Graded Motor Imagery

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Whenever we get a referral for a patient with a unilateral or neuropathic pain condition, one of the first tools we reach for in our pain therapy tool kit is “Graded Motor Imagery” therapy.

Graded Motor Imagery combines several (evidence based) therapies, which target the synapses in the brain and provides a “top down” therapy that can alter the sensitive networks of the neuromatrix in the brain and brain stem.
The “Gate Control Theory of Pain” (Melzack and Wall 1965) introduced the Central Nervous System Mechanisms as an essential component of the pain process.

However, the pain experience “phantom pain” after limb or organ amputation and the pain experienced by persons with paraplegia, and neuropathic pain could not be explained by the “Gate Control Theory”.

The Neuromatrix concept was suggested and identified that brain mechanisms may underlie some kinds of chronic pain.
Phantom Limb Pain

- When a limb is amputated the proprioceptive and visual inputs for that limb are removed, but the nerves are still in tact.

- Approximately 60 – 80% of amputees are affected by phantom pain.

- Even though there is no limb the representation of the limb is still held on the somatosensory cortex.
A Brain Neurone
Phantom Pain

- FMRI Studies by Herta Flor et al (1995) 2006 proved that there was neuronal activation in the somatosensory cortex area representing the amputated limb during the patients experience of phantom pain.

- The intensity of phantom limb pain is correlated with the extent of cortical reorganization in the somatosensory cortex and motor cortex.
FMRI proof that cortical reorganisation occurs during PLP
(Herta Flor et al Phantom Limb Pain as a perceptual correlate of massive cortical reorganisation of the somatosensory cortex in upper extremity amputees nature 357 (1995) 482-484)
HOW DID GMI COME ABOUT?

- GMI is an eclectic therapy designed in 2004 by Dr G Lorimer Moseley and David Butler. It’s conception responded to the plethora of studies that were coming out regarding the relationship between the plasticity of the brain and chronic pain states and the process of central sensitisation.

- More importantly it responded to the Neuromatrix paradigm of Pain initiated by the late Patrick Wall and Ronald Melzack.

- David Butler says that GMI has been designed to activate the somatosensory and motor cortices which desmudges the brain and facilitates cortical reorganisation.
GMI is a sequential therapy...

1. **Laterality** reconstruction attempts to restore the accuracy and speed of identifying the left and right sides of the body. (Recognising left and right)

2. **Motor Imagery** is the Mental representations of postures, movement and activities without any body movement. (Imagining Action) aimed at activating the premotor cortex.

3. **Mirror Therapy** is the use of a Mirror to present the reverse image of a limb to the brain “tricking the brain”.
1. GMI – Laterality Training – Implicit Motor Imagery


- The Patient is taught to safely recognise right and left in images of feet / hands / shoulders / neck / back with different postures.

- The goal of this therapy is to stimulate the somatosensory cortex on the contra lateral side of the affected limb. The brain is plastic and changeable if given the right stimulus for long enough, it is possible to reconstruct the brain’s feature of laterality.
1. Laterality discrimination, recognition, and restoration

- Programme licence was purchased on an 2 monthly basis at [www.recognise.com](http://www.recognise.com)

- The Patient is given a Token and Key to the “recognise” website and is expected to practice laterality exercises every waking hour or as many as possible, for hands, feet, neck and shoulder and backs.

- Both patient and therapist access the website to monitor progress and results of the hand laterality exercises, which shows timing and pain levels.

- Normal accuracy is considered at 92.5% with an average time of 2.4 seconds for hands and 1.6 seconds for neck and shoulders.
LEFT OR RIGHT?
2. From Laterality to Motor Imagery

- The progression from laterality to motor imagery came about because studies showed that Limb Laterality recognition activates pre motor (association) cortices not the primary motor cortex.

- Motor Imagery is the mental rehearsal of postures or an action without the actual movement – imagining the body part in a certain position.

- Functional Neuro imaging studies by (Grezes and Decety 2001) show that motor imagery and action are mediated by the same neuronal circuits.
2. Graded Motor Imagery

- The Patient is shown pictures from the “recognise” website, magazines, you tube clips, movies, sitting in café’s etc.

- They are asked to imagine adopting the posture on the screen with their own arm, leg, neck and shoulders, or back and then returning their body part to where it was. They are asked to imagine a pain free smooth action.

- Viewing static snapshots that imply human action activate the human motor system. (Urgesi, Moro et al 2006)

- Grasping at tools: Corticospinal excitability reflects observed had movements (a study reported in the Cerebral Cortex 2012 22...)
2. Motor Imagery ....

- The result of conscious access to neurosignatures representing intention, preparation carrying out and eventual movement has been used in sports in healthy people. (Dickstein and Deutsch 2007)
3. GMI - Mirror Therapy -

- Vilayanur Ramachandran is a neuroscientist who is known for the invention of the mirror box and MVF (Mirror Visual Feedback) in the 1990’s.

- MVF has since been proven an effective therapy for those with phantom pain, and many other unilateral pain conditions.

- FMRI studies have since verified that the brain represents the actual perception not the physical stimulus.
This is a simple “self administered therapy”, 25 minutes per day, relaxed environment, 8 weeks before re-evaluating it’s use, can do booster sessions if pain returns, might need support, must look in the mirror for the duration of the treatment, take off jewellery or identifying features, can do gentle movements with foot or arm....
3 GMI – Mirror Therapy

- Performing various actions whilst observing the reflected image of the intact limb (live example)
- Activities are graded to sequentially unsmudge the brain
- Graded via speed of performance, number of repetitions
- Patients can massage their limb to enhance the activity in the visual cortex particularly the dorsal visual stream where kinaesthetic and visual inputs converge (Macaluso et al 2000)
- Vision dominates over proprioception (Pascale Touzalin, Chretien et al 2010)
- No significant correlation between amount of time since amputation and benefit of treatment
Mrs S with Lamb chop 4 days post amputation!

The illusion of the phantom is played out in the mirror!

Mrs S is now 2 years post amputation, she practices the Mirror Visual Feedback Technique every night just before going to sleep. She has had no phantom pain since 6 days post amputation, and she is back working fulltime.
Mirror Therapy

- The invasion of areas neighbouring the representation of the amputated limb into the cortical representation zone is related to pain intensity.

- Pain Relief induced by Mirror Therapy is accompanied by a reversion of cortical organization. Reduction of this shift is correlated to the reduction in pain experienced.
Mirror therapy

- FMRI imaging before and after 4 weeks Mirror training and practice resulted in mirrored hand movements caused significant bilateral activation in SMC before and after treatments as well as the insular cortex and the inferior parietal cortex.

- However distortions of the phantom might complicate the integration of visual and proprioceptive inputs into a coherent percept and reduce the effects of mirror therapy.
Telescoping Phantom

- In the case of the telescoping phantom limb, Mirror Therapy was unable to reduce the activity in the Inferior Parietal Cortex.

- The perceived intensity of telescoping was negatively correlated with the treatment effect.

- Without telescoping, reported 50% decrease in PLP; with telescoping, 1% success (Herta Flor et al. 2013)
Virtual Reality Treatment - Advantages

- High Adaptability image can be processed in several ways before presenting it on head mounted display
- If amputee experiences phantom as shrunken or telescoping can
- If CRPS may have swollen limbs or perceive them as larger than they are
- MT may **fail** to achieve spatial congruence between mirrored image of intact limb and the percept of the amputated limb
New findings about Mirror Therapy and Virtual Reality

- The concept of “body matrix” (Moseley) proposes that activity in specific cortical regions is related to the ability to subjectively incorporate a limb not belonging to one’s body.

- The feeling of observing one’s own hand, or body part is necessary for treatment benefit.
ILLUSIONS CAN HELP PATIENTS MANAGE THEIR PAIN.
The Use of Graded Motor Imagery in Phantom and Neuropathic Orofacial Pain

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Introduction: Patients with Orofacial Neuropathic or Phantom Pain have few non-pharmacological treatment options. Limited evidence has been provided linking positive effects for Mirror Therapy and Graded Motor Imagery alone (1). Recent fMRI Studies show significant S01 functional reorganisation (expansion) in the area responding ongoing pain in patients with painful Trigeminal Neuropathia (2) and also reveal a relationship between change in pain after Mirror Therapy and a reversal of dysfunctional cortical organisation in the primary somatosensory cortex in patients with Phantom Pain. We applied the principles of “Graded Motor Imagery and Mirror Therapy alone” as a pain management option with Orofacial Phantom and Neuropathic pain conditions.

Method: The conventional mirror technique component of Graded Motor Imagery is difficult to apply to the head and neck. To apply the therapy techniques we combined a Mirror with Prism Glasses (creating a kaleidoscope effect) or two mirrors, to reverse the image of the patient’s “face and neck” in the mirror.

The treatment is self-administered. It involves using a pair of PRISM glasses and a mirror or two mirrors. The patient puts on the PRISM glasses and looks into the mirror, the reflected image in the mirror creates the illusion that the patient’s face has reversed – the left side of the face becomes the right side and vice versa. If using two mirrors, the patient looks into the left side mirror, the reflected image in the left mirror from the right side mirror creates the illusion that the patient’s face has reversed.

The patient must be seated whilst administering the therapy.

Once the illusion is achieved by the patient in the mirror they are then instructed to:

• “Observe” the affected side (which is in fact their non-affected side) in the mirror paying attention to the contours of their face, their forehead, lips and cheeks, for 3–5 minutes.

• “Massage” the affected side (which is in fact the unaffected side) in a gentle massage fashion beginning with the lips, chin and cheek; ear area, neck area, around the outside of the glasses and then the forehead and scalp for 3–5 minutes.

• “Perform” movements with the affected side (which is the unaffected side) in a systematic manner, move mouth open and close it, move cheek up and down, practice chewing movements, smiling movements and grimacing movements, forehead movements - whilst observing these movements.

• Repeat this process up to three times per day (morning noon and night) but especially just prior to retiring to bed at night.

The patient completes a weekly diagrammatic assessment of the pain sensations they are experiencing which is colour and key coded to monitor progress.

Case Study – Phantom Orbit Pain

47 year old female patient with left sided retinoblastoma excised when she was three who then had reconstructive surgery in 1990 with a rib transplandt and coral implant into the left orbital rim. Following this she developed numbness over the area of reconstruction area over the distribution of the trigeminal nerve.

After treatment for a dental abscess she started to develop sensations around the edge of the construction and presented to the pain clinic with hyperesthesia and allodynia affecting the first trigeminal area and the region of the orbit. This was triggered by cold wind, bright lights and she was not effectively managed with combination therapy with ibuprofen, amitriptyline and oxybutynin. She had at times resorted to using local anaesthetic cream over the area. She had started to wear a hat when outside or during sleep to prevent aggravation of her pain.

Results: After 5 weeks of the GMI technique identified using the 2 mirror technique, the patient reported significant reduction in her pain experience, a reduction in her use of pharmacology, less hyperesthesia, and normalisation of sensation of the skin of her forehead above the affected eye.

Case Study – Trigeminal Neuralgia

Pre GMI Prism Glasses Therapy

In 2008 an 80 year old man presented with Trigeminal Neuropathia causing intolerable pain, difficulty eating and drinking and left eye pain. He had had two balloon rhinotomies and bilateral percutaneous tractography and was receiving standard pharmacotherapy with tegretol, phenytoin and gabapentin.

Eight months after cryosurgery he continued to experience sharp short bursts of pain (described as 10/10) exacerbated by cold wind, rain, and other unpredictable factors.

There was asymmetry of the left eye and discolouration of the left cheek. He was restricted in what he could eat and experienced a sensation of numbness and dryness in his mouth. He was reluctant to socialise for fear of an attack of pain.

Medications were increased to 70 mg Baclofen and further 20 mg Amitriptyline. This was holding the pain but causing intolerable sedation and it affected his balance and walking which he found frustrating.

Post Therapy Results

GMI mirror/prism glasses therapy (method 1) begun in February 2011.

November 2011 – 10 months of MFP Prism Glasses Therapy

Medications reduced to 30mg Baclofen per day, no pain attacks for 10 months since the beginning of GMI Prism glasses therapy and reduction of medication by 40 mg of Baclofen per day, symmetry in the face and normal in the left cheek, he is able to eat and drink freely, he has remarkable social situations now, he is not sleepy, has more energy and is able to walk confidently and has resumed gardening.

Conclusion: Kaleidoscopic Graded Motor Imagery Mirror Therapy (including Prism Glasses Therapy) can be considered as a non-pharmacological treatment option for Trigeminal Neuropathia and a variety of Orofacial Neuropathic pain conditions.

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