



WEBINAR

Neuroplasticity and robotic rehabilitation

- How can robotics act on neuroplasticity?
- What is its relationship with body representation, self-perception and motor recovery?
- How is the clinical application of robotic devices?
- What are the protocols useful to stimulate neuroplasticity?

Thursday March 25th 2021
3.00 PM - 4.00 PM GMT+1
Register for free at
www.gloreha.com/webinar

Speakers

Dr. Franco Molteni

Director of Villa Beretta
Rehabilitation Centre
Costa Masnaga - Italy



Alejandro Losana Ferrer

Physiotherapist at IRF La Salle
Madrid - Spain



Presentation slides of the webinar “Neuroplasticity and robotic rehabilitation”.

For any further information, please write to:

info@gloreha.com



NEUROPLASTICITY AND ROBOTIC REHABILITATION

FRANCO MOLteni MD

DIRECTOR H.VALDUCE VILLA BERETTA REHABILITATION CENTER

COSTA MASNAGA

ITALY

EXERCISE ACTS AS A DRUG: THE PHARMACOLOGICAL BENEFITS OF EXERCISE

VINA J et al

British Journal of Pharmacology 2012



When a living system is suffering
from ill health, the remedy is found
by connecting with more of itself.

— *Francisco Varela* —

AZ QUOTES



MOTOR ABILITY

CYBERNETICS

BIOLOGY
SCIENCE
LEARNING
FUNCTIONS
COGNITION
ENGINEERING
PROCESSES
COMMUNICATION
EFFICIENCY
TECHNOLOGY
CONTROL
ADAPTION
FEEDBACK
SYSTEM

Neural Interface Technology

for

Rehabilitation:

**Exploiting and Promoting
Neural Plasticity**

CyberTherapy & Rehabilitation

Issue 2 / 2013 The Official Voice of iACToR

FEATURES:

Virtual Rehabilitation: Beyond Gaming
p 10

fMRI as a Breakthrough to Studying Effects
of Virtual Reality on Brain Activity
p 21

ASK THE EXPERT:

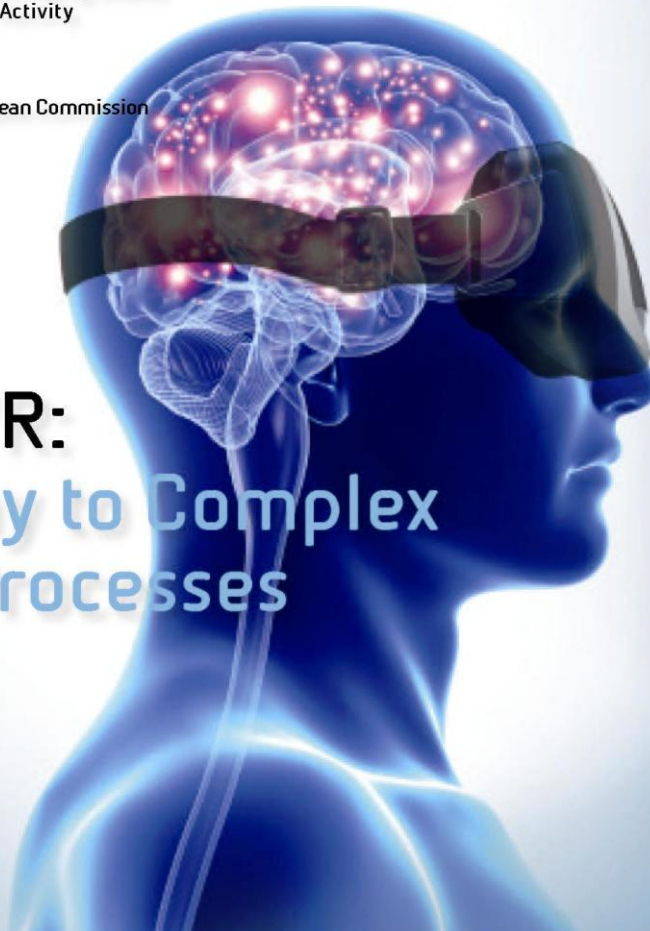
Vice-President of the European Commission
Neelie Kroes
p 31

COUNTRY FOCUS:
Greece
p 40

COVER STORY:

fMRI-VR: Gateway to Complex Brain Processes

**and
much
more...**





ACTION

REACTION

INTERACTION



AUTOMATIC

ADAPTIVE

VOLUNTARY



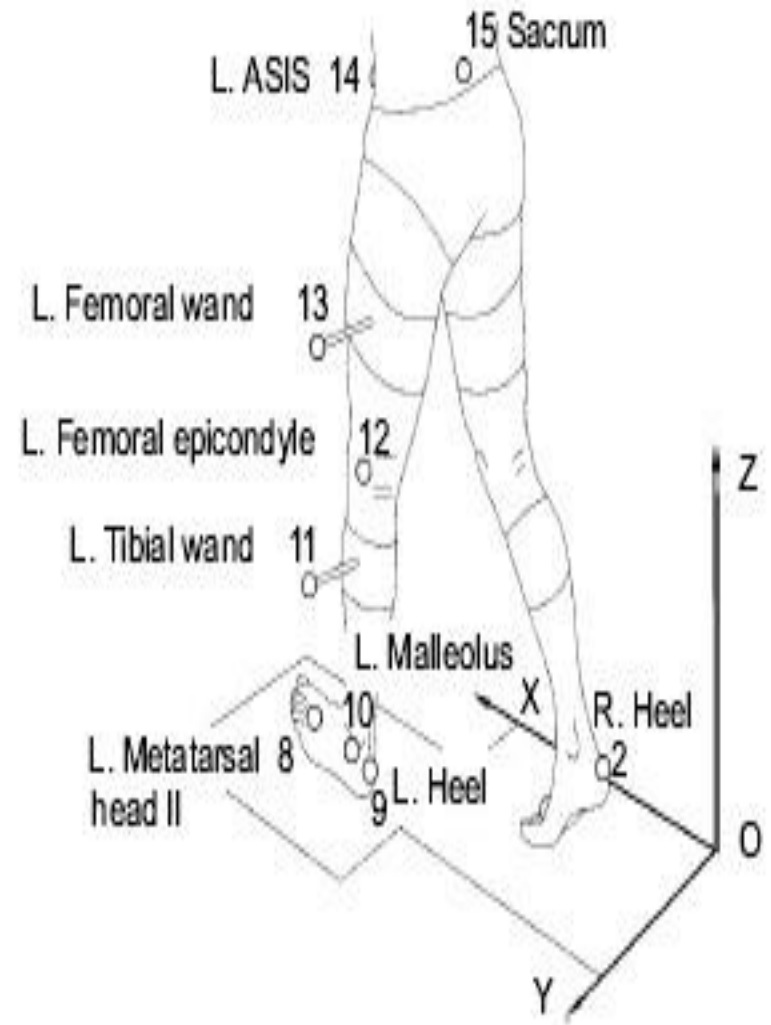
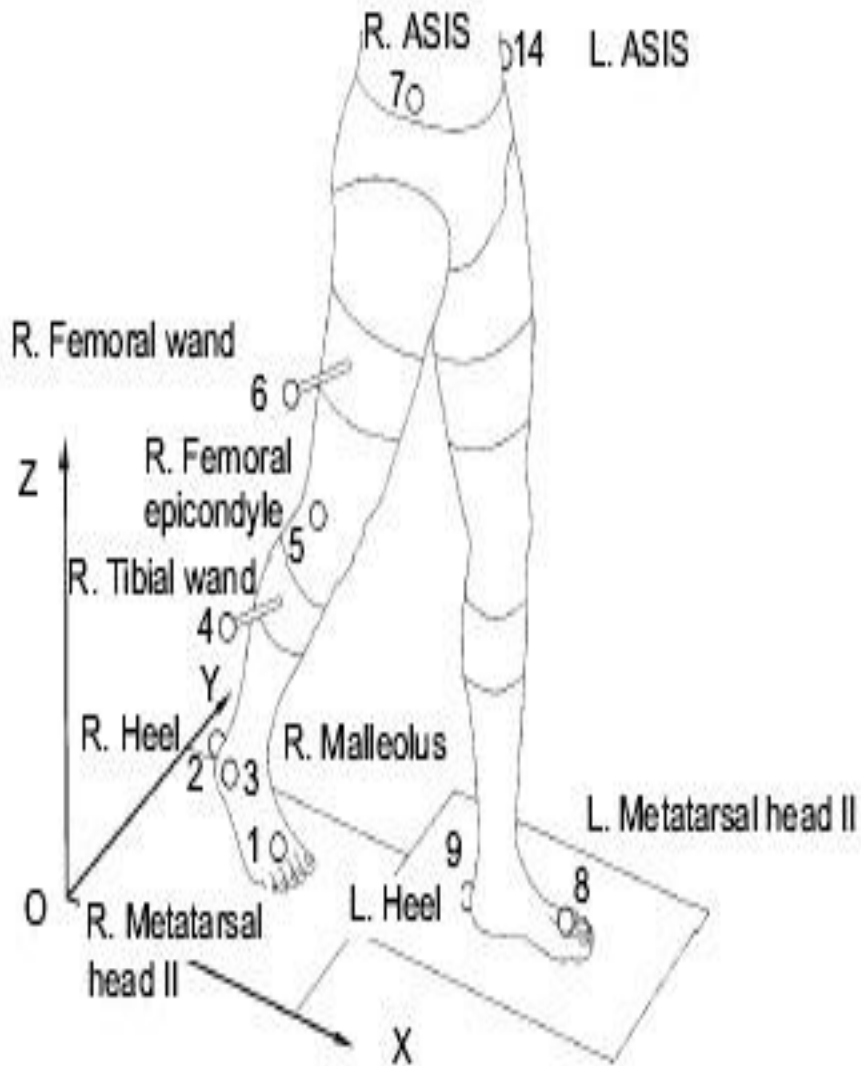
CONTROL

FEEDFORWARD

and

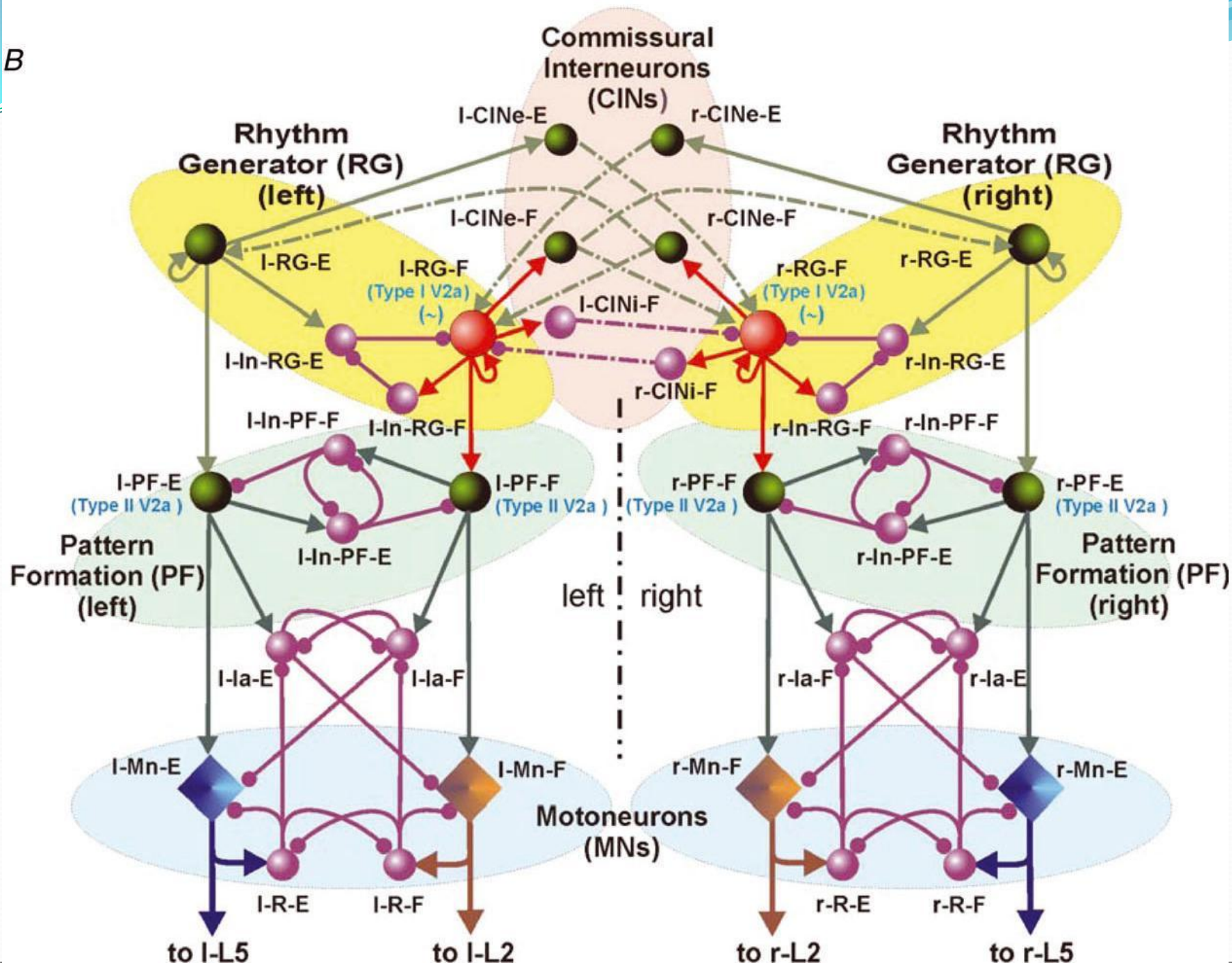
FEEDBACK

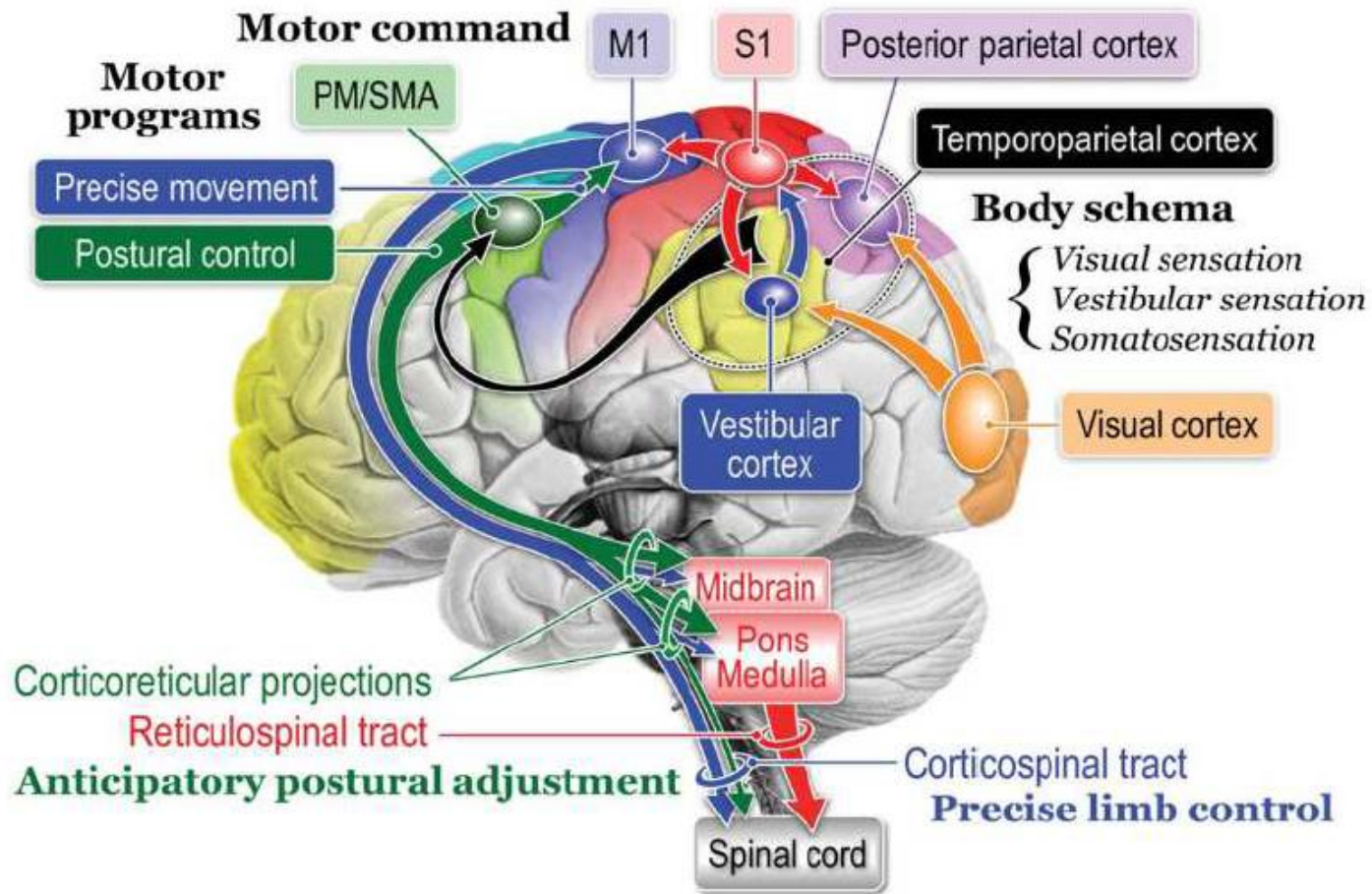
3D MODEL



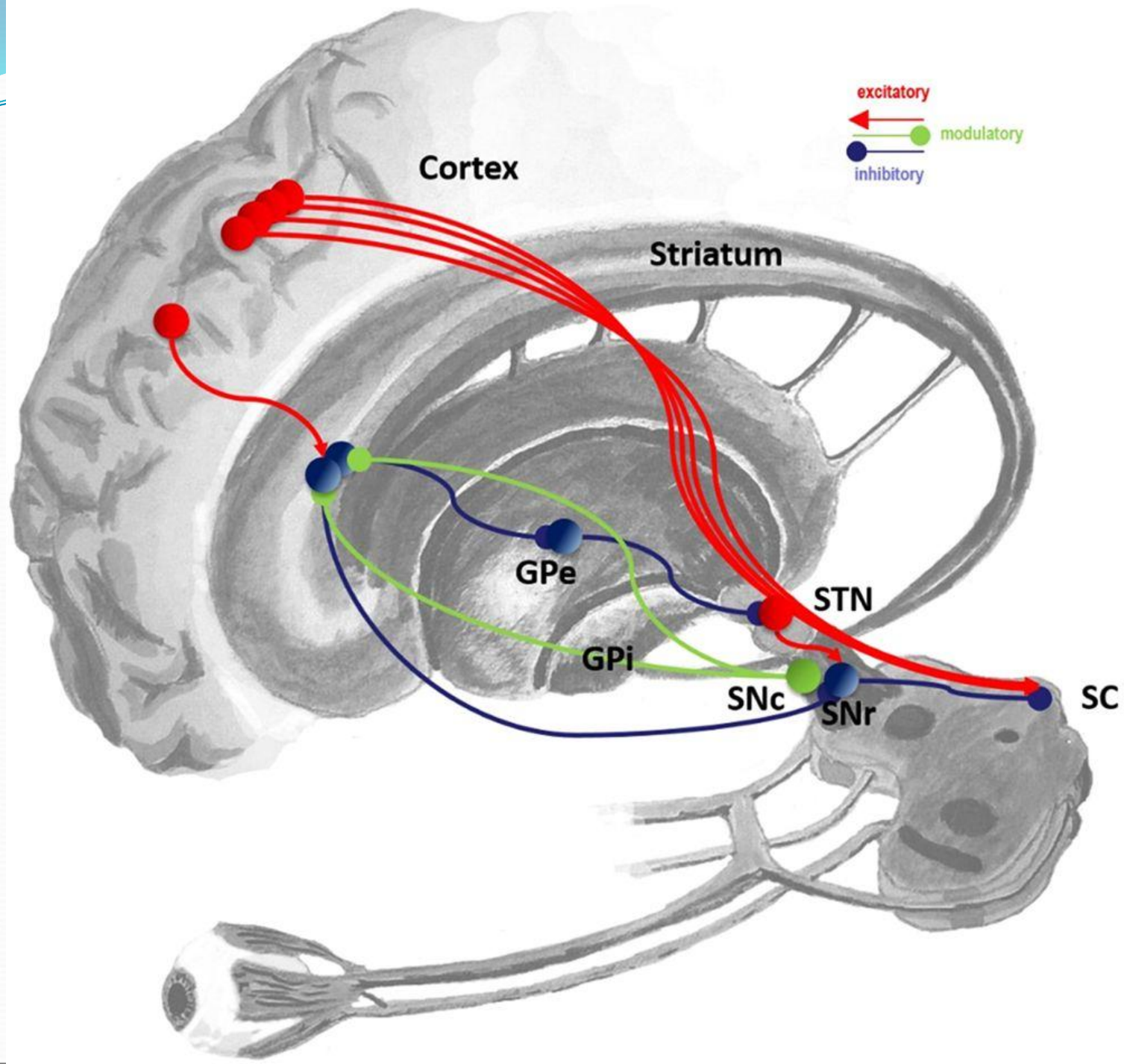


B

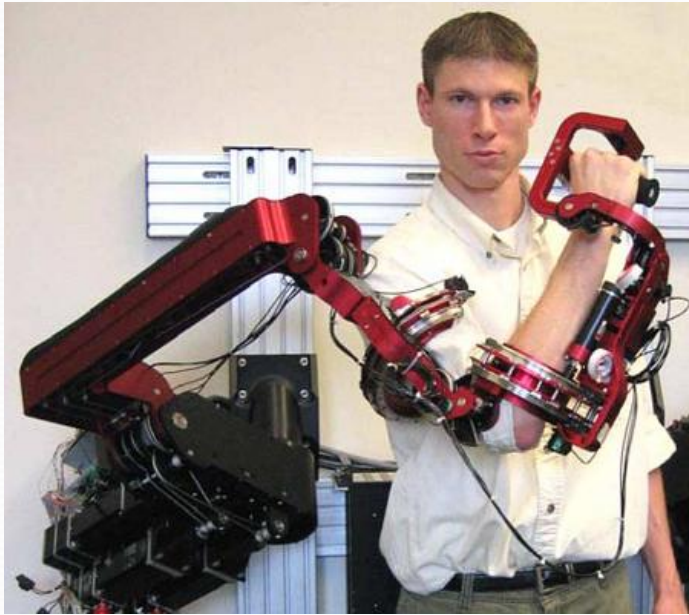




TAKAKUSAKI, 2013



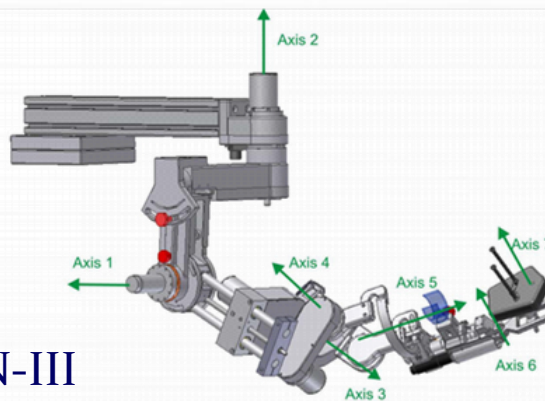
Upper limb exoskeletons



CADEN-7



PERCRO

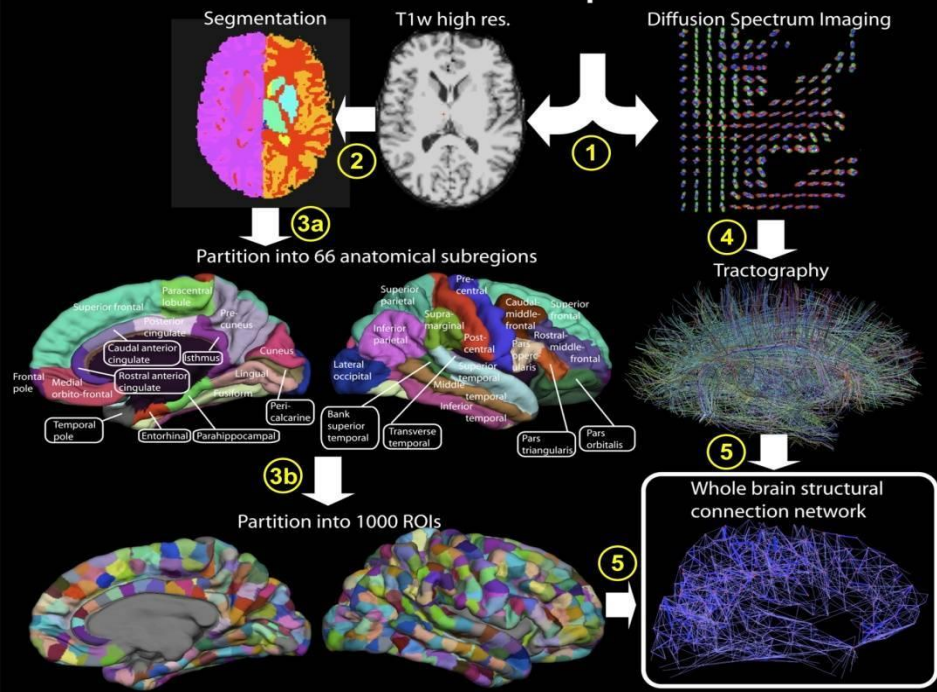


ARMIN-III





MRI Acquisition



COMPLEX ADAPTIVE SYSTEM

DYNAMIC NETWORKS

ACTION AND **INTERACTIONS**

INTERACTIONS ARE **NON LINEAR**

CHANGES AS A RESULTS
of **EXPERIENCE**



INTENTION

INTENSITY

ENGAGEMENT

EMBODIMENT



Intention

The ultimate brain workout

Different physical exercises can bring specific mental gains, from improving memory to dealing with cravings or reducing stress

LIFTING WEIGHTS

Prefrontal cortex
complex thinking, reasoning, multitasking, problem-solving

SPORTS DRILLS

Prefrontal cortex
Basal ganglia
attention, switching between tasks, inhibition

YOGA

Frontal lobe
Insula
integrates thoughts and emotions

Parietal lobe
visual-spatial processing

Amygdala
fear and anxiety

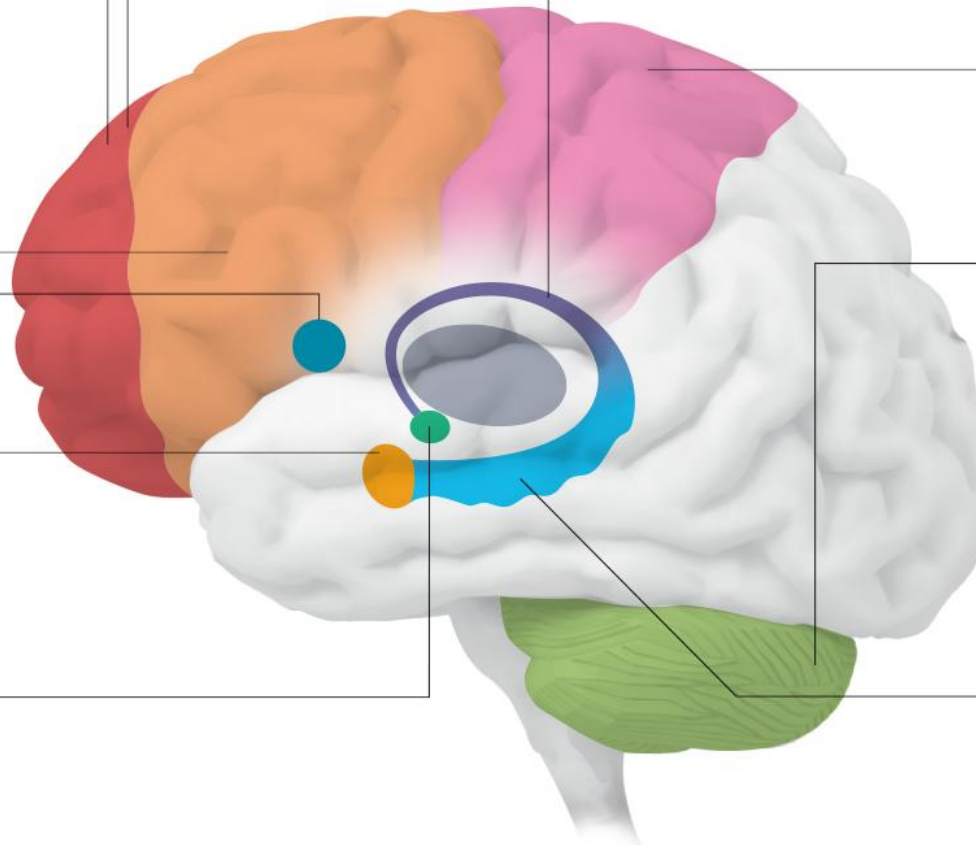
Cerebellum
attention

HIGH-INTENSITY INTERVALS

Hypothalamus
appetite regulation, cravings and addiction

AEROBIC EXERCISE

Hippocampus
memory



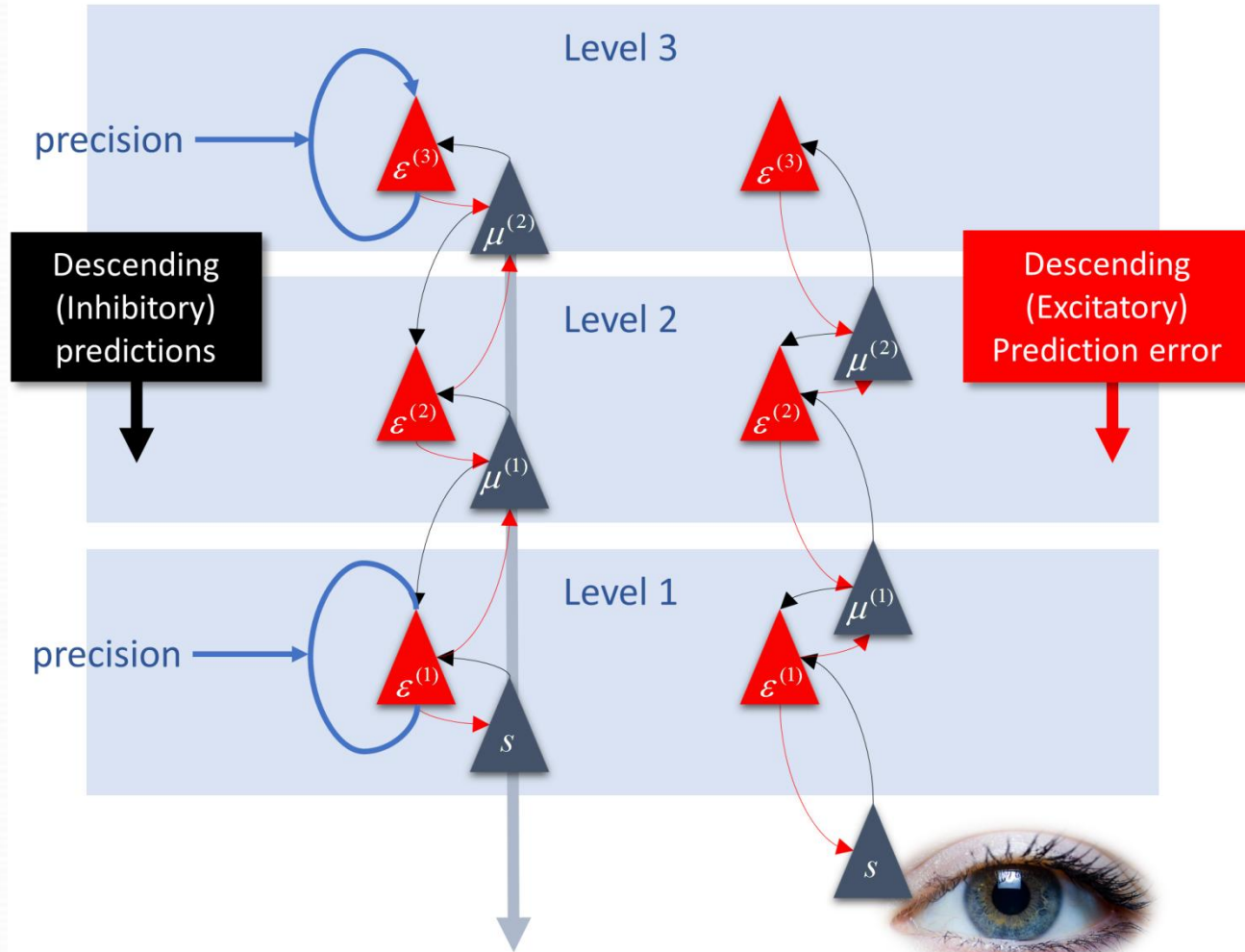


LEARNING THROUGH IMITATION: a BIOLOGICAL APPROACH TO ROBOTICS

Fabian Chersi

IEEE Transactions on Autonomous Mental Development 2012

Hierarchical predictive coding



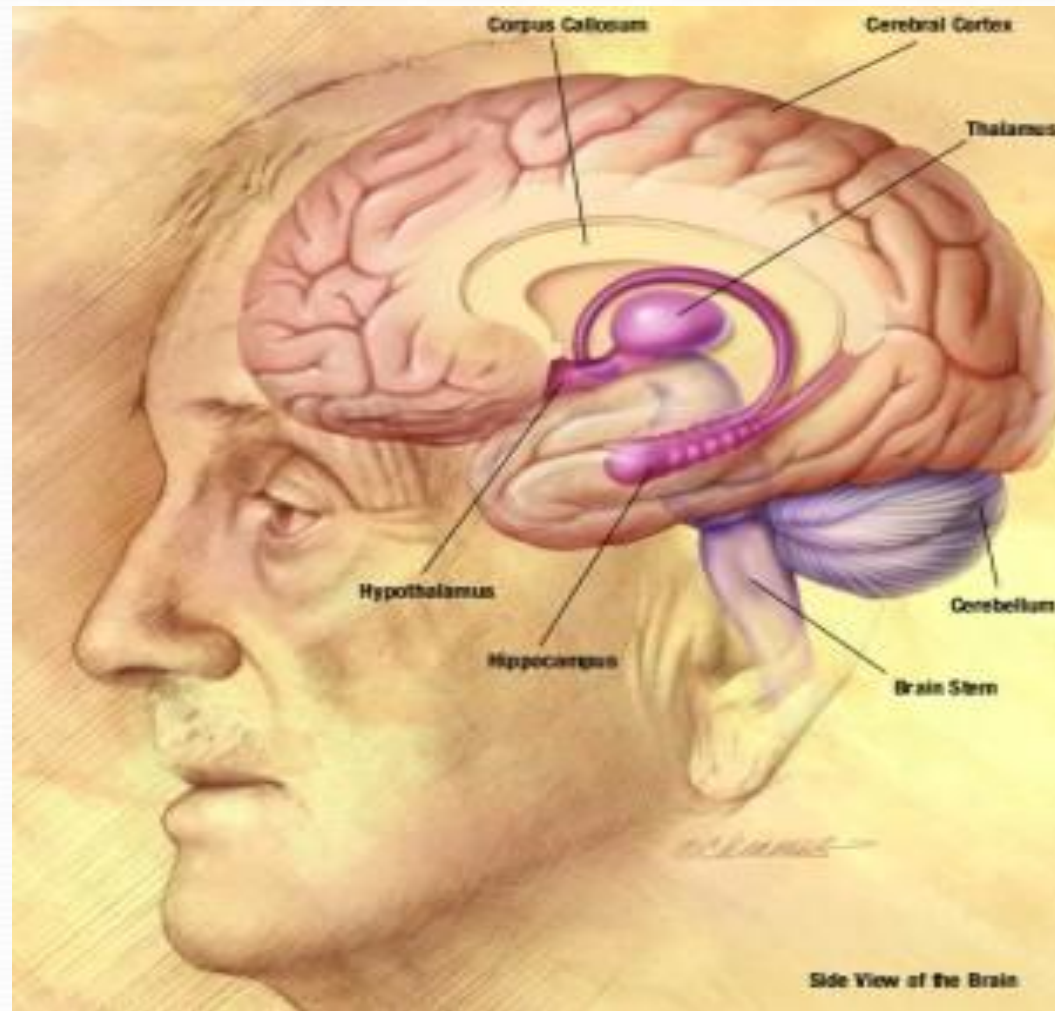
$$\dot{\mu}^{(1)} = D\mu^{(1)} + \Gamma \nabla g \cdot \Pi \cdot \epsilon^{(1)}$$

$$\epsilon^{(1)} = s - g(\mu^{(1)})$$









COMPLEX ADAPTIVE SYSTEM


DYNAMIC NETWORKS

ACTION AND **INTERACTIONS**


INTERACTIONS ARE **NON LINEAR**

CHANGES AS A RESULTS

of **EXPERIENCE**



**HOW WE SELECT
OUR ACTIONS
OF THE MANY ACTIONS
POSSIBLE?**



**HOW ARE
THESE BEHAVIOURS
SEQUENCED FOR
APPROPRIATE
ORDER AND TIMING
BETWEEN THEM?**



**HOW DOES
PERCEPTION
INTEGRATE
WITH
MOTOR CONTROL ?**



HOW ARE

PERCEPTUAL-MOTOR SKILLS

ACQUIRED?



BRAIN

ASAN

INFERENCE ENGINE

ACTIVE INFERENCE

The brain uses an internal generative model to predict incoming sensory data

Active inference : a Process Theory

Karl Friston et al

Neural Computation 2017

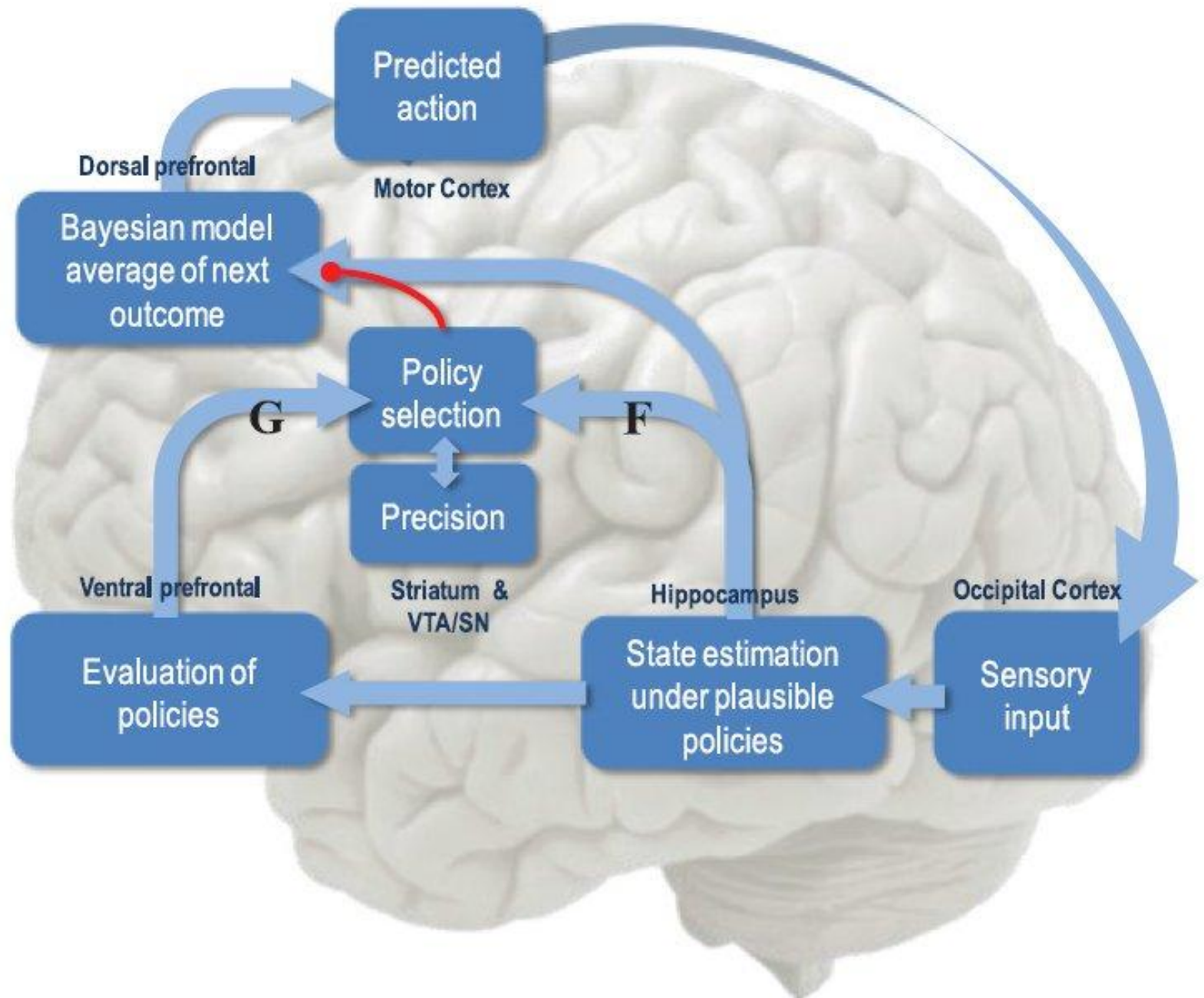


The Anatomy of Inference: Generative Models and Brain Structure

Parr T, Friston K

Frontiers in Computational Neuroscience November 2018

Functional anatomy

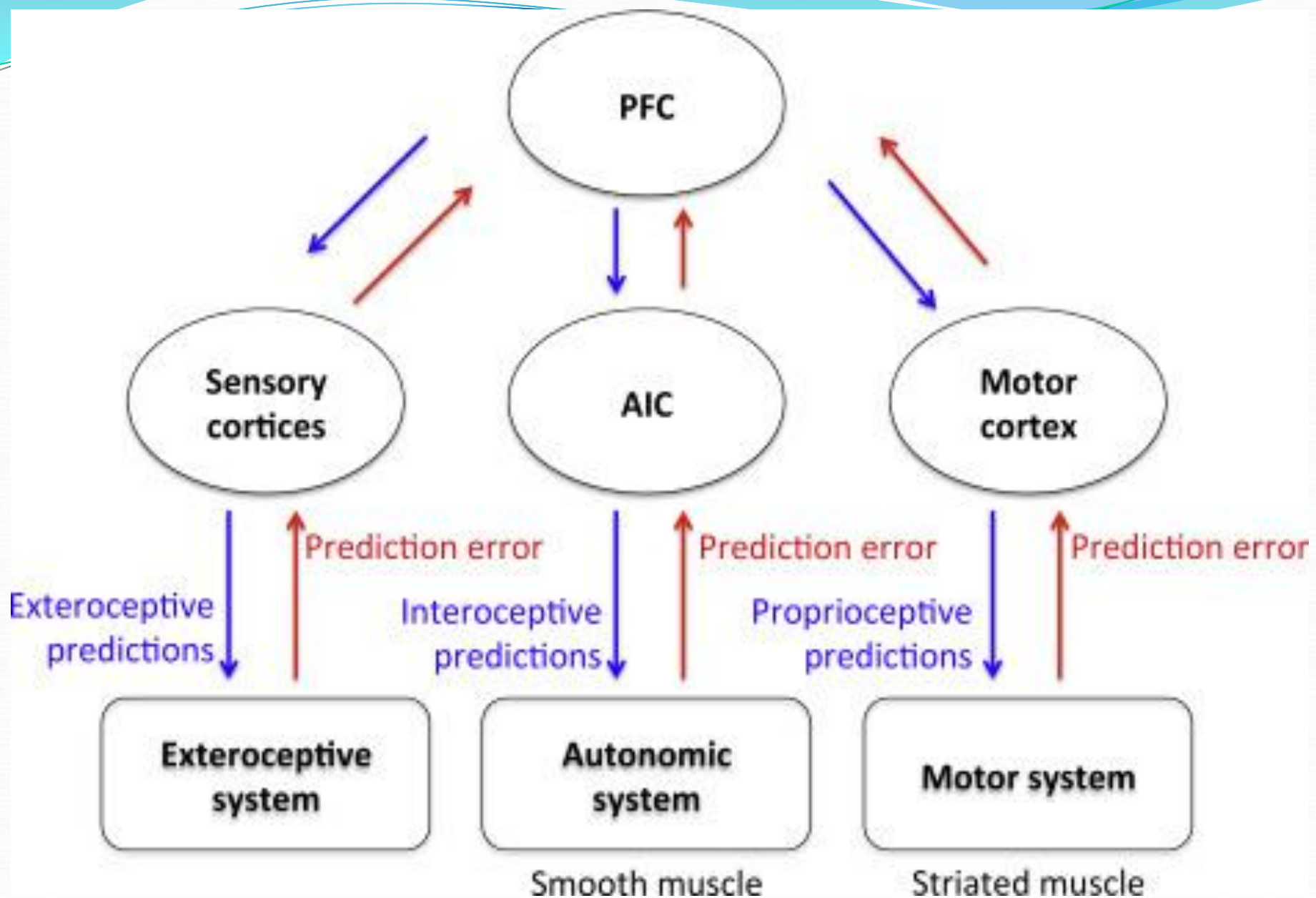




Prefrontal computation as Active Inference

Parr T, Rikhye RV, Halassa MM, Friston K

Cerebral Cortex July 2019





Behaviour flexibility

Context sensitivity

Associative learning processes
COMBINING

Higher-level controller
Lower –level controller
AND
Internal modeling



Action-Inter-Action

SPACE

TIME

SPACE

**THE THREE-DIMENSIONAL EXTENT
IN WHICH OBJECTS AND EVENTS
HAVE
RELATIVE POSITION AND DIRECTION**

***ALLOCENTRIC
AND
EGOCENTRIC
ACTION EXPERIENCE***



TIME

**The period
during which an action or condition
exists or continue**



TIMING

the temporal structure of a movement

SMOOTHNESS

quality related to non-intermittency of a movement

EFFICIENCY

ratio of work performed compared to energy expended to do the work



AFFORDANCE


**FEATURES OF THE ENVIRONMENT
THAT CREATE POSSIBILITIES
FOR USEFUL ACTIONS**

BODY OWNERSHIP

how we feel own our body

SENSE OF AGENCY

**how we feel the control
over actions and their consequences**


- 
- **MEANING OF THE BODY**
 - **MEANING OF THE MOVEMENT**
 - **SELF CONSCIOUSNESS**
 - **EMBODIMENT and DISEMBODIMENT**



**INNATE AND ACQUIRED ABILITIES
STRICTLY CONNECTED
TO EXPERIENCE AND LEARNING
PROCESSES**



HUMAN MOVEMENT
RELATED TO
HUMAN DEVELOPMENT
RELATED TO
GENETIC AND EPIGENETIC
FACTORS
INFLUENCED BY
SOCIO-CULTURAL ENVIRONMENT



Epigenetics
is emerging a science
that examines processes-
beyond DNA sequence
alteration-producing
heritable characteristics

Epigenetic Changes Induced by Exercise

Trevor Archer

Department of Psychology, University of Gothenburg, Sweden

Journal of Reward Deficiency Syndrome

2015



**Exercise influences
hippocampal plasticity
by modulating
BDNF processing**

**Ding Q, Ying Z, Gomez-Pinilla F
Neuroscience 2011**

Mechanobiology

application of biophysics or biomechanics to understand and elucidate biological and physiological functions at the different hierarchical levels.

- conformational changes or interactions of proteins that control gene transcription at the molecular level**
- protein complexes and modules that drive cell migration, transmit force through cell adhesions and transport materials including ions within and between cells at the cellular level**

**physical and chemical
interactions
between and among cells
and with the
surrounding extracellular matrix
are what
determine the complex
architecture of tissues**

Tissue Remodeling



Tendon Mechanics

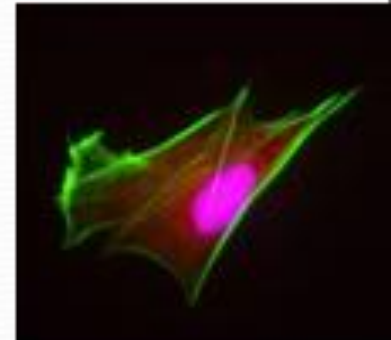
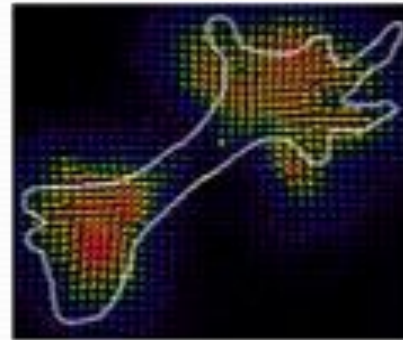
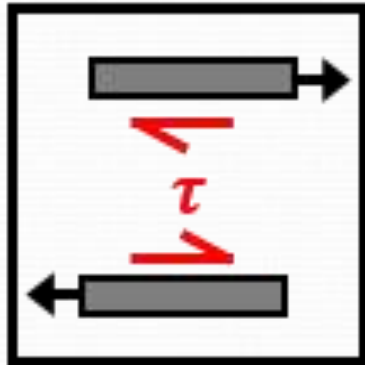
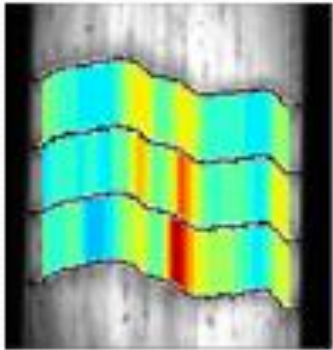
Mechanobiology

Multiscale
Testing

Computational
Modeling

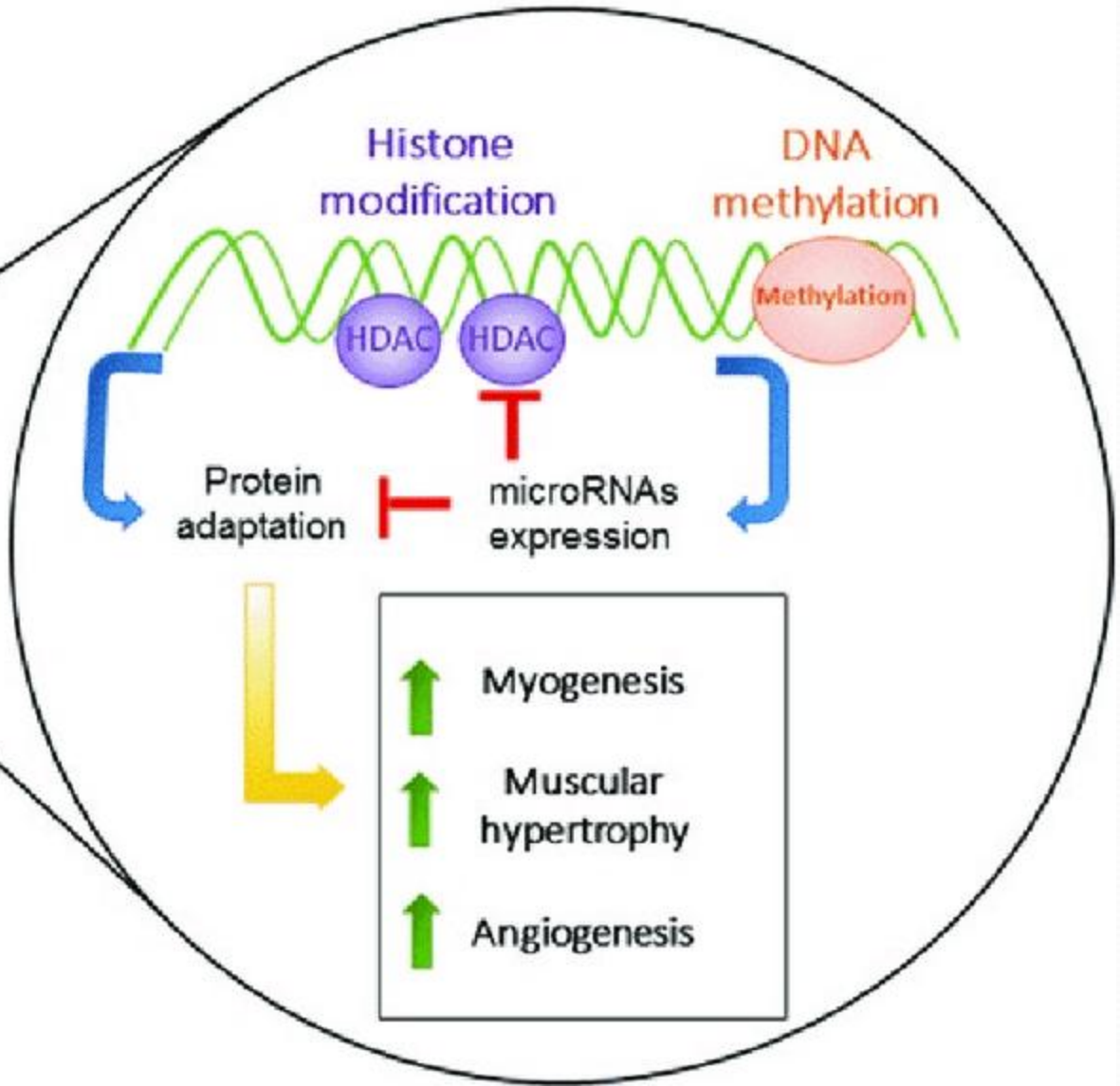
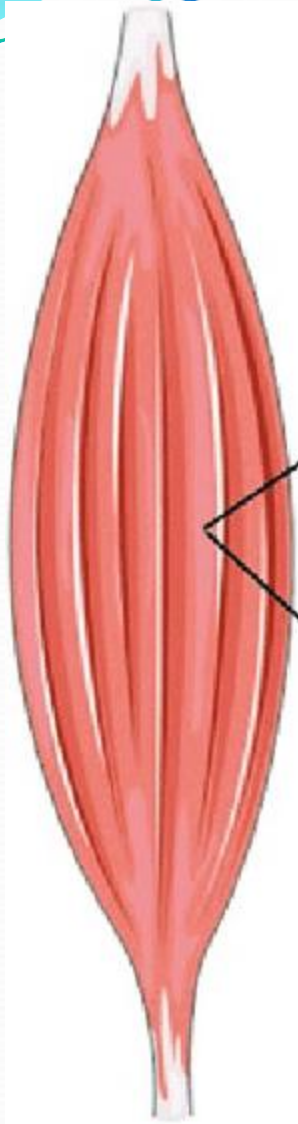
Biophysical
Stimuli

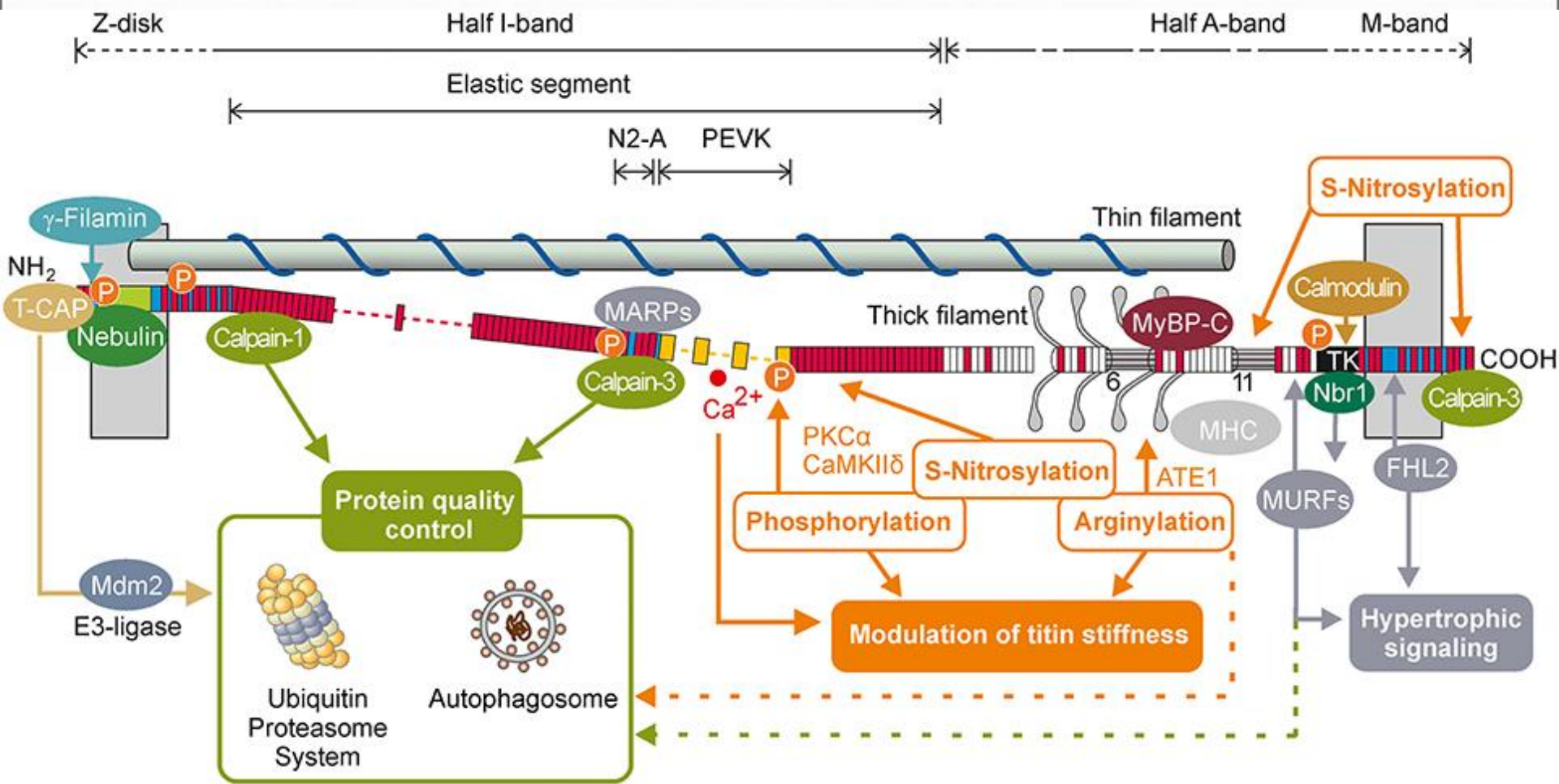
Biological
Response

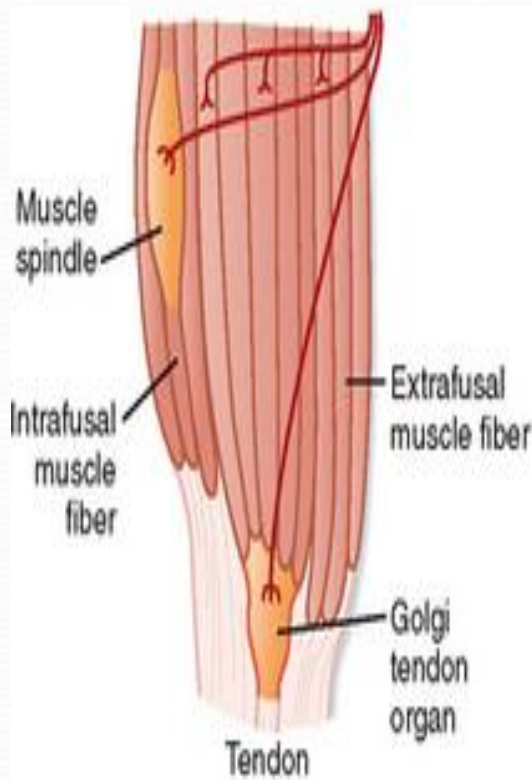


Regulation of skeletal muscle by micro RNAs

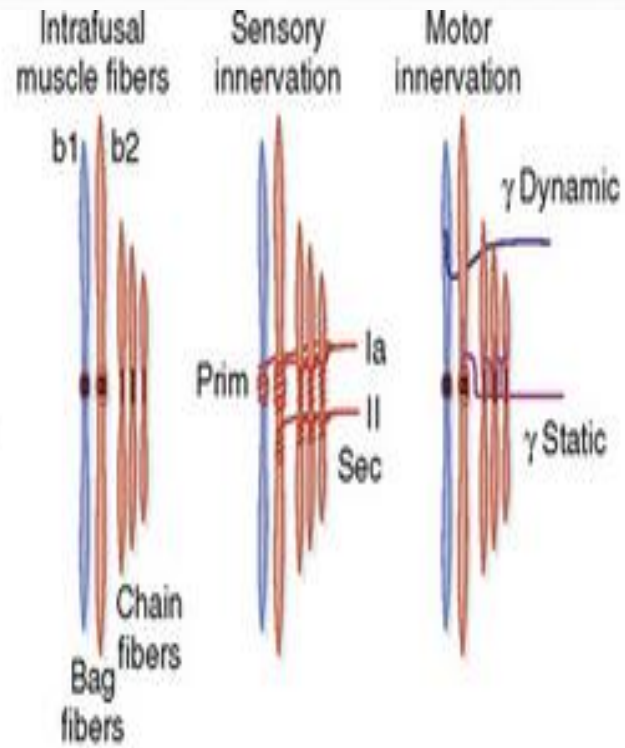
**Diniz GP et al
Compr Physiol 2016**



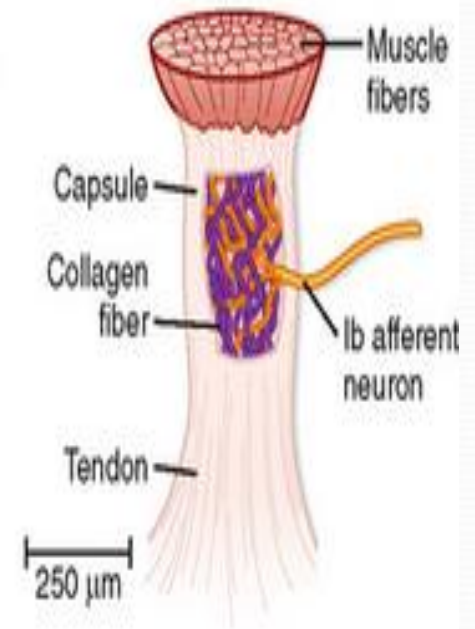





A



B

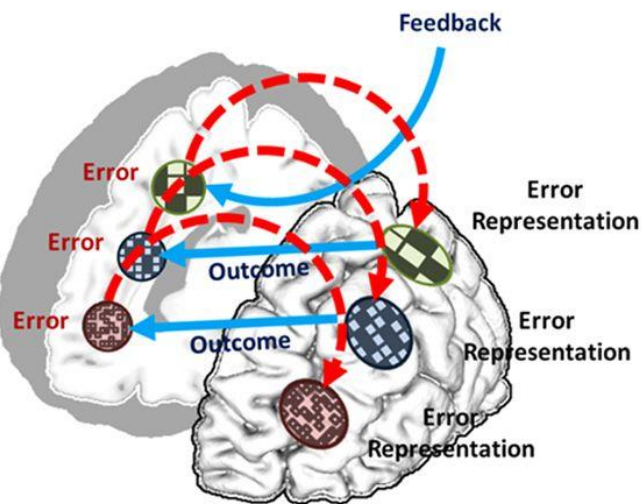


C

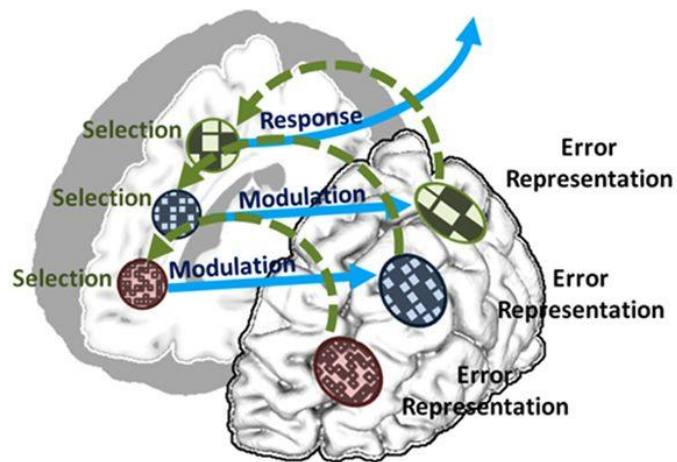


**Rheologic properties
of muscle-plasticity
and visco-elasticity
also influence the
control of muscle**

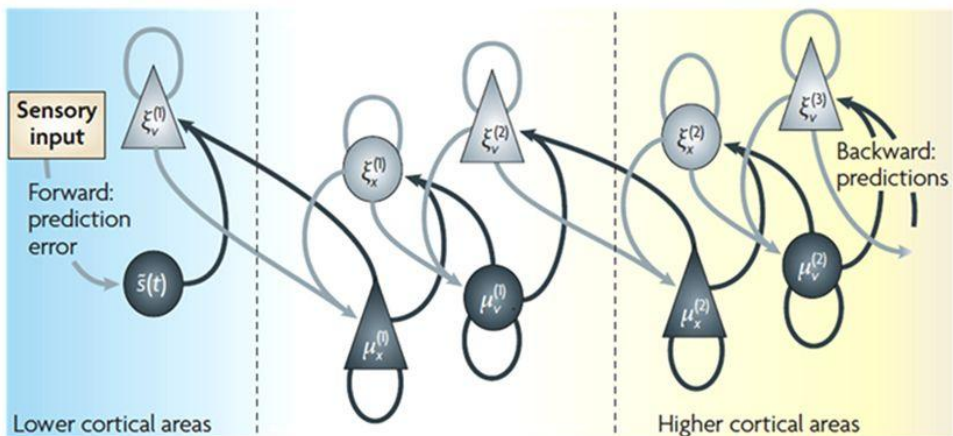
A Bottom-Up Processing



Top-Down Processing

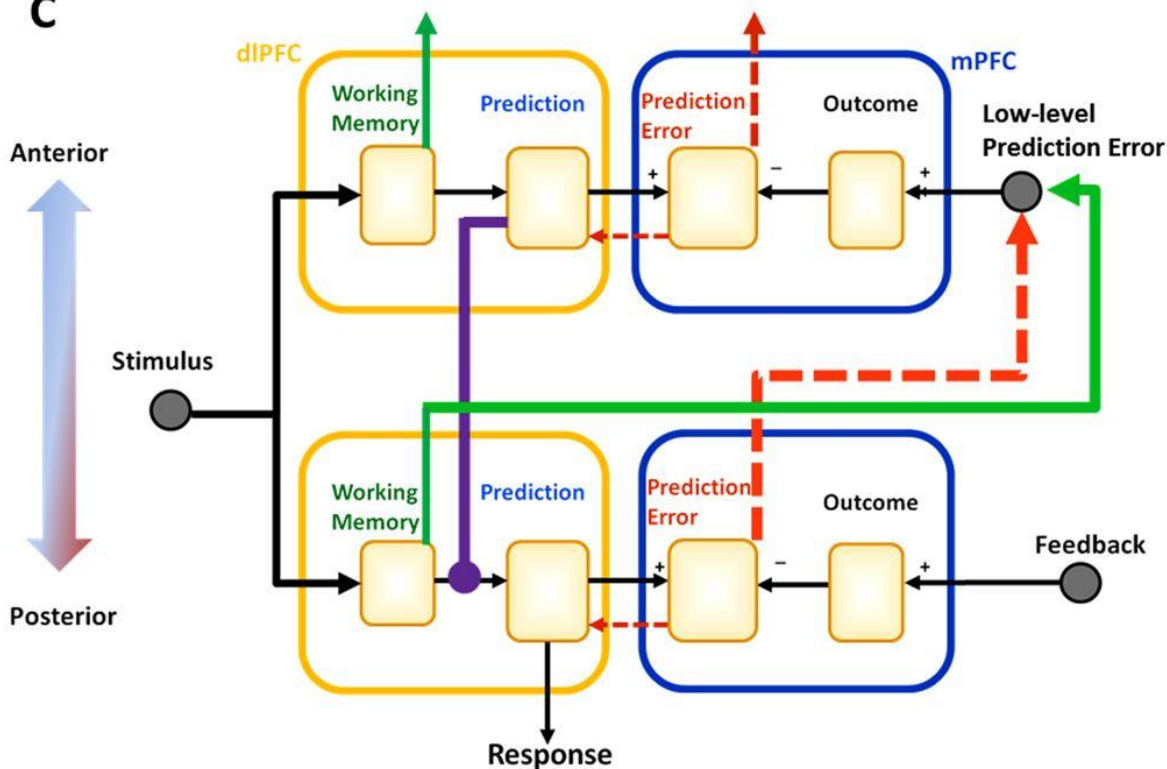


B




Friston, 2010

C



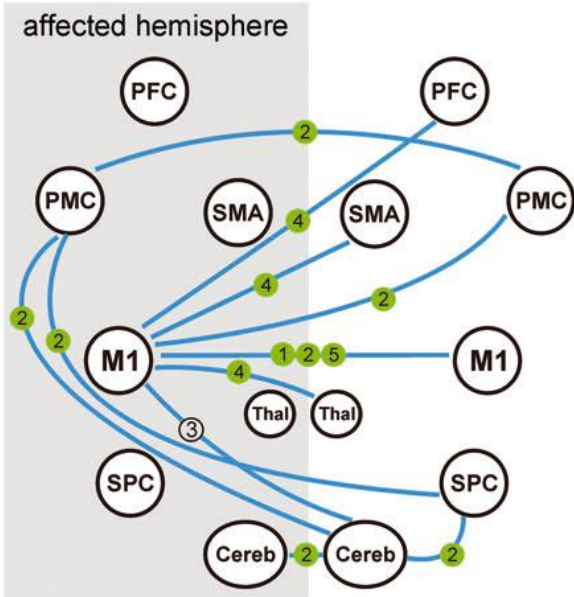




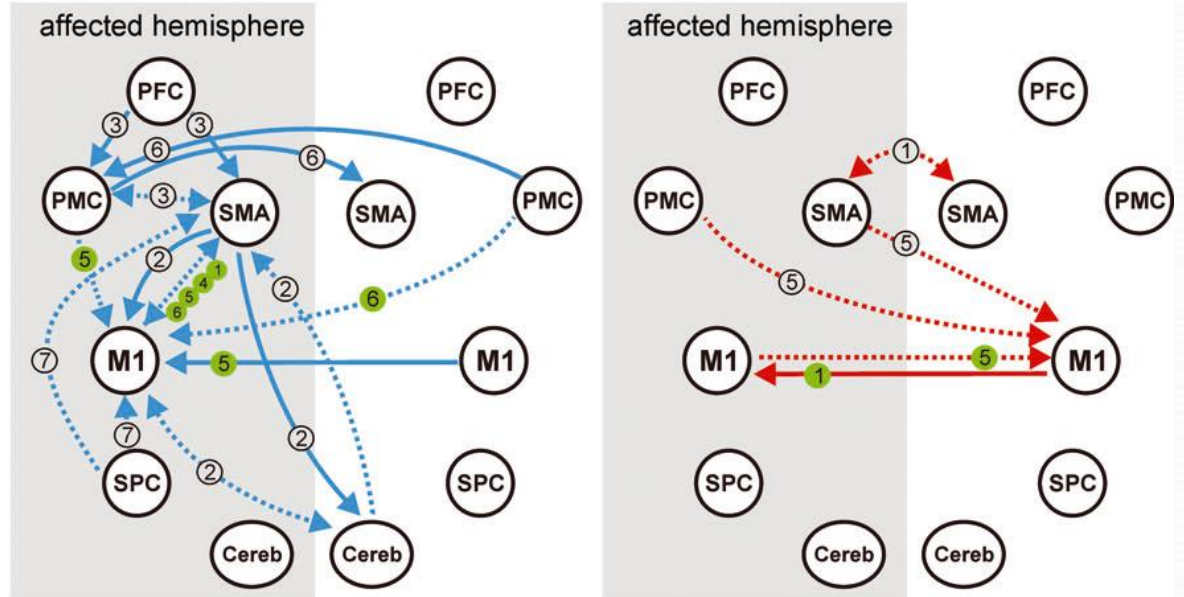
**Ergodicity
reveals assistance and learning
from
physical human-robot interaction**

**Kathleen Fitzsimons et al
SCIENCE ROBOTICS APRIL 2019**

A Resting-state functional connectivity



B Effective connectivity



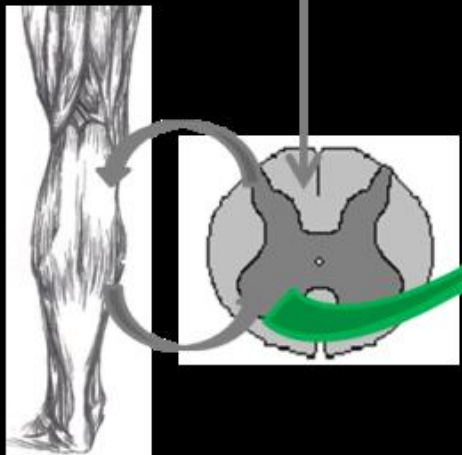
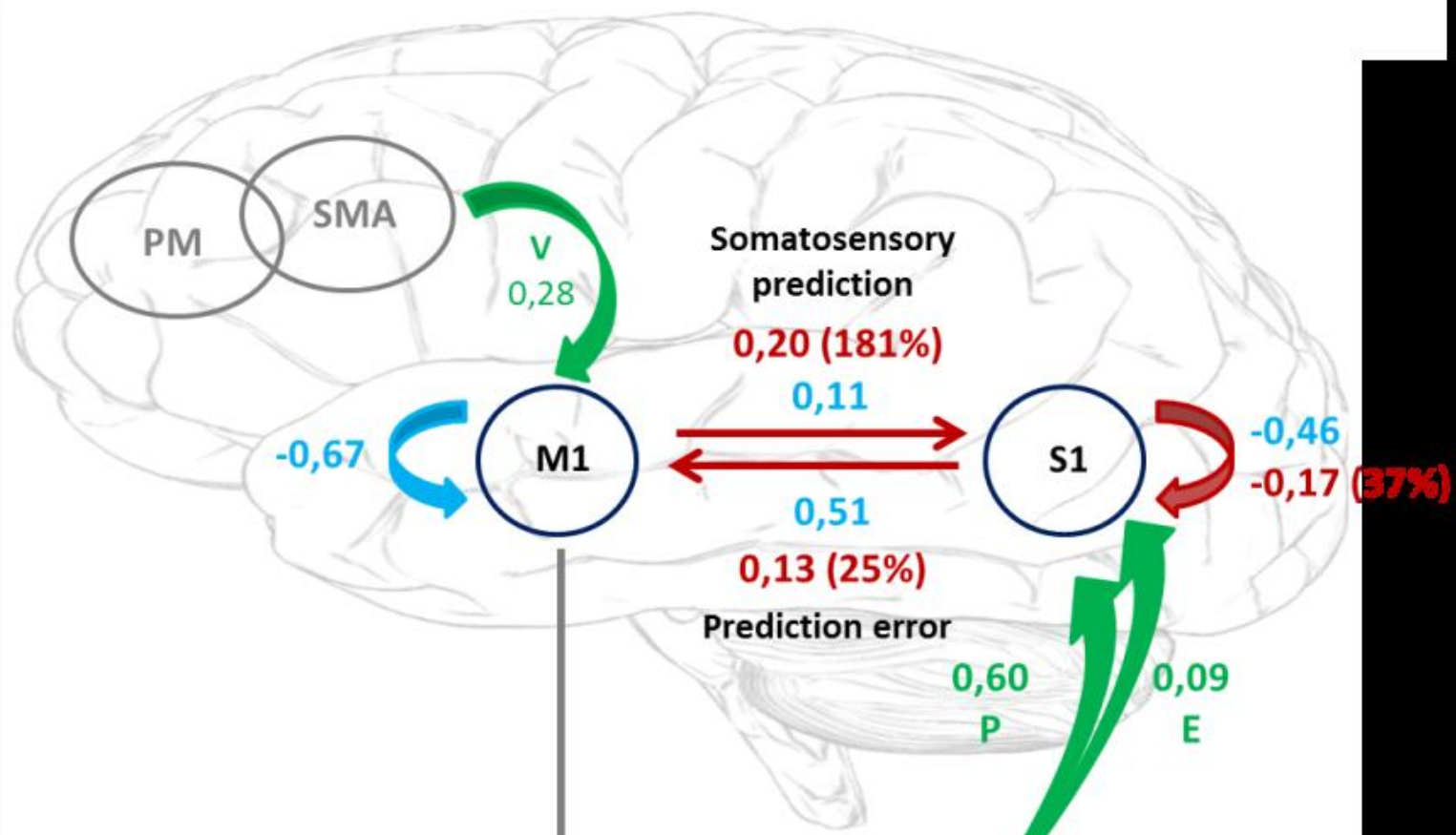
Changes in excitatory interactions


Changes in inhibitory interactions

- ① Carter *et al.*, 2010
 - ② Wang *et al.*, 2010
 - ③ Lu *et al.*, 2011
 - ④ Park *et al.*, 2011
 - ⑤ Carter *et al.*, 2012
- correlation with motor deficit

- ① Grefkes *et al.*, 2008
- ② Mintzopoulos *et al.*, 2009
- ③ Sharma *et al.*, 2009
- ④ Grefkes *et al.*, 2010
- ⑤ Rehme *et al.*, 2011
- ⑥ Wang *et al.*, 2011
- ⑦ Inman *et al.*, 2012

- reduced excitation
- increased excitation
- reduced inhibition
- increased inhibition
- correlation with motor deficit





Plasticity and modular control of locomotor patterns in neurological disorders with motor deficits

Ivanenko Y.P. et al

Frontiers in Computational Neuroscience 2013

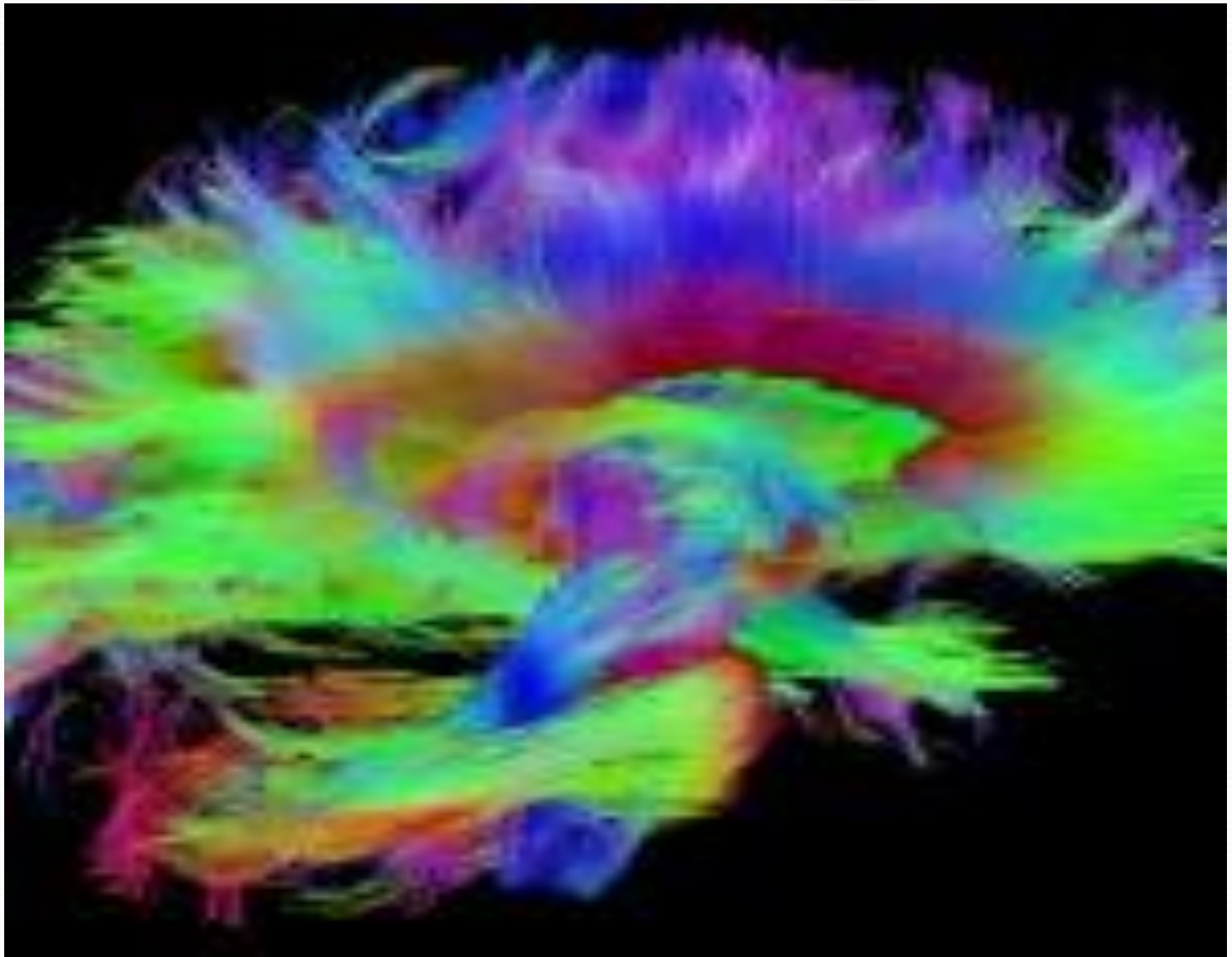


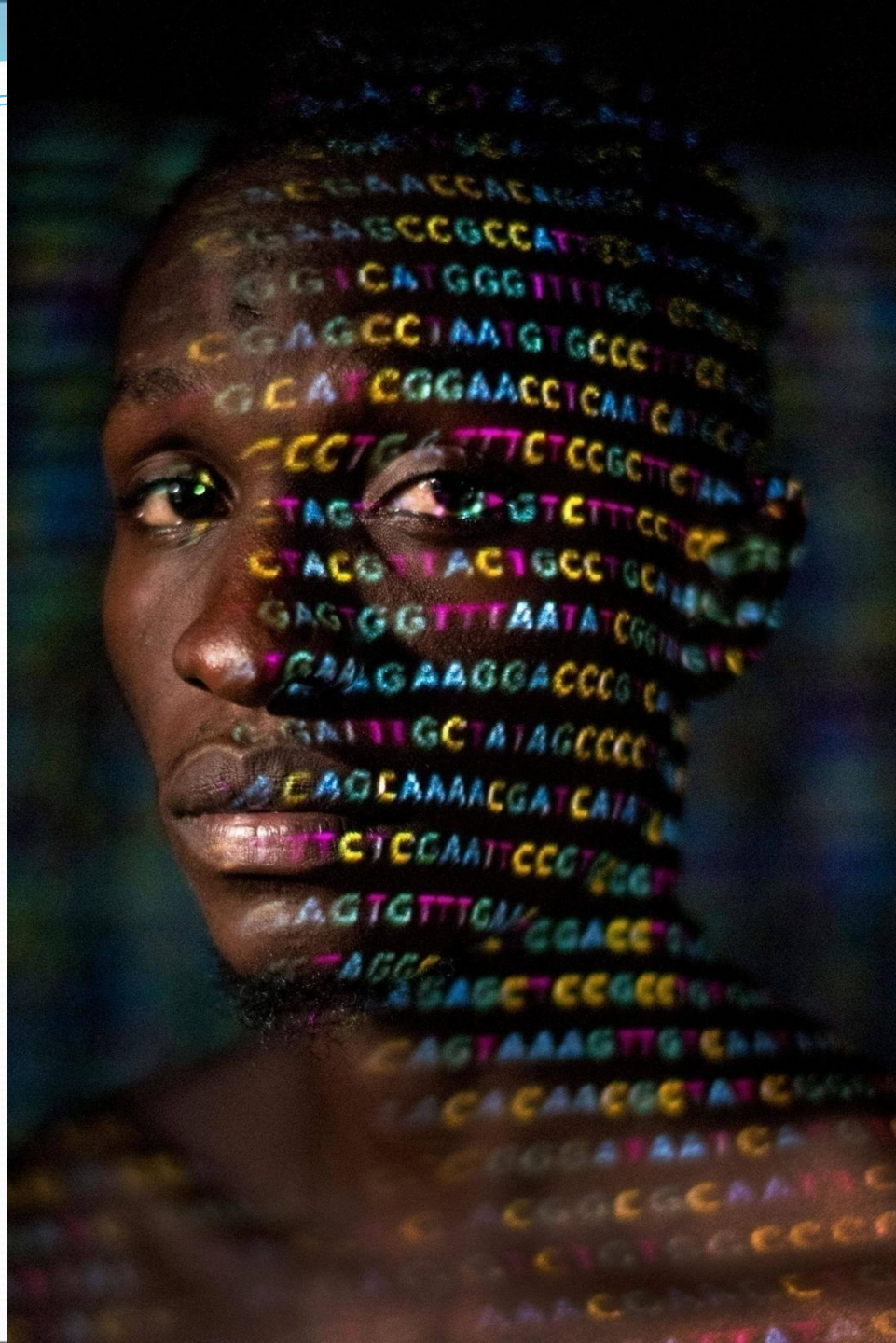


**Re-thinking the role of motor
cortex:
Context-sensitive motor outputs?**

**Gandolla M, Ferrante S, Molteni F, Friston K, Ward
NS**

Neuroimage 2014







**Thank you for
your attention!**