

GRADED MOTOR IMAGERY: ACHIEVING OPTIMAL FUNCTION THROUGH NEUROPLASTICITY

WESTERN REGIONAL OT SPRING SYMPOSIUM
MARCH 4TH, 2023

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CERTIFIED APPLIED PREVENTION HEALTH PROMOTION THERAPIST



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OBJECTIVES

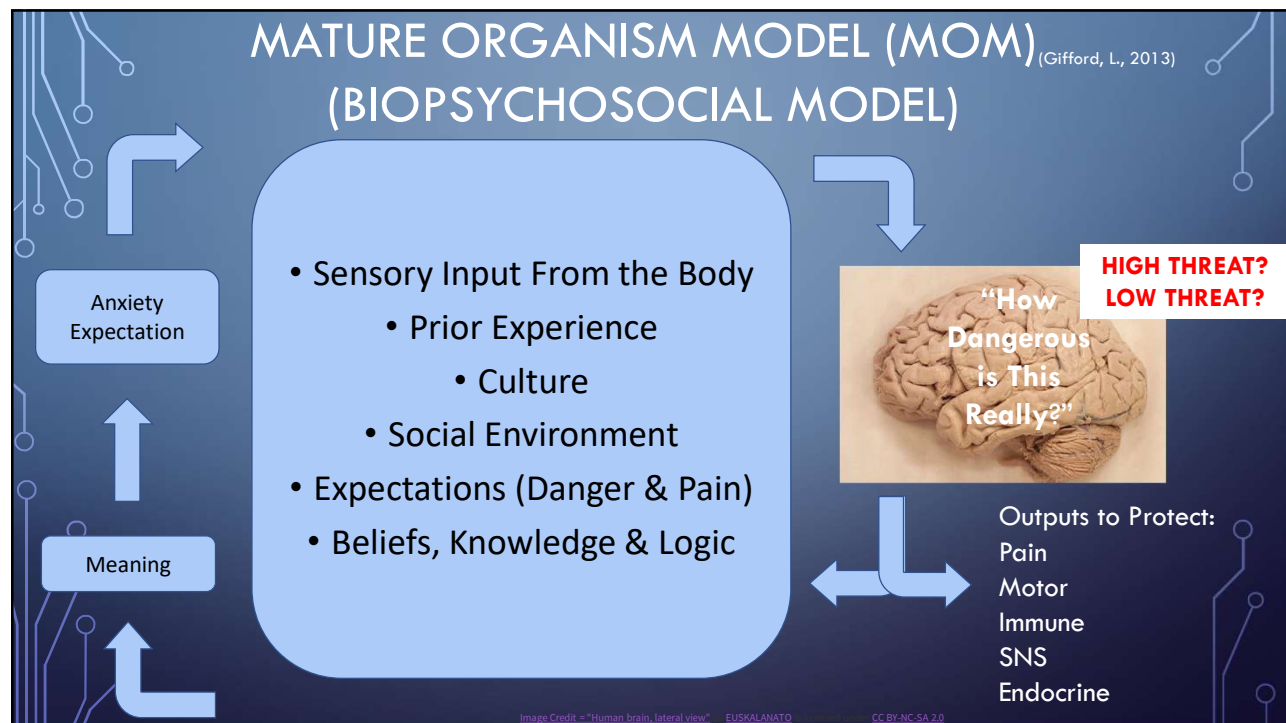
- 1. Identify at least three components of pain neuroscience education as it relates to the background of graded motor imagery (GMI) in occupation-based practice.
- 2. List all five stages of GMI and recognize the rationale behind the sequencing of each stage.
- 3. Demonstrate through lab breaks and group discussion/case studies the basic skills and tools involved in implementation of GMI to various pain and neurological conditions.

2

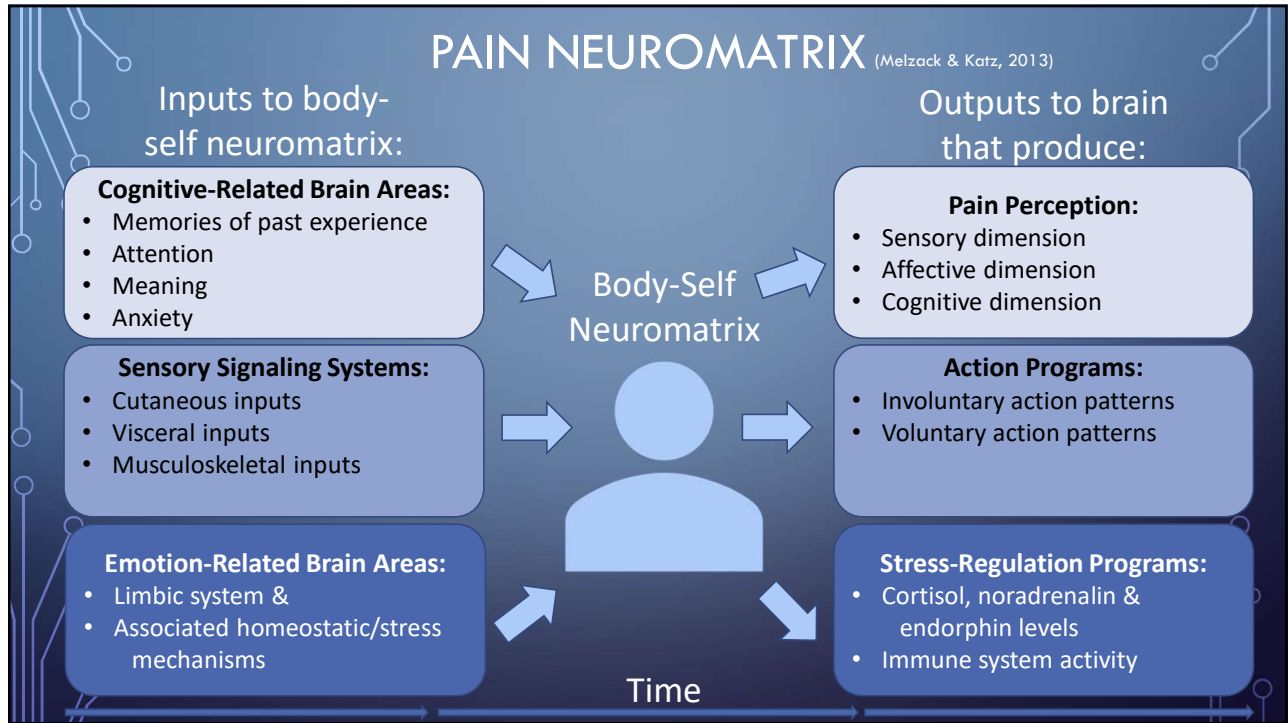
WHY DO WE EVEN HAVE PAIN?!

“An unpleasant sensory and emotional experience associated with, or resembling that associated with, actual or potential tissue damage” (Raja et al., 2020)

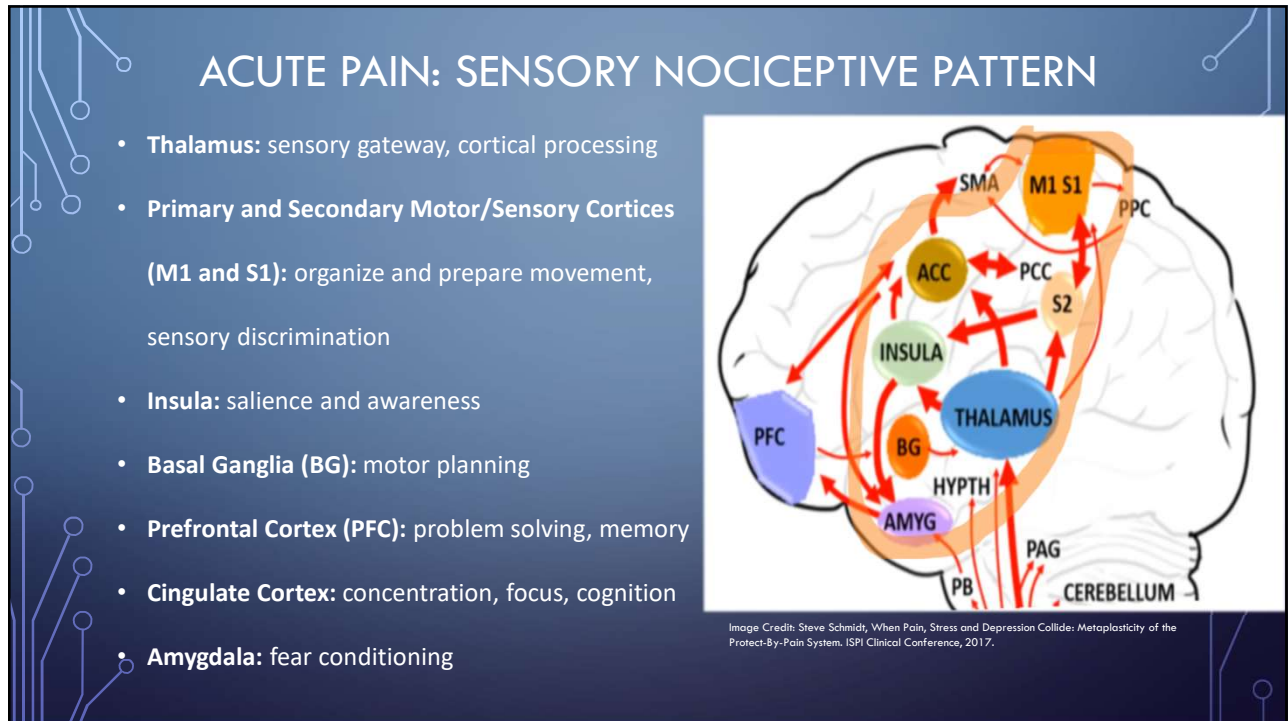
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CHRONIC PAIN: LIMBIC, EMOTIONAL, FRONTAL PATTERN

- **Amygdala:** fear conditioning, aversive behavioral reactions
- **Prefrontal Cortex (PFC):** problem solving, memory, role in negative cognitions
- **Basal Ganglia (BG):** integration of motor, emotional, autonomic and cognitive responses to pain.
- **Hippocampus (HIPPO) and Nucleus Accumbens (NA):** increased connectivity with prefrontal cortex

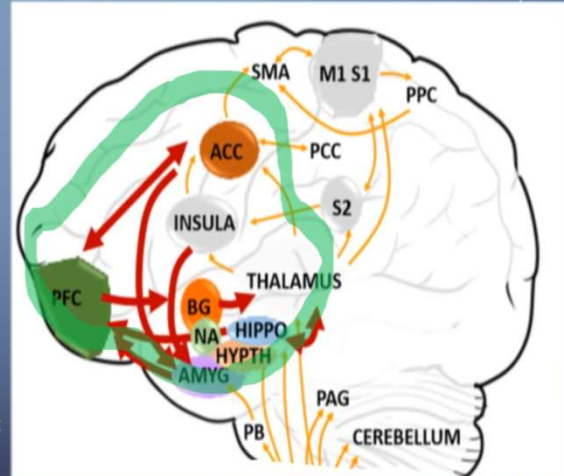
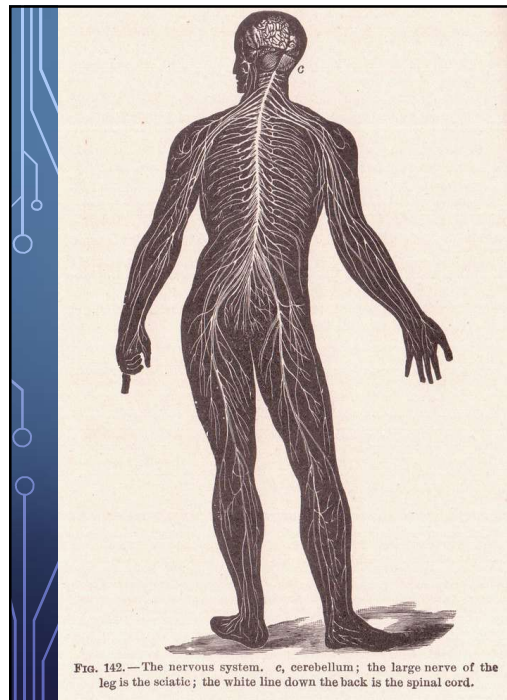


Image Credit: Steve Schmidt, When Pain, Stress and Depression Collide: Metaplasticity of the Protect-By-Pain System. ISPI Clinical Conference, 2017.

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"page 21.4 Nervous System" by gerritloppm is licensed under CC BY 2.0

I'D LIKE YOU TO
MEET...
YOUR NERVOUS
SYSTEM!

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(Louw et al., 2018).

ANKLE SPRAIN VS BUS

**Pain is a BRAIN construct
not a TISSUE construct!**

"sprained ankle" by Marc van der Chijs is licensed under CC BY-ND 2.0 "Motorcyclist dies following crash with school bus" by dffirecop is licensed under CC BY-ND 2.0

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NERVOUS SYSTEM AS ALARM SYSTEM

(Louw et al., 2018).

Lots of Room before alarm is set off
High Threshold

Minimal Room before alarm is set off
Low Threshold

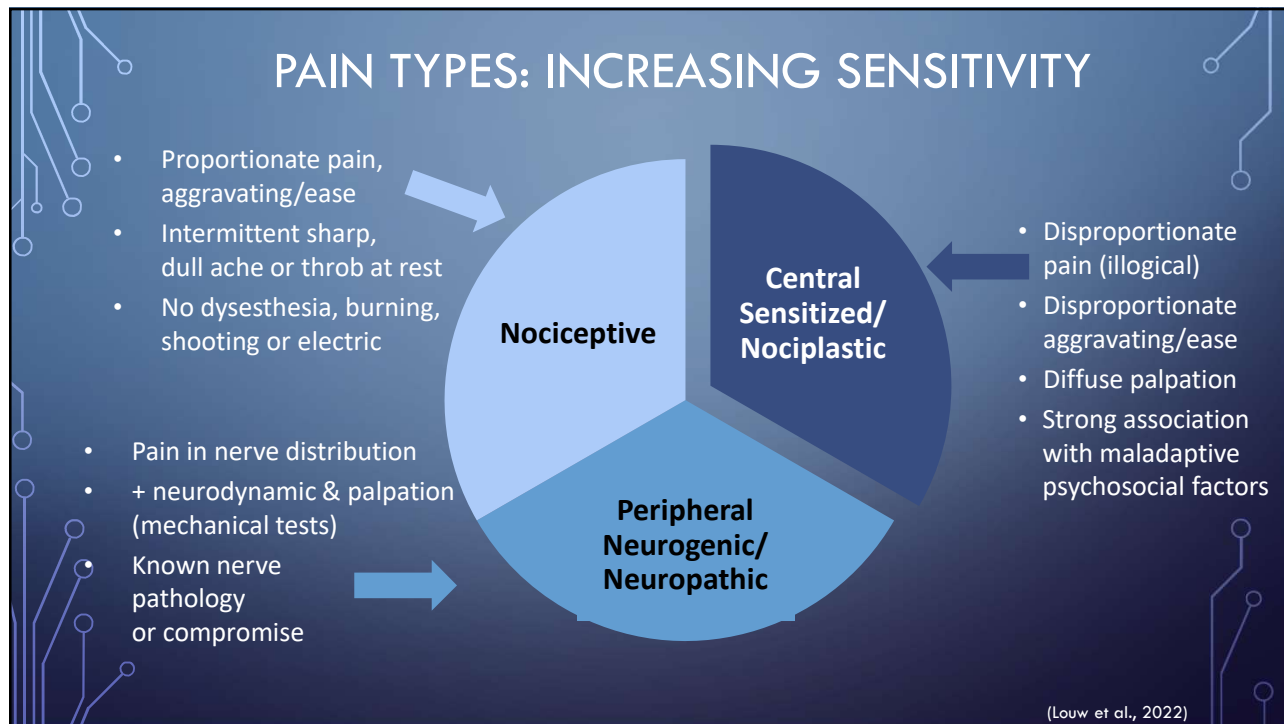
Injury or Stressor

Stays Sensitive Due to...?

Comes back down to resting level

"Alarm System" by www.homejobsbymom.com is licensed under CCBY2.0

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PAIN SCIENCE EDUCATION: THE WHY

When Our Clients Understand Their Pain, They Have...

- ✓ Less Disability
- ✓ Improved Behavioral and Emotional Responses
- ✓ Improved Pain Cognitions (positive view of pain)
- ✓ LESS PAIN (Treat vs “Manage”)
- ✓ Reduced Risk of Transition From Acute to Chronic Pain
- ✓ Increased Engagement In Desired Activities!!!

(Louw et al., 2018)

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REORGANIZATION OF BODY MAPS

- Altered body maps (schema) in the brain associated with pain, neurological deficits.
- Physical body represented in the brain by a network of neurons = representation body part in the brain or homunculus.
- Body schema = neural representation of the body.
- Representation = pattern of activity evoked when a particular body part is stimulated; tactile or movement, and dynamically maintained.
- People with pain display different body schema maps.
- Body schema maps expanding or contracting; increasing or decreasing body map representation in brain.
- Changes in shape and size of body maps = increased pain and disability.
- Altered cortical representation of body maps in S1; neglect and decreased use of painful body part may be significant source of altering of body maps.

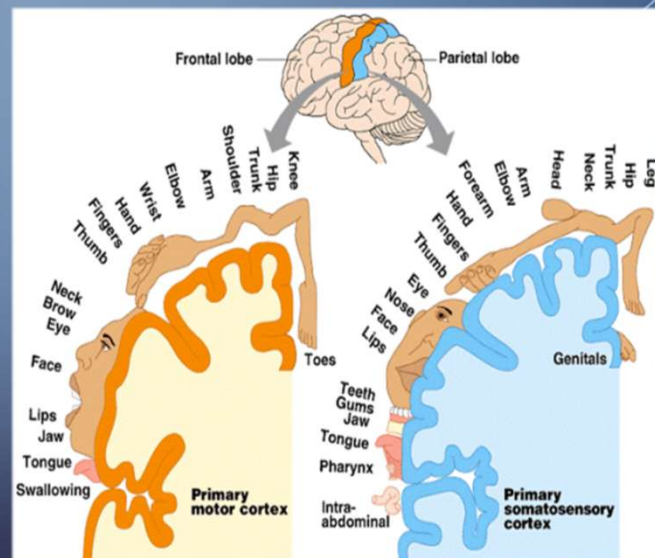
(Louw, Birley et al., 2022)

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REORGANIZATION OF BODY MAPS

- Biologically coded, but environmentally sculpted
- Rapid changes with practice
- If it is plastic in daily life, it's plastic after injury, disuse, immobilization, neglect, etc.
- Use it or lose it!

(Butler et al., 2012)



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Research Paper

PAIN

How central is central poststroke pain? The role of afferent input in poststroke neuropathic pain: a prospective, open-label pilot study

Simon Haroutounian^{a,b,*}, Andria L. Ford^c, Karen Frey^a, Lone Nikolajsen^{d,e}, Nanna B. Finnerup^{d,f}, Alicia Neiner^a, Evan D. Kharasch^{h,g}, Pall Karlsson^d, Michael M. Bottros^{a,b}

- Small study, but peripheral block abolished “central” pain.
- Results suggest: unlikely that central post-stroke pain is autonomously generated in the CNS, but dependent on afferent input from periphery.
- Pain may be mediated by misinterpretation of peripheral sensory input by sensitized neurons in the CNS.

(Haroutounian et al., 2018)

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Research Article

Cortical Plasticity in Rehabilitation for Upper Extremity Peripheral Nerve Injury: A Scoping Review

Patrick J. Zink, Benjamin A. Philip

- Cortical plastic mechanisms may influence sensory and motor outcomes.
- Altered or reduced afferent input = alteration of the corresponding body parts' cortical representations.
- Loss of function can interfere with healthy changes in cortical representations of body parts; maladaptive plasticity.
- Traditional sensory reeducation; activity-based sensory reeducation; selective deafferentation; cross-modal sensory substitution; mirror therapy; mental motor imagery; action observation with simultaneous peripheral nerve stimulation.

(Zink & Philip, 2020)

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Spinal Cord (2016) 54, 809–815

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www.nature.com/sc

ORIGINAL ARTICLE

Pain assessment according to the International Spinal Cord Injury Pain classification in patients with spinal cord injury referred to a multidisciplinary pain center

S Mahnig¹, G Landmann², L Stockinger² and E Opsommer¹

- Musculoskeletal pain = 58%
- At-level neuropathic pain 53%
- Below level neuropathic pain 42%
- Visceral pain 3%

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> Musculoskelet Sci Pract. 2021 Dec;56:102447. doi: 10.1016/j.msksp.2021.102447. Epub 2021 Aug 12.

Two-point discrimination and judgment of laterality in individuals with chronic unilateral non-traumatic shoulder pain

Marília Caseiro¹, Felipe José Jandre Dos Reis², Amanda Matias Barbosa¹, Marco Barbero³, Deborah Falla⁴, Anamaria Siriani de Oliveira⁵

- Body schema of painful shoulder in 52 patients with chronic unilateral *nociceptive* shoulder pain.
- Two-point discrimination test (TPDT); Left/Right Judgement Task (LRJT).
- TPDT at anterosuperior/lateral regions of both shoulders; LRJT of shoulder/foot laterality.
- No difference in TPDT between shoulders; no difference response time or accuracy of LRJTs.
- Conclusion = alterations in body schema may depend on *primary pain mechanism*.

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MAPPING CHANGES DEMONSTRATED IN:

- ✓ Amputees
- ✓ CRPS
- ✓ Chronic back pain
- ✓ CTS
- ✓ Hand and Knee OA
- ✓ Frozen shoulder
- ✓ Radiculopathy
- ✓ Pregnancy
- ✓ Aging
- ✓ Obesity
- ✓ Dystonia
- ✓ Post-stroke
- ✓ Immobilization
- ✓ Anesthesia
- ✓ Surgery
- ✓ Headaches
- ✓ Facial pain
- ✓ Expectation of pain

(Beales et al., 2016; Breckenridge et al., 2020; Falling & Mani, 2016; Louw, 2015; Magni et al., 2018; Meugnot et al., 2014; von Piekartz & Mohr, 2014)

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GRADED MOTOR IMAGERY (GMI)

PNE*

Laterality (implicit motor imagery)

Motor Imagery (explicit motor imagery)

Sensory Discrimination*

Mirror Therapy

***Added to original sequence**

Graded Exposure

(AOTA, 2021; Louw, Puentedura et al., 2022)

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FULL GMI RECENTLY STUDIED IN...

- Complex Regional Pain Syndrome (Strauss et al., 2021)
- Post-Amputation Phantom Limb Pain (Limakatso et al., 2020)
- Post-Stroke Upper Extremity (Geubtner & Matilla, 2021; Ji et al., 2021)
- Frozen Shoulder (Sawyer et al., 2018)
- Post-surgical lumbar spine (Louw et al., 2015)
- Distal Radius Fracture (Dilek et al., 2018)

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TOP SECRET

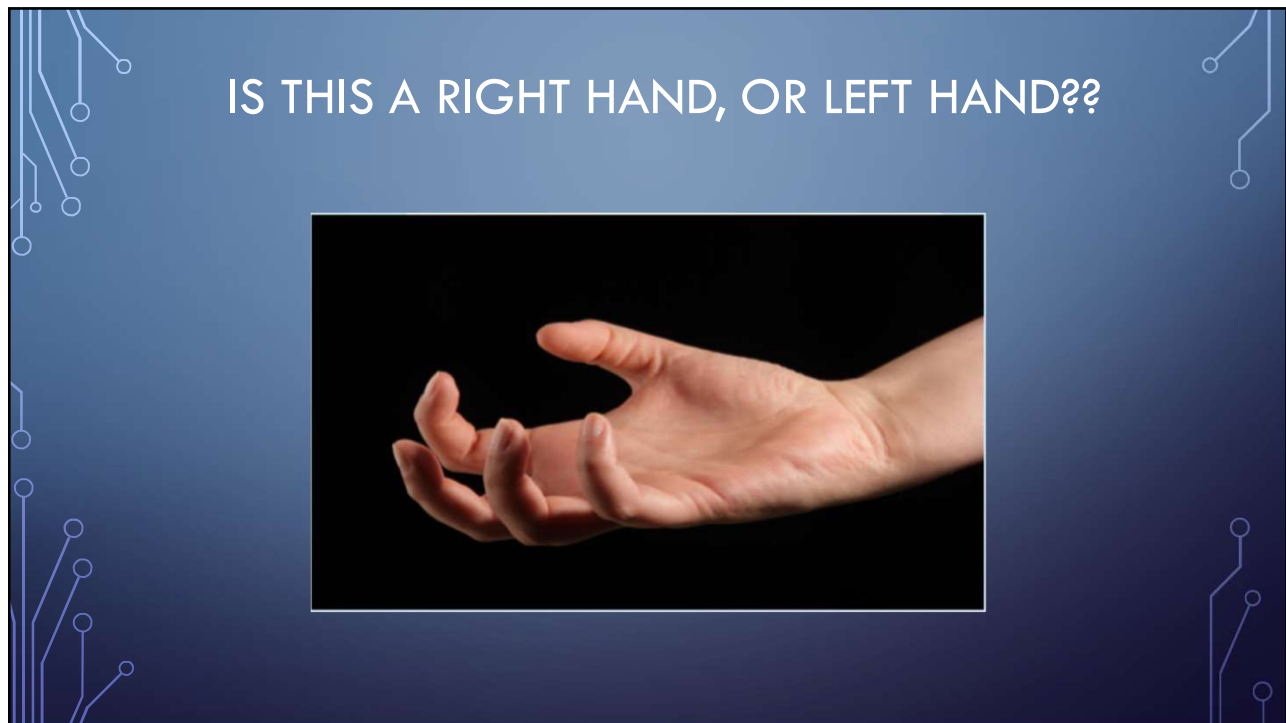
The Tests Are the Treatment!

Image Credit: rubberstamps.com

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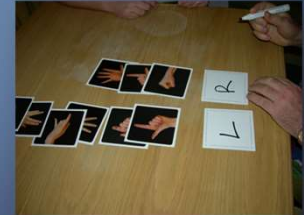
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RIGHT/LEFT DISCRIMINATION: TESTING

- Flashcards or Recognise™ App
- Normative data:
 - ✓ Accuracy >80% Hands/Feet
 - ✓ Hands/Feet Reaction time 2.0 seconds +/- 0.5
 - ✓ Neck/ Back 1.6 sec +/- 0.5



- Activates pre-motor cortex via implicit imagery
- Caveat: May Also Be Due to Slow Processing, Difficulty with Coordination, Dyslexia; Lefties Slower Than Righties
- Scores Which Vary Notably → Trial of Laterality Treatment

(Butler et al., 2012)

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RIGHT/LEFT DISCRIMINATION: TREATMENT

- ✓ Exercise for Brain (Fatiguing!)
- ✓ Pain Flare-up → Do Opposite Side or Adjacent Body Part
- Magazines, Flashcards, or Recognise™ app
(Vary Factors and Environments to Grade)
- *When to move on to Visualization/Motor Imagery?*
 - ✓ If Initially Tests Well or Achieves Norms; No Flare-Ups
 - ✓ Faster Progression for Acute vs Chronic State Likely



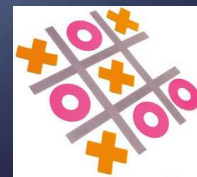
(Butler et al., 2012)

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THE FUNCTIONAL APPLICATION: L/R DISCRIMINATION

How could this be implemented into daily occupations?

- Games of tic tac toe, matching with flashcards with kids
- 5 min standing or sitting break during workday
- Identify L vs R while watching TV



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“HOW COMMON IS LATERALITY-DEFICITS IN PATIENTS ATTENDING OUTPATIENT PHYSIOTHERAPY WITH LOWER EXTREMITY INJURIES?” (LOUW, BIRLEY ET AL., 2022)

- n = 40 patients with knee, foot or ankle pain; ages 19-93; 55% female.
- 45% experiencing pain > 6 months; 92.5% had surgery before; 50% brace/cast.
- Most common diagnoses = knee pain; ankle sprain; foot pain; knee replacement; knee meniscus injury; knee ACL injury; ankle surgery; Achilles' injury.
- Methods: mean score of two tests of foot laterality accuracy and speed; compared to normative data, which clinical presenting signs and symptoms correlate to abnormal laterality scores.
- Results: Fourteen patients (35%) recorded an abnormal laterality score (speed or accuracy); greatest correlation with female gender and age, not duration/intensity of pain, immobilization or surgery.

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LAB BREAK



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EXPLICIT MOTOR IMAGERY/VISUALIZATION

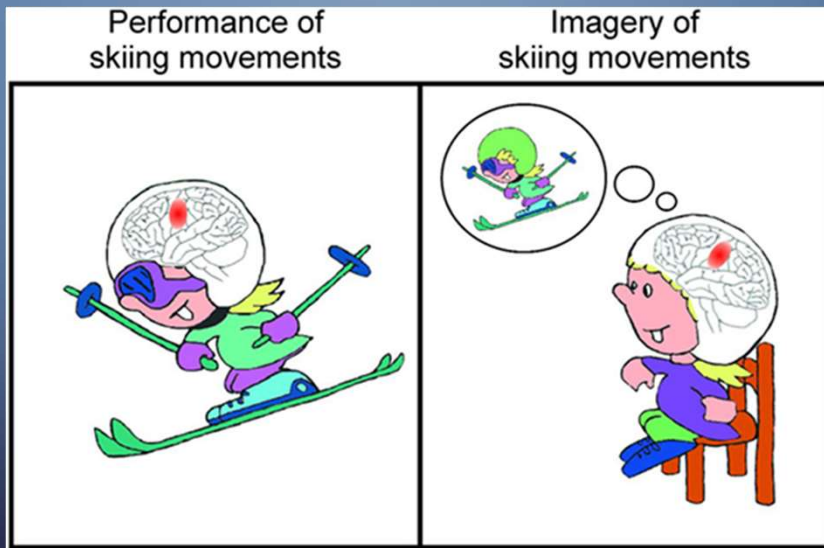


Image Credit: kids.frontiersin.org

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EXPLICIT MOTOR IMAGERY/VISUALIZATION: TREATMENT

- Provides Background
 - ✓ Imagine Movements BEFORE Doing Them (Motor Cortex)
 - ✓ Improves Communication Between Body and Brain
 - ✓ Select an Activity: Static > Dynamic > Activity Based
 - ✓ Imagine Doing it Pain Free (Incorporate All Senses)
- Person-Centered: Select Important Activities!
- *When to Move on to Sensory Retraining/Discrimination?*
 - ✓ Dynamic Visualization With No Pain/Anxiety Flare Ups
 - ✓ More Acute Versus Chronic/HEP Established



(Butler et al., 2012)

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EXPLICIT MOTOR IMAGERY/VISUALIZATION: TREATMENT

- ✓ Where are you?
- ✓ What is the weather like?
- ✓ What kind of surface are you standing on?
- ✓ Is there anyone there with you?
- ✓ What are you wearing?
- ✓ How does it feel on your skin?
- ✓ What do you hear?
- ✓ What do you smell?
- ✓ How does it feel to move?
- ✓ What are you thinking about?



Can Combine with Guided Imagery

Image Credit: udel.edu

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THE FUNCTIONAL APPLICATION: IMAGERY

How could this be implemented into daily occupations?

- People watching at the mall.
- Integrated into guided imagery/mind body skills.
- Watching video games or yoga videos.
- Grade up or down: environment, other sensory cues, emotional connections.



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Gain confidence in ability to complete task and identify potential modifications by thinking it through first.

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“EFFECTIVENESS OF MOTOR IMAGERY FOR IMPROVING FUNCTIONAL PERFORMANCE AFTER TOTAL KNEE ARTHROPLASTY: A SYSTEMATIC REVIEW WITH META-ANALYSIS” (LI ET AL., 2022).

- Included 6 RCTs looking at the effect of motor imagery in addition to standard care after TKR, versus standard care alone in the control group.
- Measurements included range of motion, strength intensity, Visual Analogue Scale, Time Up and Go Test, Oxford Knee Score, Western Ontario and McMaster Universities Osteoarthritis Index.
- Motor imagery group achieved effective treatment for strength enhancement, pain reduction and physical activities improvement versus control group.

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LAB BREAK



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SENSORY DISCRIMINATION/RE-TRAINING (NOT DESENSITIZATION)

- Sensory Re-training vs Desensitization
- Testing: 2 Point Discrimination
- Localization: "Where Am I Feeling That??" (Body "Grids")
- Stereognosis
- Graphesthesia
- Pressure Pain Thresholds (Pressure Algometer)
- Hot/Cold
- Fabrics: "This is felt" "This is cotton"
- Use During Manual Treatment and Neuro Re-Ed! (Self-Localization)



(Louw et al., 2018; Louw, Puentedura et al., 2022)

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WHY DISCRIMINATION AND NOT INTEGRATION OR DESENSITIZATION??



Pain 137 (2008) 600-608

PAIN

www.elsevier.com/locate/pain

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

G. Lorimer Moseley ^{a,b,*}, Nadia M. Zalucki ^{c,d}, Katja Wiech ^b

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TWO POINT DISCRIMINATION

- Test protocol:

- Pressure sufficient to blanch skin.
- Average of 5 ascending and 5 descending measurements.
- Start at 0mm, increase until 2 points clearly felt (and visa versa for 1 point).
- Subject clearly states one or two points, if unsure report one.
- If 2 points recognized by a temporal delay due to assessor, reject that trial.
- Approximately 3 minutes to complete.



(Catley et al., 2013)

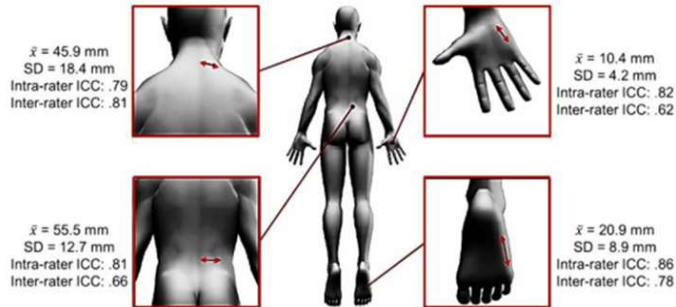
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TWO POINT DISCRIMINATION

All clinicians need to keep on hand the normative data:

Catley MJ, et al (2013) Rheumatology

2 point discrimination norms



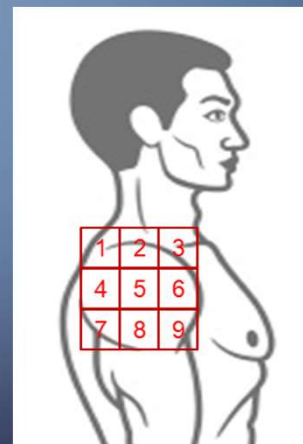
Other normative values reported in mm (see Nolan MF - 1982, 1983, 1985)

Upper lateral arm: 42.4	Mid medial forearm: 31.5	1 st D. interosseous: 21.0
Finger pad: 2.5	Inf angle scapula: 52.2	Mid posterior thigh: 42.2
Distal lateral leg: 41.6	1-2 Met interspace: 23.9	Tip great toe: 6.6

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LOCALIZATION TESTING AND TREATMENT

- Where was I touched?
- Stimulus from therapist then identification from client
- Impaired tactile acuity relates to impaired motor control
- Application to post-stroke



(Louw et al., 2015)

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SENSORY DISCRIMINATION/RE-TRAINING: TREATMENT

- Discrimination: What Am I Feeling??
 - ✓ Sharp or Dull
 - ✓ Big or Small
 - ✓ Warm or Cool
 - ✓ Rough or smooth
 - ✓ Carpet or Tile (Neuropathic Foot Pain)
- Stereognosis
- Graphesthesia: Easy O X W 1 3 7 - + !
- Grading: 75-80% Accuracy; 15-30 min blocks 2-3x/day
- *When to Move on to Mirror Therapy?*
 - ✓ Demo Sensory Awareness at Level Needed for Functional Use
 - ✓ Progress has Stalled (Sooner With Phantom Limb Likely)



(Louw et al., 2018; Louw, Puenteudura et al., 2022)

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THE FUNCTIONAL APPLICATION: SENSORY DISCRIMINATION

How could this be implemented into daily occupations?

- Gathering items from pocket, purse, or bag
- Folding laundry
- Making a game out of it to play with kids or social supports
- Integrate it onto self-care tasks with caregiver
- As a distraction during dressing changes
- Dig your feet in the dirt, feel the grass



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“CHANGE IN FUNCTIONAL ARM USE IS ASSOCIATED WITH SOMATOSENSORY SKILLS AFTER SENSORY RETRAINING POSTSTROKE” (TURVILLE ET AL., 2017)

- Aim: changes in functional arm use after retraining for stroke-related somatosensory loss; changes associated with somatosensory discrimination skills?
- N = 80 from two RCTs somatosensory retraining; Motor Activity Log for perceived amount of arm use in daily activities; Action Research Arm Test for performance capacity.
- Retraining = graded tasks; variety of textures, limb angles, objects, practice conditions; intensive training; goal-directed attention without vision; anticipation; feedback on accuracy; vision or touch of unaffected hand; problem solving for everyday tasks.
- Results: Participants’ functional arm use improved after somatosensory retraining; change in daily arm use related to small variance in somatosensory outcomes.

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LAB BREAK



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MIRROR THERAPY



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MIRROR THERAPY

- Purpose and Preparation:
 - ✓ Builds on Foundation
 - ✓ “Tricks” the Brain
 - ✓ Prepare the Patient (Emotional Response)
- Setting up the Mirror
- Progressing Treatment:
 - Static → Dynamic → Functional Use
- *When to Move on to Traditional Therapies?*
 - ✓ Tolerating/Emerging Movement Behind Mirror
 - ✓ Tolerable Pain Symptoms to Allow for Movement Therapies



(Butler et al., 2012)

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THE FUNCTIONAL APPLICATION: MIRROR THERAPY

How could this be implemented into daily occupations?

- Watching body complete daily tasks such as
 - Writing
 - Dressing
 - Feeding

- Use games or fidgets



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Future applications of virtual reality for embodiment, occupational engagement, and bilateral applications are limitless!!!

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“MIRROR THERAPY AND TASK-ORIENTED TRAINING FOR PEOPLE WITH A PARETIC UPPER EXTREMITY” (BONDOC ET AL., 2018)

- Aim: effect of mirror therapy and task-oriented training on the paretic UE function and occupational performance of people with stroke.
- n = 4; at least 3 months poststroke; home-dwelling status, >24 on the Mini-Mental State Examination; arm and hand function at Brunnstrom Approach Recovery Stage III or above; at least 21 y.o.
- 4-wk intervention both mirror therapy (min 150 repetitions/session) and task-oriented training (three priority activities >150 repetitions) 2x/wk for 45- to 60-min sessions in clinic and 4x/wk at home.
- Results : clinically meaningful improvements in self-identified goals after intervention and follow-up; perceived improved movement quality at varying points of assessment.

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LAB BREAK



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MAKING A HEP

- **Laterality:** Magazines, Cards, Recognise™ Apps
- **Motor Imagery:** “People Watching”;
Pre-Selecting Images/Movements to Imagine
(Guided Imagery/Relaxation Techniques)
- **Sensory Discrimination:** 2-Point with Paperclips; Fabric Pieces;
Plastic Number/Letter Magnets, Localization Grids, etc.
- **Mirror:** Self Made Mirror Box or
Purchase Free-Standing Door Mirror for Larger Body Parts (e.g. leg)

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CASE STUDY: TRAUMATIC AMPUTATION CASE

- 25 year-old male with 1 year history of traumatic left AKA.
 - Only survivor of suicide attack at a checkpoint
- HPI:
 - Patient reports ongoing residual limb pain in addition to phantom limb pain that is increasing in frequency and intensity.
 - Low back pain and residual limb pain worsen with prolonged gait.
- Patient Goals
 - Be able to play outside at the park with his son out of his wheelchair.
 - Be on fewer medications to improve childcare.



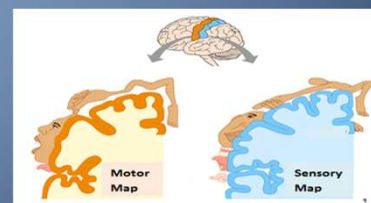
(Marth & Doyle, 2019)

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EXAM- GMI

- Left/Right Discrimination Testing: (using Recognise app)

	Time	Accuracy
• Feet:		
• RIGHT	3.3	70%
• LEFT	4.0	54%
• Back:		
• RIGHT	2.5	77%
• LEFT	3.0	70%



- 2-point discrimination- L thigh outside of norms and when compared to R

Localization

LE – L thigh 70% accurate with 6 section grid

(Marth & Doyle, 2019)

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TREATMENT: EARLY PHASES

- PNE:
 - Central nervous system and hyper-vigilance
 - Explanation for phantom limb pain

- Left/Right Discrimination:
 - Magazines
 - Games with son

- Visual Imagery:
 - Observation
 - Virtual reality/Avatar
 - Guided imagery



(Marth & Doyle, 2019)

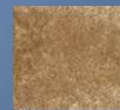
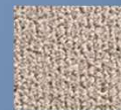
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TREATMENT: LATE PHASES

- Discrimination:
 - Fabrics
 - Toys

- Mirror therapy
 - Dynamic movement
 - Combined with sensory
 - Homework- door mirror

- Other factors: sleep, CBT, self-efficacy



(Marth & Doyle, 2019)

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CASE STUDY: GMI COMPONENTS FOR FACIAL SCARS

(Exhibit 3, AOTA, 2021)

- For allodynia of facial scars → graded motor imagery sequence was used:
 - Laterality of faces: circling right or left side of faces in magazines → identifying facial expressions in others (e.g. on TV)
 - Visualization of own facial expressions
 - Sensory discrimination: initial tolerated textures → graded exposure to achieve tolerating textures of makeup sponges/ brushes
 - Cognitive Behavioral Therapy intervention + sensory discrimination (e.g. changing language from “this texture is gross” to “this texture feels different but is safe for my skin.”)



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DRIVES PLASTICITY

- Exercise
- Novelty & surprise
- Healthy lifestyle
- Move with your whole body
- Pay attention
- Strong representations are fundamentally anti-pain
- Become a bright-eyed child
- Be social

INHIBITS PLASTICITY

- Sedentary lifestyle
- Chronic stress
- Poor sleep
- Poor mood
- Alcohol & substance abuse
- Stereotypic movement
- General health issues: DM, HTN, diet, hydration

(Merzenich, 2013)

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MAIN TAKEAWAYS

- The nervous system (and therefore neuroplasticity) is ALWAYS at play!
- Be aware of a patient's dominant pain mechanism, and their personalized risk factors for potential transition to a more central/nociplastic pain state.
- The GMI intervention tests are the treatment; if it is within norms, move on.
- Each GMI stage has a place in treatment, but the ultimate goal is OCCUPATION.


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GRADED MOTOR IMAGERY RESOURCES

- Neuro Orthopaedic Institute (NOI): <https://www.NOIgroup.com>
- General overview and research <http://www.noigroup.com/documents/noi-gmi-evidence.pdf>
<http://www.gradedmotorimagery.com/>
- Recognise™ app or NOI flash cards for testing laterality-tests accuracy and reaction time
- Videos: What is GMI? <https://www.youtube.com/watch?v=fWYUJscRBRw>
- Smudging of the brain: <https://www.youtube.com/watch?v=3QVAY5stO3U>
- Mirror therapy: <https://www.youtube.com/watch?v=hMBA15Hu35M>
- Nerves, knowledge and tubing:
<https://www.youtube.com/watch?v=gdKldyXgkgs>

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THANK YOU!!!



QUESTIONS?

Contact me at meganosgooddoyle81112@gmail.com

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