

Combined Sections Meeting – Anaheim, CA – February 17-20, 2016

Mirror, Mirror in My Brain:



Graded Motor Imagery to Improve Clinical Outcomes

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Acknowledgements & disclosures

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Gratitude to the Neuro Orthopaedic Institute, David Butler and colleagues for their continuing efforts to improve global pain literacy. Images used with permission. Both CSM speakers have taught numerous seminars for NOI Group. Robert is the education director for NOI USA.

www.noigroup.com
www.noijam.com
www.gradedmotorimagery.com
www.bodyinmind.org



Workshop aims

Following completion of this lecture, the participant will be able to:

- Describe some of the basic science underpinning the use of GMI, including: neuromatrix paradigms, bio-plasticity, mirror neurons and dynamic representation of the body
- Explain elements of GMI in a way that is understandable for both clinicians and patients
- Discuss use of implicit and explicit motor imagery, mirror therapy and graded exposure in the context of a rehab program

Workshop outline

Stephen Schmidt – hour 1

- What is GMI
- Modern neuro-immune notions of pain & the neuromatrix
- Body maps, representation and schema
- Graded exposure and pacing applied to GMI
- Review of evidence

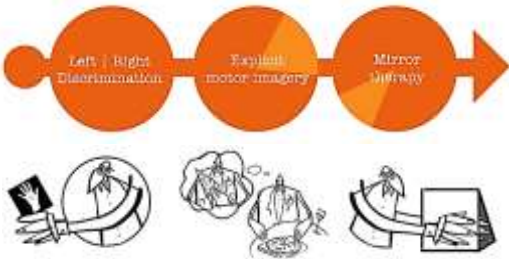
Robert Johnson – hour 2

- Biopsychosocial perspectives on pain
- Practical application of GMI related to:
 - Implicit motor imagery or L/R discrimination
 - Explicit motor imagery
 - Mirror therapy
 - Conceptual change and training progression

What is GMI?

Graded Motor Imagery

- A graded approach for treating pain



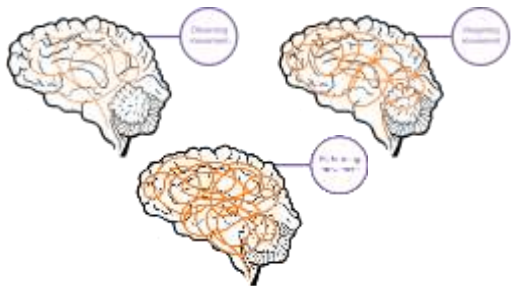
Left/Right Discrimination

- Brain-based discrimination exercise to identify alterations to body schema/representation, work “under the radar” in movement systems when physical movement is too impaired or too painful



Motor imagery

- Thinking about moving without actually moving



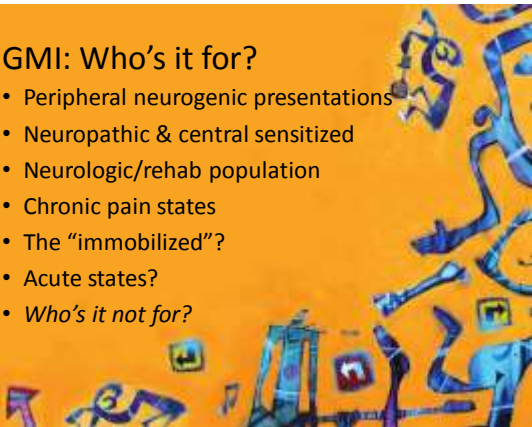
Mirror therapy

- Therapist as illusionist – retraining the brain to re-experience what the problematic body part should look/feel/move like (as applicable)



GMI: Who’s it for?

- Peripheral neurogenic presentations
- Neuropathic & central sensitized
- Neurologic/rehab population
- Chronic pain states
- The “immobilized”?
- Acute states?
- Who’s it not for?



GMI and brain stuff...

- Anytime you start talking about the brain (esp. related to persistent pain) what does the patient think?
- In order to foster a healthy therapeutic environment, it is key to explain the process in a way that is easy for the patient to understand and follow



got pain?

~30%

of the population in the USA
experience an ongoing pain state*

*Pain without apparent biological value persisting
beyond expected healing time
(generally >3-6 months)*

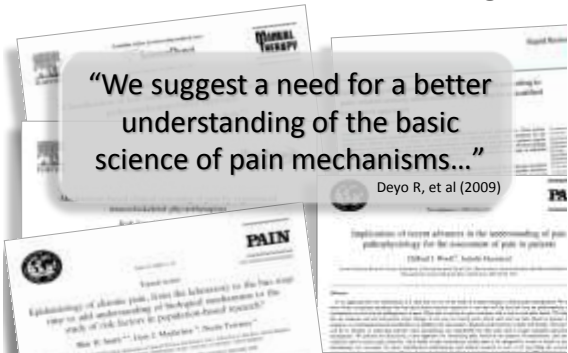
* Inst. Of Med. (2011): Relieving Pain in America

“It is inherently ridiculous
to consider pain as an
isolated entity”

– Patrick Wall (1999)

13

A call for more understanding



What is pain? Emerging ideas...

Pain is a multiple system output, activated by an individual’s specific pain neural signature. The neural signature is activated whenever the brain concludes that the body tissues are in danger and action is required.

Melzack R (2001) *Pain and the neuromatrix in the brain* - J of Dental Ed
Moseley GL (2003) *A pain neuromatrix approach...* Manual Therapy
Butler D & Moseley GL (2003) *Explain Pain*

Common pain neurosignatures

Spinal cord:
Basic processing, switchboard

Thalamus / hypothalamus:
Stress response, ANS, motivation

Sensory cortex

Premotor & motor cortex:
Movement preparation & response

Cerebellum:
Movement response

Amygdala:
Fear, addition, conditioning

Hippocampus:
Memory, spatial recognition

Insula & cingulate cortex:
Concentration, attention

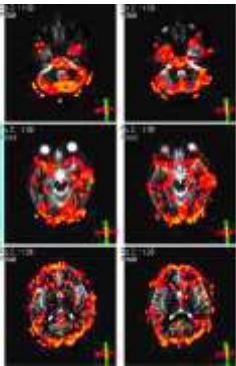
Prefrontal cortex:
Problem solving, memory

Courtesy of Professor Wikimedia Commons

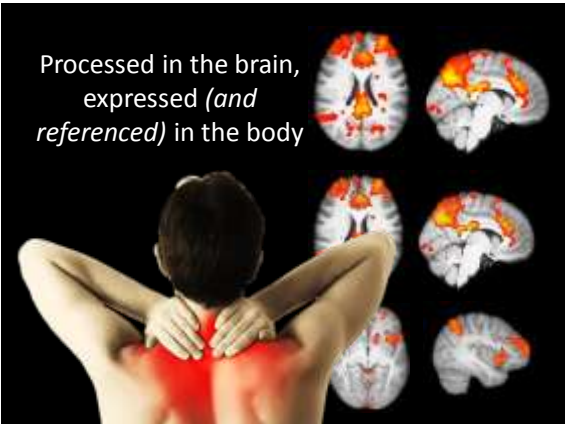
(e.g. Flor H, Bushnell MC, Casey KL, Petrovic P, Ingvar M.)

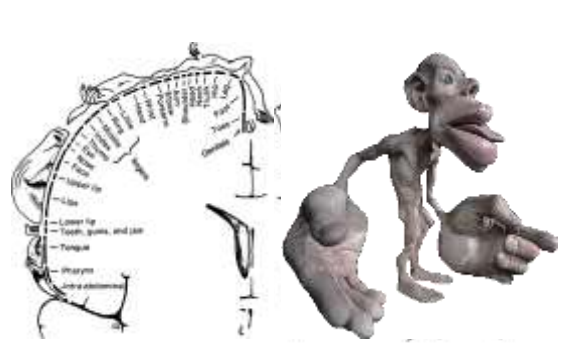
A pain neurosignature:

- Patient with low back pain and radiculopathy during an anterior pelvic tilt

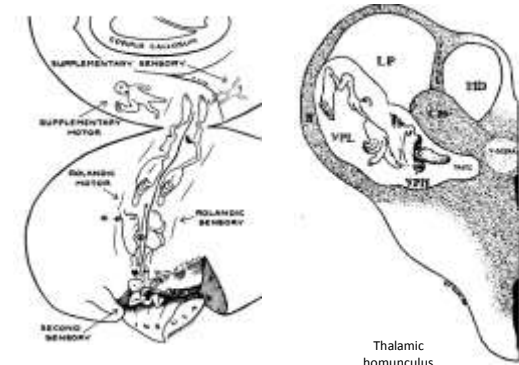


Louw A, et al (2015) Preoperative Neuroscience Education for Lumbar Radiculopathy: A Single Case fMRI Study





Penfield & Boldrey (1937)



Penfield & Boldrey (1937)

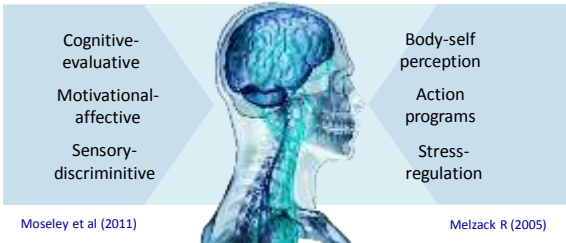
Plastic maps!

- Biologically coded, but environmentally sculpted
- Braille readers
- Local anesthetic
- Rapid changes with practice
- Maps can even take on non-organic parts and represent the space around you

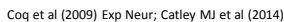


Cortical-body matrix

- A body-centered multisensory representation of our body and peripersonal space



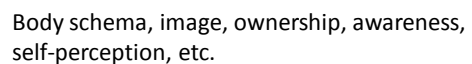
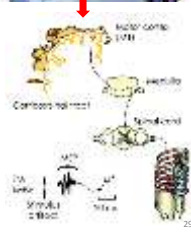
- Phantom *takeovers*
 - Amputation
 - SCI
 - Nerve injury
 - CNS injury
- Focal dystonia, RSI, CTS, CRPS
- Chronic LBP, knee OA, chronic pain, etc.



- Size/resolution/orientation?
- Discrimination ability with “intact” sensory testing
(complex sensory impairment)



- How's that motor control going?



- Terms are often debated, have overlap and are appreciated in distinct ways by various disciplines
- *For simplicity... will describe it as the brain's dynamic representation of the body:*
 - sculpted by exteroceptive and interoceptive experiences
 - modulated by beliefs, memory and psychosocial factors
 - guided by plastic body maps

Lotze & Moseley (2007), Bray & Moseley (2011)

Disorganization of body representation

Assumption: accurate body representation underpins skilled movement, sensory localization & discrimination, etc.

Chronic pain appears to be associated with disruption of body-related cortical representations

(Moseley & Flor, 2012)

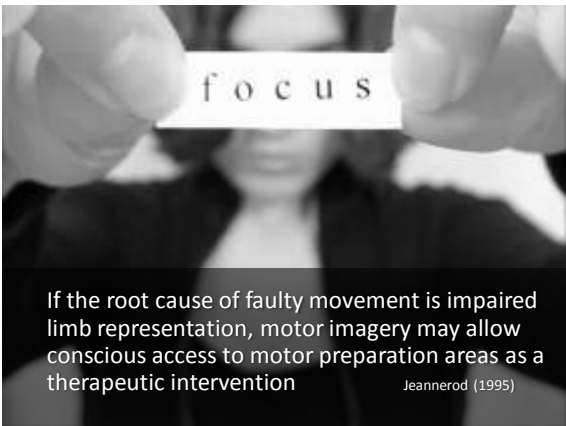
Where does brain plasticity fit?

Features	Interventions
↓Endurance	Deep stabilizer training
↑Fatigue	progression, motor control, graded
↓Strength	progression of targeted exercise
↓Muscle coordination	
↓Proprioception	Repositioning accuracy
↑Pain	Manual therapy & pain relieving procedures
↓Range of motion	
Addressing the impairment	Vehicle to change the brain

What about the other groovy stuff?

- Widespread pain (beyond typical territories)
- Body representation/schema disruption
 - “it has a mind of its own”
 - “it feels swollen and tight”
 - “it doesn’t feel like it is mine” ... etc.
- Complex sensory dysfunction:
 - Two point discrimination
 - Sensory localization errors
 - Hyper vs. hypoesthesia vs. *neglect*?

Is it is the representation that we ultimately treat?



What underpins all of these changes?

The elastic,
plastic...
fantastic brain



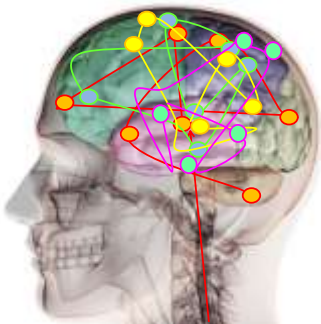
Pain in learning for survival value...
Is persistent pain *destructive* learning?

- Brain as the ultimate survivor
- Dynamic brain representations (framework constructed initially by genetics but then sculpted by experience)
 - Brain turf wars
 - Smudging – corruption of sensory, motor and other homunculi
- Neglect-like syndromes observed in persistent pain states
 - Laterality, perceptual changes, “antalgic” patterns, CRPS, etc.



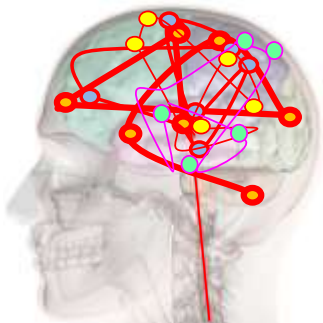
Brain neurosignatures

- = neurosignature for back pain sitting at work
- = neurosignature for sitting in the car
- = neurosignature for thinking about sitting
- = neurosignature for standing in line at the coffee shop



Brain neurosignatures

- = neurosignature for back pain sitting at work
- = neurosignature for sitting in the car
- = neurosignature for thinking about sitting
- = neurosignature for standing in line at the coffee shop



- The transition from acute to persistent pain relates strongly to:
 - Brain/CNS as the protector
 - Association with harmful (or suspected harmful) activities
 - Learning about the consequences (or suspected consequences) of activities

Essentially, the brain becomes better at producing pain

Therapeutic aim:

- Un-couple pain neurosignatures (restoring the balance of brain inhibition)
 - Can be done with movement-based therapies, but may be limited due to pain, immobilization, weakness etc.
 - Can also be achieved with GMI (as a precursor or complimentary to movement therapies)



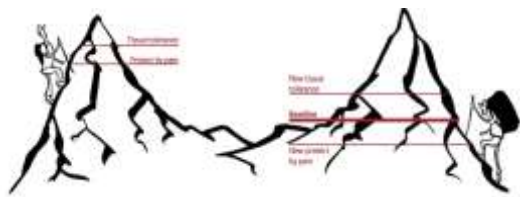
Graded Exposure

- **Graded exposure** requires identification of both **physical and contextual fear-related challenges**. It therefore combines the principles of both graded activity and exposure in vivo (Leeuw et al. 2007)

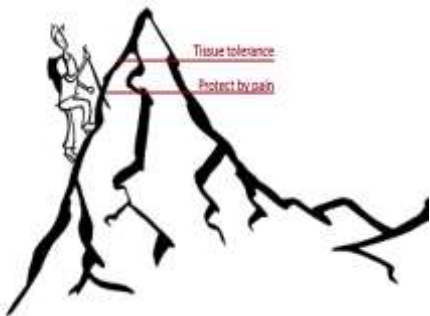


Graded exposure, the pain neurotag
and the Twin Peaks model...

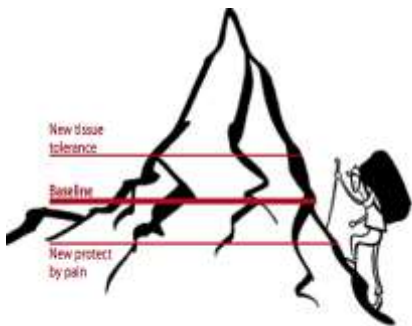
disentangling neurotags and the protect by pain line...



Twin Peaks model...



Twin Peaks model...



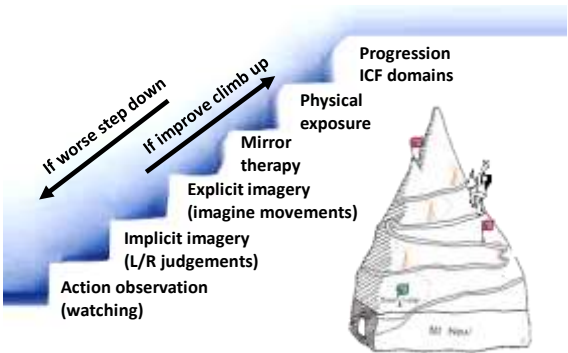
Context variation as part of
graded exposure

- Any task can be broken down into parts. A simple way of doing this is to consider a more **physical** aspect, which is perhaps more traditional and a **contextual** component
 - Physical – *deconstruct the whole task into more manageable bits*
 - Context = *the temporary environment of an action or planned action*



Context variation as part of
graded exposure

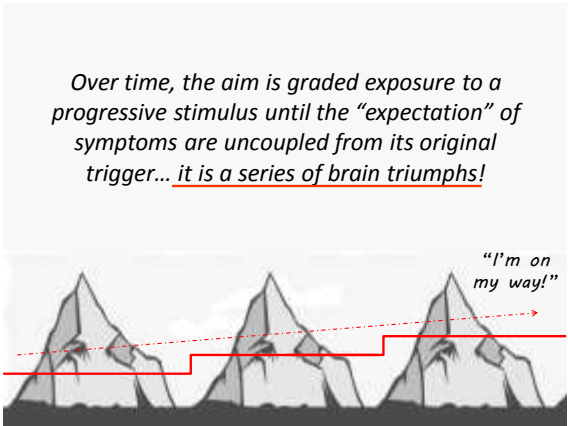
- Contextualisation is given new power by knowledge of the distributed nature of the representation. *An identical movement will be represented by different neural populations depending on the context that the movement is carried out in*
 - Contextualisation allows flexibility to make the task more or less threatening



Examples of graded exposure in GMI process

Patience and persistence

- It is through repeating and gradually ‘exposing’ the brain to the activity in many different ways that allows a reduction in pain and improvement in activity (*also critical for functional restoration*)
- **Patience & persistence are key** - to appreciate small incremental changes (brain becomes accustomed to the changes without being threatened)



The cautionary story before the techniques...

- *GMI is a novel management strategy with some clinical and basic sciences behind it. It is a newborn – a toddler perhaps.*
- *Do it as best you can, combine it with other appropriate strategies, keep up with the basic sciences and clinical sciences behind it.*
- *And remember, you may be dealing with human pain states that have been unchanged for some time. It's hard work.*



Explaining it to patients...

- Listen for clues during the patient interview (it's not mine, disconnected, mind of its own, feels like a block of wood, etc. – *disownership statements*)
- Watch for clues during the physical exam:
 - Sensory exam: localization (how do you know where I touched you? Show the homunculus, discuss plastic/dynamic maps, provide personal story of changing maps – e.g. new cell phone)
 - Observe for movement impairments (motor control, motor learning, atalgic patterns)

How about some evidence...

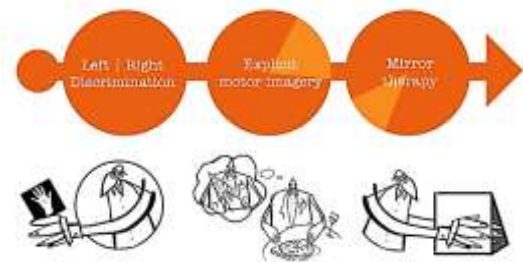


GMI and the NNT

- The Number Needed to Treat (NNT) is the number of patients you need to treat to achieve the desired outcome
- For pain research, this is often stated as the number of patients needed to treat to achieve a 50% reduction in pain
- A few NNT’s for neuropathic pain:
 - Gabapentin 7.2
 - Strong opioids 4.3
 - Amitryptiline 3.6
 - Graded Motor Imagery 2

Moseley L (2004) Pain; Finnerup NB et al. (2015) Lancet Neurol. 2015

And now, for Bob and tips on practical application!



Clinical Case
scenario/vignette

- Weekend Warrior
- (L) wrist fx 2 weeks ago
- Prior (L) shoulder impingement
- Hx of Whiplash 6 yrs. prior
- Mild Fear-Avoidance
- Mild Pain Anxiety due to pain ‘memory’

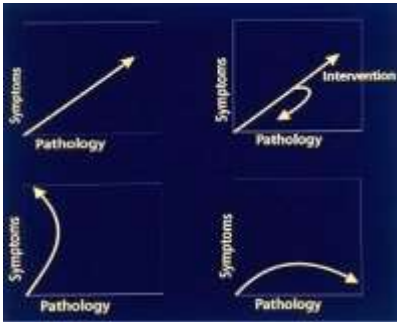


Biomedical
Linear



- Orthopedic physical therapy historically based on **structural assessment model** (biomechanical)
- Assumes pathology is directly related to pain
- Does not adequately explain all clinical pain states

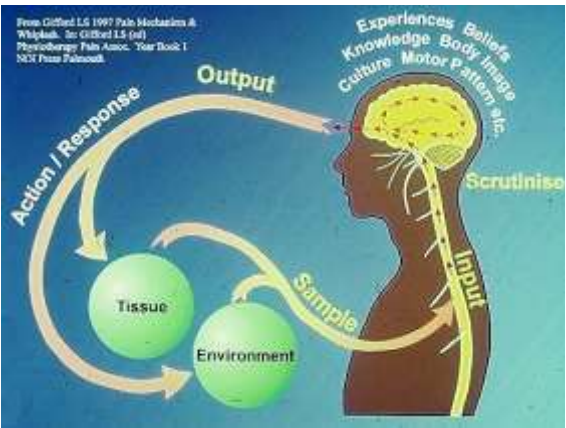
Biomedical ?



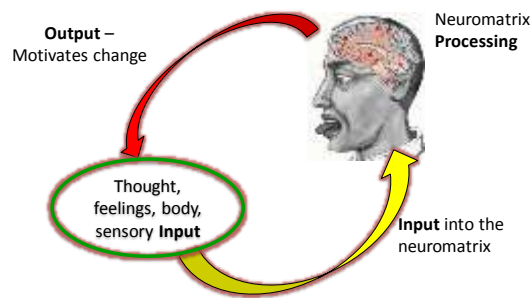
Bio-psychosocial
Emergent

- Pathology is not directly related to pain in many clinical 'pain' states
- A **bio-psychosocial paradigm** includes a neurobiological interpretation that adequately explains many behaviors encountered clinically

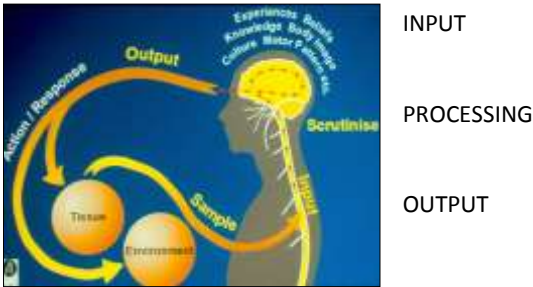
This requires 'reconceptualization' of known pain mechanisms!



Continuous cycle through time... **inputs** at conscious and subconscious levels into the neuromatrix (**processing**) and the subsequent **outputs**

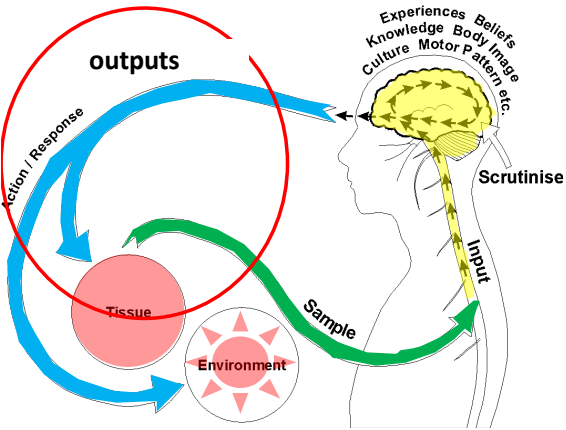


Mature Organism Model = Bio-psychosocial

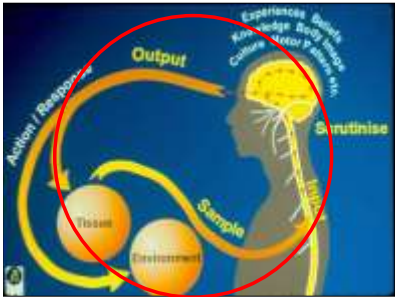


Input

- Peripheral
- Traditional & body based
- Biomedical & Biomechanical
- Bottom-up
- Manual therapy Exercise Modalities
- ~ 80% get better
- Keep Doing it!



Output Mechanisms



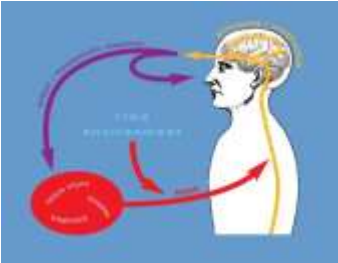
"Biological coping systems" for the stress of life. (escape danger, cope and heal)

Designed for short term coping benefits.

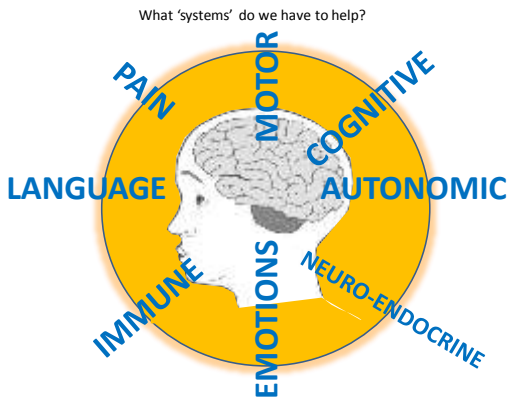
Become our Habits & Behaviors

Harmful long term influences.

What comes in, must go out...

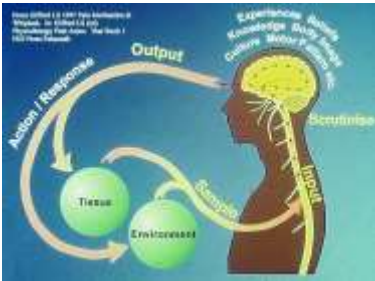


- Sensory input from body
- Previous experiences
- Cultural factors
- Social / work environments
- Expectations & consequences of danger
- Beliefs, knowledge & logic



What 'systems' do we have to help?

Outputs are what we see and treat



MOVEMENT related

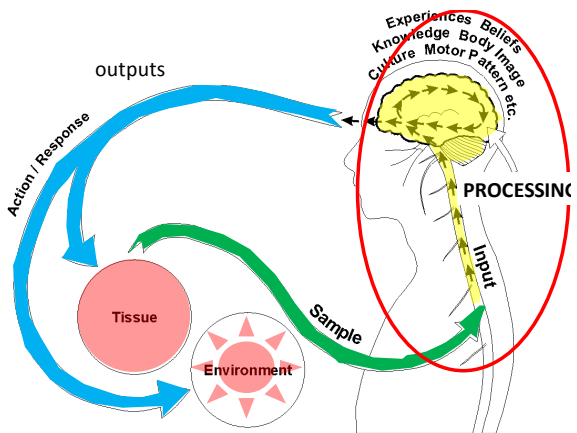
Tissue based.

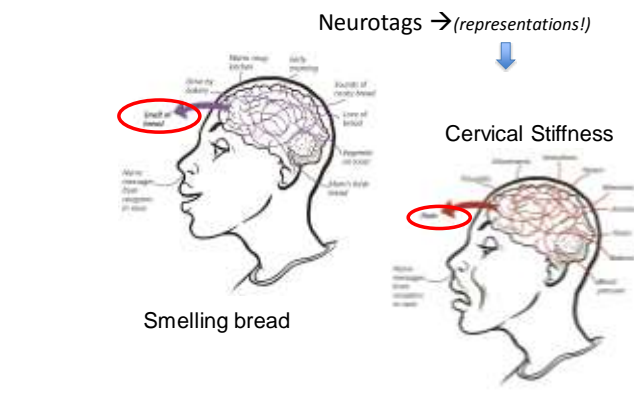
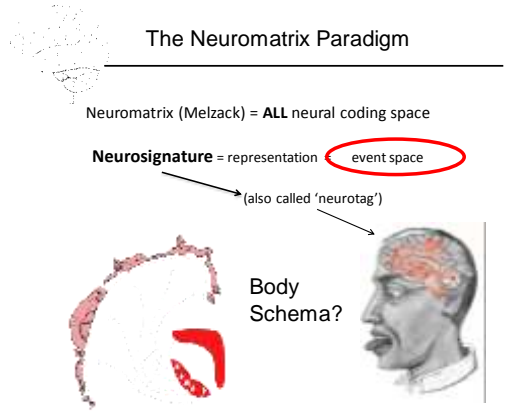
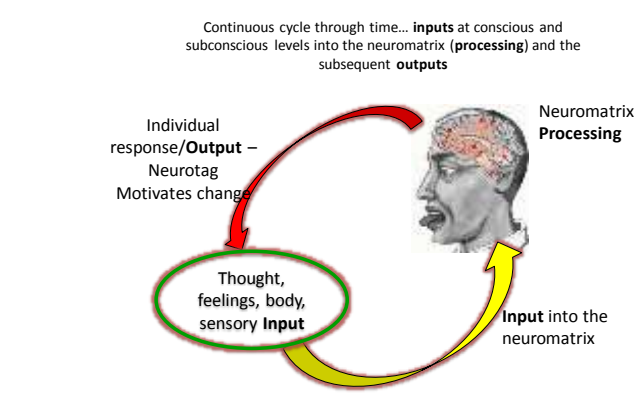
Active & Passive.

ROM

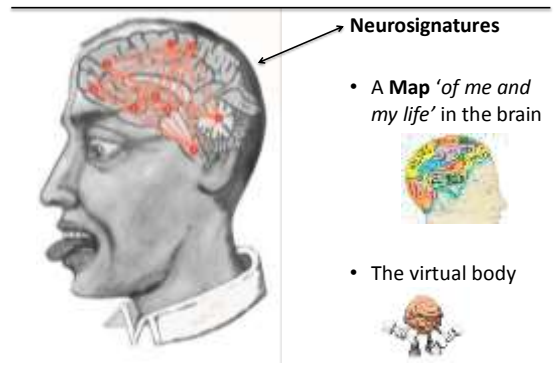
Strength

Function





Processing = Neuromatrix = Representation



The Body Neurosignature
(body representation / schema)

- There are **representations** of the body within the
 - Spinal cord
 - Thalamus
 - Cortical structures
- These all play a role in the guidance of **imagined** and **actual** movements.
- This is the **body neurosignature**

Body Maps in the brain!
image/schema/neurosignature

- Sensory
- Motor
- Emotions
- Language
- Cognitions
- Immune
- Endocrine
- Autonomic

These maps are used by the brain to create our perceptions and our world!

The neuromatrix paradigm



- Genetic basis
- Sculpted by life experiences
- Constantly evolving
- Represents Body Organization
- MOVEMENT is necessary

Healthy individuals maintain an organized, and healthy, body schema through **movement/exercise** and a positive sense of life, etc.



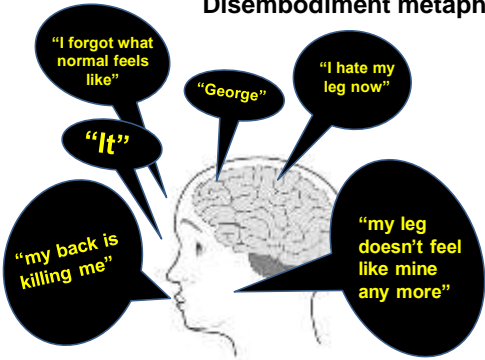
Neurons representing a healthy hand within the CNS

Injury (input) creates automatic changes in body organization/schema....
This is a protective 'output' response



Neuroplastic changes of neurons representing the hand after injury (smudging & disinhibition)

Disembodiment metaphors



Treatment interventions have always created adaptive changes in the body and the CNS for pain-free function to return after injury



This should be a **paradigm shift** in our clinical reasoning

Implicit Motor Imagery
or
Laterality recognition

“my leg doesn’t belong to me”
or
“it doesn’t feel like the other side”
or
“I forgot what normal feels like”

SLIPPING UNDER THE RADAR OF THE PAIN NEUROTAG

The Neuromatrix & The Body Neurosignature

Movement

- Modified by observation of others
 - Mirror neuron system
- Modified by tool use
 - Increases influence of the body
- Modified by experience (S1)
 - Musical instruments, Braille

- Recognizing a body part moving requires an intact ‘body image’ in the brain.



Input alone is NOT sufficient to change body representation of the affected side



Body representation is influenced by cognitive processes

(Moseley et al 2005 Cog Brain Res 25: 188–194)

Under the radar of the neurotag?

Treating the changes in the body image representation may reduce pain.....
Treating pain may also normalize the body image representation

Top down & Bottom up !

(Lotze & Moseley 2007)

Left/right judgement tasks & body representation

Laterality recognition = ability to select whether a presented image of a limb is right or left sided.



Cognitive psychologists have used laterality experiments to investigate the body representation (Parsons 2001 Acta Psychologica 107:155-181)

Reaction time (RT)

proportional to the angular position of the limb..... and requires;
- initial selection of right or left
- mental spatial transformation to confirm the choice.
- IMPLICIT

Accuracy.....

Qualitative information – important and often forgotten – may related to emerging disembodiment metaphor and/or other non-verbal behaviors.

“Is this a right or left hand?”

- A response requires initial selection of left or right
- then a mental (sometimes physical) spatial transformation to confirm the choice.



- As such the spatial transformations require an intact body representation.

- Following several images this task becomes less of a conscious effort to perform and is as such described as *implicit*

Is this a left or right hand?



Rapid initial choice

Mentally manoeuvre body part



Reject or confirmation

(Parsons LM 1987, Cognitive Psychology, vol.19, p.178-241)



Implicit motor imagery
activates **premotor cortex**

Explicit motor imagery.....
activates **motor cortex**



Moseley et al 2003

Implicit Motor Imagery?

- Implicit motor imagery disengages the primary motor cortex (M1). (but still engages the **pre-motor cortex**)
- In this way, it is aimed at getting **'under the radar'** of the neurotag.
- It could be said to **'dissociate movement and pain'**
- Offering a way of being **less threatening** than imagined movements
- Following ~~several images~~ this task becomes less of a conscious effort to perform, and more **IMPLICIT**.



What is the difference between implicit & explicit motor imagery?

Implicit motor imagery (left/right judgements)	Explicit motor imagery (imagined movements)
You don't know you are mentally moving	You know you are mentally moving
Premotor cells modify primary motor cells without activating them	Primary motor cells are activated
Less likely to activate the pain neurotag	More likely to activate the pain neurotag

Is this person moving to the left or the right?



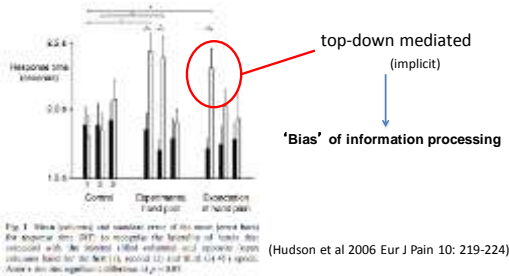
Is the facial feature deviated to the left or the right?



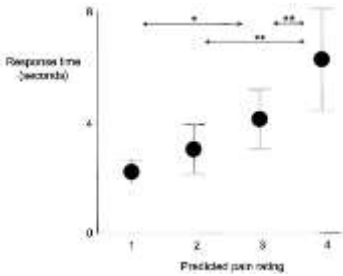
- Could it be a way of being **less threatening** than imagined movement ?



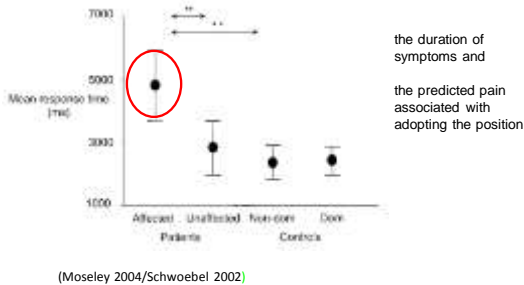
Expectation of pain influences implicit motor imagery



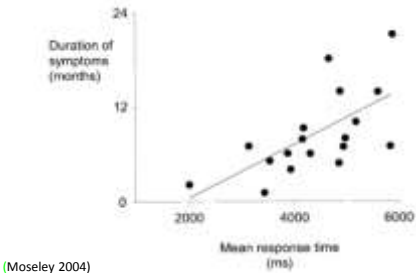
Positions **expected to be painful** are slower in CRPS
(Moseley 2004 Neurology 62: 2182-2186)



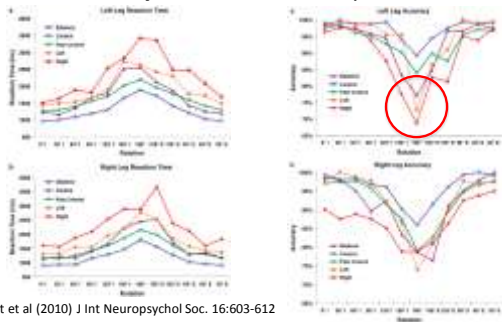
Slower RT on affected side in acute CRPS1



Duration of symptoms correlate with response times

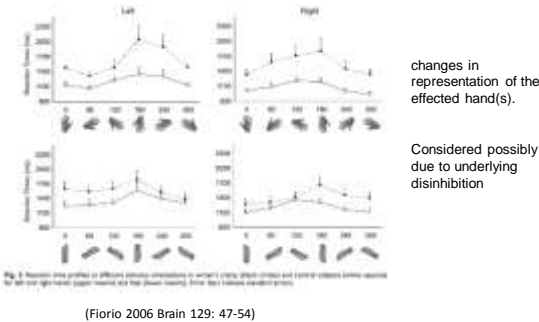


Leg pain also presents with **reduced accuracy** in the foot laterality task



Coslett et al (2010) J Int Neuropsych Soc. 16:603-612

Focal hand dystonia shows changes in implicit motor imagery



So somewhere in the progress of the problem, the brain changes “survival tack”



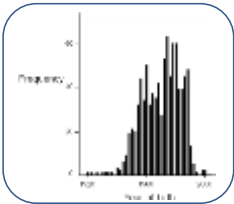
“I am protecting you.. I won’t let you move.
I will even limit your premotor preparation-
lay off me!”

What is normal Response and Accuracy?

1737 participants
(1315 pain-free)

65% female
40 countries worldwide

Variety of occupations
e.g. healthcare practitioners,
forestry and farming industry,
education, unemployed



Wallwork et al 2013

What are normal values in the hands, neck & backs?

- 2.0 sec RT hands & feet +/- 0.5 sec
 - 1.6 sec RT necks & backs +/- 0.5sec
 - 88% accuracy hands; 92% accuracy neck & back
-
- Accuracy and RT should be fairly equal for left & right
-
- Patient results should remain fairly stable, so they do not fade with stress and remain consistent for at least a week

Wallwork et al (2010) Submitted; Bowering et al 2010 Submitted

limitations in ACCURACY?

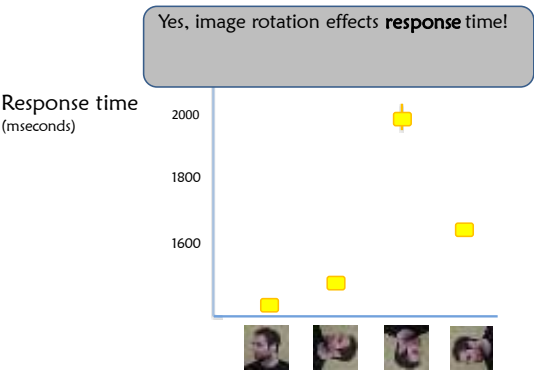
- Infers substantial **impairment** in the working **body schema**
- may be a reflection of imprecision within the neurotags (disinhibition)
- suggesting a problem **integrating the neurotag with preparation of movement**

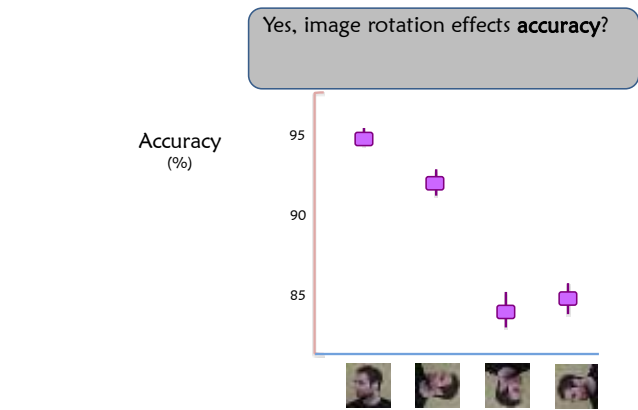
Reaction time

- Increased with age
- males are a bit faster
- left handers are bit faster

Accuracy

- reduced with age
- unaffected by gender and handedness
- Magnitude of image rotation had an effect





- Practice effects in normals
- Response times are generally faster on the second attempt of the task
 - There is often a small increase in accuracy in control subjects
 - Following several images the task requires less attention, hence *implicit*

(Boonstra et al 2012 Int J Rehabil Res 35: 278-280)

- Getting started
- Sometimes patients will complain of pain during the initial stages of L/R judgement tasks.
 - Possibly because they are using explicit MI initially in order to understand the pictures.
 - This should settle when they have repeated several times until it becomes an unconscious (implicit) task.
- **Recognise online**
 - Flashcards
 - Magazines
 - Digital camera
 - Other methods
 - Contextualise

- Recognise online (www.noigroup.com)
- Images of left and right body parts are presented randomly in predetermined;
- numbers (eg 5 to 100)
 - time (eg 1 second to 20 seconds)
 - Context – vanilla to context
-

recognise

Welcome To **Recognise™** online

Recognise™ is the first way to accurately measure the ability to recognise left and right body parts and movements, and to train left/right recognition as part of a comprehensive rehabilitation programme. You can have more about how laterality recognition forms part of the Graded Motor Imagery rehabilitation process at <http://www.gradedmotorimagery.com>

- Join to begin your laterality training with customised testing
- Try a series of Hands, Feet or Face and Movements
- Purchase through the assigned online shop

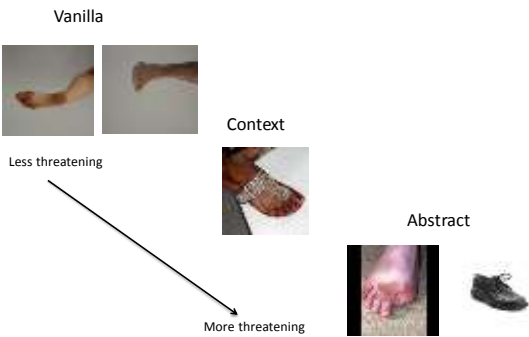
Being a unique programme, **Recognise™** undergoes continual development and improvement. In order to do this well, we rely on feedback from our 'on the ground' users of the programme. So here's your chance to say what you think, send your comments via the contact us form.

Quick Start

Vanilla Hand, Vanilla Feet, Vanilla Park & Shoe



Recognise 'Choices'

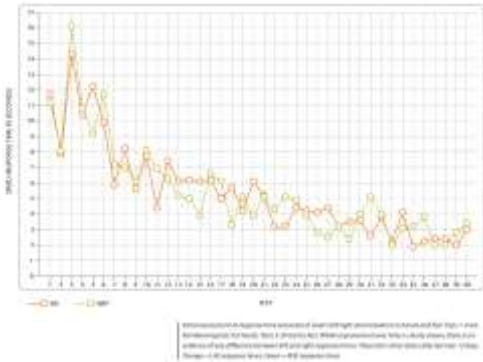


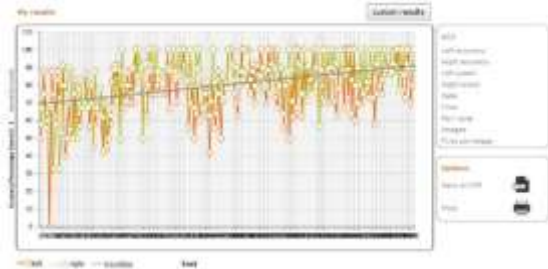
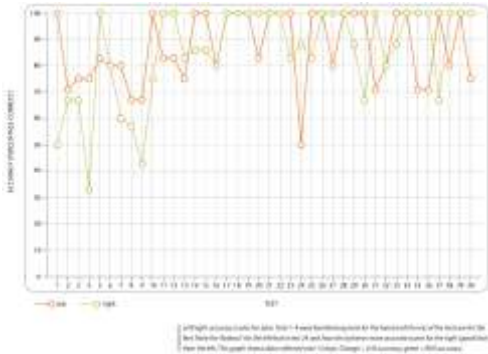


 recognise



 recognise





dominic@noigroup.com

Quick practice.....
Implicit imagery & Accuracy

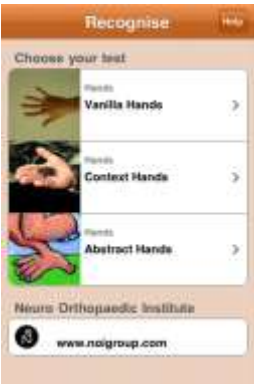
- View the 20 images on the screen
- You have 3 seconds to determine R or L
- Check R or L under appropriate column
- Determine your accuracy after all images have played

Right	
Left	

Recognize Apps for;

- *hand
- *feet
- *knees
- *shoulders
- *necks
- *backs

Limitations
and uses



Flash cards.....Let's Flash!





GAMES.....



Fun....
Non-threatening.....
Family & friends.....



Simple



Creative

Magazines are Easy!



slowest



Best L/R discrimination



Slower and less accurate



“Love
the
body
part”

Laugh out loud

Digital cameras are great



Decreased left right discrimination performance
has been noted in:

CRPS	(Schwoebel 2001, 2003, Moseley 2004)
Spatial neglect	(Coslett 1988)
Amputees	(Nico et al 2004)
Back pain	(Bray and Moseley 2011, Bowering 2012)
Neck pain	(Leake 2012)
Painful knee OA	(Stanton et al 2012)
Carpal tunnel syndrome	(Schmid and Coppieters 2012)
Cervical dystonia	(Fiorio et al 2007)
Focal dystonia	(Fiori et al 2006)
Congenitally absent hand	(Funk and Brugger 2008)

Changes in body ‘representation’

Left / Right Discrimination ?

Anecdotally:

- Post immobilisation
- Post brain surgery
- Regularly in stroke
- Post heart surgery
- Spinal cord injury
- Nerve roots
- Sprains & Strains
- Post-op



So.... What about our patient, in a cast, 2 weeks
s/p fracture?



- **Goal** in acute/sub-acute injury.....
- To **maintain normal body representation** during the healing/repair process.
- Recognize on line?
- Recognize Apps?
- Flash cards?
- Magazines?
- Observing others?

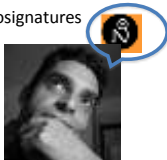
Theory and techniques
Explicit Motor Imagery

*“A man is not idle because he is
involved in thought.
There is visible labor and invisible
labor”*

Victor Hugo

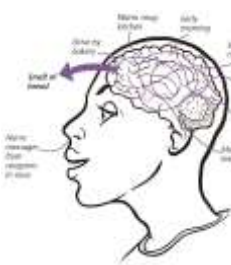
What is explicit motor imagery?

- Explicit motor imagery (MI) is a **cognitive process** of imagining a movement of your own body (or part) without actually moving it.
(Jeannerod (2003) Behavioural Brain Research 142: 1-15)
- The result of conscious access to the neurosignatures representing;
 - intention
 - preparation
 - carrying out
 - evaluation of a movement
- It depends on a **dynamic relationship** between the individual, the movement and the environment.
(Stevens (2005) Cognition 95:329-350)



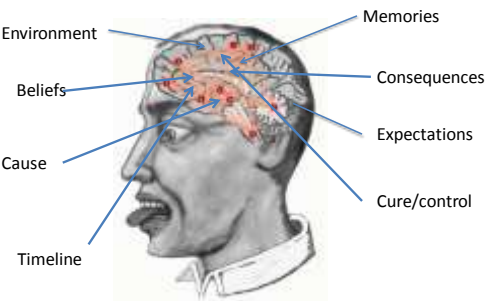
Think about it.....

Don't we use imagery all the time?



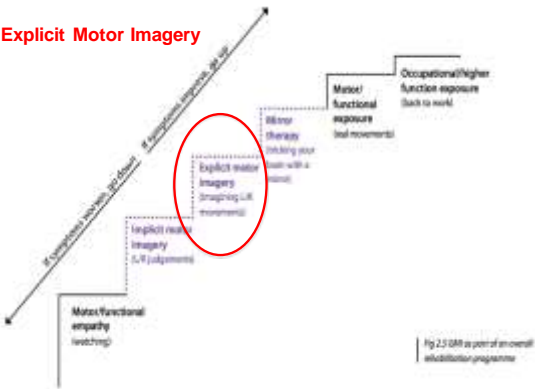
- Research indicates negative MI plays a large role in many psychological disorders
- Thought virus?
- Positive MI was found to decrease anxiety and avoidant behaviors in patients with social anxiety.

Notion of cognitive representation



“There is nothing either bad or good
but thinking makes it so.”
(Epictetus / Shakespeare)

We are what we believe we are.
C.S. Lewis



Watching movement & imagining movement



- Motor imagery in **sports** is known to improve performance
(Pelle & Lenders 1985, Adams et al 2008 Exp Brain Res 194:205-213)
- Use of MI has been shown to improve recovery of motor function in **stroke rehabilitation** (de Vries & Mulder 2007 J Rehabil Med 39:5-13)
- MI used with **musicians** improves cortical representation of the motor cortex similar to practice...
- MI is used to develop explicit **learning of surgical skills** that are cognitively demanding.
- MI is highly effective in treatment of **psychological disorders**, including anxiety, PTSD, sleep disturbances, depression, etc.
- **Demonstrating** exercises in the clinic
- Feldenkrais, etc.....?



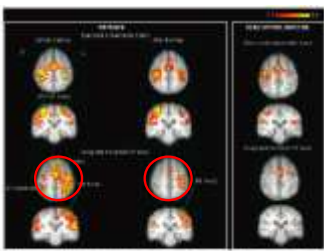
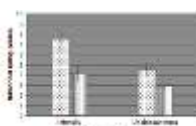
Training explicit motor imagery

Training explicit MI can significantly improve the performance of a task, even when never having performed the task before (Allami et al, 2008)

As an intervention for PLP it alters cortical activation correlating with improved pain intensity and unpleasantness. (MacIver et al, 2008)



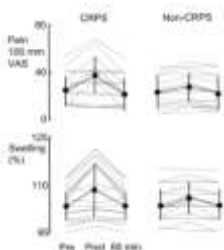
Training explicit motor imagery



(MacIver et al 2008 Brain 131: 2181-2191)

Fig. 1. Group effects in activation in response to left and right hand movements during graded motor imagery when compared to observation in healthy volunteers.

But what if thinking about the hand hurts?



- Imagined movements have been found to increase pain and swelling in CRPS 1 patients.
- Thus demonstrating that just activating the representation of the affected body part may be sufficient to ignite the individual pain neurotag.
- It also indicates the importance of progressing each stage only when appropriate.

(Moseley, 2008)



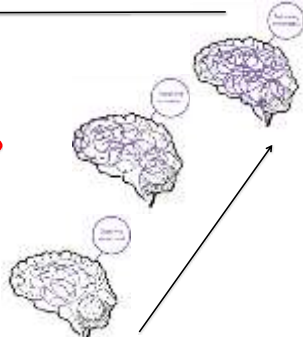
You must be aware of the patient's threats & fears, as this is ultimately what they are working towards imagining.

Reflect back

Implicit motor imagery (left/right judgements)	Explicit motor imagery (imagined movements)
You don't know you are mentally moving	You know you are mentally moving
Premotor cells modify primary motor cells without activating them	Primary motor cells are activated
Less likely to activate the pain neurotag	More likely to activate the pain neurotag

When people use MI properly they experience **autonomic responses** in anticipation / readiness / preparedness to move

There is a high degree of overlap in brain regions involved in observation, imagination and actual movements



- Imagined movements activate the same motor regions.... As actual movements.....
(but to a much smaller degree) (Ehrsson, et al 2003)
- Explicit motor imagery is a way of grading the exposure to movement

Explicit motor imagery
grading exposure to executed movements



Ehrsson et al (2003) Journal of Neurophysiology 90: 3304-3316



Essentially.....

Watching someone move will activate motor regions, but to a lesser extent than imagined, or actual, movements.

(Nedelko, et al, 2010)

likely due to the mirror neurons

Mental Imagery creates a broader neurosignature as compared to observation



Taking a step back to watching as therapy

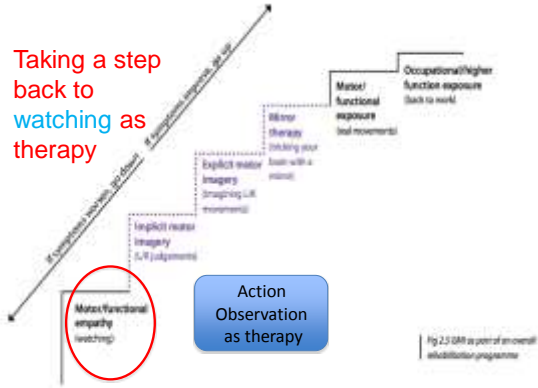


Fig 2.5 (B) is part of an overall rehabilitation programme

Explicit Motor Imagery...Getting started

- This is a kinesthetic activation.... Not visual!
- The patient must **IMAGINE & FEEL** themselves doing the movement.
- Not as an observer watching themselves doing the movement (Dickstein & Deutsch 2007/Driediger 2006)
- It is a **FIRST** person task
- Visual/THIRD person imagery may be a good way of stepping back!




Patient and Clinician Reflections

- Where do I do it?
- Eyes open or closed?
- What position do I adopt?
- Me moving or someone else?
- How long will I do it?
- Task complexity and intensity?
- What words should I use?
- Prior demonstration?
- Cues to heighten the process?
- Relaxation or meditation in conjunction?
- How much do I know about the brain and what I am trying to deal with?



Explicit Imagery

- It may be that you need to vary different elements of the task to **make it more individualized, understandable or threatening...**including: (environment, mo language, etc)
- Eyes open or closed (Heremans (2009) Brain Research 1278:50-58)
- Starting position
- Environment
- Demonstration of movement (Buccino et al (2006) Cog Behav Neurol 19(1): 55-63)
- Sensory cues
- Words used to describe the process
- Memories
- Emotions
- Length of time/time of day




Any Injury

The PETTLEP model is the most widely used and well documented method of preparing a MI intervention

P - physical	All imagery tasks should consider and include; <ul style="list-style-type: none">Movement goalThreat considerationsLess threatening to startSpecific to the individualA Neurobiology explanationRobust environmental sensationsShort time frames (5-10 min.)Frequent practice daily
E - environment	
T - Timing	
T - Task	
L - Learning	
E - Emotion	
P - Perspective	


Imagine

- Imagine what it might feel like to have a body part in a certain position
- Imagine what it might feel like to have a body part doing a certain movement
- Imagine what it would be like to manipulate an object
- Imagine what it is like to move like a certain person
- Just 'watching' may be 'easier' on the brain than thinking about movement




Imagery Options


- » Recognize Online
- » Picture books
- » Movies/ You tube
- » Mall / Airport, etc.
- » Work / Home
- » Audio recordings
- » Smart phone specific for each individual/client



So.... What about our patient, in a cast, 2 weeks s/p fracture?




- Goal in acute/sub-acute injury.....
- To maintain normal body representation during the healing/repair process.
- Progress from static MI positions to dynamic movement and functional activities...



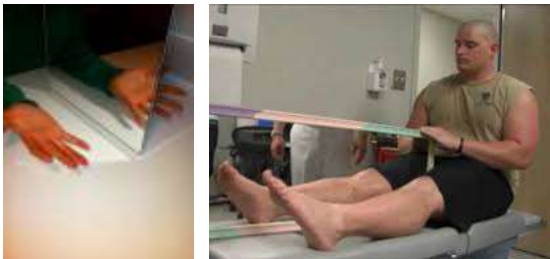
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Mirror Therapy
therapist as illusionist!



Use of mirrors in patient care following CVA

- Mirrors have been used in many forms over the years.



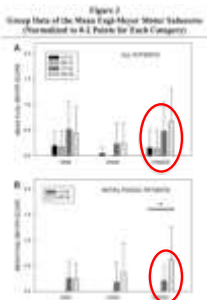
Clinicians often use mirrors to show postural and movement related feedback

Mirror therapy is ‘an experience to be explored’
Not a Rx applied to a clinical condition

- Changes in body schema create altered sensory & movement sensitivity.
- A ‘mirror reflection’ of the intact limb tricks the brain into ‘seeing’ the sensitive body part more normally.
- Mirror exercises create a less threatening neurosignature of the body part and alter the body schema



Mirror therapy in acute stroke shows improvements in motor, sensory & attentional measures
(Dohle et al 2009 Neurorehab Neural Repair 23(3): 209-217)



Mirror therapy?

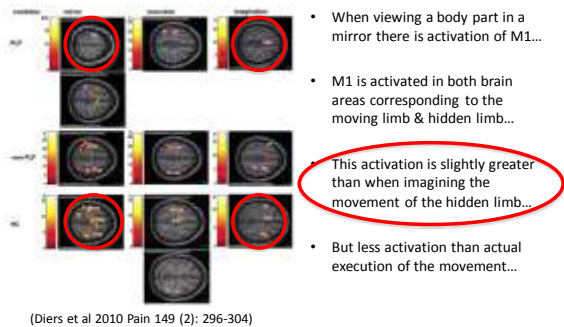
Using the mirror to trick the brain into thinking that the limb moving is in fact the hidden limb.

Easiest to set up for hands and feet

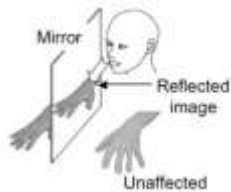
Requires more careful positioning and larger mirrors for legs, hips, trunk, shoulders, neck.



Mirrors & graded exposure to movement



What about the patient who presents with Dysynchia?



- It is a frequent occurrence in CRPS patients, that when using a mirror they note pain or pins/needles in their hidden, affected, hand, while looking at their virtual hand in the mirror....
- (Acerra & Moseley 2005 Neurology 65:751-753)

Dysynchia is not a feature of other neuropathic pain states.
(Kr mer et al 2008 Eur J Pain 12:128-131)

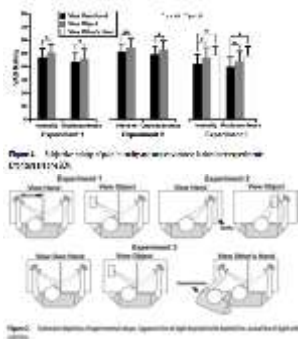
Mirrors & cortical reorganization

- In patients with PLP, activation of the hidden limb appears to be lost or "less"....
- This can be re-trained...
- Effective functional training using mirrors shows changes in cortical activity of motor areas



(Michielsen et al 2011 Neurorehab Neural Repair 25: 223-233)

Viewing your own body creates an analgesic effect in nociception



- It appears that viewing the reflection of a limb has analgesic properties similar to looking at the limb when it is not hidden

(Longo et al 2009 J Neurosci 29 (39): 12125-30)

Practitioner Perspective

- Engage active participation
- Optimistic & confident, (+)
- Relaxation instructions;
 - Encouragement about seeing, feeling, thinking, **EXPLORING**
- Introduction to mirror
- Minimal intervention after this point



Patient's Perspective

- Expectations
- Active Participation
 - Life changing
 - Understand correct procedure for best results
- FOCUS** – very important
 - If focus is not there, return to expectation, management/instruction
- Correct mind-set for 'exploration' is crucial



Reaction

- Often **verbal reactions**
 - Surprise
 - Semi-‘Shock’
- **Emotional Reunion**
 - **DO NOT** interrupt
 - No matter how long
 - Full emotional relief
- **Fascination & Exploration**
- **Fatigue**



Practicalities when progressing to a mirror

- Mirror Box of high quality
- Guided by a skilled clinician who knows the brain
- Prepare the patient ?
- Sit “evenly”
- No jewelry or tattoos– “total illusion”
- Graded exposure principles
 - Pain & associated sx’ s?
- Determine appropriate activity
 - Looking, movement, touching, weight bearing

Some suggested Mirror Progressions

- Look at hand
- Turn hand up and down via elbow
- Flatten out the hand
- Flatten hand and then take weight through it
- Move individual fingers
- Finger thumb opposing
- Tapping fingers
- Add increasing muscle activity to each movement



Other Practicalities & Progression

- “conquer the movement” before progressing
- Modify the **context** ; music, emotions, smells. Etc
- “knock on the door first” but “don’t come in until you are welcomed”
- Painful limb positioning/non painful limb positioning?
- Odd asynchronous movements



Context variables to alter

- Place (from safe to feared places)
- Emotion
- Time of day
- Try movements while distracted (whistling a tune)
- Music
- Sitting, standing, lying down
- Smells
- Noises
- Background
- Textures (carpet, cloth)
- Water

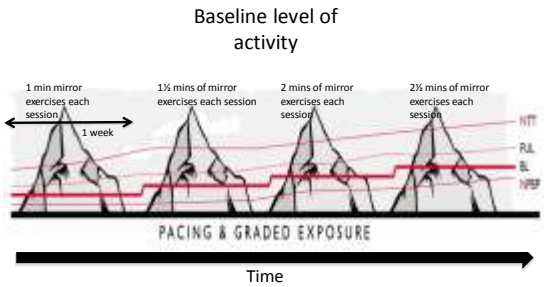
Mirror Progressions

- Use tools, shoes, etc..
 - Screw driver, nail cutters, pen, scissors, knife, etc.
 - Running shoes, work boots, high heels
- Introduce clinician’s hand onto affected body part
- Massage and caressing by a loved ones hand
- Interventions should progress in context/environment from “**Less threatening to More threatening**”



Mirror progression –
graded exposure & contextual change

Threat value	Inside box	Outside box
Less threatening	Keep hand still/comfortable	Keep hand still – just observe reflection
	Keep hand resting	Slowly form a fist
More threatening	Oppose fingers	Oppose fingers & press with force
	Move fully – include a tool	Copy hand in box
	Include tools that have threat attached to them	Copy hand in box
Most threatening		Copy hand in box



‘Virtual Reality’ exercises need frequent practice....
You are exercising to improve synaptic endurance and strength
No data on how much, how many, how long.....
I recommend 2 X 15’ sessions/day for 4-5 weeks for my patients

The clinical reality

- Training has to be intense & behaviourally relevant for cortical reorganisation

Integrating Graded Motor Imagery into practice



Preparing your patient



Neuroscience/psychology blended style

Neuroscience style
(+) impact when using neuroscience links to the health of body and tissues
Decreased THREAT.....



Neuroscience style education is effective



Reconceptualisation is required

Takes structural pathological issues - **BIOMEDICAL**

Places them on a framework of neuroscience
- **BIOPSYCHOSOCIAL**

- Patients able to be trained in pain neurobiology
- Health professionals underestimate ability of patients to understand information

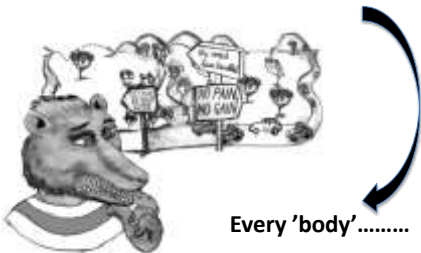


Moseley (2003) J Pain 4(4): 184-189

Reconceptualisation is Necessary

- May challenge long held beliefs
- Underlying brain changes does not mean brain damage
- This is reversible but will take patience and persistence
- Requires good understanding of the concept & endorsement of the treatment by the clinician
- Knowledge is context – considered an ‘output liberator’ it changes patient’s thoughts and beliefs
- Take ‘Explain Pain’ before GMI !!!!

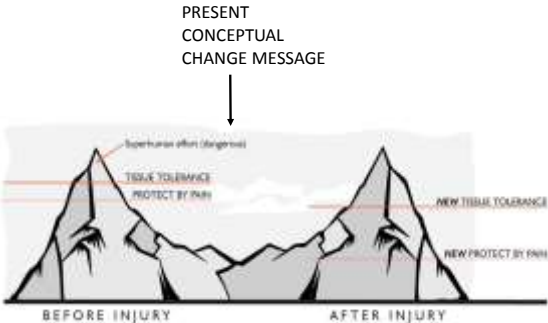
Who would I consider using
GMI for?

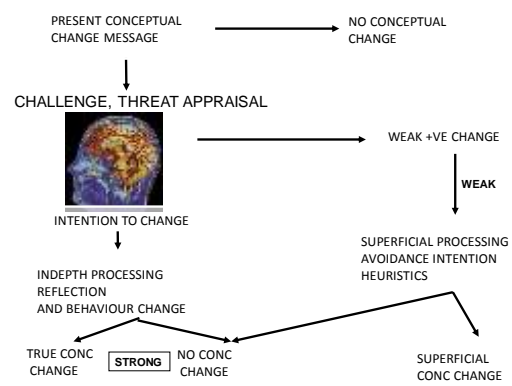
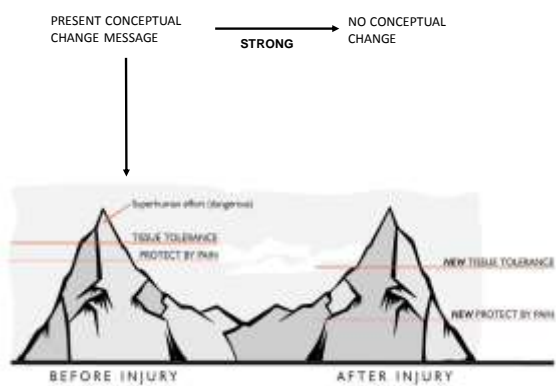


Know Pain or no Gain

- EP/TNE evidence suggests a variety of education tools you might need....
 - Data or facts
 - Reading materials
 - Pictures
 - Stories
 - Metaphors
 - Video or photo’ s
 - Internet
 - Magic dust

?

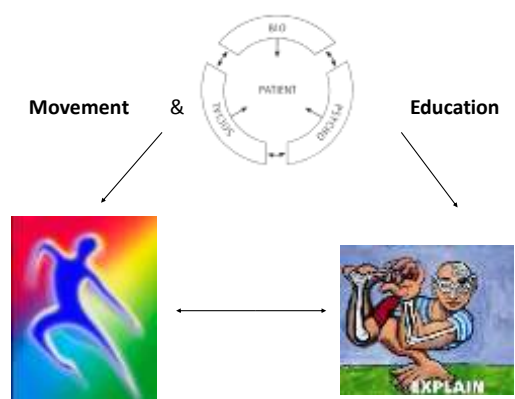
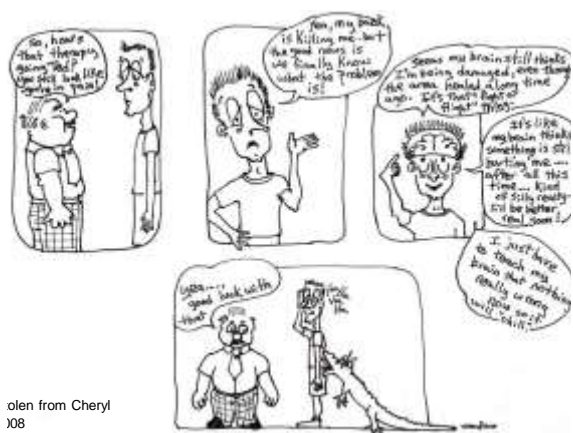
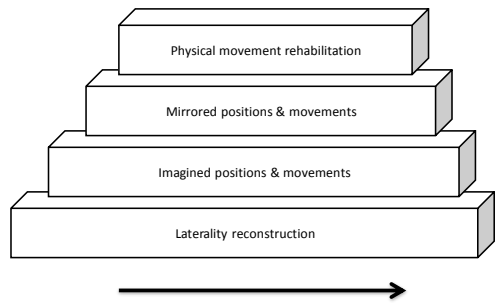




GMI summary

- **Laterality Reconstruction**
 - Number of images
 - Speed of images
 - Rotation of images
 - Accuracy
 - Threat value of images
 - **Motor Imagery**
 - Duration
 - Complexity of mental image
 - 'Feeling' the movement (*kinesthetic awareness*)
- **Mirror Feedback**
 - Complexity of mirror action
 - Duration
 - Environmental input (*noise, aroma, etc*)
 - Contextual 'visual field' input (*tools, objects, etc.*)
 - **Active Movement**
 - ROM
 - Repetitions
 - Resistance
 - Distractions

Graded Exposure Summary:





rob@noiigroup.com



robertjohnson.noi@gmail.com

Thank you!

Contacts:

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robertjohnson.noi@gmail.com

Resources:

www.noiigroup.com

www.noijam.com

www.gradedmotorimagery.com

www.bodyinmind.org

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