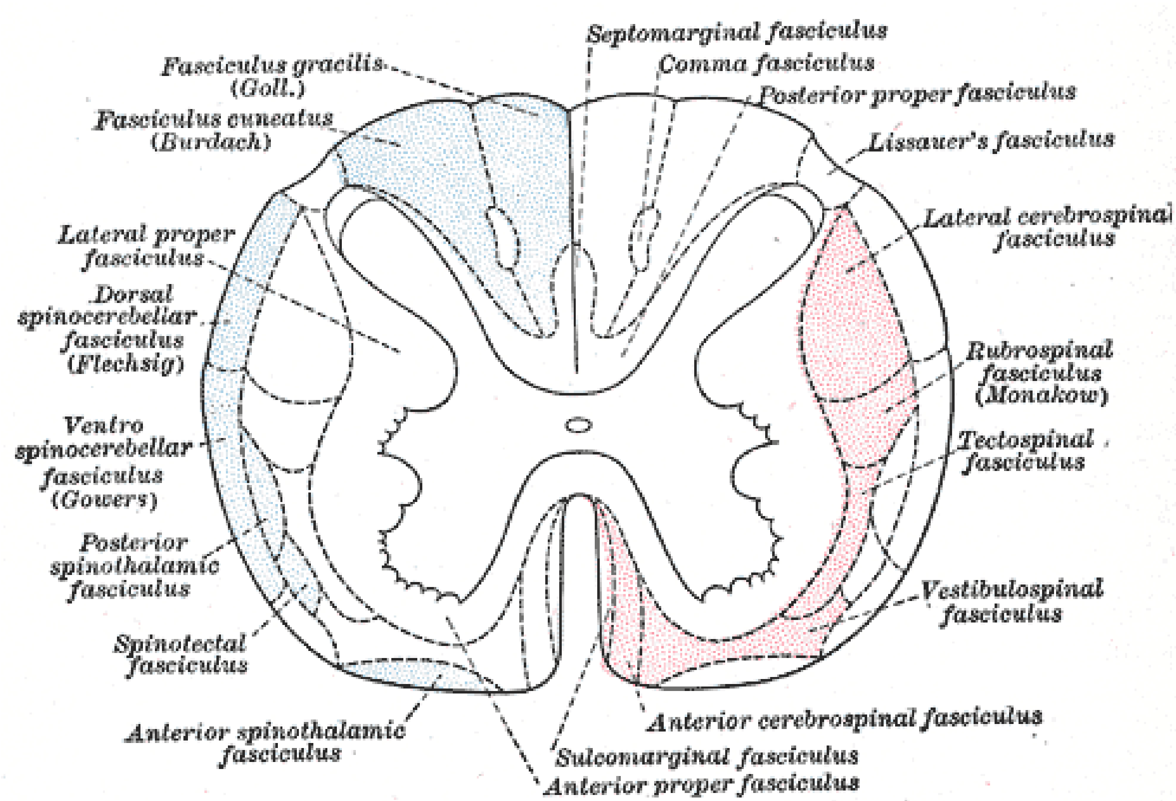


https://commons.wikimedia.org/wiki/File:Gray764.png#/media/File:Gray764.png

How the brain controls the muscles

- Extrapyramidal system
  - Tectospinal tract
  - Vestibulospinal tract
  - Reticulospinal tract
- Involuntary movements
  - Posture, balance, arousal

Extrapyramidal system



https://upload.wikimedia.org/wikipedia/commons/b/be/Gray672.png

This figure shows that the descending motor pathways in red on the right have their own spatial organization depending on where they originate in the brain.

Disorders

- Parkinson's
- Huntington's

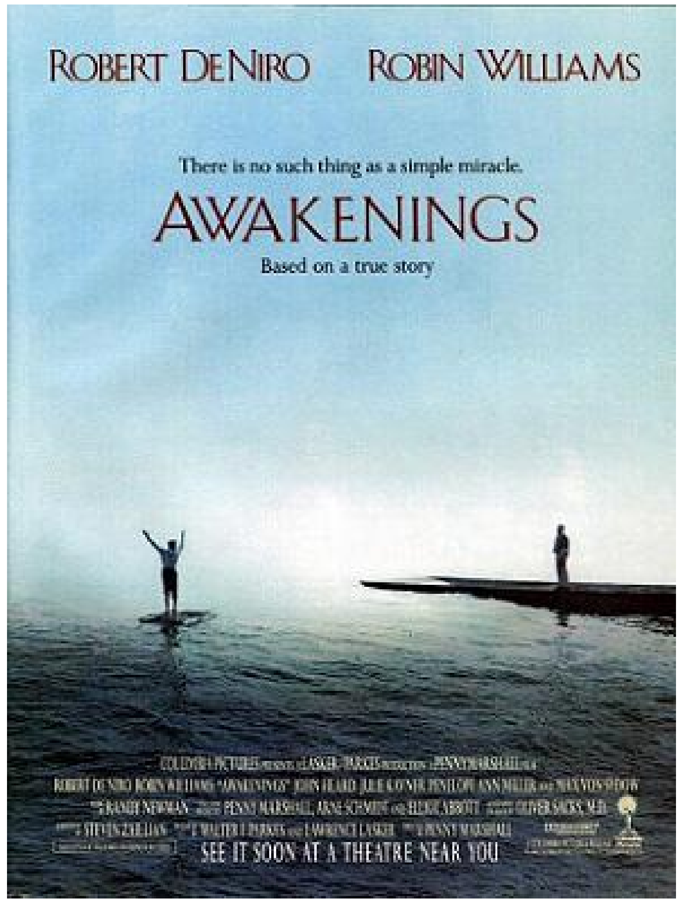
The Faces of Parkinson's

Faces of Parkinson's

Parkinson's

- Slow, absent movement, resting tremor
- Cognitive deficits, depression
- DA Neurons in substantia nigra degenerate
- Treatments
  - DA agonists
  - DA agonists linked to impulse control disorders in ~1/7 patients (Ramirez-Zamora et al. 2016)
  - Levodopa (L-Dopa), DA precursor

Awakenings


ROBERT DENIRO ROBIN WILLIAMS
There is no such thing as a simple miracle.
AWAKENINGS
Based on a true story
SEE IT SOON AT A THEATRE NEAR YOU

Huntington's

http://cp91279.biography.com/1000509261001/1000509261001 guthrie-centennial-1.jpg

Huntington's

- Formerly Huntington’s Chorea
  - "Chorea" from Greek for "dance"
  - “Dance-like” pattern of involuntary movements
- Cognitive decline
- Genetic + environmental influences
- Disturbance in striatum
- No effective treatment

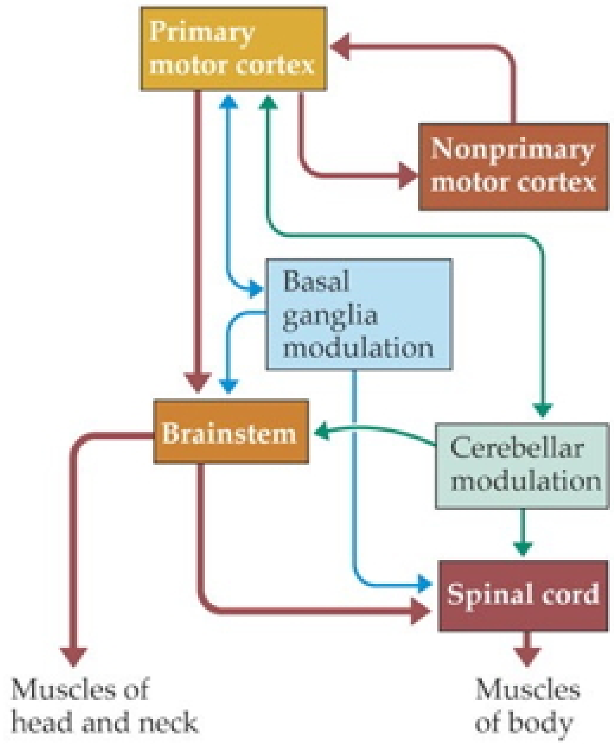
Huntington's

A family struggles with Huntington's Disease

Remember

- Control of movement determined by multiple sources
- Cerebral cortex + basal ganglia + cerebellum + spinal circuits

Multiple, parallel controllers



Cerebellum as predictor of future sensory states? (Ito 2008)

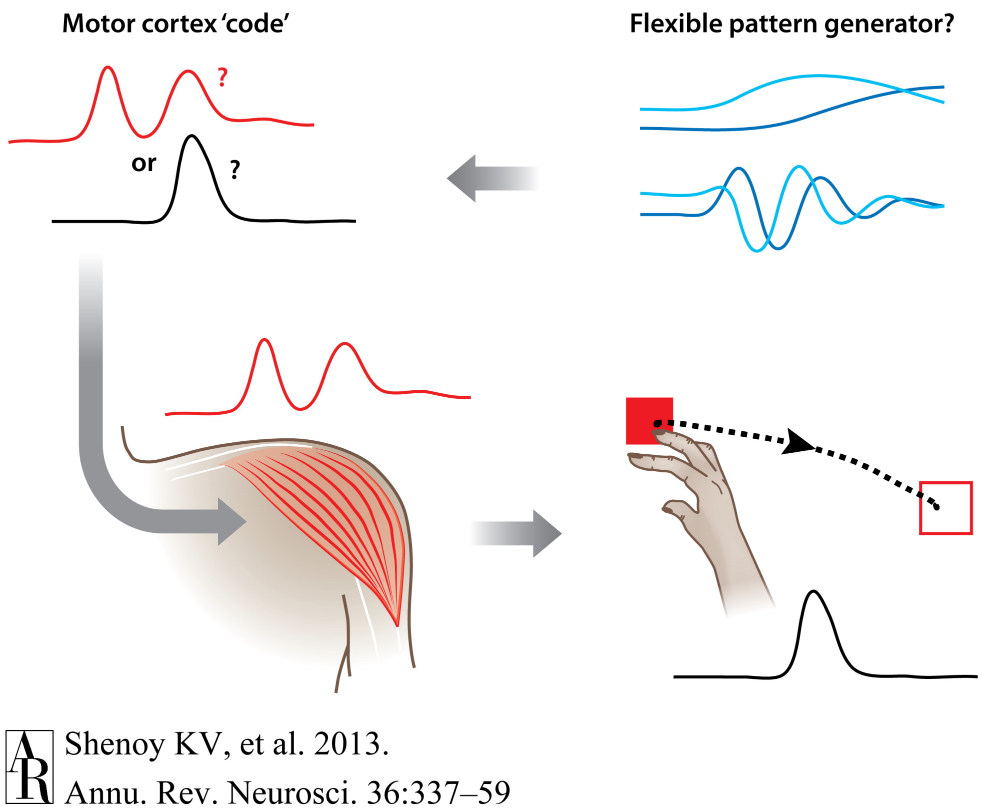
http://venturebeat.com/wp-content/uploads/2009/10/star-trek-holodeck.jpg

The Real Reason for Brains

Daniel Wolpert
The real reason for brains

What does motor cortex activity encode?

Muscle activity? Limb velocity? Or…?



[Shenoy et al., 2013]

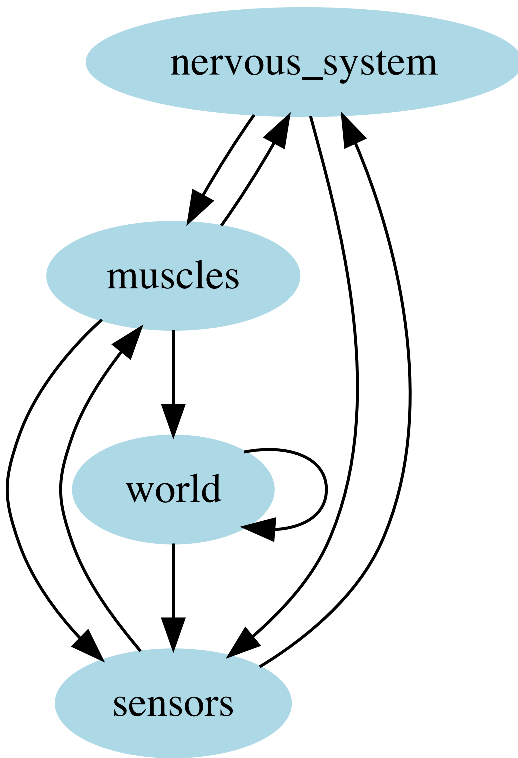
Cortical Control of Arm Movements: A Dynamical Systems Perspective

Annual Review of Neuroscience

Vol. 36:337-359 (Volume publication date July 2013)
First published online as a Review in Advance on May 29, 2013
https://doi.org/10.1146/annurev-neuro-062111-150509

Dynamic systems perspective

- Dynamics of
  - World events, $W(s)$
  - Extero- and interoceptive sensory systems, $S(t)$
  - Nervous system states, $N(t)$
  - Muscle states, $B(t)$
  - Effects of muscles on world


nervous_system
muscles
world
sensors

Next time…

- Cognition
- Quiz 2 due

References

Ito, Masao. 2008. "Control of Mental Activities by Internal Models in the Cerebellum." *Nat. Rev. Neurosci.* 9 (4): 304–13. doi:10.1038/nrn2332.

Ramirez-Zamora, Adolfo, Lucy Gee, James Boyd, and José Biller. 2016. "Treatment of Impulse Control Disorders in Parkinson's Disease: Practical Considerations and Future Directions." *Expert Rev. Neurother.* 16 (4): 389–99. doi:10.1586/14737175.2016.1158103.