FRIEDRICH-ALEXANDER
UNIVERSITÄT
ERLANGEN-NÜRNBERG
FACULTY OF ENGINEERING

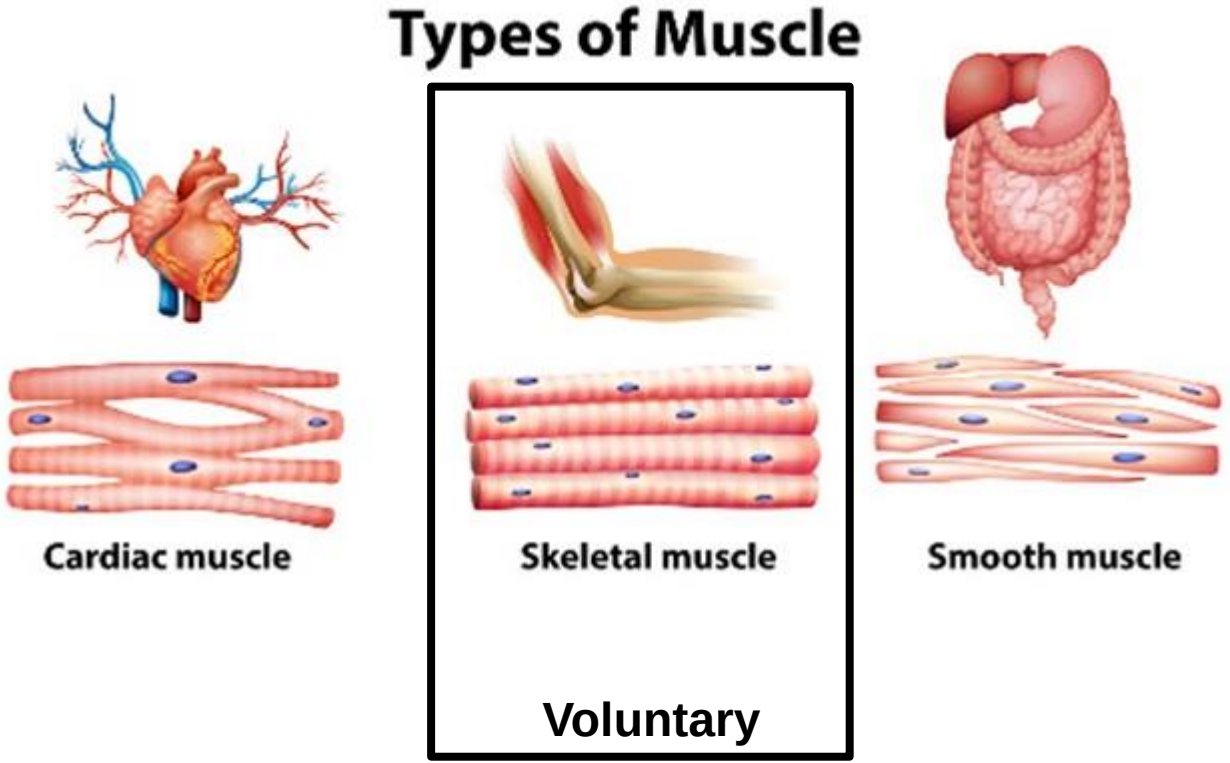
Cognitive Neuroscience for AI Developers

Week 11 –Motor control

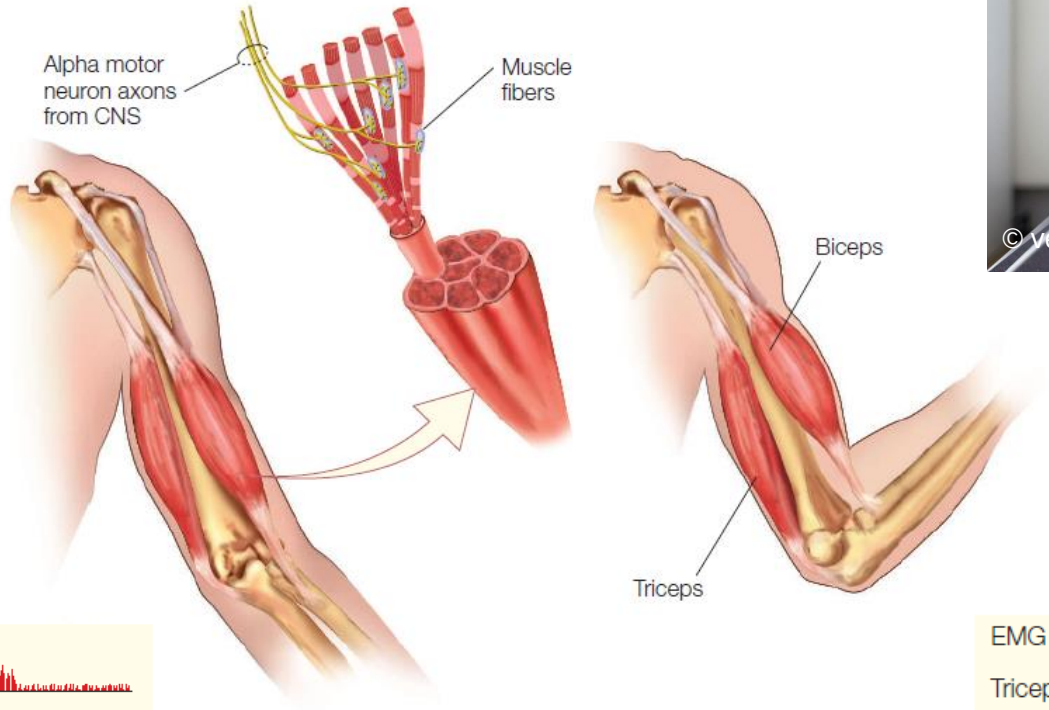
The motor system

Daniel Wolpert – TED Talk

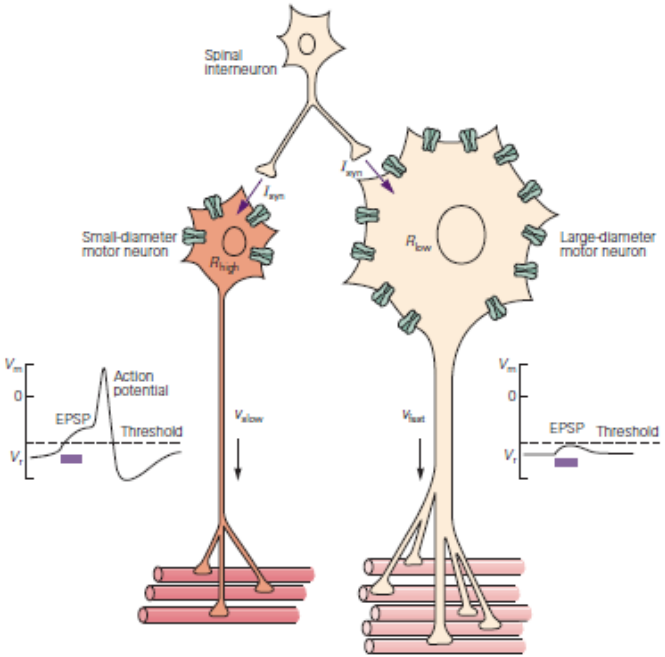
Two kinds of behaviors

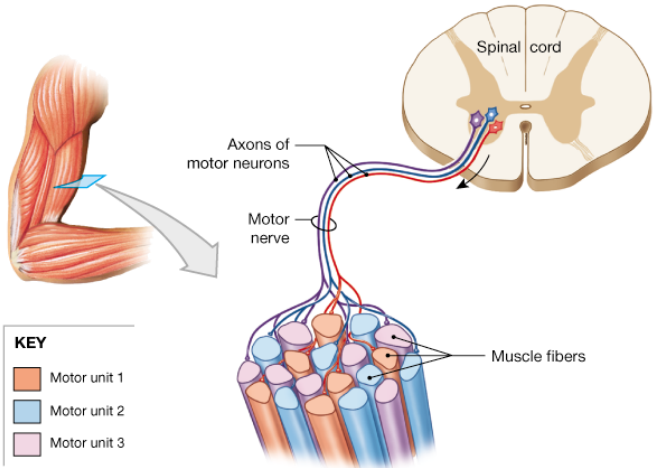


How do we elicit behavior?

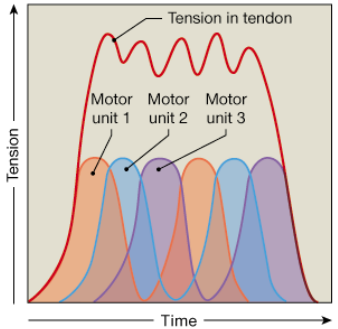


How to gain torque and force?



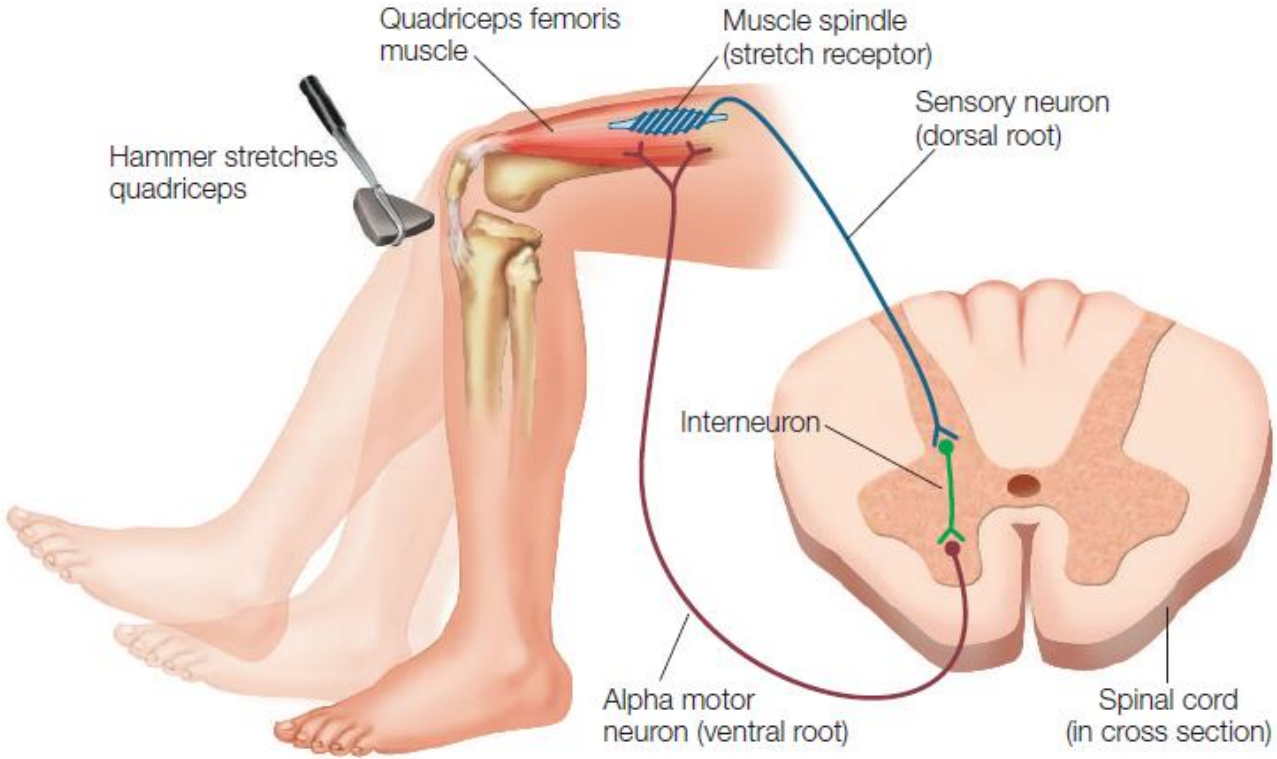


a Muscle fibers of different motor units are intermingled, so the forces applied to the tendon remain balanced regardless of which motor units are stimulated.

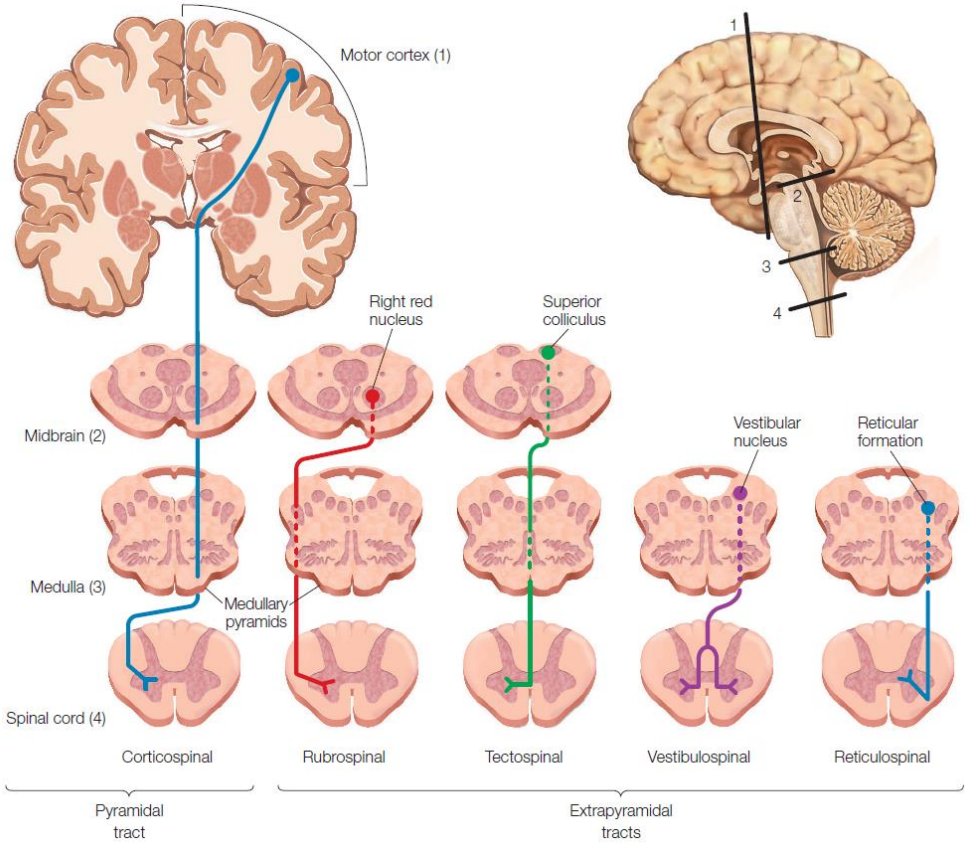


b The tension applied to the tendon remains fairly constant, even though individual motor units cycle between contraction and relaxation.

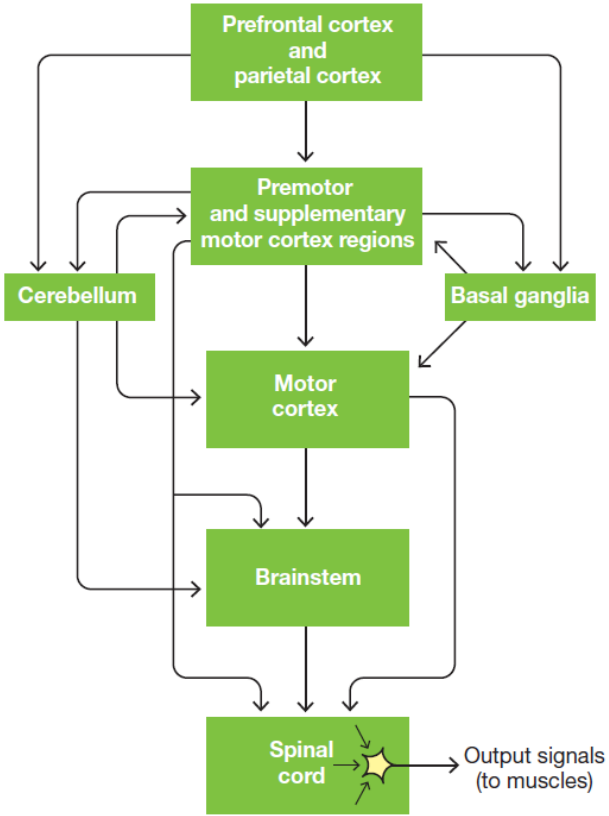
Spinal cord reflex

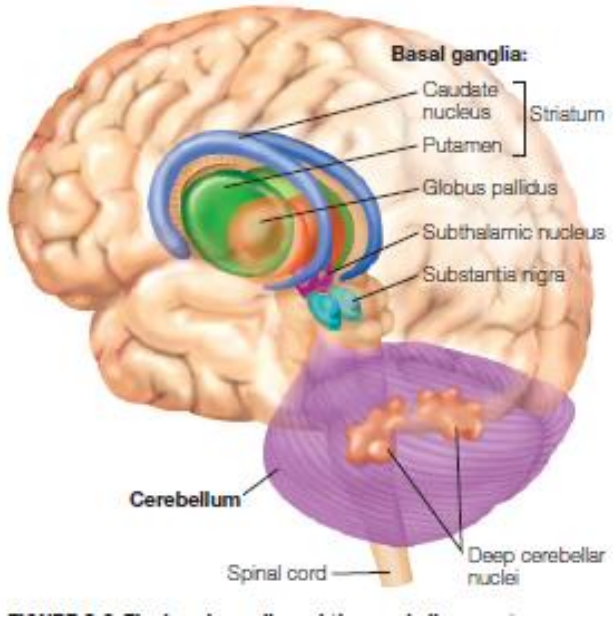


Brain to spinal cord pathways

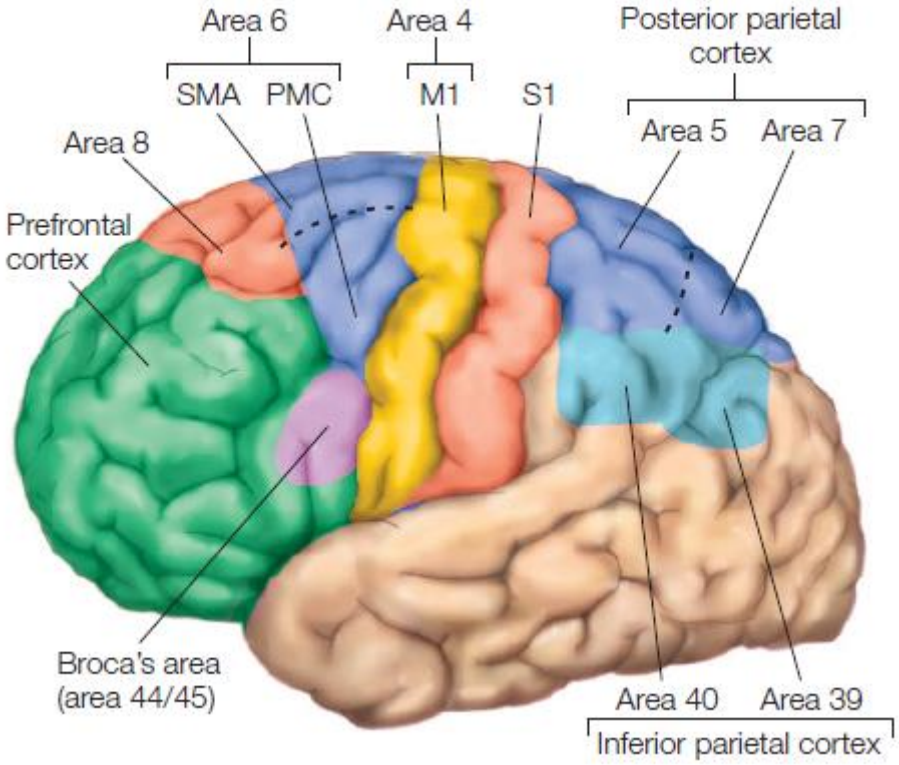


Brain regions involved in motor generation

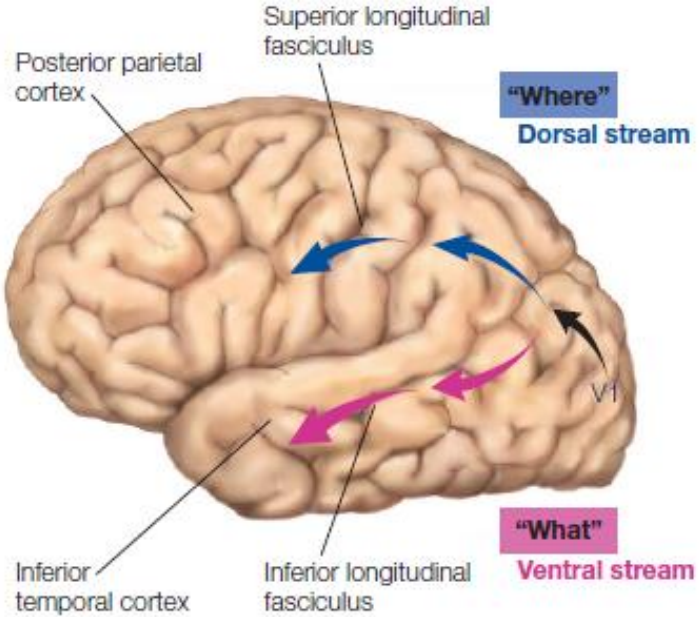




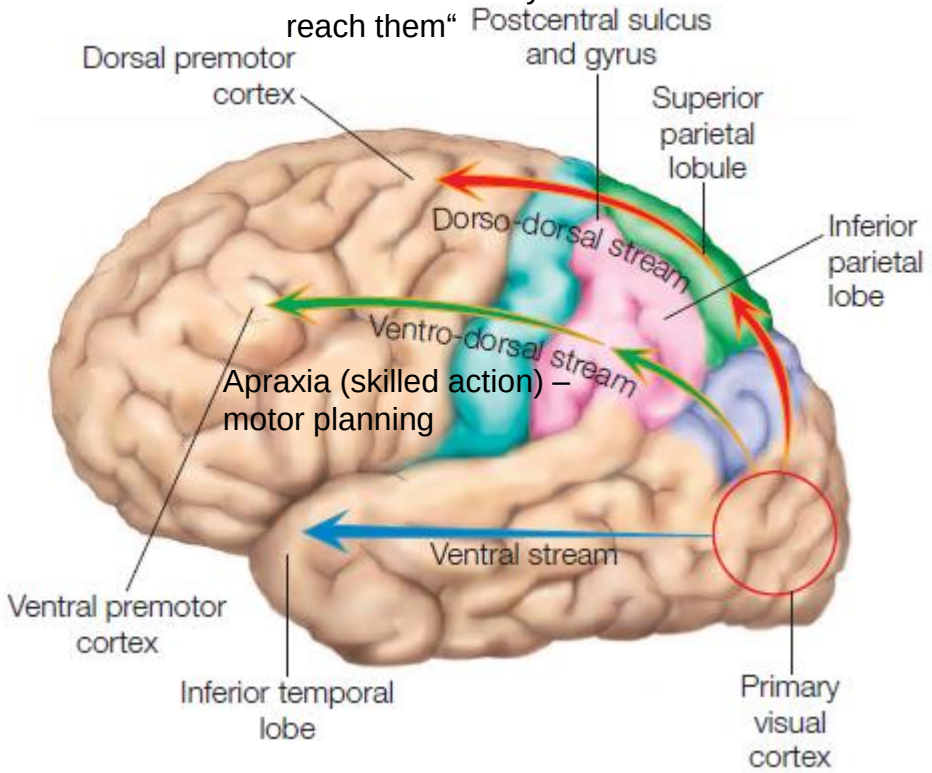
Important motor areas of the cerebral cortex



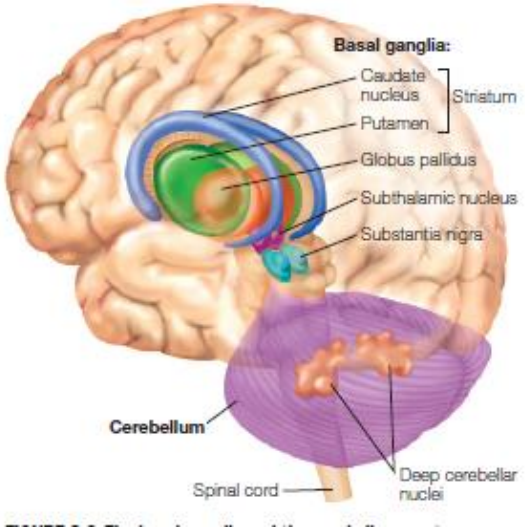
Streams in motor control

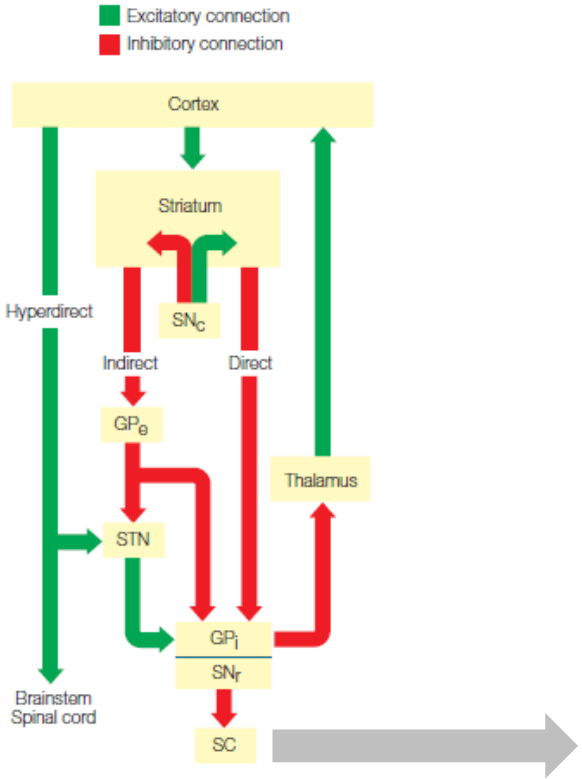


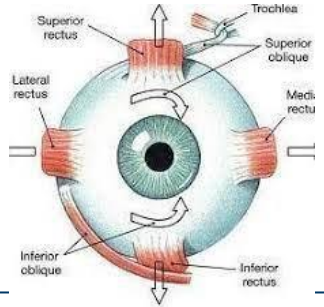
Optic ataxia
„know what objects are but can barely reach them“



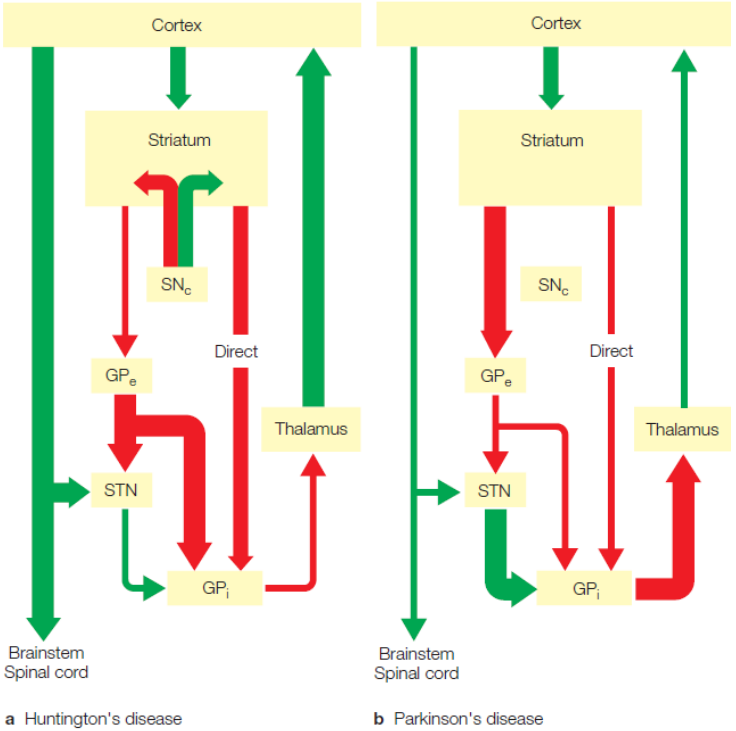
Basal ganglia





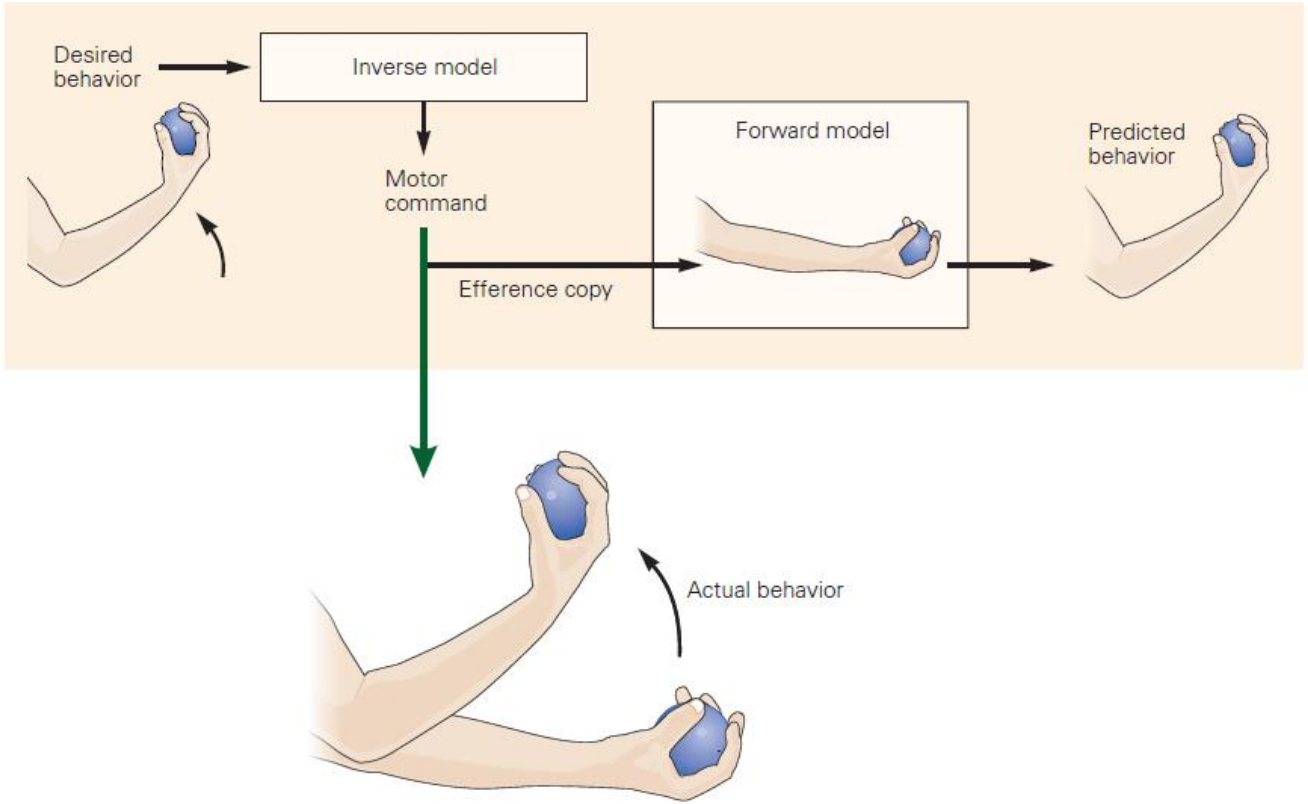


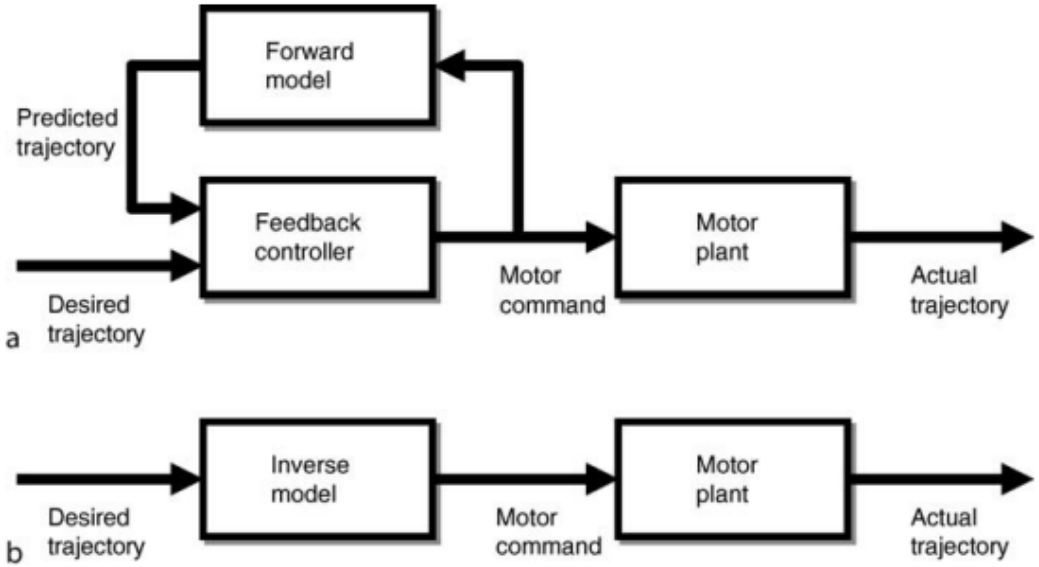
Basal ganglia - disorders



https://theconversation.com/parkinsons-four-unusual-signs-you-may-be-at-risk-112035

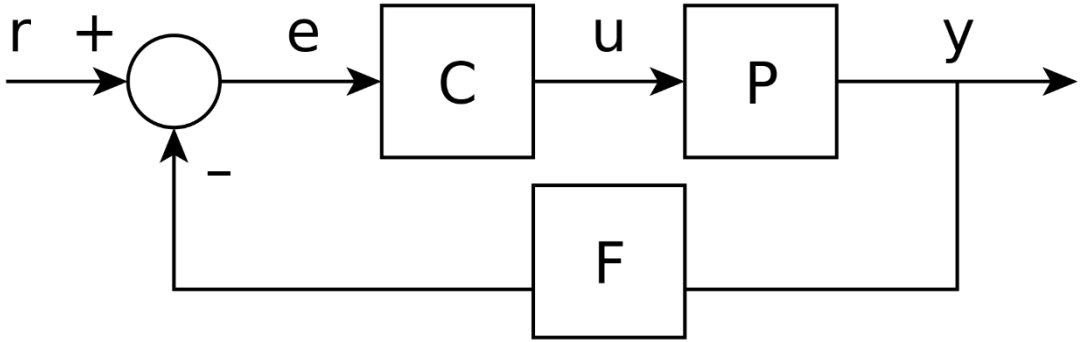
Internal models

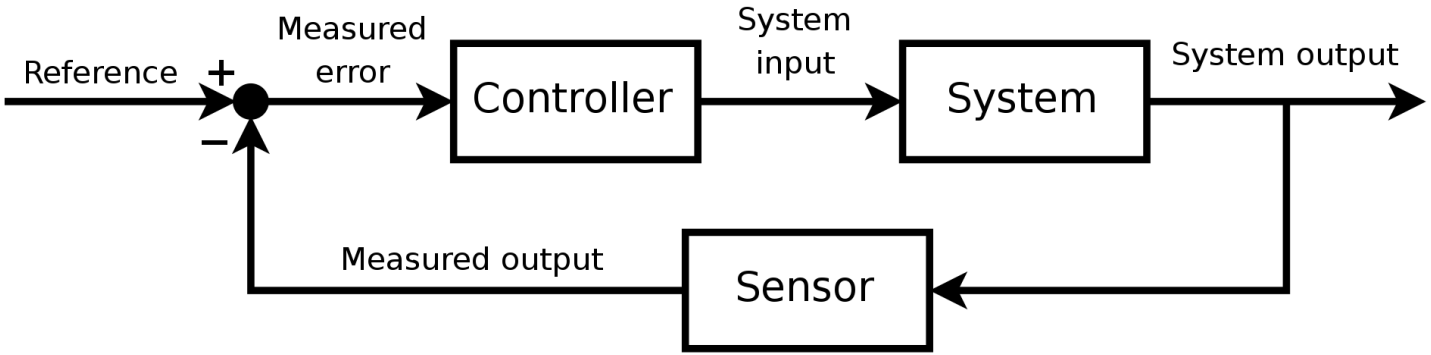




Internal Models. Figure 1 Examples of the two most basic types of internal models and their placement within a control system. (a) A forward model can be used within a feedback control system to provide a prediction of the trajectory that results from a particular motor command being sent to a particular motor plant. This can be used to compensate for plant properties without waiting for actual feedback about the resulting movement to return from the periphery. Thus, a forward model can be used to implement zero-lag feedback control. (b) If an inverse model of the plant has been learned, then it can be used to generate the required motor command to produce a given desired trajectory. Thus, an inverse model can be used to implement accurate feed-forward control.

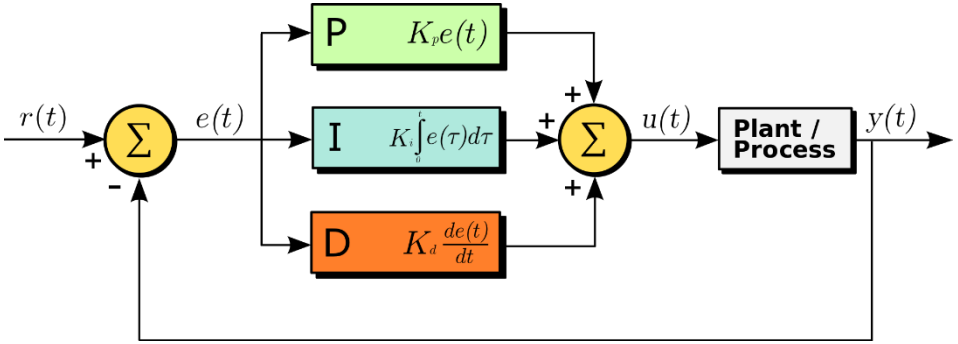
Control theory



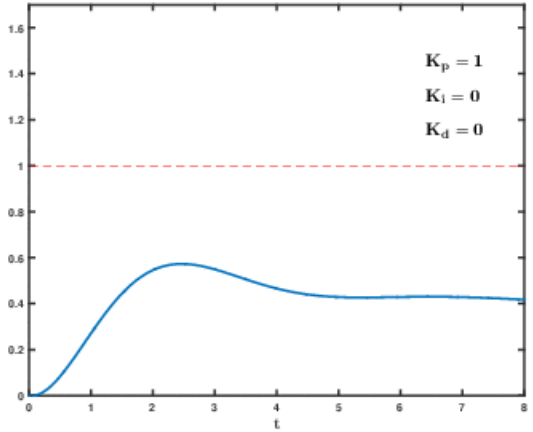


PID controller

Proportional, **I**ntegral, **D**ifferential
Now Past Future

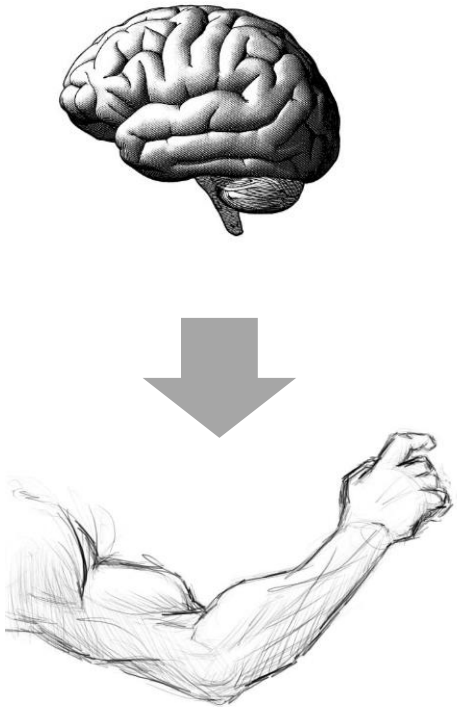


Effect of K

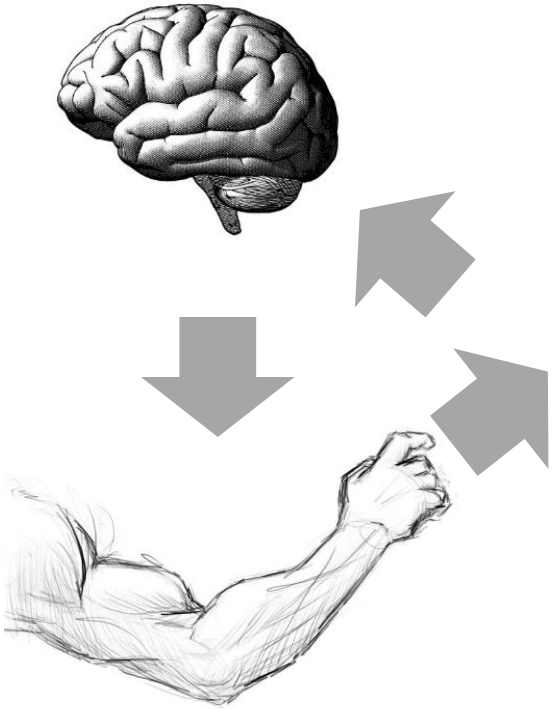


K needs to be tuned for each application!

Brain-Machine-Interfaces (BMI)



unidirectional



bidirectional

Tremault5 (Deviant art)

BMI interfaces - challenges

Invasiveness

Placement of BMI

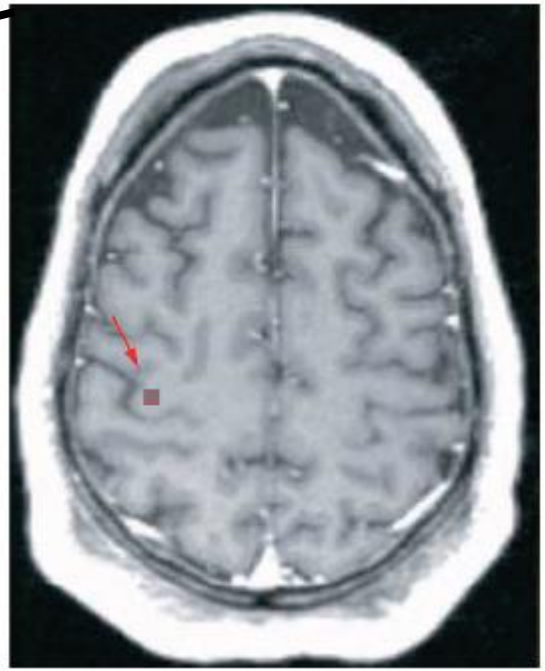
Motion

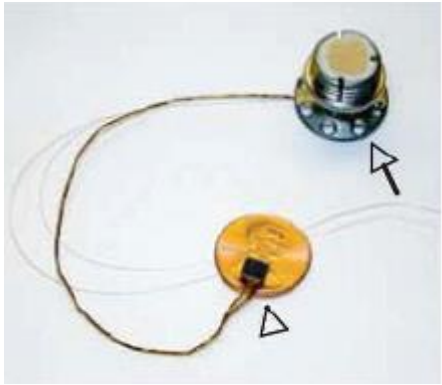
Biocompatibility

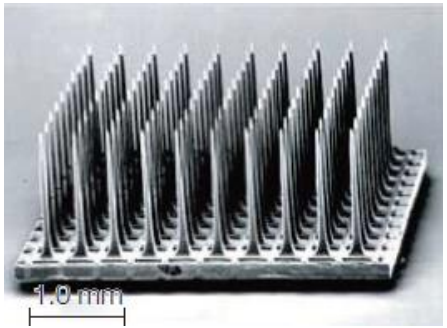
Durability

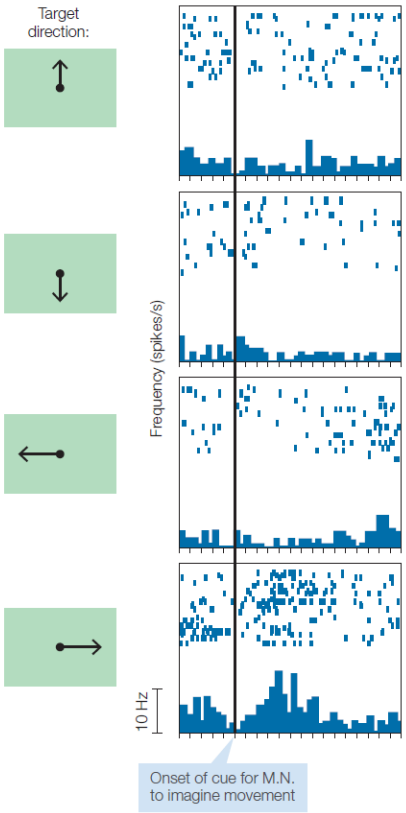
Complexity/Bandwidth

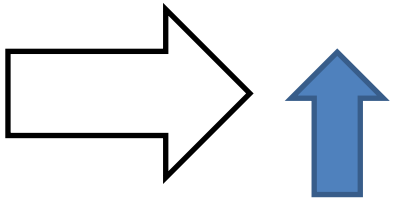
The patient M.N.








Target direction:
Frequency (spikes/s)
10 Hz
Onset of cue for M.N. to imagine movement



Brain-Machine-Interface (BMI)