

Complex Regional Pain Syndrome

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APTA Combined Sections Meeting 2012
Chicago IL – February 8-11, 2012



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Objectives

Upon completion of this educational session the participants will be able to:


1. Understand the pathobiology of the development of CRPS
2. Recognize the current criteria for the diagnoses of CRPS
3. Identify bio-psycho-social factors associated with the development of CRPS
4. Be updated on the latest evidence based approaches for managing patients with CRPS
5. Apply the information from the educational session into clinical practice



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Neuroscience CRPS definition...


CRPS is a multiple system output, activated by the neuromatrix in response to perceived threat



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Introduction

- Pain in combination with sensory, autonomic, trophic and motor abnormalities.
- CRPS-1: A nerve lesion cannot be identified
- CRPS-2, A nerve lesion can be identified




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Introduction

- **Criticism**
 - Bone fracture or surgery will damage peripheral nerve fibers but post-fracture and post-surgical CRPS are almost always classed as CRPS-1.
 - Pathological studies on chronic CRPS-1 limbs that have been amputated and skin biopsies of CRPS-1 limbs show degeneration of small (C and A-δ) nerve fibers which serve nociceptive and autonomic functions. (Albrecht, van der Laan and Oaklander)
 - **Nerve degeneration causes CRPS-1?**
 - Other causes of neuropathic pain are frequently associated with a loss of C-fiber peripheral terminals, the specificity of these findings with respect to CRPS is questionable (Devigili).




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Introduction

- Our understanding of CRPS has increased substantially in the past decade.
- **Three major pathophysiological pathways:**
 1. Aberrant inflammatory mechanisms
 2. Vasomotor dysfunction
 3. Maladaptive neuroplasticity.
- Between-individual variability




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Clinical presentation & diagnosis

- After minor or moderate tissue injury (i.e., a wrist fracture).
- In the acute phase, the injured limb is usually extremely painful, red, warm (although sometimes it quickly becomes cold) and swollen (Veldman 1993).



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Clinical presentation & diagnosis

- Allodynia (non-painful stimuli evoke pain)
- Hyperalgesia (painful stimuli evoke more intense pain than usual)
- Changes in sweating,
- Changes in hair and nail growth
- Muscle weakness.

Clinical presentation & diagnosis


- Mechanical and thermal hyperalgesia are frequently present.
- Pain often spreads
- Voluntary motor control is reduced
- Hyperpathia
- Negative sensory signs (hypoesthesia, hypoalgesia, and hypothermesthesia).

Clinical presentation & diagnosis

- Characterized by a mixture of noxious sensations and sensory loss.
- Over months, the warm limb often becomes cold.
- Dystonia
- Tremor
- Myoclonus
- Activity of the limb typically exacerbates signs and symptoms.
- Over time, clinical features spread proximally (but not distally) and can even emerge on the opposite or ipsilateral limb.

Clinical presentation & diagnosis

- **Diagnosis of CRPS:**
 - Orlando criteria
 - International Association for the Study of Pain
 - Modified version called the Budapest criteria (panel)
 - Diagnosis according to the Budapest criteria - grouping of signs and symptoms into four distinct categories




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Epidemiology

- Unclear.
 - 5 cases per 100 000 person-years in the USA
 - 26 per 100 000 person-years in the Netherlands.
 - Might expect that 20 000–80 000 new cases of CRPS would be identified per year in the USA.
- Incidence increases with age until 70 years of age, and 3–4 times more women than men are affected.
- The arm is affected in about 60% of cases and the leg in about 40%.




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Epidemiology

- **Resolution rate:**
 - Ranging from 74% in the first year to 36% within 6 years.
- Fractures (about 45%), sprain (about 18%), and elective surgery (about 12%) are the most frequently reported triggering events.




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Epidemiology

- Spontaneous-onset CRPS, which presents with a similar clinical picture, is uncommon (<10% of cases).
- Associated with substantial disability, loss of quality of life, and personal and societal economic burden.




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Risk factors & prognostic determinants

- Lots of people have fractures, injuries and surgery and **DO NOT** develop CRPS.
- Some individuals are more susceptible than others.




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Psychological risk factors

- Compelling evidence that patients with CRPS are more anxious and depressed than healthy control individuals.
- Whether patients with CRPS are more anxious and depressed than patients with other chronic pain syndromes is unclear




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Psychological factors

- No evidence of psychological risk factors for CRPS onset.
 - A large population-based case control study reported no difference in psychological variables between those who developed CRPS after trauma
 - Recent prospective multi center cohort study - 600 consecutive patients with a fracture reported that none of the psychological factors predicted the development of CRPS-1.
- The popular presumption that anxiety and depression predispose to CRPS is incorrect.




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Immobilization of the injured limb

- **Immobilization - risk factor for CRPS.**
- Topical application of capsaicin (induces neurogenic inflammation):
 - Mechano sensitivity
 - Thermo sensitivity,
 - Perceptual disturbances
 reported in people whose limb was subsequently immobilized for 24 h, but not in people whose limb was not immobilized (Moseley GL, unpublished).
- The signs rapidly resolved once the limb was moved again.




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Epidemiological findings


- Angiotensin-converting-enzyme inhibitors at the time of trauma and a history of migraine or asthma - associated with increased risk of developing CRPS.
- ◉ Migraine - risk factor for CRPS
 - Both of these risk factors implicate inflammation: angiotensin-converting-enzyme inhibitors increase the availability of substance P and bradykinin, which are important mediators of inflammation, and migraine and asthma share an underlying mechanism of neurogenic inflammation with CRPS.



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Epidemiological findings


- ◉ Fracture is associated with a more favorable course than soft tissue injury.
- ◉ Sex does not seem to affect prognosis
- ◉ Women have a higher risk of developing a more severe CRPS than men
- ◉ Cold CRPS - impaired thermoregulatory blood flow (cold): worse prognosis than those with warm CRPS (vasodilatation)



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Epidemiological findings


- ◉ Longitudinal study
 - 1549 nearly consecutive patients who presented with wrist fracture and who were managed non-surgically were assessed within 1 week of their fracture and then followed up 4 months later (Moseley GL, unpublished).
- ◉ Mean pain intensity over the past 2 days (> 5/10): Red flag for CRPS.



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Genetic findings

- ◉ CRPS sometimes occurs in several family members and siblings of young-onset cases have an increased risk of developing the syndrome
 - Suggest potential genetic predisposition to CRPS.



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Before we move on...

- Putting the preceding information into clinical practice:
 - Ion channels
 - Adrenaline



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Meet your nerve sensors

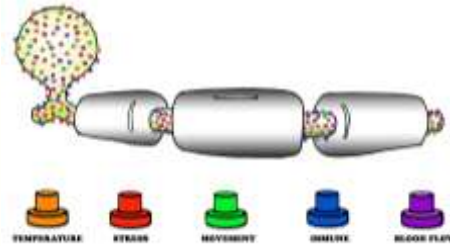
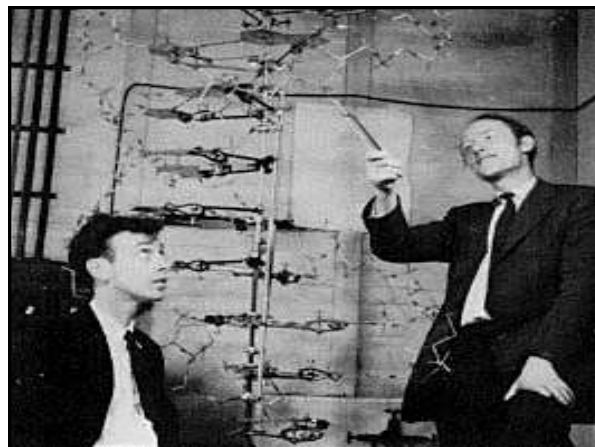


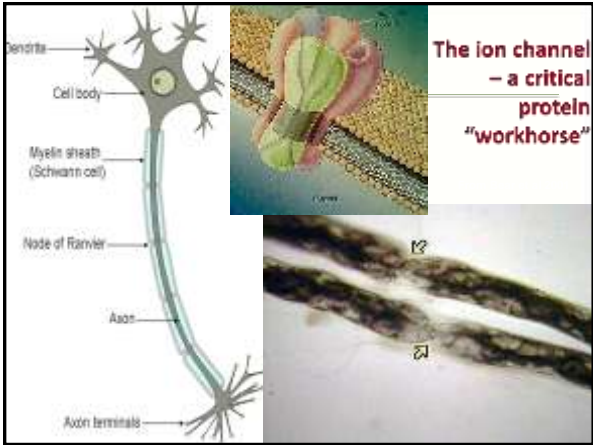
Image from Louw, et al 2011



The essence of molecular biology – the basis of the self constructing, distributed & representational brain

DNA → mRNA → Proteins (workhorses of the body)



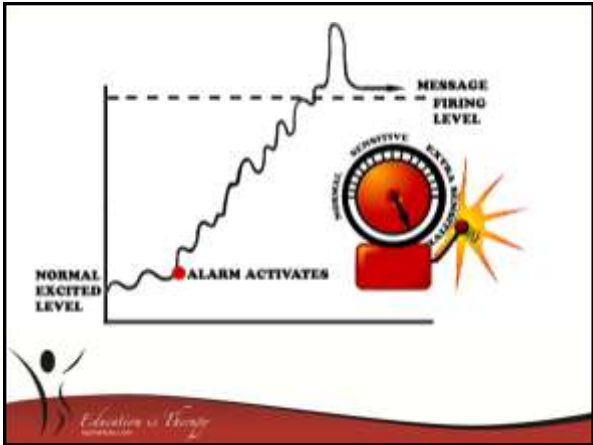


Ion channels & nerve sensitivity

- Ion channels are pores in the axolemma with a hole in it.
- They can open or close to cause an action potential
- Located at:
 - Nodes of Ranvier
 - DRG
 - Injured nerve without myelin
- Different types of ion channels

- Only live 2 days!
- Therapy changes ion channels

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Recap...CRPS (peripheral neuropathic)

- Genetics/family – ion channel expression
- Stress/Anxiety
 - High level of initial pain – adrenaline ion channels
 - Fracture, surgery, sprain – adrenaline ion channels
- Temperature sensitization – ion channels
- Female/male - ? Hormonal/ion channels
- Extreme sensitization – nerve up-regulation
- Spreading pain – connected nervous system
- Immobilization – movement channels

More to come...

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Key pathophysiological changes

- **Three major pathophysiological pathways:**
 1. **Aberrant inflammatory mechanisms**
 2. **Vasomotor dysfunction**
 3. **Maladaptive neuroplasticity.**



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1. Aberrant inflammatory mechanisms




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1. Inflammation

- Minor tissue trauma - amplify cytokine signaling in the traumatized tissue.
- Cytokines and nerve growth factor (NGF) - excite nociceptors and induce long-term peripheral sensitization.
- Cytokines and NGF enhance the release of inflammatory neuropeptides in primary afferent neurons.
- Activation of cutaneous nociceptors can induce retrograde depolarization of small-diameter primary afferents (axon reflex), causing the release of neuropeptides such as substance P and calcitonin-gene-related peptide (CGRP).
- Neuropeptides - vasodilation and protein extravasation in the tissue:
 - Neurogenic inflammation
 - Redness, warm and swelling




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1. Inflammation

- Serum concentrations of CGRP and substance P – higher in patients with CRPS than in healthy control individuals.
- Elevated CGRP release is probably responsible for the augmented flare response in patients with CRPS




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1. Inflammation

- ⦿ Mechanism for neurogenic inflammation
 - Substance P produces greater extravasation in both the affected and the unaffected limbs of patients with CRPS than in control individuals.
 - Increased substance P signaling might also account for the increased cytokine expression seen in CRPS




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1. Inflammation

- ⦿ Facilitated cutaneous neuropeptide signaling contributes directly to the enhanced extravasation, limb edema, and increased cytokine expression that are present in CRPS.
- ⦿ Immune and nervous systems interaction - still not fully understood and need further research.




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1. Inflammation

- ⦿ Concentrations of TNF α and interleukin-6 (IL-6) in blister fluid are greater in the CRPS-affected limb than the unaffected one.
- ⦿ TNF α and IL-6 concentrations are also higher in skin biopsies from patients with CRPS than in patients with fracture who do not have CRPS.




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1. Inflammation

- ⦿ Cytokine changes are associated with the extent of mechanical hyperalgesia
- ⦿ Mechanical hyperalgesia
 - Hallmark of central sensitization
 - Excitability of neurons in the spinal cord is increased
- ⦿ inflammatory cytokines:
 - ⦿ Acts locally in the limb
 - ⦿ Sensitization of secondary nociceptive neurons in the spinal cord or by glial–neuronal interaction.



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1. Inflammation

- Central sensitization due to inflammatory cytokines:
 - Increased interleukin-1 β and interleukin-6 cytokine concentrations in spinal fluid from patients with chronic CRPS (mean symptom duration 7–8 years).



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1. Inflammation

- **Autoimmune mechanisms?**
 - About 35% of patients with CRPS have surface-binding autoantibodies against sympathetic and mesenteric plexus neurons and differentiated cholinergic type neuroblastoma cell lines.



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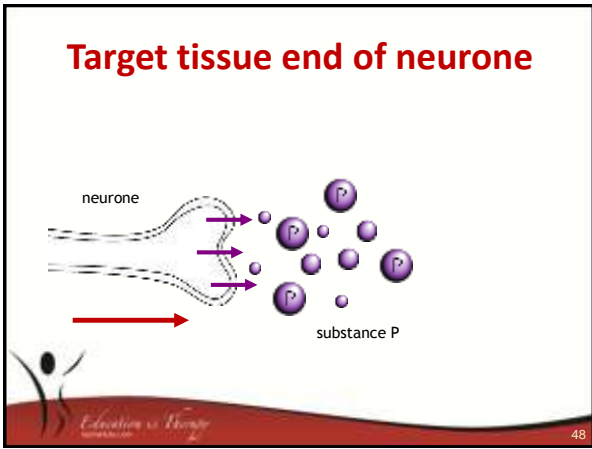
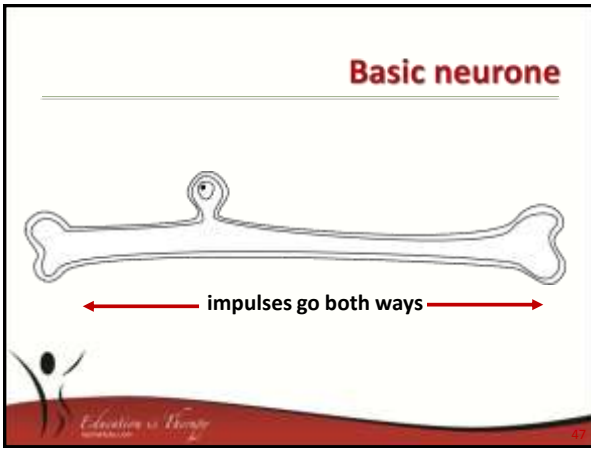
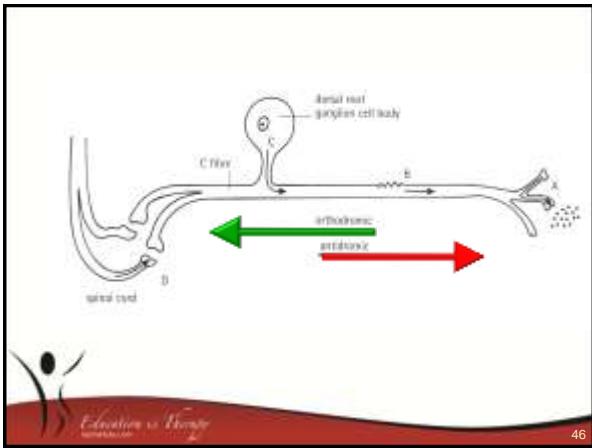
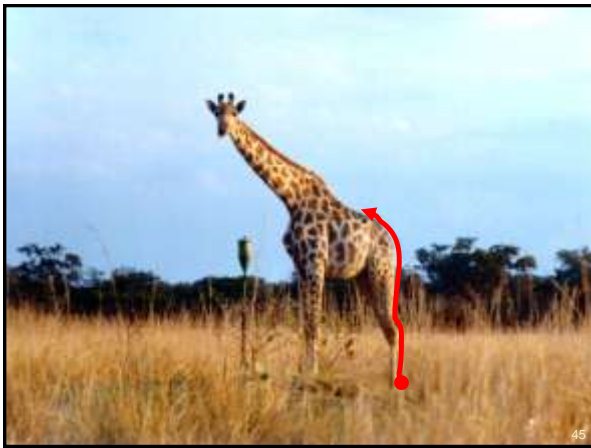
2. Vasomotor dysfunction

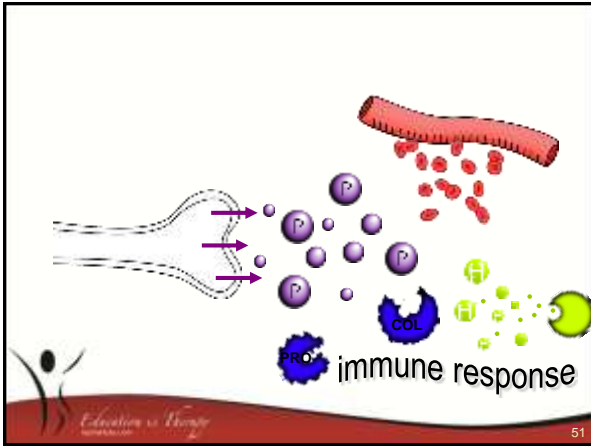
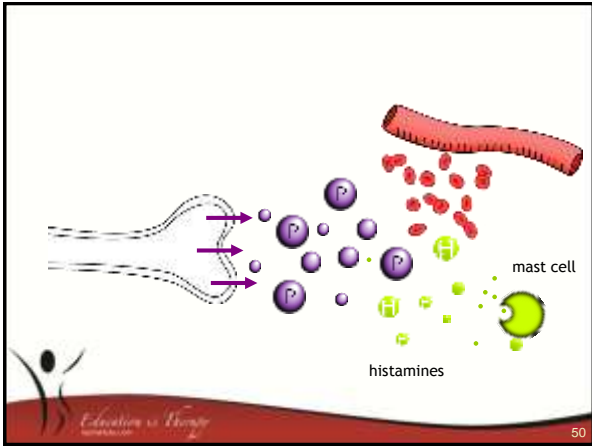
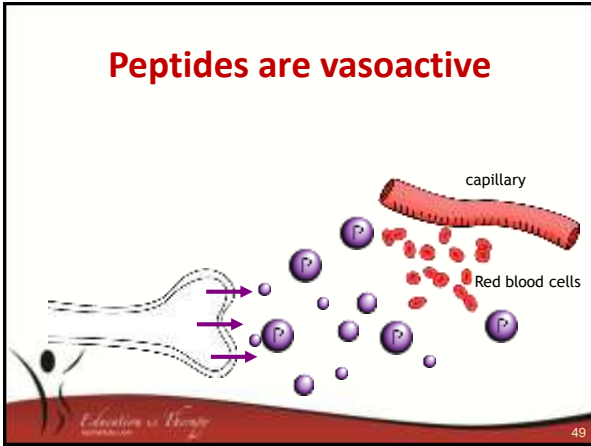


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SNS is efferent & contribute to pain by:

- Dorsal root ganglion – non-myelinated
- Action potential develop due to adrenaline
- Nerve fires....both ways

2. Vasomotor

- Common in CRPS
- Affected limb:
 - Usually warmer than the healthy limb early on
 - Colder than the healthy limb later
 - Temperature shift - activity in vasoconstrictor neurons
 - Three distinct patterns of temperature change:
 - Warm type
 - Intermediate type
 - Cold type

2. Vasomotor


- **Warm type**
 - Affected limb warmer and skin perfusion values were higher than the contralateral limb (CRPS for a mean of 4 months).
 - Norepinephrine concentrations from the venous effluent above the painful area is lower in the affected limb than in the contralateral one.

2. Vasomotor

- **Intermediate type**
 - Temperature and perfusion either warmer or colder, depending on the amount of sympathetic activity (mean disease duration of 15 months).
- **Cold type**
 - Temperature and perfusion in the affected limb consistently lower than those in the contralateral limb (mean of 28 months).
 - Norepinephrine concentrations lower on the affected side.

2. Vasomotor

- In addition to inflammatory vasodilatation, CRPS is associated with a unilateral inhibition of cutaneous sympathetic vasoconstrictor neurons, which leads to a warmer limb in the acute stage.
- Thermoregulatory impairment probably caused by functional changes in the spinal cord, brainstem, or brain that are triggered by the initial trauma.




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2. Vasomotor

- There are suggestions that cutaneous sympathetic vasoconstrictor activity returns to normal as CRPS persists, even though the limb becomes cold and bluish.




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2. Vasomotor

- Central disturbances in efferent sympathetic outflow seem to be predominant in the acute stage of CRPS, disturbed neurovascular transmission and development of hyper-reactivity of blood vessels to circulating catecholamine's seem to predominate in the chronic stage.
- About 20% of patients with CRPS have the cold type from the start. These patients not only differ in skin temperature but also in sensory symptoms and history.




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2. Vasomotor

- The sympathetic nervous system, in addition to its effect on peripheral circulation in CRPS, might also contribute to pain.
- Nociceptors develop catecholamine sensitivity, probably as a result of decreased activity of cutaneous sympathetic vasoconstrictor neurons.
- Norepinephrine released by the sympathetic nerve fibers activate or sensitize the altered afferent neurons.




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2. Vasomotor


- A sympathetic–afferent interaction probably also occurs in tissues of the deep somatic domain, such as bones, muscles, or joints.



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2. Vasomotor

- Changes in the endothelium play a part in impaired peripheral circulation in chronic CRPS.
- Endothelial dysfunction is associated with a decreased ability to release endothelial nitric oxide, which leads to sustained vasoconstriction.
- Decreased concentrations of nitric oxide have been noted in CRPS.
- Whether these changes are important in the development of CRPS or are a consequence of the trophic changes that affect the skin, muscles, and bones in people with CRPS is unclear.



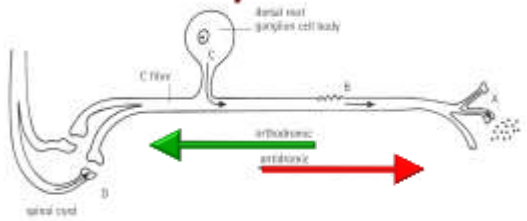
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3. Maladaptive neuroplasticity

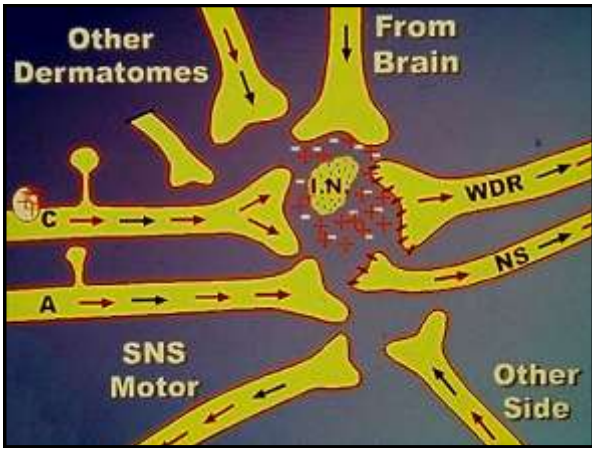
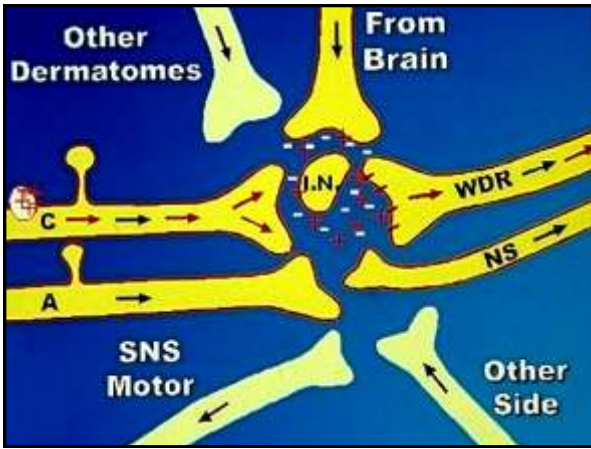
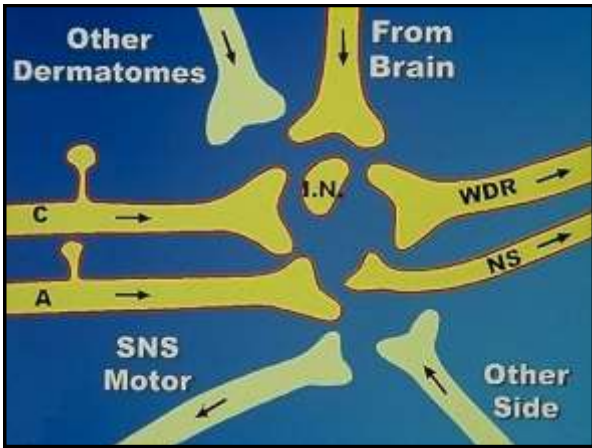
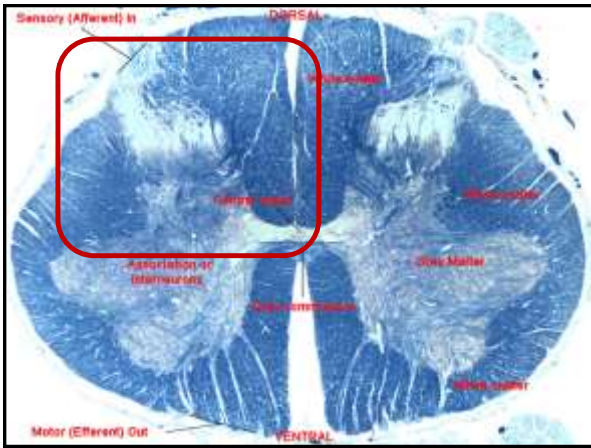


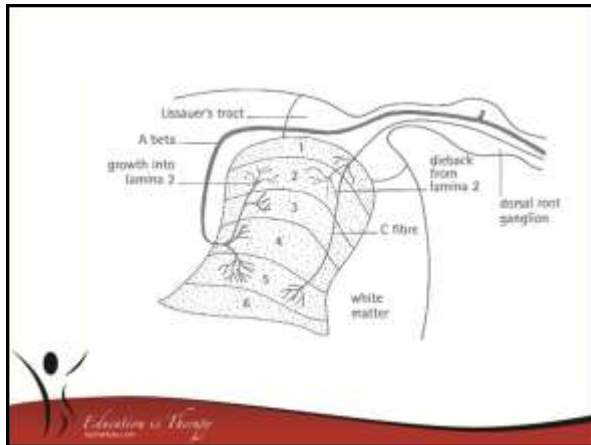
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Which way do nerves fire?



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3. Neuroplasticity

- The CNS undergoes functional and structural changes in people with persistent pain.
- Lead to central sensitization.
 - Dis-inhibition of spinal and trigeminal nociceptive neurons or facilitation of nociceptive activity by excitatory neurons that project from the rostro-ventral medulla.
 - Similar changes occur in structures involved in the emotional aspects of pain, such as the amygdala, anterior cingulate gyrus, and prefrontal cortex
 - ? long-term cognitive and mood changes – i.e., conditioned fear and addictive behavior.

3. Neuroplasticity

- The sensitizing process distort or suppress non-noxious sensations.
- Loss of an inhibitory influence of normal cutaneous sensations in the CRPS-affected limb enhance the excitability of thalamo-cortical nociceptive networks, thereby creating a vicious circle.
- Activation and up-regulation of glutamate receptors, which enhance signal transmission in the nociceptive circuitry from the spinal cord to the cerebral cortex
- Sensitized spinal nociceptive neurons become more responsive to peripheral input and might even fire in the absence of such input.

3. Neuroplasticity

- **Central sensitization can cause chronic pain, hyperalgesia, and allodynia, as well as the spreading of pain to adjacent non-injured areas.**
 - Antagonists of, for example, the NMDA receptor, are expected to induce analgesia in CRPS.
 - Intravenous infusion of the NMDA receptor antagonist ketamine over several days caused a clinically significant reduction in pain for 11 weeks in patients with CRPS.
 - This long lasting analgesic effect in CRPS suggests that ketamine causes long-term desensitization of the NMDA receptor or, at least, an as yet unspecified NMDA-mediated downstream process.

3. Neuroplasticity

- **Hyperalgesic priming**

- In some patients a transient insult can lead to chronic pain
- A transient insult triggers long lasting changes in primary afferent nociceptors that prime them to become hyper-responsive to future mild insults that would normally not evoke pain in the unprimed state.
- The epsilon isoform
- The resultant abnormal afferent activity can trigger plastic changes in the CNS.



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3. Neuroplasticity

- **Impaired motor function**

- Common after most injuries but generally resolves
- In CRPS susceptible patients develop marked movement disorders.
- Dystonia - most prevalent movement disorder in CRPS
- Characterized in the arm by persistent flexion postures of the fingers and wrist and in the leg by plantar flexion and inversion of the foot, with or without clawing of the toes.



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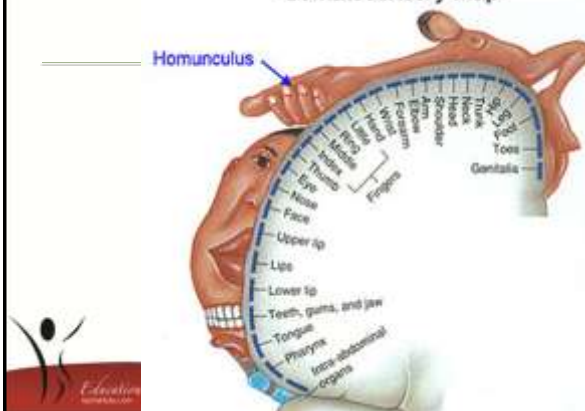
3. Neuroplasticity

- The risk of dystonia spreading to additional limbs in patients with CRPS increases with the number of limbs that are already dystonic.
- This accelerated disease course is a typical characteristic of maladaptive neuronal plasticity.
- Dystonia does not respond to intravenous ketamine, which suggests that neuroplastic changes have occurred that are distinct from those associated with sensitization.



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Somatosensory Map



- Not constrained by gyri and sulci
- Humanoid but not quite (somatopic)
- Use dependent
- Takes on non-organic parts eg collars
- Can be separated from the actual anatomy it represents
- One of many neurosignatures
- Part of a total body matrix

Butler DS, Coppiters MW 2012

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3. Neuroplasticity

- People with longstanding CRPS tend to perceive their affected limb to be larger than it really is.
 - CRPS patient believes the hand feels 107% bigger
 - Hurts more when it looks bigger
 - Does not move different
 - More swelling when it looks bigger

Visual distortion of a limb modulates the pain and swelling evoked by movement

C. Loreise Ntouyas^{1,2}, Timothy J. Parsons¹ and Charles Spence¹

NEUROLOGY 2009;68:109-110

Patterns of cortical reorganization in complex regional pain syndrome

Christian Malhotra, MD; Hermann D. Handwerker, MD, PhD; Richard Nussbaumer, MD; and Frank Diakidis, MD

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Smudging

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3. Neuroplasticity

- They also report distortions of the mental image of their limb—i.e., missing components or alterations in shape, posture, and temperature of the whole limb or of discrete parts of the limb.

Pain 133 (2007) 111–119

Body perception disturbance: A contribution to pain in complex regional pain syndrome (CRPS)

Jennifer S. Lewis ^{1,2,3}, Paula Kersten ³, Candida S. McCabe ^{4,5},
Kathryn M. McPherson ⁶, David R. Blake ^{4,6}



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3. Neuroplasticity

- They can report feelings of hostility or disgust towards the affected limb, or feel as though it is a separate entity, a foreign body that they would like to have amputated.

Pain 133 (2007) 111–119

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3. Neuroplasticity

- Higher order disturbances are not simply a consequence of having CRPS, but might in fact exert a top-down effect on the limb itself.
- Limb-specific disruption of temperature control and tactile dysfunction—can be evoked experimentally in healthy volunteers by inducing an illusion of disownership of that limb.

A. Stimulation



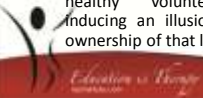
B. Condition



Tactile discrimination, but not tactile stimulation alone, induces chronic limb pain

G. Lussier-Monney ^{1,2}, Nico M. Zehnder ^{1,2}, Karin Wirth ³


Pain 137 (2008) 600–608



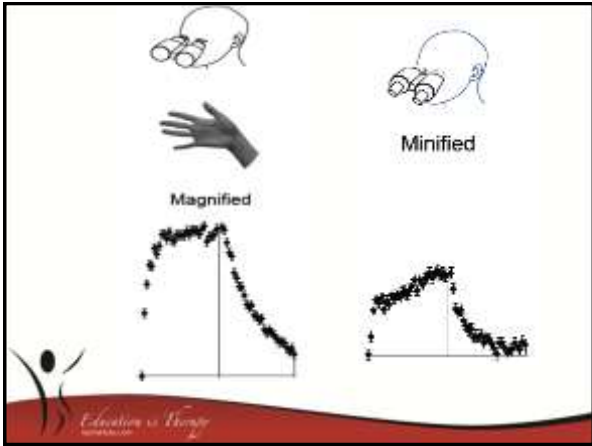
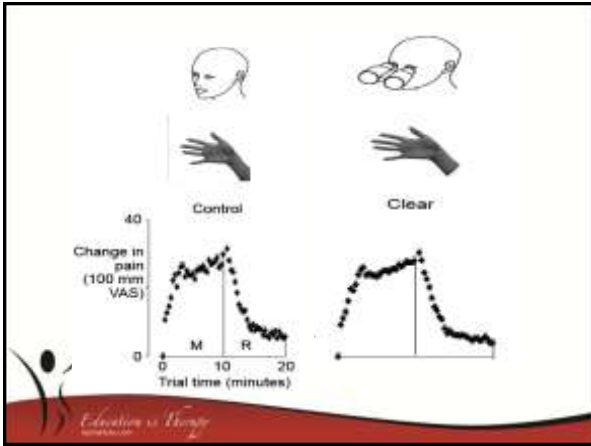
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3. Neuroplasticity

- Swelling and pain evoked by movement of the CRPS-affected limb is more severe if patients view a magnified image of the limb; if it looked bigger, it hurt more and became more swollen.
- Experimentally induced pain in healthy volunteers is decreased when the view of the limb is magnified, further pointing to cortical maladaptation in CRPS.



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3. Neuroplasticity

- The perceptual disturbances in CRPS similar to disturbances associated with unilateral neglect after stroke.
 - Patients can perceive touch on the affected limb if they watch the mirror image of the unaffected limb being touched.

Acerra & Moseley 2005 Neurology 65; 751-753

CRPS Patients:
Visual input of a tactile stimulus on the non-affected side, cause pain on the affected side


CRPS Hand


Mirror image

Normal Hand

3. Neuroplasticity

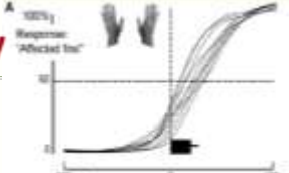
- Patients perform poorly on tasks in which they are required to judge the laterality of a pictured limb.



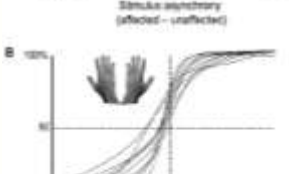

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3. Neuroplasticity


- Patients show a bias in tactile processing away from the affected side rather than the affected limb; that is, when patients cross their limbs, tactile input from the affected limb, now on the unaffected side of the midline, is prioritized over that from the unaffected limb, now held in the affected side of space.



A
Response 'Affected limb'





B
Response 'Unaffected limb'


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3. Neuroplasticity

- Recent work has suggested that cold-type CRPS is associated with a cold side of space—i.e., crossing the arms so that the healthy hand is on the affected side of the midline reduces the temperature of the healthy hand




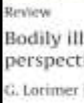

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Neuroscience and Biobehavioral Review 36 (2012) 34–46

3. Neuroplasticity

- The idea that maps in the brain of external space can influence thermal regulation is consistent with the recent suggestion of a cortical body matrix, which integrates somatotopic and spatial representations, the sense of ownership, and homeostatic regulation of the body.



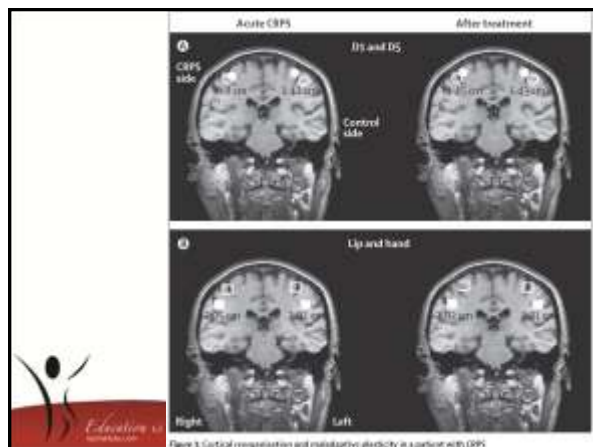

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3. Neuroplasticity

- CRPS - always aware of their altered feelings towards the limb
- They invariably state that although they believe that the limb is theirs, they feel as though it is not.
- Neglect-like disturbances reported in CRPS are a result of an implicit mechanism to avoid provocation of pain or an altered representation of aspects of the limb, rather than a direct consequence of actual neural damage.

3. Neuroplasticity

- Functional imaging - substantial reorganization of the somatotopic map within the primary somatosensory cortex (S1) contralateral to the affected limb in patients with CRPS.
- The S1 representation of the affected hand was smaller than that of the opposite hand, and the S1 representation of the hand shifted towards the ipsilateral mouth.
- The extent of these changes is associated with spontaneous CRPS pain and mechanical hyperalgesia.
- When CRPS symptoms decreased after treatment, this S1 cortical reorganization also reverses




3. Neuroplasticity

- **Cortical reorganization might explain:**
 - The spatial distribution of sensory disturbances in a glove-like or stocking-like pattern, the occurrence of tactile induced referred sensations
 - The perception that the limb is bigger than it really is, and the presence of hemisensory deficits.

3. Neuroplasticity


- Cortical changes also affect the primary motor cortex in patients with CRPS.
- Decreased inhibitory mechanisms and increased excitability in the contralateral primary motor cortex in patients with CRPS.
- Abnormalities of inhibitory mechanisms were also noted in the ipsilateral motor cortex of patients with CRPS, which is consistent with reports of slight preclinical motor impairment of the unaffected limb.
- Widespread impairment of central motor processing in CRPS.



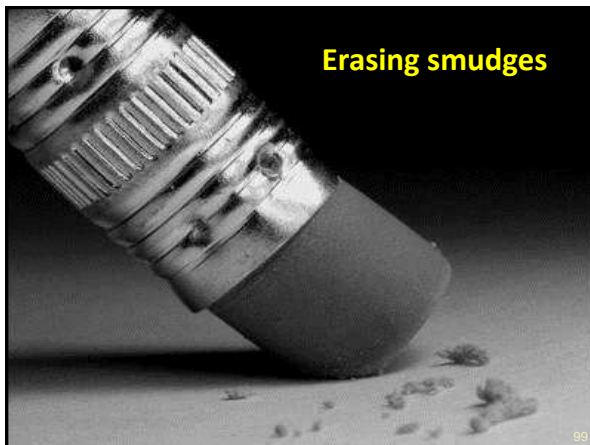
97

3. Neuroplasticity

- fMRI study on cortical activation during tapping movements of the CRPS affected hand showed that patients with CRPS had substantial reorganization of central motor circuits, with greater activation of primary motor and supplementary motor cortices than control individuals undertaking the same task.
- Furthermore, there was increased activation of the ipsilateral motor cortex, and the magnitude of motor dysfunction correlated with activation of the posterior parietal cortices, supplementary motor cortex, and primary motor cortex.




98



Where are we at right now?

1. With persistent pain and altered processing, the brain develops a “poorer” view of the tissues. The map of the affected area is “fuzzy.”
2. The more the map is messed up, the more the pain.
3. Correcting the brain’s view of the image is essential to manage pain.



100

Current Best Evidence...

European Journal of Pain 13 (2009) 339–353


Review

Does evidence support physiotherapy management of adult Complex Regional Pain Syndrome Type One? A systematic review

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Conclusions: Graded motor imagery should be used to reduce pain in adult CRPS-1 patients. Further, the results of this review should be used to update CRPS-1 clinical guidelines.



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1

Also consider...


Arch Phys Med Rehabil Vol 92, December 2011

SYSTEMATIC REVIEW

The Effect of Neuroscience Education on Pain, Disability, Anxiety, and Stress in Chronic Musculoskeletal Pain

Adriaan Louw, PT, MAppSc, Ian Driess, PT, PhD, David S. Butler, PT, EdD, Emilio J. Paravola, PT, DPT


Conclusions: For chronic MSK pain disorders, there is compelling evidence that an educational strategy addressing neurophysiology and neurobiology of pain can have a positive effect on pain, disability, catastrophization, and physical performance.



10
2

What is the most common technique to enhance or start urination?



- In 1996 it was shown that the same neurones which fire when performing a motor act, fire when watching another person do the same act.
- They were called **“mirror neurones”** i.e. they reflected acts performed by another person (Gallese, Fadiga et al. 1996).



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3

Embryonic therapies


Working deep into the neuromatrix – some practicalities

10
4

Virtual body exercises

- Focus placed on synaptic exercises and health
- Brain exercises vs. muscle/joint




Education is Therapy

10
5

The Main Techniques

- **Laterality**
 - Restore accuracy and speed of L versus R
- **Motor Imagery**
 - Imagining movements/postures
 - Visualization
- **Mirror Therapy**
 - Mirrors to trick the brain
- **Graded Motor Imagery**
 - Sequential process of the above



Education is Therapy

10
6

Graded Motor Imagery: The sequence matters


Laterality reconstruction

↓

Motor imagery

↓

Mirror therapy




Education is Therapy

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7

GMI Sequence

- In the most recent randomised controlled trial, the graded motor imagery package has demonstrated good evidence for outcome (reduced pain and disability in Complex Regional Pain Syndrome1 (CRPS1) (Moseley 2004; Moseley 2005) and CRPS1 and phantom limb pain (Moseley 2006). It works best if carried out in the sequence of laterality recognition, motor imagery and mirror therapy (Moseley 2006). Note : 2 weeks of each component with graded trial numbers.



Education is Therapy

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8

GMI Sequence

- CRPS and phantom limb pain are severe neuropathic pain states. It would seem that the GMI process would be beneficial for other pain states such as overuse syndromes (variously focal dystonia, repetition strain injury, cumulative trauma disorder) and various arthritic syndromes. Anecdotal evidence supports this contention, suggesting that trials are worthy

Laterality

- Laterality signatures as critical premotor association signatures to optimal motor output.
- Loss of laterality is known to occur in patients with CRPS and phantom limb pain. (Schwoebel, Coslett et al. 2002; Moseley 2004; Nico, Daprati et al. 2004).
- An evolutionary biology viewpoint may be that it is a form of protection, maybe neglect. Patients may say their arm belongs or not belongs to them

Laterality

- However in experimental pain (Moseley, Sim et al. 2005) and expectation of pain (Hudson, K. et al. 2006) , there is delayed recognition of the opposite limb.
- Limb laterality recognition activates pre motor (association) cortices, not primary motor cortex, imagined movements activate both (Moseley, Schweinhardt et al. 2003), allowing a basis to the GMI progression.

Stage 1 GMI Laterality (LRD)

Left/right discrimination is the accuracy and speed of identifying whether a picture or body part is a right or left part of the body (as in the limbs) or tuning to the left or the right (as in the spine). This recognition is altered in some pain states.



Judging a left from a right



Rapid initial choice



Mentally manoeuvre body part




Reject or confirmation

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

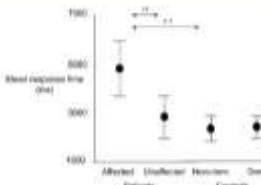


11 3


Acute vs. Chronic



In CRPS1 it takes longer to recognise the affected hand
(Moseley GL 2004, *Neurology*, vol.62, p.2182)



In acute hand pain it takes longer to recognise the non-injected hand
(Moseley et al. 2005, *Cognitive Brain Research*, vol.25, p.188, Hudson et al. 2006, *European Journal of Pain*, vol.10, p.219)




11 4

Laterality reconstruction:

Restoring the brain's ability to recognize left and right

- Recognize: Computer program
- Hands everywhere: Books/magazines/HEP
- Flash cards



11 5

Recognise online



www.noigroup.com



11 6

Recognise online

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 to moving

Reaction time and accuracy are scored and graphed.



11

Images



Left - 'a'

Right - 'd'

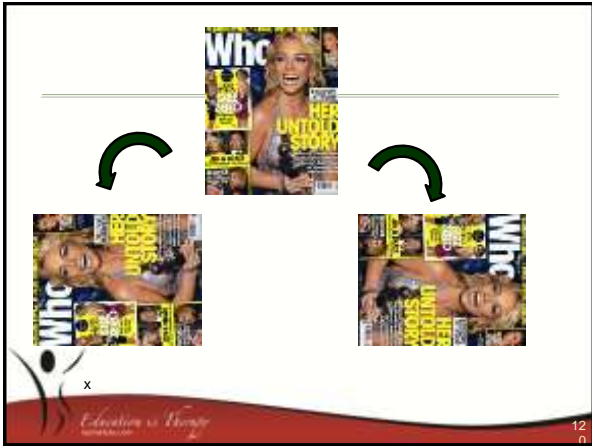


25% 25% 25% 25%

11



11



12



12
1



12
2




12
3

What is normal ?

1737 participants
(1315 pain-free)
65% female
40 countries worldwide
Variety of occupations
e.g. healthcare practitioners, forestry and farming industry, education, unemployed

Education is Change

12
4

RQ. 1 

a) What is a 'normal' response time?


Necks 1.6 ± 0.5 seconds
Hands 2.0 secs (mean)

b) What is a 'normal' accuracy?

92.5% (median)

Education is Change
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Recognize/Laterality



- ⊙ **Most people:**
 - Correct 90%
 - Ave time = 2.4 sec.
- ⊙ **CRPS**
 - Twice as long to recognize (4.7 sec. average)

Education is Change
12
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GMI Part 2 Motor Imagery


Mental representation of movement without moving

- The result of conscious access to the neurosignatures representing intention, preparation, carrying out and evaluating a movement
- Note the link to laterality
- Kinaesthetic less visual

Education is Change
12
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Part 2 Motor Imagery


It has been used for years in sports, childbirth, healthy people and those with neurological injury. We all do it. (Dickstein and Deutsch 2007)



Education is Change
12
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Part 2 Motor Imagery


- Imagined movements can increase pain and swelling in CRPS1 (Moseley 2004)
- May not necessarily be constrained by the biomechanical limitations of the body




Education is Therapy

12
9

Motor Imagery Guidelines



- Watch is “less brain effort” than imagining movement
- Static before movement
- Consider (or watch) what it might feel like to have a body part in a certain position
- Consider (or watch) what it might feel like to have a body part doing a certain movement
- Imagining another person less demanding than imagining self




Education is Therapy

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Motor Imagery Guidelines

- Could use Recognise, picture books, movies, people, work, dreams etc
- Progression examples
- Smooth gentler movements
- Increase ROM
- Increase speed
- Bring in functional/feared movements
- Use tools
- Alter environment



Education is Therapy

13
1

GMI stage 3 Mirror therapy

McCabe S et al 2003
Rheumatology 42:97

Moseley GL 2005 Pain 114:54





Education is Therapy

13
2

Practicalities: the mirror box

- Box construction
- Beer cartons can work
- Good quality perspex mirror
- Collapsible to take home




Education is Change

13

Practicalities – from the patients perspective

- Be guided by a clinician who understand brain function
- Sit “evenly” and no jewelry
- Forget the hand in the box at least initially




Education is Change

13

Practicalities –the mirror box

Graded hand activity examples

- Looking at the hand
- Turning hand up and down (elbow movement not hand movement)
- Flattening out the hand
- Flattening the hand and taking some weight thought it
- Moving individual fingers
- Finger thumb opposing
- Tapping fingers
- Add increasing muscle activity to each movement
- Use tools (screwdriver, nail cutters, pen scissors etc. – make appropriate to the left or right hand)
- Introduce clinicians’ hand
- Touch the face in the mirror



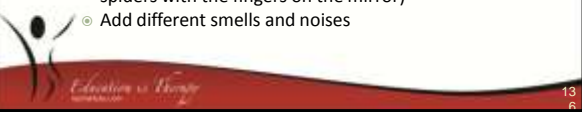
Education is Change

13

Practicalities –the mirror box

Context change

- Place (safe to feared places)
- Emotion
- Time of day
- Try movements distracted (eg while balancing on a chair)
- Music (play a song in your brain) play an external song.
- Sitting, standing, lying
- Use metaphors (eg. Open hand to free a bird, play spiders with the fingers on the mirror)
- Add different smells and noises



Education is Change

13

What about the hand in the box?

- Some move it as well
- Asynchryia
- Move hand in the box as treatment for many hand pains



13
7

Mirror Therapy

- There is good evidence for the use of mirror therapy alone for acute CRPS (McCabe, Haigh et al. 2003; McCabe, Haigh et al. 2004)
- Mirror therapy alone for phantom limb pain has shown benefits in small trials (Ramachandran and Rogers-Ramachandran 1996; McLachlan, McDonald et al. 2004). There are case reports of successful mirror therapy management of CRPS (Karmarker and Lieberman 2006) and post hand surgery pain (Rosen and Lundborg 2005) in respected medical journals.
- Benefits of mirror box therapy with cognitive behavioural therapy demonstrated in three patients with CRPS1. (Vladimir Tichelar, Geertzen et al. 2007)



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Mirror Ideas

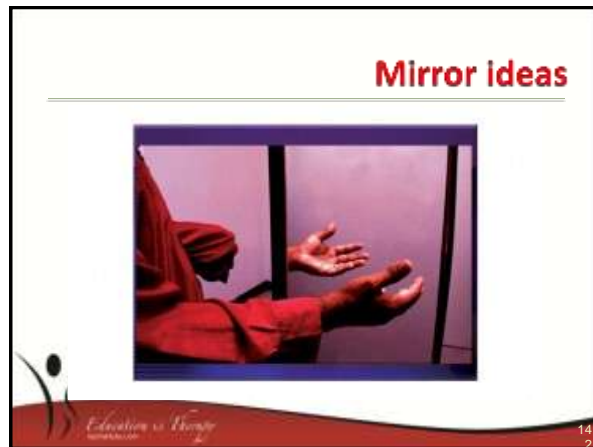


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Mirror Ideas



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How much, how many, how long?

Moseley RCT: 2weeks x 2hrs
laterality, imagery mirrors
(Moseley 2006).


Daly A 2008 Systematic review "GMI effective in reducing pain in CRPS1' Eur J Pain 2008

14
3

- GMI from the clinical side, anecdotes**
1. Around 20% CRPS1 no shift
 2. Occasional quick resetting with Left/right discrimination and mirrors (but not like "House"
 3. Stress will influence outcomes (L/R discrimination fallout)
 4. May need to go around the whole body with L/R discrimination training
 5. May need to do feet for "hot hands" and vice versa
 6. Rare "freak-outs"
- 14
4

Some clinical anecdotes

8. The place of NS education
9. May help with other perturbed outputs (performance, motor)
10. Mixing treatment not unusual
11. Fun initially: the clinical reasoning, compliance, goal setting and support essential
12. “Learning from the shadows” m- George (www.noigroup.com)
13. Laterality lost in dyslexia



14
5

Some clinical anecdotes

14. Cricketers have superb laterality, but injury may offset it
15. Laterality deficits may be severe enough to use the foot for the hand and vice versa
16. Mirrors used for all hand pains
17. Mirrors for out of plaster stiffness
18. GMI could be pre-emptive
19. Mirrors may be a life time pain management tool for some
20. L/R discrimination may be diagnostic



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6

THANK YOU & ACKNOWLEDGEMENTS...

Adriaan@ispinstitute.com

- University of Stellenbosch, South Africa
- Dr. Ina Diener (Stellenbosch)
- David Butler, Neuro Orthopedic Institute
- Dr. Louie Puentedura, UNLV
- International Spine & Pain Institute
- Dr. Lorimer Moseley
- Rockhurst University (Kansas City)
- RehabAuthority (Boise, ID)
- Sports Rehab (Overland Park, KS)
- Orthospineandpain.com
- Iowa PT Association Research Grant




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