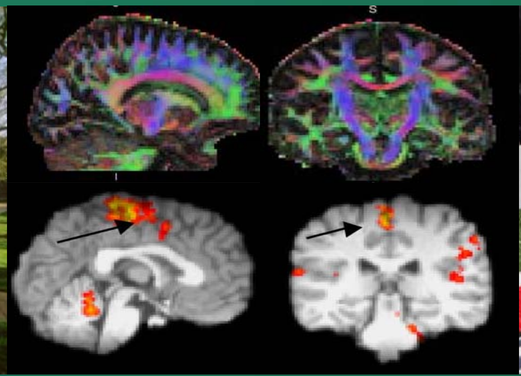
Neuroplasticity in Athletic Training

Dustin Grooms, PhD, ATC, CSCS
Ohio University
Athletic Training

Presenter Conflict

No Conflict

- The views expressed in these slides and the today's discussion are ours
- Our views may not be the same as the views of my company's clients or my colleagues
- Participants must use discretion when using the information contained in this presentation

Objectives

Objectives

- Understand how the brain changes after musculoskeletal injury
- How as athletic trainers they can induce neuroplasticity in their patients
- Apply novel concepts from neuroscience to athletic training practice to enhance injury prevention and rehabilitation

fMRI to assay neural control of human movement

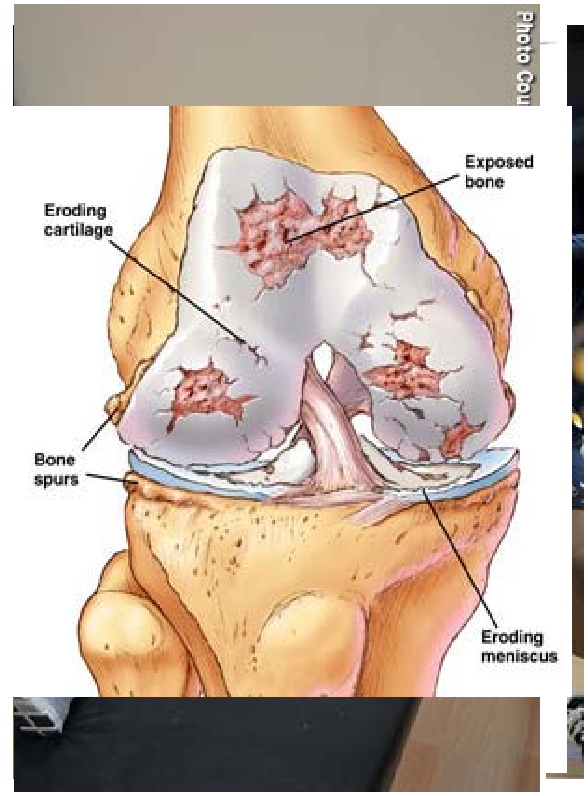
Overview

- How I get here
- Neuroplasticity
- Neuroimaging
- Clinical Implications

Anterior Cruciate Ligament Rupture

- 1 in 20 collegiate level athletes[2,3]
- 1 in 50 high school athletes[4,5]
  - **<u>70% are non-contact[8,9]</u>**

- 50% - 100% Radiographic Osteoarthritis[11,12]
  - Accelerated Knee Degeneration
- 30% failure rate of reconstruction and rehabilitation[13,14]
  - Rehabilitation focus on joint adaptations
  - “Insufficient evidence for clinical effect”
- **<u>What are we missing?</u>**

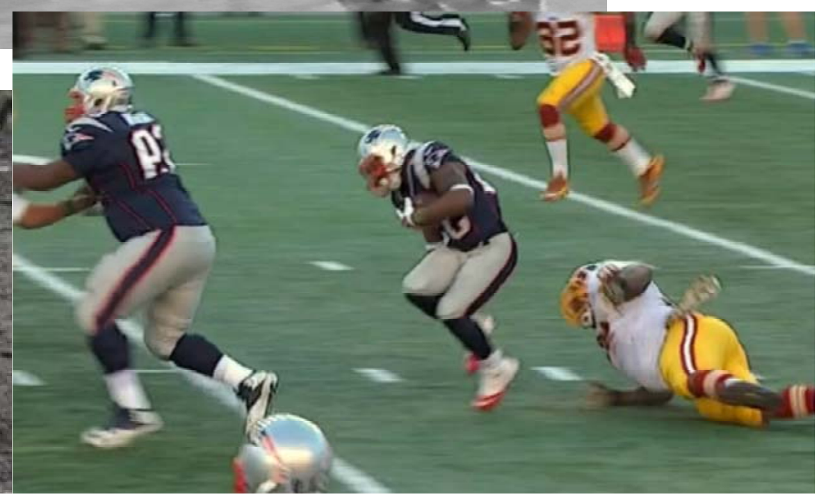


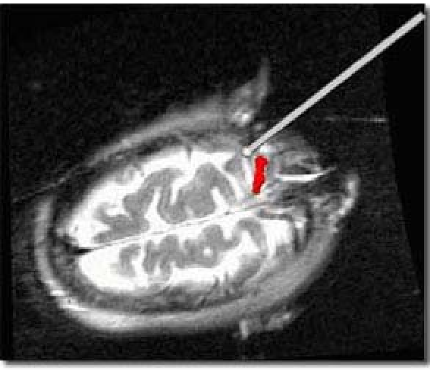
1) Nordenvall 2012 *AJSM* 2)Hootman 2007 *JAT* 3) Majewski 2006 *Knee* 4) Hewett 1999 AJSM 5) Ferretti 1992 *AJSM* 6) Gerberich 1987 *Phys Sportsmed* 7) Chandy 1985 *Phys Sportsmed 8)* McNair 1990 *NZmedJ* 9)Griffin 2000 *JAAOS;* 9) Pearl diver 2011, 10) Wojtys 2010 JAT 11)Lohmander 2004 AR 12)Porat 2004 ARD 13) Salmon 2005 Arthro 14) Paterno 2010 AJSM

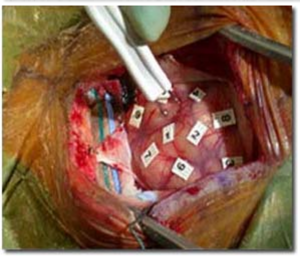
Athletic training

- What aspect of physiology changes first when you interact with a patient?
- Do you think an ankle sprain changes your nervous system?
  - Permanently?
- Have you ever seen a noncontact injury?

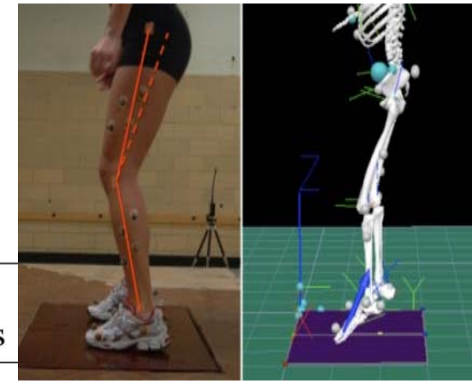
Non-Contact Injury







Neural Control of Human Movement



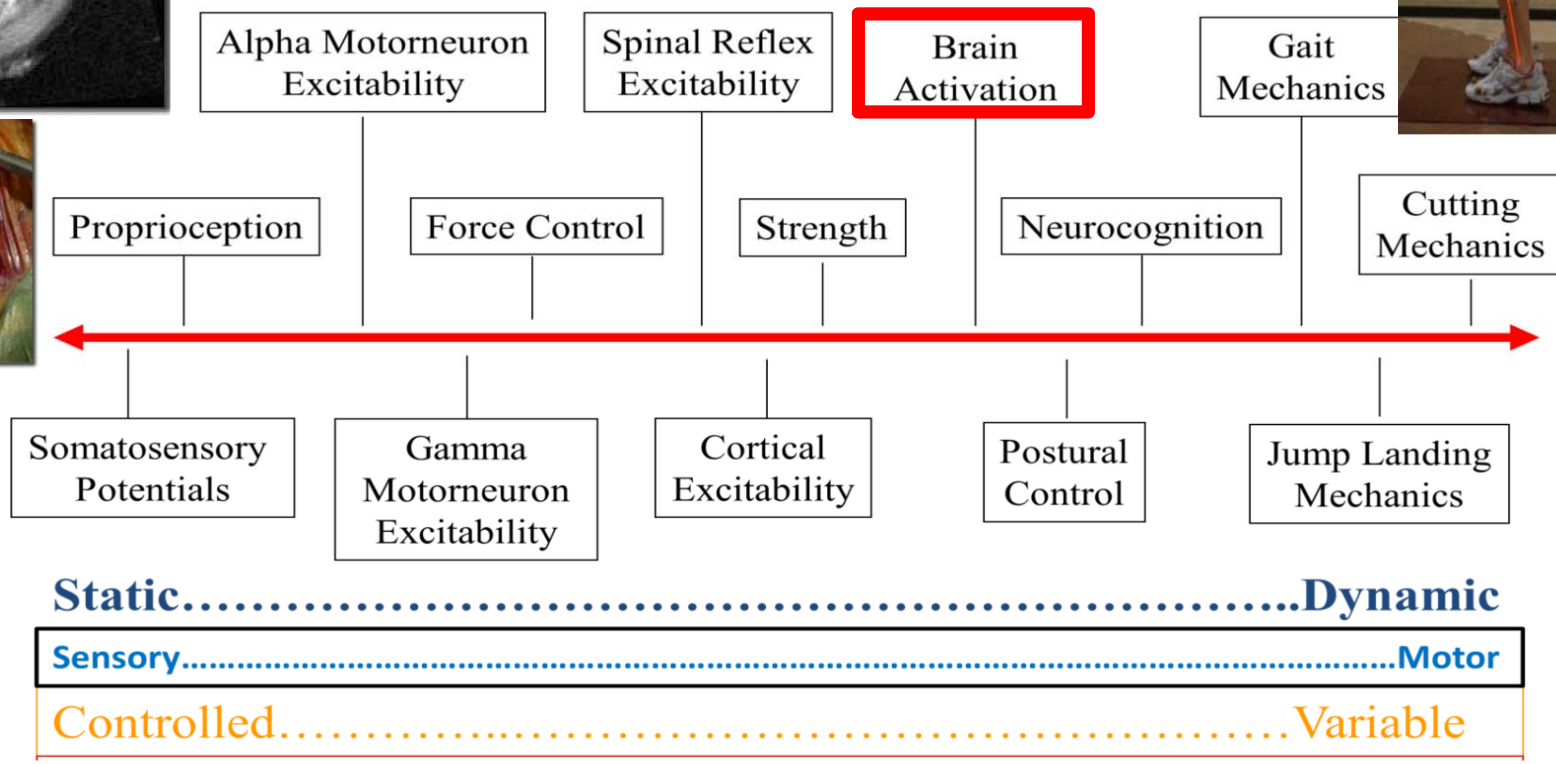
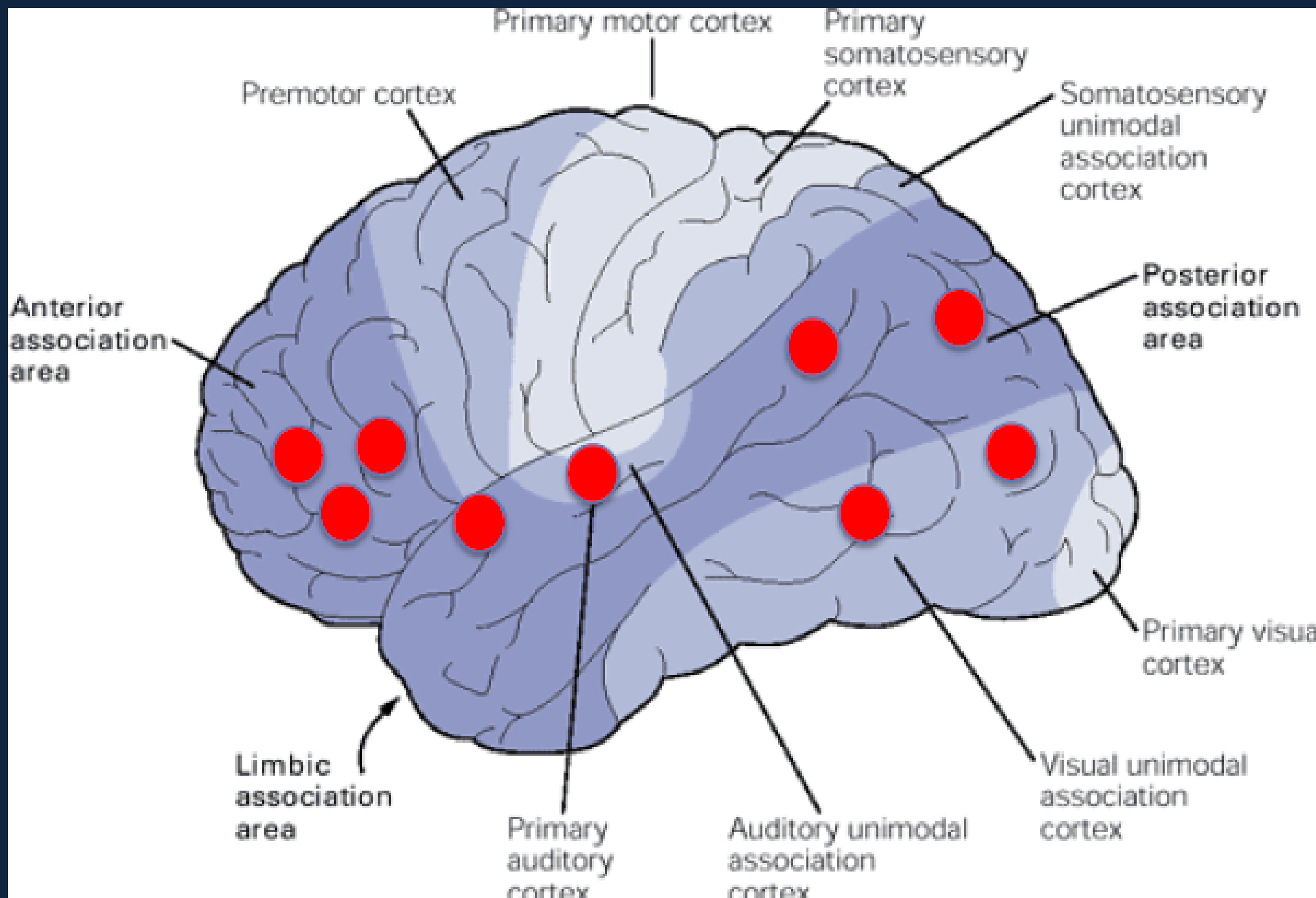


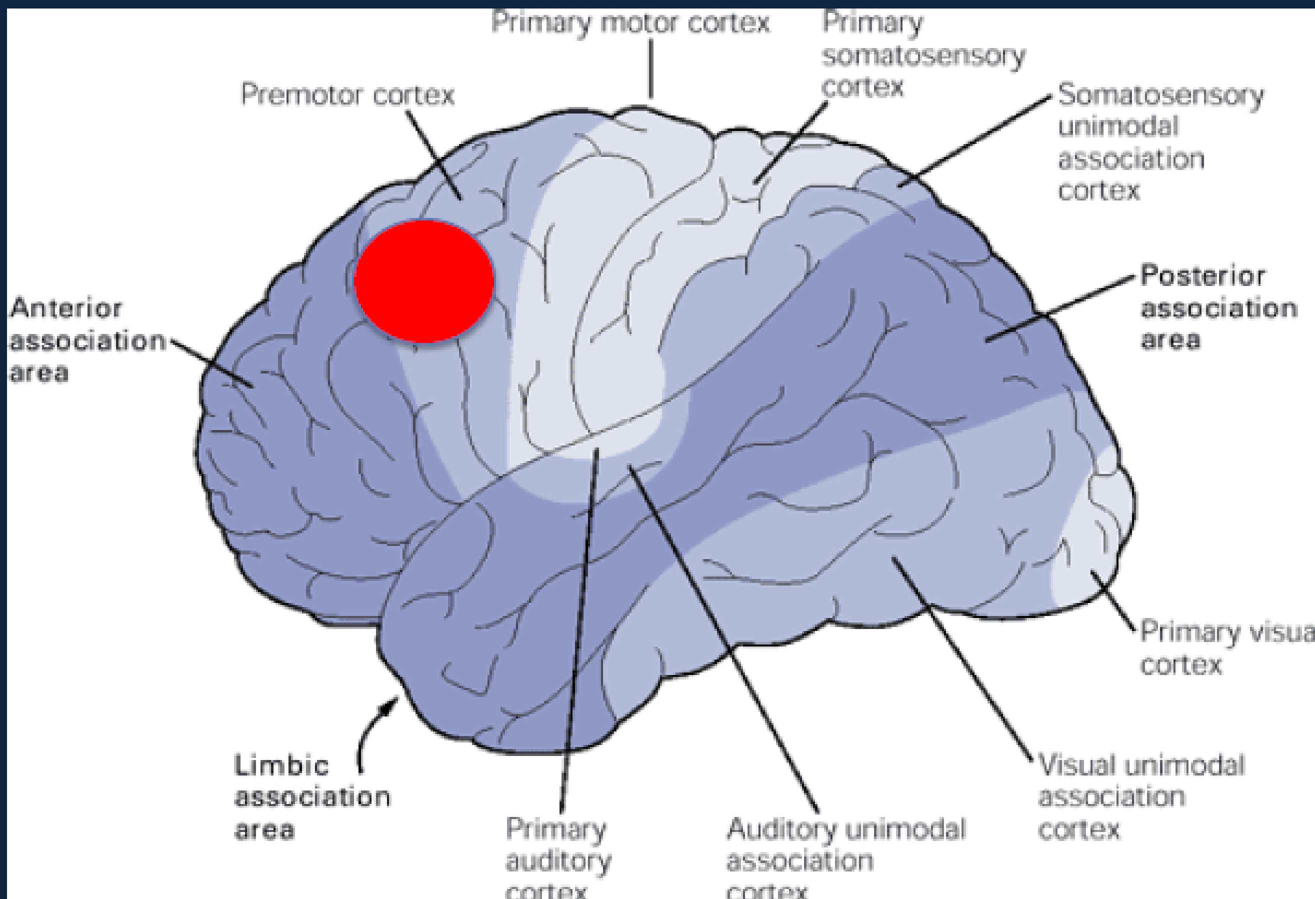
Figure modified from Hertel 2008 Sensorimotor deficits with ankle sprains and chronic ankle instability

Creating a Motor Program



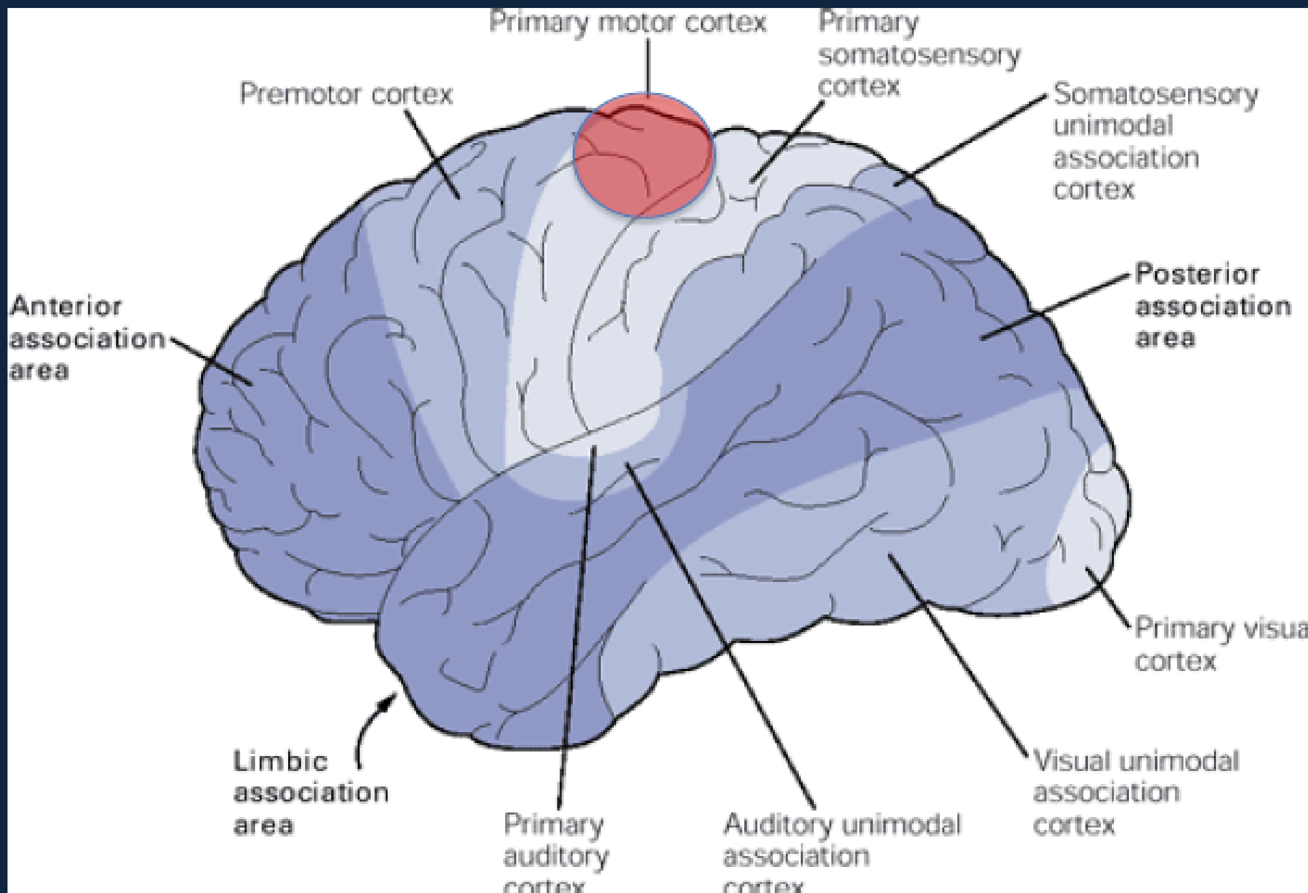
Slide Courtesy of Brain Pietrosimone NATA 2014

Creating a Motor Program



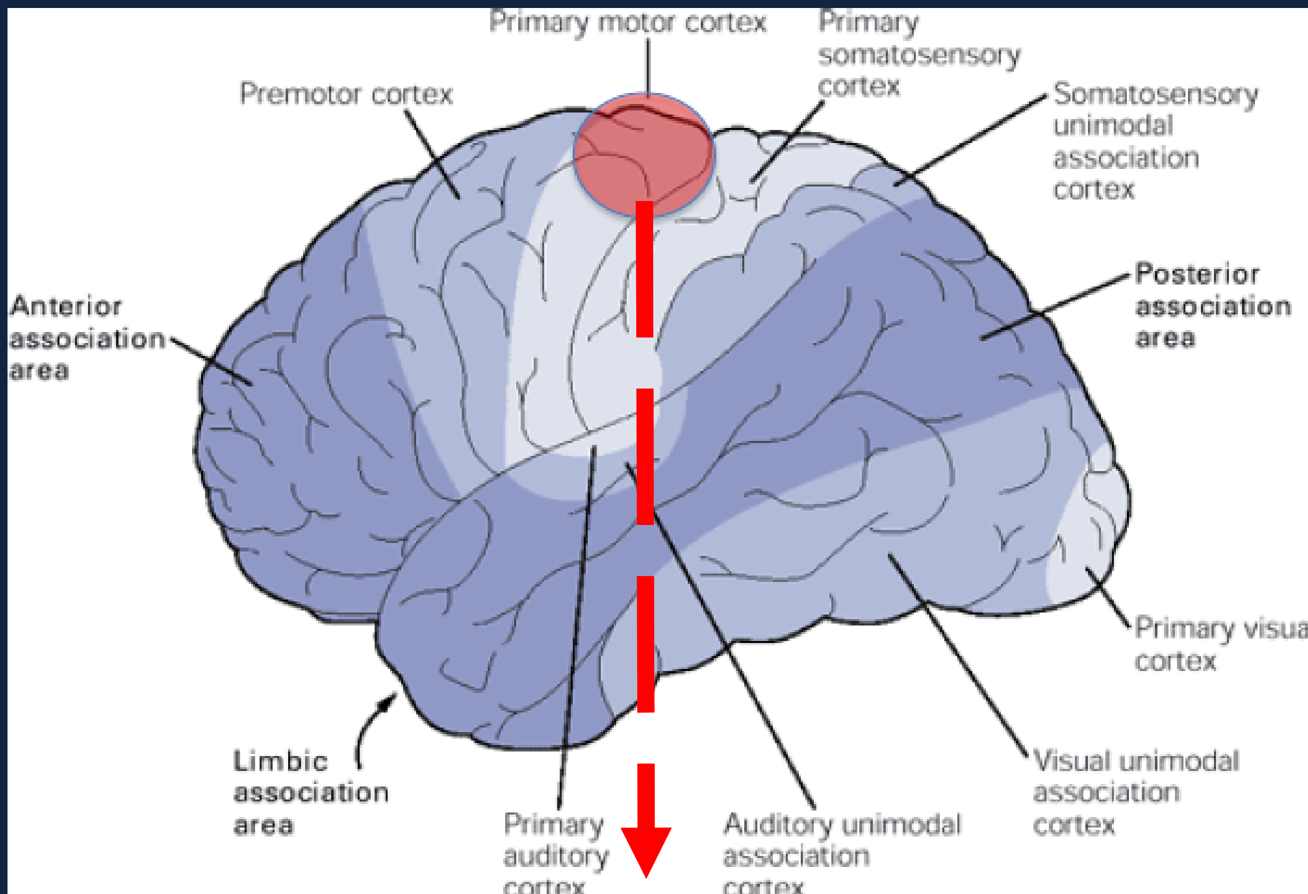
Slide Courtesy of Brain Pietrosimone NATA 2014

Creating a Motor Program



Slide Courtesy of Brain Pietrosimone NATA 2014

Creating a Motor Program



Slide Courtesy of Brain Pietrosimone NATA 2014

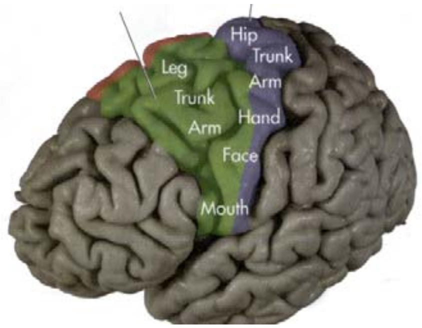
Brain Anatomy

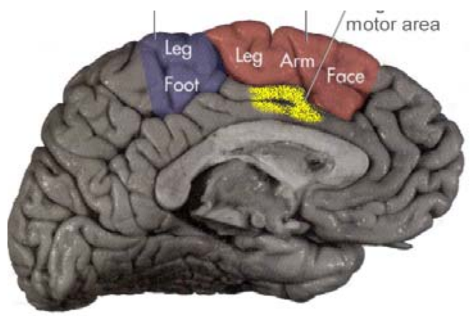
<u>Cortical</u>

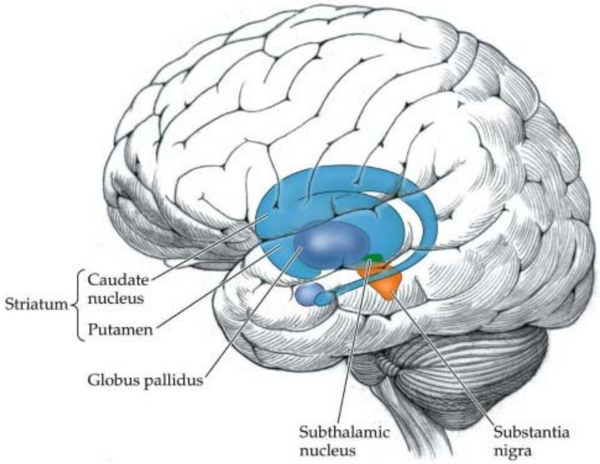
- Pre-central Gyrus
  - Primary Motor (M1)
- Post-central Gyrus
  - Primary Somatosensory (S1)
- Supplementary Motor Area
- Premotor Area

<u>Subcortical</u>

- Basal ganglia
- Cerebellum

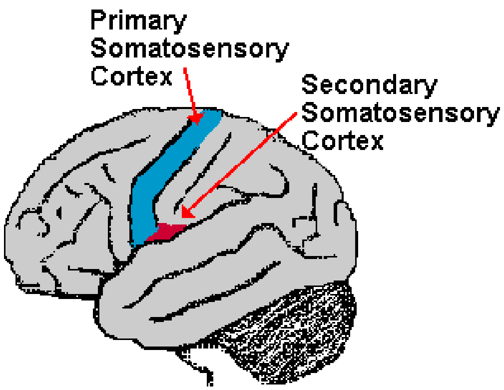


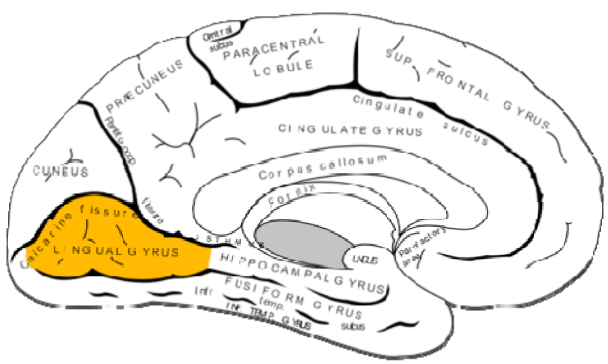


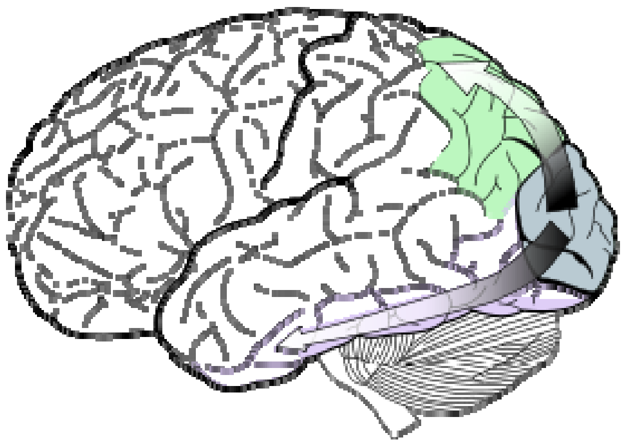


Brain Anatomy

- Secondary Somatosensory area
  - Pain, chronic adaptation
- Lingual gyrus
  - Combined sensory-vision integration
- Dorsal & Ventral visual-motor processing







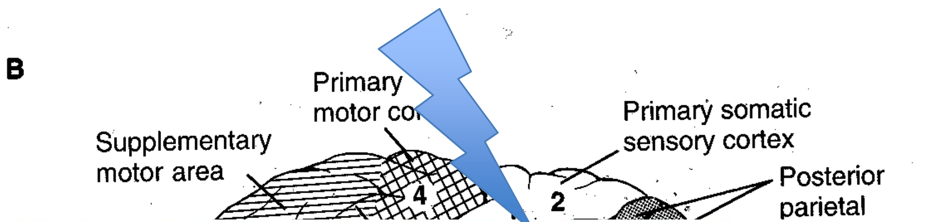
Neuroplasticity

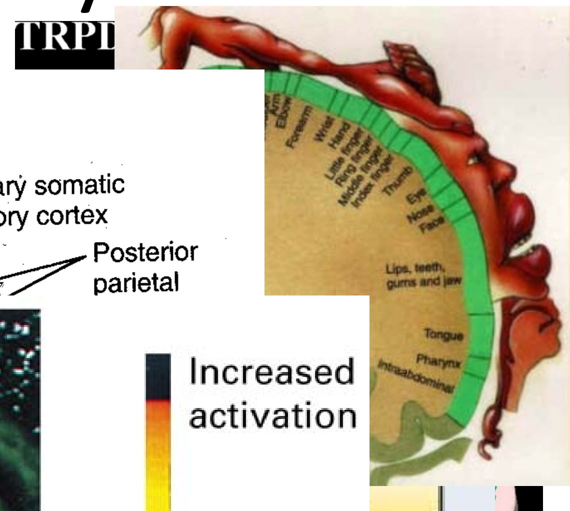
- Ability of neurons to change their function, chemical profile (amount and types of neurotransmitters produced) or structure
- Recovery of function is associated with a return of activity and responsiveness in the motor network
- This is your job!

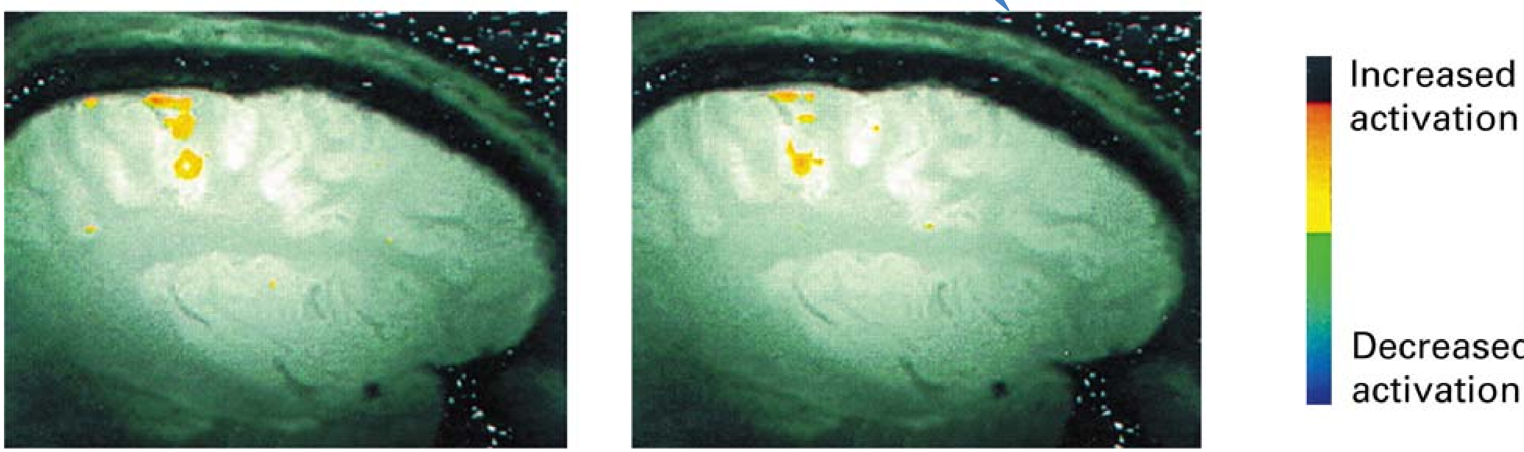



Neuroplasticity

- Neural Efficier
- Increased cort with skill
-







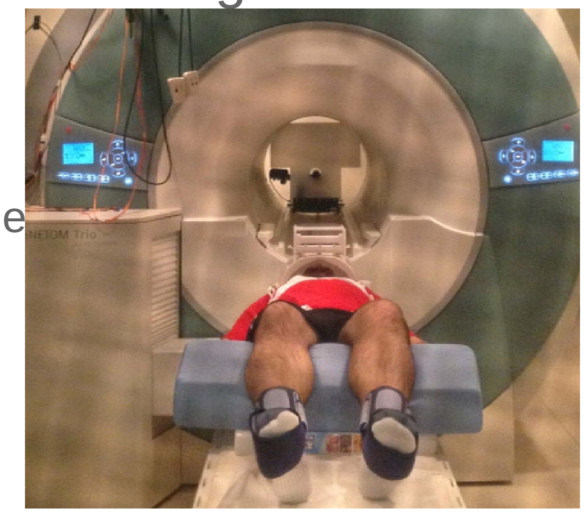
Trained sequence

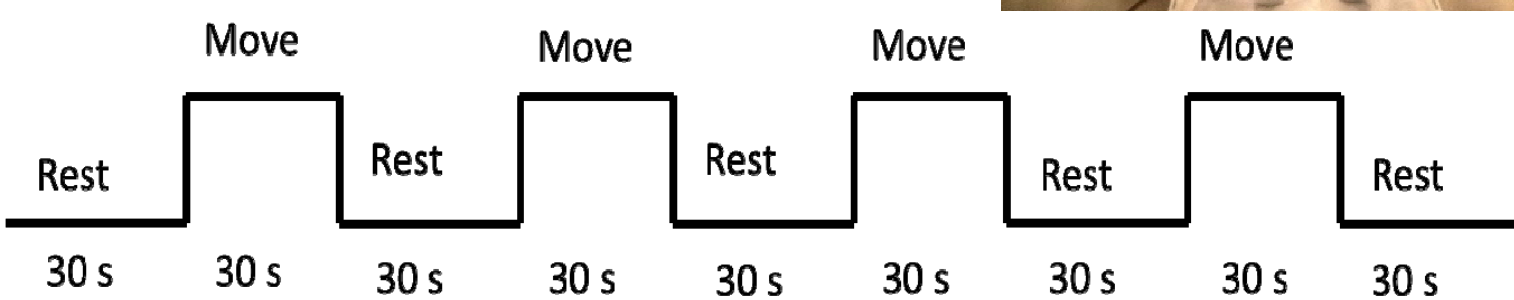
Untrained sequence

(b)

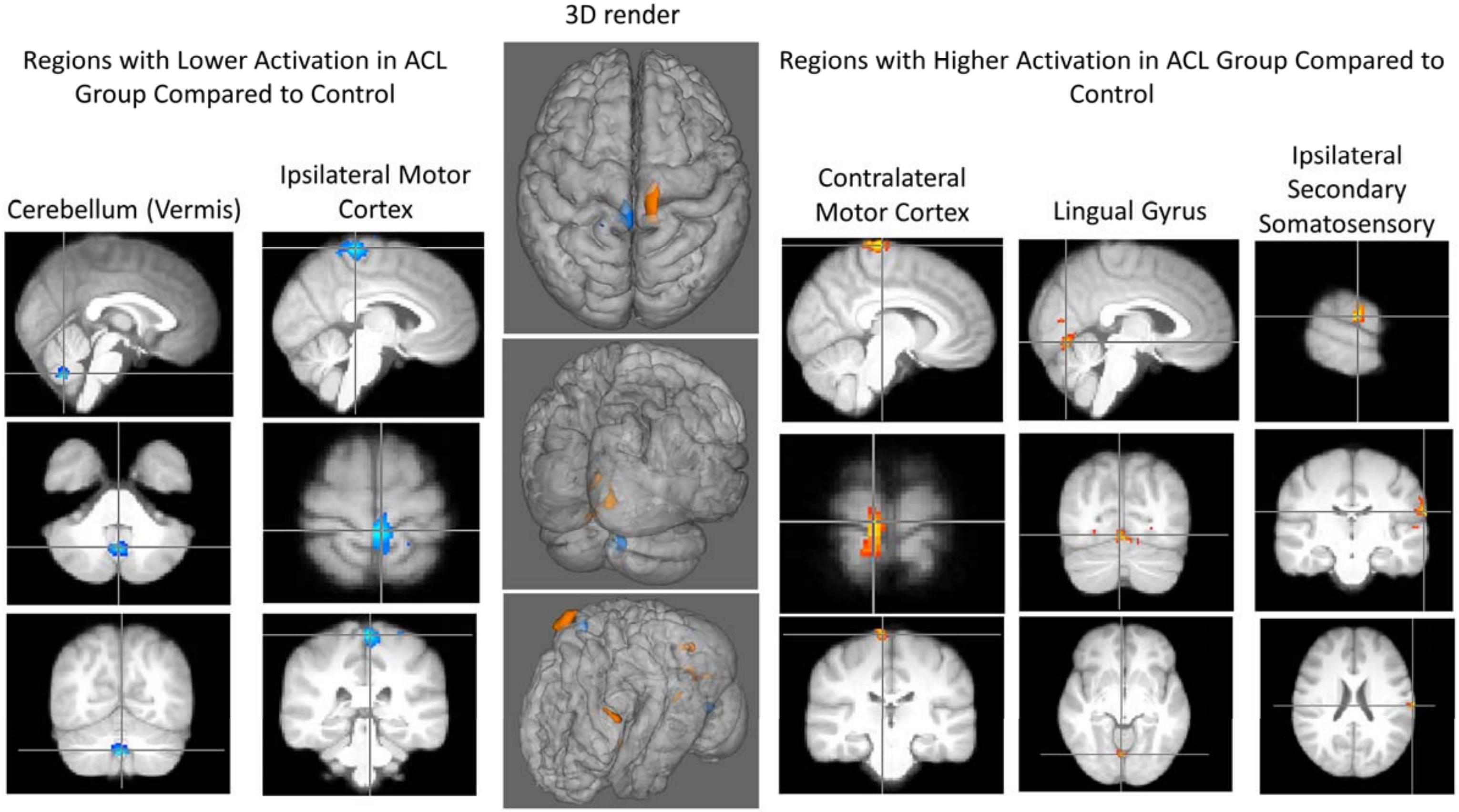
Measuring the Brain

- Movement paradigm – 4 sets – Block Design
  - Rest 30 seconds
  - Knee Extension-Flexion
    - 30 seconds
    - 1.2 Hz movement frequency (36 cycle



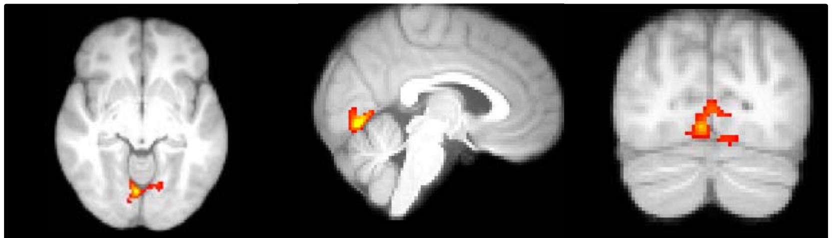


Knee Motor Control

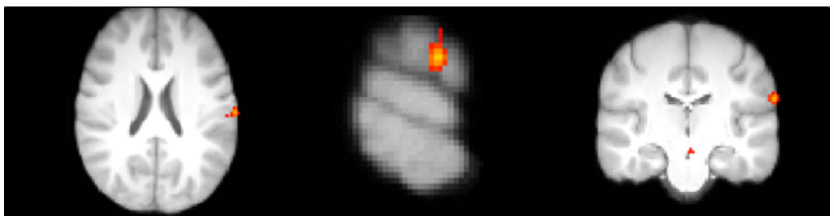


N=30

Knee Motor Control



Area	MNI Coordinates			Z Value
	X	Y	Z	
Left Lingual Gyrus	4	-70	-8	8.315



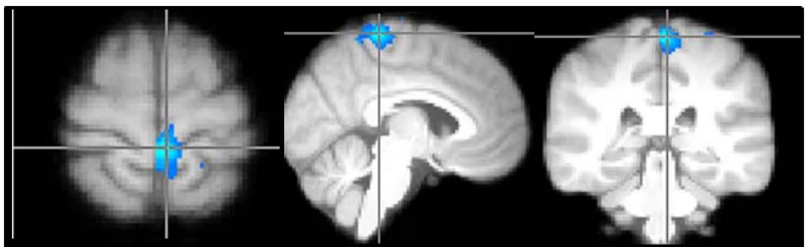
Area	MNI Coordinates			Z Value
	X	Y	Z	
Left Secondary Somatosensory	--68	-18	24	11.27

23)Servos CC 2002; 24)Torquati NI 2005

- Lingual gyrus[23]
  - Visual processing
  - Visual memory
  - Altered sensory
- Secondary somatosensory[24]
  - Adapted sensory processing
  - Pain

Knee Motor Control

Area	MNI Coordinates			Z Value
	X	Y	Z	
Right Sensorimotor	8	-30	76	12.46



Area	MNI Coordinates			Z Value
	X	Y	Z	
Left Sensorimotor	-2	-36	68	12.32

21) Kapreli NI 2006; 22) Tinazzi NSL 1998

N=30

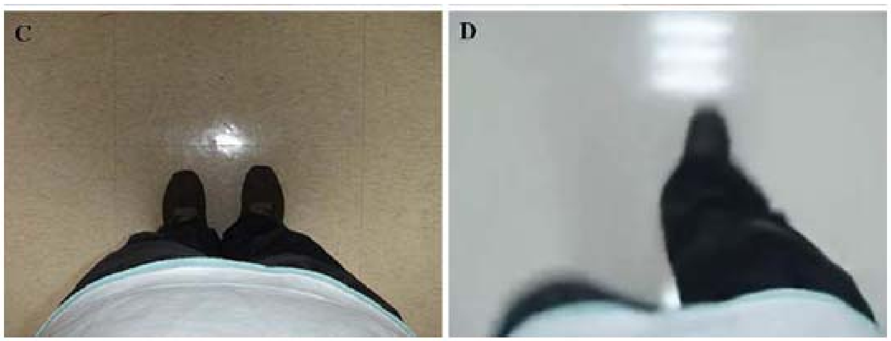
- Contralateral Sensorimotor[21]
  - Motor drive
  - Conscious control
  - Sensory integration
- Ipsilateral Sensorimotor[22]
  - Contralateral inhibition
  - Neural efficiency

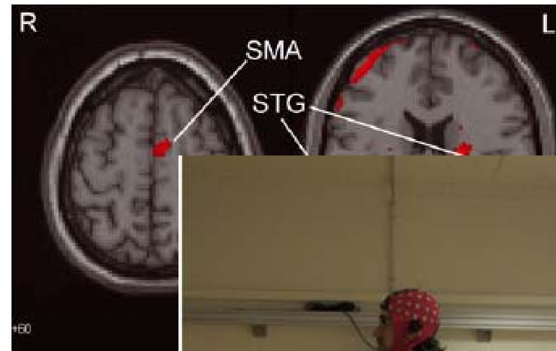
Action-Observation & Motor Imagery

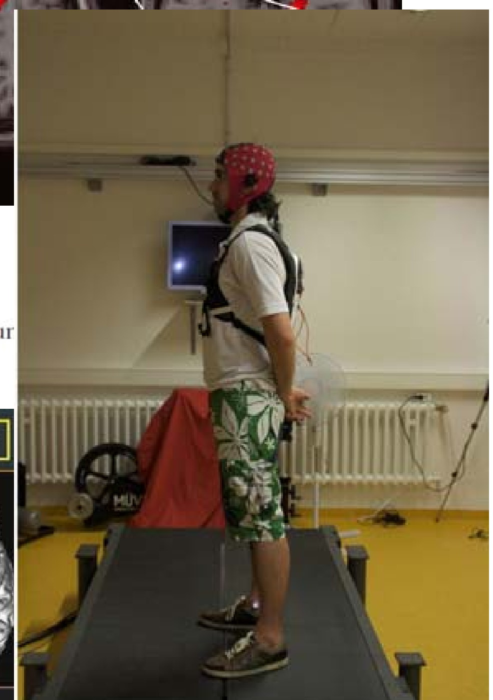
Cortical control of gait in healthy humans: an fMRI study

ChiHong Wang · YauYau Wai · BoCheng Kuo ·
Yei-Yu Yeh · JiunJie Wang

J Neural Transm (2008) 115:1149–1158



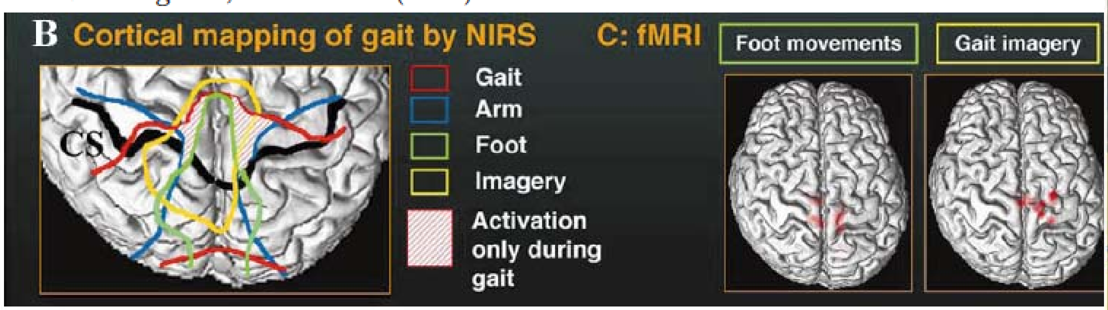




Cortical Mapping of Gait in Humans: A Near-Infrared Spectroscopic Topography Study

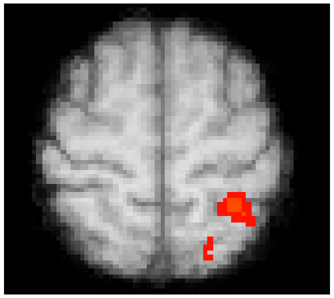
Ichiro Miyai,* Hiroki C. Tanabe,† Ichiro Sase,† Hideo Eda,† Ichiro Oda,‡ Ikuo Konishi,‡ Yoshio Tsur
Tsunehiko Suzuki,* Toshio Yanagida,†·§ and Kisou Kubota*·¶

NeuroImage **14**, 1186–1192 (2001)



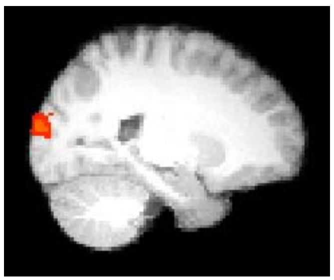
Primary Findings

Red –ACLR Higher



Parietal cortex – *S1 BA1 L* – supramarginal gyrus

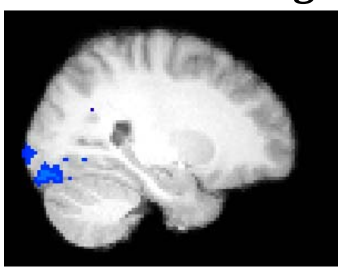
- **Greater visual-sensory integration**



Visual cortex V2 - *BA18 L* – occipital pole - Dorsal

- **Greater internal motor control**

Blue – Control Higher

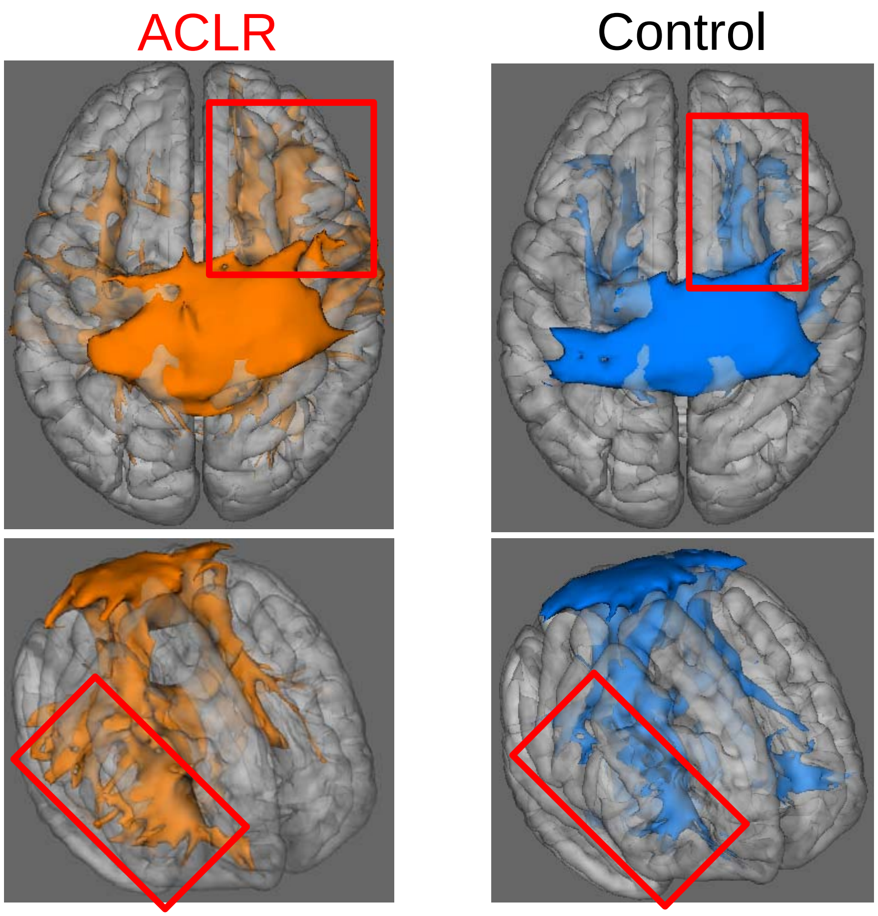


Occipital fusiform gyrus – *V3V R* – Ventral

- Relative suppression in ACL group
- **Less external motor control**

Grooms 2015 NATA

Structural Connectivity

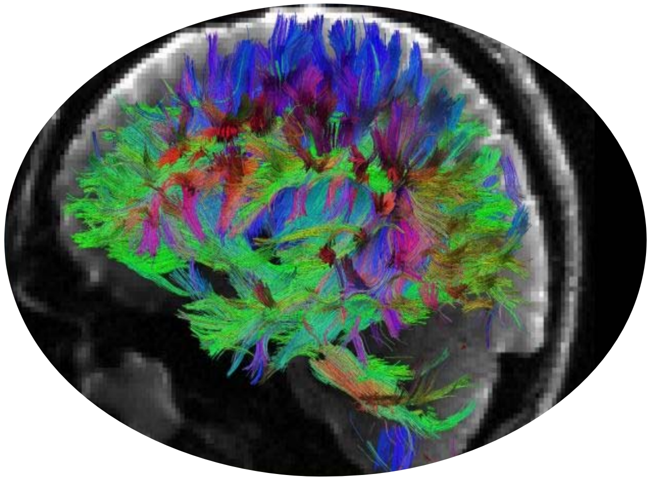


Grooms 2015 ACL research retreat

Clinical Implications

- What can you do with this information?

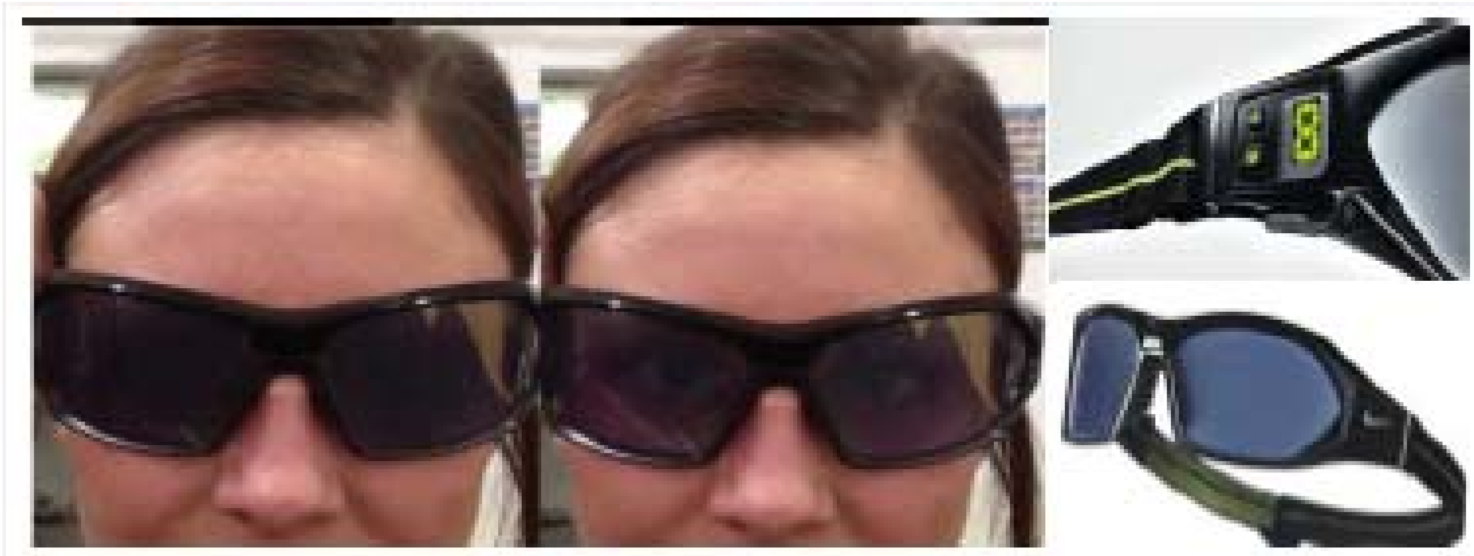
- A few ways you can induce neuroplasticity in your patients TODAY!!!



Cascade of Neuromuscular Control Dysfunction

- Video analysis of actual injury events
- Distractors
  - Ball
  - Another player
  - Stressful situation
  - Cognitive load

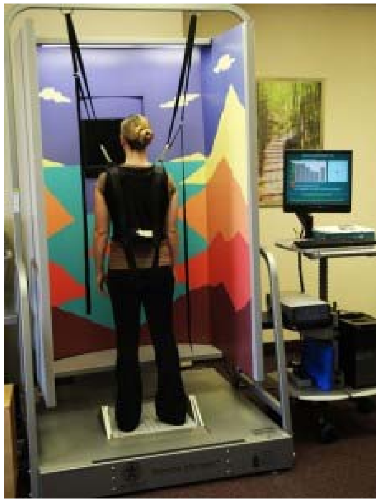
Visual Feedback Disruption



- Visual – Motor Disruption
  - Stroboscopic visual knockdown[21,22]
    - Allows complex action
    - Improves visual processing and action anticipation

19) Destaso IES 1997 20) Horita EJAP 1996 21) Appelbaum 2011 *JSS* 22) Appelbaum 2012 *BJSM*

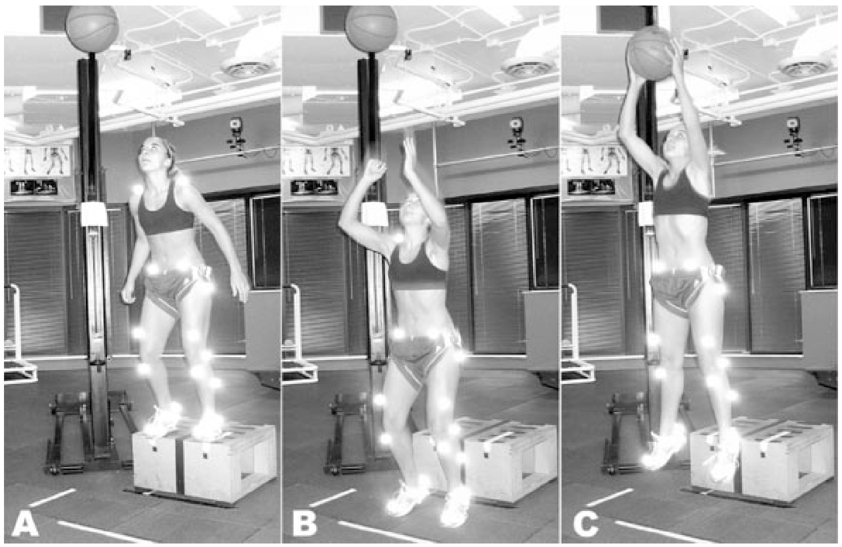
Virtual Reality

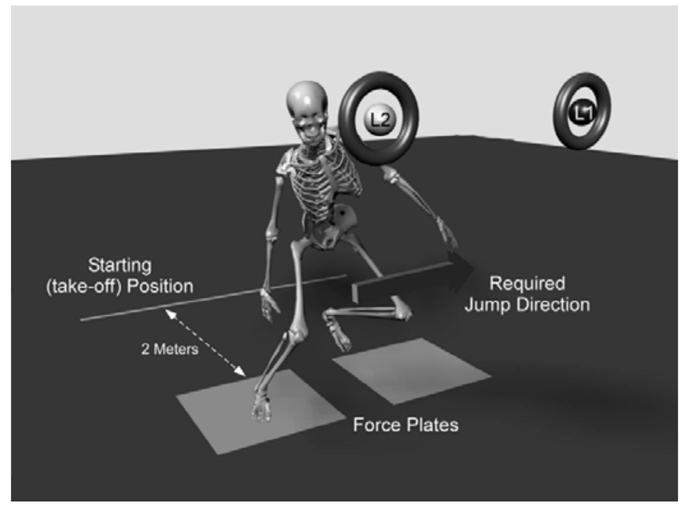


Environment & Anticipation

USE OF AN OVERHEAD GOAL ALTERS VERTICAL JUMP PERFORMANCE AND BIOMECHANICS

KEVIN R. FORD,[1] GREGORY D. MYER,[1] ROSE L. SMITH,[2] ROBYN N. BYRNES,[2] SARA E. DOPIRAK,[2] AND TIMOTHY E. HEWETT[1,2,3]





Differences between Sexes and Limbs in Hip and Knee Kinematics and Kinetics during Anticipated and Unanticipated Jump Landings: Implications for ACL injury.

Environment & Anticipation

IJSPT

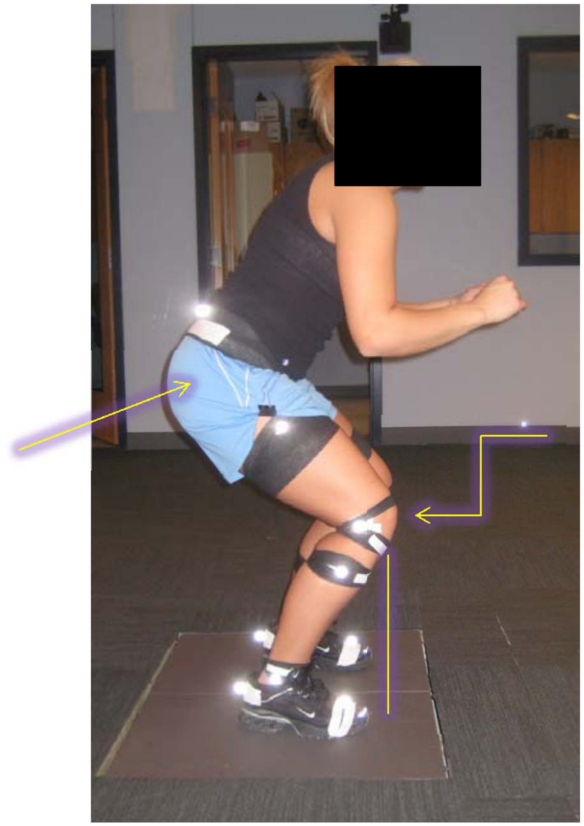
CASE REPORT

REHABILITATION STRATEGIES ADDRESSING NEUROCOGNITIVE AND BALANCE DEFICITS FOLLOWING A CONCUSSION IN A FEMALE SNOWBOARD ATHLETE: A CASE REPORT

John Faltus, DPT, MS, SCS, LAT, ATC, CSCS[1]

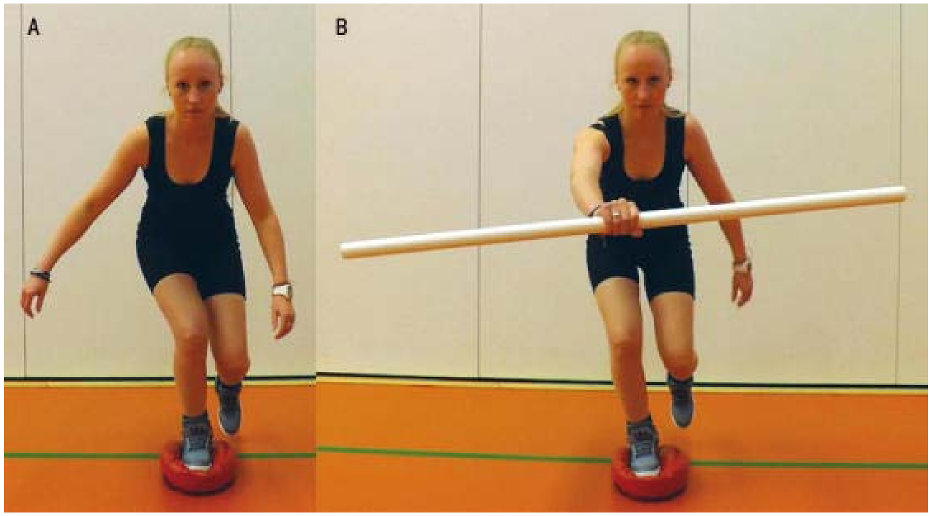
Internal Feedback Model

Frontal View



Sagittal View

External Feedback Model



Feedback specific

- Feedback specific cortical activation
  - Frontal pole – working memory & attention
  - Occipital pole – visual spatial processing
  - Precuneous – sensory integration

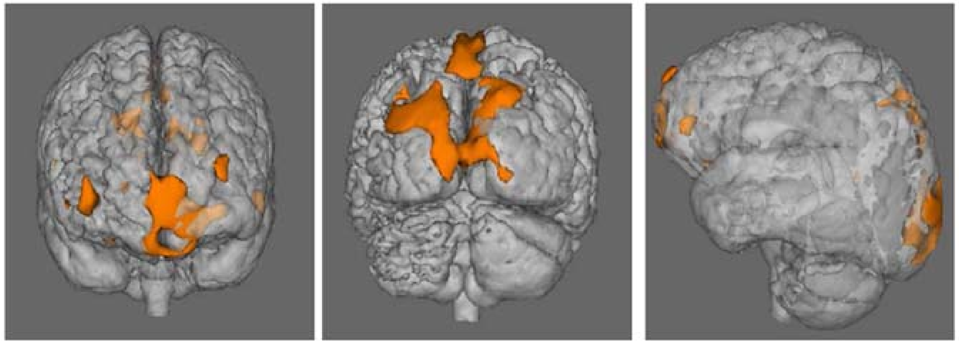


Figure 1: Areas of brain activation when participants used an external focus of attention compared to an internal focus of attention, all $p < .001$.

Feedback specific

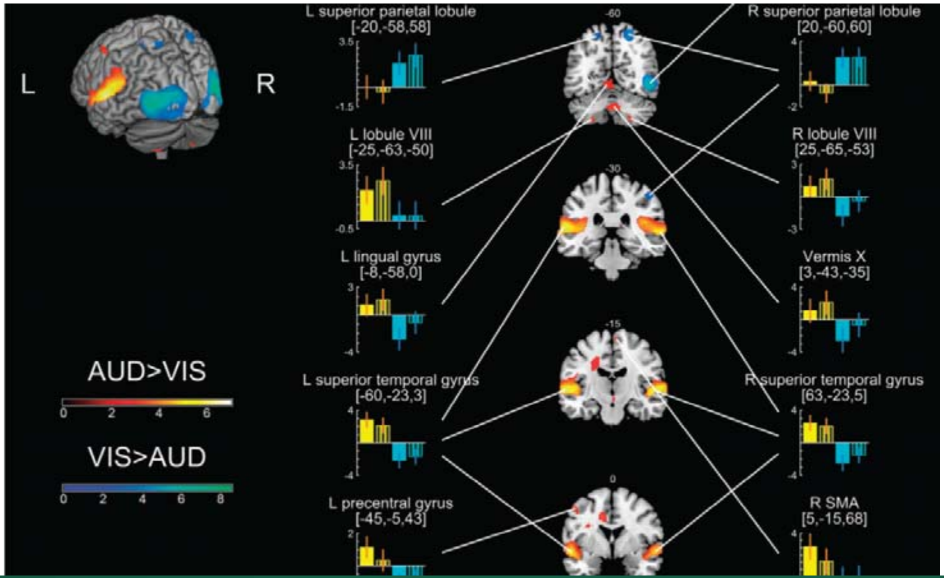
Feedback specific cortical activation

Auditory

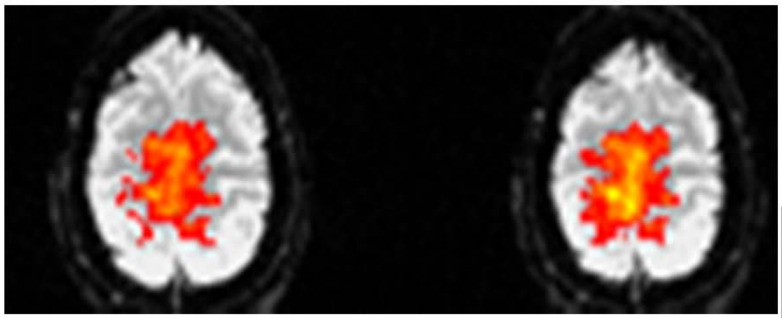
Perform without feedback >>decrease activation >> facilitate autonomous stage

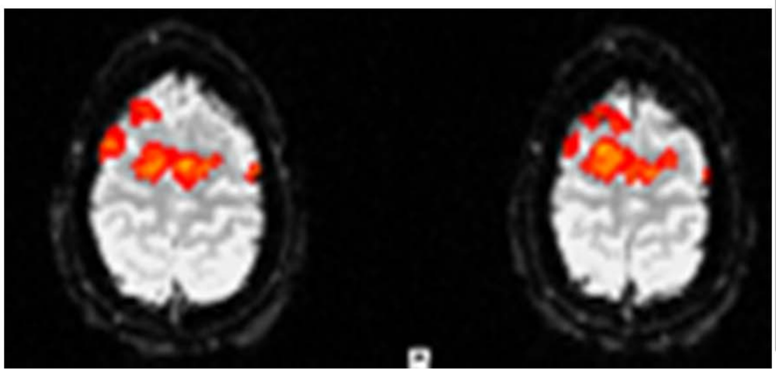
Visual

Reliant on feedback >> Increase activation >> inhibit motor learning progression



Motor Imagery – Mental Practice

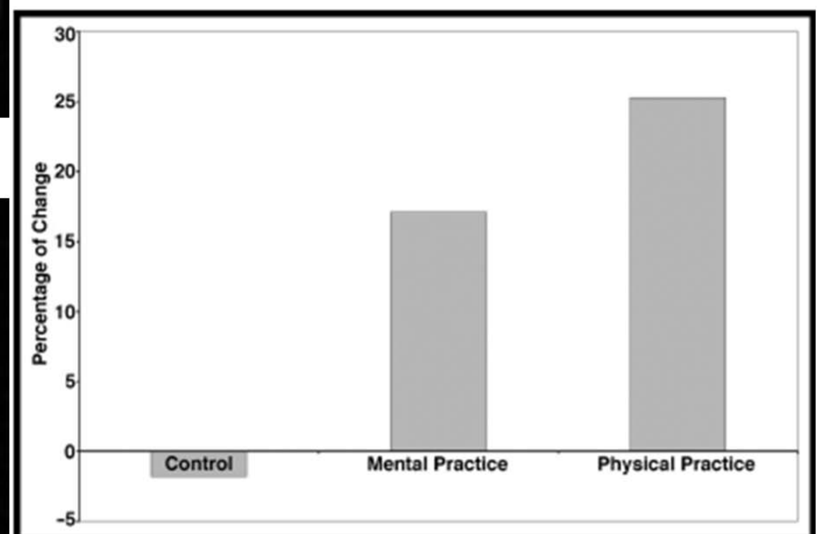




Can Mental Practice Increase Ankle Dorsiflexor Torque?

Physical Therapy

Ben Sidaway, Amy (Robinson) Trzaska

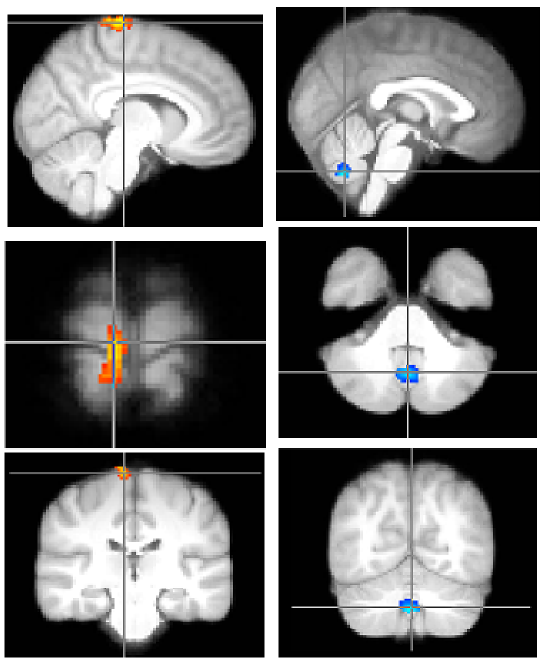


Strength Training

Normal

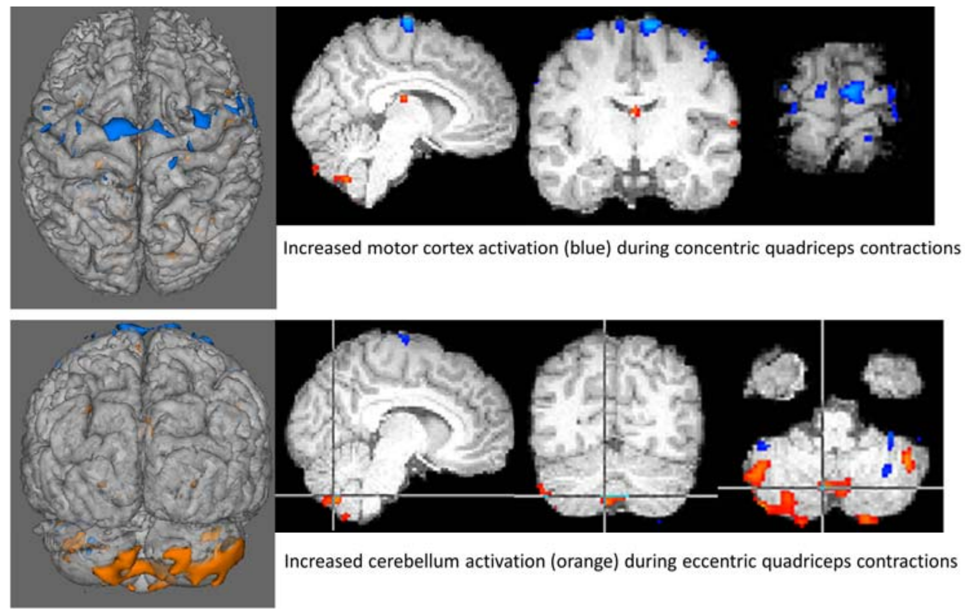
Contralateral Motor Cortex

Cerebellum (Vermis)



Regions with higher activation ACLR group (orange) and lower activation ACLR group (blue) compared to healthy matched controls.

Eccentrics



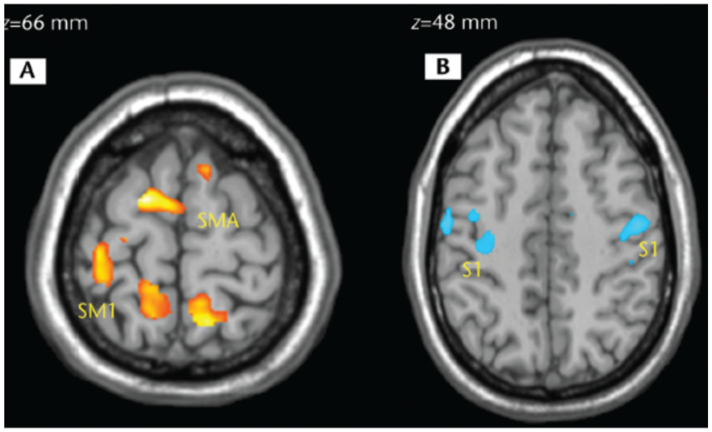
Regions with higher activation eccentric quadriceps contraction (orange) and lower activation (blue).

What if I just throw some tape on it?

Neuroplasticity of Tape

Effects of Patellar Taping on Brain Activity During Knee Joint Proprioception Tests Using Functional Magnetic Resonance Imaging

Michael J. Callaghan, Shane McKie, Paul Richardson, Jacqueline A. Oldham



- Changes brain motor and sensory activation!
- DECREASE activation
  - Sensory cortex – Efficient processing
- INCREASE activation
  - Motor cortex – Increased output
  - Supplementary motor

How Does this Change Clinical Practice

- THINK!
  – About the brain in all your intervention efforts
- **Neuroscience Tools can Optimize Interventions**
  – Motor Learning
  – Visual-motor
  – Virtual Reality
  – Neurocognition
  – Eccentric training
  – Motor Imagery
  – Taping

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