Persistent pain is a complex issue

- Pain is an output that is the result of input from multiple areas of the brain:
  - Thalamus and Hypothalamus: stress response, autonomic regulation, motivation
  - Amygdala: fear, fear conditioning
  - Prefrontal and frontal cortex: makes sense out of the situation.
  - Cingulate cortex: concentration and focus, affected by attention to pain
  - Cerebellum: Perception of movement
  - Hippocampus: memory, spatial cognition, fear conditioning
Persistent pain is a complex issue:

- **Sensory homunculus:**
  - Receives input from the body and localizes the source.
  - This can become blurred and “smudged” with changes in movement habits.
- **Premotor and Primary motor cortex:**
  - Organizes and prepares for movement.
  - Affected by fear of hurting oneself.

- In the presence of persistent pain, the nervous system undergoes changes which help perpetuate the presence of pain.

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**Neuromatrix**

- **All** of the connections in the brain make up a bodyself neuromatrix.
- This self representation is constantly evolving; being sculpted by life.
- The “coding space” of all events of the brain.

19th Century engraving of Goethe’s Faust and the Homunculus
Neurotag

• The self-generated representation in your brain of a movement or posture without actually performing the movement or posture.¹
• Activation in multiple areas of the brain results in the activation of a neurotag.
• There is an activation threshold required to produce an output of a neurotag, similar to a single neuron.
• The output defines the neurotag.
• Each movement has its own neurosignature.
• Pain also has its own neurosignature.

Central Sensitization

• **Sensitization**
  • Increase in excitability of the member brain cells of a neurotag lowers the activation threshold.
  • In a pain neurotag this results in pain that is more easily produced.

• **Disinhibition**
  • Decrease in the inhibition of non-member brain cells surrounding the neurotag.
  • In the presence of disinhibition neurotags lose their precision
  • Disinhibition of movement neurotags manifests as imprecise movements or perhaps in extreme dystonia
  • Disinhibition of pain neurotags results in poorly localized pain.
  • Result in altered sensory perception of a body part.

Graded Motor Imagery

• This treatment method has evolved out of a growing understanding of the neurobiology of complex pain due to central sensitization.

• It exercises the brain through a stepwise progression of activities to improve synaptic health in a graded fashion, taking advantage of neuroplasticity.

• The process of graded motor imagery serves to guide the sensory and motor cortices through activities without activating the pain neurotag associated with movement.

• The goal is uncoupling the link between the movement neurotag and pain neurotag by reshaping the movement experience, resulting a different the output with the activation of the neurotag

• Some of the common diagnoses treated:

  • Complex Regional Pain Syndrome (CRPS)
  • Phantom Limb Pain
  • Pain related to Spinal Cord Injury (SCI) or Stroke
  • Persistent Neck, back, or extremity pain
  • Pain following peripheral nerve injury
  • Possible use for Pain Prevention
    • Amputation
    • Fracture
Step process

- Motor/functional empathy (watching)
- Implicit Motor Imagery (L/R judgments)
- Explicit Motor Imagery (imagining L/R movements)
- Mirror Therapy (tricking the brain with a mirror)
- Motor/functional exposure (real movements)
- Occupational/higher functional exposure (back to work)


Techniques

- Left/right discrimination (Implicit Motor Imagery)
- Imagined motion (Explicit Motor Imagery)
- Mirror Therapy
- Graded Exercise Exposure
Baseline level

• It is important to establish the level of activity (or thinking about an activity) that can be accomplished without pain.
• This must be established before starting training in order to begin the process of disassociation of pain and an activity or movement.
• This allows the patient and the clinician to establish criteria for success and when it is appropriate to change the activity.

Sequence of Treatment

• The order of treatment is important.
• Mirror Therapy was not affective in decreasing pain when used as the first intervention.\(^5\)
• Graded Motor Imagery done in this order was found to decrease pain in patients with CRPS\(^1\)\(^6\)
Step 1

Implicit Motor Imagery (L/R judgments)

Explicit Motor Imagery (imagining L/R movements)

Mirror Therapy (tricking the brain with a mirror)

Motor/Functional Exposure (real movements)

Occupational/higher functional exposure (back to work)

Motor/functional empathy (watching)


Left/Right Discrimination or Laterality

• The process of identifying one side of the body as distinct from the other.

• The brain is mentally manipulating the body part, but we are not aware.

• When a person looks at an image:
  • The response should be immediate, spontaneous, and unconscious
  • This is a mental movement- maneuver body part in your mind
  • This process will use parts of a neurotags that create movement
Left/Right Discrimination or Laterality

- Body schema is created through input from the spinal cord, thalamic tracts and cortical structures.
- Recognizing a body part moving requires an intact body image.
- In the presence of complex, persistent pain body image becomes distorted.
- There is a bias in tactile processing away from the painful body part.

Left/Right Discrimination or Laterality

- Implicit motor imagery does not light up the Primary Motor Cortex (M1), but does activate the Pre-motor Cortex, the area where planning movement occurs.
- Activation of the Pre-motor Cortex through implicit motor imagery can result in a change in the activation threshold of the neurotags.
- It also can increase inhibition of neighboring non-member cells.
- This helps restore precision to the neurotag in sensory and motor issues.
Tools for Implicit Motor Imagery

- Recognise™ App
  - Available on iTunes for iOS and Android
  - Feet, knees, hands, necks and backs

- Flash Cards
  - Easy to use in different contexts

- Magazines
  - Ones you like, ones you don’t like

- Creativity and Imagination

### Implicit Motor Imagery
(left/right judgements)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>You don’t know</td>
<td>you are mentally moving</td>
</tr>
<tr>
<td>Premotor cells</td>
<td>modify primary motor cells without activating them</td>
</tr>
<tr>
<td>Less likely to</td>
<td>activate the pain neurotag</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
RECOGNISE™ App

• Establish a baseline for activity without pain production.
• Suggested trial:
  • 20 images
  • 5 seconds/image
  • Quick test or basic

Response times

• Response Time
  • 1.6 sec +/- .05 sec = necks and backs
  • 2.0 sec +/- .05 sec = hands and feet
• Accuracy of Judgments
  • 80% or above
• Side to Side Difference
  • Response time and accuracy should be equal
Flash Cards

- NOI has cards for hands, feet, necks, backs and shoulders.
- Make them with a digital camera
- Can be used in a variety of settings (i.e. on the bus, at work)
- Can play games:
  - Tic Tac Toe
  - Sorting into R/L piles
  - Memory

Magazines

- Initially look through the magazine.
- Identify body parts
- Identify the direction a neck or back is turned or side bent.
- Rotate the picture to increase the difficulty.
If implicit motor imagery causes pain?

- Results should be stable in various contexts (i.e. under stress or varied environments) and consistent for at least 1 week before progressing activity.

- If pain is increased when the images progress, look for a pattern, is there a specific image that triggers pain. Then break down the image into parts (i.e. holding a hammer, etc.).

Implicit Motor Imagery Lab

- Recognise App
- Flash Cards
  - Right left discrimination
  - Tic-tac-toe
- Magazine
  - Flip through the pages and identify a body part
  - Which side of the body?
  - Is the neck or trunk turning right or left?
  - Side bending right or left?
Rethinking Pain

Step 2

Imagined movement

• “The self-generated representation (neurotag) in your brain of a movement without actually performing the movement or posture”.

• Has been widely used by athletes to improve performance.

• Engages the sensory cortex as well as the motor cortex.

• This process helps to train inhibition of non-member brain cells and improve precision with the sensory system.

Explicit Motor Imagery
(Imagined Motions)

You know you are mentally moving

Primary motor cells activated

More likely to activate the pain neurotag

Imagined Movement

• 1st Person Exercise: Imagine the feeling of doing an activity, rather than seeing the performance.

• Imagined motions can cause pain and swelling on a patient with CRPS1

• If this is too painful, the exercise can be done in 3rd person, “watching” themselves do the movement or activity.

• If someone has persistent pain they may have difficulty visualizing the body part.
  • They can:
    • Visualize the opposite side.
    • “Watch” themselves
    • Watch others
    • Start proximal and work toward the affected area
Explicit Motor Imagery Lab

• Find a partner
• Pick a script on the table.
• Take turns guiding each other through the activity.
• For the “clinician” speak slowly as you give the instructions.
• For the “patient” concentrate on the directions, focus on feeling the body part.

Step 3

- Motor/functional empathy (watching)
- Implicit Motor Imagery (L/R judgments)
- Explicit Motor Imagery (imagining L/R movements)
- Mirror Therapy (tricking the brain with a mirror)
- Motor/Functional Exposure (real movements)
- Occupational/Higher functional exposure (back to work)

Mirror Therapy

- Goal is to perform an activity with both sides of the body, but view the uninvolved side as though it was the involved side.
- This tricks the brain into thinking that the limb visualized in the mirror is the affected limb.
- Activation of primary Motor Cortex both for the moving limb and the hidden limb.
- More activation than imagined movement
- More success with patients who have the ability to imagine moving the effected limb.

Mirror Therapy

Tools:
Mirror Box or tall mirror
- A good mirror won’t distort body parts
- Make it believable – take off jewelry, watches, cover tattoos
<table>
<thead>
<tr>
<th>Threat Value</th>
<th>Inside the Box</th>
<th>Outside the box</th>
</tr>
</thead>
<tbody>
<tr>
<td>Static Posture</td>
<td>Keep the hand still/resting in a comfortable position</td>
<td>Keep the hand still/resting in the same position as the hand in the box-observe the reflection</td>
</tr>
<tr>
<td></td>
<td>Keep the hand still</td>
<td>Rotate the hand</td>
</tr>
<tr>
<td></td>
<td>Keep the hand still/resting in the same position as the hand in the box-observe the reflection</td>
<td>Oppose each finger separately</td>
</tr>
<tr>
<td>More threatening</td>
<td>Keep the hand resting with a slight bend in the fingers</td>
<td>Make a fist, then slowly relax; repeat</td>
</tr>
<tr>
<td></td>
<td>Keep the hand still/repeating the hand</td>
<td>Oppose each finger separately</td>
</tr>
<tr>
<td></td>
<td>Keep the hand resting with a slight bend in the fingers</td>
<td>Make a fist, then slowly relax; repeat</td>
</tr>
<tr>
<td></td>
<td>Oppose the fingers gently touch together</td>
<td>Oppose the fingers and press with some force</td>
</tr>
<tr>
<td></td>
<td>Oppose the fingers gently touch together</td>
<td>Oppose the fingers and press with some force</td>
</tr>
<tr>
<td></td>
<td>Make a fist, pushing into some discomfort</td>
<td>Make a fist and squeeze in repetitions</td>
</tr>
<tr>
<td></td>
<td>Move both hands full and include tasks such as squeezing a ball or writing</td>
<td>Copy the hand in the box</td>
</tr>
<tr>
<td>Most Threatening</td>
<td>Include tools that are more threatening, such as a knife</td>
<td>Copy the hand in the box</td>
</tr>
</tbody>
</table>

Reproduced from the Graded Motor Imagery Course Manual, NOI 2012

Contextual changes as part of a graded progression

- Location
- Noise
- Vision
- Emotion
- Gravity
- Time of day
- Distraction
- Expectations
In summation

• With persistent pain cortical changes result in functional changes.
• The nervous system can be retrained, BUT this is difficult work that takes patience and persistence over time.
• There will be flare ups, but reinforce this is a protective strategy of the body, not a sign of injury.
• Stick to the plan.
• Don’t push beyond on a good day.

Thank you!

Questions?


7. Moseley GL. I can't find it! Distorted body image and tactile dysfunction in patients with chronic back pain. Pain 2008; 140: 239-243


Rethinking Pain

- Persistent pain is a complex issue.

Experiences, Beliefs, Knowledge, body Image, Culture, motor Pattern etc..

adapted from material from Brendon Haslam: Pain, Plasticity and Rehabilitation course material 2014