
Focus on Neurology

The Role of Patient Mobility In the Recovery of the Neurologic Patient

Neural Stimulation through Mobilization

A Presentation in Conjunction with the *Patsy Getz Initiative*

Mobility is Medicine

Patsy Getz

September 18, 2009

For those of you who were never fortunate enough to know Patsy, let me take a moment to honor her. Patsy was a Nurse who devoted her entire professional life to the quality of patient care here at Emory. As a Clinical Nurse Specialist in orthopedics and rehabilitation, Patsy was adamant about the necessity of early mobilization for the health and recovery of our patients. As one of the founding planners for the Center for Rehabilitation Medicine, Patsy put this sentiment into practice. It was in her honor, and now in her memory, that we initiate this mobility program.

Presentation

- Definition of Rehabilitation & Compensation
- Overview- Role of Brain Stimulation in Functional Recovery
- Functional MRI and New Evidence on Motor Recovery
- It's as Simple as ROM
- The Virtual Body- the Brain's Organization
- Consequences of Limited Brain Stimulation due to Lack of Movement
- How Fast Can the Brain Change?
- Summary

Definitions

"Rehabilitation"

- **re·ha·bil·i·tate**

- **To restore** to good condition, operation, or capacity.

- **Origin**

Medieval Latin rehabilitāre, rehabilitāt-, *to restore to a former rank* : Latin re-, *re-* + Late Latin habilitāre, *to enable*

"Compensation"

- **com·pen·sa·tion**
- Biology: the **improvement** of any defect **by the excessive development or action of another structure** or organ of the same structure.

- **Origin:**

1350–1400; Medieval latin: compensacioun: equiv. to

Our Goal

To rehabilitate (enable/ restore) function by stimulating the development of compensatory cells within the brain.

The question is: HOW?

Overview

The Role of Brain Stimulation in Functional Recovery

What do the studies show?

Integrated technology for evaluation of brain function and neural plasticity.

Rossini PM, Dal Forno G. Phys Med Rehabil Clin N Am. 2004 Feb;15(1):263-306

- The study of neural plasticity has shown the remarkable ability of the developing, adult, and aging **brain** to be **shaped by environmental inputs in the healthy state and after a lesion.**

- **Neurons adjacent to a lesion** in the sensori-motor brain areas become **hyper-activated** and **can take over the functions** previously performed by the damaged neurons.
- **The amount of the brain devoted to a body part can enlarge** to bring in potentially useful neurons.

- **This reorganization largely underlies the clinical recovery of motor performances and sensori-motor integration after a stroke.**

Integrated technology for evaluation of brain function and neural plasticity.

Rossini PM, Dal Forno G. Phys Med Rehabil Clin N Am. 2004 Feb;15(1):263-306

CONTINUED

- Functional MRI (fMRI)demonstrates enhanced recruitment of the affected cortex, in 2 ways:
  - Recruitment of Intact neurons around the lesion, as in the case of cortical stroke (using new unassigned cells)
  - Recruitment of Intact but deafferented cortex, as in sub-cortical strokes (running wiring to intact but unwired cells)

Integrated technology for evaluation of brain function and neural plasticity.
Rossini PM, Dal Forno G. Phys Med Rehabil Clin N Am. 2004 Feb;15(1):263-306
CONTINUED

Reinforcing the use of the affected side can cause activation to increase again in the affected side with a corresponding enhancement of clinical function.

AND (AMAZINGLY)

There is inter-hemispheric activity that underlies recovery- meaning that the stimulation of the unaffected side can facilitate reorganization of the affected hemisphere

FUNCTIONAL IMPLICATIONS

After a lesion, the brain is still shaped by in-coming impulses

Undamaged cells surrounding the lesion become hyper activated and can be facilitated to assume the function of the damaged cells

Undamaged but deafferented cells surrounding the lesion become hyper-excited and can be recruited to assume the function of the damaged cells

Impulses act bilaterally, so unaffected hemisphere can input to affected side

FUNCTIONAL IMPLICATIONS

BOTTOM LINE

The sooner a patient experiences body movement, even on the unaffected side, the sooner we stimulate the brain, the sooner motor recovery begins

Bilateral stimulation is critical

Functional MRI and Motor Recovery

What We Now Know about Mobility and the Brain

New testing procedures have provided us with useful information on how sensory input effects the Brain and how it can influence its motor recovery.

We will specifically consider the research on <u>Functional Magnetic Resonance Imagery</u> (fMRI)

Functional MRI

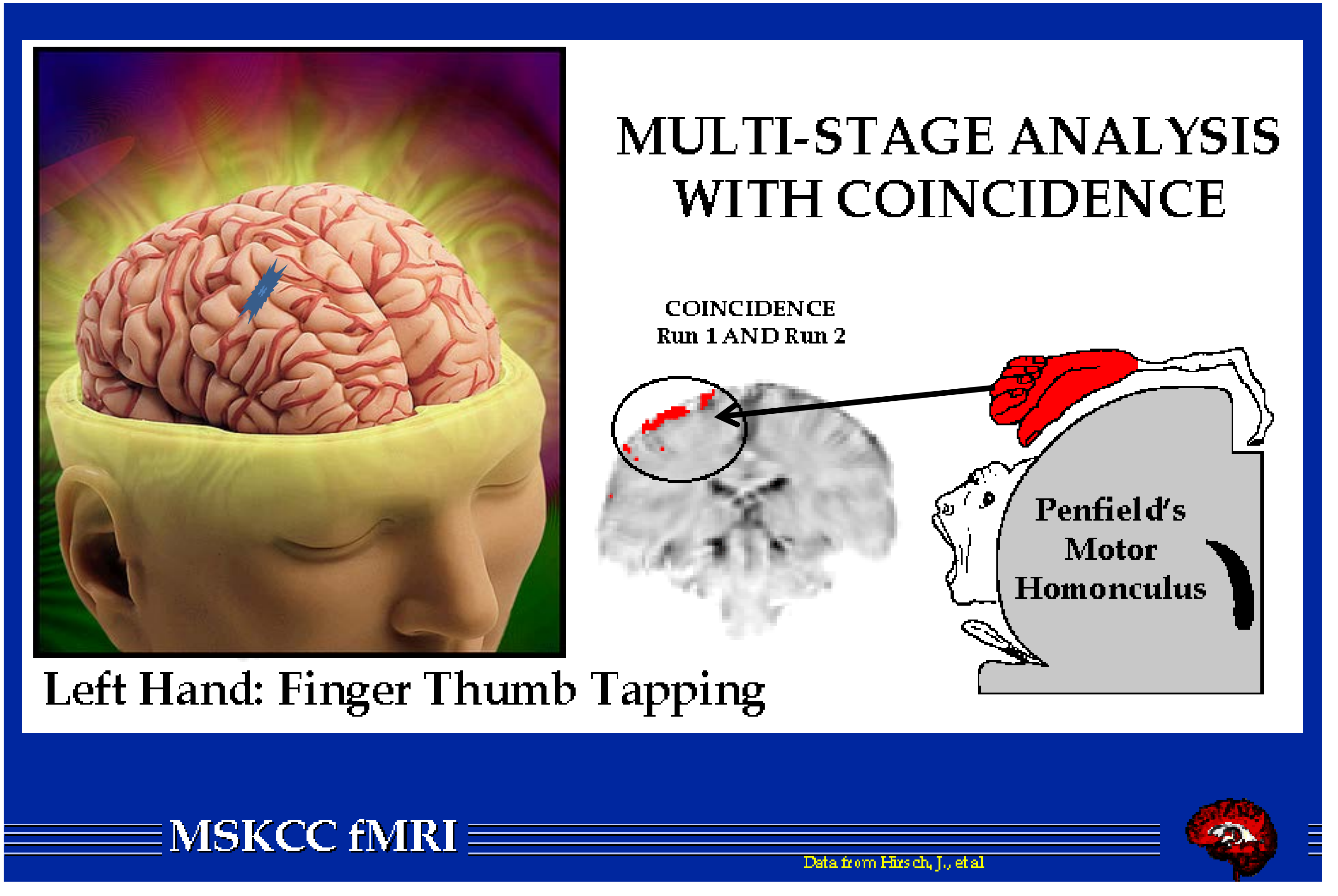
- fMRI gives us the ability to observe which structures participate in specific functions

- This new ability to directly observe brain function advances our understanding of brain re-organization

WHAT IS fMRI?

- Neural activity in the brain causes local increased blood flow
- The increased blood flow results in a local decrease in deoxyhemoglobin
- Deoxyhemoglobin serves as the source of the signal for fMRI.

fMRI example



It’s as Simple as Range Of Motion

What do the studies show?

Motor homunculus: passive mapping in healthy volunteers by using functional MR imaging--initial results.

Radiology. 2009 May;251(2):485-92. Epub 2009 Mar 4.

Kocak M, Ulmer JL, Sahin Ugurel M, Gaggl W, Prost RW.

Both **active and passive** movements of:

hand, elbow, shoulder, ankle, knee, and hip produced activation of the primary motor cortex

Altered cortical activation with finger movement after peripheral denervation: comparison of active and passive tasks.

[Reddy H](), [Floyer A](), [Donaghy M](), [Matthews PM]().

Exp Brain Res. 2001 Jun;138(4):484-91

- **Purpose**: Compare cortical activation during hand movements in profoundly weak **patients with motor neuropathy** and in **normal** controls , using fMRI

- **Healthy individuals:** patterns of brain activation during **active and passive** index finger movements :
  - activated neurons in the primary motor cortex contralateral to the hand moved (CMC) were **40% lower for the passive than for the active task**

- **Patients with severe distal sensory neuropathy**: No activation with passive movement was found. Increased activation with active motion.

- **Patients with severe pure motor neuropathies**: showed substantial **increases** in the amount of activation compared to controls for **both the active and passive tasks were similar.**

Functional Implication of Study

These results confirm passive and active motions can activate neurons outside the lesion zone for motor lesions.

In cases of severe sensory impairment, active motion must be used.

Identifying brain regions for integrative sensorimotor processing with ankle movements.

Ciccarelli O, Toosy AT, Marsden JF, Wheeler-Kingshott CM, Sahyoun C, Matthews PM, Miller DH, Thompson AJ.

Exp Brain Res. 2005 Sep;166(1):31-42. Epub 2005 Jul 21. Links

Findings:

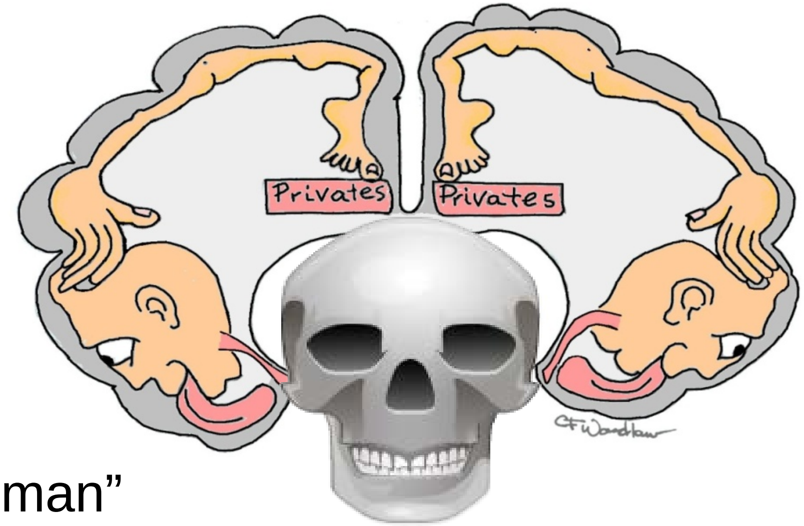
- Both cortical and subcortical structures activated during both active and passive movements of the ankle:
  - Both passive and active movements activated the same cortical regions that are used in walking (active more than passive)
  - Active movements of both feet generated greater activation than passive movements in regions important for motor planning.
  - Areas activated (by AROM and PROM)
    - **contralateral primary motor** and **sensory cortices**
    - **premotor cortical** regions (such as the bilateral rolandic operculum and **contralateral supplementary motor area**)
    - **subcortical regions** (such as the **ipsilateral cerebellum** and **contralateral putamen)**

Functional Implication of the Study

- Passive and active movements fire cortical and sub-cortical neurons *(the 2 areas we can effect!!)*
- Passive and active movements can fire the brain in a functional pattern *(like as in walking)*
- Active is better than passive
- Bilateral is better than unilateral *(like in dangling and transfers)*
- Multiple regions of the brain are stimulated at the same time through the simple application of movement, *(just as they do during function)*

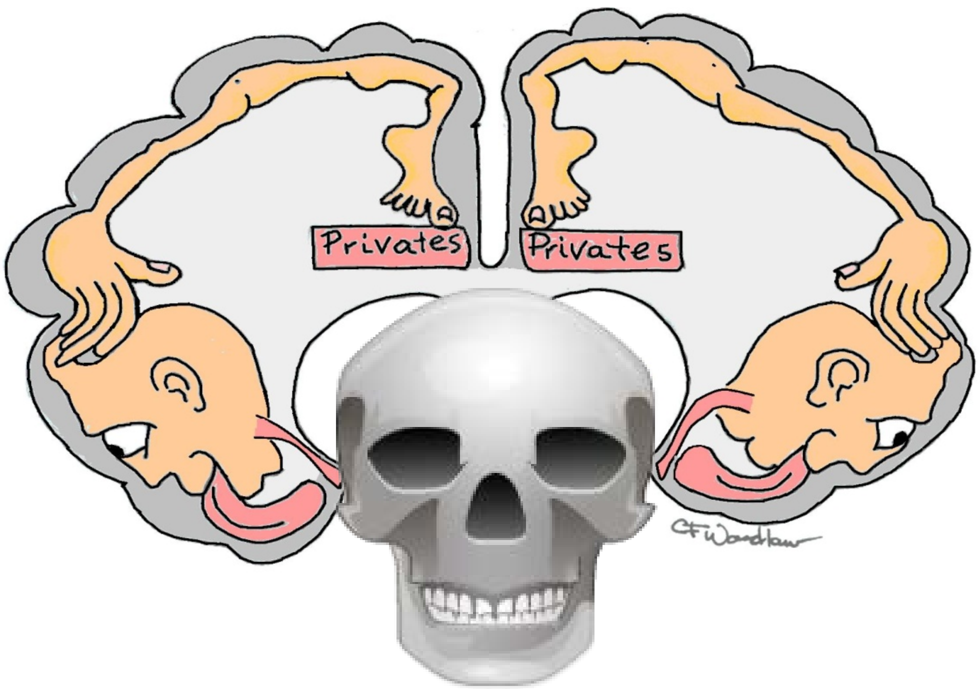
The Virtual Body- the Brain’s Organization

The “Homunculus”



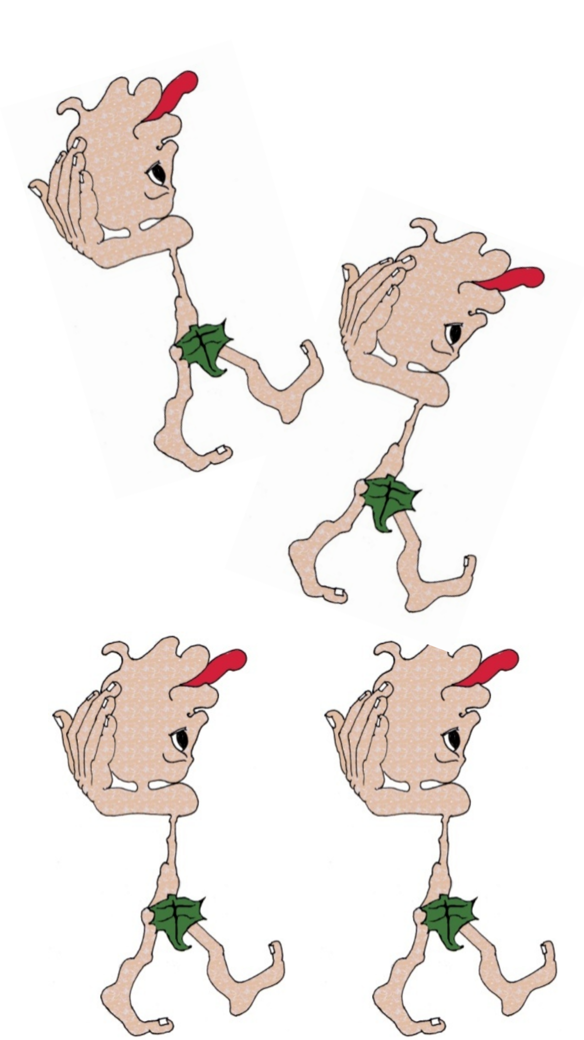
- ✓Meaning “little man”
- ✓Gives us a visual way to remember how cells are clustered in the brain
- ✓Every part in the body is represented in the sensory regions of the brain AND in the motor regions of the brain
- ✓The size of each virtual body part is based on the sensitivity of the actual part
- ✓This organization allows the brain to know where impulses are coming from and to produce a response in the right places

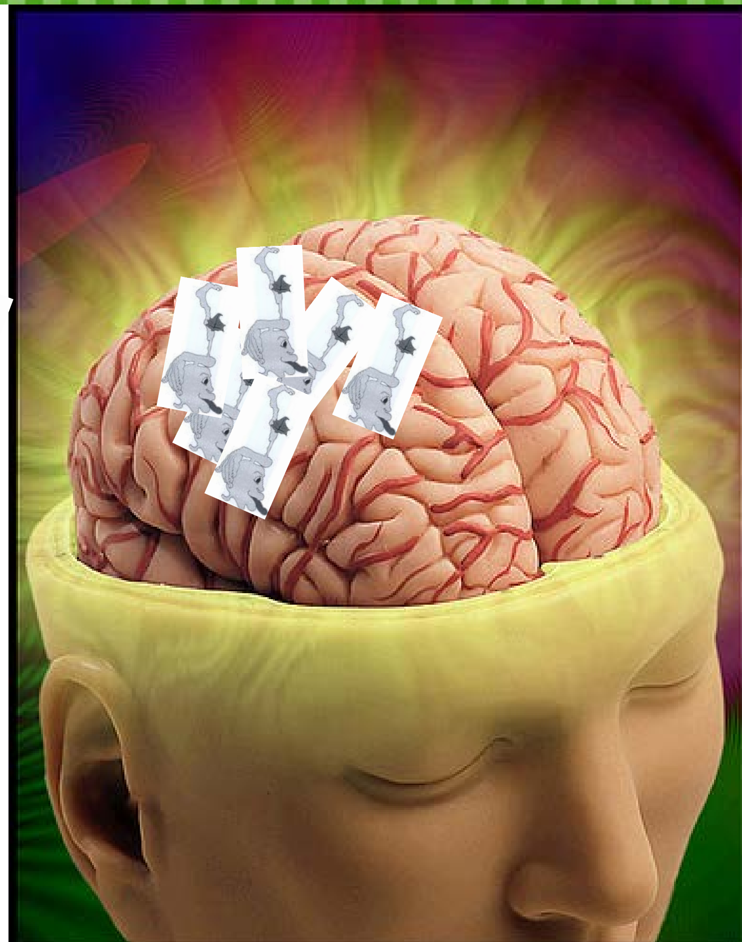
Contrary to what we may have been taught, we do not have just one "homunculus", or "virtual body" representation in the brain



We have dozens

(and they “talk” to each other)

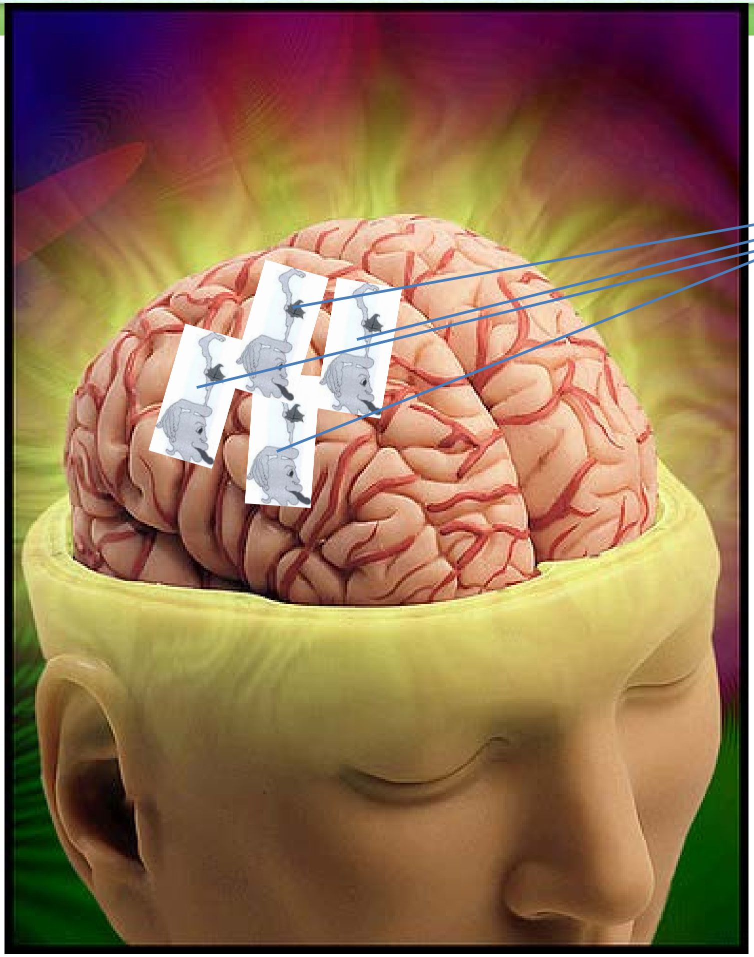


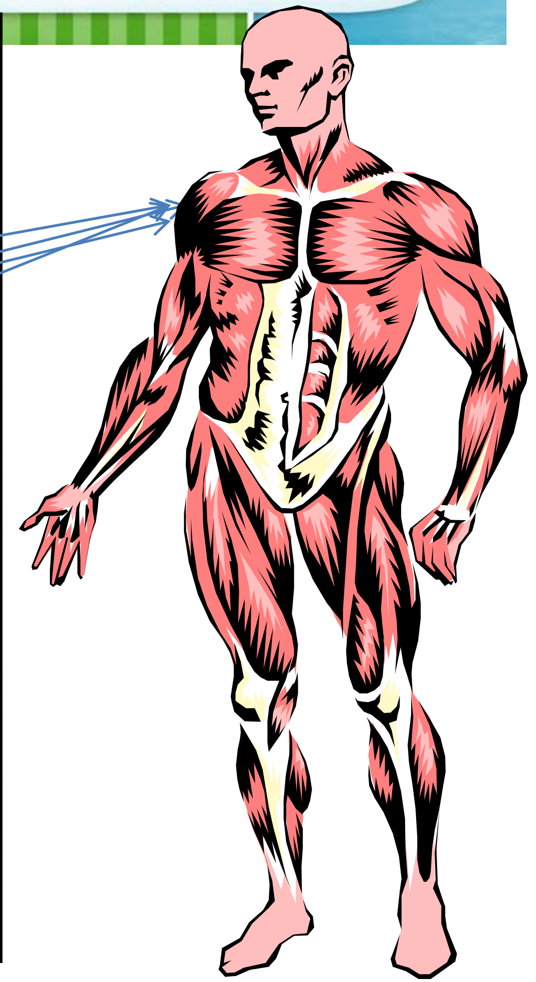


The Virtual Bodies signal in different ways

ONE

Multiple motor homunculi's output can converge on ONE muscle

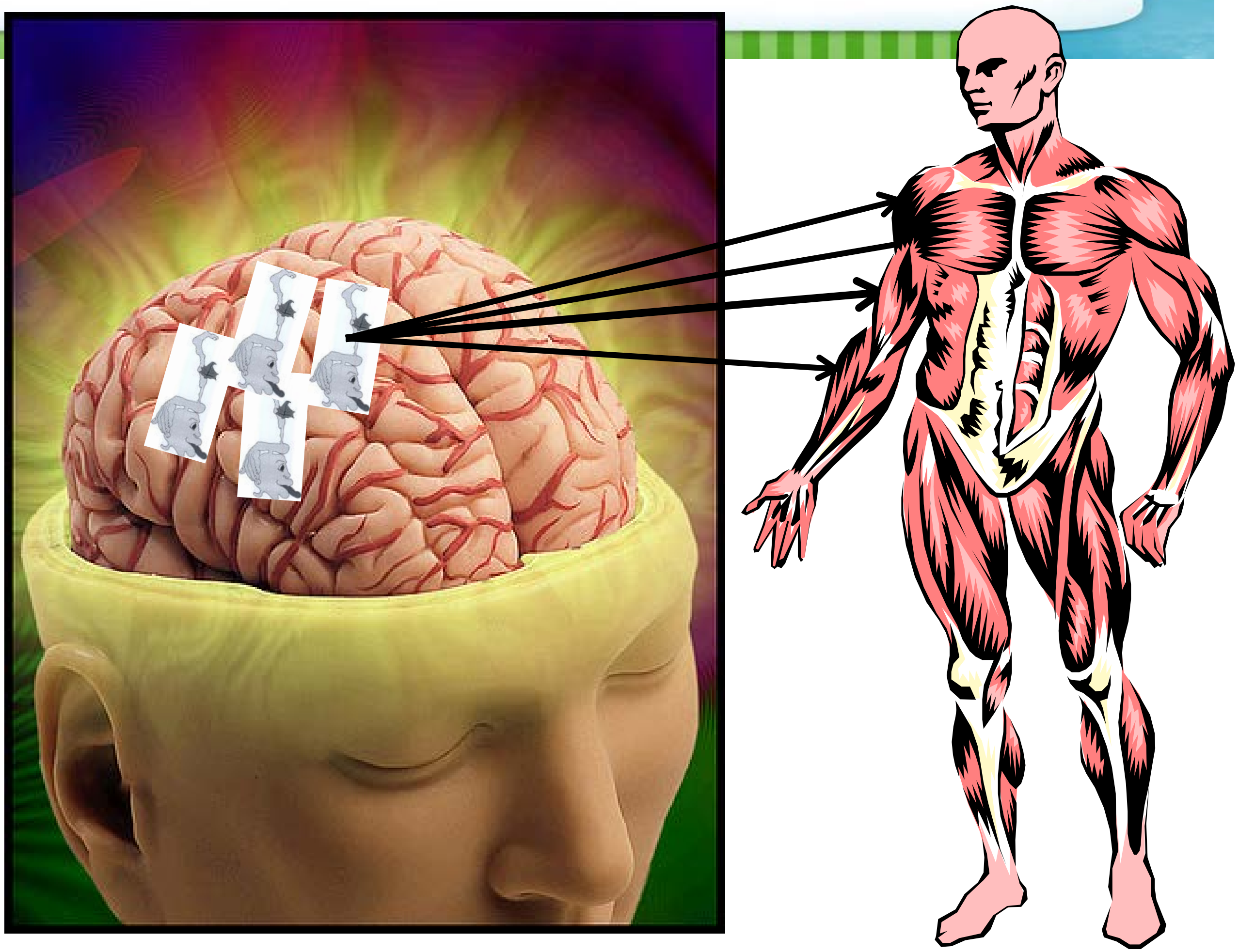




The Virtual Bodies signal in different ways

TWO

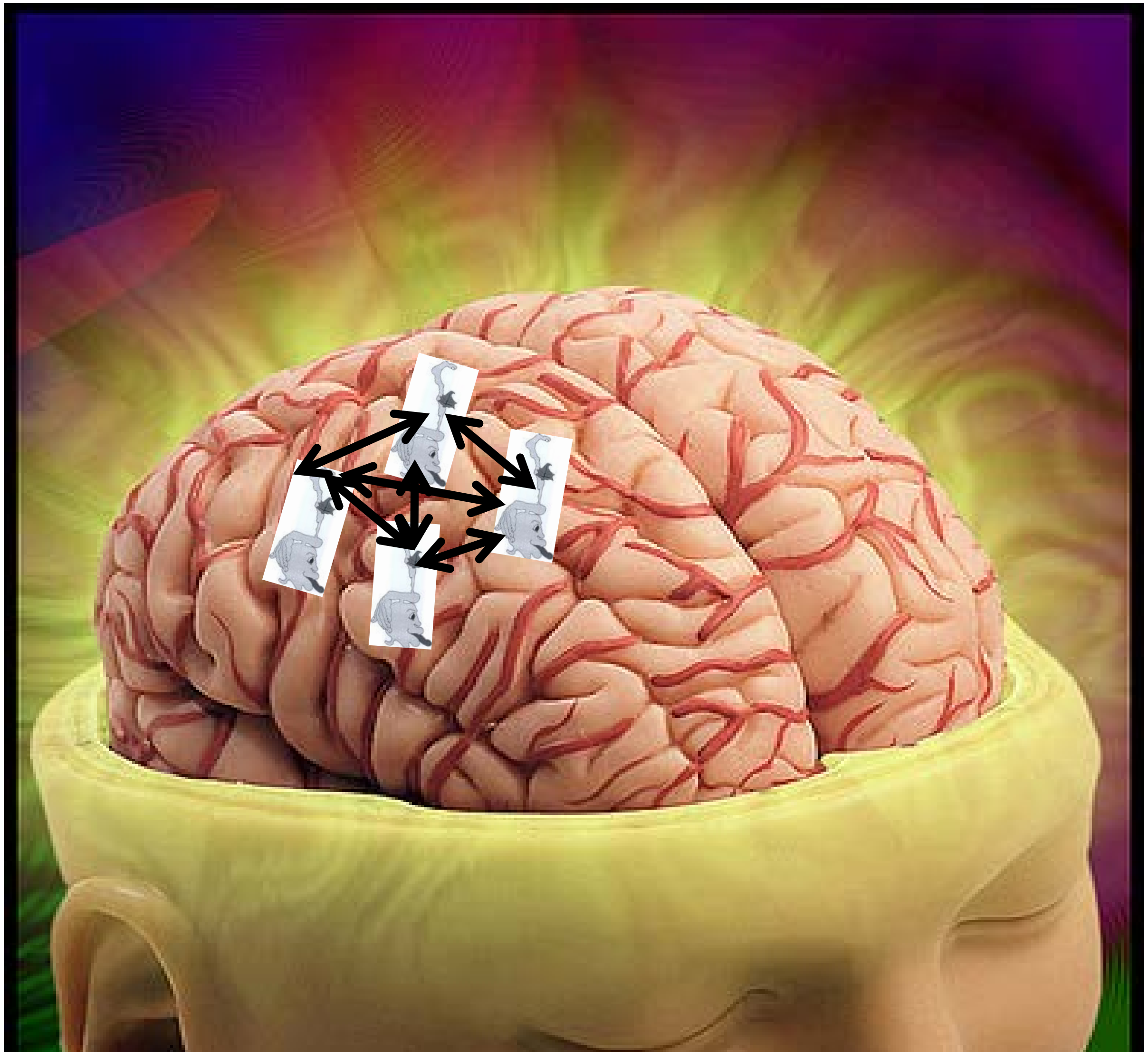
A single motor homunculi's output can diverge to multiple muscles



The Virtual Bodies signal in different ways

THREE

Multiple horizontal interconnects exist among homunculi as much as 8 mm apart.



Consequences of Limited Brain Stimulation due to Lack of Movement

"Smudging" and "Disconnect"

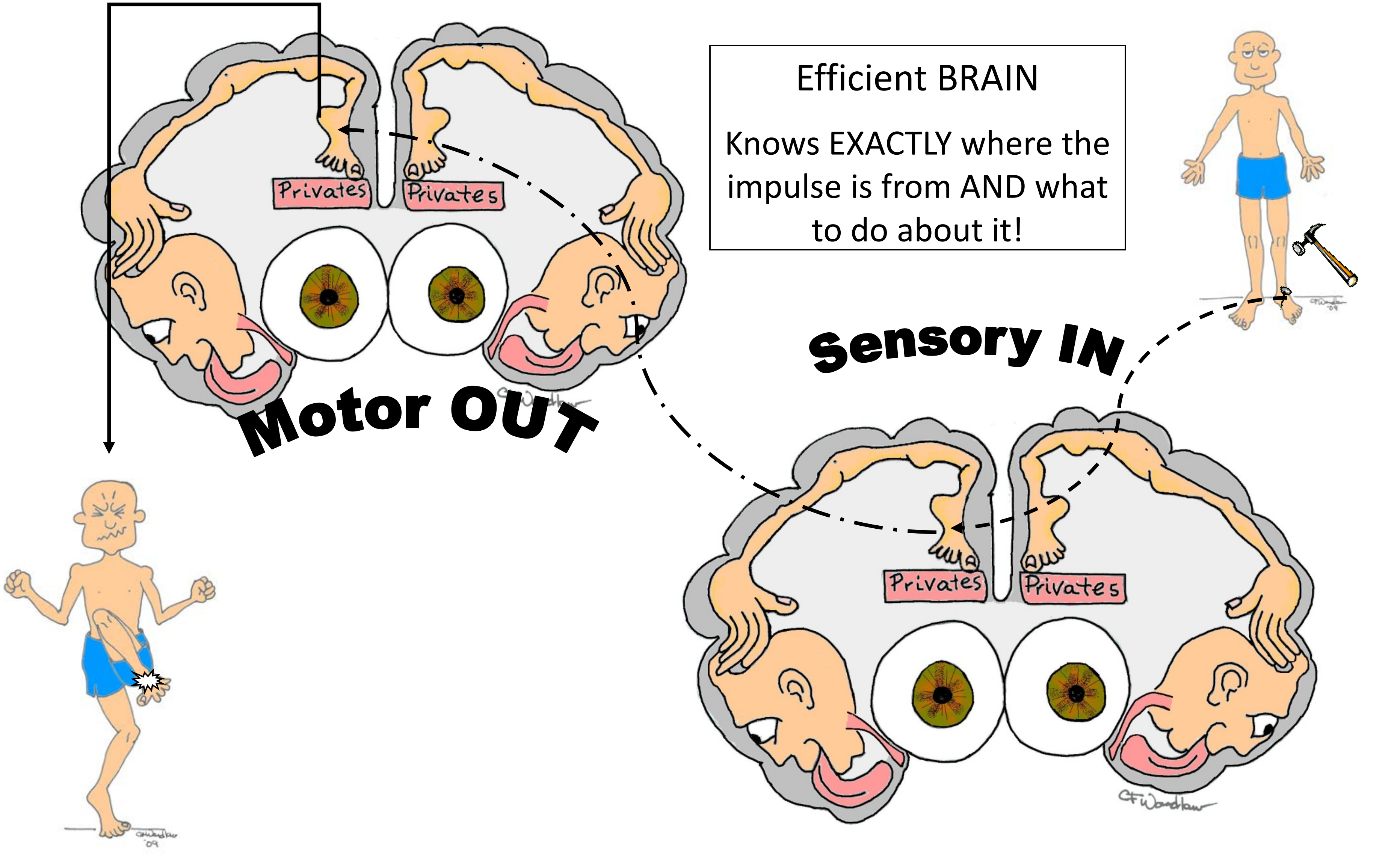
Definitions

- Smudging:
  - ❖ Loss of specificity in structure representation, i.e. regions blur so that impulses can be mis-interpreted by the cortex as being from a different location
  - ❖ Loss of Lateralization, i.e. mis-interpretation by the cortex on the side of the impulses
- Disconnection:
  - ❖ Loss of cortical activation in a region due to lack of use in a portion of the range of motion so that the patient perceives weakness or loss of range in that region

The efficient state =

impulses in and **Reaction out**

Normal Sensory - Motor Route

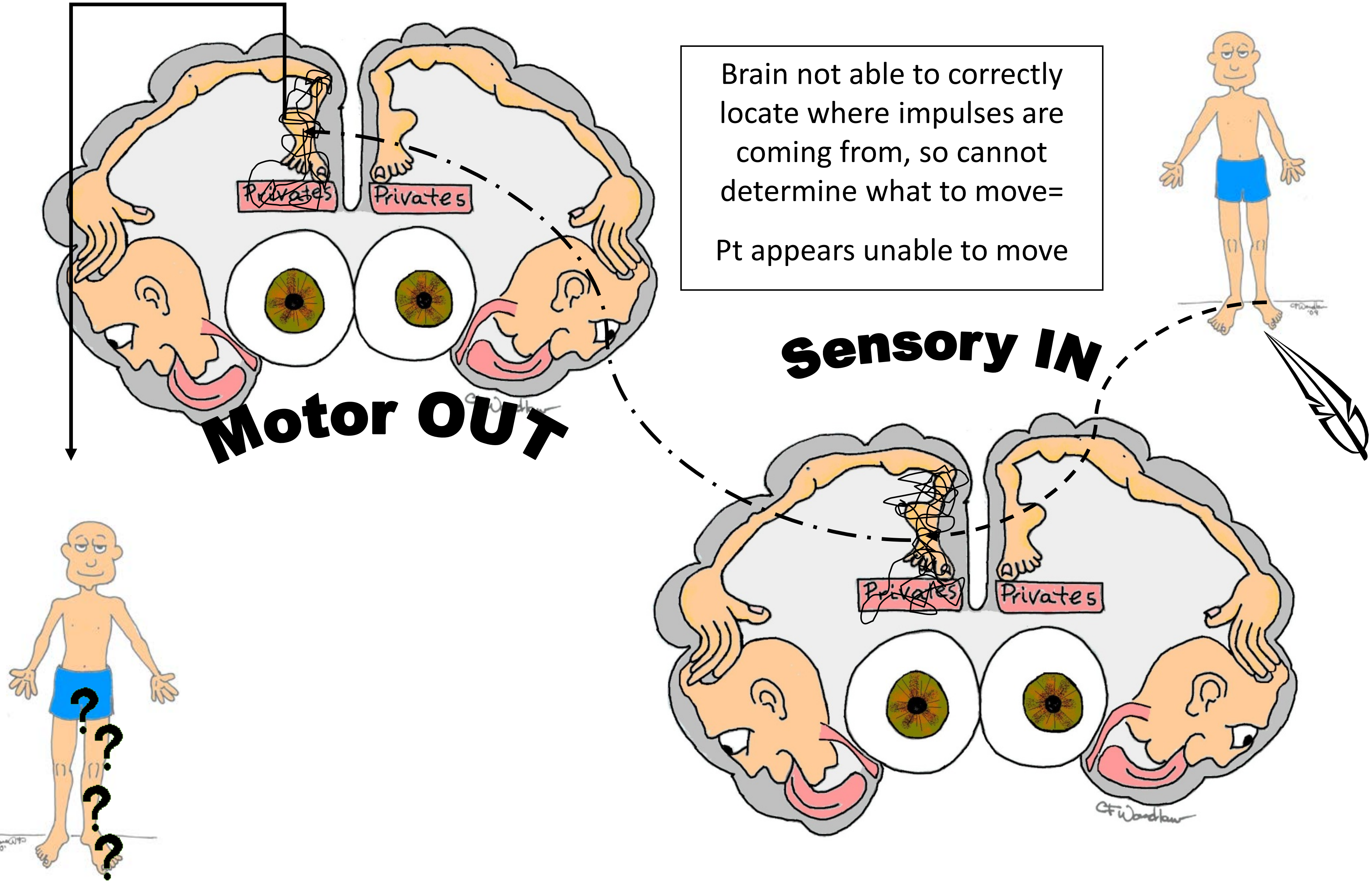


The quality and specificity of this relay system relies on “sharpening the system” through using the body.

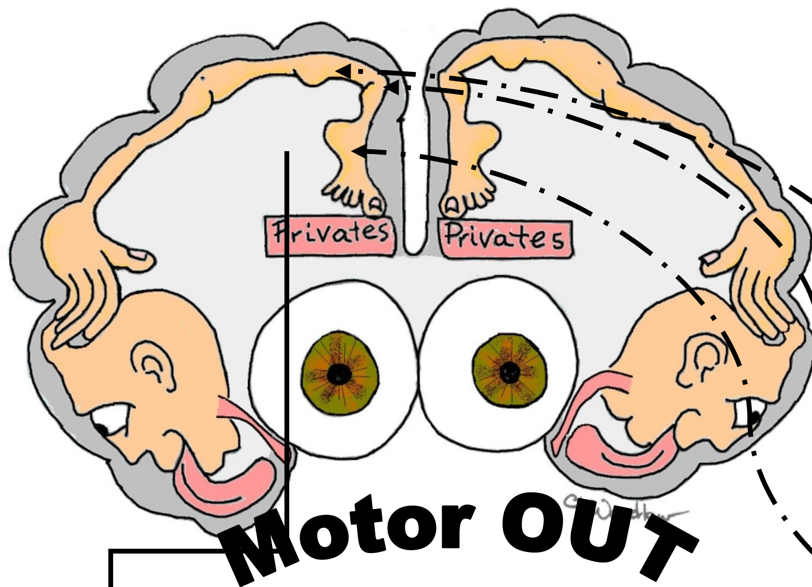
"Smudging" : Loss of specific region recognition

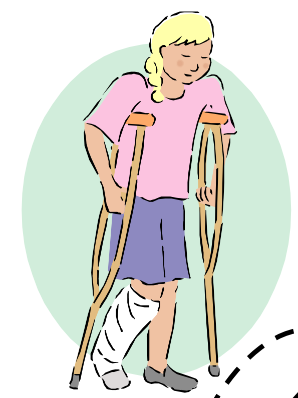
Brain not able to correctly locate where impulses are coming from, so cannot determine what to move=

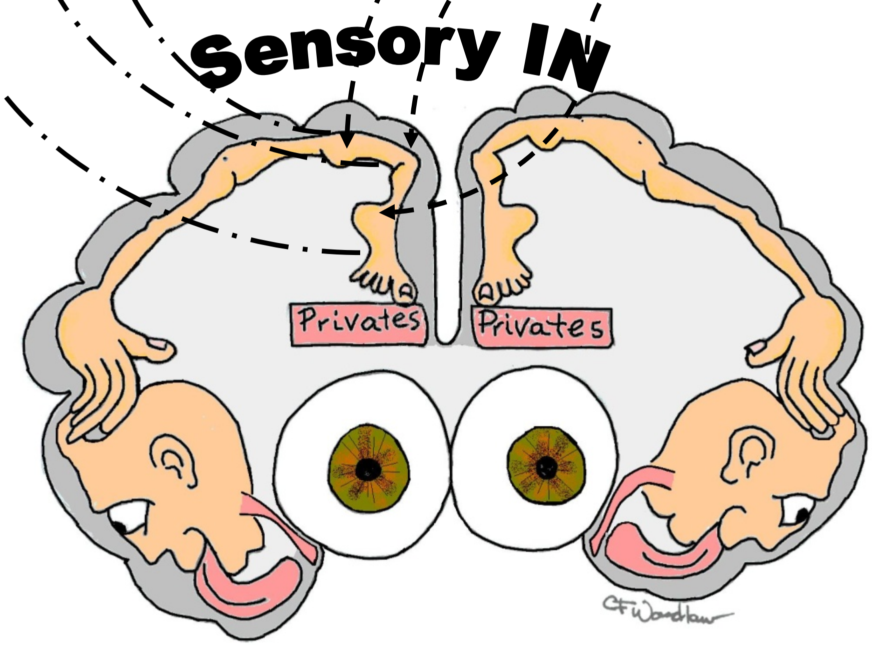
Pt appears unable to move



Rx Loss of Region Recognition with **Movement**



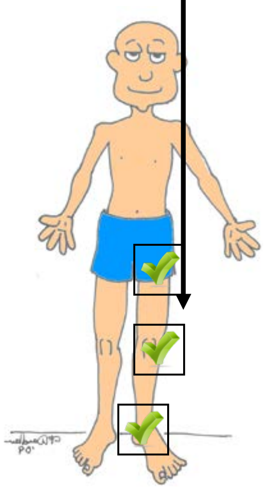




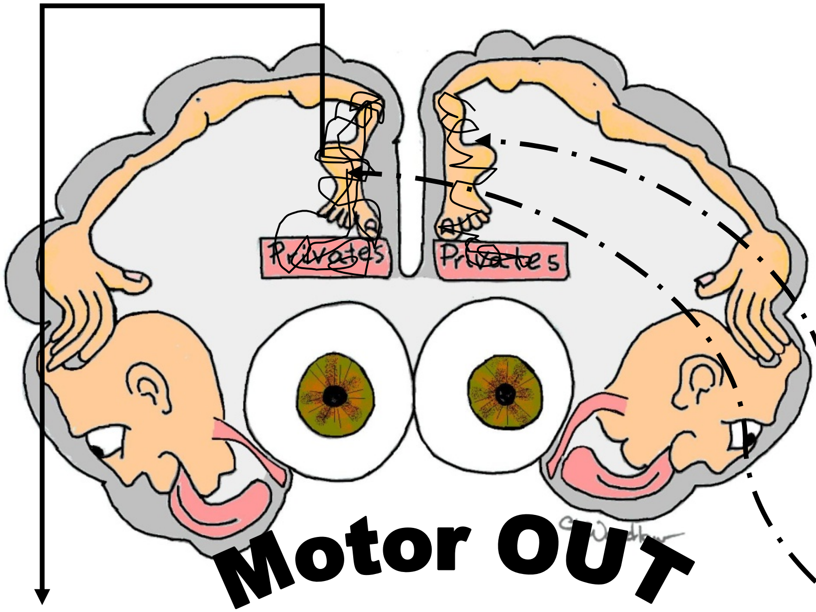
Cortex can be "refreshed"

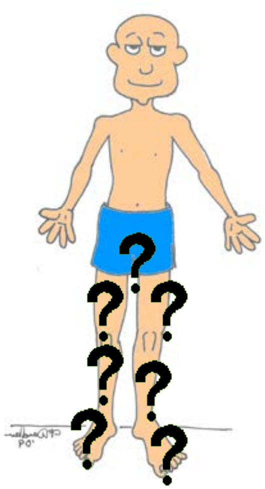
Through movement

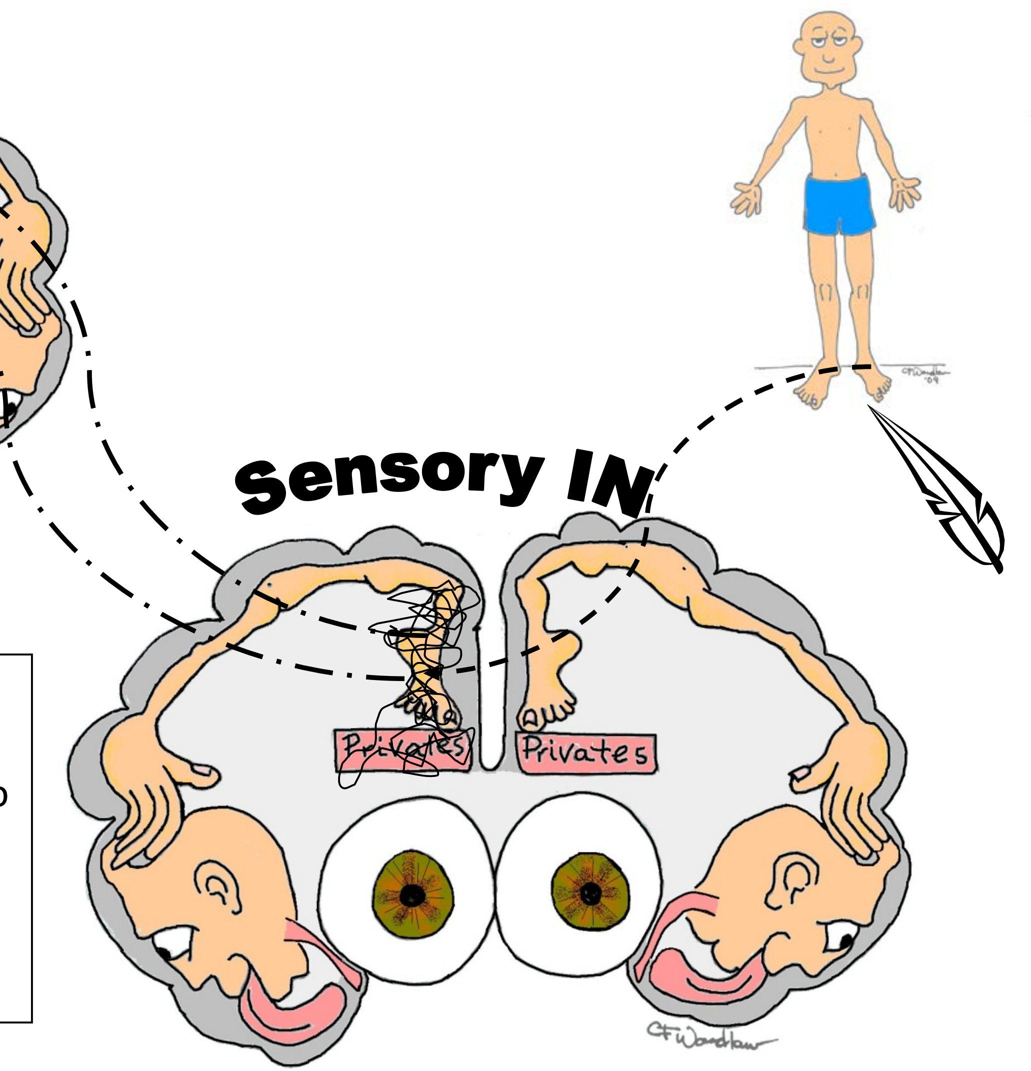
(remember that passive and active ROM or a functional activity like getting patient OOB send impulses to the brain!)



“Smudging”: Loss of Lateralization



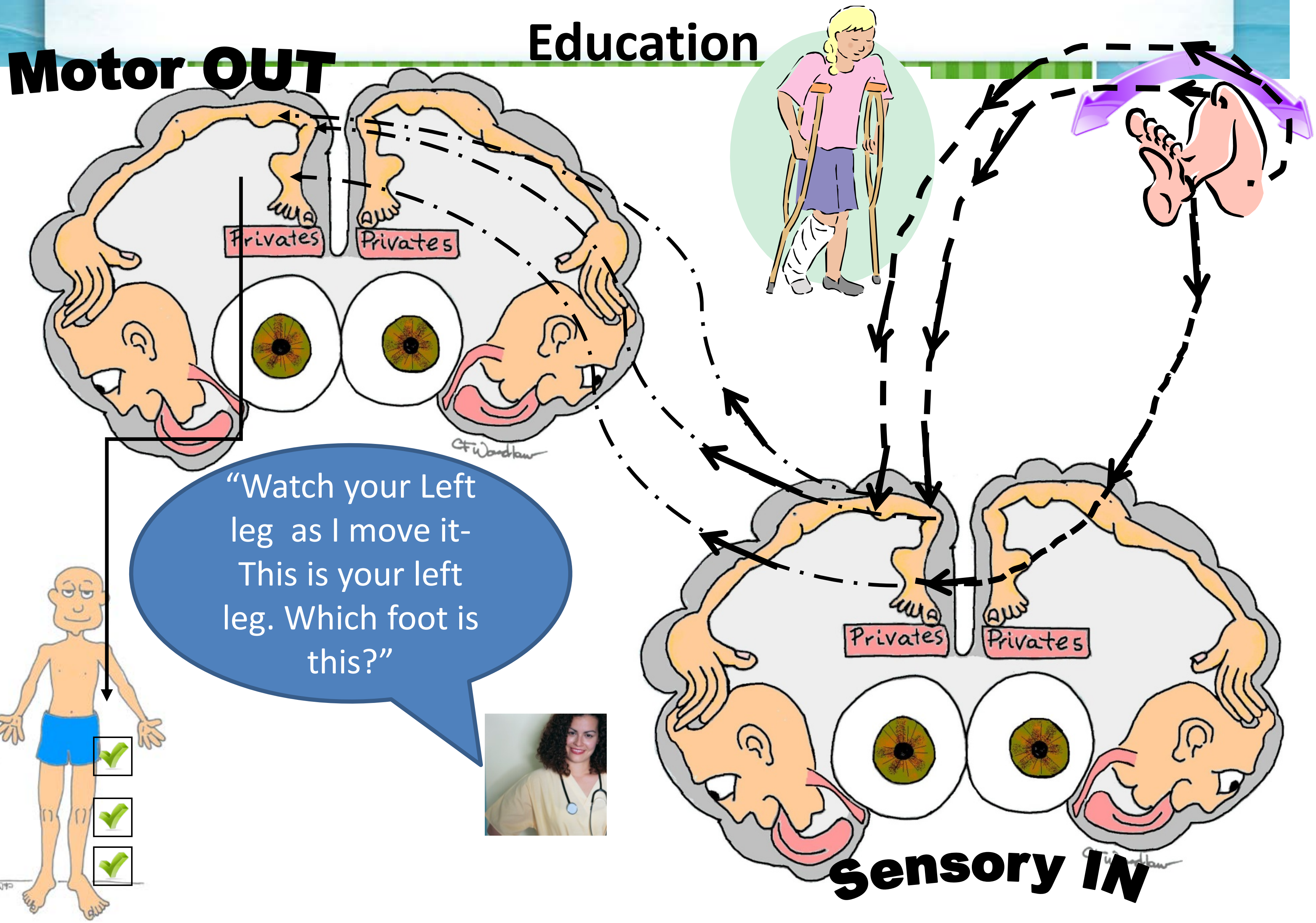




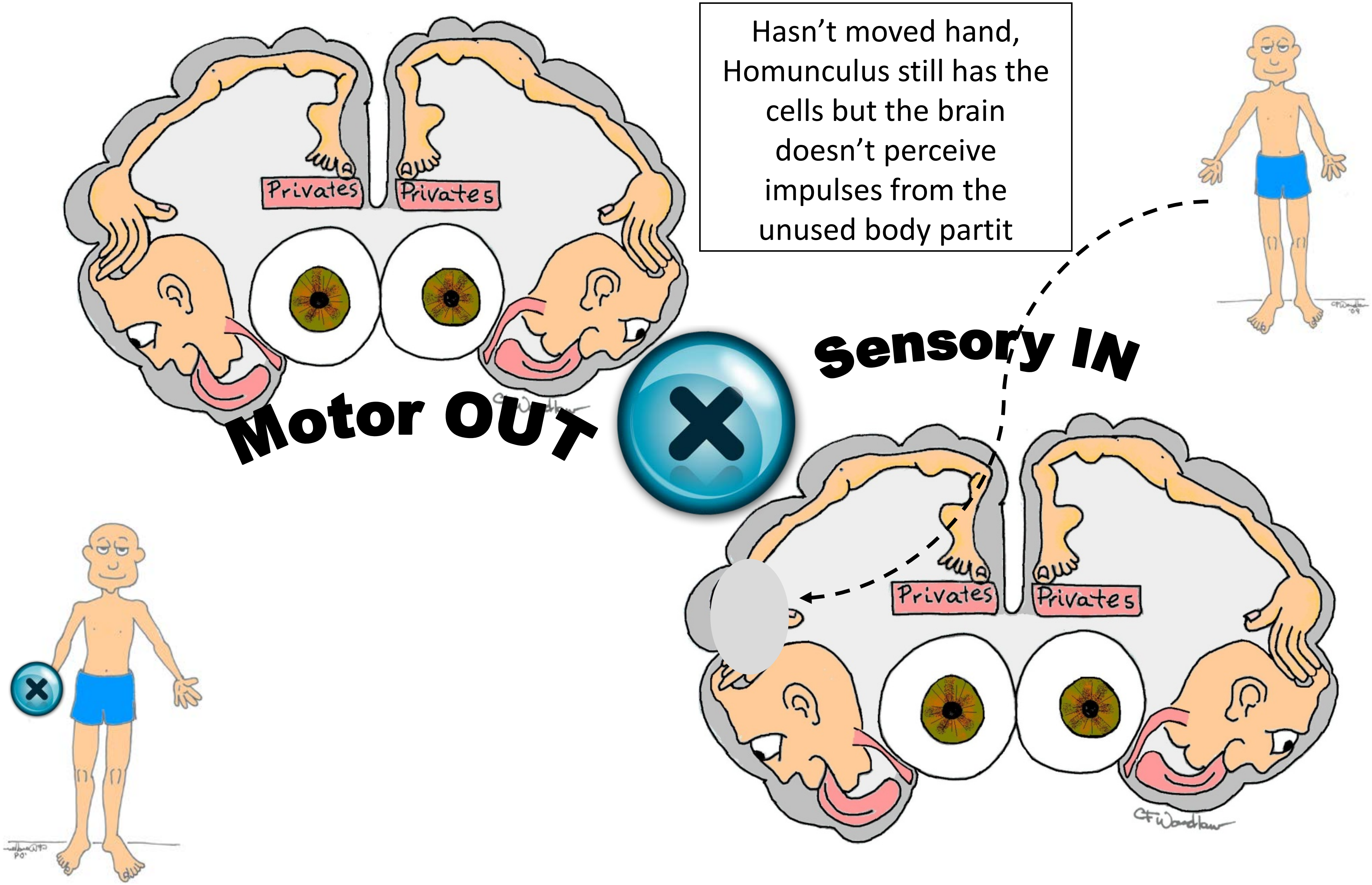
Brain not able to correctly locate which SIDE the impulses are coming from, so cannot determine what to move=

Pt appears unable to move

Rx Loss of "Lateralization" with **Movement and Education**

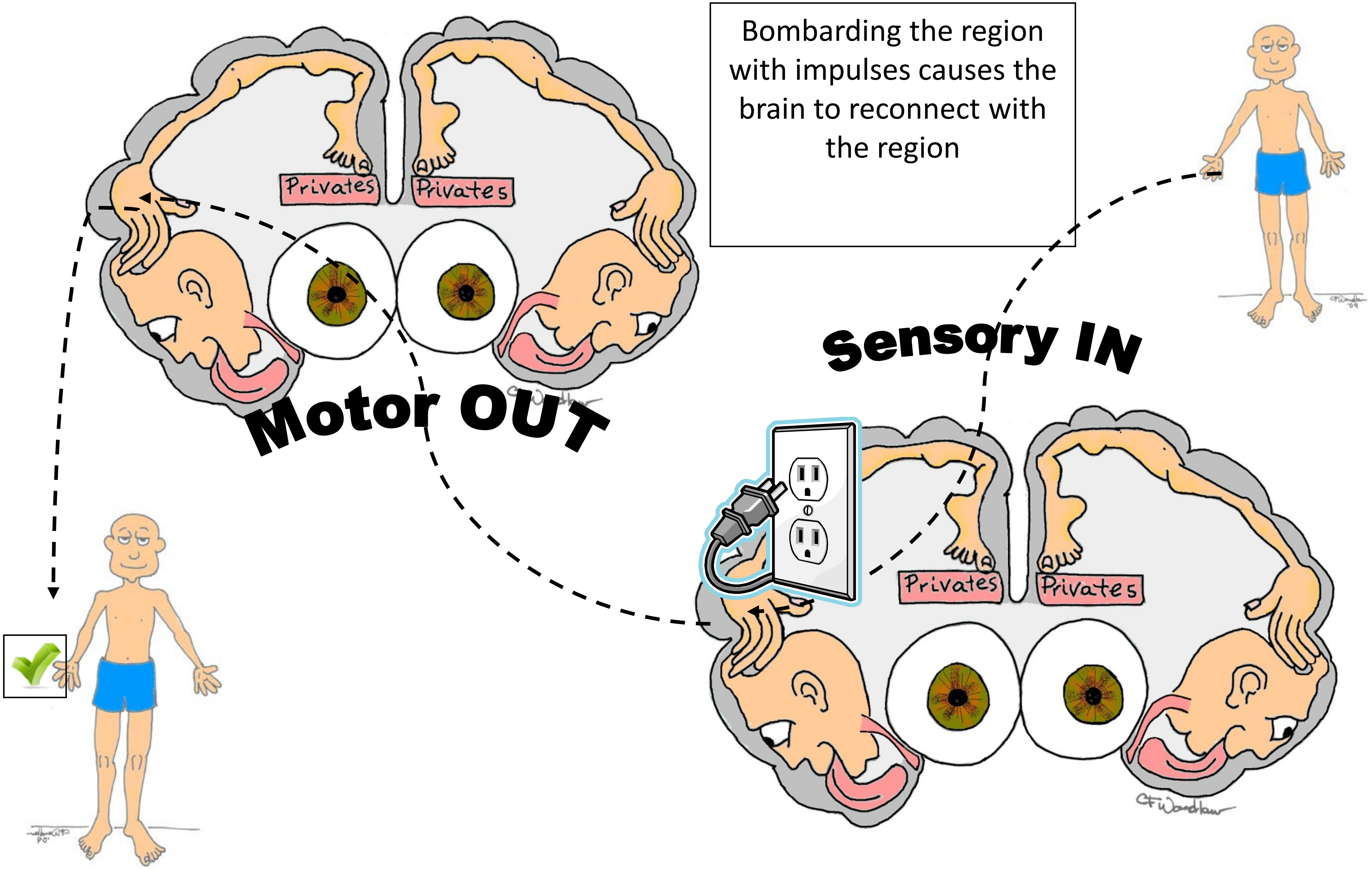


Disconnection: Loss of Cortical Activity in a Region



Rx Loss of Cortical Activity with **Movement**

Bombarding the region with impulses causes the brain to reconnect with the region



How Fast Can the Brain Change?

What do the studies show?

Temporal dynamics of plastic changes in human primary somatosensory cortex after finger webbing.

Stavrinou ML, Della Penna S, Pizzella V, Torquati K, Cianflone F, Franciotti R, Bezerianos A, Romani GL, Rossini PM.

Cereb Cortex. 2007 Sep;17(9):2134-42. Epub 2006 Nov 16

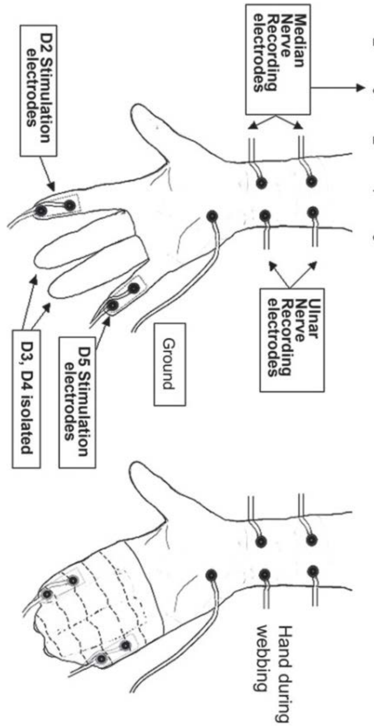
1.

Protocol: a temporarily webbed condition of 4 fingers (index to little finger) was used to simulate an artificial syndactyly and was maintained for about 5 h during which

finger somatotopy in the somatosensory cortex was monitored. Experimental and control group) Overall time frame: 5.5 hours.

Compared Pre and Post sensory cortex activation "hot spots" for index and little finger, measured:

- ✓ BEFORE taping on dominant hand
- ✓ After 30 minutes of being "webbed"
- ✓ After 1 hour and every hour for 3 more hours
- ✓ 30 minutes after the taping was removed



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RESULTS:

The brain changed its activation pattern from demonstrating impulses consistent with 5 fingers, to impulses consisten with 2 fingers (one finger and a thumb) in as little as 30 minutes of the experience. (No testing was done in less than 30 minutes)

Other studies have shown a change in as little as a few minutes!

Functional Implications of the Study

The brain is a plastic organ with the ability to rewrite/ refresh itself in minutes to days.

SUMMARY

The Role of the Bedside Caregiver

What We Can All do to Facilitate the BEST Functional Outcome

- Remember that the brain is changed by input: passive, active, one sided or bilateral
- Remember that active and bilateral produce more positive input than passive and one sided
- Remember that the brain can be changed in minutes to days
- Remember that the lack of movement (even passive) negatively effects the brain's ability to create a motor response.
- Functional Activities produce the greatest positive input to the brain: getting up, dangling, getting out of bed, and participating in ADL

What We Can All do to Facilitate the BEST Functional Outcome

Functional Activities produce the greatest positive input to the brain:

getting up, dangling, getting out of bed, and participating in ADL bombards the brain with the impulses it needs to begin rehabilitation of the cortical and sub-cortical structures

Mobility is Medicine

“He who rests, rots.”

Arthur Fiedler, Conductor of the Boston Pops Symphony Orchestra ,at age 82

For the patient’s sake, all of us must play an active role in the frequent and early mobilization of the patient