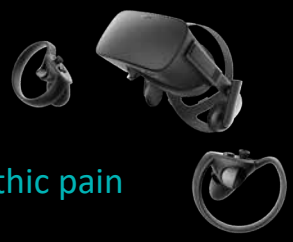

Virtual Reality for chronic pain

From low back pain to spinal cord injury-related neuropathic pain

Therapeutic Interventions and Practices Research Stream
Musculoskeletal Health & Persistent Pain Research Group

Prof Michel Coppieters
Research Stream Leader Therapeutic Interventions and Practices
Menzies Foundation Professor of Allied Health Research (MHIQ / The Hopkins Centre)
Dr Daniel Harvie
NHMRC Post-doctoral Research Fellow (MHIQ / The Hopkins Centre)

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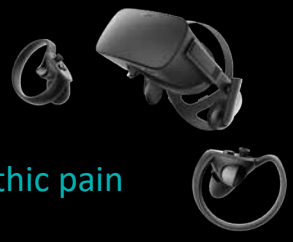
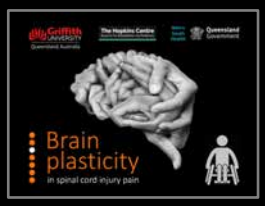
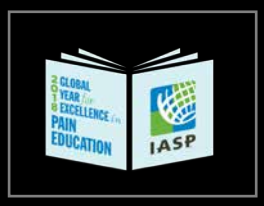


Virtual Reality for chronic pain

From low back pain to spinal cord injury-related neuropathic pain





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A VIRTUAL WALK IN NATURE HELPS WITH ACUTE PAIN MANAGEMENT

Virtual reality (VR) distraction has become increasingly available in health care contexts and is used in acute pain management. Often it it thought that VR in itself provides a distraction from pain. However, there has been no systematic exploration of the importance of the content of VR environments. To fill this void, two studies have tested how interacting with nature VR influenced experienced and recollected pain after 1 week.

With the growing use of VR as a distraction intervention in health care settings, it is important to address the question, to what extent VR interventions are more or less successful in helping patients cope with procedural pain than other types of distraction interventions, the researchers behind the study In general, effects of VR distraction on pain, compared with control conditions, are large (see for a review, Kenney & Milling, 2016).

Study 1 used a laboratory pain task (cold pressor), Study 2 was a randomized controlled trial with patients undergoing dental treatment. In the first study, nature (a peaceful coastal walk) VR reduced both experienced and recollected pain compared with no VR. In the second study , the nature walk VR reduced experienced and recalled pain in dental patients, compared with urban VR (a busy situation full of distractions) and standard care.

Researchers have now tested this assumption under new circumstances, including a cold pressor lab setup and real world dental procedures during which patients wore virtual reality headsets. They were immersed in two very different environments, one a calm beachside walk and the other a busy urban situation full of distractions.

https://www.ictandhealth.com/news/a-virtual-walk-in-nature-helps-with-acute-pain-management/

Virtual and augmented reality are rarely used with ***chronic*** pain, but have potential for remote use, going beyond distraction, with a focus on improving function and reducing distress. Early studies are promising but small.

Eccleston et al, *Pain* 2020

- Pleasant environments, activities, meditation, etc
- Psychological interventions (pain-depression-anxiety)
- Pain (neuroscience) education
- Embodiment
- Underlying pathophysiological mechanisms
  (e.g., altered cortical representation)
- …

Original Paper

Virtual Reality as an Adjunct Home Therapy in Chronic Pain Management: An Exploratory Study

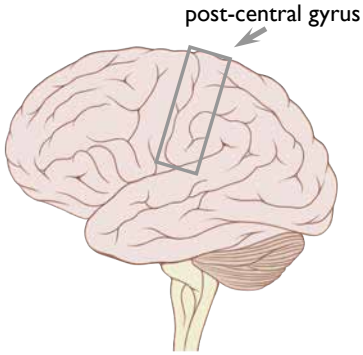
PLOS ONE

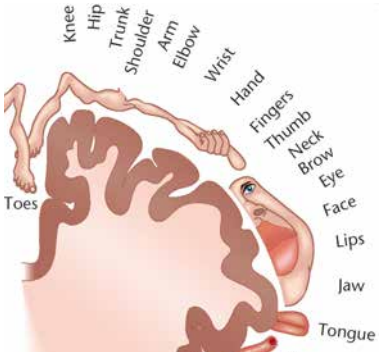
The Impact of Virtual Reality on Chronic Pain

Abstract

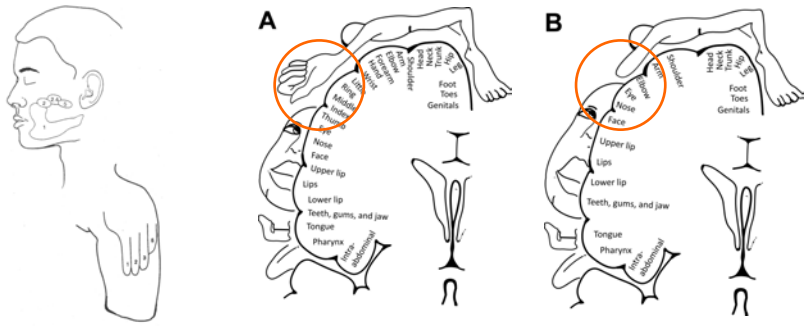
Introduction

Representation: Somatosensory cortex & homunculus





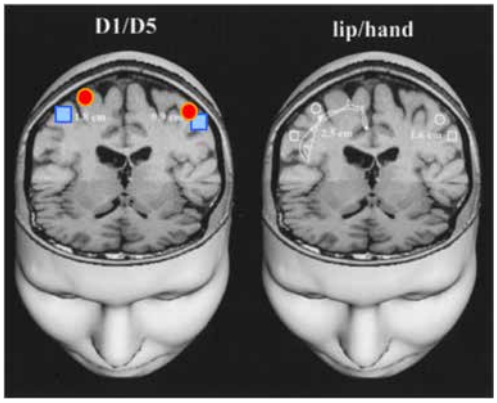
Reorganisation of the somatosensory cortex



A few weeks after arm amputation, sensory stimuli applied to the ipsilateral face are experienced as arising from the missing (phantom) arm. This referral of sensations is probably caused by reorganisation of somatosensory maps in the brain. Sensory input from the face, which normally projects only to the face area, now 'invades' the vacated territory corresponding to the denervated hand territory. As a result, stimuli applied to the face now activate the hand region of the brain and are therefore interpreted by higher brain centers as arising from the missing phantom hand.

Flor et al (1995); Ramachandran & Hirstein (1998)

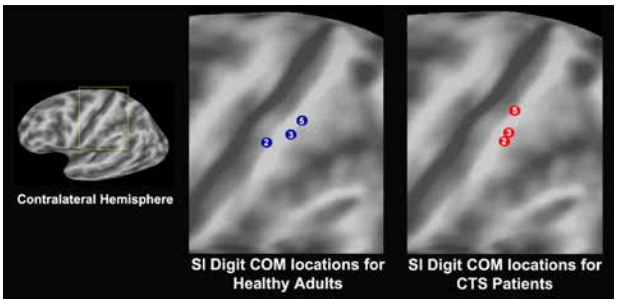
- Amputation
- Complex regional pain syndrome



Reduction in the cortical extension of the hand from 1.8 cm (unaffected side) to 0.9 cm (CRPS side)

Maihofner et al 2003 *Neurology* 61: 1707-1715

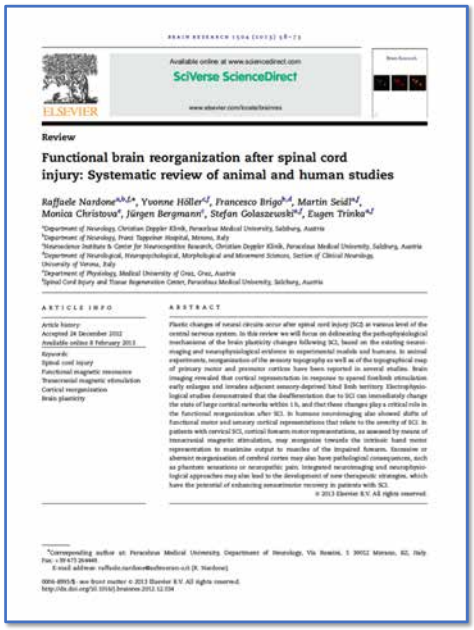
- Amputation
- Complex regional pain syndrome
- Carpal tunnel syndrome
- …



Napadow V et al. *Neuroimage*. 2006;31:520–530

- Amputation
- Complex regional pain syndrome
- Carpal tunnel syndrome
- …
- Spinal cord injury

Excessive or aberrant reorganisation of cerebral cortex **may have pathological consequences, such as phantom sensations or neuropathic pain**.

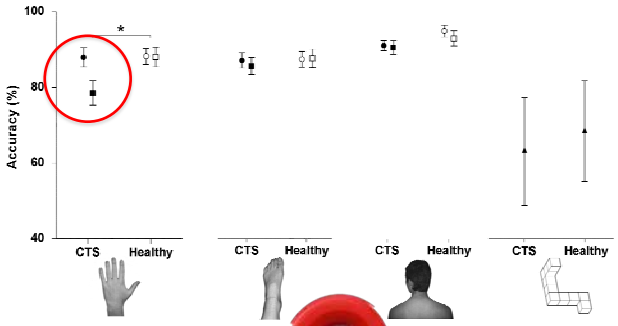


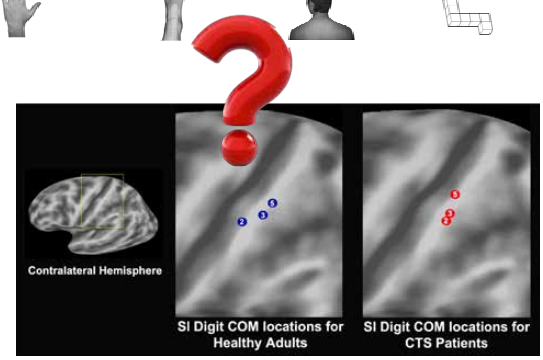
Review

Functional brain reorganization after spinal cord injury: Systematic review of animal and human studies

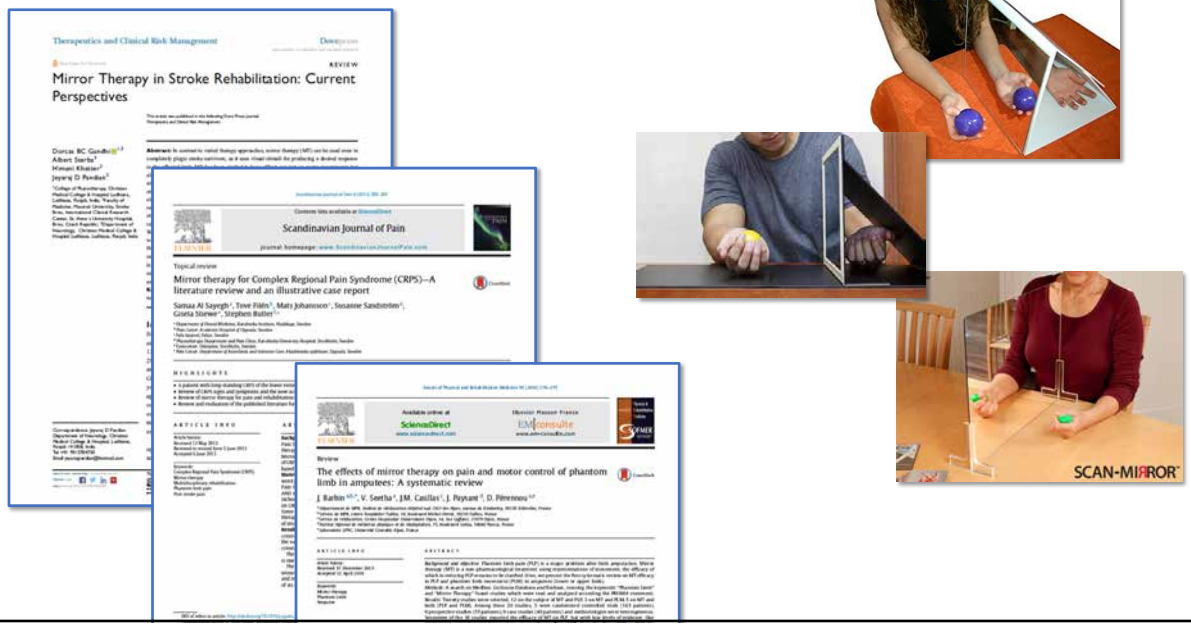
Raffaele Nardone, Yvonne Höller, Francesco Brigo, Martin Seidl, Monica Christova, Jürgen Bergmann, Stefan Golaszewski, Eugen Trinka

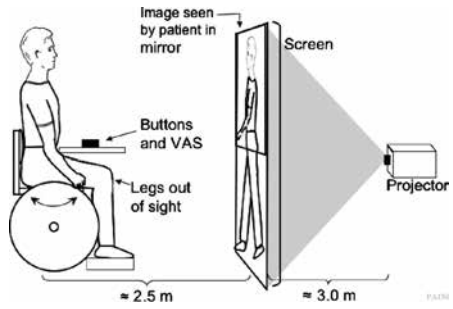
Left – Right discrimination

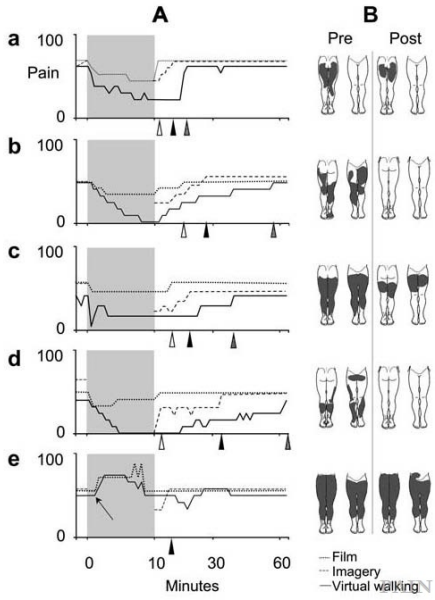




Mirror therapy – VR *'avant la letter'*







Moseley (2007) *Pain*

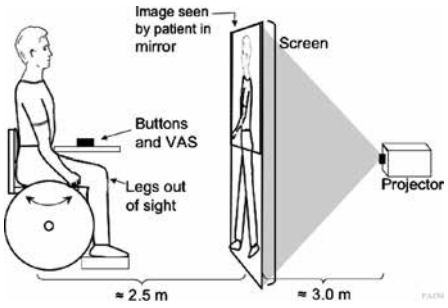


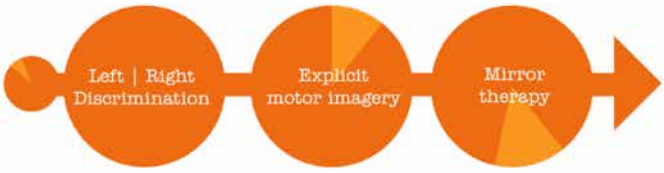
Fig. 1. The experimental set-up. An inertial sensor (MTx miniature inertial measurement unit, Xsens Technologies BV, Enschede, the Netherlands) was attached to the subject's right upper arm. A dummy sensor was attached to the left upper arm to avoid focusing on one arm. The virtual reality system was controlled by D-flow software (CAREN, Motek Medical BV, Amsterdam, the Netherlands), and the virtual scene was projected in 3D (2 projectors, CP-WX8255A, 1920 × 1080 High Definition, Hitachi, Tokyo, Japan) on a large silver-coated projection screen (projection surface 3.05 m × 2.06 m). The inertial sensor was connected to the virtual reality system via a wireless Bluetooth connection. The rotation data for the sagittal plane, acquired with the inertial sensor, was used to animate the progress bar in the lower left corner. In addition, during avatar trials the same signal was used to go through a pre-programmed walk-cycle animation of the avatar.

Moseley (2007) *Pain*

Roosink et al (2016) *Restorative Neurology and Neuroscience*

What is graded motor imagery?

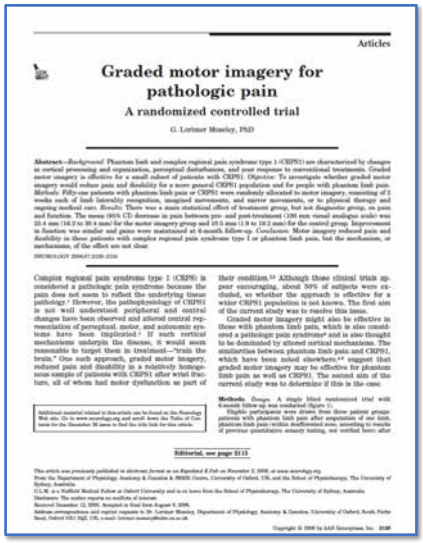
Graded Motor Imagery (GMI) is the most up to date rehabilitation program – based on the latest science and clinical trials – to treat many complex pain, and movement problems.



The three stages of GMI

Graded motor imagery is broken down into three unique stages of treatment techniques, each exercising your brain in different ways.

http://www.gradedmotorimagery.com/



Articles

Graded motor imagery for pathologic pain

A randomized controlled trial

G. Lorimer Moseley, PhD

Abstract—Background: Phantom limb and complex regional pain syndrome type 1 (CRPS1) are characterized by changes in cortical processing and organization, perceptual disturbances, and poor response to conventional treatments. Graded motor imagery is effective for a small subset of patients with CRPS1. *Objective:* To investigate whether graded motor imagery would reduce pain and disability for a more general CRPS1 population and for people with phantom limb pain. *Methods:* Fifty-one patients with phantom limb pain or CRPS1 were randomly allocated to motor imagery, consisting of 3 weeks each of limb laterality recognition, imagined movements, and mirror movements, or to physical therapy and ongoing medical care. *Results:* There was a main statistical effect of treatment group, but not diagnostic group, on pain and function. The mean (95% CI) decrease in pain between pre- and post-treatment (100 mm visual analogue scale) was 23.4 mm (18.2 to 30.4 mm) for the motor imagery group and 10.5 mm (1.8 to 19.2 mm) for the control group. Improvement in function was similar and gains were maintained at 6-month follow-up. *Conclusion:* Motor imagery reduced pain and disability in these patients with complex regional pain syndrome type 1 or phantom limb pain, but the mechanism, or mechanisms, of the effect are not clear.

Complex regional pain syndrome type 1 (CRPS1) is considered a pathologic pain syndrome because the pain does not seem to reflect the underlying tissue pathology.[1] However, the pathophysiology of CRPS1 is not well understood: peripheral and central changes have been observed and altered central representation of perceptual, motor, and autonomic systems have been implicated.[2] If such cortical mechanisms underpin the disease, it would seem reasonable to target them in treatment—"train the brain." One such approach, graded motor imagery, reduced pain and disability in a relatively homogeneous sample of patients with CRPS1 after wrist fracture, all of whom had motor dysfunction as part of their condition.[3,4] Although those clinical trials appear encouraging, about 50% of subjects were excluded, so whether the approach is effective for a wider CRPS1 population is not known. The first aim of the current study was to resolve this issue.

Graded motor imagery might also be effective in those with phantom limb pain, which is also considered a pathologic pain syndrome[5] and is also thought to be dominated by altered cortical mechanisms. The similarities between phantom limb pain and CRPS1, which have been noted elsewhere,[5,6] suggest that graded motor imagery may be effective for phantom limb pain as well as CRPS1. The second aim of the current study was to determine if this is the case.

Methods. *Design.* A single blind randomized trial with 6-month follow up was conducted (figure 1).

Eligible participants were drawn from three patient groups: patients with phantom limb pain after amputation of one limb, phantom limb pain within deafferented zone, according to results of previous quantitative sensory testing, see method here: after

Additional material related to this article can be found on the Neurology Web site. Go to www.neurology.org and scroll down the Table of Contents for the December 26 issue to find the title link for this article.

Editorial, see page 2115

This article was previously published in electronic format as an Expedited E-Pub on November 2, 2006, at www.neurology.org.

From the Department of Physiology, Anatomy & Genetics & IMSER Centre, University of Oxford, UK; and the School of Physiotherapy, The University of Sydney, Australia.

G.L.M. is a Wellcott Medical Fellow at Oxford University and is on leave from the School of Physiotherapy, The University of Sydney, Australia.

Disclosure: The author reports no conflicts of interest.

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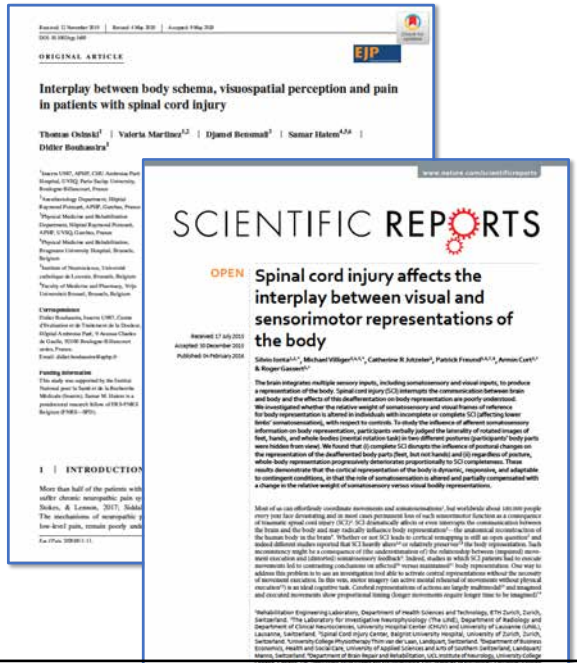

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EJP

ORIGINAL ARTICLE

Interplay between body schema, visuospatial perception and pain in patients with spinal cord injury

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1 | INTRODUCTION

More than half of the patients with suffer chronic neuropathic pain sy Stokes, & Lemon, 2017; Siddal The mechanisms of neuropathic p low-level pain, remain poorly und

www.nature.com/scientificreports

SCIENTIFIC REPORTS

OPEN

Spinal cord injury affects the interplay between visual and sensorimotor representations of the body

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Silvio Ionta[1,2,*], Michael Villiger[3,4,5,*], Catherine R Jutzeler[3], Patrick Freund[3,4,7,8], Armin Curt[3,*] & Roger Gassert[1,*]

The brain integrates multiple sensory inputs, including somatosensory and visual inputs, to produce a representation of the body. Spinal cord injury (SCI) interrupts the communication between brain and body and the effects of this deafferentation on body representation are poorly understood. We investigated whether the relative weight of somatosensory and visual frames of reference for body representation is altered in individuals with incomplete or complete SCI (affecting lower limbs' somatosensation), with respect to controls. To study the influence of afferent somatosensory information on body representation, participants verbally judged the laterality of rotated images of feet, hands, and whole bodies (mental rotation task) in two different postures (participants' body parts were hidden from view). We found that (i) complete SCI disrupts the influence of postural changes on the representation of the deafferented body parts (feet, but not hands) and (ii) regardless of posture, whole-body representation progressively deteriorates proportionally to SCI completeness. These results demonstrate that the cortical representation of the body is dynamic, responsive, and adaptable to contingent conditions, in that the role of somatosensation is altered and partially compensated with a change in the relative weight of somatosensory versus visual bodily representations.

Most of us can effortlessly coordinate movements and somatosensations[1], but worldwide about 180,000 people every year face devastating and in most cases permanent loss of such sensorimotor function as a consequence of traumatic spinal cord injury (SCI)[2]. SCI dramatically affects or even interrupts the communication between the brain and the body and may radically influence body representation[3]—the anatomical reconstruction of the human body in the brain[4]. Whether or not SCI leads to cortical remapping is still an open question[5] and indeed different studies reported that SCI barely alters[6,7] or relatively preserves[8,9] the body representation. Such inconsistency might be a consequence of (the underestimation of) the relationship between (impaired) movement execution and (distorted) somatosensory feedback[10]. Indeed, studies in which SCI patients had to execute movements led to contrasting conclusions on affected[11] versus maintained[12] body representation. One way to address this problem is to use an investigation tool able to activate cortical representations without the necessity of movement execution. In this vein, motor imagery (an active mental rehearsal of movements without physical execution[13]) is an ideal cognitive task. Cerebral representations of actions are largely multimodal[14] and imagined and executed movements show proportional timing (longer movements require longer time to be imagined)[15]

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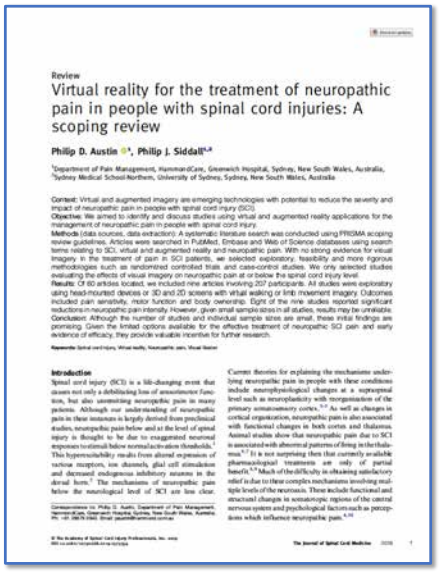


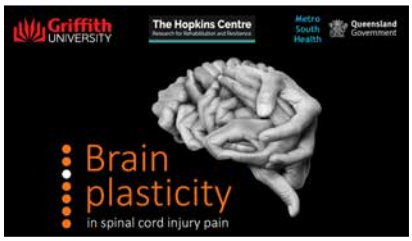
Review

Virtual reality for the treatment of neuropathic pain in people with spinal cord injuries: A scoping review

Philip D. Austin, Philip J. Siddall

Conclusion: Although the number of studies and individual sample sizes are small, these **initial findings are promising**. Given the limited options available for the effective treatment of neuropathic SCI pain and early evidence of efficacy, they provide **valuable incentive for further research**.

Design and feasibility testing of a Graded Motor Imagery application to manage neuropathic pain in people with spinal cord injury



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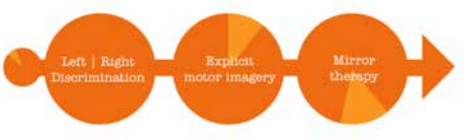
Soo Or
Scott Roberts (VR development)
Melanie Plinsinga (RO)
Kimberly Talaber (PhD student)



- Left – Right discrimination test & training
- Motor imagery
- Virtual reality