CASE REPORT

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■ SUPPLEMENTAL VIDEO ONLINE

Monkey See, Monkey Do—Using Graded Motor Imagery in the Management of Chronic Low Back Pain: A Case Report

■ **BACKGROUND:** The lifetime prevalence of low back pain (LBP) is high and recurrence is common. Graded motor imagery is a treatment method used in patients with chronic pain that has 3 stages: left/right discrimination or laterality recognition, explicit motor imagery, and mirror therapy.

■ **CASE PRESENTATION:** A 33-year-old man self-referred to physical therapy for chronic LBP. He demonstrated misconstrued beliefs regarding his LBP, impaired laterality recognition, and fear-avoidance behaviors.

■ **OUTCOME AND FOLLOW-UP:** This "monkey see, monkey do" approach, in conjunction with other interventions, resulted in a 10% improvement of modified Oswestry Disability Index score, greater than 90% laterality accuracy, and a reduction in pain levels.

■ **DISCUSSION:** Graded motor imagery can facilitate sensory cortex reorganization. A unique approach to improving laterality recognition was demonstrated in this case: the patient could not improve his laterality scores to acceptable levels until he watched his wife successfully complete the task. *JOSPT Cases 2021;1(1):61-67. doi:10.2519/josptcases.2021.9875*

■ **KEY WORDS:** *explicit motor imagery, graded motor imagery, laterality recognition, pain, physical therapy*

Low back pain (LBP) has a high lifetime prevalence and high recurrence rates.[8,23] Between 48% and 79% of patients report LBP symptoms after 3 months and 65% report pain at 1 year.[8,23] Graded motor imagery (GMI) is a treatment method used in patients with chronic pain, including chronic LBP.[2,3,13,14,18,20,21,25,28,29,33,34] Graded motor imagery has 3 stages: left/right discrimination or laterality recognition, explicit motor imagery (EMI), and mirror therapy.[2,3,13,14,18,20,21,25,29,33,34] The first stage, laterality recognition, requires individuals to correctly identify whether an image portrays a person turning left or right with the back exposed. The second stage, EMI, requires the patient to imagine performing certain movements without pain.[31] The final stage is mirror therapy.[25,26,31] Graded motor imagery has been theorized to facilitate sensory cortex reorganization to reduce pain (**APPENDIX A**).[25,26,31] This case demonstrates the value of using GMI and describes a unique "monkey see, monkey do" approach to improve a patient's laterality recognition scores. The 10 years of failed intervention for this patient might have been avoided if the concept of pain neuroscience education (PNE) had been more widely understood. Informed consent was obtained, and the rights of the patient were protected.

CASE PRESENTATION

A 33-year-old man presented to physical therapy for chronic LBP of 10 years in duration (**FIGURE 1**). Five years prior, the patient underwent an L4-5 discectomy and laminectomy. The surgery resulted in a complete resolution of radicular symptoms for 1 year. However, after 1 year, his pain symptoms, though always present, increased and sometimes left him bedridden for days, provoking recurring cycles of increased pain and unpredictable pain responses to activity. He reported this by stating, "I could stack firewood or carry concrete bags up a flight of stairs with no issue. However, if I walked on concrete floors or bent over to tie my shoes, I would be crippled for the next week.... My reason was that I was structurally damaged and had to protect my back."

Previously, the patient had failed conservative treatment with several other medical and rehabilitation providers (**VIDEO**). Magnetic resonance imaging revealed a new L3-4 disc herniation, negative electromyography for nerve damage, and a negative computed tomography scan for serious lumbar pathology. During our examination, the patient reported bilateral numbness and tingling from the buttock into the posterior thighs, but denied changes in bowel and bladder function or other red flags. The patient's goal was to avoid another lumbar surgery.

DIFFERENTIAL DIAGNOSIS

The orthopaedic and neurological examination revealed no significant limitations (**APPENDIX B**); however, high activation of his trunk-stabilizing

muscles was palpated during active lumbar flexion. The patient demonstrated high disability (42%) on the modified Oswestry Disability Index (ODI).[7] On the Fear-Avoidance Beliefs Questionnaire (FABQ), he reported a score of 16/42 on the work subscale and 20/24 on the physical activity subscale.

Central sensitization was suspected, and laterality recognition was assessed with the Recognise application (Neuro Orthopaedic Institute, Adelaide, Australia). The application calculates the accuracy of identifying a back moving to the left or right side, as well as the speed at which each side is identified. Accuracy of 80% or above is considered normal. For the patient, the accuracy of those scores was below 80% (**FIGURE 2, APPENDIX B**). This indicated an inability of the patient to distinguish his left from his right side, suggesting that cortical reorganization (**APPENDIX A**) had occurred in the somatosensory cortex and primary motor cortex in the brain due to his LBP.[2] Low back pain due to central sensitization was confirmed, based on the patient's history, the cyclical pattern of pain, and the patient's misconception of pain.

TREATMENT
Pain Neuroscience Education

At initial evaluation, the patient was educated on the role of the brain in pain processing. He was instructed to watch videos of Dr O'Sullivan interacting with a patient named Jack, who had debilitating LBP, and of Dr Moseley discussing his experience with pain after a snake bite.[13,18] The videos facilitated the patient's PNE and, at a follow-up appointment, he commented that when he watched someone pick something up his back would hurt. He also held multiple negative beliefs about his back, including that his back was fragile and injured, that pain meant damage was occurring, that he needed to be cautious with his back after surgery, and that he feared LBP due to a family history of LBP. Last, at a subsequent follow-up the patient watched another video, "Understanding Pain in Less Than 5 Minutes, and What to Do About It!"[34] and was educated using Dr Louw's "Why Do I Hurt?" story flash cards (Why You Hurt: Therapeutic Neuroscience Education; International Spine & Pain Institute, Louisville, KY), which explain pain science in patient-friendly terminology and metaphors.

Graded Motor Imagery: Laterality Recognition

At initial examination, the patient was advised to use Recognise (Neuro Orthopaedic Institute) to improve his ability to discern laterality of the back. The patient demonstrated minimal improvement in his laterality recognition scores (less than the 80% threshold) at the second follow-up. Prior to the third physical therapy visit, the patient reported that after becoming frustrated with consistently low scores, he watched his wife perform the laterality recognition in Recognise. By the third visit, the patient improved his ODI score (a decrease of 10%), and his laterality recognition accuracy was greater than 90% (**FIGURE 2**).[9] The patient noted a dramatic change in performance on laterality recognition testing after watching his wife use Recognise. The patient was educated based on the Neuro Orthopaedic Institute website (https://www.noigroup.com/) recommendations on how to progress or regress using the application.

Graded Motor Imagery: Explicit Motor Imagery

Explicit motor imagery was performed by having the patient think of other

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FIGURE 1
Timeline of events leading up to current physical therapy.

10 years ago: back pain started

5 years later: lumbar discectomy/ laminectomy surgery

1 year post surgery: back pain and radicular symptoms return

Pursuit of various health care providers

Physical therapy: June 2019

FIGURE 2
Outcome measures.

Abbreviation: ODI, Oswestry Disability Index.
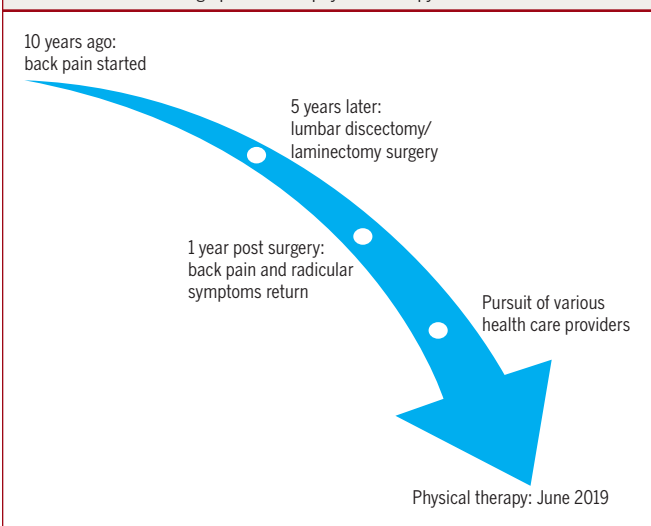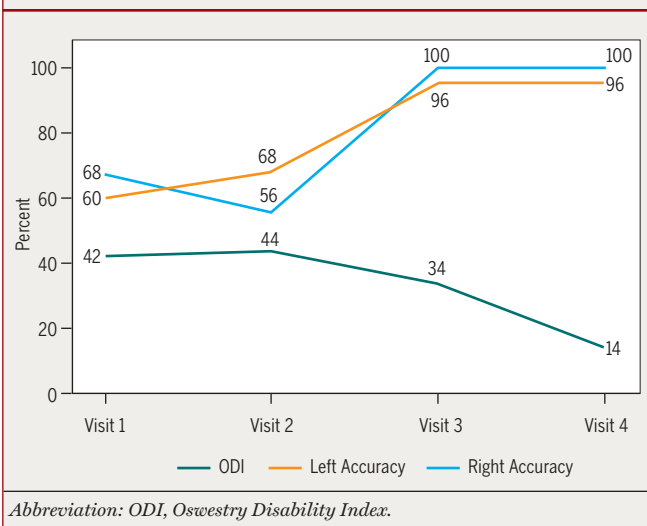
people performing lumbar flexion movements that were nonthreatening to him. This was initiated by discussing multiple real and fictional situations of people bending at the low back without pain. Examples used included Homer Simpson picking up a donut, James Bond picking up a gun, and a toddler picking up his rattle.[11,12] The patient performed EMI on his own for 5 minutes every day during his lunchtime. This was progressed to him thinking of himself performing pain-free lumbar flexion movements in various situations.

Stress/Anxiety Management

He was educated on stress/anxiety management strategies using the Headspace application (Headspace Inc, Santa Monica, CA), as his LBP seemed worse in times of stress. Diaphragmatic breathing was also taught in multiple positions, including in prone and hook-lying.[22]

Graded Exposure/Therapeutic Exercise

Graded exposure exercises into pain-free lumbar flexion were initiated and progressed as the patient was able to flex at the lumbar spine without engaging his trunk-stabilizing muscles.[4] As the patient's pain levels and ODI score decreased, strengthening exercises were added.[24] Finally, the patient was encouraged to walk for 15 minutes every day for cardiovascular exercise and to increase that time by 5 minutes every week, as long as his pain did not increase.

OUTCOME AND FOLLOW-UP

The patient was followed for 4 formal physical therapy visits (**APPENDIX B**). The patient yielded substantial, clinically meaningful changes in ODI and FABQ scores and demonstrated more positive thoughts about his back. For the full patient perspective, see **APPENDIX C** and the **VIDEO**.

DISCUSSION

By mastering each stage of GMI and incorporating other multimodal treatments, the patient was able to decrease his pain levels, his disability based on the ODI, and his fear of movement based on the FABQ in 4 visits. This case is unique, because of the aforementioned "monkey see, monkey do" approach to improving laterality recognition scores and helping drive the progression of treatment. Our case suggests that when a patient has plateaued at a laterality recognition level of less than 80% accuracy, watching a person successfully perform the laterality recognition exercise may help improve scores. The idea of "monkey see, monkey do," or gaining a skill by watching someone else, is not new to physical therapy. Physical therapists commonly demonstrate neuromuscular control exercises (eg, single squat, lunge) to patients for optimized skill acquisition, which is known as "modeling." Modeling may be important when initially learning a task, as it provides the patient with a reference for the task[16] and sensory input to formulate a schema for execution of the skill or task.[1,5,10-13,17, 30] Further, modeling may involve mirror neurons, which are used in the observation and execution of movement.[17]

This case report described the unique use of laterality recognition using the "monkey see, monkey do" approach in treating a patient with chronic LBP, along with the second stage of GMI, PNE, graded exposure, and stress management exercises. Although our findings are limited to a case report, they support previous research that GMI and PNE can lead to altered brain schemas or processing in the premotor cortex and somatosensory cortex, ultimately improving perceived pain reports, function, and disability.[2-4,19,21,27,29,31]

Learning Points

- When patients have difficulty progressing with laterality recognition, observing someone with no deficits (greater than 80% accuracy) perform the given task may help to improve laterality scores.
- Ten years of failed intervention for this patient might have been avoided if the concept of PNE had been more widely understood and practitioners had been more familiar with executing those interventions at the correct time and with the right patient.
- Modeling GMI and laterality training may be worth further investigation to see whether they can help to improve outcomes for appropriate patients. ■

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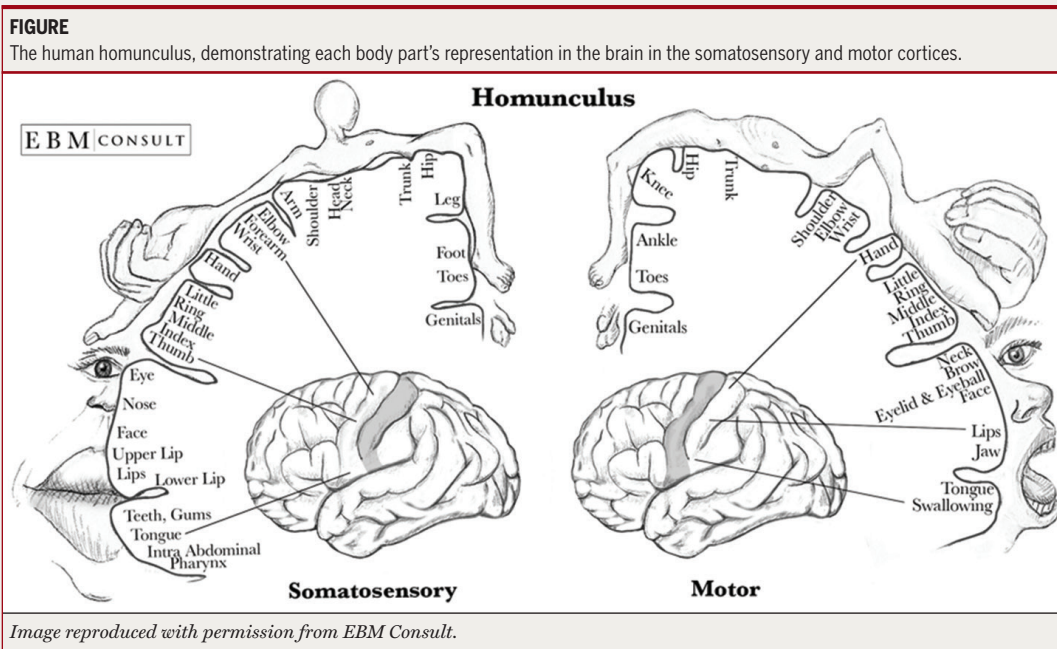
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APPENDIX A

CORTICAL REORGANIZATION EXPLAINED

Cortical reorganization, while not well understood, is best explained using the homunculus (**FIGURE**). The homunculus is a specific area of the brain that represents the sensory and motor aspects of the different body regions. Normally, the brain has an allotted area for each body part along the cortex.[2,30] When in pain, due to the changing sensory inputs to the brain, the area of the body represented in the homunculus can change, resulting in cortical reorganization, which can affect the output of pain. While this concept is not well understood in low back pain, brain imaging studies in chronic low back pain populations have demonstrated cortical reorganization changes in the area of the brain representing the back the longer patients have been in pain.[6,15,27,29,32] Laterality recognition is a way to identify and start to treat this cortical reorganization. Normative values for laterality recognition, according to the Neuro Orthopaedic Institute, indicate that a score of less than 80% accuracy is suggestive of cortical reorganization occurring to the primary sensory and motor cortices.

FIGURE
The human homunculus, demonstrating each body part's representation in the brain in the somatosensory and motor cortices.

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APPENDIX B

TABLES

OBJECTIVE MEASURES FROM EVALUATION

AROM (% of normal)	Strength Testing (MMT)	Accessory Mobility Testing	Balance Testing	Neurological Screen
100% in all directions[a]	5/5 on all lower extremity muscle tests	Not tested[b]	No deficits noted[c]	Cleared: no deficits noted

Abbreviations: AROM, active range of motion; MMT, manual muscle testing.
[a]*In flexion, the patient had high activation of the abdominal muscles.*
[b]*Not tested because the patient had full AROM.*
[c]*Single-leg balance test, 30 seconds with eyes open.*

OUTCOME MEASURES

Visit	ODI, %	Laterality Accuracy, %		Time, s		FABQ-PA	FABQ-W
		Left	Right	Left	Right		
1	42	60	68	0.7	0.6	20	16
2	44	68	56	2.5	2.0	...	...
3	34	96	100	1.5	1.4	...	...
4	14	96	100	1.5	1.4	12	9

Abbreviations: FABQ, Fear-Avoidance Beliefs Questionnaire; ODI, Oswestry Disability Index; PA, physical activity subscale (0-24); W, work subscale (0-42).

TREATMENT PROGRESSIONS, WITH SUBJECTIVE REPORTS

Visit	Treatment	Patient's Subjective Statements
1	• Education: back bends, use of lumbar roll, move every hour • Education videos on pain[13,18] • Laterality recognition via Recognise application (basic level)[a]	"My back will give out just walking. I will be bedridden for days."
2	• Discussed videos and beliefs about his back • Laterality: basic level continued • Explicit motor imagery: patient imaging (Homer Simpson, James Bond, and toddler performing different lumbar flexion movements)[11,12] • Initiated graded exposure: single knee-to-chest in supine	"My back is fragile. When I have pain, it causes damage."
3	• Watched video[34] • Dr Louw: pain quiz and "Why Do I Hurt?" education system[b] • Progressed laterality: vanilla level • Continued with visit 2 explicit motor imagery • Stress management introduced: Headspace application[c] • Progressed graded exposure: double-leg squat • Initiated McGill's[24] 3 big core exercises: side planks, bird dog, and modified curl-up • Encouraged cardiovascular exercise via walking for 15 min every day	"I don't have pain using a sledgehammer. Getting into/out of the car is better."
4	• Laterality regressed: context level • Progressed explicit motor imagery: patient performing nonthreatening lumbar flexion movements • Graded exposure: progressed to double knee-to-chest in supine	"I can lift 100-lb slabs of maple tree. I can perform double knee-to-chest now."

[a]*Neuro Orthopaedic Institute, Adelaide, Australia.*
[b]*Why You Hurt: Therapeutic Neuroscience Education, International Spine & Pain Institute, Louisville, KY.*
[c]*Headspace Inc, Santa Monica, CA.*

APPENDIX C

FULL PATIENT NARRATIVE: UNEDITED

As a male at the age of 17, I had my first episode of back pain. The pain caused me to be bedridden for a few days but returned to normal. Within a year, I repeated the same symptoms and scheduled a visit with my doctor. They performed a few X-rays and reviewed my family history. They determined I had degenerative disc disease, with a possibility of a herniation. I was prescribed some painkillers, along with a muscle relaxer. Being 18 years old, I bounced back quickly, and soon the pain was gone. Over the next 10 years, I would have the debilitating pain, but with increased frequency. In those 10 years, I was in physical therapy for 90% of the time while being on and off pain medication. With multiple MRIs and X-rays, it was determined that I had a herniated disc in my lower back that was causing pressure on my sciatic nerve. I had a discectomy and laminectomy on my lower levels in 2014 at the age of 29.

I woke up from surgery feeling better but with a very guarded mentality towards my surgical site. In the hospital, I learned how to bend and turn without stressing my lower back. This included getting in and out of the car, lifting things, and getting in and out of the shower. As time progressed, I never stopped being guarded, so much that I would not attempt to do anything that put me at risk of hurting my back.

Within a year, the pain that I thought was gone would return. Over the next 4 to 5 years, it would increasingly get worse. With additional MRIs, it was confirmed I had another minor herniation in my lower back. Another round of surgery was suggested. To confirm that the nerve was being aggravated, an EMG was performed. The EMG came back negative for any nerve issue, but the doctors still wanted to do another surgery. I decided to get another opinion.

In 2019, I found Dr Mansfield at OSU Sports Medicine. My first visit with Dr Mansfield was very unique from the 10-plus years of therapy. I did zero stretching and no strength training the first day. Instead, he had me explain my symptoms and past history. I realized, by talking it over with him, that I was able to do certain things without injury but much more minor things would cause me to be crippled. For example, I could stack firewood or carry concrete bags up a flight of stairs with no issue. However, if I walked on concrete floors or bent over to tie my shoes, I would be crippled for the next week. He noticed that I was very tight or guarded when I moved. My reason was that I was structurally damaged and had to protect my back. My mind had programmed itself to believe that any feeling in my lower back meant injury, so any time I felt the slight muscle soreness I would lock up.

Dr Mansfield explained that the body does not sense pain; it instead sends a signal to the brain. The brain's job is to determine what the signal means. My brain had programmed itself to see any signal from my back as pain, and it would go into guarding itself. It's hard to hear that your brain is tricking you into being hurt when you feel so hopeless and not in control of the pain or trigger points. He explained that the pain is very real, but misguided. He had me do some movements and realized my range of motion was fine. He also made me realize that my MRIs and EMG confirmed that nothing structural was going on in my back. However, when you feel it, it's hard to deny. He had me watch a presentation by Dr Moseley, which talked about how your brain looks for past events to determine the meaning of a signal it receives. It can be tricked into feeling something that's not accurate. An example would be feeling something cold but believing you are being burned. My brain was looking back on 10 years of pain and kept that programming even when it wasn't accurate. So Dr Mansfield's job was to begin reprogramming a stubborn brain.

We began by me imagining nonthreatening movements and calming myself a few times a day. This meant taking an hour or so a day to relax and think through motions that I thought were threatening to my back. Through this process, I was able to begin to bend over without thinking, "I could get hurt." I realized that when I disassociated my movements from pain, I was able to have a wider range of motion pain free. As progress continued, we began doing movements and exercises that I previously thought would injure me. At a slow pace, these movements became much more natural and progressed into my everyday. I still have flare-up of pain, but with some simple stretching I can get through the episode within a day. I am not completely healed by any means, and every day I have to remind myself that my back is not structurally damaged. However, my health is trending in an upwards direction.

One of the biggest moments for myself was when my wife and I did some yard work. The next day, my back was very sore. My initial thought was that I was hurt because this was my normal response in the past. I then heard my wife say that her back was sore as well. I realized that my soreness was a natural response to just being out of shape and aging. Without a doubt, Dr Mansfield's therapy has changed my life for the better. I still have work to do, but I believe I have the tools to do it now.