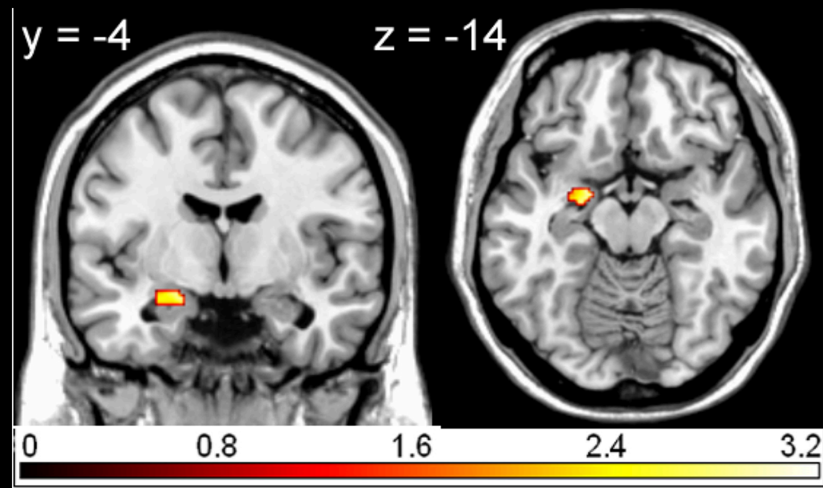
An Introduction to Neuroscience

Dr. Olav E Krigolson
krigolson@gmail.com



Tonight
Parkinson's Disease
Motor Control
Transcranial Magnetic Stimulation

Other Information
Next week is Attention
krigolsonlab@gmail.com

Levels of Motor Control

1. Reflexes
2. Postural Control
3. Cyclical Movements
4. Goal Directed Action
5. Motor Control

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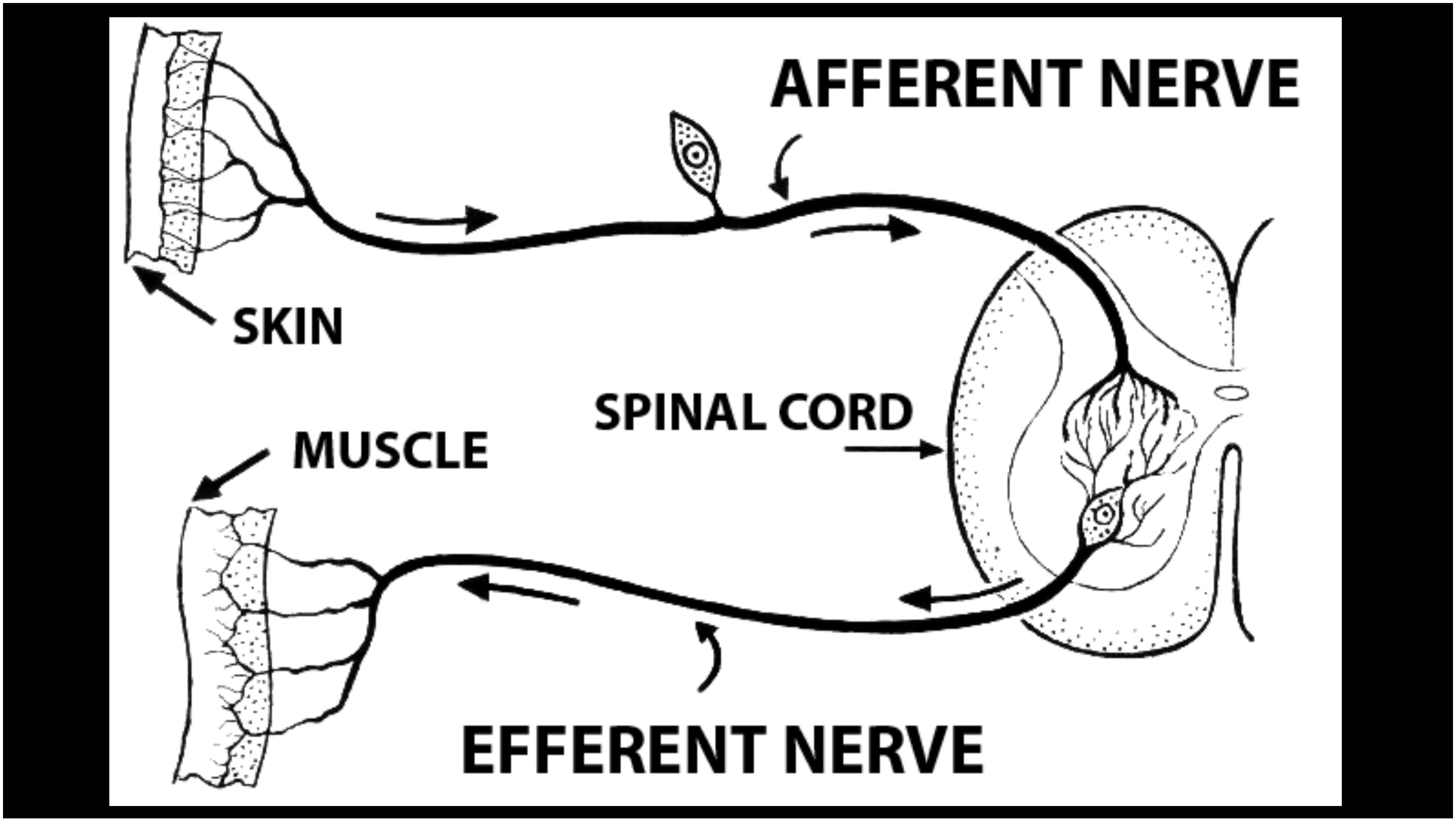
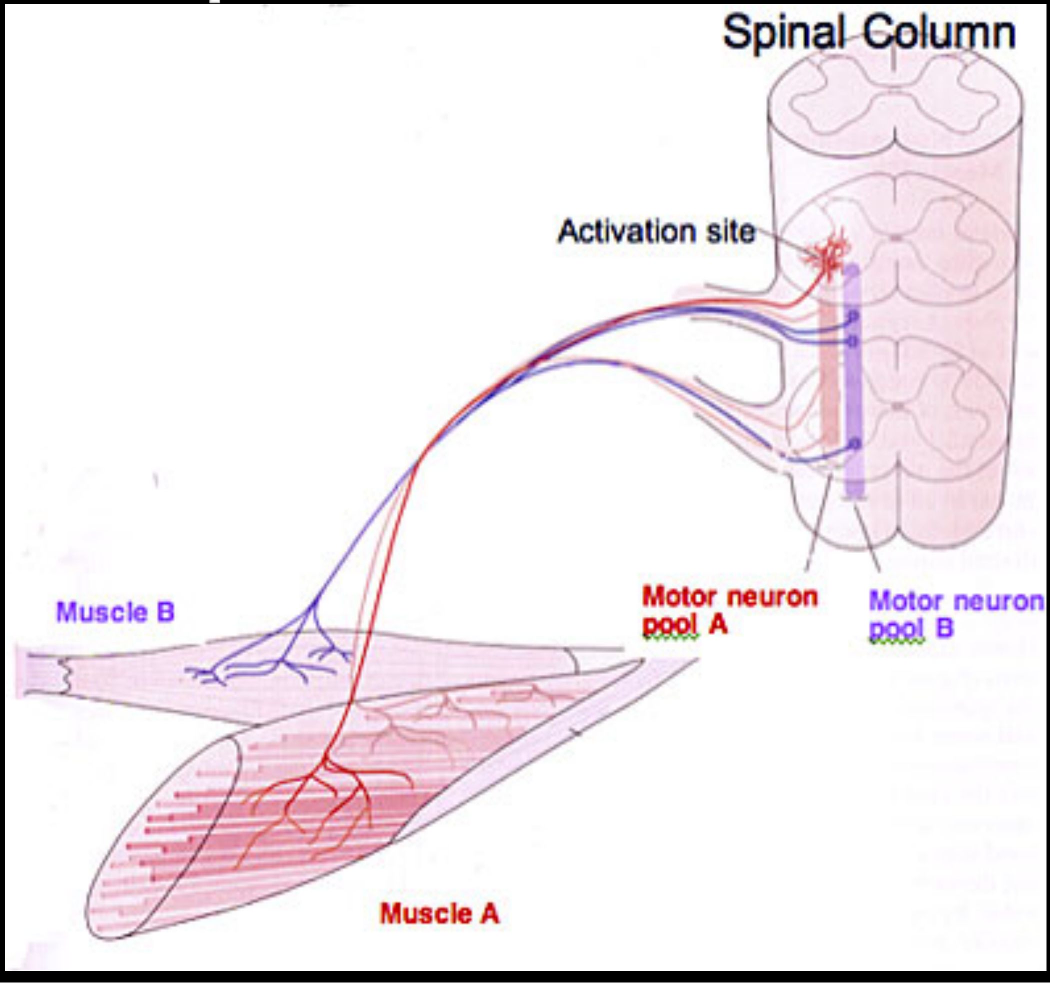
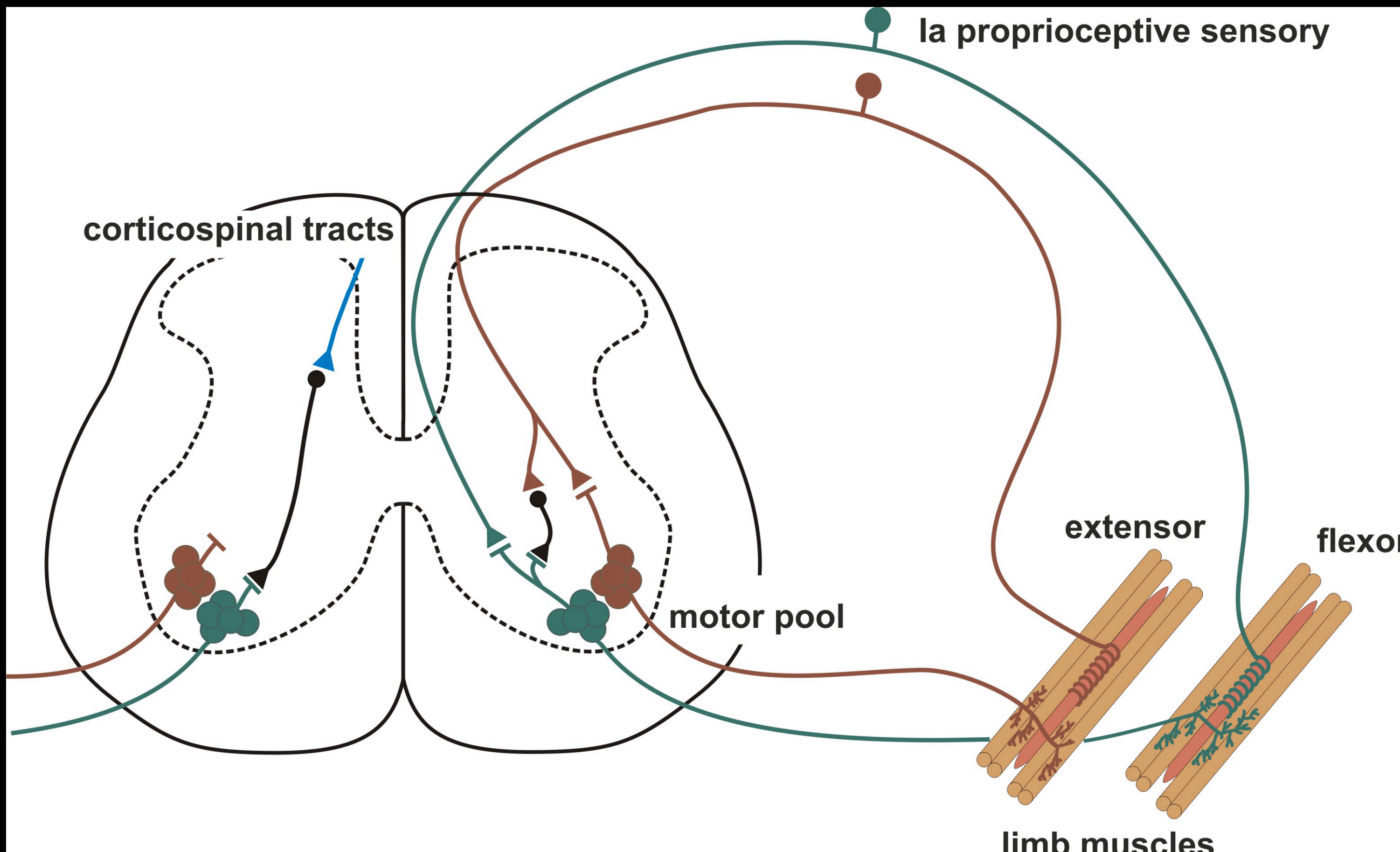

AFFERENT NERVE
SKIN
SPINAL CORD
MUSCLE
EFFERENT NERVE

Alpha Motor Neuron



1a Sensory Neuron



Definition of the Reflex

"A simple reflex is probably a purely abstract conception, because all parts of the nervous system are connected together & no part of it is probably ever capable of reaction without affecting & being affected by various other parts, & it is a system certainly never absolutely at rest. But the simple reflex is a convenient, if not a probable, fiction. Reflexes are of various degrees of complexity, & it is helpful in analysing complex reflexes to separate from them reflex components which we may consider apart & therefore treat as though they were simple reflexes."

– Sir Charles S. Sherrington, "Integrative Action of the Nervous System" (1906)

Reflexes

Muscle Reflex: Contraction induced by external stimulus

Once thought to be immutable

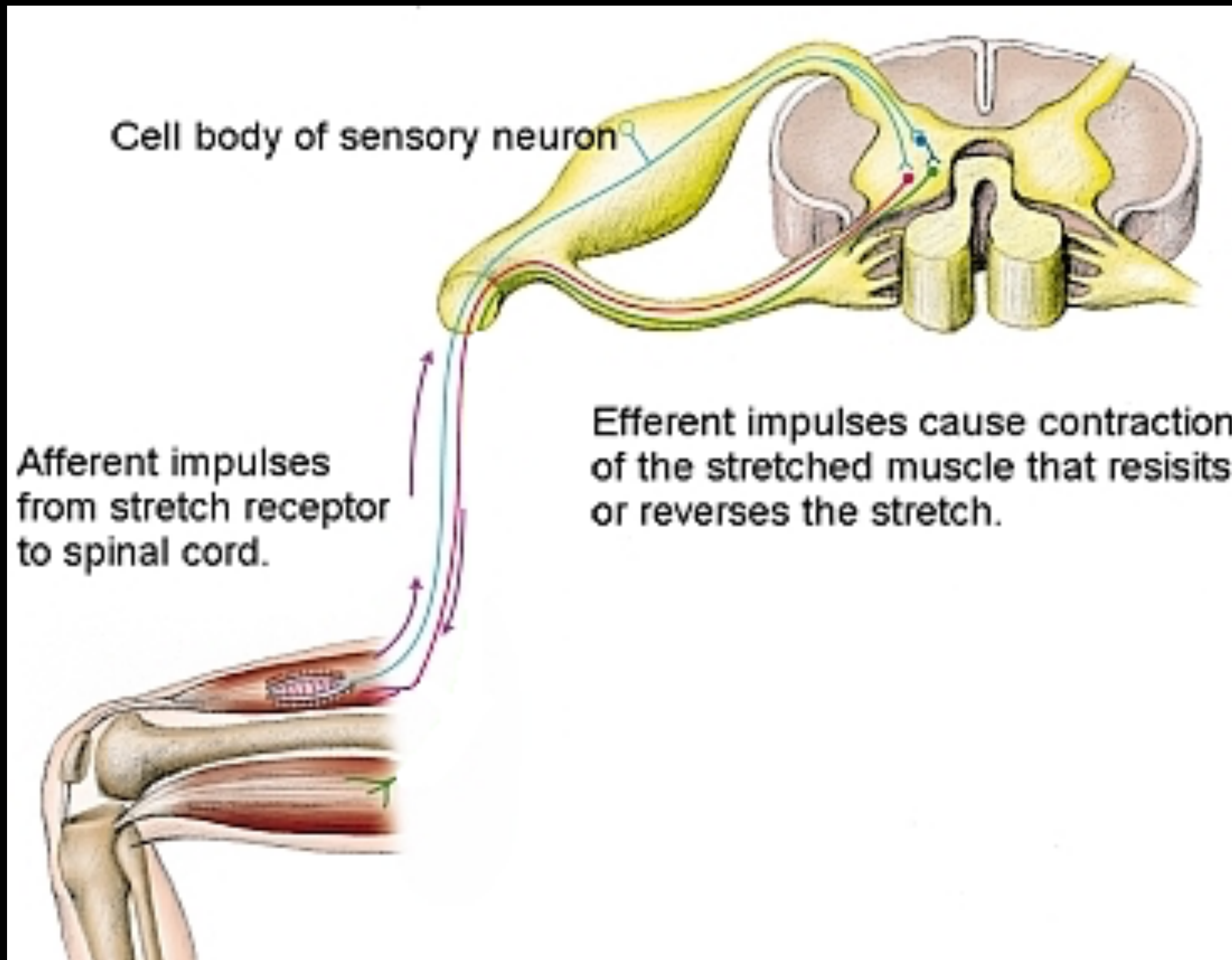
Now concept of reflex modulation predominates

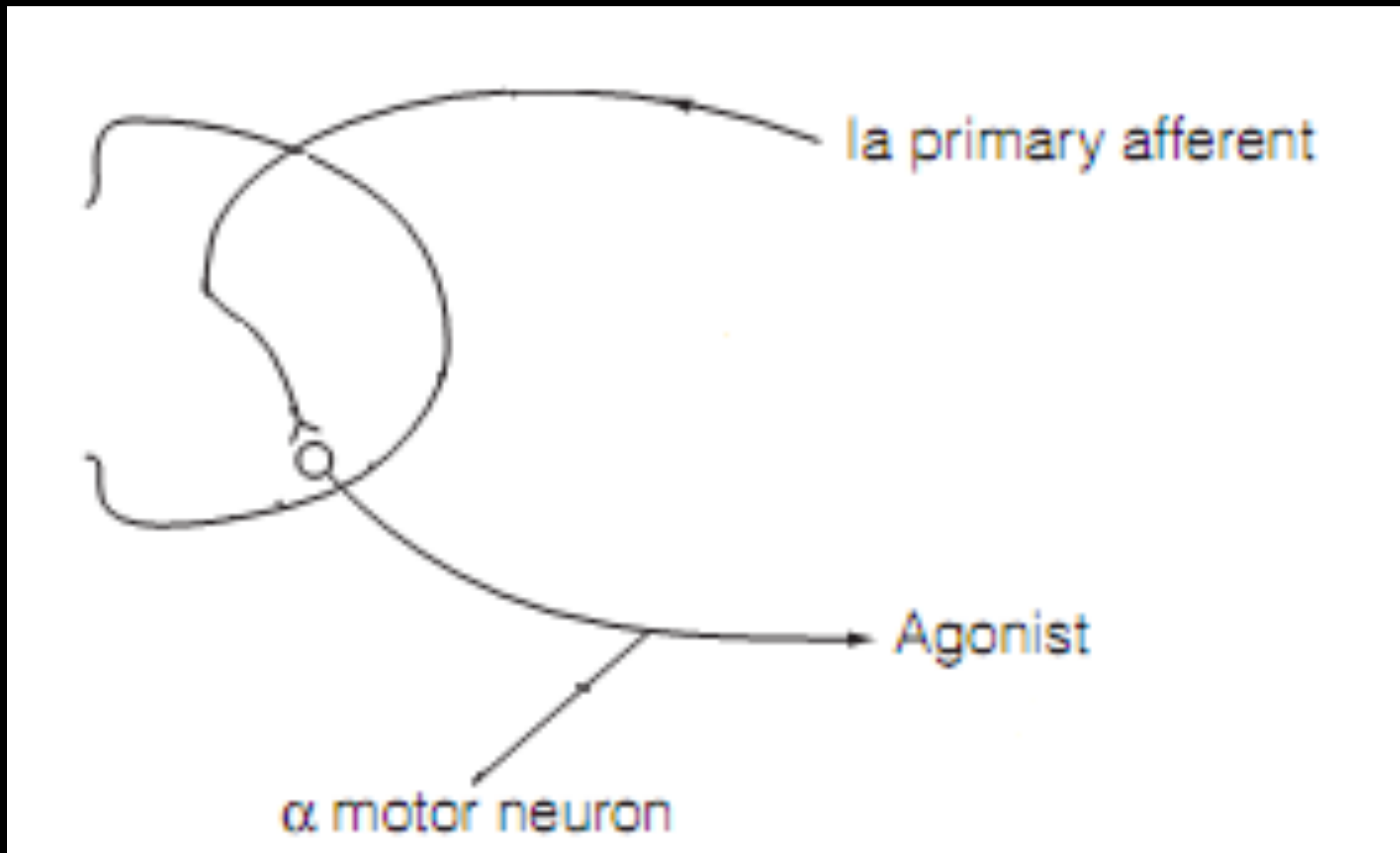
- Nature of a reflex depends on the context
- (e.g., sitting versus standing)

Why Do We Care About Reflexes?

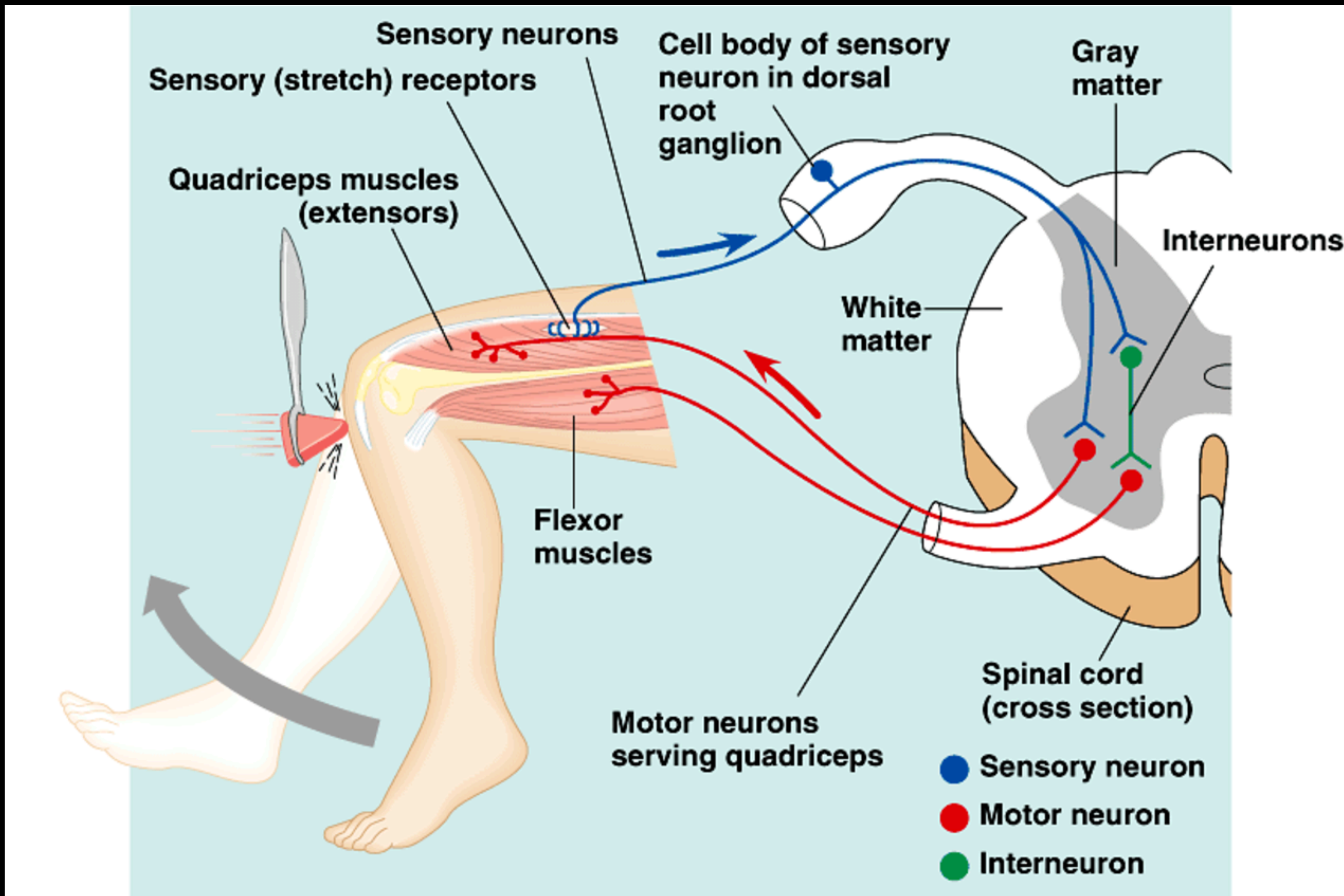
They underlie and support all posture and movement!

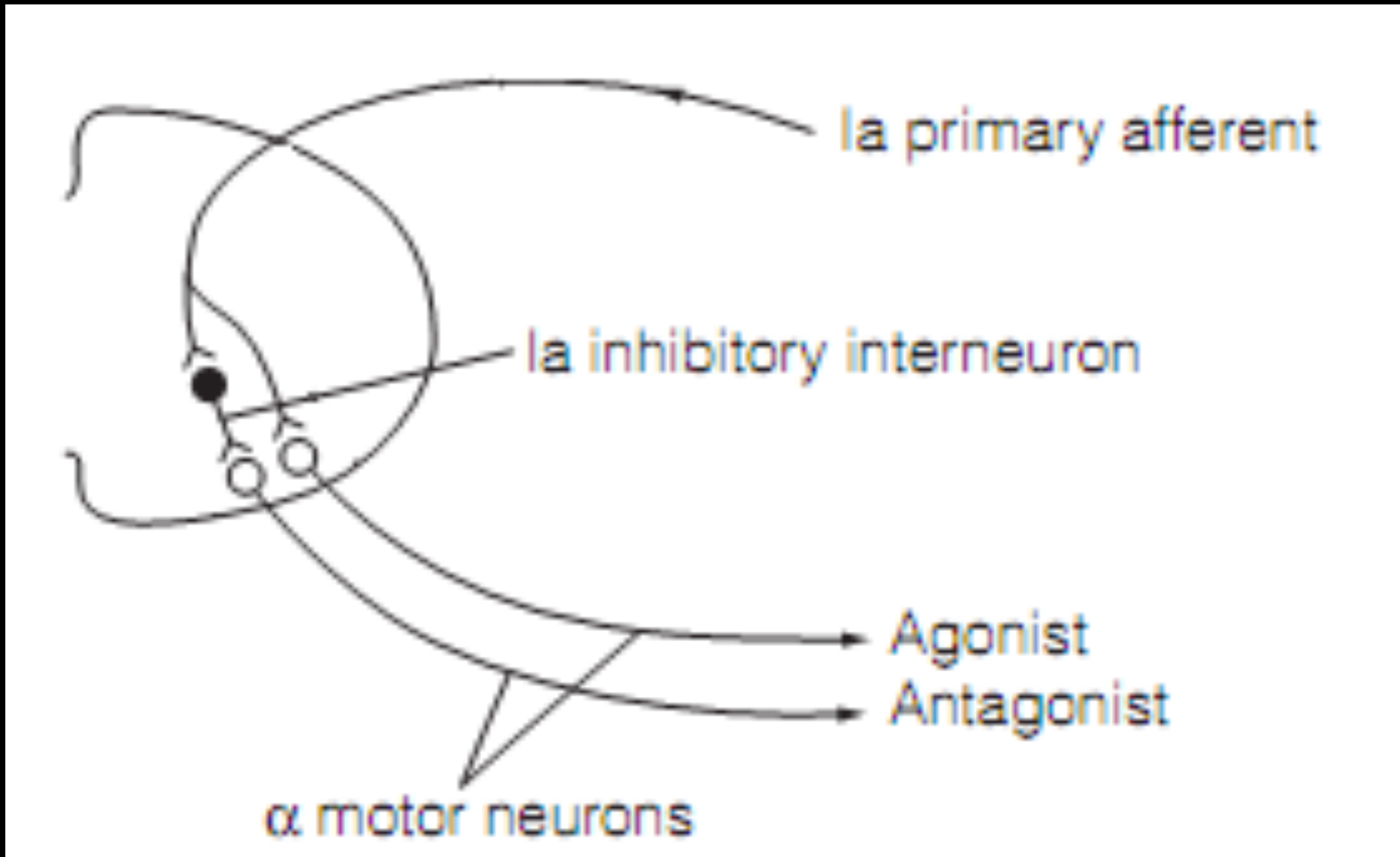
The Simple (?) Monosynaptic Stretch Reflex


Cell body of sensory neuron
Afferent impulses from stretch receptor to spinal cord.
Efferent impulses cause contraction of the stretched muscle that resisits or reverses the stretch.

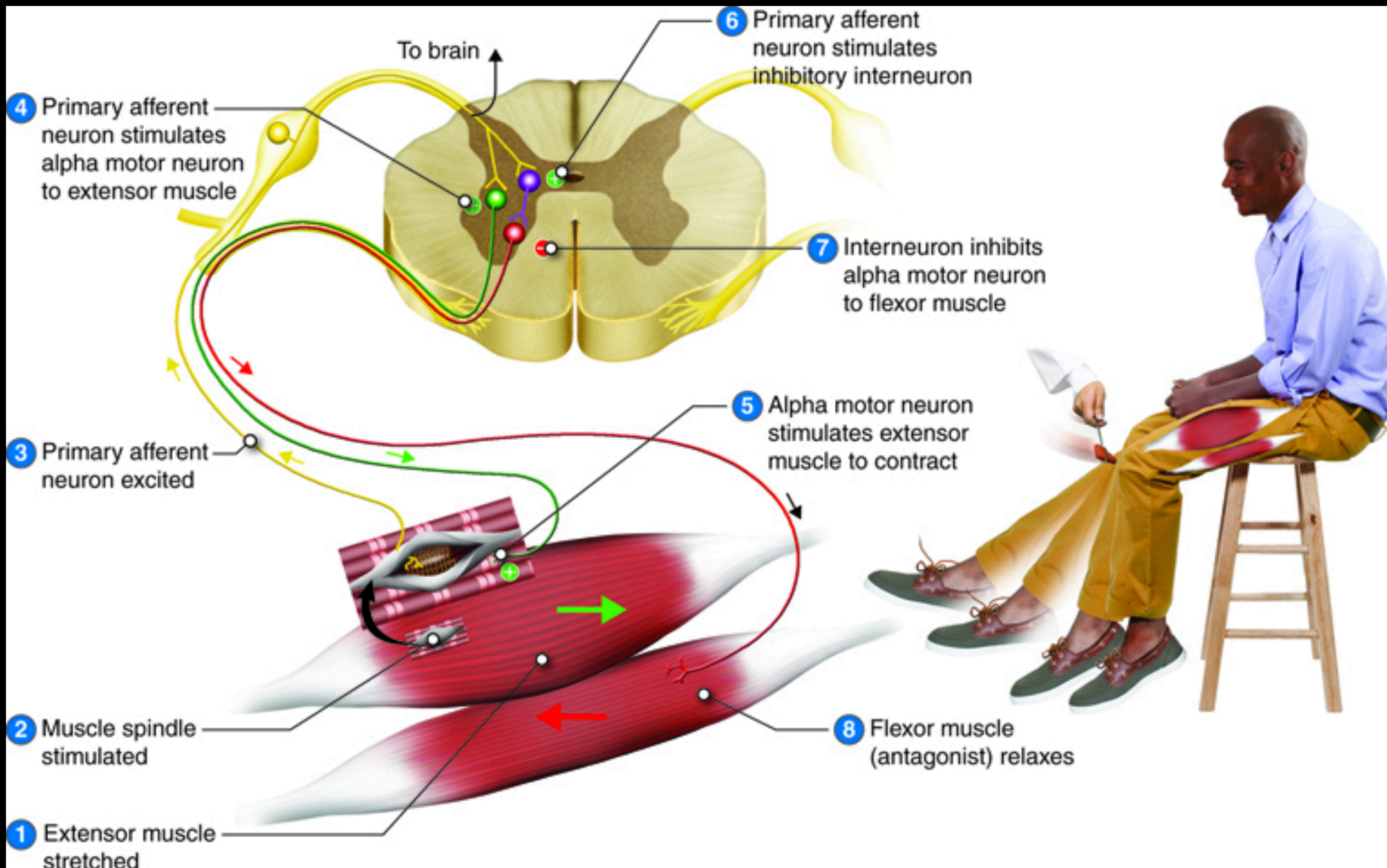

Ia primary afferent
Agonist
α motor neuron

Reciprocal Inhibition




Ia primary afferent
Ia inhibitory interneuron
Agonist
Antagonist
α motor neurons

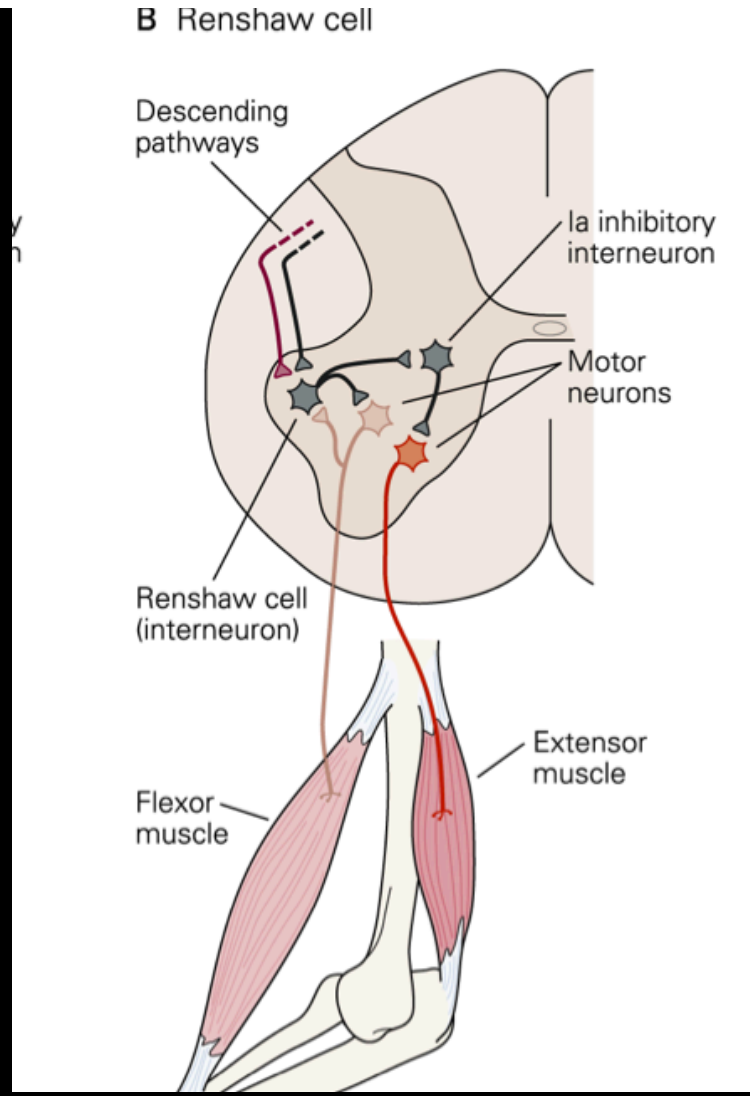
Stretch Reflex (e.g. Tendon Tap)



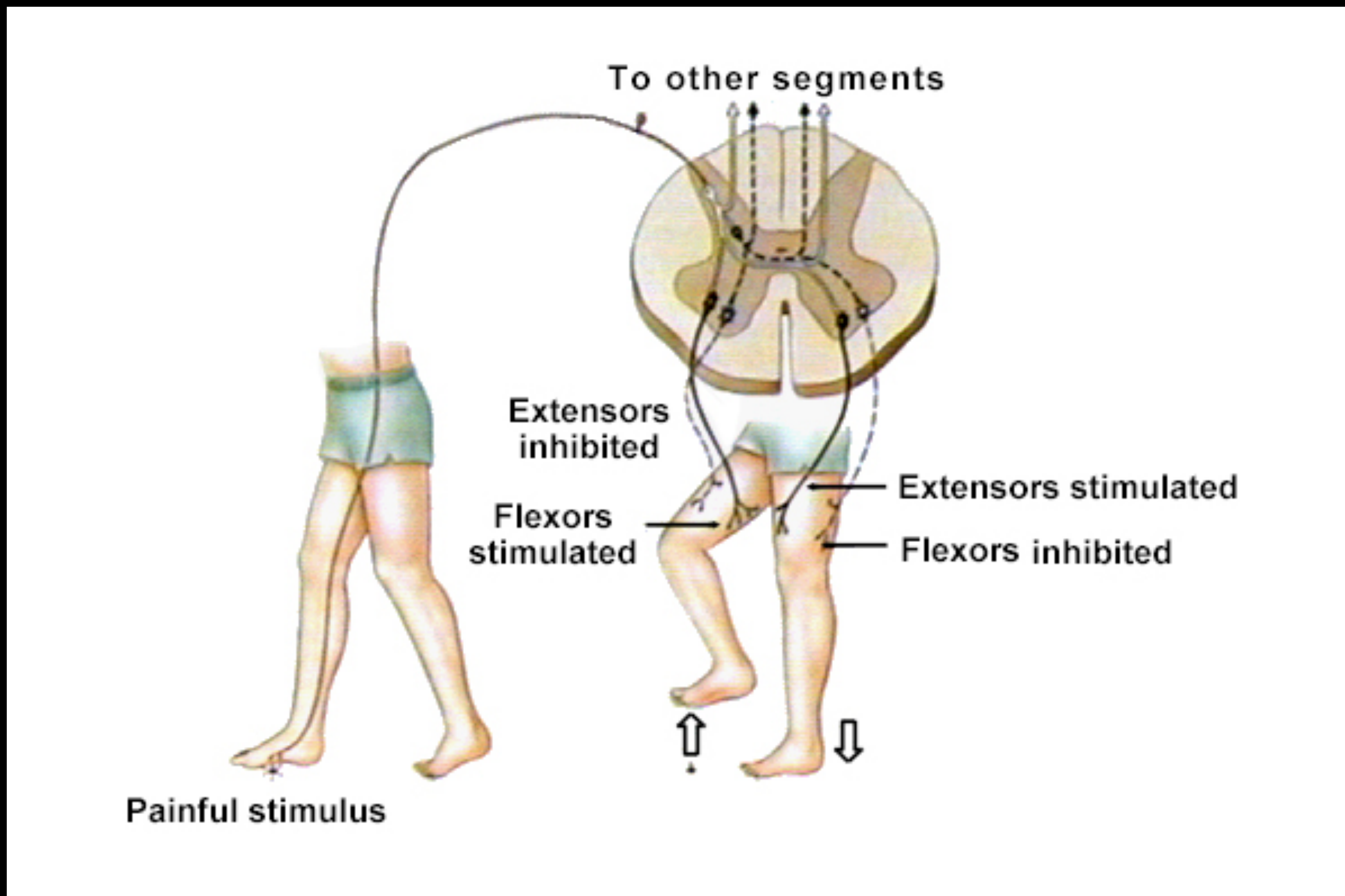
Renshaw Cells

RECURRENT INHIBITION

- regulates the firing of the alpha motor neuron (the MN can inhibit itself)
- removes "noise" by dampening the firing frequency of over-excited neurons
- prevents weakly excited alpha motor neurons from firing.



Flexion Withdrawal Reflex…



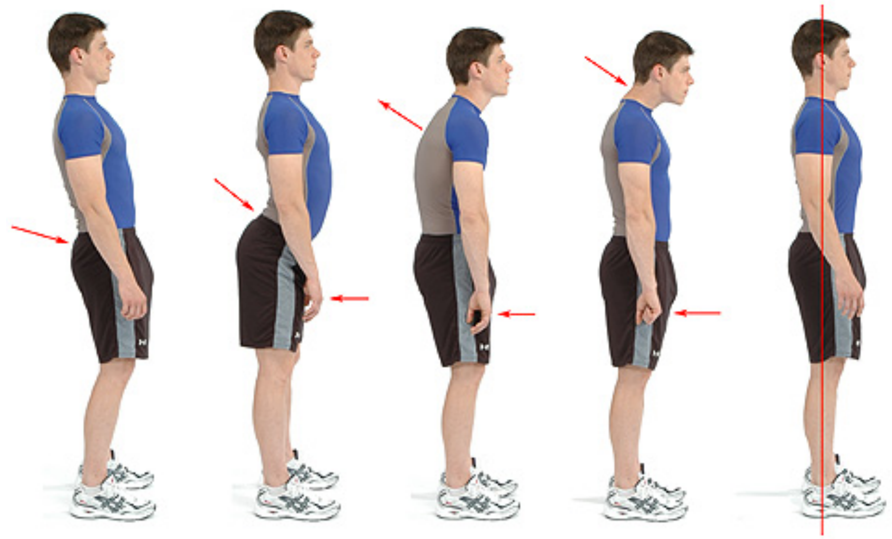
Levels of Motor Control

1. Reflexes
2. Postural Control
3. Cyclical Movements
4. Goal Directed Action
5. Motor Control

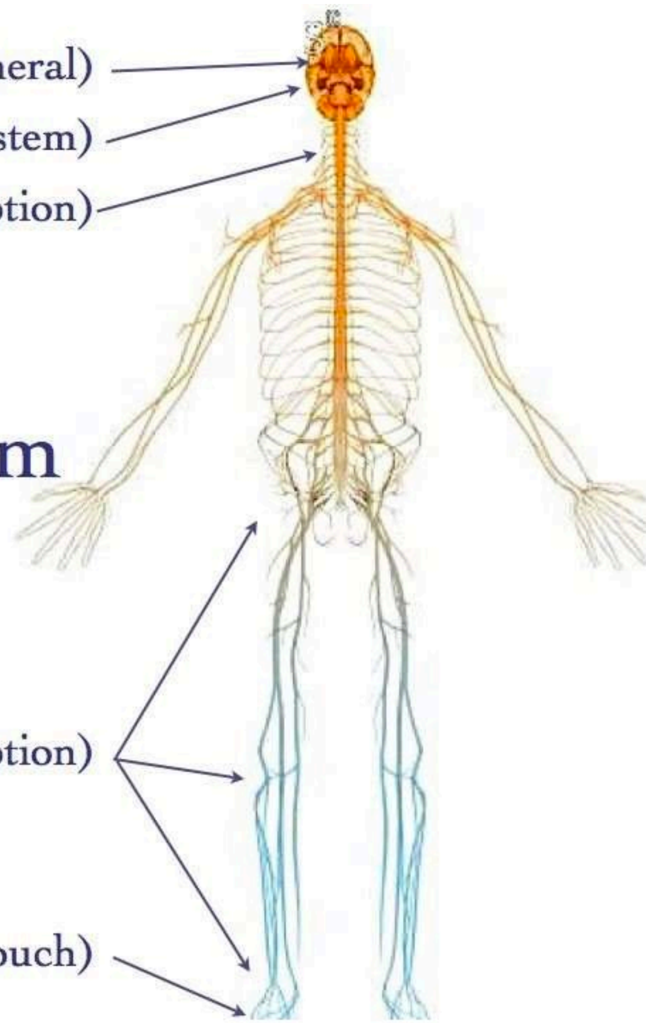
Posture:

relative position of various parts of the body with respect to each other

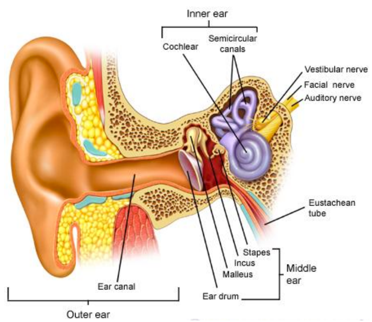
- Egocentric (within)
- Exocentric (with world)
- Geocentric (with gravity)

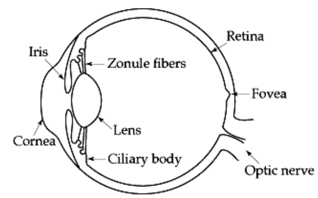


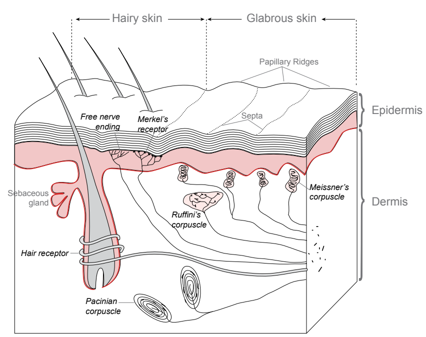
Equilibrium system

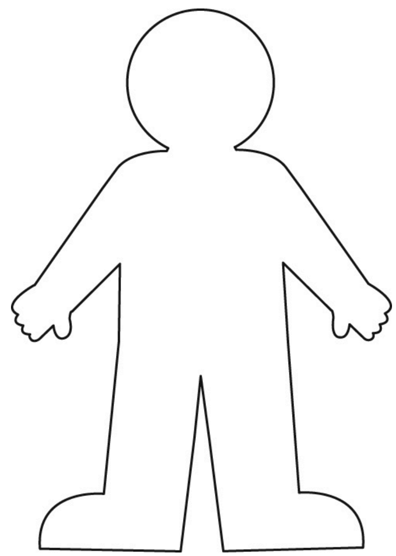


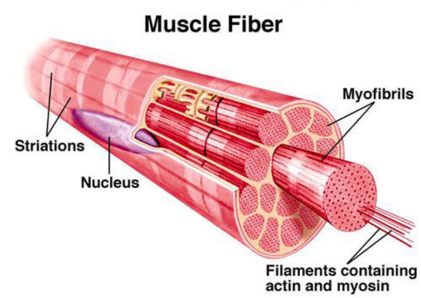
How (Where) Does Postural Control Occur?







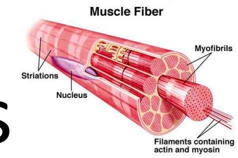




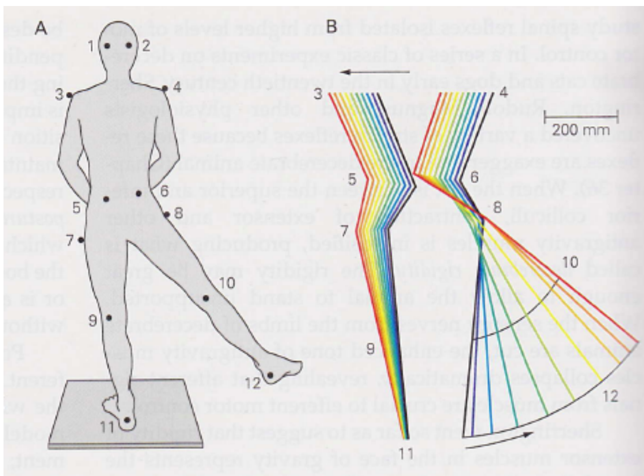
Posture: Lines of Defense

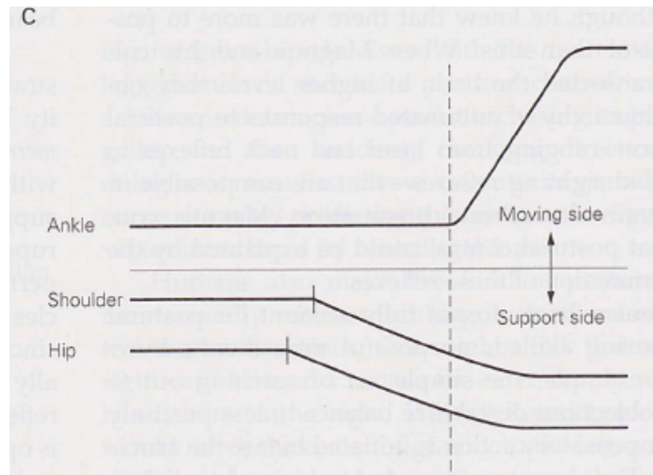
Mechanism	Typical Time Delay	Important Features
1. Anticipatory Postural Actions	-600 ms - 0 ms	Based on predicting a perturbation
2. Muscle and tendon elasticity	0 ms	Can be modulated (pre-flexes)
3. Equilibrial triad (vision, vestibular, proprioception)	20 ms -70 ms	Poorly controlled, low gain
4. Pre-programmed reactions	80 ms	Approximate correction
5. Voluntary actions	150 ms	Too late!

1. Anticipatory Movements



Try at home experiment: stand against wall and raise outside leg





- Hip and shoulders move before ankle rises
- Counterbalancing movement 600 ms prior

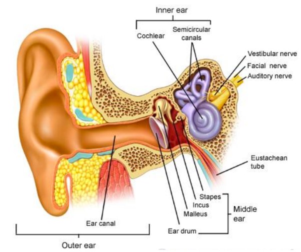
2. Muscle and Tendon Elasticity

- Auto-stabilize movements
- Tensing muscles to enhance stiffness
- Agonist, antagonist pairs
- Visco-elastic properties
- CNS can control the baseline level of activation in postural muscles
- "Pre-flexes"
- Instantaneous response for unexpected perturbations

3. Equilibrial Triad

A. Vestibular System
B. Vision
C. Proprioception

A. Vestibular System



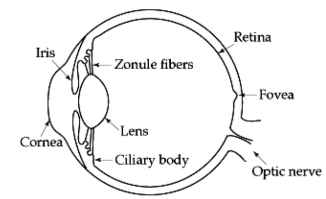
'Which way is up?'

Major factor in the maintenance of upright posture with reflexive action

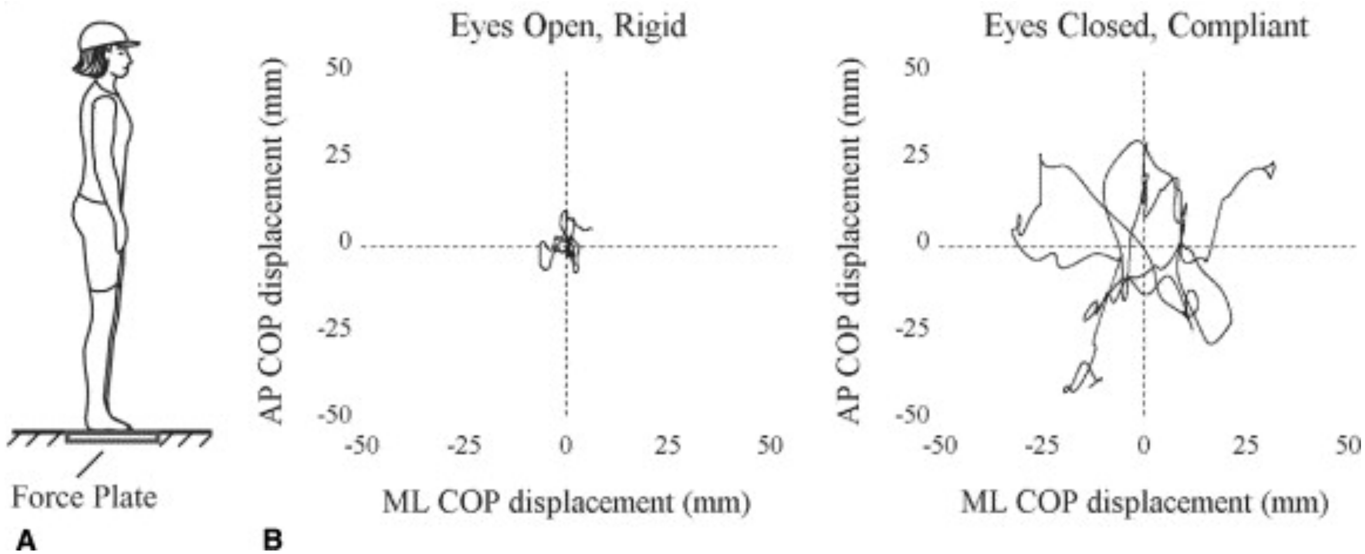
- To control upright posture
- To control eye movements

Normally, we are not conscious of this system

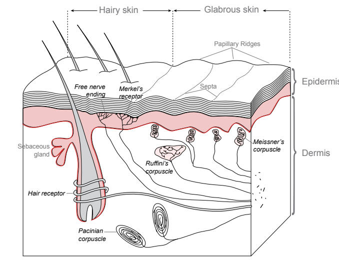
B. Vision



- Most reliable sense
- Postural sway worsens without vision

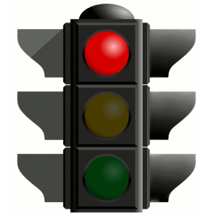


C. Proprioception



- In order make use of vestibular and visual circuits, you must have information about body position in space
- From peripheral receptors
  - Skin
  - Muscle
  - Tendon
  - Joint

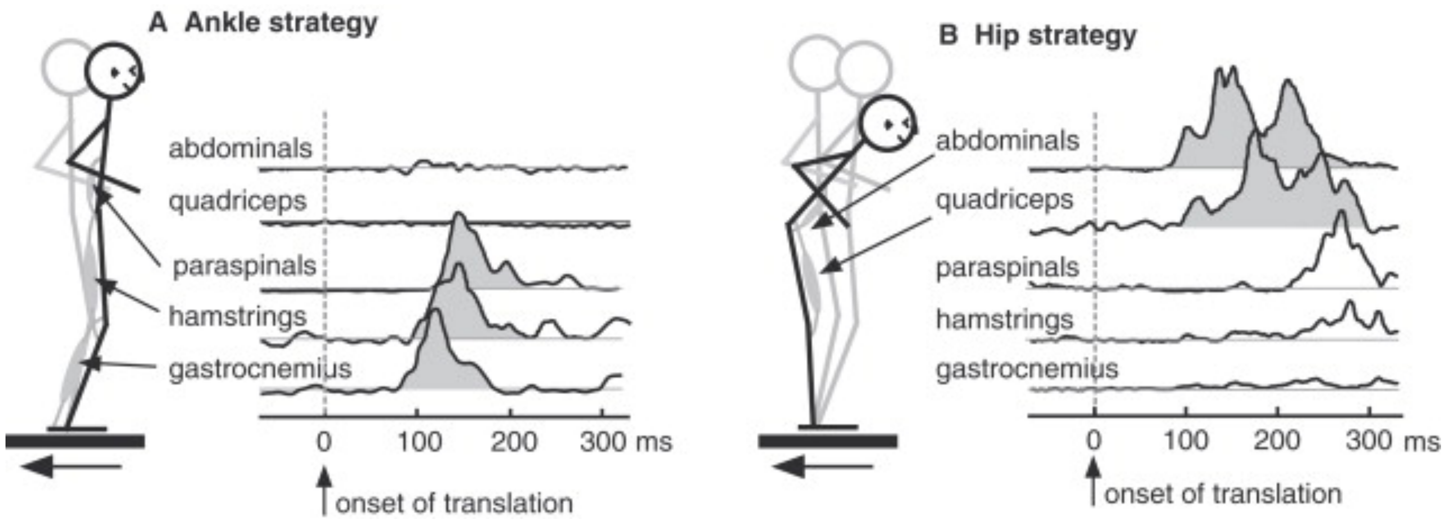
4. Pre-Programmed Reactions



- Preferred patterns of corrective postural reactions
- Specific combination of muscle activity
- Longer delay; 80 ms
  - Too slow for reflex
  - Too fast for voluntary
- More powerful and more flexible
- Triggered by activation of visual, vestibular, and proprioceptive input
- Postural synergies: preferred pattern of muscle co-activation to maintain balance

(Ting, 2006 Prog in Brain Res)

Postural synergies



- Forward body sway
- Dorsal muscles
- Distal to proximal
- Efficient, dangerous
- For slow perturbations

- Backward body sway
- Ventral muscles
- Proximal to distal
- Safe
- For fast perturbations

5. Voluntary Actions

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Hierarchical Error Evaluation: The Role of Medial-Frontal Cortex in Postural Control

Cameron D. Hassall[a], Stephane MacLean[a] & Olave E. Krigolson[a]

[a] Psychology and Neuroscience, Dalhousie University, Halifax, Nova Scotia

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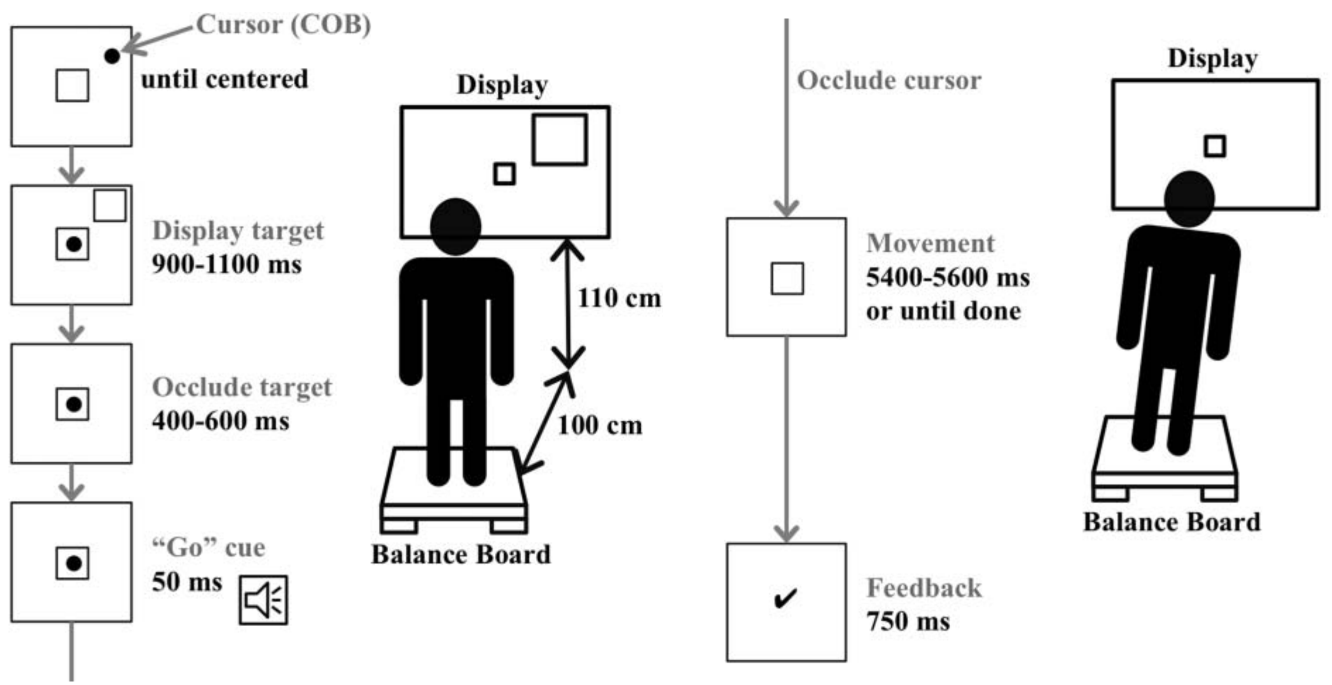
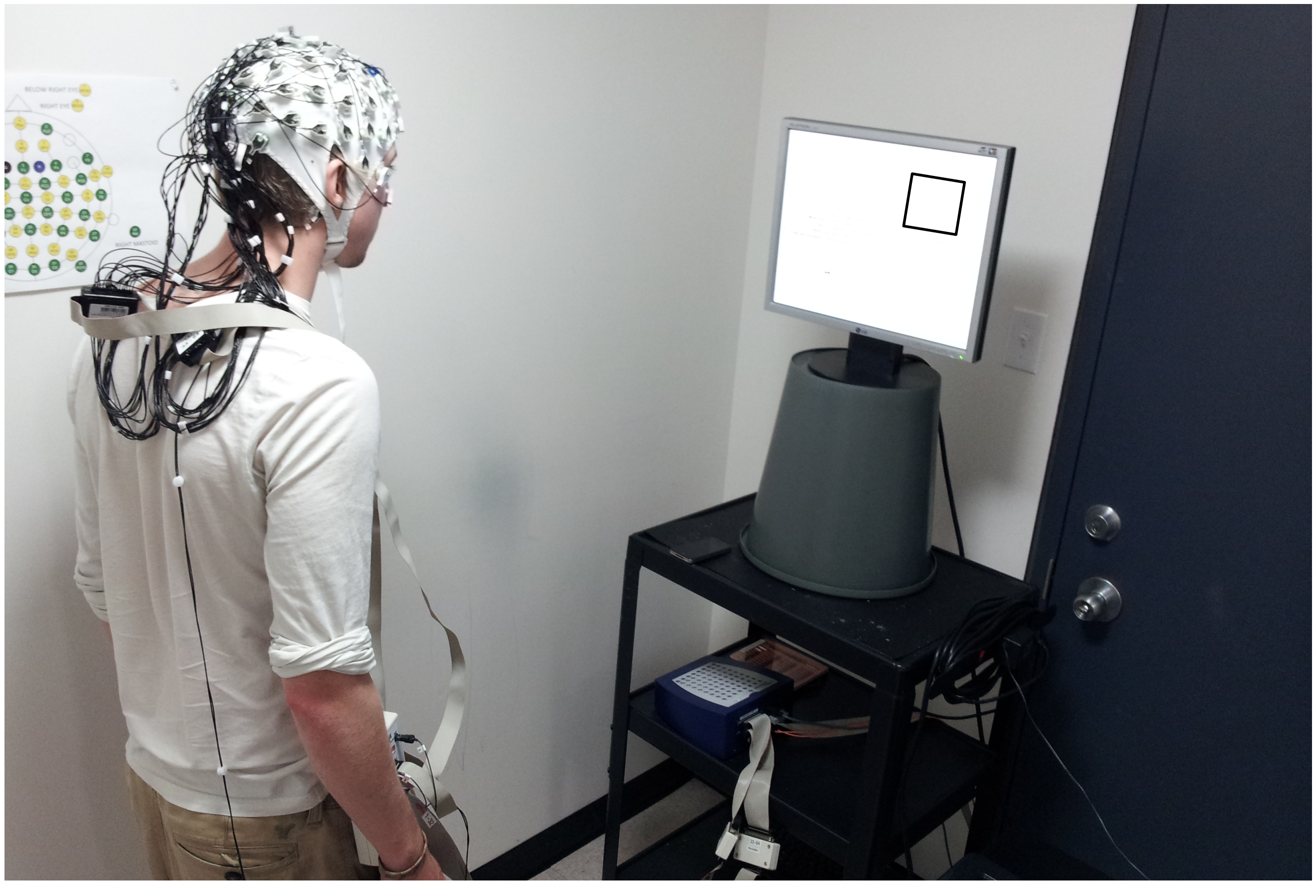
Medial-Frontal Cortex

Cortical Control

The Task

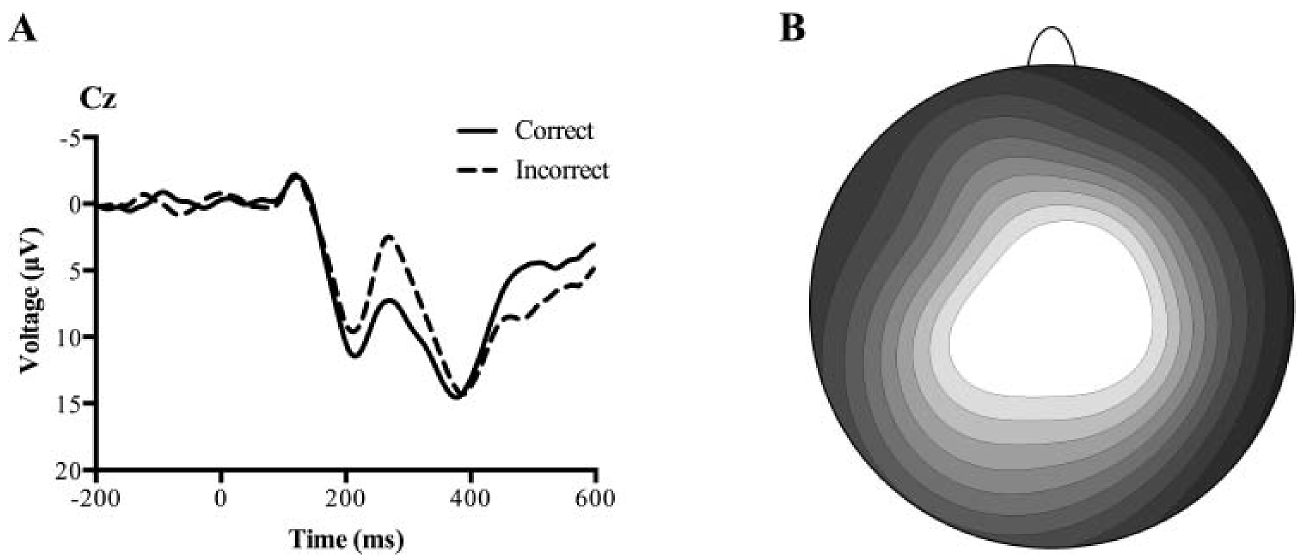


Cursor (COB)
until centered
Display target
900-1100 ms
Occlude target
400-600 ms
"Go" cue
50 ms
Display
110 cm
100 cm
Balance Board
Occlude cursor
Movement
5400-5600 ms
or until done
Feedback
750 ms
Display
Balance Board



ERP Results

- ERP: event-related potential – average scalp voltage response to an event



Summary

1. Anticipatory postural actions
2. Muscle and tendon elasticity
3. Equilibrial triad
   A. Vestibular
   B. Vision
   C. Proprioception
4. Pre-programmed reactions
5. Voluntary actions (Cortex)

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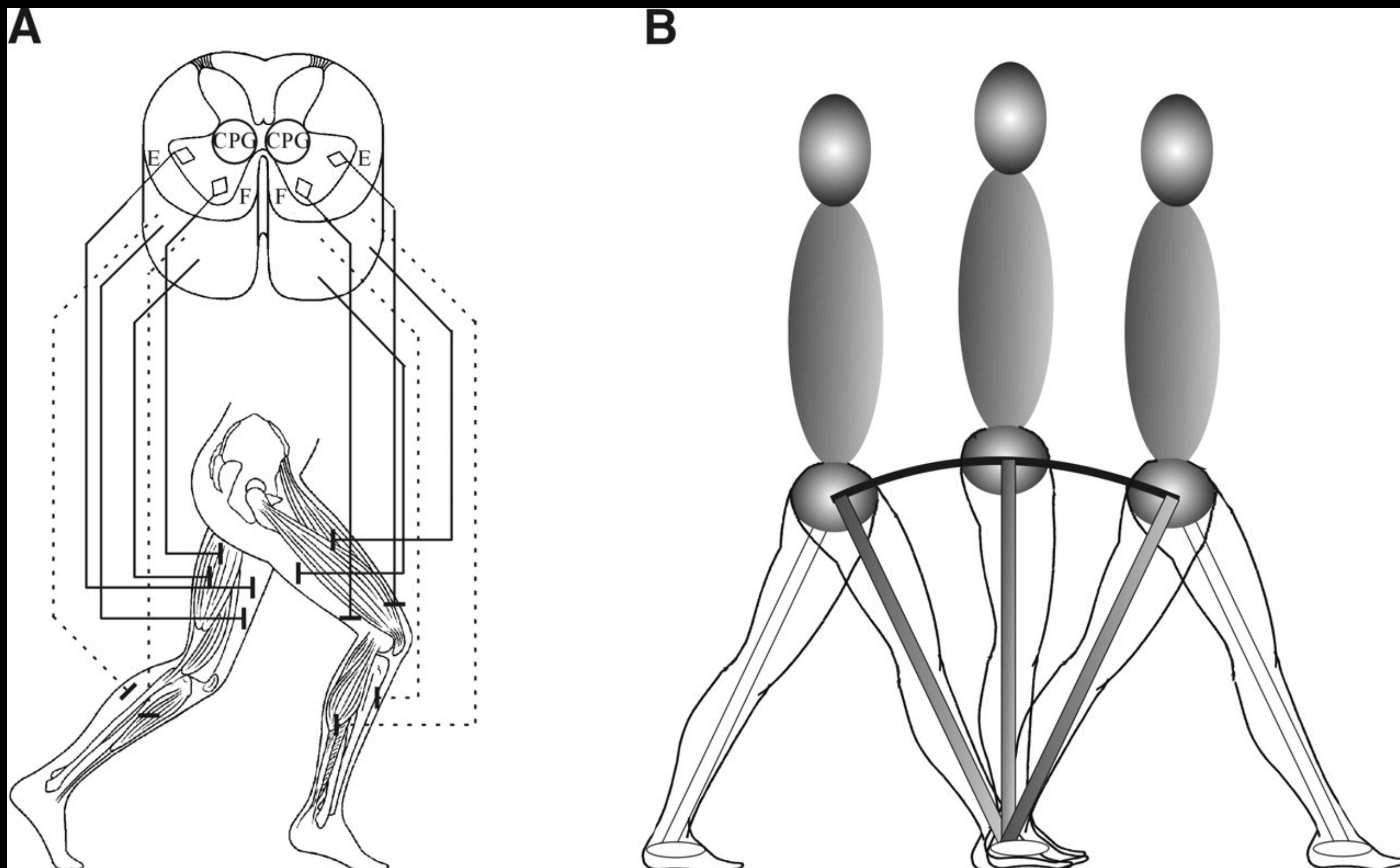
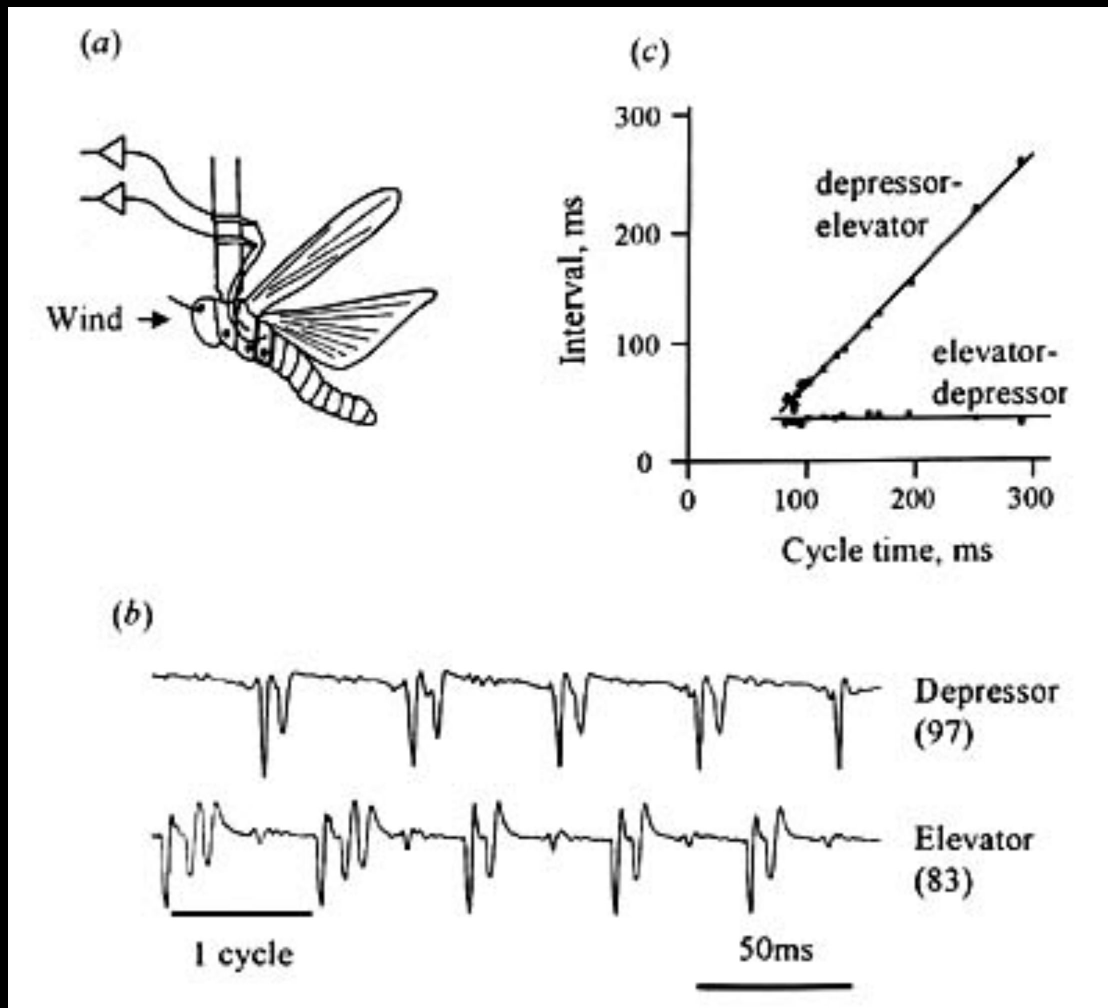
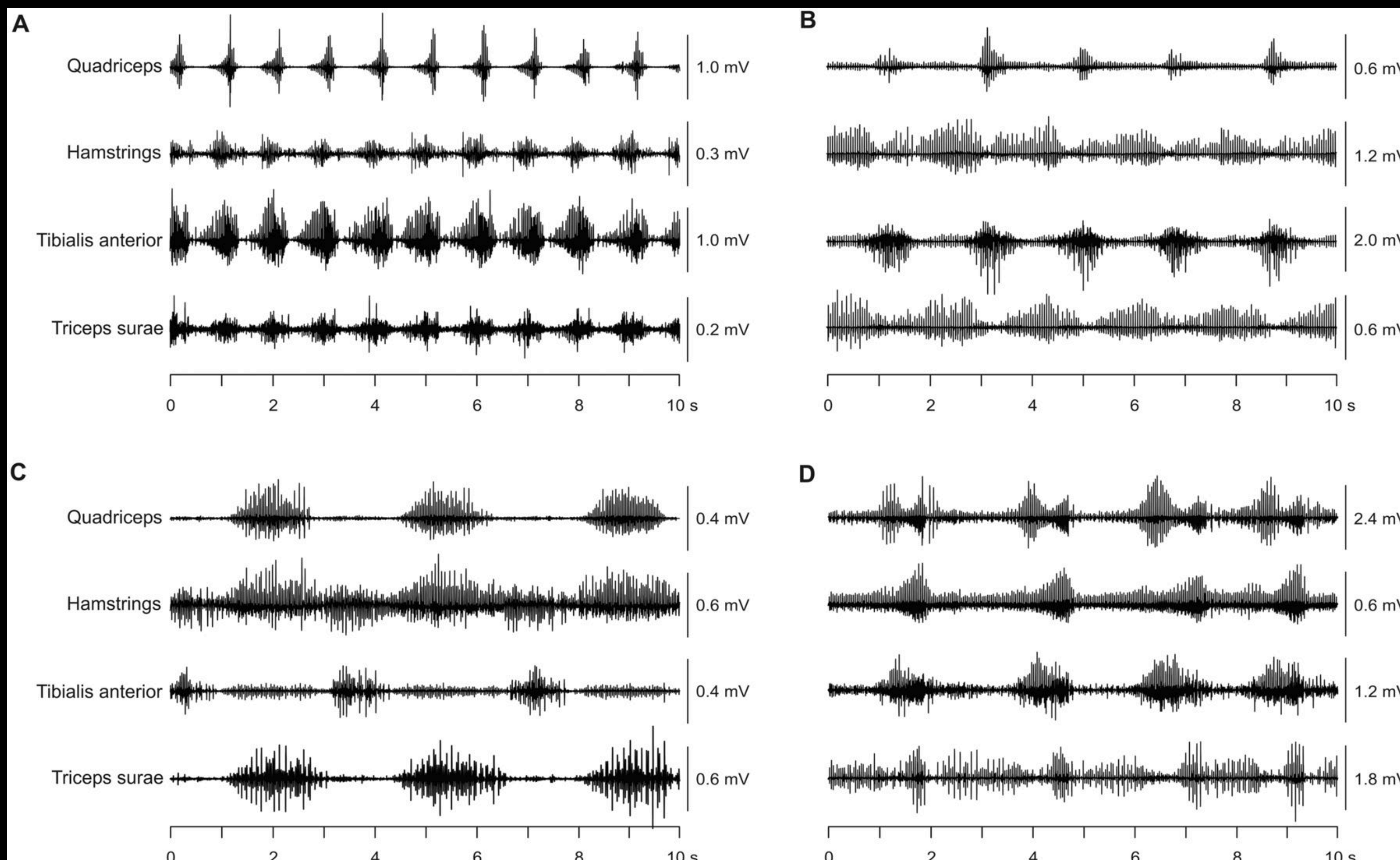
Central Rhythm/Pattern Generators (CPGs)

- Most complex spinal networks
- Patterns of neuronal connections in spinal cord
  - generate purposeful movements and behaviours
    - e.g. walking, breathing
- Can generate **spontaneous repetitive patterns** of movement without further sensory input



A
B
CPG
CPG
E
E
F
F


(a)
Wind
(c)
300
200
100
0
Interval, ms
depressor-
elevator
elevator-
depressor
0
100
200
300
Cycle time, ms
(b)
Depressor
(97)
Elevator
(83)
1 cycle
50ms


A
Quadriceps
1.0 mV
Hamstrings
0.3 mV
Tibialis anterior
1.0 mV
Triceps surae
0.2 mV
0
2
4
6
8
10 s
B
0.6 mV
1.2 mV
2.0 mV
0.6 mV
0
2
4
6
8
10 s
C
Quadriceps
0.4 mV
Hamstrings
0.6 mV
Tibialis anterior
0.4 mV
Triceps surae
0.6 mV
0
2
4
6
8
10 s
D
2.4 mV
0.6 mV
1.2 mV
1.8 mV
0
2
4
6
8
10 s

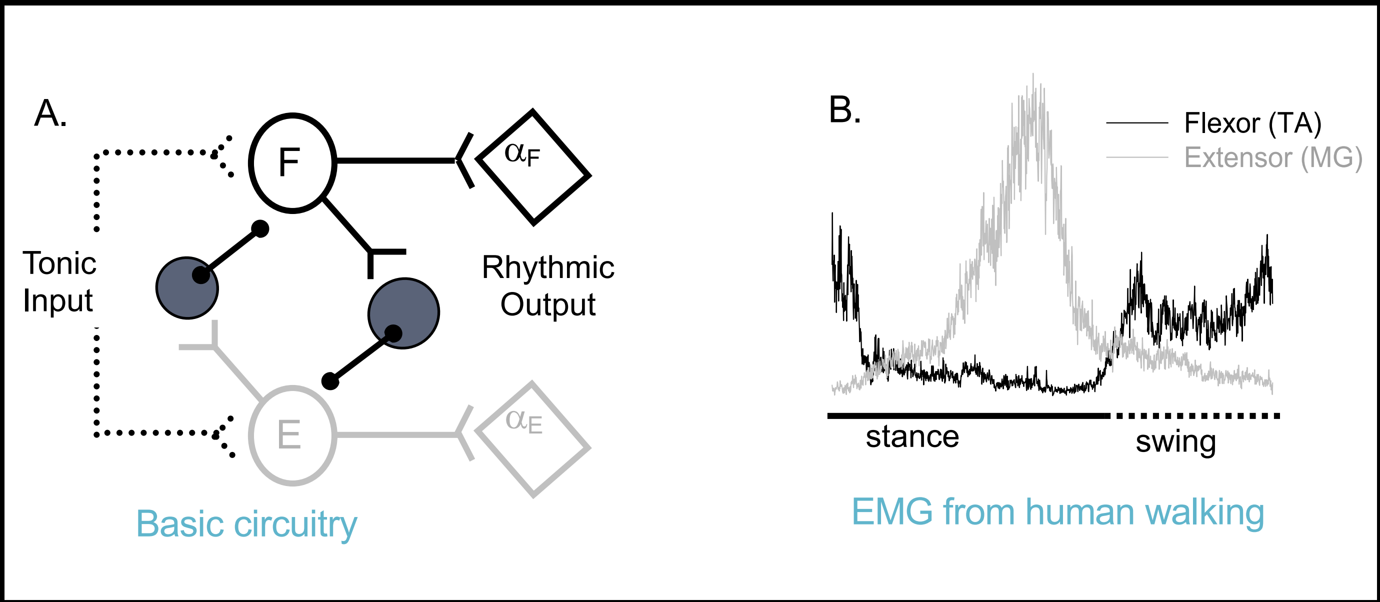
CPGs are "built" from spinal reflexes

- Remember the flexor withdrawal reflex?
- Different reflex **pathways can be integrated** and used by the CPG

- Thus spinal mechanisms can be used in complicated behaviours
- One of the first demonstrations was in the **"scratch reflex"** of the dog

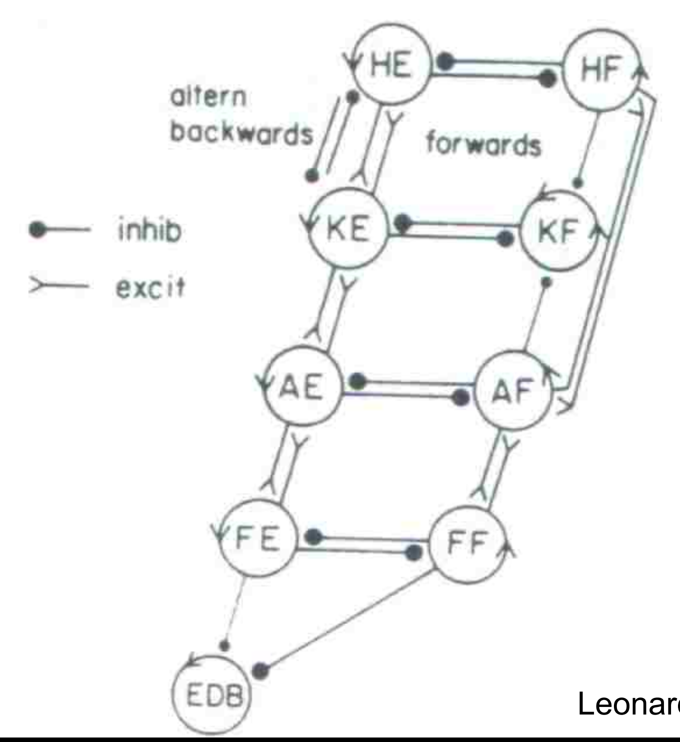
CPGs: Half-Centre Model

- generates rhythmic output from tonic input
- interneurons controlling flexor and extensor motor neurons have reciprocal inhibitory connections
  - also Left-Right control in swimming (e.g. Lamprey)



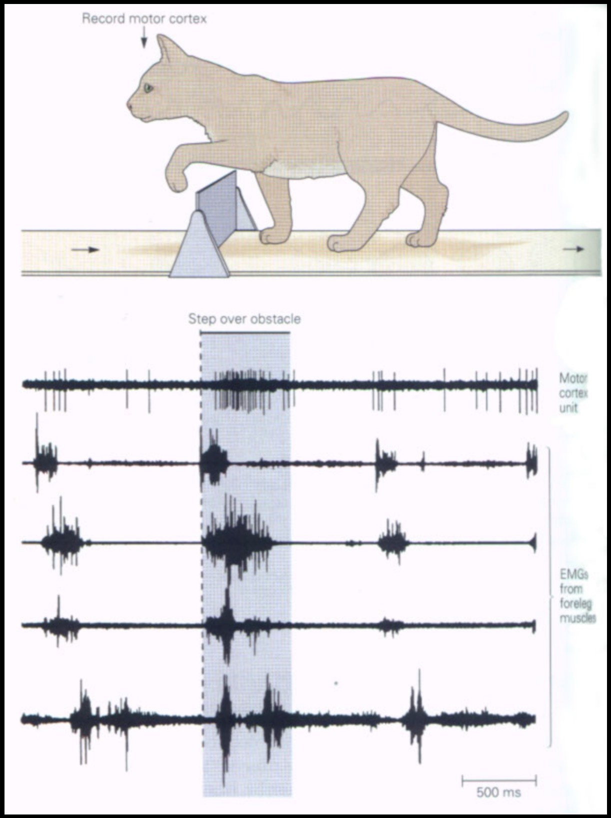
Basic schema for CPGs controlling quadrupedal locomotion

- Note interactions between:
  - 1) flexors and extensors
    - **Reciprocal inhibition**
  - 2) limb segments
    - Ankle, knee, hip
- Each joint is a "unit"



Leonard (1998)

Connections with cortex…



- The **basic rhythm** is carried out by **CPG**
  - Online control from **cortex** is active
    - Cells in motor cortex respond when hitting an obstacle with the foot!

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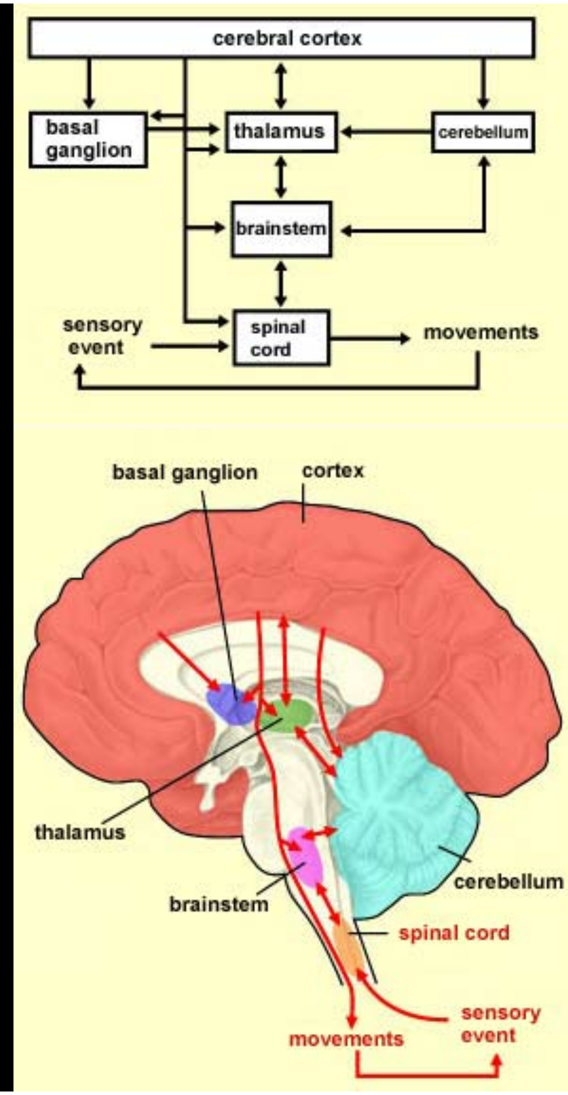
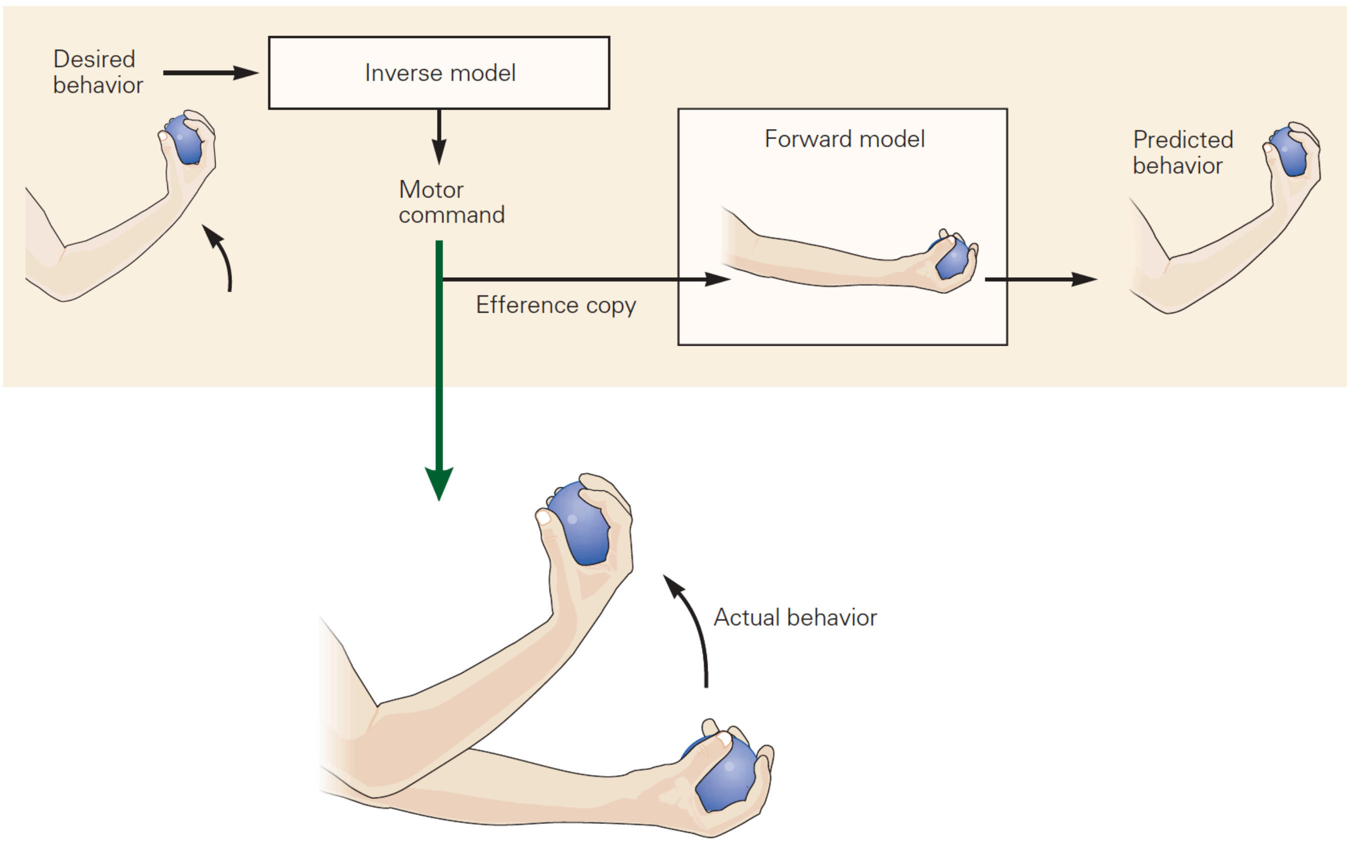
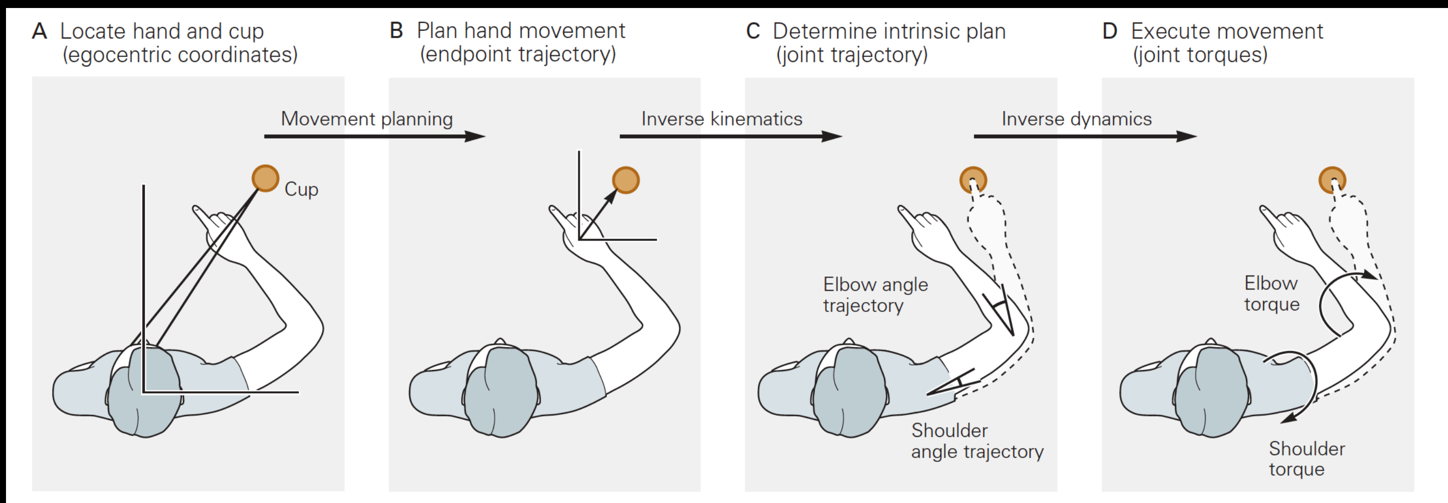
The Flow of Information
for Goal Directed Movements



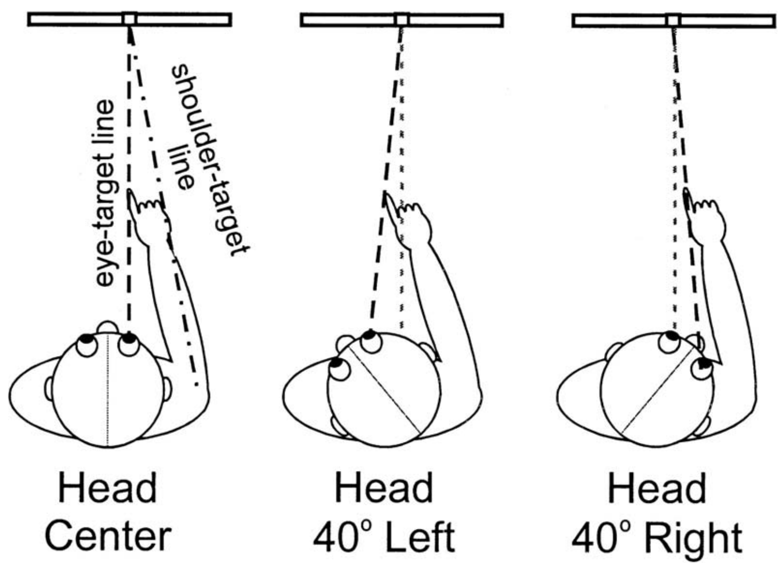


Desired behavior
Inverse model
Motor command
Forward model
Predicted behavior
Efference copy
Actual behavior

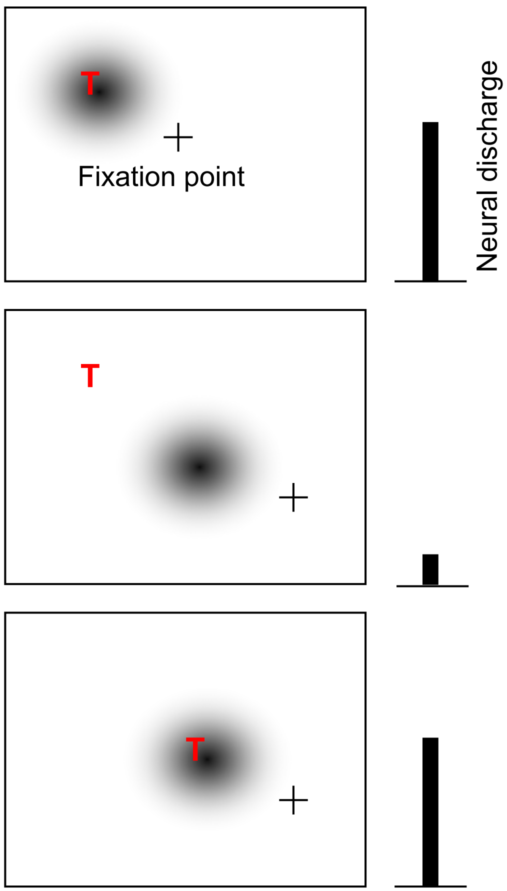

A Locate hand and cup
(egocentric coordinates)
B Plan hand movement
(endpoint trajectory)
C Determine intrinsic plan
(joint trajectory)
D Execute movement
(joint torques)
Movement planning
Inverse kinematics
Inverse dynamics
Cup
Elbow angle
trajectory
Shoulder
angle trajectory
Elbow
torque
Shoulder
torque

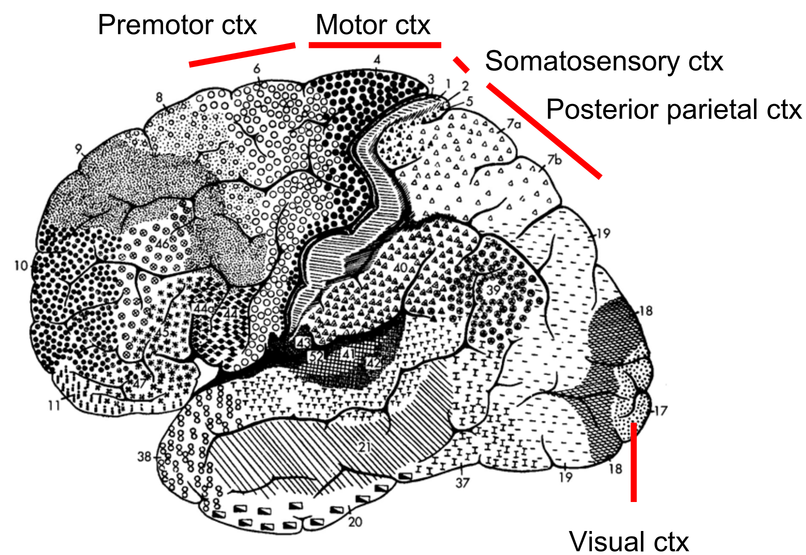
Visuomotor Transformations

When you point, you align your finger with the retinal location of the target

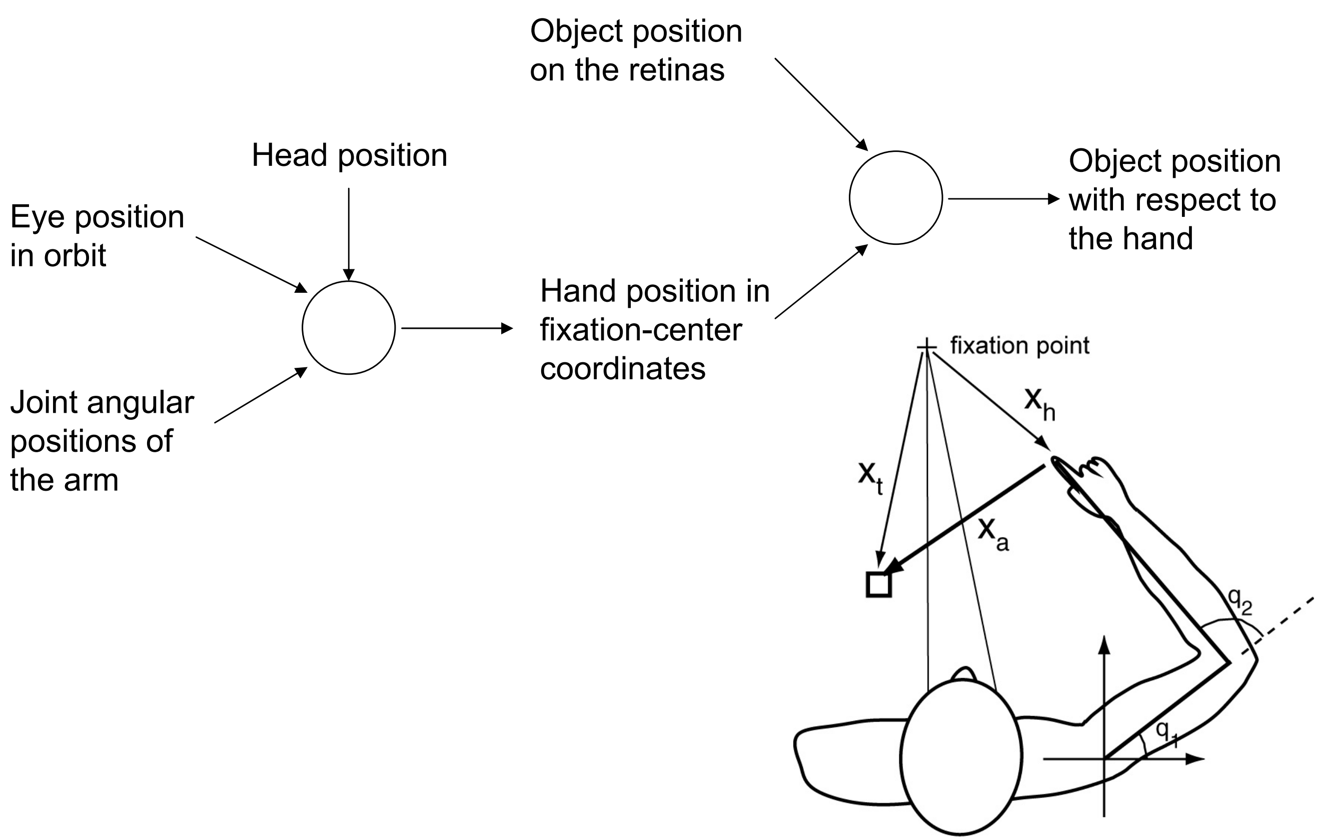


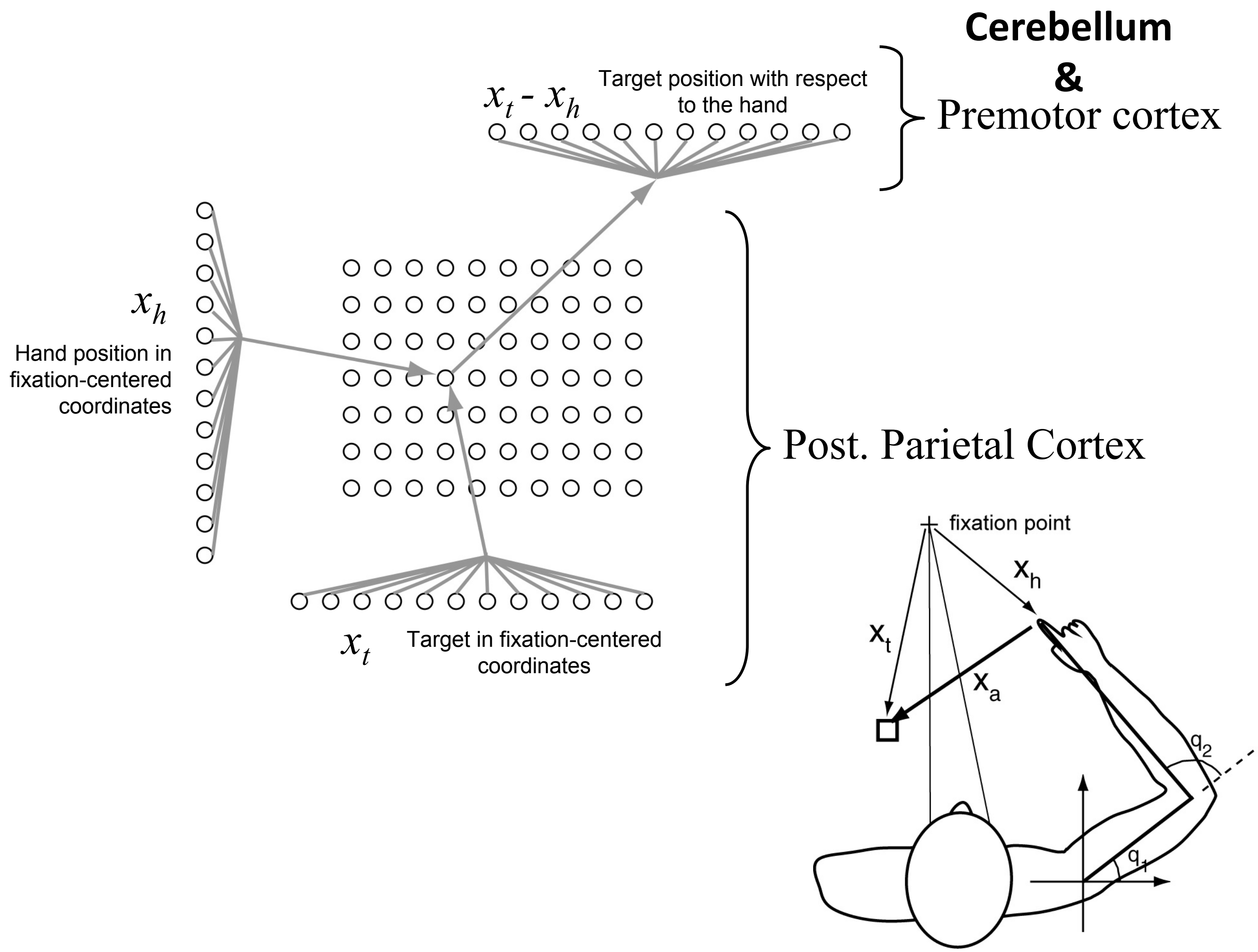
Coding location of target with a retinocentric receptive field

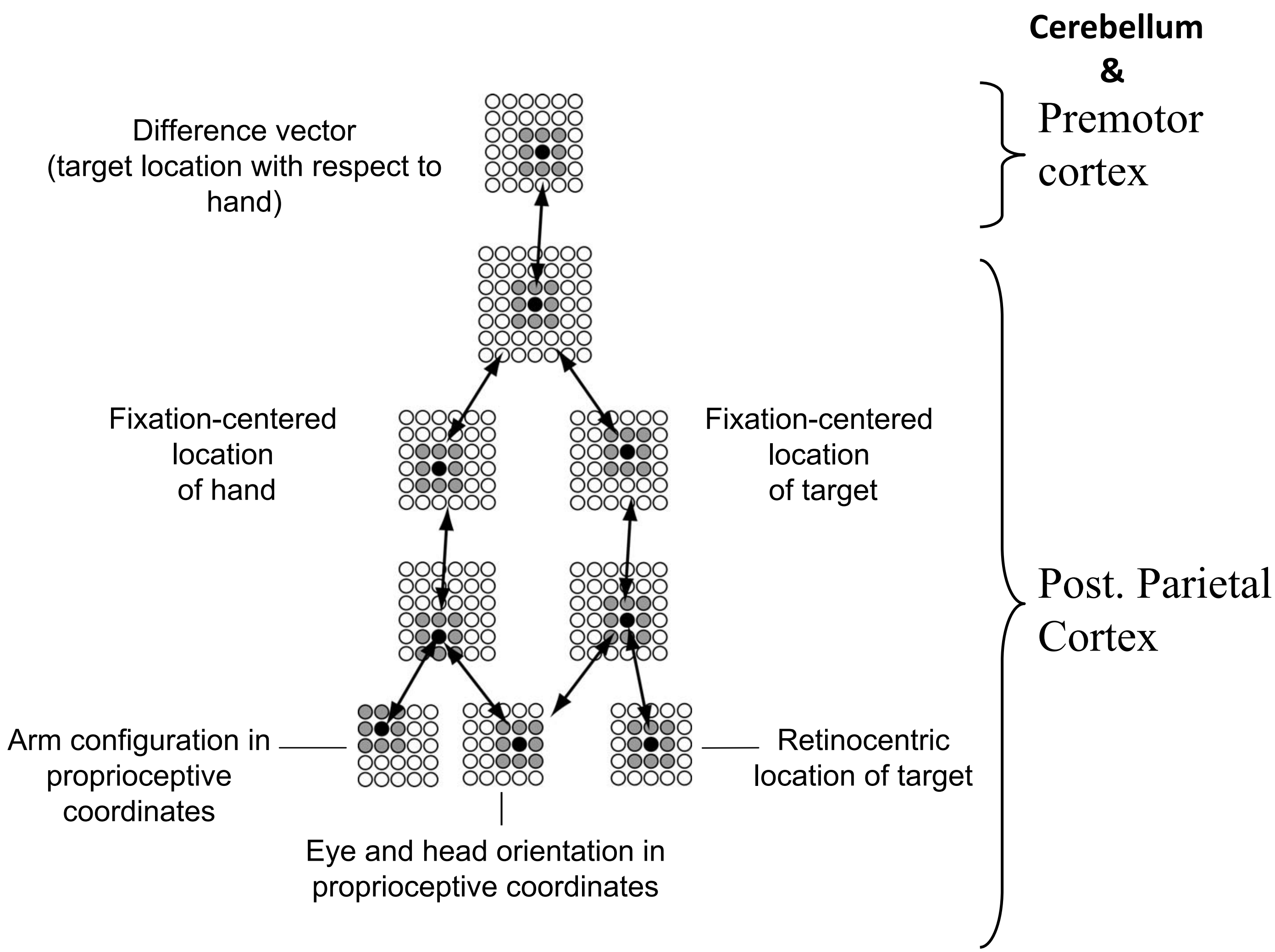




To reach a target, hand position is computed in fixation-centered coordinates

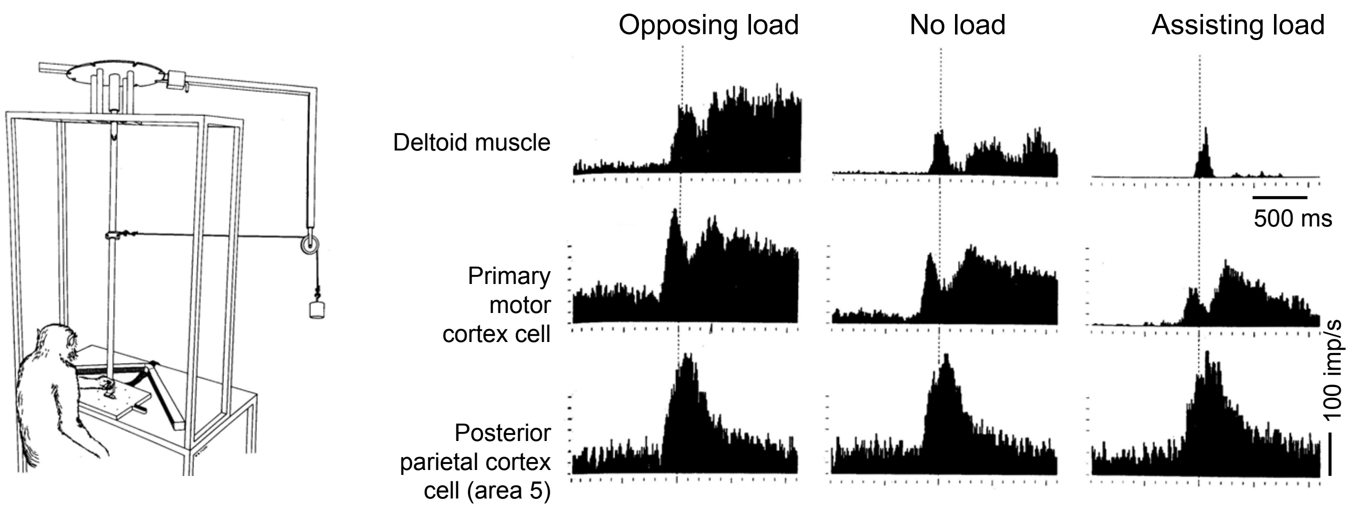



Cerebellum
&
Premotor cortex
x_t - x_h
Target position with respect to the hand
x_h
Hand position in fixation-centered coordinates
Post. Parietal Cortex
x_t
Target in fixation-centered coordinates
fixation point
x_h
x_t
x_a
q_2
q_1



Cerebellum
&
Premotor
cortex
Difference vector
(target location with respect to
hand)
Fixation-centered
location
of hand
Fixation-centered
location
of target
Post. Parietal
Cortex
Arm configuration in
proprioceptive
coordinates
Retinocentric
location of target
Eye and head orientation in
proprioceptive coordinates

PPC neurons encode target location and not the forces necessary to reach that target



So…

The PPC is all about computing the visuomotor transformations necessary to generate:

x_h: the position of the hand in fixation centered coordinates
x_t: the position of the target in fixation centered coordinates

The movement vector can be expressed mathematically as: $X_{movement\ or}\ X_m = X_t - X_h$

* NB, X_m would be expressed as a three dimensional vector but for simplicities sake we simplify to one dimension

So, we know we need X_m what's the next step?

We know the vector to the target, now we meet a motor command – a trajectory to the target location that takes into account:

Muscles involved

Joints involved

Relative force needed

Relative timing

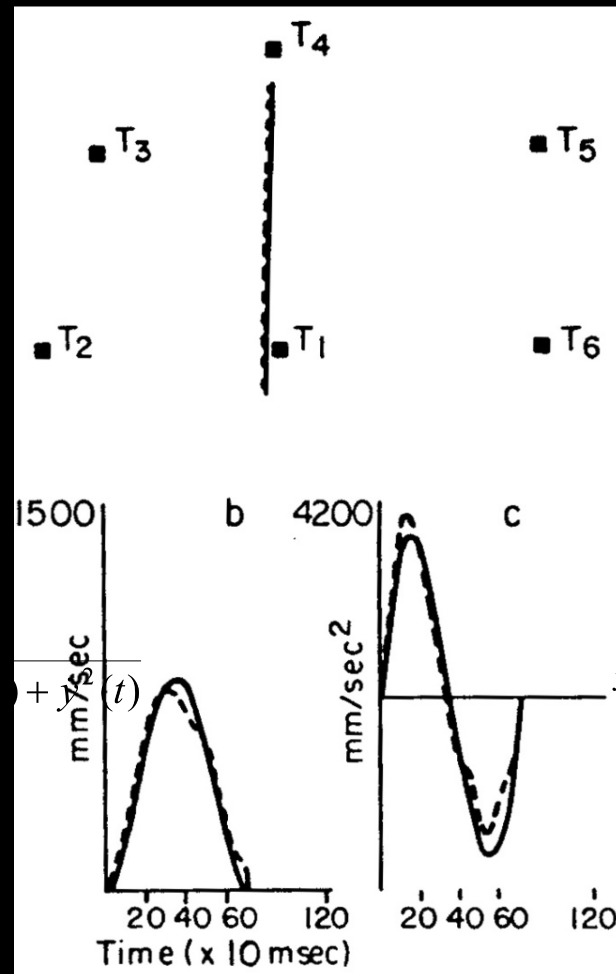
I.E., the MOTOR PROGRAM (Invariant & Variant Parameters)

Determining the Motor Command: The Inverse Model

Why an Inverse Model?
(and to be fair, Forward Models too)

Point to point movements generally exhibit similar characteristics:

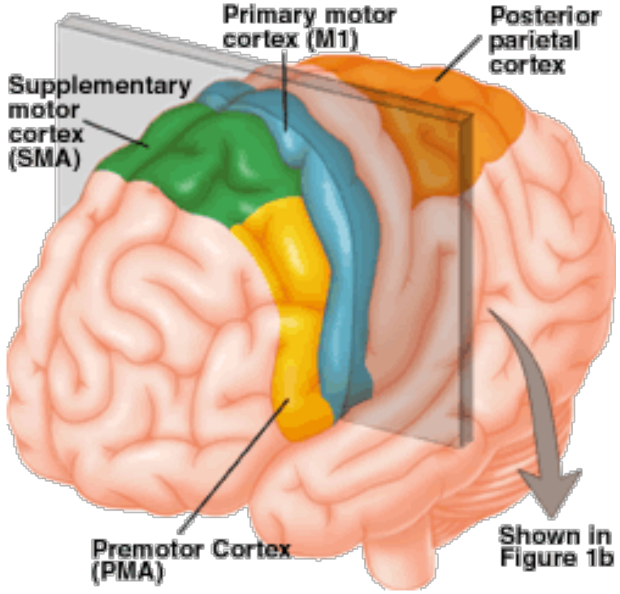
- hand trajectory is along a straight line
- hand speed follows a smooth, bell shaped time course
- hand speed is typically symmetric about the midpoint of the movement.

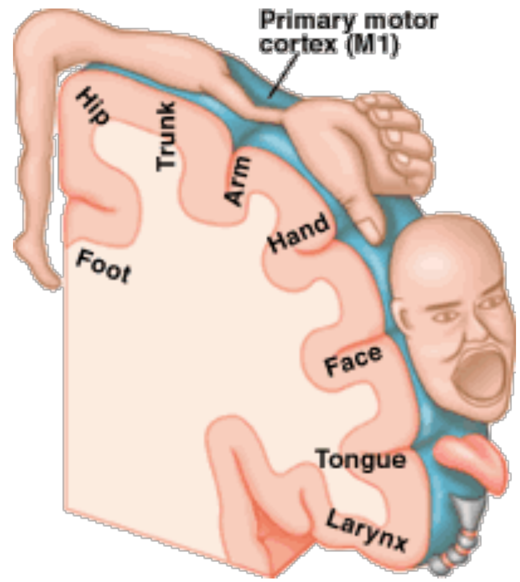


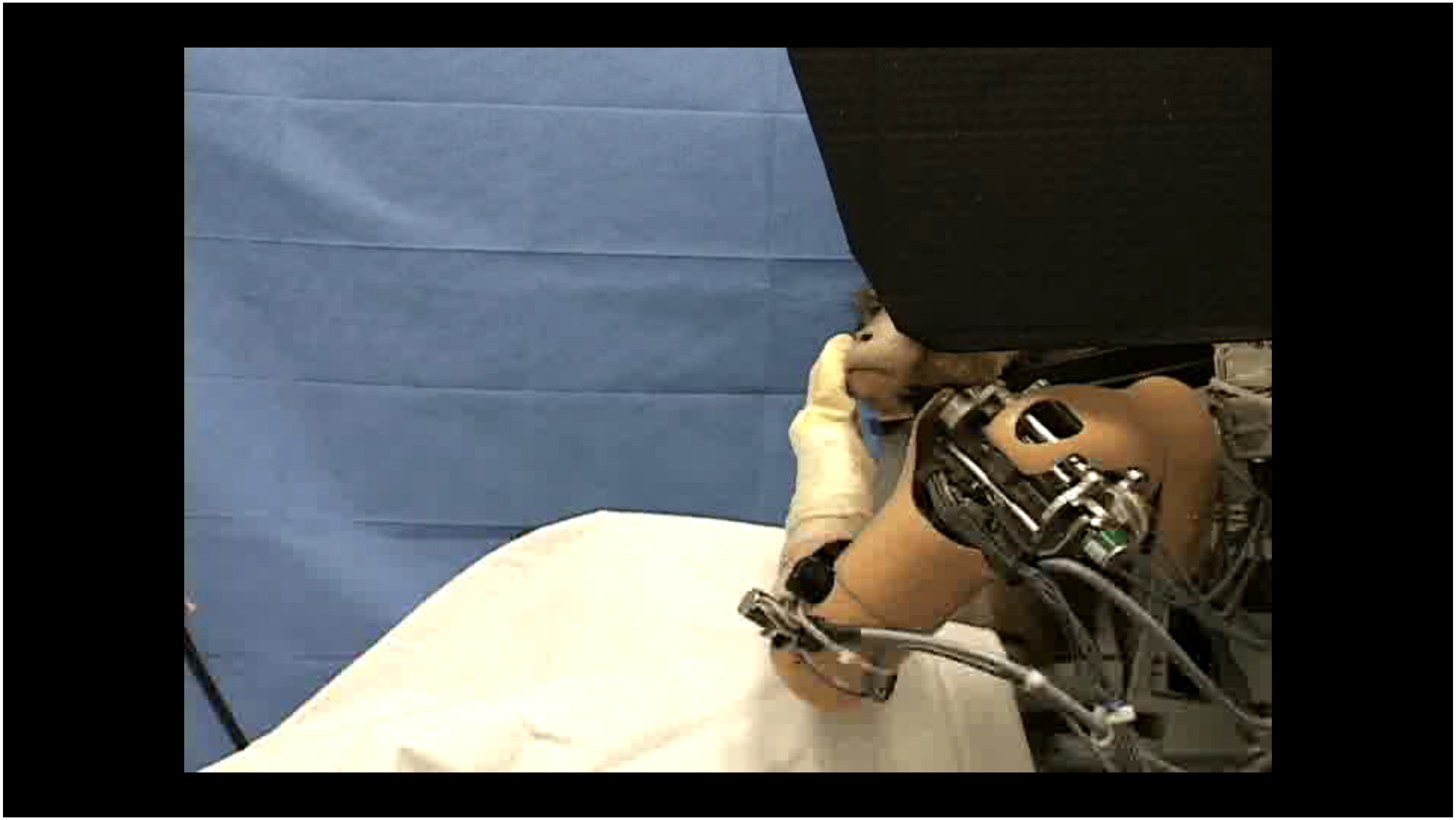
Let’s step back a second…

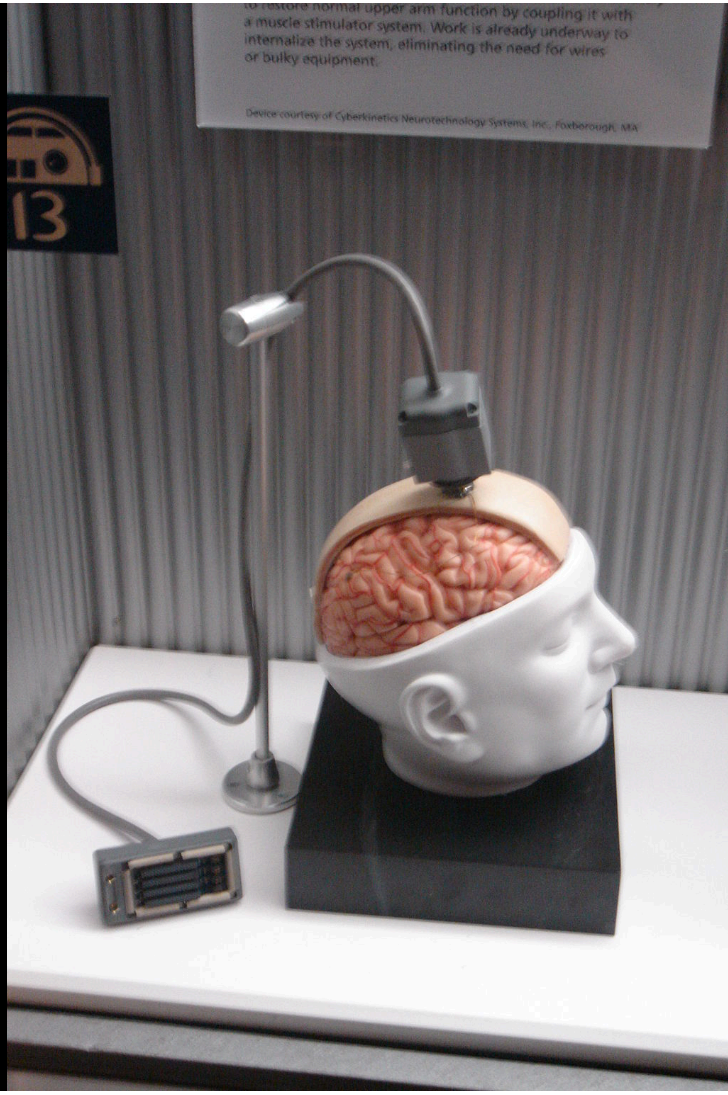
What is a “motor command”

- the neural activity that results in muscular contraction
- which muscles, how long, how much, sequencing, etc


Primary motor cortex (M1)
Posterior parietal cortex
Supplementary motor cortex (SMA)
Premotor Cortex (PMA)
Shown in Figure 1b


Primary motor cortex (M1)
Hip
Trunk
Arm
Hand
Foot
Face
Tongue
Larynx




a muscle stimulator system. Work is already underway to
internalize the system, eliminating the need for wires
or bulky equipment.
Device courtesy of Cyberkinetics Neurotechnology Systems, Inc., Foxborough, MA
13

BRAIN-COMPUTER INTERFACE RESEARCH

UPMC Rehabilitation Institute and the University of Pittsburgh School of Medicine

Study participant Jan Scheuermann feeds herself

1) Nov. 28, 2012 - Chocolate bar
2) Nov. 30, 2012 - Chocolate bar
3) Nov. 30, 2012 - Chocolate truffle
4) Nov. 30, 2012 - String cheese
5) Nov. 30, 2012 - Red pepper

December 2012

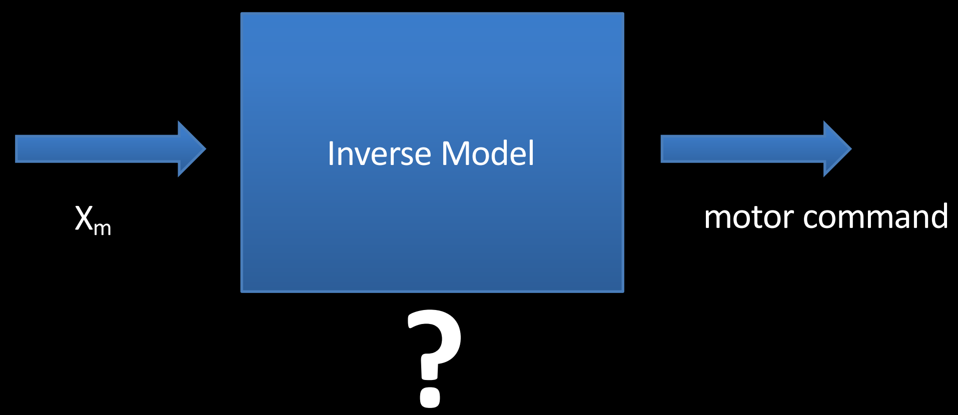
TRT 05:27

So what is the motor command?

It is the set of instructions sent to M1 that result in muscular contraction

In the Schwartz Lab they place an electrode array over M1 so that they can use the brains neural activity in M1 to control the various motors in the “arm”.

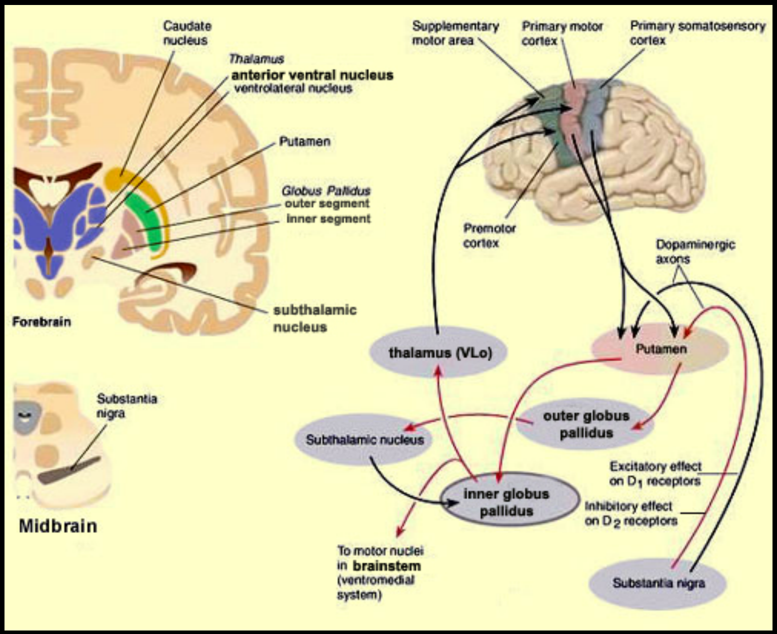
The Inverse Model



What We Believe…

The inverse model helps with the computation of X_m (cerebellum) and outputs a motor command (premotor cortex)

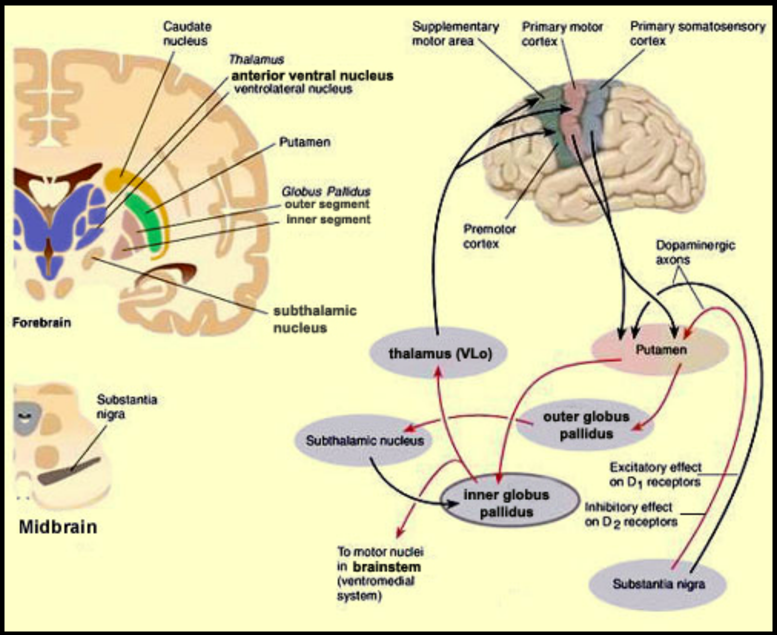
What we do know…



The Basal Ganglia

- a collection of nuclei in the midbrain
- definitely play a role in movement planning and control (Parkinson's)
- (also play a role in reinforcement learning and motivation)
- implicated in postural stability and control (and that may be there role in goal directed action – to stabilize the body for movement?)
- but very few in any direct connections to descending pathways
- another idea is that the BG is a gateway system that only allows activity in SMA (voluntary movement) if a sufficient level of firing is achieved.

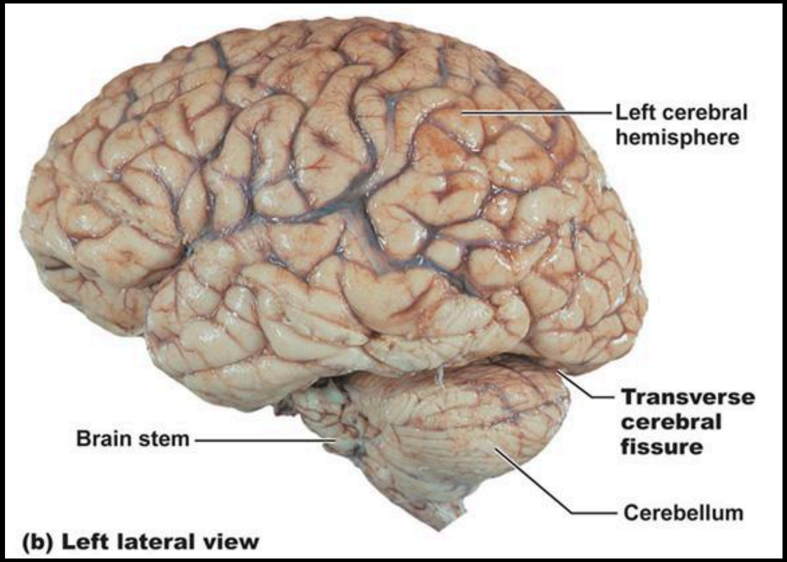
What we do know…



The Basal Ganglia

- to expand on that:
- a **direct pathway** selectively facilitates certain motor (or cognitive) programs in the cerebral cortex that are adaptive for the present task, whereas an **indirect pathway** simultaneously inhibits the execution of competing motor programs. An upset of the balance between the direct and indirect pathways results in motor dysfunction

What we do know…

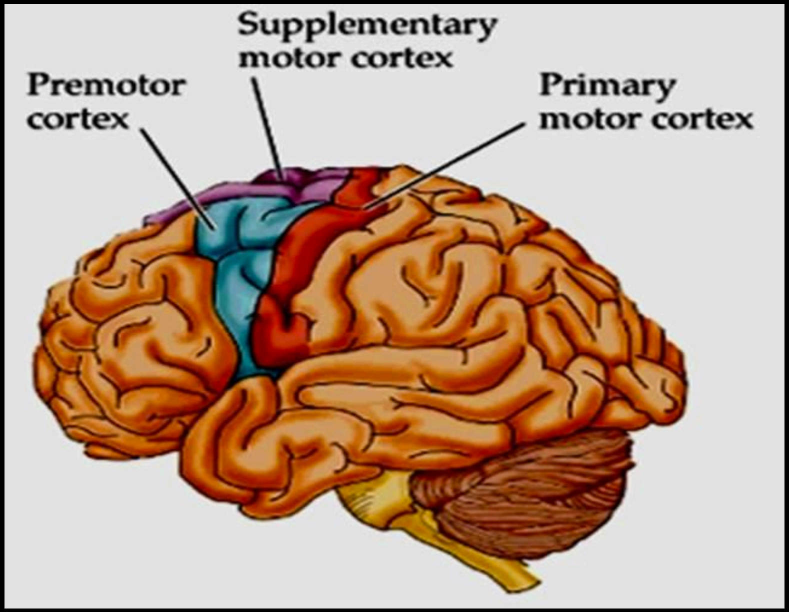


The Cerebellum
- control of timing
- estimation
- prediction

(some argue this is the “home” of forward and inverse models
- we do know that movement deficits such as cerebellar axatia result in uncoordinated and poorly controlled movements

Cerebellar Axatia

What we do know…



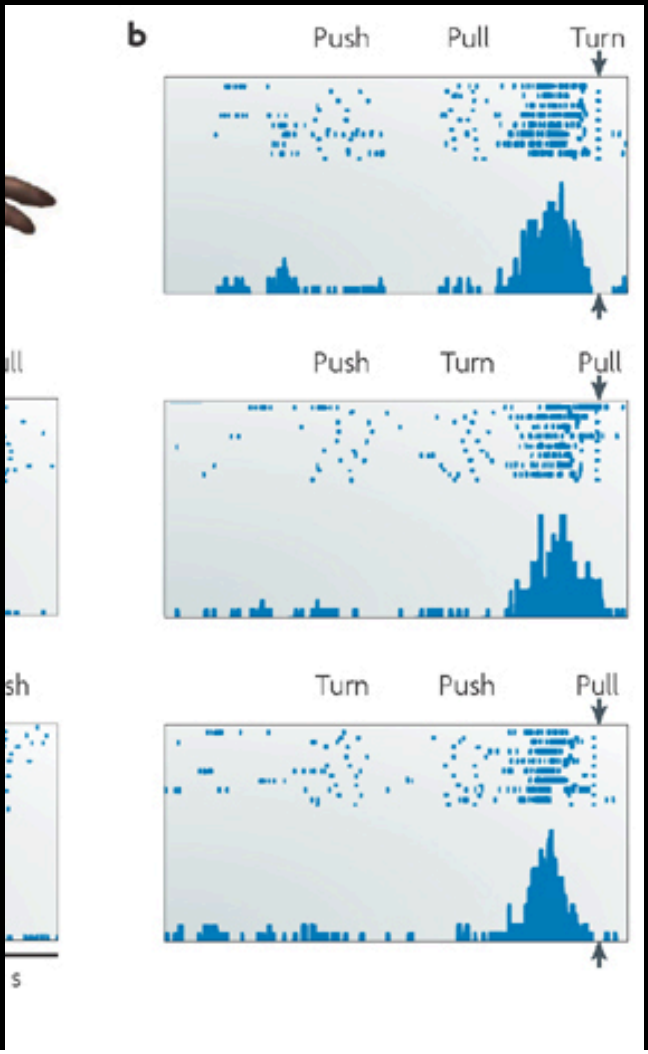
SMA & PMC

- the secondary motor areas (PMC and SMA) work with the cerebellum to specify the precise sequence of contractions of the various muscles that will be required to carry out the selected motor action

- recall X_m, this still needs to be converted into a set of intrinsic co-ordinates in muscle terms, this could be part of what the SMA does with the help of the Cerebellum, the same is true for Premotor Cortex

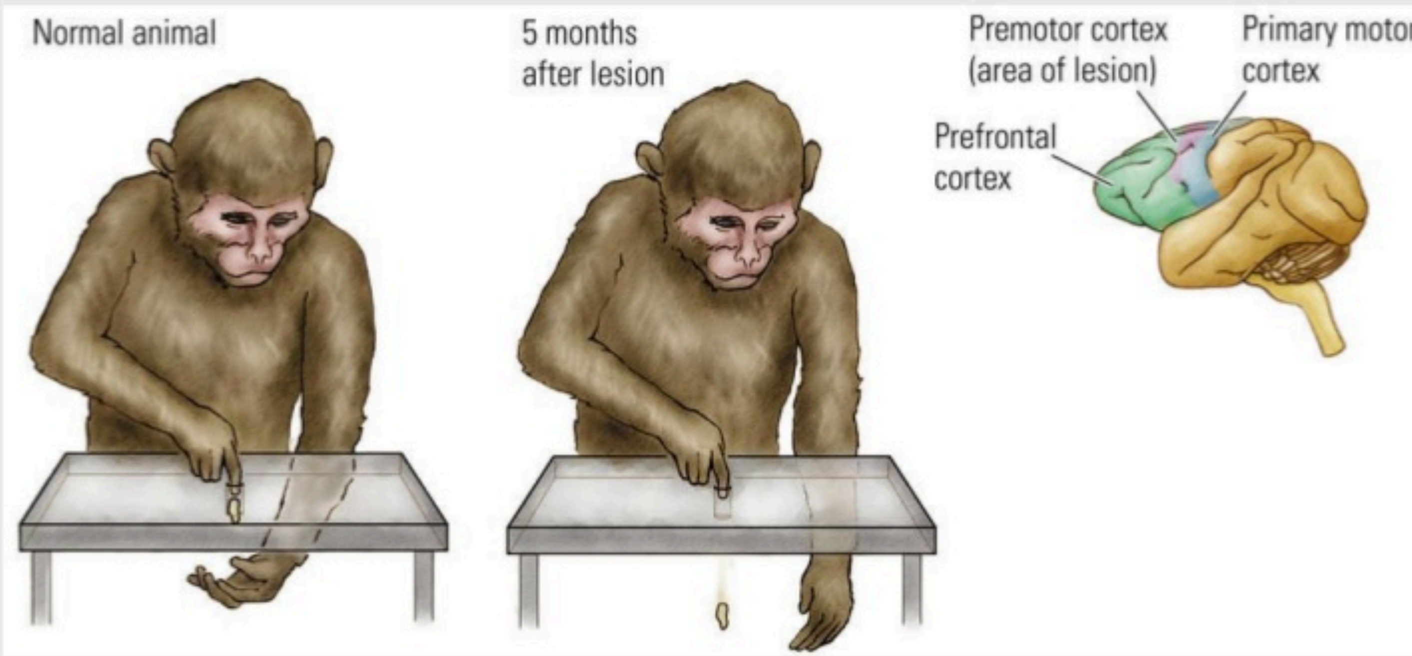
- SMA also seems crucial for well learned movements and internally generated movements

- additionally movement sequencing

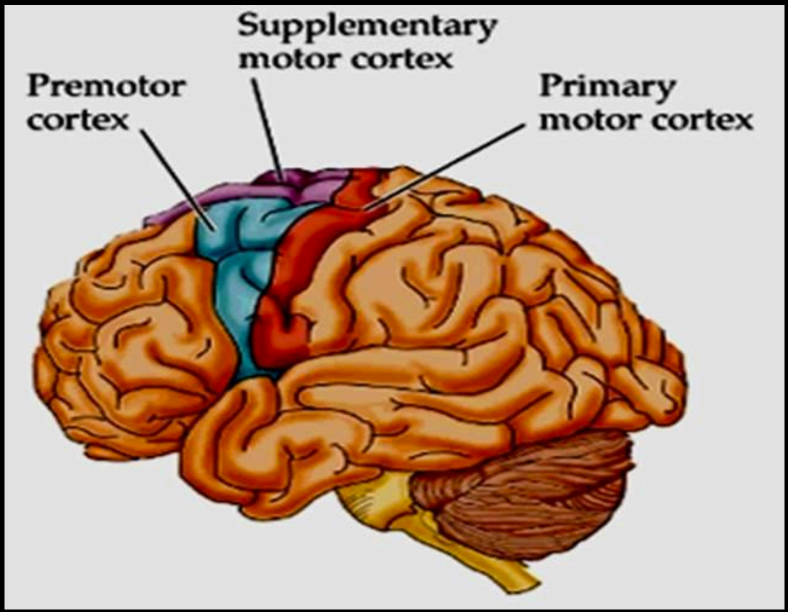


An interesting study where one particular neuron in SMA only fired before the third movement in a sequence, but note, irregardless of what the third movement was

Animals with damage to the premotor cortex cannot put motor sequences together



What we do know…



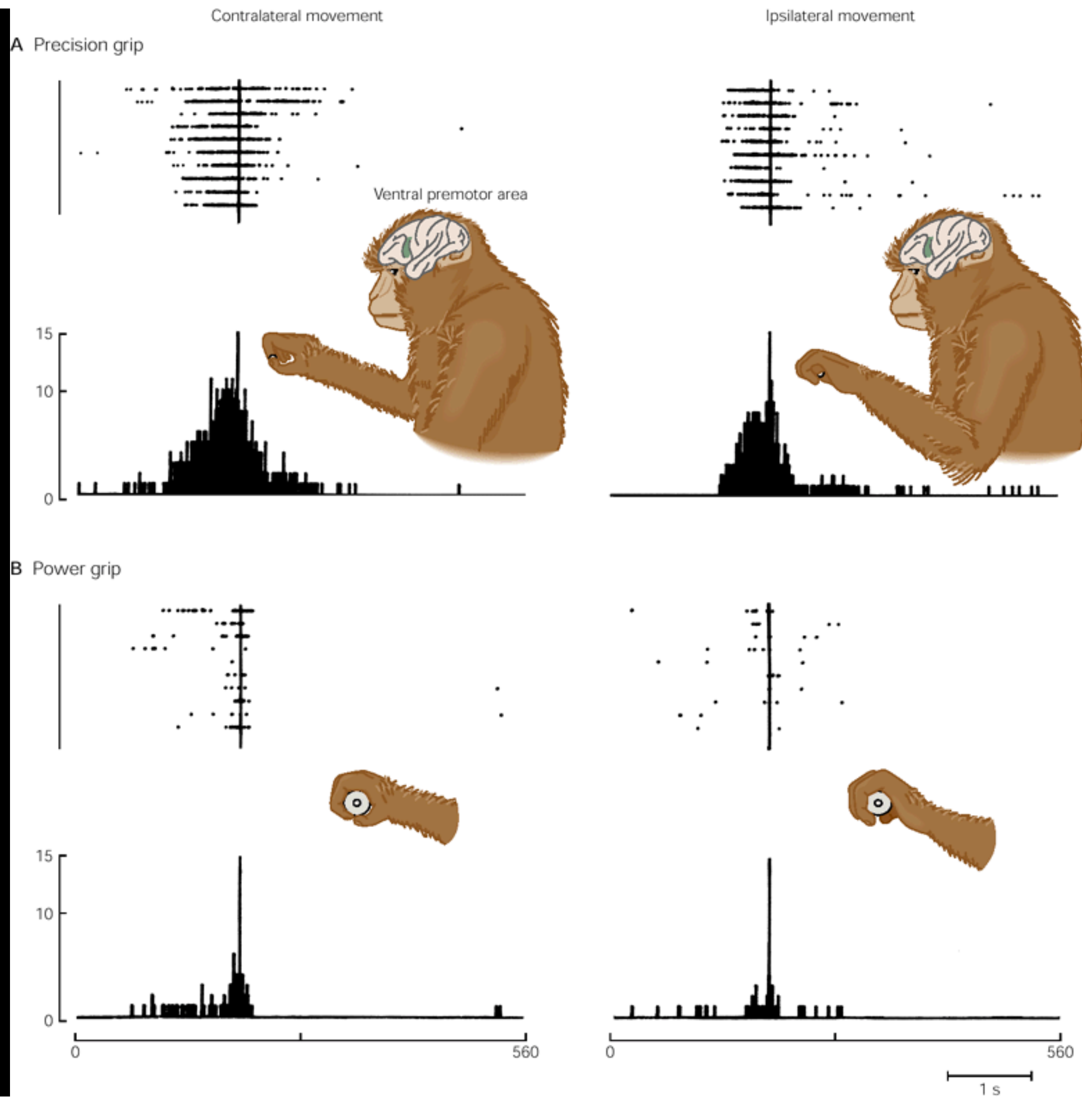
PMC

- the secondary motor areas (PMC and SMA) work with the cerebellum to specify the precise sequence of contractions of the various muscles that will be required to carry out the selected motor action

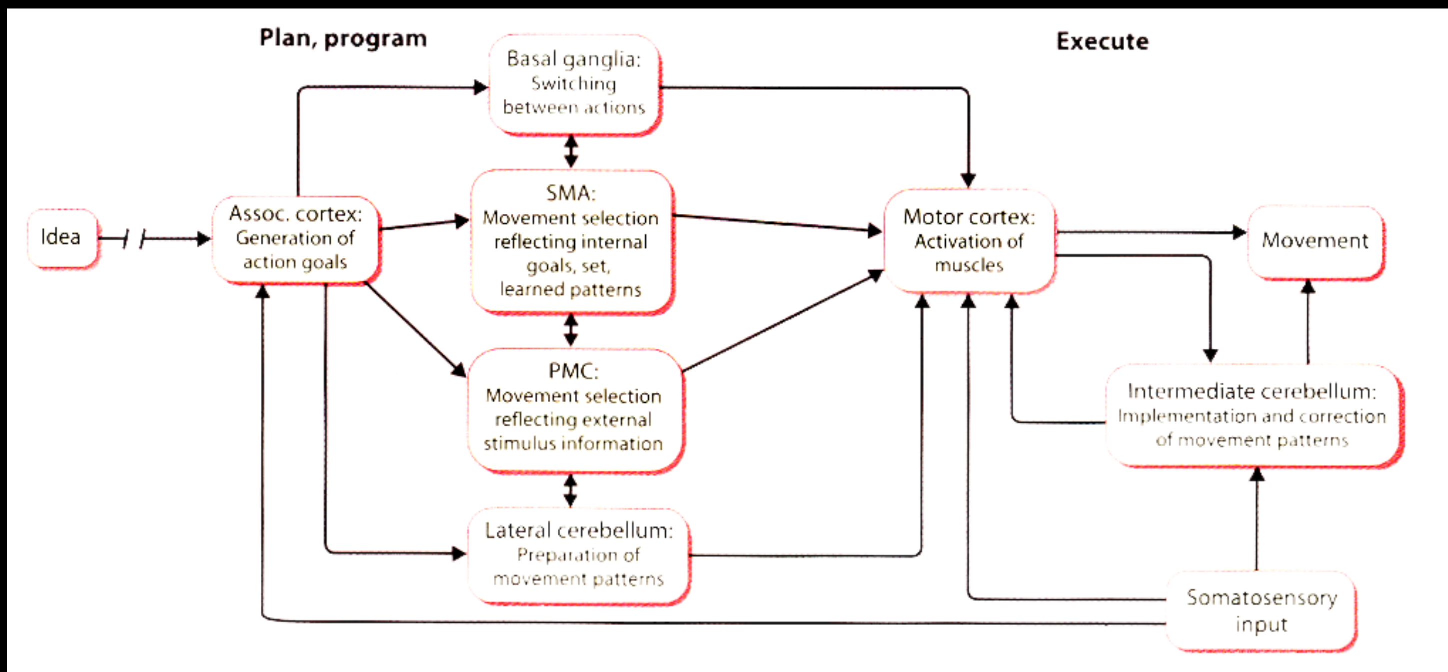
- recall X_m, this still needs to be converted into a set of intrinsic co-ordinates in muscle terms, this could be part of what the SMA does with the help of the Cerebellum, the same is true for PMC

- PMC also seems crucial for externally driven actions

- additionally movement direction



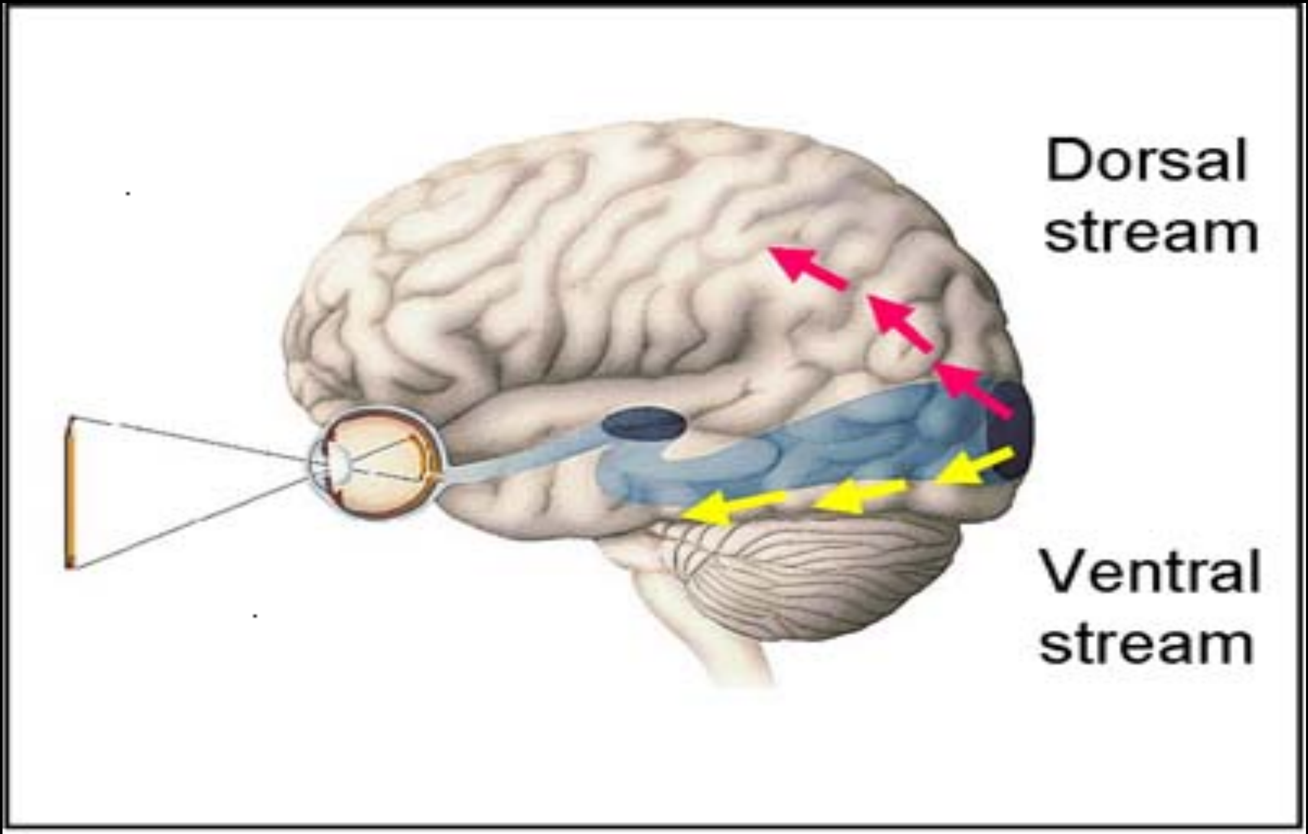
Contralateral movement
Ipsilateral movement
A Precision grip
Ventral premotor area
15
10
0
B Power grip
15
10
0
0
560
0
560
1 s

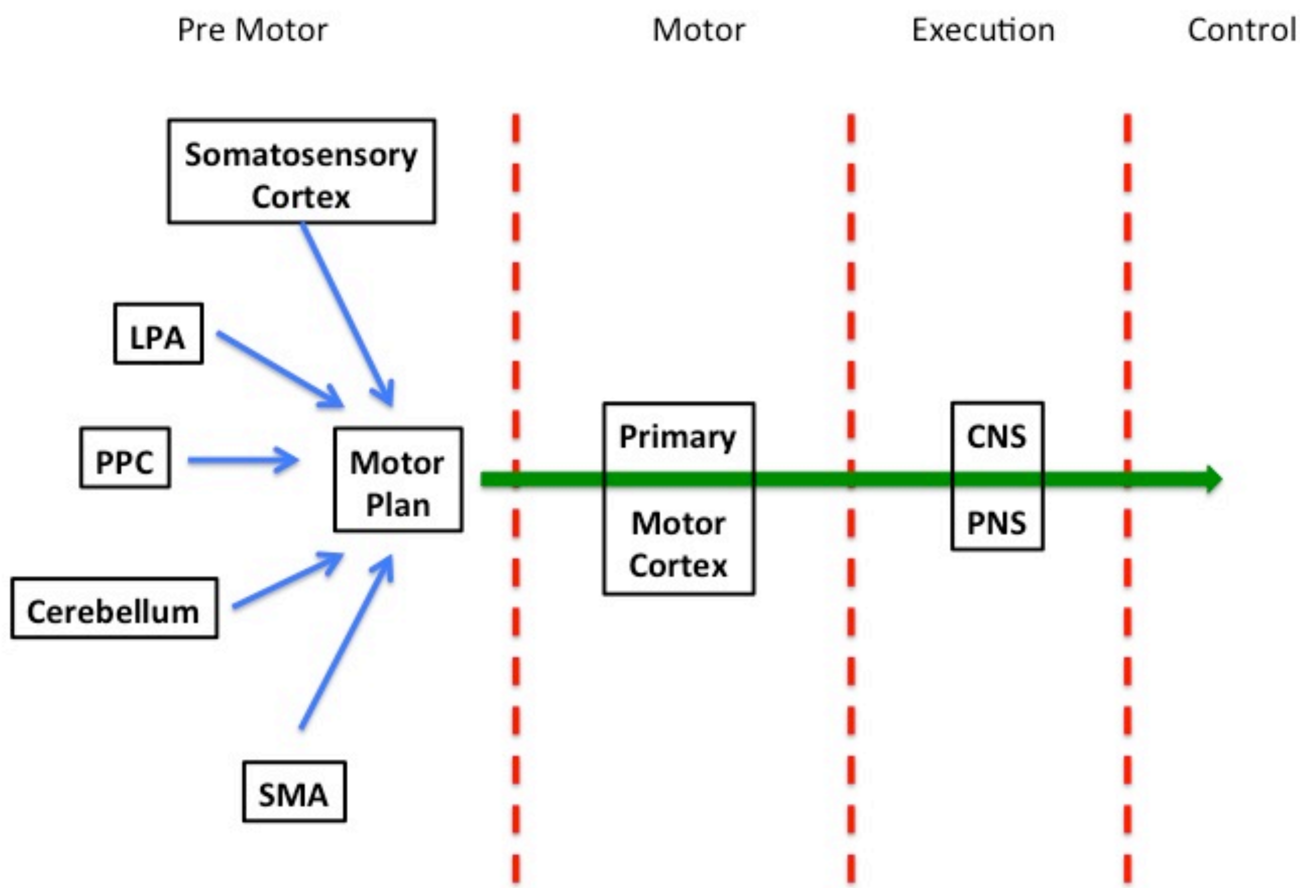


Plan, program
Execute
Idea
Assoc. cortex: Generation of action goals
Basal ganglia: Switching between actions
SMA: Movement selection reflecting internal goals, set, learned patterns
PMC: Movement selection reflecting external stimulus information
Lateral cerebellum: Preparation of movement patterns
Motor cortex: Activation of muscles
Movement
Intermediate cerebellum: Implementation and correction of movement patterns
Somatosensory input

Levels of Motor Control

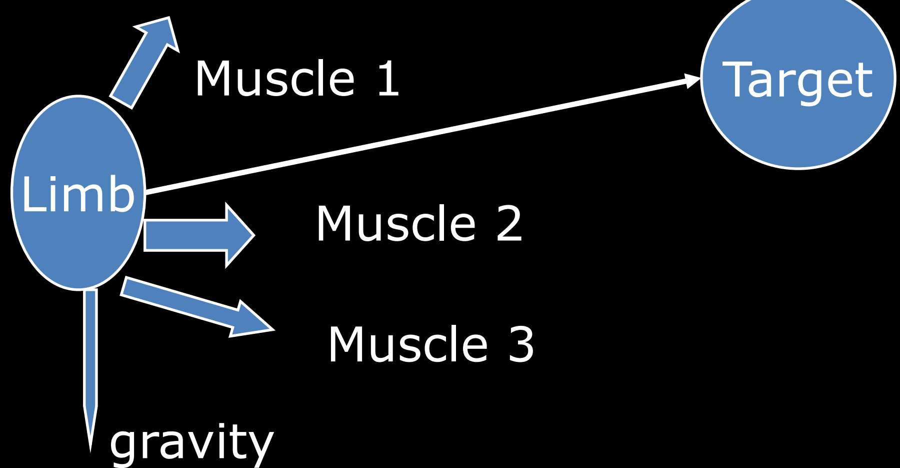
1. Reflexes
2. Postural Control
3. Cyclical Movements
4. Goal Directed Action
5. Motor Control


Dorsal
stream
Ventral
stream


Pre Motor
Motor
Execution
Control
Somatosensory Cortex
LPA
PPC
Motor Plan
Cerebellum
SMA
Primary Motor Cortex
CNS
PNS

The Need for Control

There are errors in a motor command



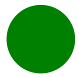
Three Sources of Errors

1. A Poor Motor Command (imperfect memory)

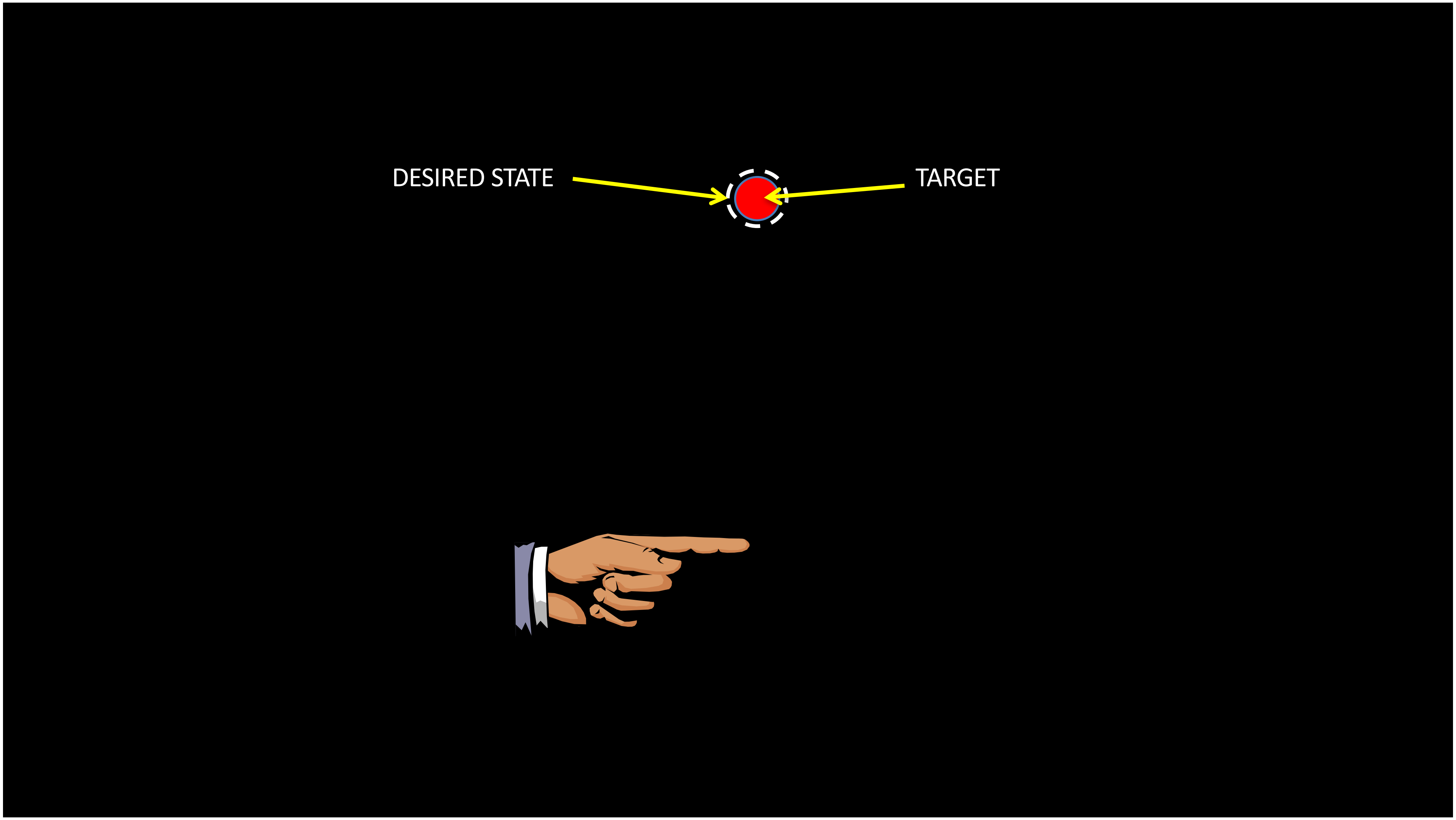
2. Neuromotor Noise

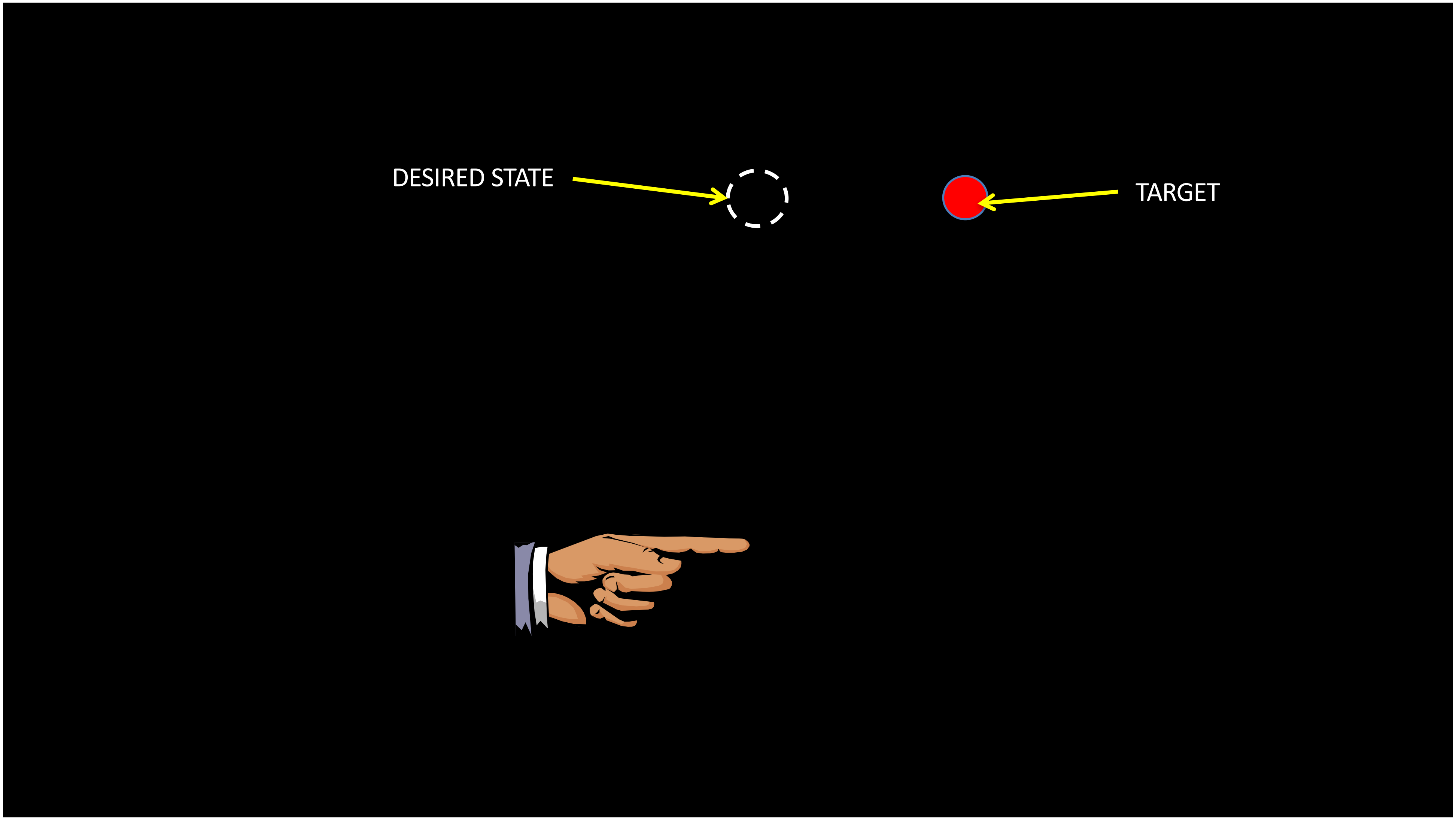
3. Changes in the Environment

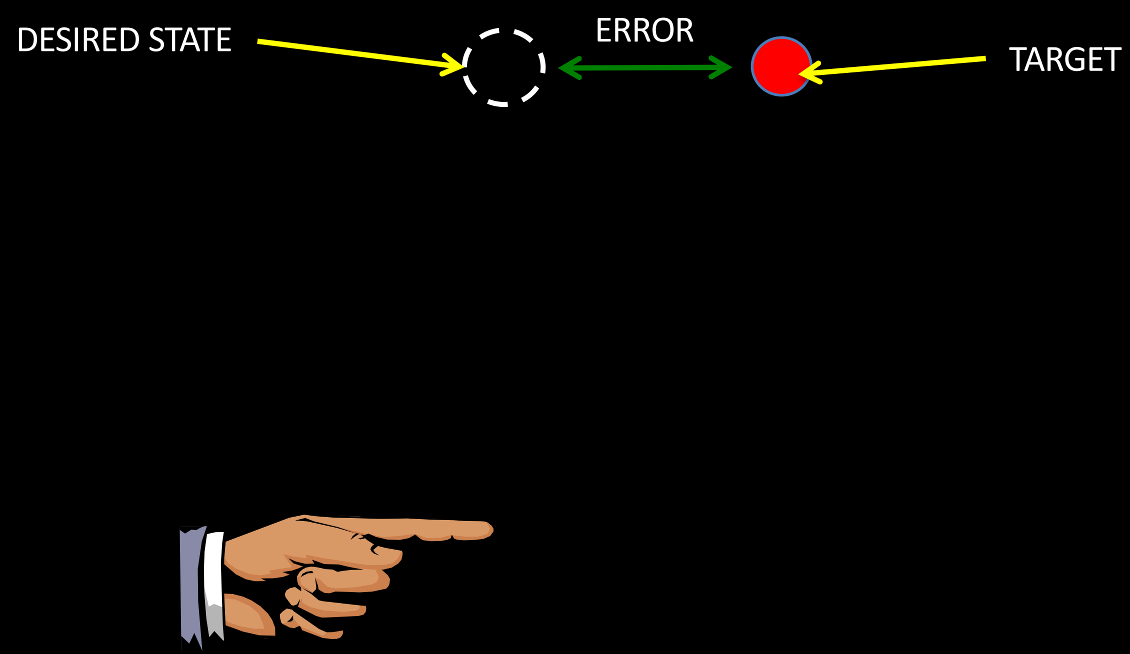
Goodale, Pelisson, & Prablanc (1986)



Goodale, Pelisson, & Prablanc (1986)

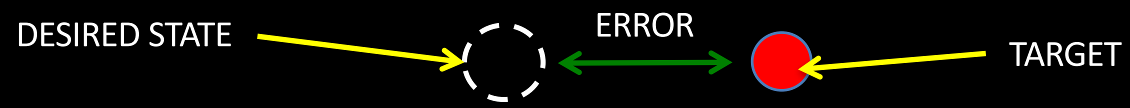

DESIRED STATE
TARGET


DESIRED STATE
TARGET

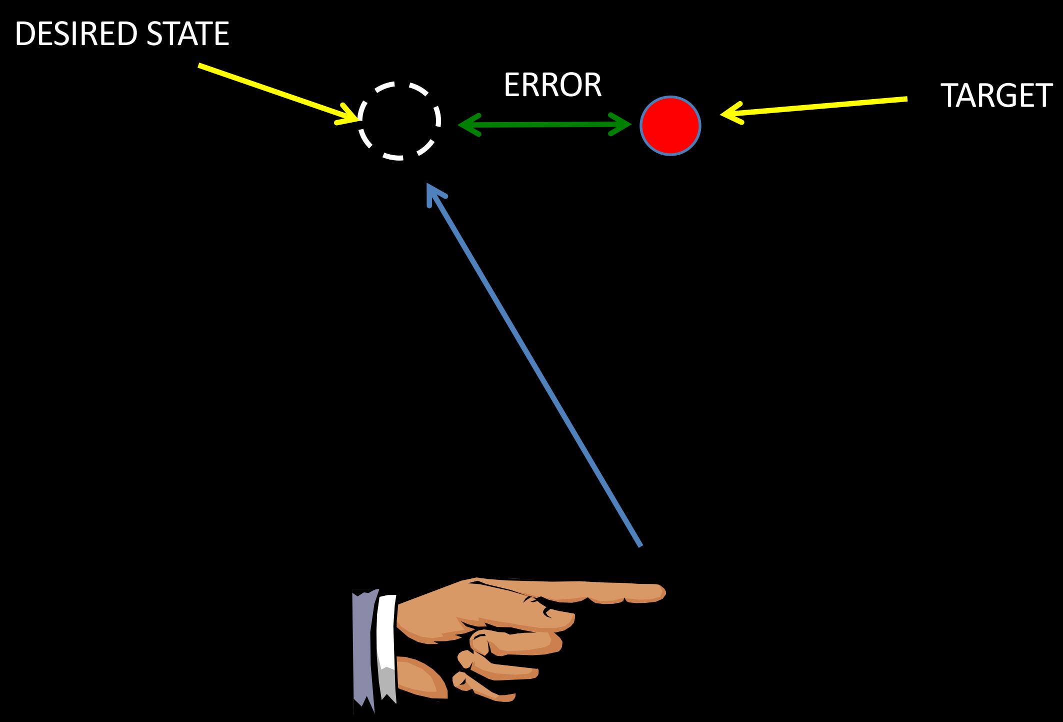


$$ERROR = X_t - X_d$$

The motor system is continually working to minimize ERROR



But never forget it takes time to COMPUTE X_d and X_t , thus corrections are not instantaneous, but occur after a visual processing delay (100 – 150 ms)



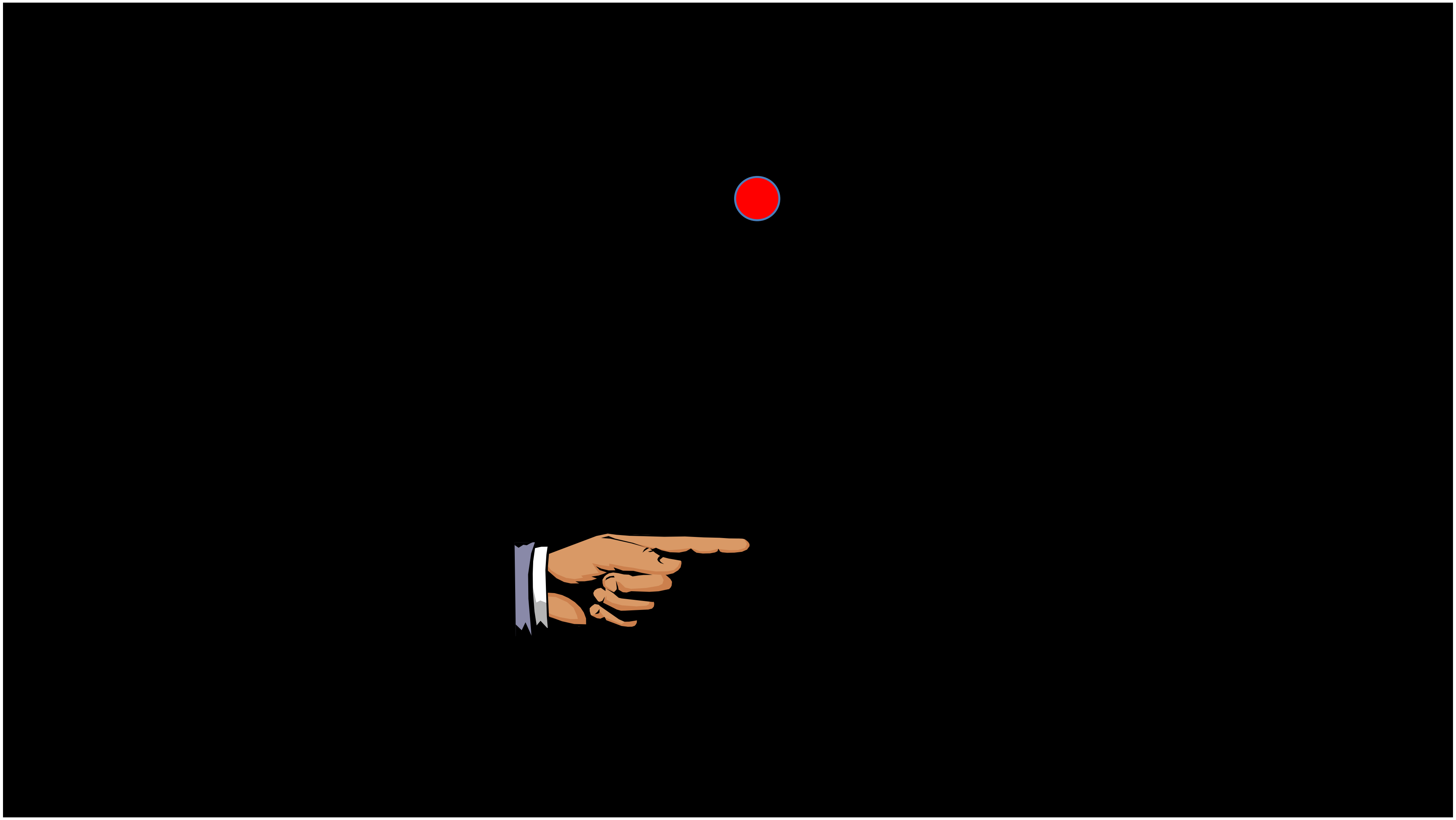
ERROR = $X_t - X_d$

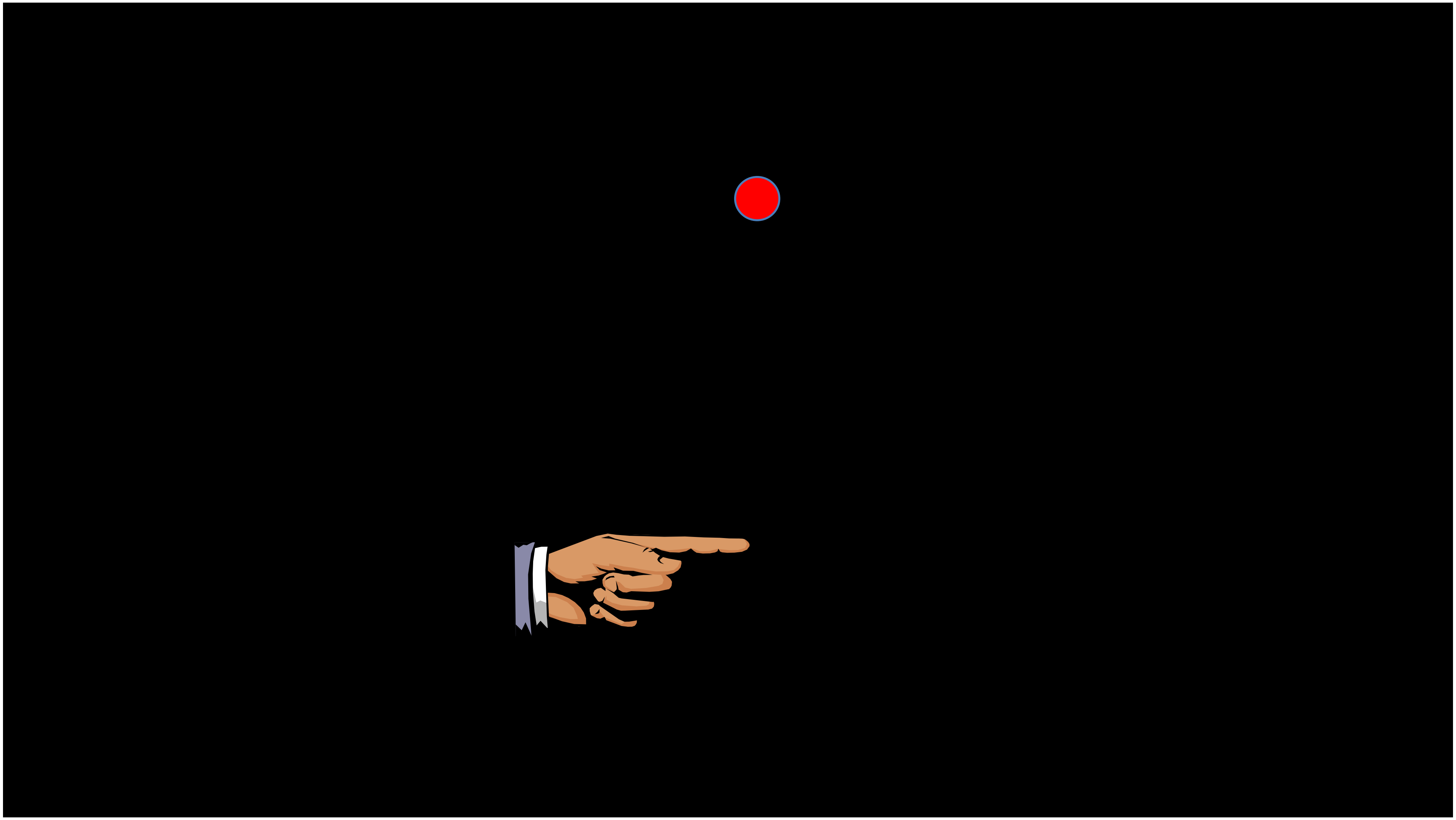
The motor system is continually working to minimize ERROR

Two Types of Control

1. Feedback Based
2. Forward Control (maybe…)

Westwood, Heath, Roy (2001)





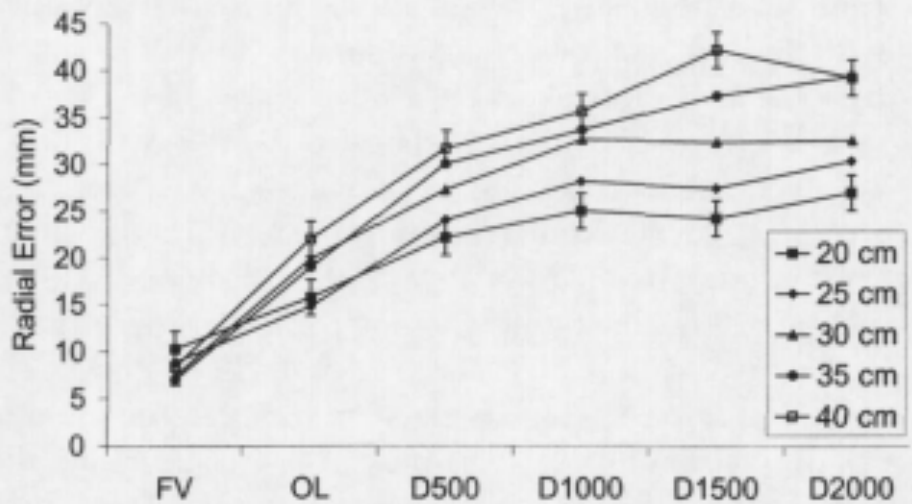


Figure 1. Radial error (mm) for reaching movements to 20, 25, 30, 35, and 40 cm target amplitudes in full vision (FV), open-loop (OL), and 500-2000 ms delay conditions (D500-D2000). Bars represent within-subjects SEM; for clarity, bars are only shown for the 20 cm and 40 cm targets.

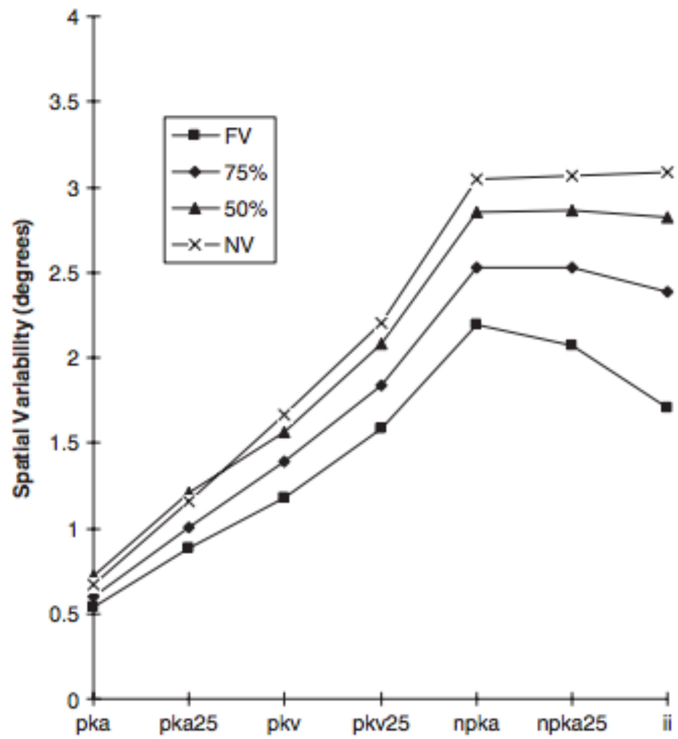
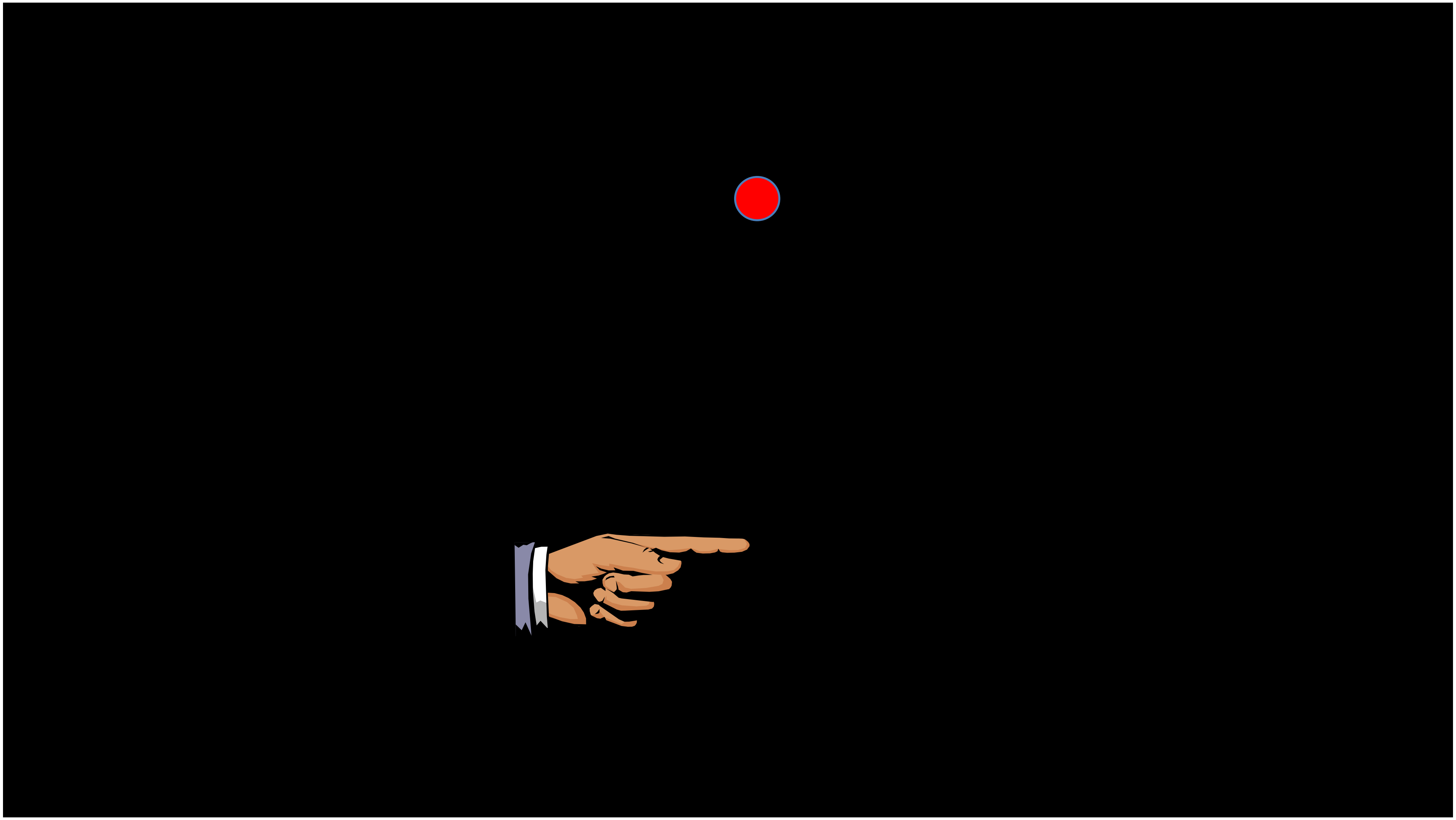
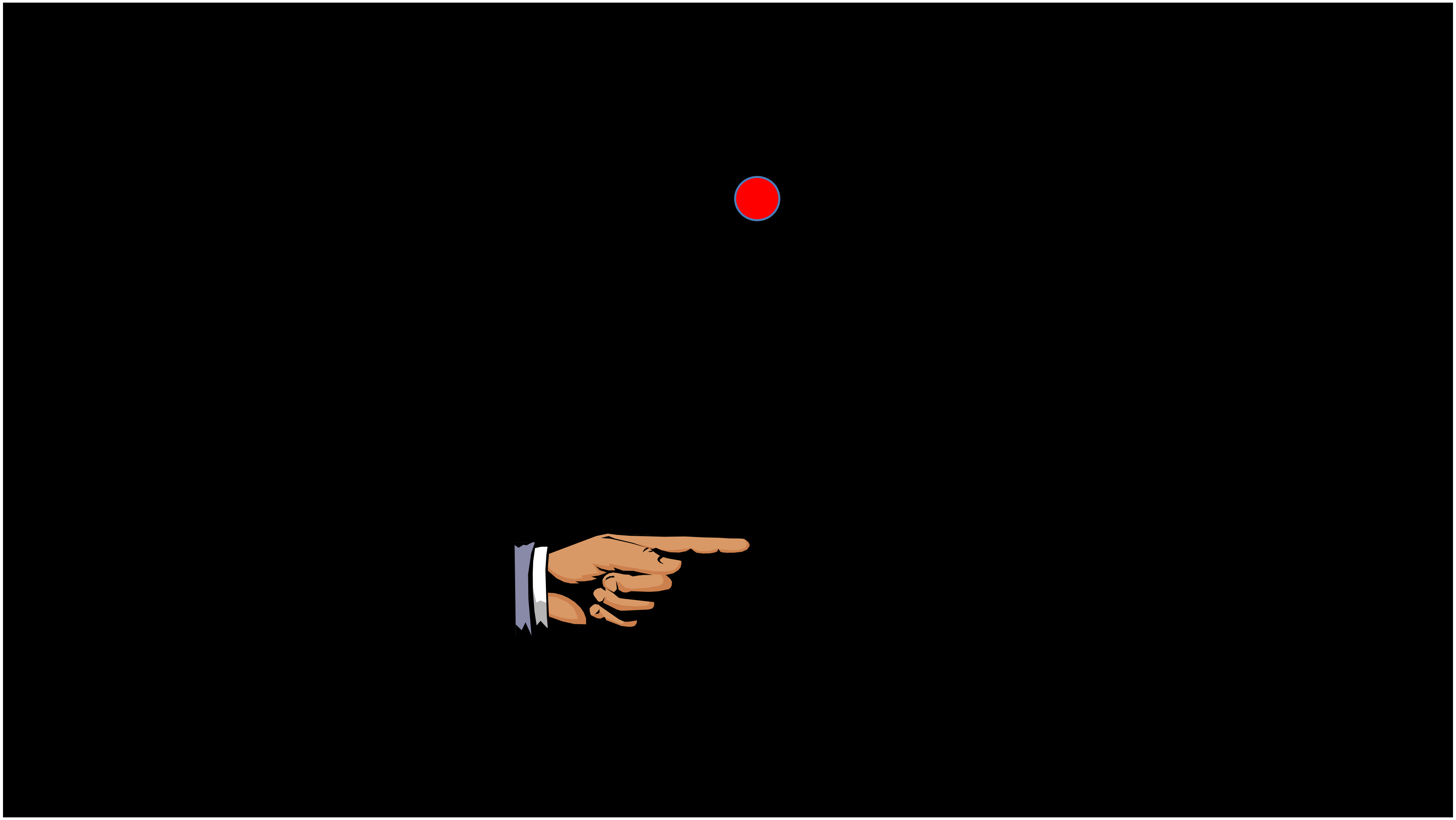
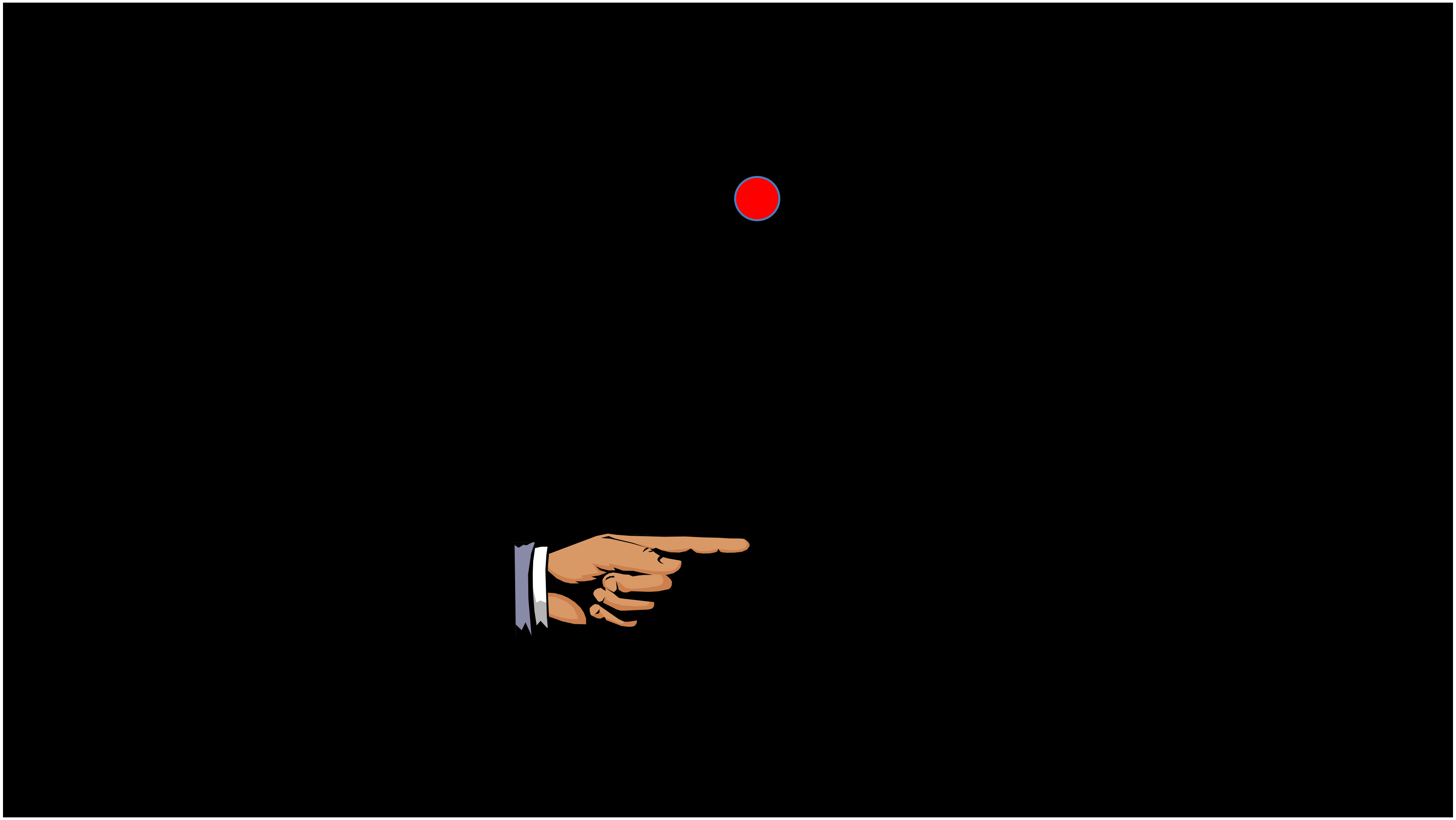


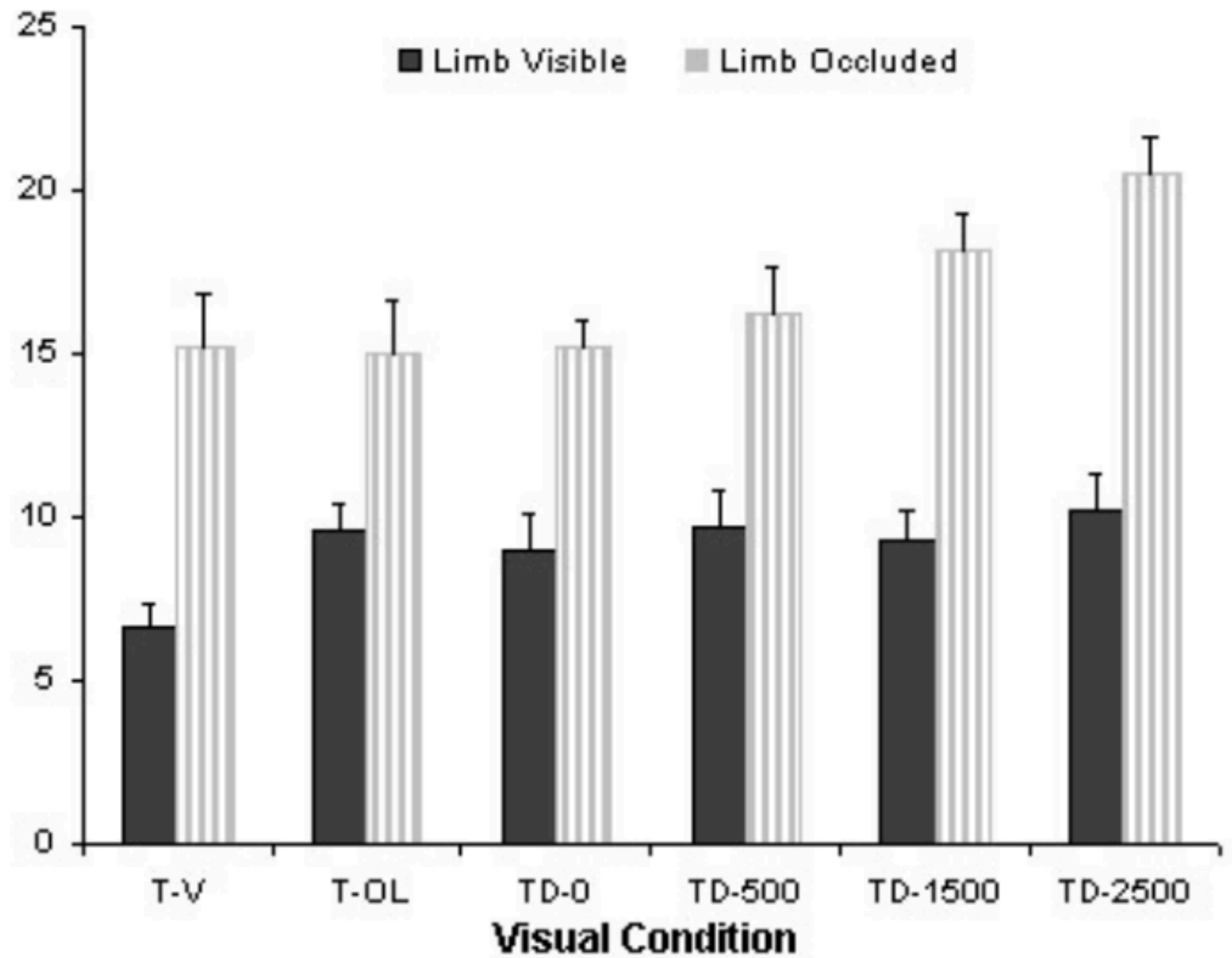
Fig. 2. Variability in distance traveled at peak acceleration (pka), peak acceleration + 25 ms (pka25), peak velocity (pkv), peak velocity + 25 ms (pkv25), negative peak acceleration (npka), negative peak acceleration + 25 ms (npka25), and at the end of the initial impulse (ii) for the FV, 75%V, 50%V and NV conditions (adapted from Khan and Franks (2003)).

Heath 2005

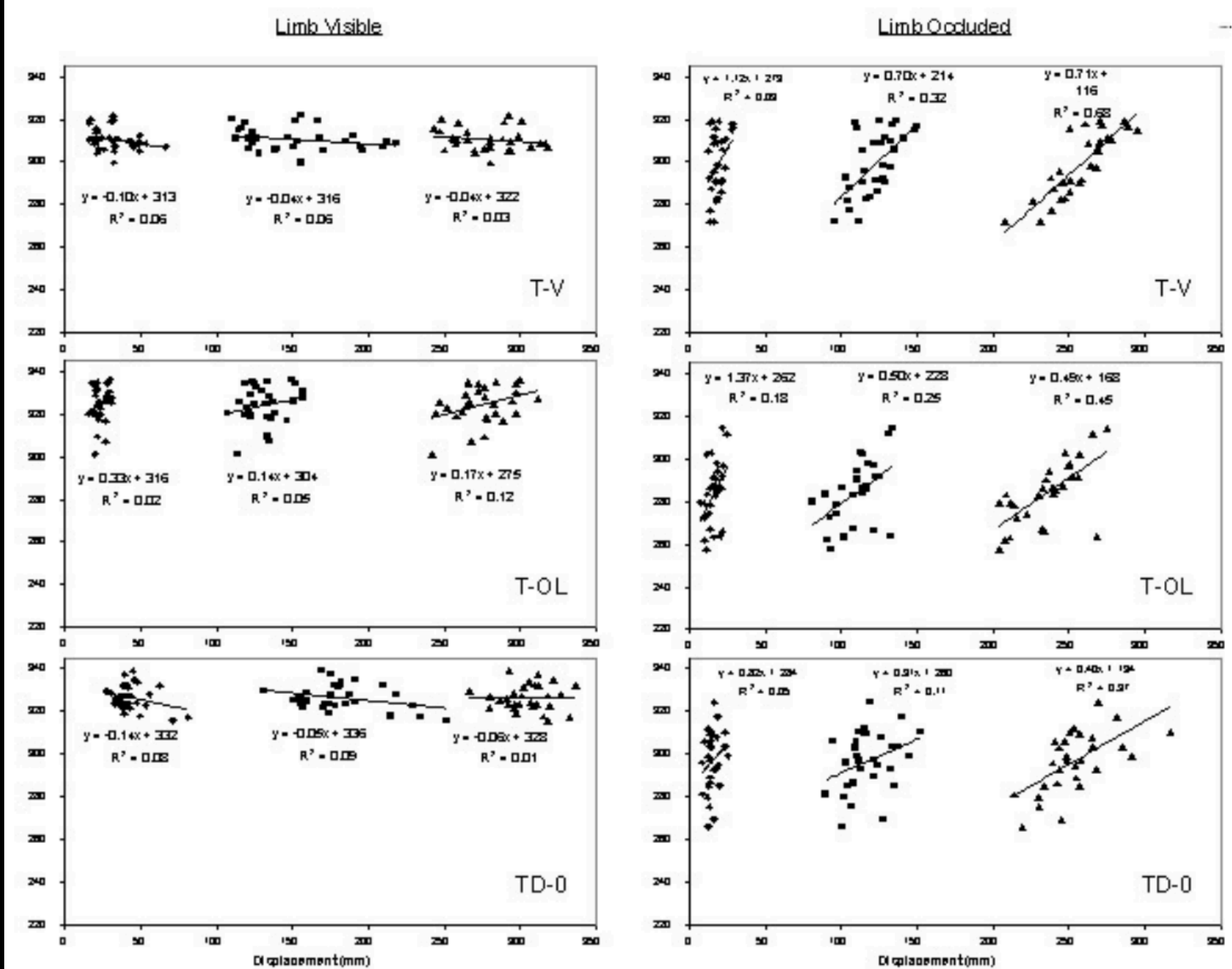




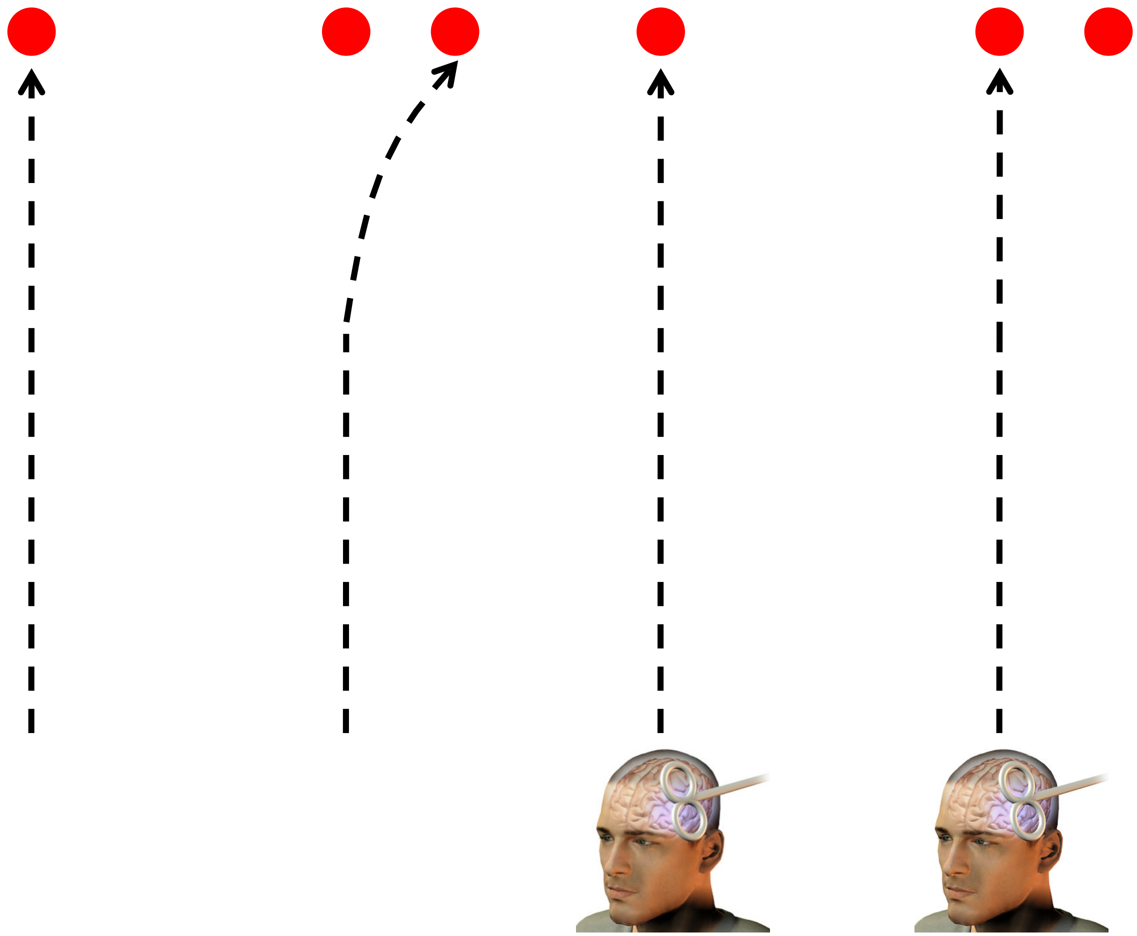




Limb Visible
Limb Occluded
25
20
15
10
5
0
T-V
T-OL
TD-0
TD-500
TD-1500
TD-2500
Visual Condition


Limb Visible
Limb Occluded
y = -0.10x + 313
R² = 0.06
y = -0.04x + 316
R² = 0.06
y = -0.04x + 322
R² = 0.03
T-V
y = 0.70x + 214
R² = 0.32
y = 0.71x + 116
R² = 0.68
T-V
y = 0.33x + 316
R² = 0.02
y = 0.14x + 304
R² = 0.05
y = 0.17x + 275
R² = 0.12
T-OL
y = 1.37x + 262
R² = 0.18
y = 0.50x + 228
R² = 0.25
y = 0.45x + 168
R² = 0.45
T-OL
y = -0.14x + 332
R² = 0.08
y = -0.05x + 336
R² = 0.09
y = -0.06x + 328
R² = 0.01
TD-0
TD-0
Displacement(mm)
Displacement(mm)

Desmurget et al. 1999



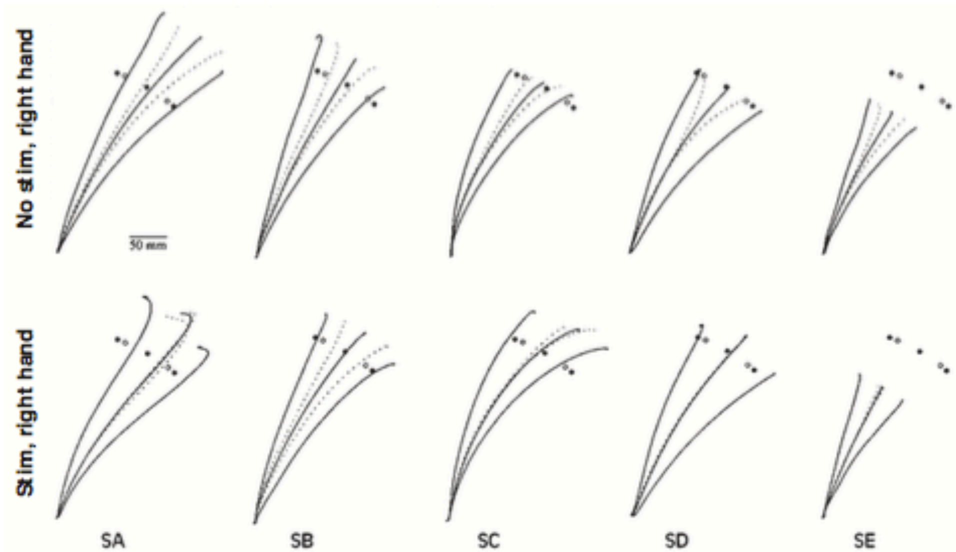
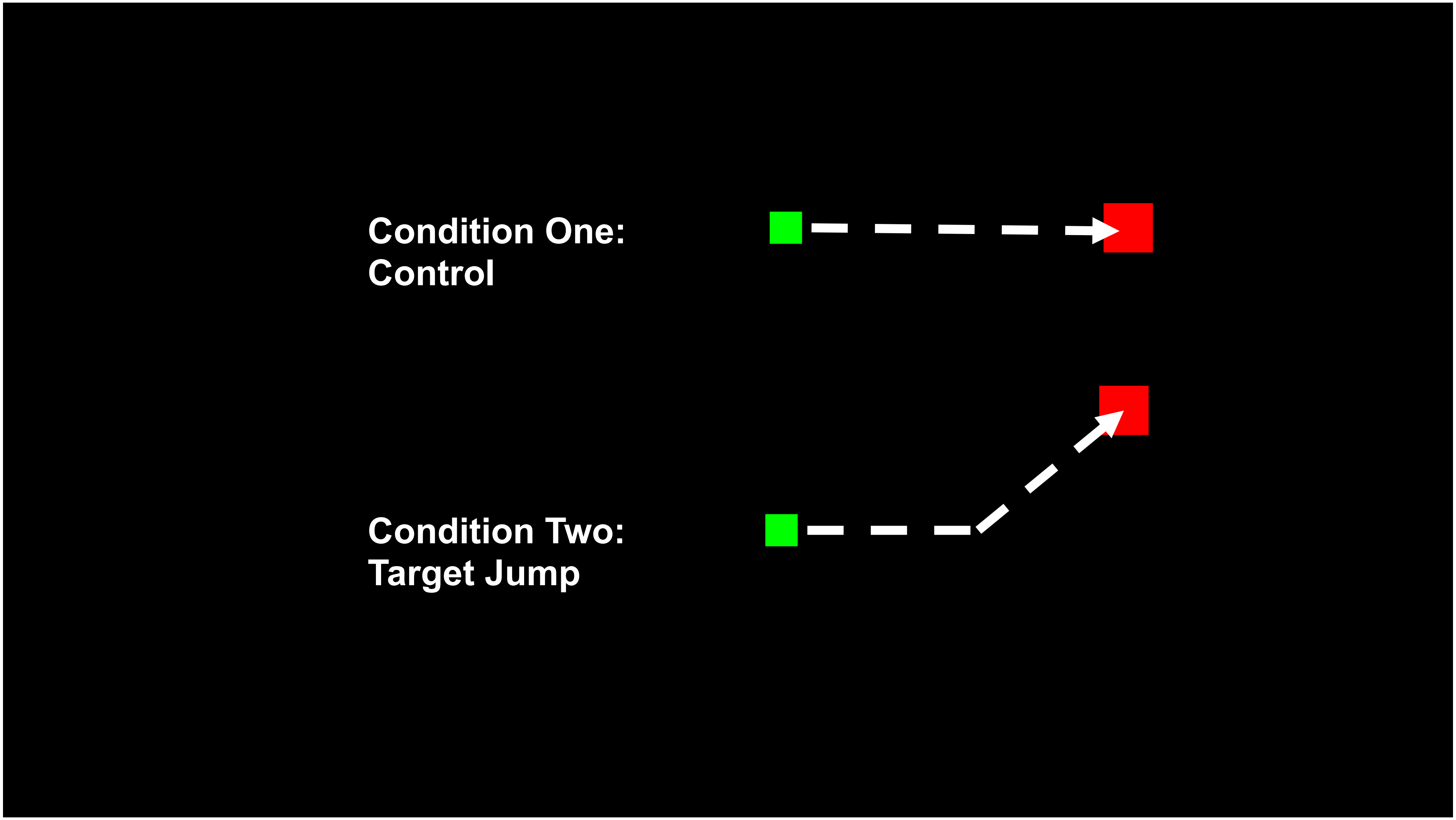


Fig. 1. Mean hand paths produced by all subjects (SA–SE) with the right, dominant hand in the non-stimulated (upper row) and stimulated (lower row) conditions. Mean trajectories were computed after temporal normalization of the individual trials ($n = 10$). The black continuous curves represent the mean paths directed at stationary targets (20, 30 and 40 degrees). The gray dashed curves represent the mean paths directed at jumping targets (30 → 22.5 and 30 → 37.5 degrees). Black circles indicate stationary target locations, whereas white circles represent jumping target locations.

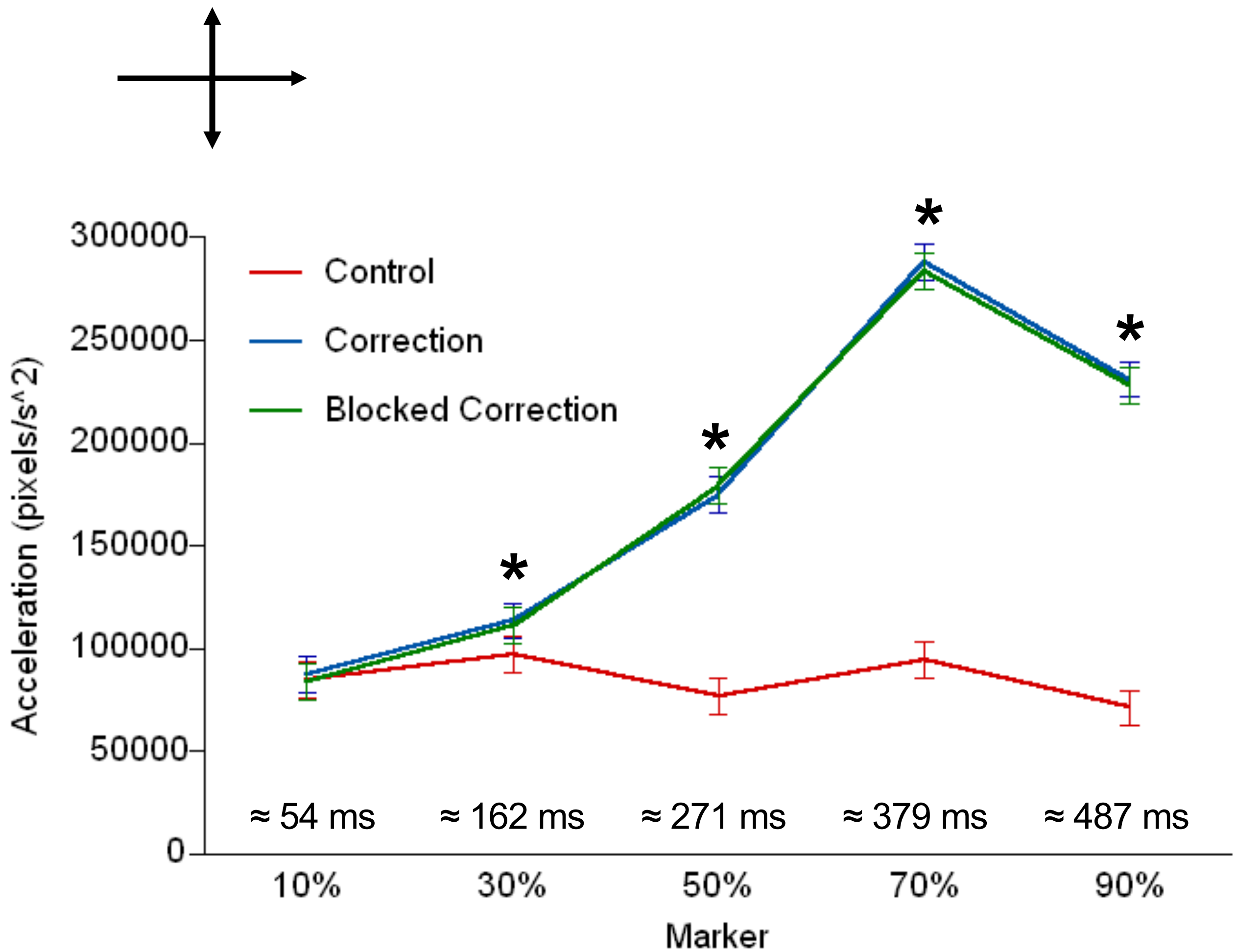
Krigolson & Holroyd 2007

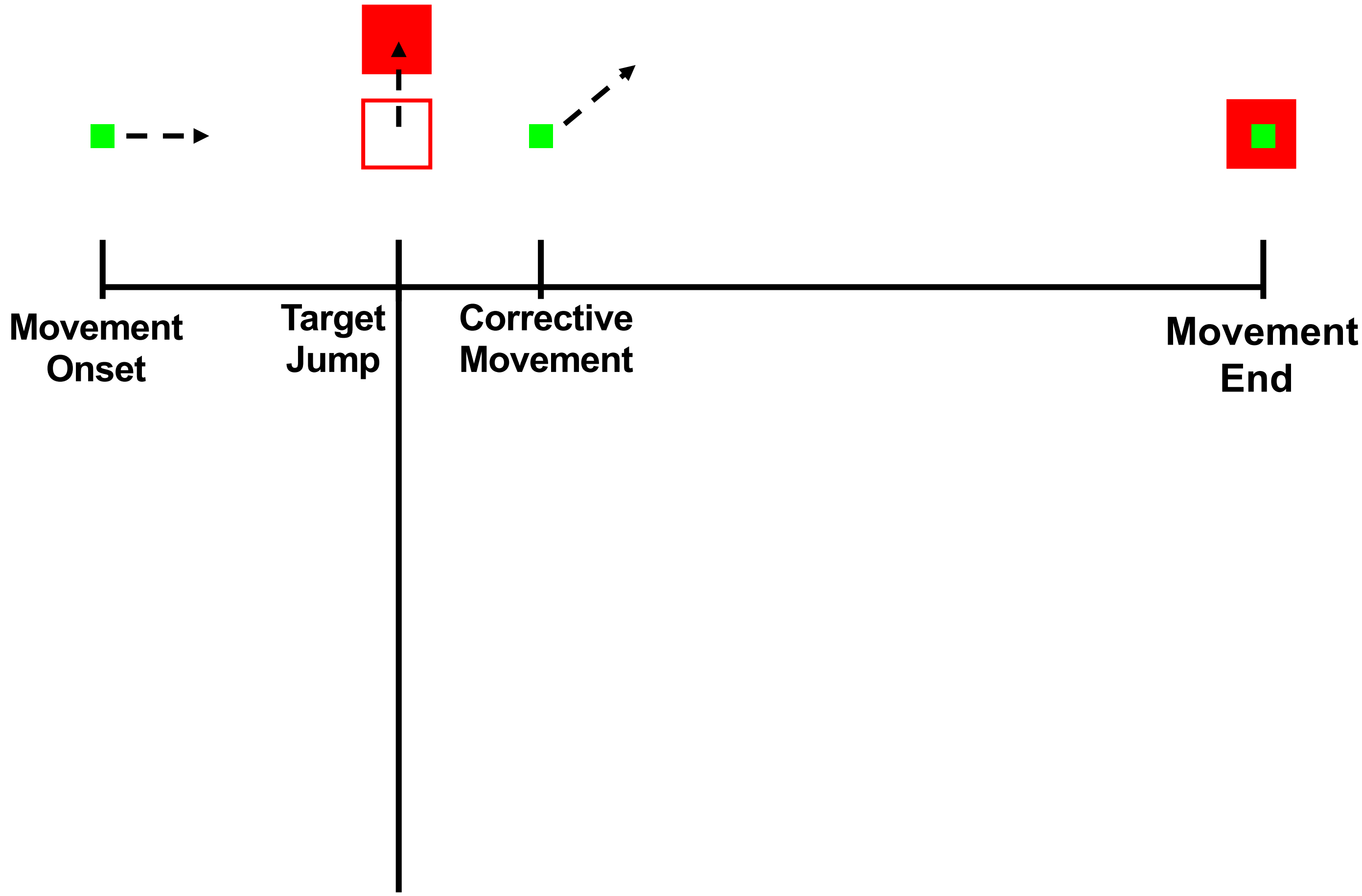
Target Errors



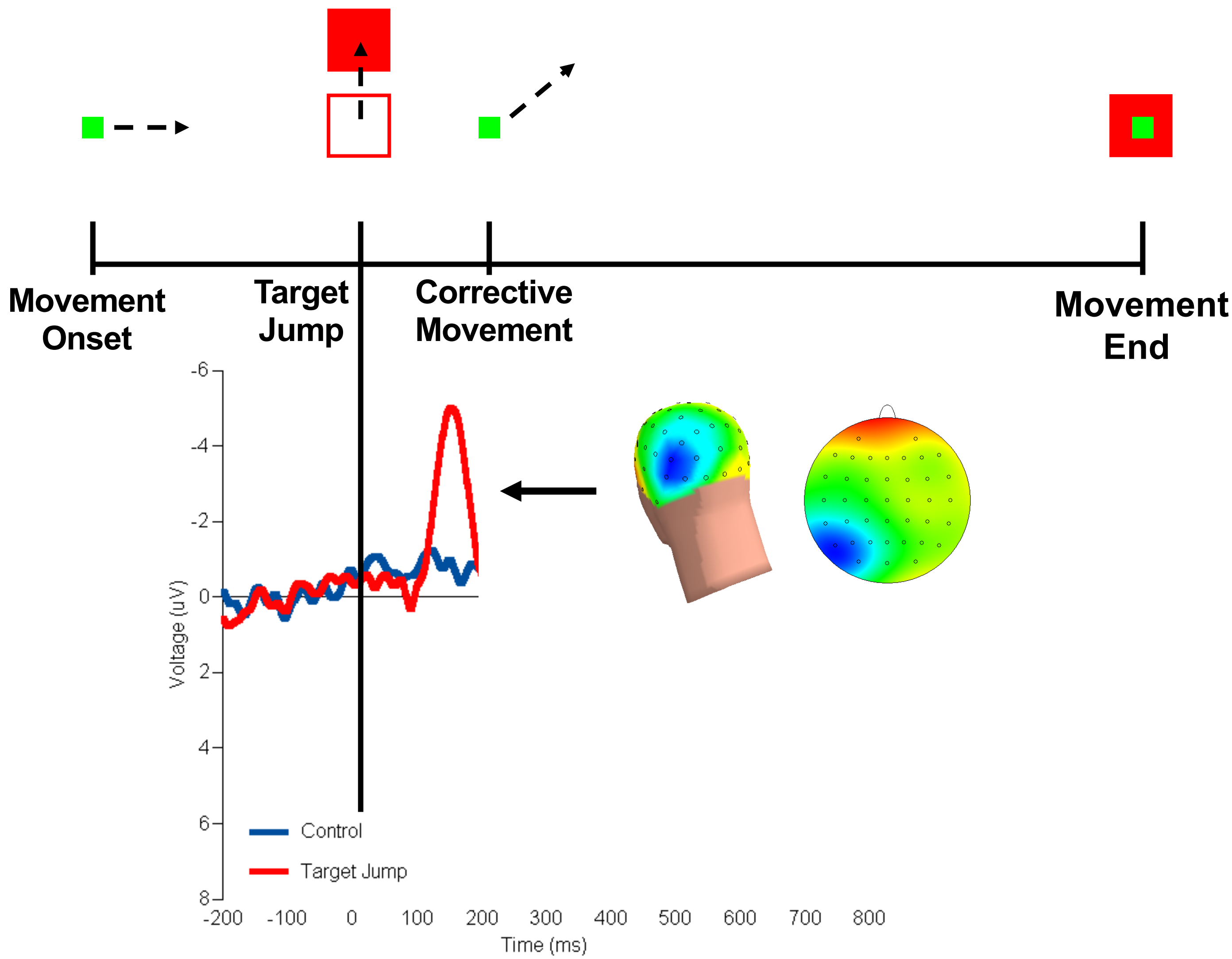
Condition One:
Control
Condition Two:
Target Jump

Secondary Movement Axis: Acceleration as a Function of Experimental Condition

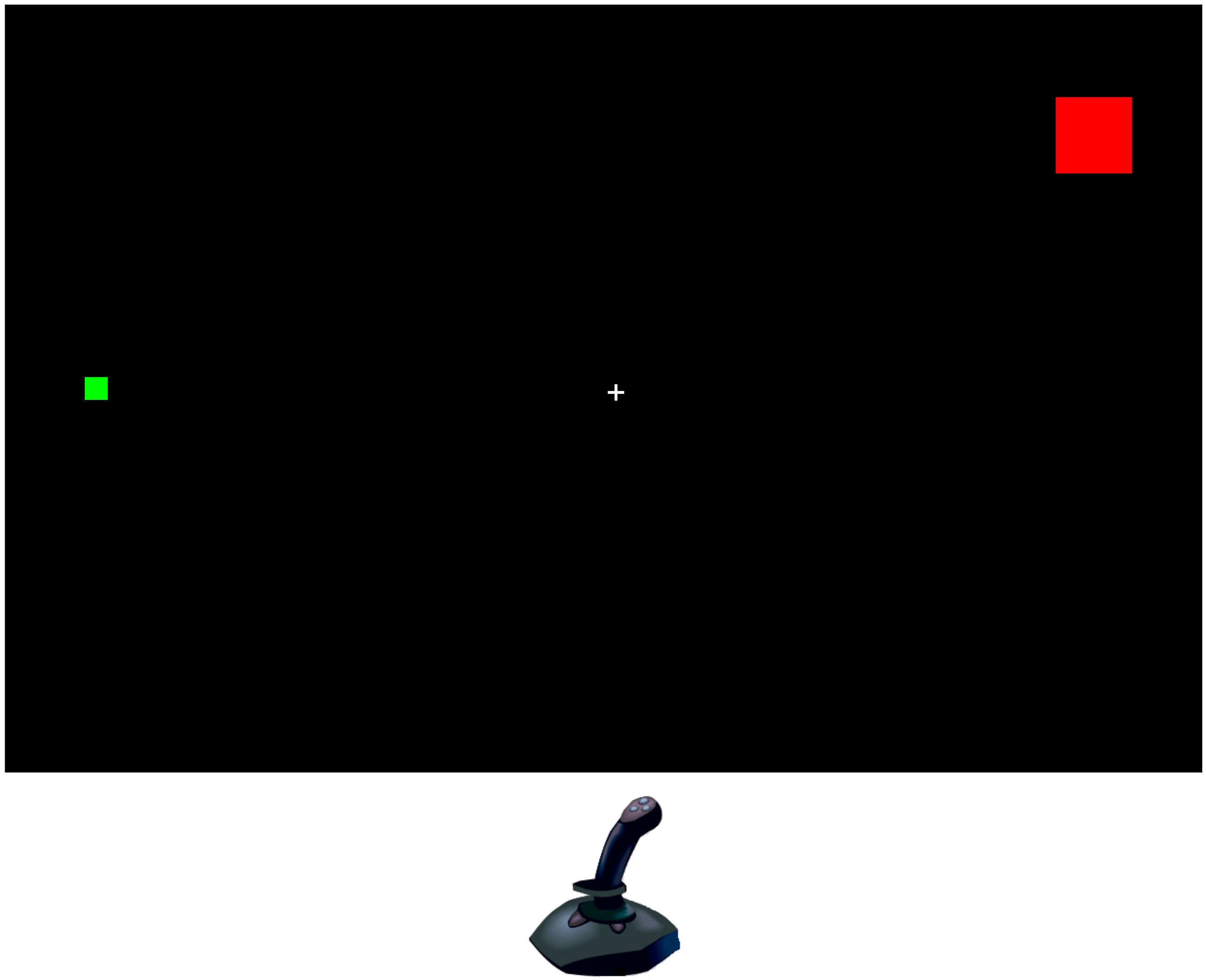


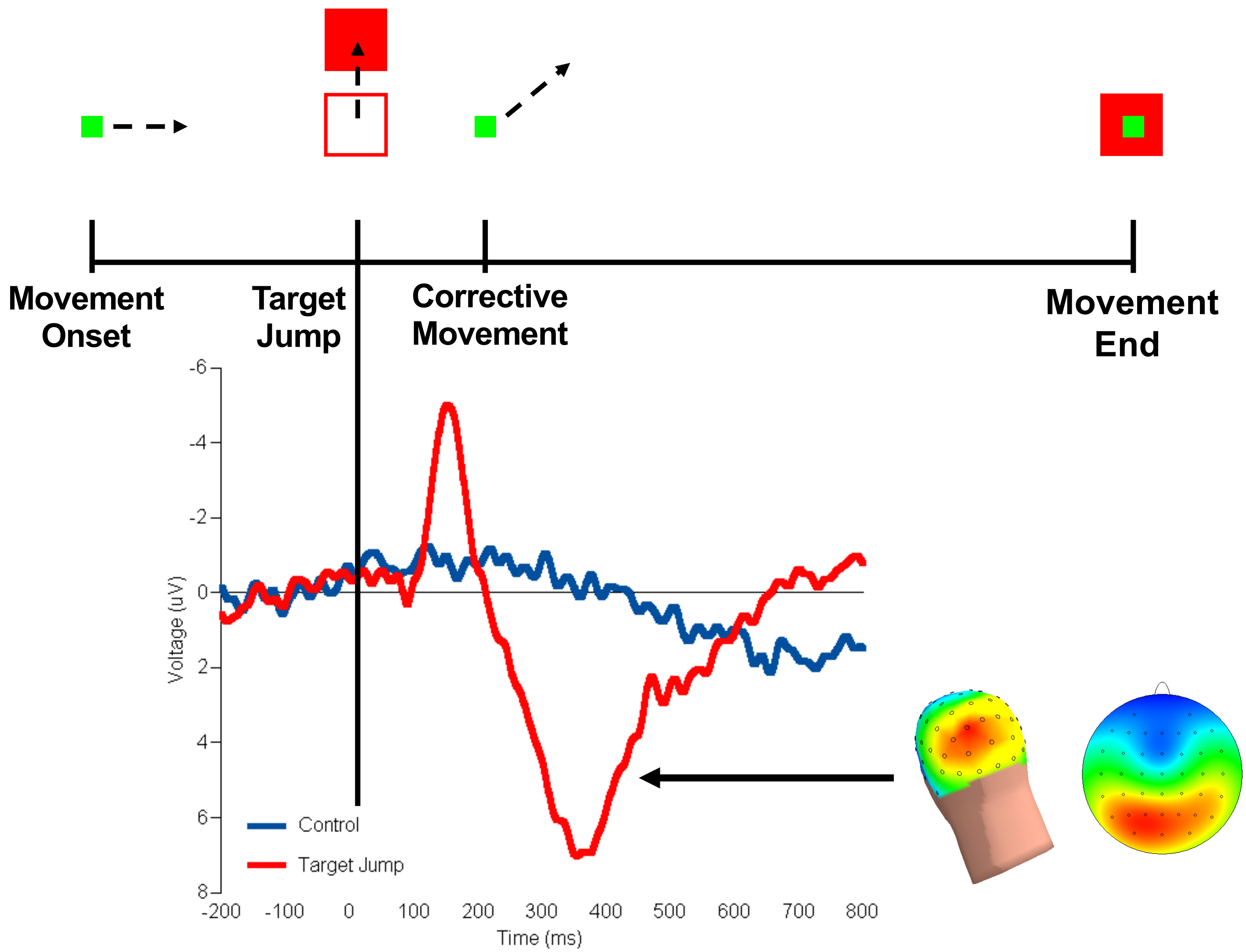


Movement Onset
Target Jump
Corrective Movement
Movement End



Movement Onset
Target Jump
Corrective Movement
Movement End
-6
-4
-2
0
2
4
6
8
Voltage (uV)
Control
Target Jump
-200
-100
0
100
200
300
400
500
600
700
800
Time (ms)

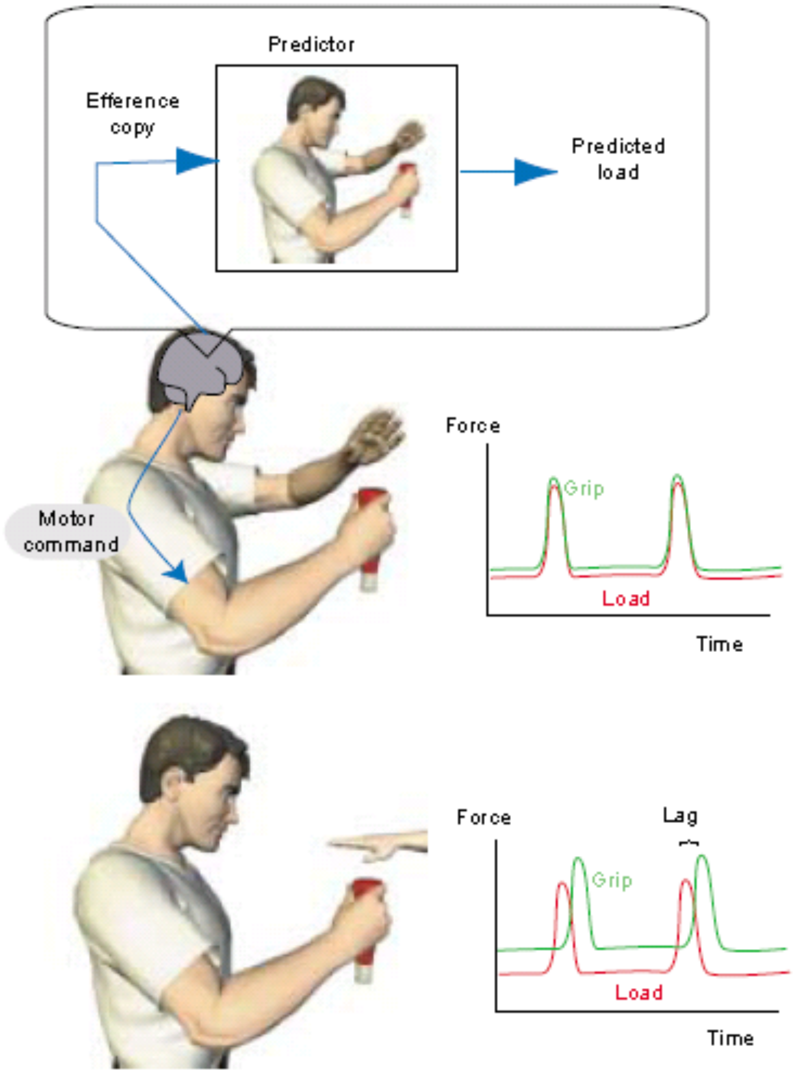



Movement Onset
Target Jump
Corrective Movement
Movement End
Voltage (uV)
-6
-4
-2
0
2
4
6
8
-200
-100
0
100
200
300
400
500
600
700
800
Time (ms)
Control
Target Jump

FORWARD CONTROL

Why aren’t feedback loops enough?

(another way to think of this is what is an inherent problem with feedback loops)



Predictor
Efference copy
Predicted load
Motor command
Force
Grip
Load
Time
Force
Lag
Grip
Load
Time

How does predictive control work?

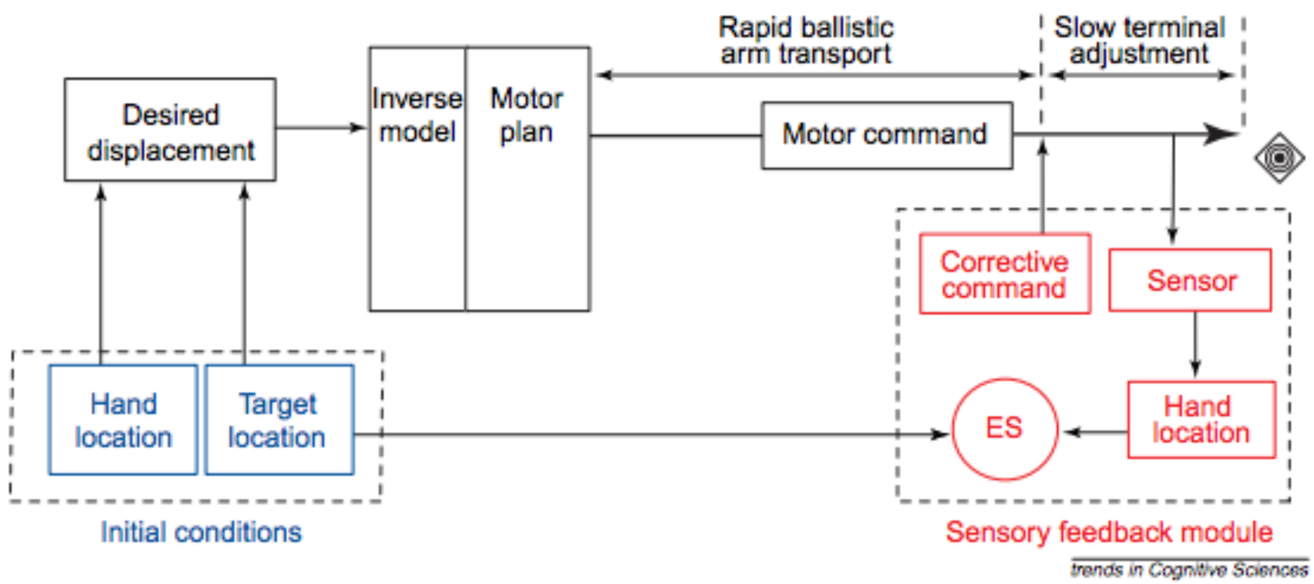
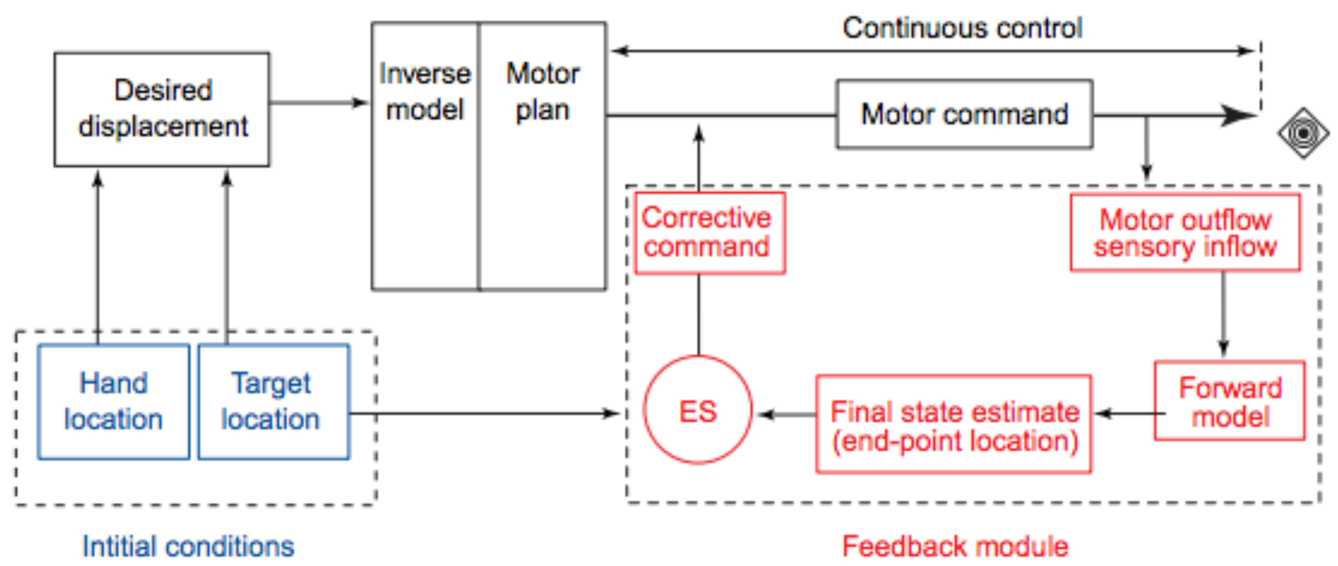


Fig. 1. The classical dual model of movement control. The required arm displacement is estimated based on the respective locations of the hand and target. This displacement is then converted into a motor plan through an inverse model. The main part of the movement unfolds under the rigid control of this plan (ballistic arm transport). Sensory feedback loops become active at the very end of the movement, when velocity is low. The current location of the hand is then compared to the target position. In case of a discrepancy, an error signal (ES) is issued and a series of corrective sub-movements is generated. The movement stops when the hand reaches the target (circle in diamond).

Predicted State
Estimate of Target Location
Physical Target Location

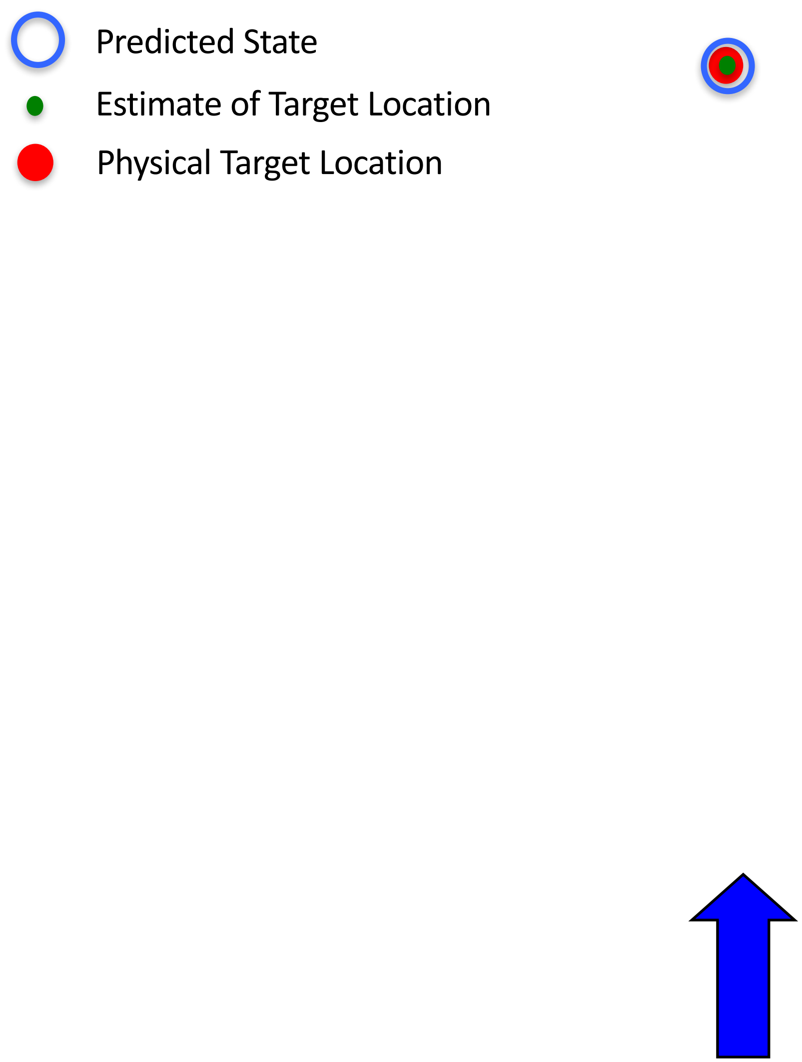
ERROR!
ERROR = Predicted – Estimate
ERROR ~= 0
Minimize Error!

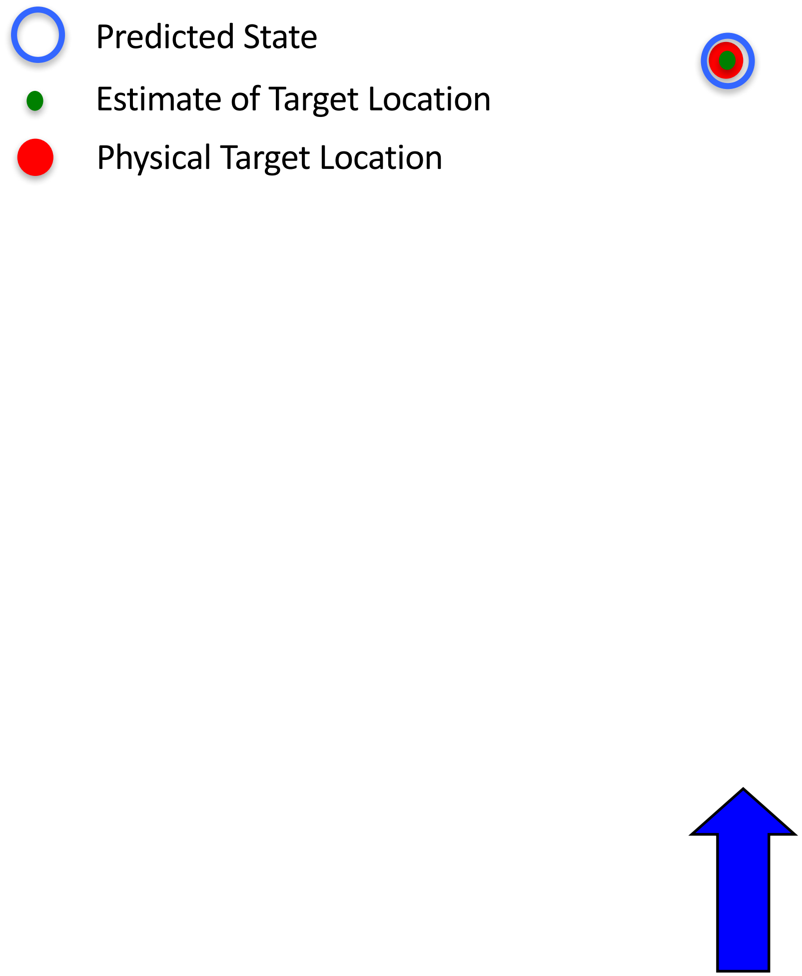
What system is fixing this problem?

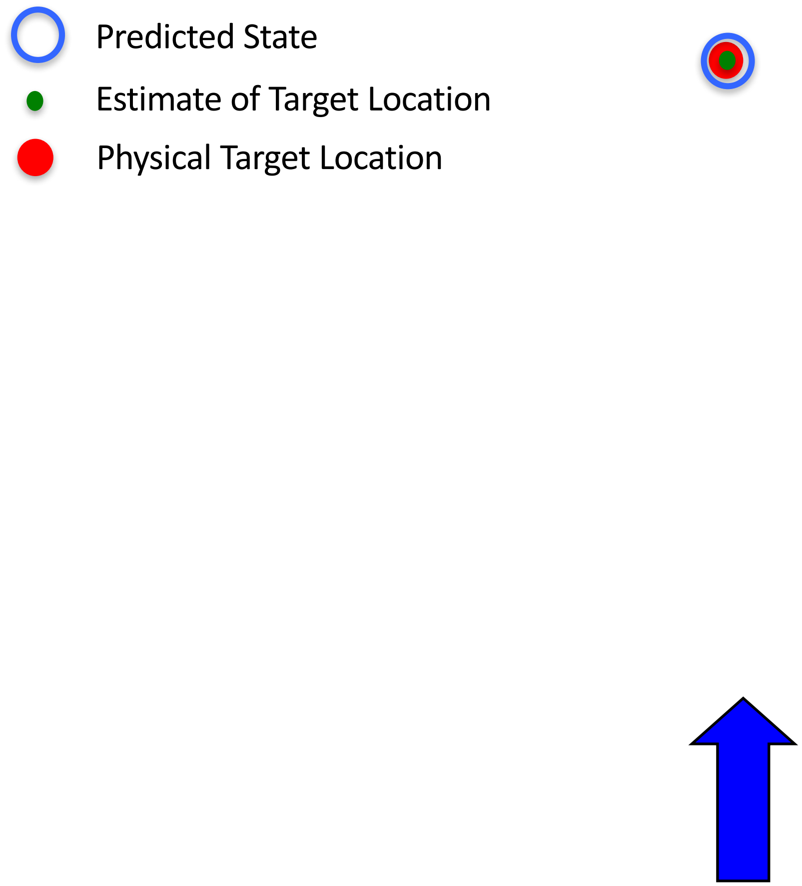


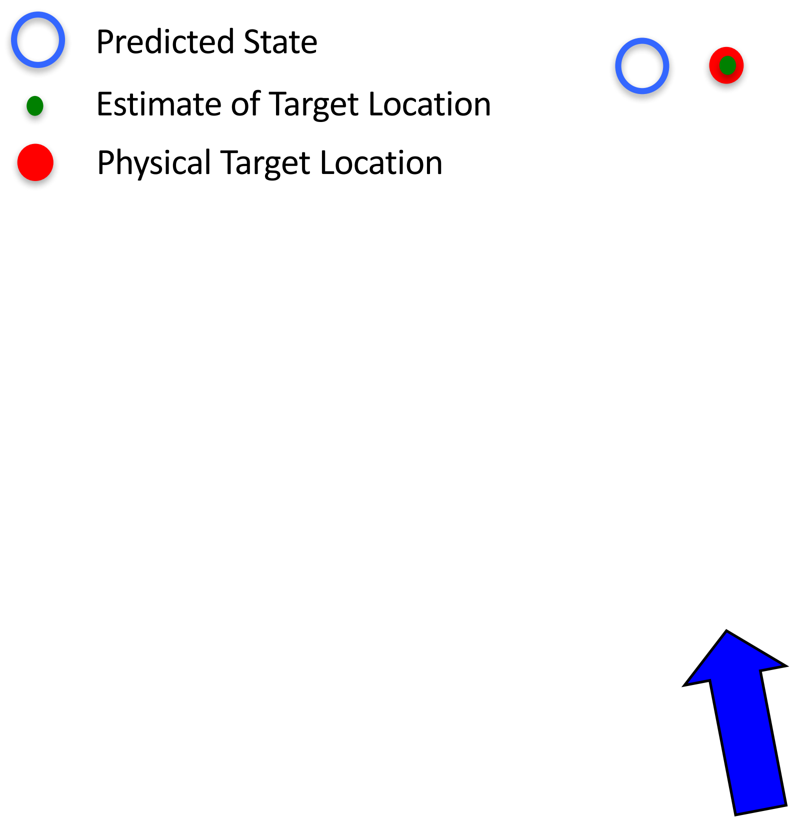
trends in Cognitive Sciences

Fig. 2. Simplified hybrid circuits that makes use of a forward model of arm dynamics for controlling hand movements. A motor plan is initially defined based on the respective locations of the hand and target. During the movement, a forward model of the dynamics of the arm is generated. This model receives the sensory inflow and a copy of the motor outflow as inputs and generates an estimate of the movement end-point location as output. This estimate is compared to the target location. In case of discrepancy, an error signal (ES) is generated, triggering a modulation of the ongoing motor command.


Predicted State
Estimate of Target Location
Physical Target Location




Predicted State
Estimate of Target Location
Physical Target Location


Predicted State
Estimate of Target Location
Physical Target Location

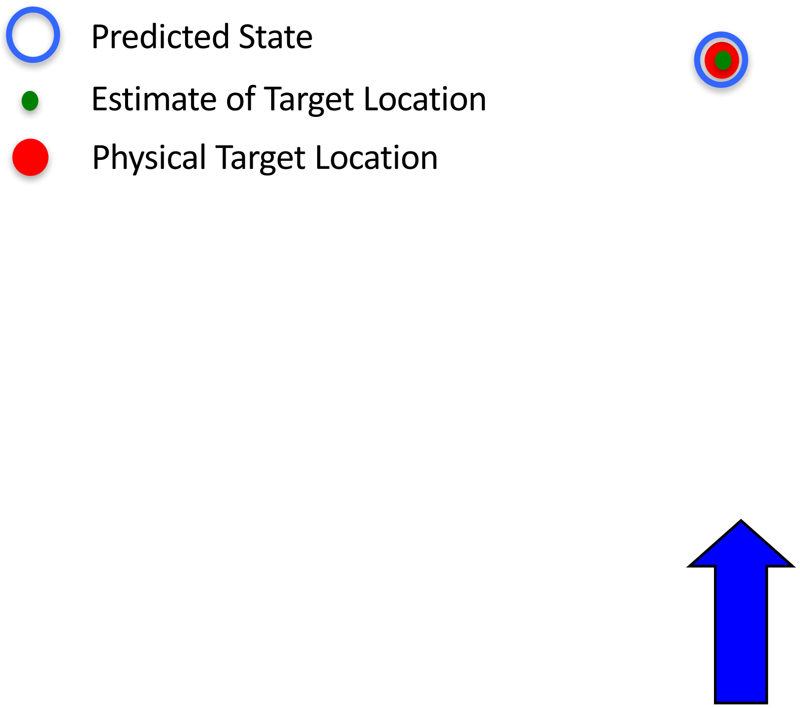
Predicted State

Estimate of Target Location

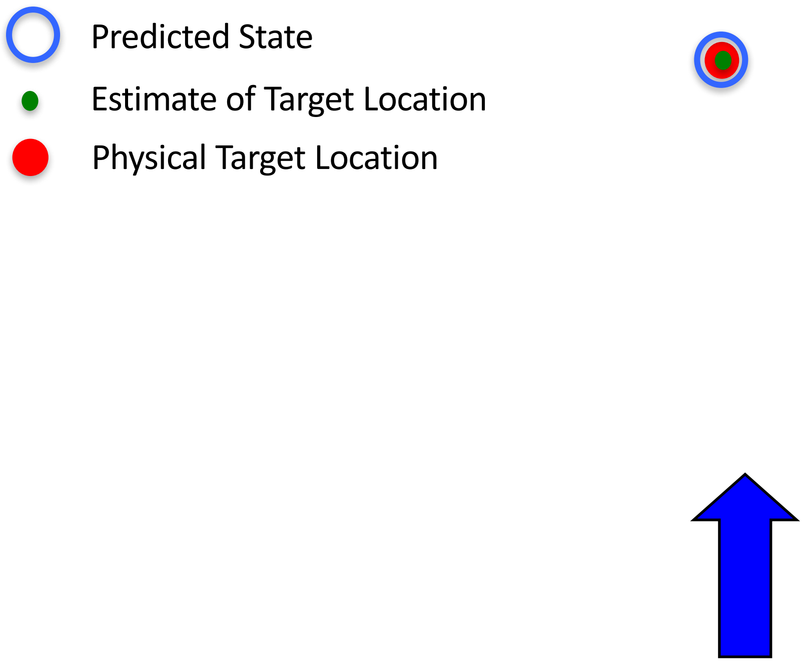
Physical Target Location

ERROR!
ERROR = Predicted – Estimate
ERROR ~= 0
Minimize Error!

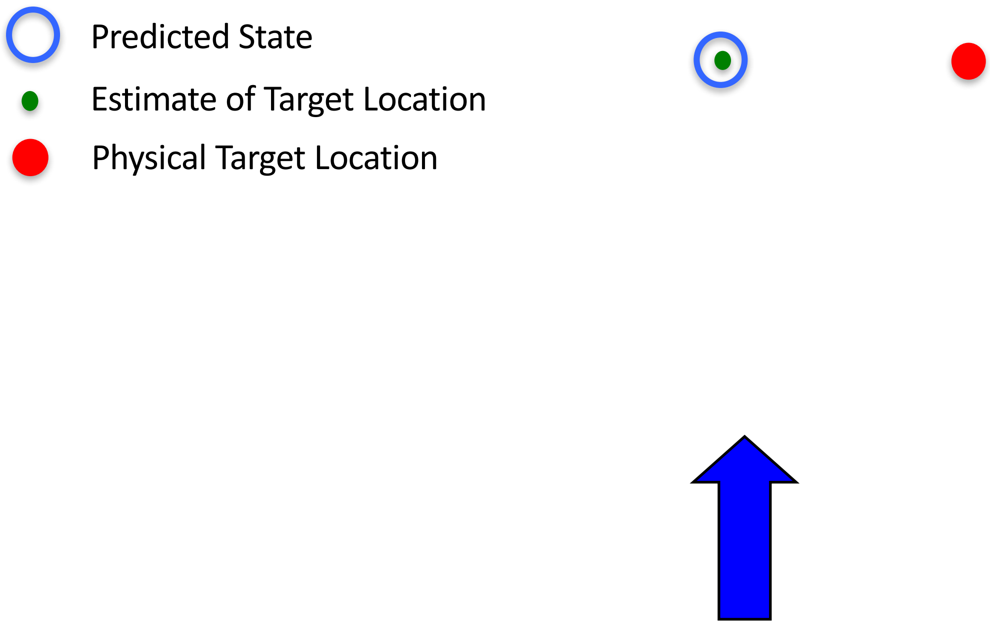
What system is fixing this problem?



No ERROR!
ERROR = Predicted – Estimate
ERROR = 0



No ERROR!
ERROR = Predicted – Estimate
ERROR = 0

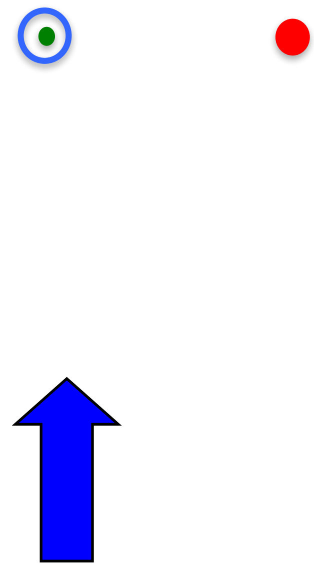


No ERROR!
ERROR = Predicted – Estimate
ERROR = 0

Predicted State

Estimate of Target Location

Physical Target Location



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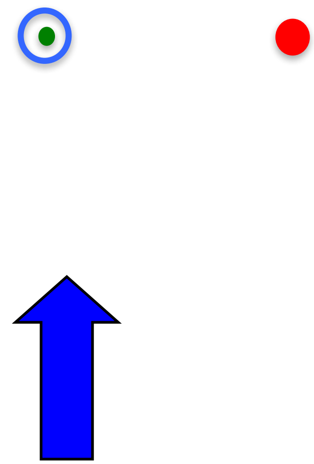

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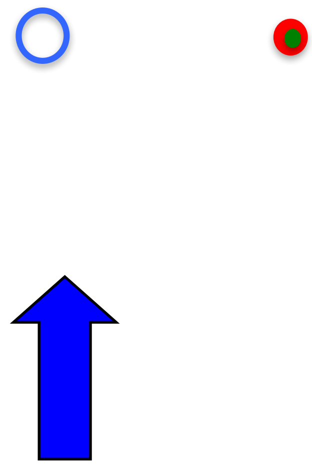
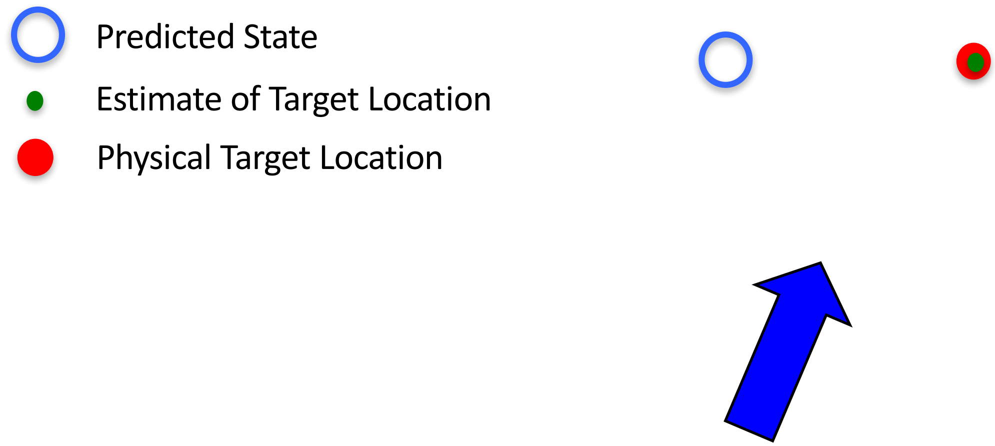


ERROR!
ERROR = Predicted – Estimate
ERROR ~= 0
Minimize Error

Why the delay this time?
What system fixes this?



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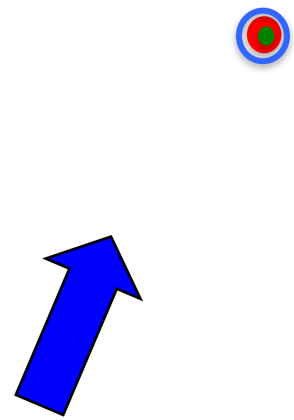

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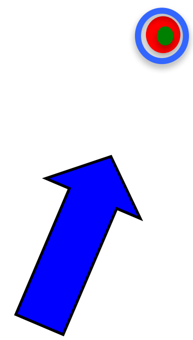

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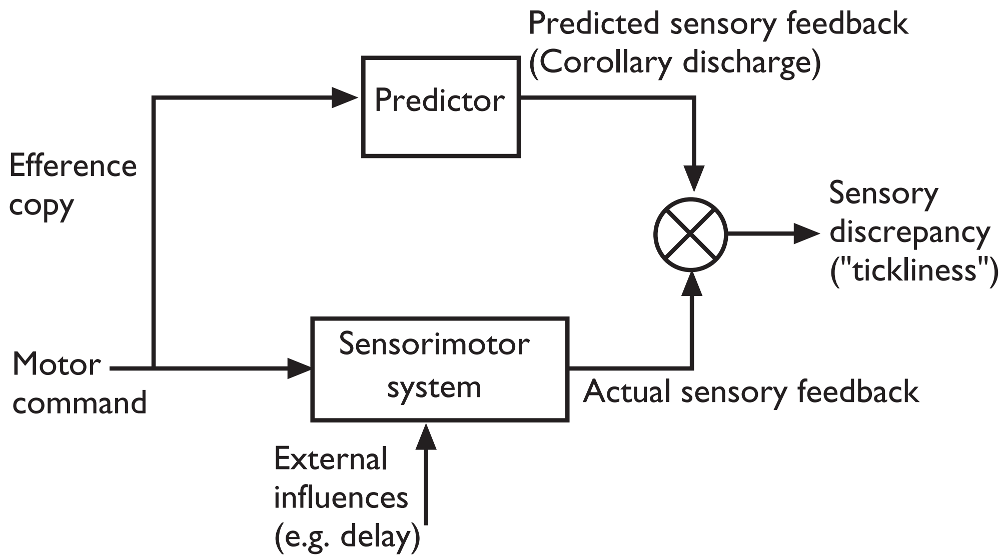

Predicted sensory feedback
(Corollary discharge)
Predictor
Efference
copy
Sensory
discrepancy
("tickliness")
Sensorimotor
system
Motor
command
Actual sensory feedback
External
influences
(e.g. delay)

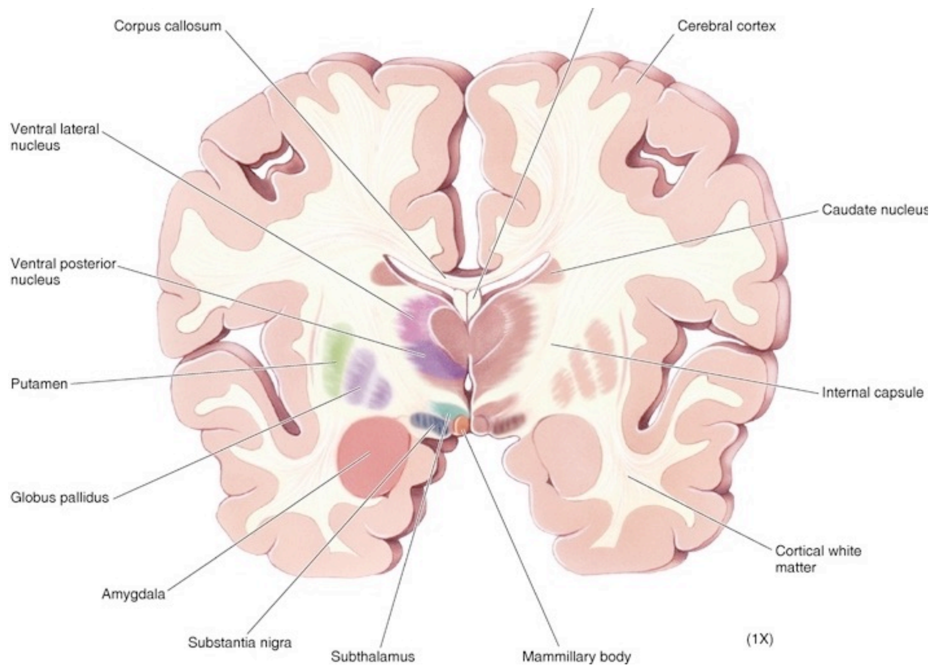
Parkinson’s Disease

Basal Ganglia - Role in Movement

- Many hypotheses
  - 1) BG are involved in feedback control
    - Honing of motor program by enhancing activity of target movement and inhibiting activity of non-target movements
  - 2) BG disinhibit areas of the motor system to allow movement to occur
  - 3) BG turn off postural control to allow voluntary movement to occur
  - 4) BG are involved in sequencing of movement fragments or whole movements

Basal Ganglia Nuclei

- Consist of 5 pairs of nuclei: (interconnected and subcortical)
- 1) caudate
- 2) putamen
- 3) subthalamic nucleus
- 4) globus pallidus (GP) internal/ external
- 5) substantia nigra (SN) - pars compacta/ pars reticulata



<u>Inputs to basal ganglia:</u>

Receive input from cerebral cortex (corticostriate pathway).

<u>Via striatum</u> = caudate and putamen

Caudate -cognitive/behavioral

Putamen - motor

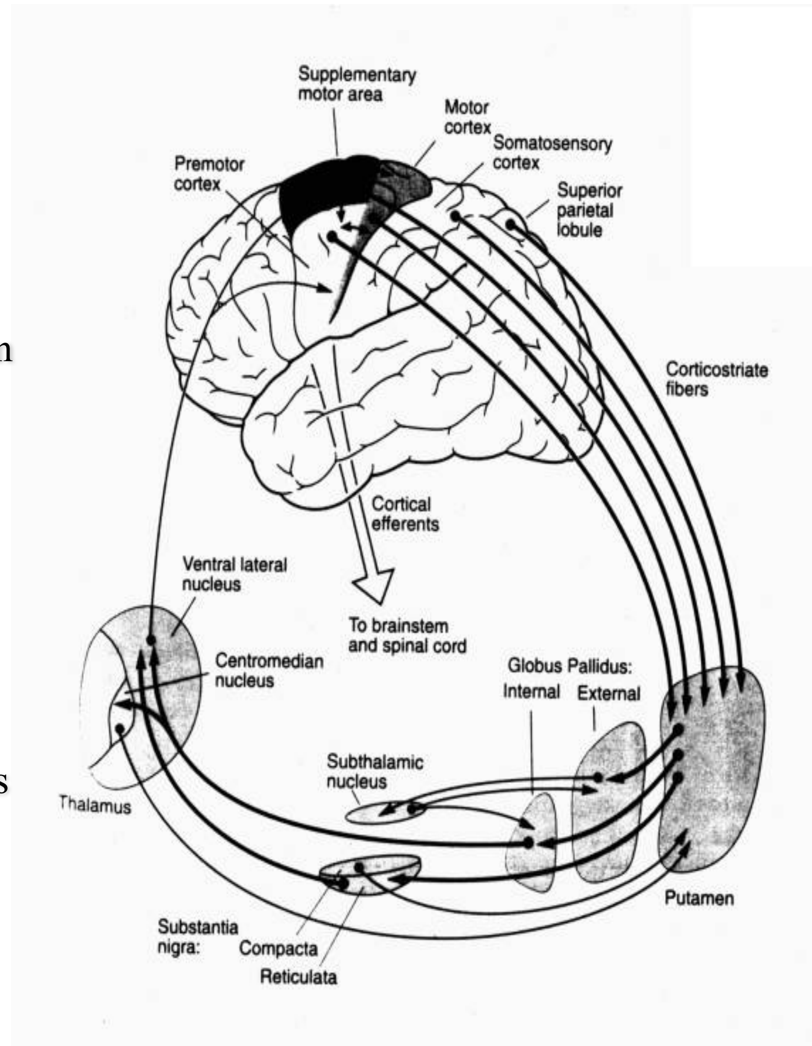
<u>From caudate and putamen nuclei to:</u>

•globus pallidus

  -internal and external segments

•substantia nigra

  -pars reticulata



Symptoms of Parkinson's Disease

- "TRAP"
  - (T)remor
  - (R)igidity
  - (A)kinesia (bradykinesia)
  - (P)ostural disturbance

Symptoms of Parkinson's Disease

1) Tremor:
   -"resting" vs. "intention"

   -pillrolling (thumb & forefinger motion)

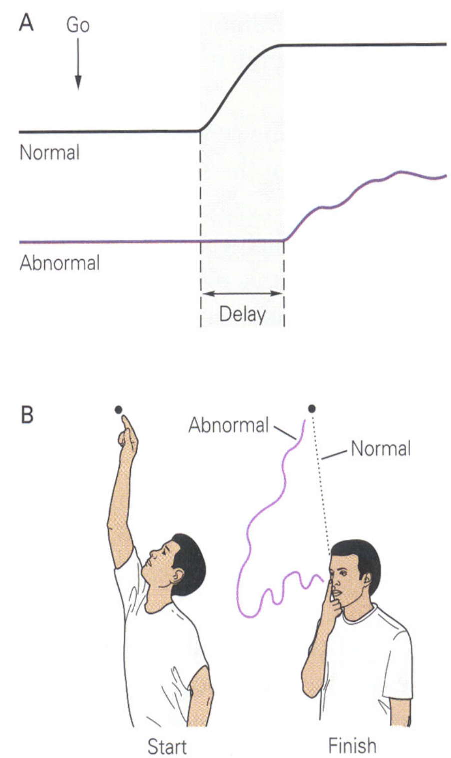
   -magnified by stress, fatigue

   -involuntary oscillation

2) Rigidity:
   -increased resistance to passive stretch
   -("cogwheel")

   -facial expression (mask-like- hypomimia)

   -decreased arm swing
   -Long latency stretch reflex is enhanced in Parkinson's Disease.



Cerebellar Patient

Symptoms of Parkinson's Disease

3) Akinesia (and bradykinesia and hypokinesia)

- increased Reaction time & Movement time
    - alleviated with external cues
    - This may also be due to muscle weakness observed in patients.
    - Increased speed accuracy trade-off.

    - Simple RT is longer, however results from choice RT studies are conflicting.

    - Bradyphrenia– slowness of thought

Symptoms of Parkinson's Disease

4) Postural deficits

•flexed posture

•decreased efficiency during postural perturbations

5) Gait Disorders

•problems to initiate

•"freezing"

•shuffling pattern

•increased speed leads to "festination"

Treatments for Parkinson's Disease

1) Pharmacological - increase dopamine levels with L-DOPA

- precursor of dopamine
- "On-Off" effects

•Dose must be increased because disease is degenerative.

- 3-5 years

•Currently, no cure.

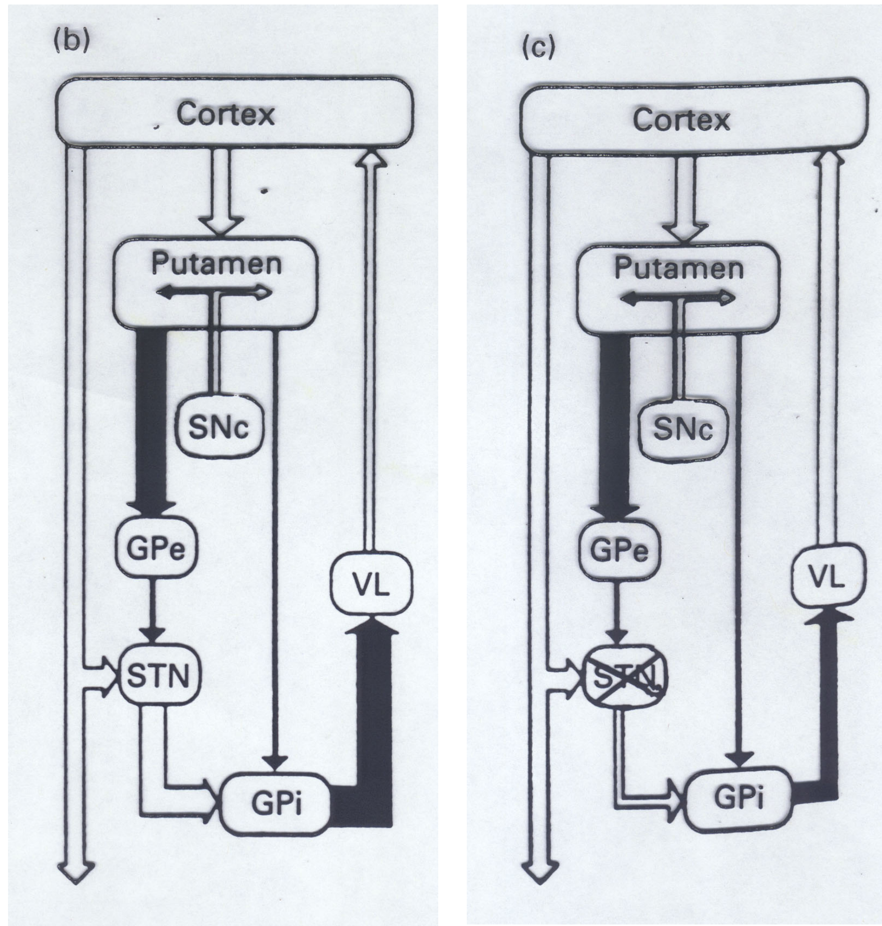
Treatments for Parkinson's Disease

<u>2) Neurosurgical</u> - restore balance of inputs to thalamus by lesioning/stimulating specific sites in basal ganglia.

<u>3) Deep Brain Stimulation</u>

• importance of placement within basal ganglia

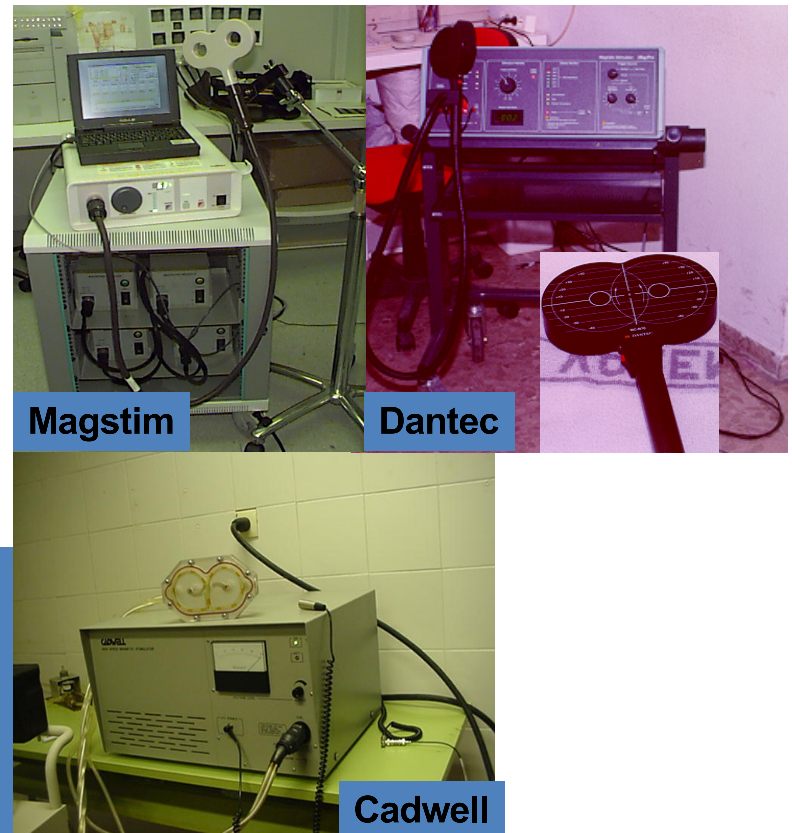
•maintain excitation/inhibition balance



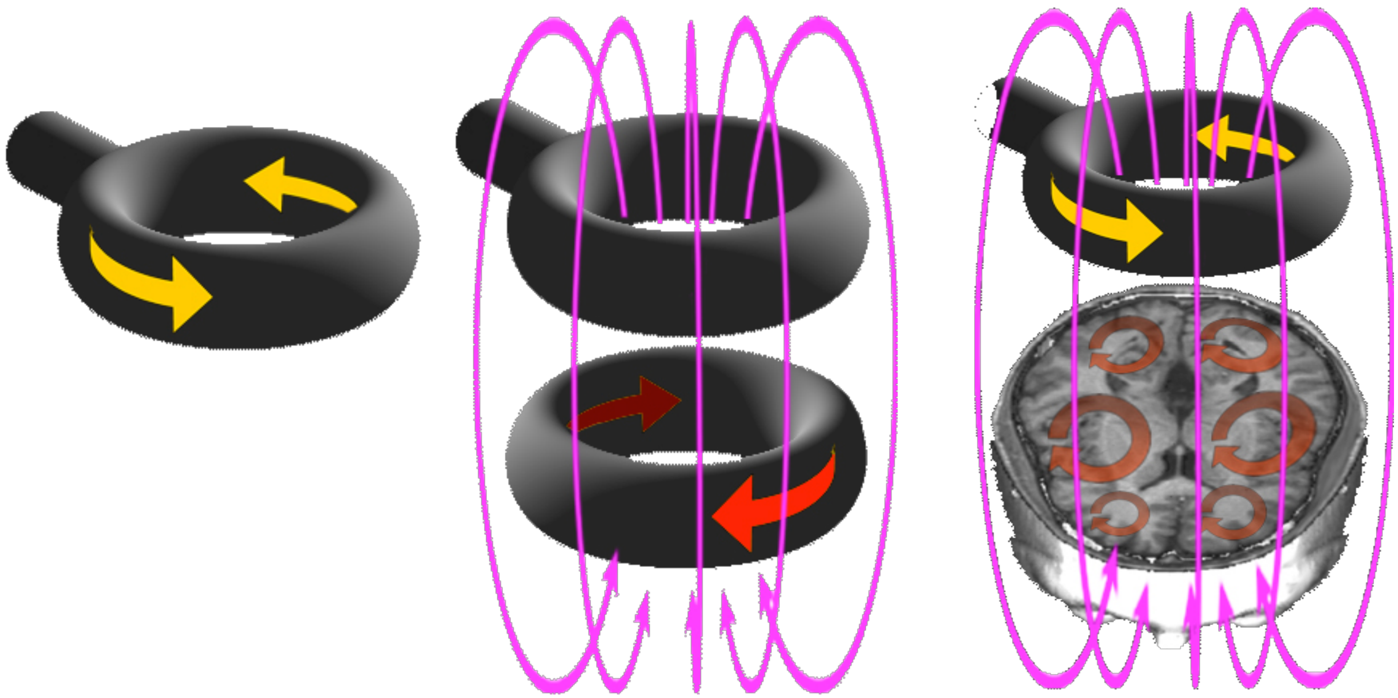
Transcranial Magnetic Stimulation

Transcranial Magnetic Stimulation allows the Safe, Non-invasive and Painless Stimulation of the Human Brain Cortex.

Common rTMS machines



Electromagnetic Induction



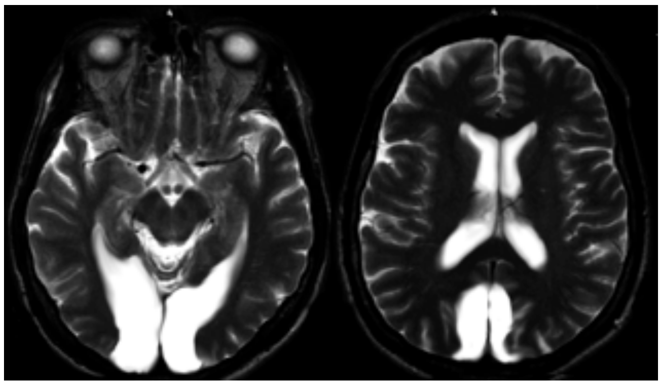
Introduces disorder into a normally ordered system

Advantages of TMS: Virtual Patients

causal link between brain activity and behaviour

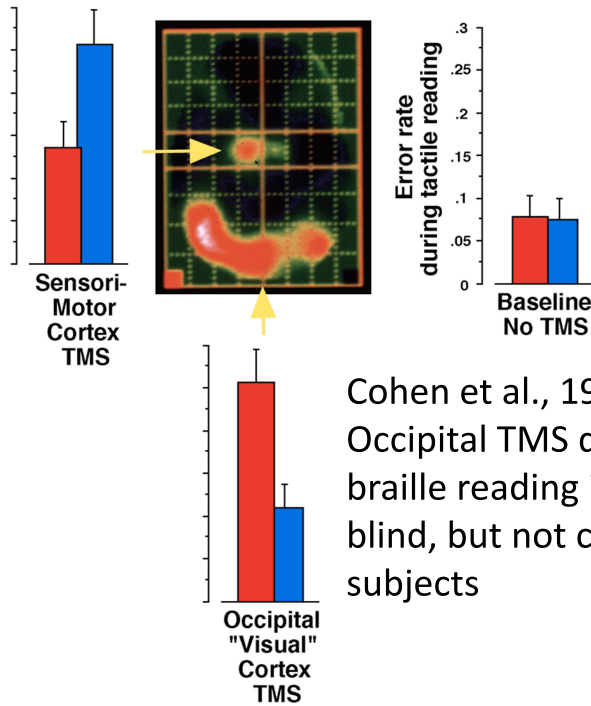
Braille Alexia

Real lesion



Hamilton et al., 2000. Reported case of blind woman who lost ability to read braille following bilateral occipital lesions

TMS lesion

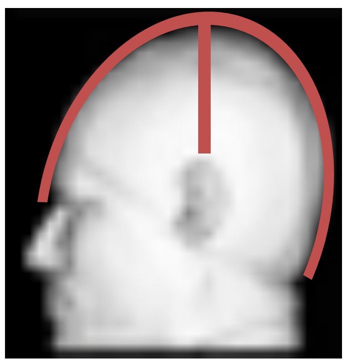


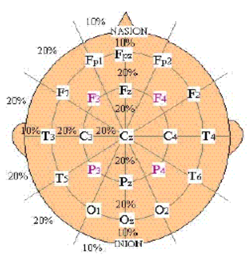
Cohen et al., 1997. Occipital TMS disrupts braille reading in early blind, but not control subjects

Blue = sighted; Red = E blind

Coil localisation - hitting the right spot

Find functional effect
M1 - hand twitch (MEP)
V5 - moving phosphenes





Find anatomical landmark
inion/nasion-ear/ear vertex
EEG 10/20 system

Move a set distance along and across (e.g. FEF = 2-4 cm anterior and 2-4 cm lateral to hand area)

Stimulation techniques and possible effects