

Mirror Visual Feedback: A Brain Based Approach to Managing Phantom Limb Pain

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Disclosure

NO CONFLICT OF INTEREST

Overview

- ▶ Phantom Limb Pain (PLP)
- ▶ Harnessing the Brain: Mirror Visual Feedback
- ▶ Can we prevent PLP?
- ▶ Review and questions

PLP: The Scope of the Problem

- ▶ Post amputation, most patients report awareness of a phantom, i.e., the continuing perception of the missing limb, with or without proportional distortions

Giummarra, M.J., et. al. (2007). *Brain Res Rev* 54, 219–232.

Hanley, M.A., et. al. (2009). *Am J Phys Med Rehabil* 88, 742–751.

- ▶ 60–90% of amputees report phantom limb pain (PLP), a sensation of pain located in the amputated limb, which has a high rate of chronicity and is difficult to treat

Weeks, S.R., et. al. (2010). *Neurologist* 16, 277–286.

Proposed Mechanisms

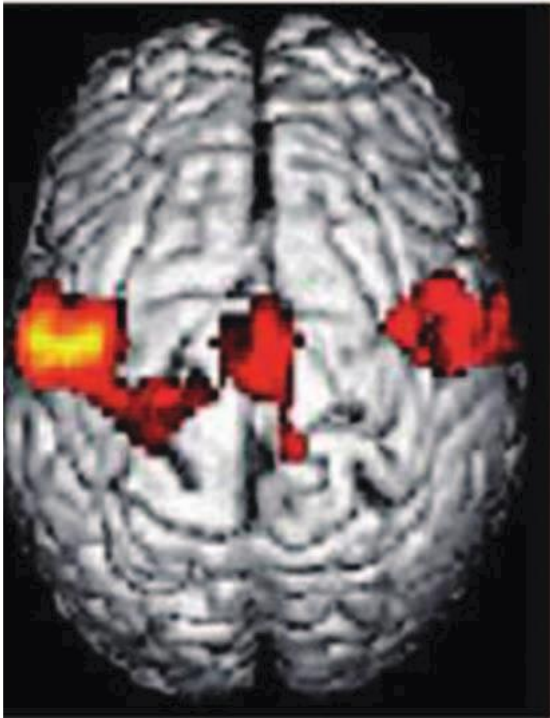
- ▶ Central changes proposed to contribute to PLP
- ▶ Reorganization of somatosensory and motor cortex – the invasion of areas neighbouring the representation of the amputated limb into the cortical representation zone
- ▶ Shown to be related to PLP intensity, suggesting that it may be related to this change after amputation

Birbaumer, N., et. al. (1997). *J Neurosci* 17, 5503–5508.

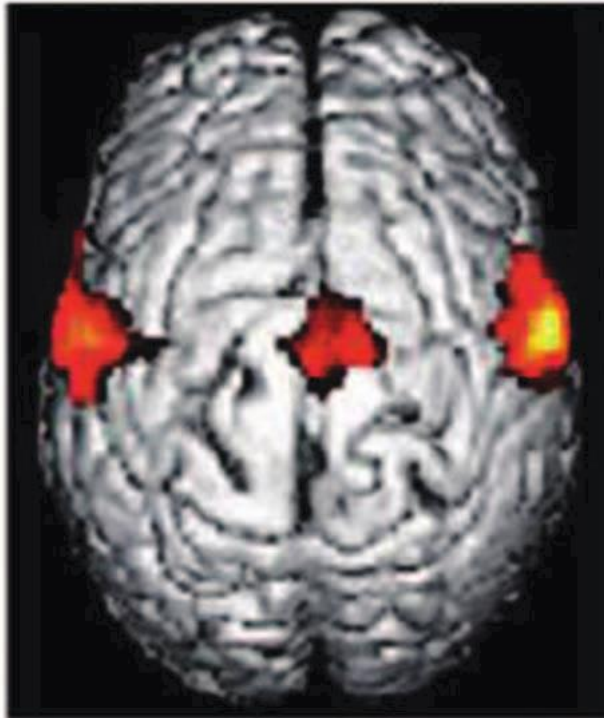
Flor, H., et. al. (2006). *Nat Rev Neurosci* 7, 873–881.

Koppelstaetter, F., et. al. (2007). *Nervenarzt* 78, 1435–1439.

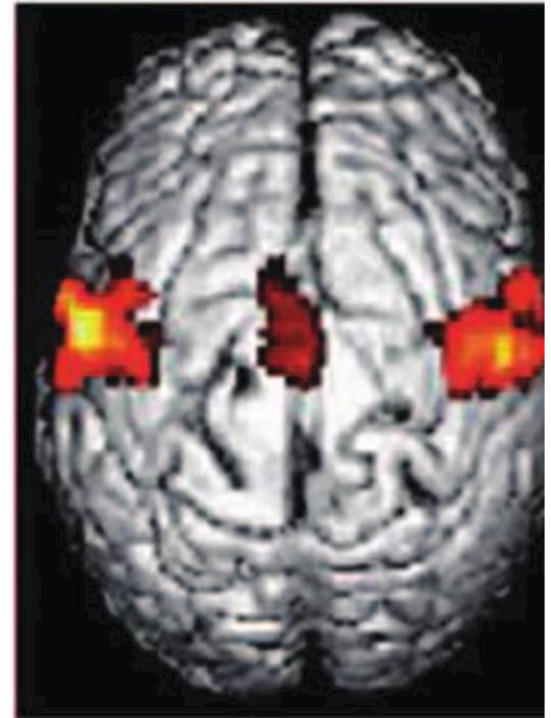
Phantom limb pain



Amputees without pain



Healthy controls

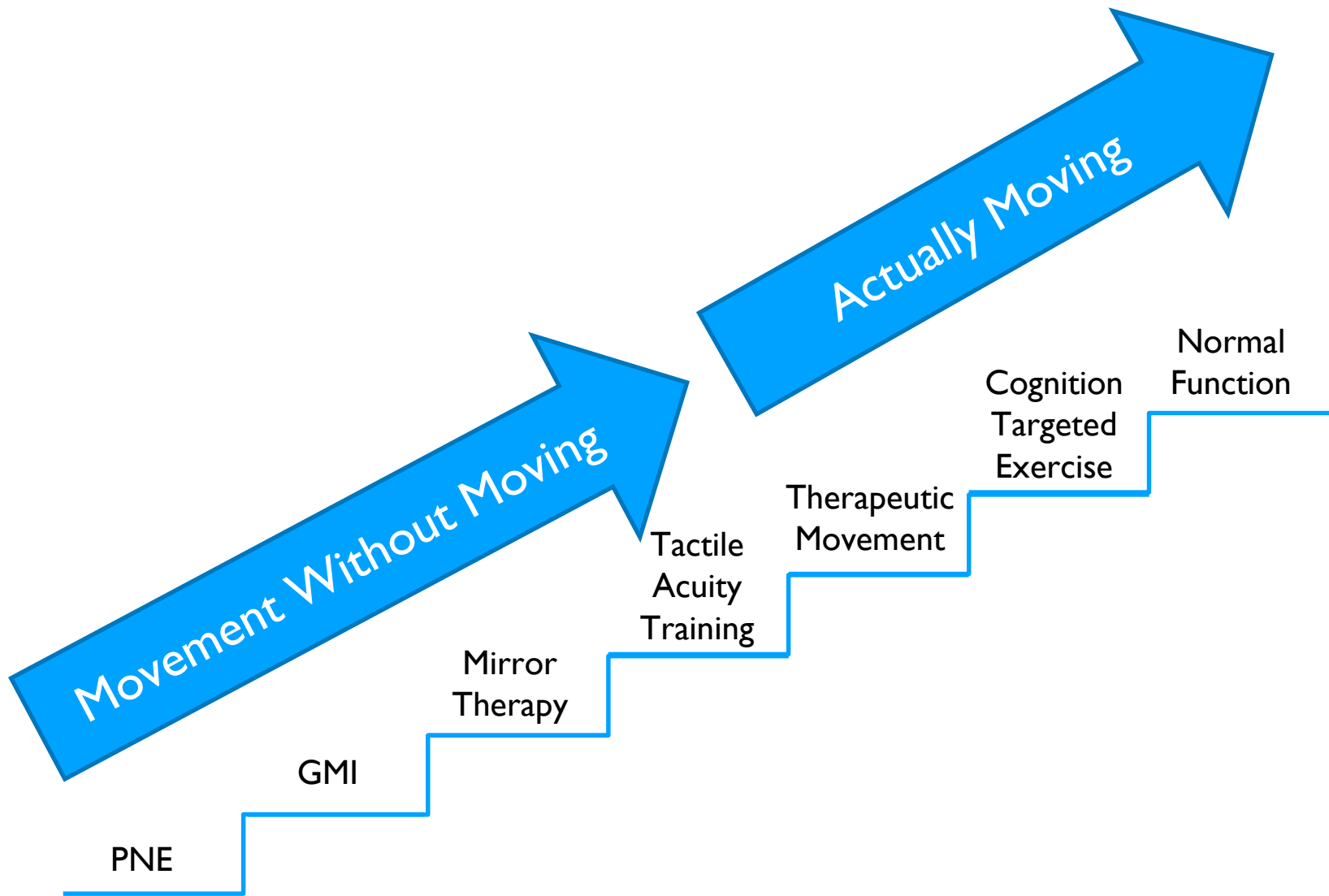


Hanling, SR., et. al. (2010) *Anesthesia and Analgesia*. 110(2): 611-14

So what should we do?

- ▶ If a distorted cortical representation contributes to the development and perpetuation of PLP... then we probably should treat that... and we need to approach it from a 'top down' cortical central processing perspective

Priganc J HAND THER. 2011;24:164-9



But how?

* Five observations

- * Visual information through a mirror dominates proprioceptive information
- * Mirror therapy increases sensorimotor cortical and spinal motor excitability
- * Sensory experiences from visual information
- * Visual input enhances tactile sensitivity
- * Cortical plasticity with mirror visual feedback has been shown

Lindhardt Egsgaard et. al., 2011 and Tominaga 2011



Hanling. SR., et. al. (2010) *Anesthesia and Analgesia*. 110(2): 611-14

Mirror Visual Feedback

- ▶ Randomized placebo-controlled study showing significant PLP decrease with recently amputated leg amputees after 4 weeks of training

Chan, B.L., et. al. (2007). *N Engl J Med* 357, 2206–2207.

- ▶ Possible mechanism of MT is the representational restitution of the missing limb in the brain by the convergence of concurrent visual and proprioceptive input

Foell, J., et. al. (2011). *Int J Low Extrem Wounds* 10, 224–235.

- ▶ About 40% of the PLP patients do not benefit from MVF

Weeks, S.R., et. al. (2010). *Neurologist* 16, 277–286.

Mirror Visual Feedback

- ▶ Daily mirror training (3 min sessions for a total of 15 minutes per day) over 4 weeks in 13 chronic PLP patients after unilateral arm amputation
- ▶ 11 participants performed hand and lip movements during a functional magnetic resonance imaging (fMRI) measurement before and after MVF
- ▶ The location of neural activity in primary somatosensory cortex during these tasks was used to assess brain changes related to treatment

Foell. J., et. al. (2013). *Eur J Pain*. 1-11.

Mirror Visual Feedback

- ▶ Significant reduction of PLP (average decrease of 27%)
- ▶ fMRI data analyses revealed a relationship between change in pain after MVF and a reversal of dysfunctional cortical reorganization in primary somatosensory cortex
- ▶ Pain reduction after mirror training was also related to a decrease of activity in the inferior parietal cortex (IPC).

Foell. J., et. al. (2013). *Eur J Pain*. 1-11.

Mirror Visual Feedback

- ▶ Treatment effects were directly related to cortical reorganization
 - ▶ As PLP decreased, the representation in the somatosensory cortices of both hemispheres became more similar

Foell. J., et. al. (2013). *Eur J Pain*. 1-11.

- ▶ Not all patients reported pain alleviation after treatment

Darnall, B. et. al., (2012). *J Rehab Med* 44, 254–60.

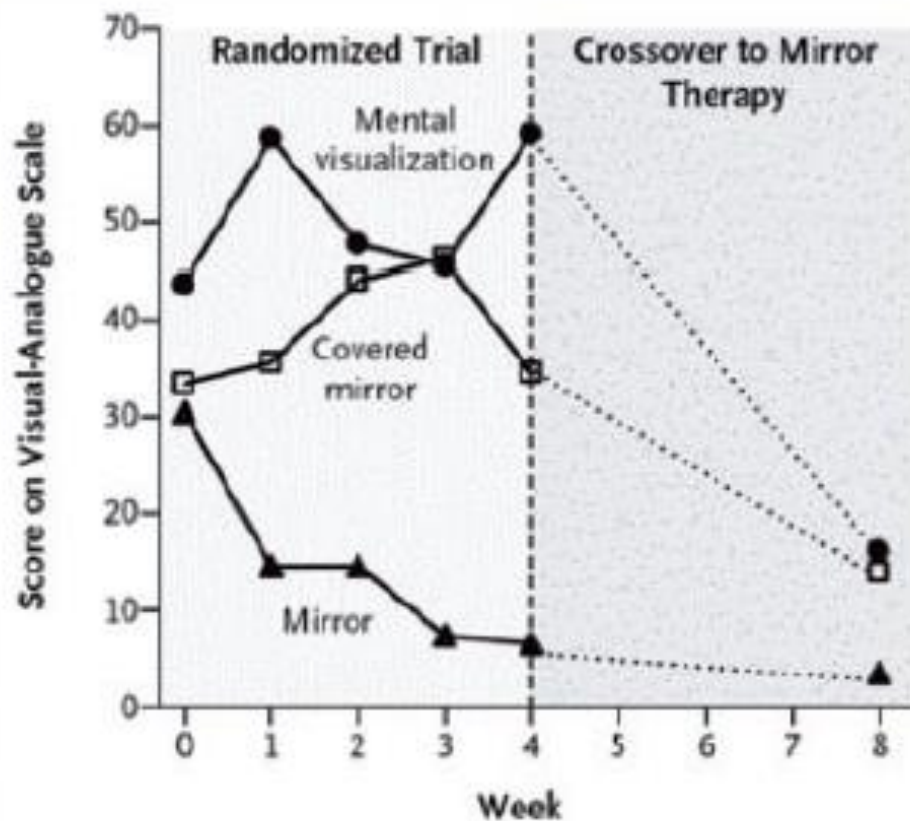


Figure 1. Changes in Phantom Limb Pain, as Measured on a 100-mm Visual-Analogue Scale.

The score on the visual-analogue scale ranges from 0 to 100, with higher scores indicating a greater severity of pain. The dotted lines represent the weeks during which patients in all three groups used to mirror therapy. Data points show medians.

How Does It Work?

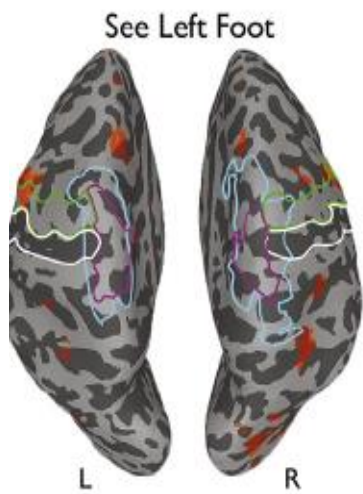
- ▶ Measurable effect on pain ratings is correlated with changes in neural activation, particularly with a reduction of dysfunctional cortical reorganization in S1.
- ▶ Treatment effectiveness depended on an ability to relate the mirror image to one's phantom.
- ▶ This finding is supported by a decrease in cortical activity in IPC, an area connected to a feeling of agency and pain generation.

Foell. J., et. al. (2013). *Eur J Pain*. 1-11.

How Does It Work?

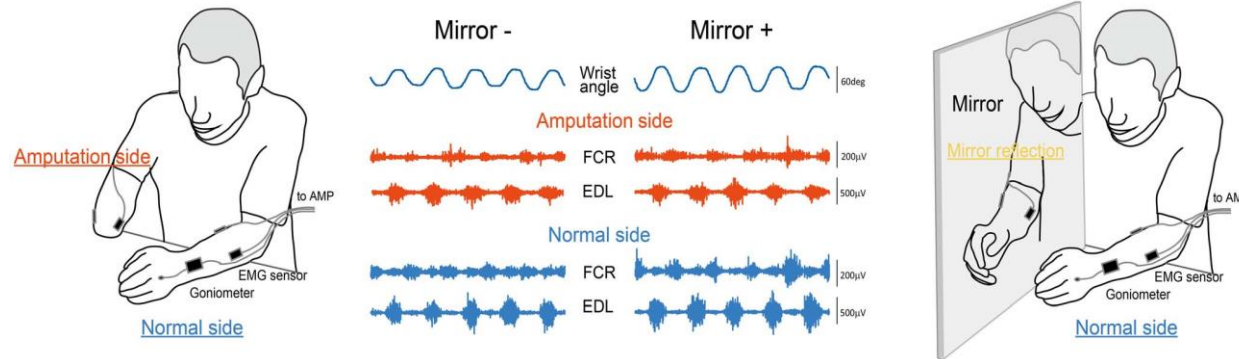
- ▶ Patients with unilateral leg amputation
- ▶ Found a strong and unexpected response in sensorimotor cortex on fMRI of amputees to visual presentation images of limbs.
- ▶ After four week mirror therapy treatment, cortical response was absent which correlated with reduction in phantom limb pain.

Chan et. al. (2019)



(Chan et. al. 2019)

Can MVF alter awareness of the phantom limb?



Consensus on MVF?

- ▶ Consensus that it takes patients 1-10 minutes to become immersed in the illusion
- ▶ Session length was usually determined by the patient's ability to concentrate and to tolerate the program
- ▶ No consensus was reached on the optimal length of MVF sessions (the range was from less than 5 minutes to 120-180 minutes) or the frequency of sessions (the range was a single session to 6 or more times a day)

Hagenberg. A., et. al. *PM&R*. 2014 Jan 9.

Consensus on MVF?

- ▶ A minority of practitioners believed strongly that practicing for a short time and often was more beneficial than longer and less-frequent sessions
- ▶ A 6 week trial?
- ▶ No consensus on the causes of nonresponse, but suggestions included a lack of remapping phenomena, effort sensation, or sensory referral

Hagenberg, A., et. al. *PM&R*. 2014 Jan 9.

Adverse Effects

- ▶ Variety of adverse effects
 - ▶ emotional reactions
 - ▶ pain increase
 - ▶ sensory changes
 - ▶ dizziness
 - ▶ nausea
 - ▶ residual limb spasms
 - ▶ Temperature of the phantom limb
 - ▶ overall sweating
 - ▶ sweating of the phantom limb
 - ▶ spontaneous movements of the phantom limb

Adverse Effects

- ▶ Emotional reactions, described by 85% of the practitioners, were associated with suddenly “seeing” the limb and sometimes with “taking it away again.”
- ▶ These reactions, observed in the first and second sessions only, ranged in severity from “amazement” to, in rare cases, significant depression.

Hagenberg. A., et. al. *PM&R*. 2014 Jan 9.

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Can we prevent PLP?

- ▶ Case series of 4 patients who performed daily mirror therapy preoperatively for 2 weeks pre-amputation
- ▶ Mirror therapy consisted of observing the unaffected leg reflected in a mirror positioned in the midline to block the view of the affected leg for 30 min
- ▶ Patients completed 5–6 mirror therapy sessions supervised by a Physiotherapist

Hanling. SR., et. al. (2010) *Anesthesia and Analgesia*. 110(2): 611-14

Can we prevent PLP?

- ▶ 4 weeks postoperatively
 - ▶ 1 patient reported no residual limb pain or PLP
 - ▶ 2 patients described mild stump pain and mild PLP
 - ▶ 1 patient reported moderate residual limb pain with brief moderate episodes of PLP
- ▶ Patients were at high risk for the development of PLP because of their prolonged courses of limb salvage surgeries and chronic moderate to severe pain

Can we prevent PLP?

- ▶ Patients remained fully functional in PT and reported no decrease in quality of life as a result of their PLP
- ▶ Outcomes are modest, however even a small improvement in the ability to prevent PLP could have a dramatic impact on the long-term prognosis of amputees

Hanling. SR., et. al. (2010) *Anesthesia and Analgesia*. 110(2): 611-14

Conclusion

- ▶ There is still a lot we don't know...
- ▶ PLP seems to be mediated by the brain.
- ▶ Mirror visual feedback offers a novel way to target the cortex in treatment and may be an effective way to reduce PLP.

