Seeing is Believing: Application of Mental Practice to Affected Arm Rehabilitation

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Departments of Rehabilitation Sciences, Physical Medicine & Rehab., Neurosciences, Neurology; Greater Cincinnati/N. Kentucky Stroke Team; University of Cincinnati Academic Medical Center
- Greater Cincinnati/Northern Kentucky Stroke Team
- One of the largest stroke teams in the US
- Numerous firsts in Cincinnati
  - tPA
  - NIH Stroke Scale
  - First interdisciplinary stroke team
  - First ER helicopter service
  - Numerous drug and device firsts
  - The Epidemiology of stroke – since 1993
- www.rehablab.org
  - Leg & arm studies @ Drake Center
- Drake Center; a 300+-bed rehabilitation hospital in Cincinnati
Some of our core philosophies...

- **Therapies your mom can use**
  - Accessible, easily implemented, and evidence-based
  - K.I.S.S. (Keep It Simple Stupid)

- **We take the “rejects”**
  - “plateaued”
  - run out of insurance
  - Are “too far” post stroke for recovery to occur
Plasticity 101
Plasticity

Traditional view:
- “static” brain
- Change can only occur in younger individuals

Plasticity - the central nervous system is not “hardwired” but, rather, responds to functional/environmental demands.
- OCCURS EVEN MANY YEARS POST INSULT!!!

Use-dependent plasticity – the brain allocates resources based on needs in the environment
- Caveat: Practice must be repetitive and challenging
- Receptors – synaptic transmission becomes stronger or weaker according to use
- Individual cells are able to vary structure and function according to behavioral needs (Edelman, 1987)

PRACTICE => PLASTICITY => FUNCTION/BEHAVIOR
Practice and plasticity of the intact human brain

- Use dependent reorganization – Cortical maps differ in ways that reflect their use

- Jenkins et al., 1990 (FIGURE) – repetitive use of 2nd, 3rd, 4th fingers caused cortical expansion of these fingers
The conundrum after stroke...

Our patients require repeated practice to facilitate plasticity, but:

- Diminishing rehabilitative contact, due to managed care
- Increasing patient:therapist ratio
  - 3:1 or 4:1
- Acute/subacute - 8.1% of the day in PT = 39 minutes (Keith, 1987)
- Only 36 min./day pts. In contact w. therapist (Lincoln et al., 1996)
- Many hours spent doing nothing (Lincoln, et al. 1996)
- Patients often discharged home and do little, have few resources and/or family support to really practice in a meaningful way that will drive plasticity

In short, the very thing they need (practice) is frequently tough to acquire!!
Mental Practice and Stroke

“…because ‘HEP’ doesn’t stand for hand ‘em photocopies”
Mental practice and stroke

- Same musculature activated during MP as during PP
- Parts of brain are activated during imagery as if actually performing movement (FIGURE)
- Repeated practice => brain reorganization => improved motor function
- So, over time, repeated MP use should have a practice effect
MP has a rich neurophysiologic history:

- Since the 1930’s, MP has been shown to activate the same musculature as physical practice

- Then, EMG studies

- Then, studies showed that the same vegetative response (e.g., heart rate, respiration) occurs during MP as during PP

- Finally, neuroimaging
Brain activation during execution and motor imagery of novel and skilled sequential hand movements.

LaCourse MG, Orr EL, Cramer SC, Cohen MJ

Neuromotor Rehabilitation Research Laboratory, Long Beach Veteran's Affairs Healthcare System, CA 90822, USA. mlacours@csulb.edu

This experiment used functional magnetic resonance imaging (fMRI) to compare functional neuroanatomy associated with executed and imagined hand movements in novel and skilled learning phases. We hypothesized that 1 week of intensive physical practice would strengthen the motor representation of a hand motor sequence and increase the similarity of functional neuroanatomy associated with executed and imagined hand movements. During fMRI scanning, a right-hand self-paced button press sequence was executed and imagined before (NOVEL) and after (SKILLED) 1 week of intensive physical practice (n = 54; right-hand dominant). The mean execution rate was significantly faster in the SKILLED (3.8 Hz) than the NOVEL condition (2.5 Hz) (P < 0.001), but there was no difference in execution errors. Activation foci associated with execution and imagery was congruent in both the NOVEL and SKILLED conditions, though activation features were more similar in the SKILLED versus NOVEL phase. In the NOVEL phase, activations were more extensive during execution than imagery in primary and secondary cortical motor volumes and the cerebellum, while during imagery activations were greater in the striatum. In the SKILLED phase, activation features within these same volumes became increasingly similar for execution and imagery, though imagery more heavily activated premotor areas, inferior parietal lobe, and medial temporal lobe, while execution more heavily activated the precentral/postcentral gyri, striatum, and cerebellum. This experiment demonstrated congruent activation of the cortical and subcortical motor system during both novel and skilled learning phases, supporting the effectiveness of motor imagery-based mental practice techniques for both the acquisition of new skills and the rehearsal of skilled movements.

Publication Types:
- Clinical Trial
The therapy:

- Administered by the same therapists in the same environment (although not at the same time)
- Therapists underwent extensive inservicing (videos, testing, literature review) to assure consistency

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<td>Research lab/Weeks 5,6</td>
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Efficacy of mental practice

- MP + Tx versus Stroke information + TX
- Fugl-meyer (Impairment)
  - MP - +13.8
  - CON - +2.9
  - p < .05
- Pilot work in chronic stroke:
  - Reduces affected arm impairment (*Page, 2000; Occ Ther J Res*)
  - Increases affected arm use & fx (*Page et al., 2005; Arch Phys Med Rehabil*)

  Makes using the arm more palatable/real/salient to patients

*Page, et al., 2001; Clin Rehabil*
Comparison of Fugl-meyer Scores

Fugl-Meyer:
MP + Tx: +6.72
R + Tx: +1.0
p < .0001

Page et al 2007; Stroke
Kinematics – another way of measuring improvement
Kinematics – objective, quantitative motor measurement

- Red curve at bottom of slides is elbow angle
- At POST – less tremor in hand; smooth elbow trajectory (red line); completion of movement

Does motor imagery training improve hand function in chronic stroke patients? A pilot study.

Dijkeman HC, Ietswaart M, Johnston M, MacWalter RS.

Heinholz Institute, Utrecht University, Heidelberglaan 2, 3584 CS Utrecht, The Netherlands. H.C.Dijkeman@ neuroscience.uu.nl

OBJECTIVE: To assess the efficacy of motor imagery training for arm function in chronic stroke patients. The relation between mental processes such as attentional and perceived personal control over recovery, and motor imagery was additionally investigated.

DESIGN AND SUBJECTS: Twenty patients with long-term motor impairments (mean two years post stroke), were assessed before and after four weeks of training. Ten patients mentally rehearsed movements with their affected arm. Their recovery was compared with patients who performed nonmotor imagery (n=5), or who were not engaged in mental rehearsal (n=5).

SETTING: Patients were recruited from the stroke database of Ninewells Hospital, Dundee. Assessment and training were performed at the patients' home.

INTERVENTIONS: The motor imagery group was asked to practice daily imagining moving tokens with their affected arm. The nonmotor imagery group rehearsed visual imagery of previously seen pictures. All patients practiced physically moving the tokens.

MAIN MEASURES: The following variables were assessed before and after training: motor function (training task, peg-board and dynamometer), perceived locus of control, attention control and ADL independence.

RESULTS: All patient groups improved on all motor tasks except the dynamometer. Improvement was greater for the motor imagery group on the training task only (average of 14% versus 6%). No effect of motor imagery training was found on perceived or attentional control.

CONCLUSIONS: Motor imagery training without supervision at home may improve performance on the trained task only. The relation between movement imagery, attention and perceived personal control over recovery remained unclear.

MeSH Terms:
- Cerebrovascular Accident/physiopathology
Training mobility tasks after stroke with combined mental and physical practice: a feasibility study.

Malouin F, Richards CL, Devon J, Desrosiers J, Belleville S.

Department of Rehabilitation, Laval University and Center for Interdisciplinary Research in Rehabilitation and Social Integration, Quebec City, PQ, Canada. francine.malouin@rea.ulaval.ca

This study examined the potential of using mental practice (MP) to promote the learning of 2 mobility tasks in persons with stroke. Twelve patients were trained with MP to increase the loading of the affected limb while standing up from a chair and sitting down. Vertical forces were recorded using force plates under each foot and the chair. Changes in the loading of the affected limb and in task duration, immediately after 1 training session and 24 h later, served as outcomes. After training, the loading of the affected limb had increased (P < 0.001) during standing up (16.2%) and sitting down (17.9%), and the improvement remained significant 24 h later, indicating a learning effect. In contrast, the duration of the performance did not change with training. The results indicate that, in the early stage of learning with MP, changes in limb-loading strategies are a more sensitive measure of performance than is speed.

Publication Types:
- Clinical Trial
- Controlled Clinical Trial

MeSH Terms:
MP (more impaired subjects) as a bridge to modified constraint-induced therapy (less impaired subjects)?
Mental practice to move patients along the continuum to mCIT

(Page, Levine, & Hermann, 2007; Am J Occ Ther)

The therapy:

– Administered by the same therapists in the same environment (although not at the same time)
– 3x/week for 6-10 weeks
– Therapists underwent extensive inservicing (videos, testing, literature review) to assure consistency

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### MP + mCIT continued

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<th>MP</th>
<th>mCIT</th>
<th>3-Month Follow-Up</th>
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<tr>
<td></td>
<td>PRE</td>
<td>POST*</td>
<td>Change</td>
</tr>
<tr>
<td>FM</td>
<td>42.5</td>
<td>46.3</td>
<td>+3.8</td>
</tr>
<tr>
<td>ARA</td>
<td>32.9</td>
<td>37.8</td>
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Simplifying MP

Try the following at the clinic…
1. Developing a MP tape...

- Identify valued ADLs for patient
  - Canadian Occupational Performance Measure
    - Forces patient to identify and prioritize valued ADLs
    - Multiple domains – some one may not think of

- Progressive relaxation (5 min)

- MP of one ADL (20 min)
  - Directly (or soon after) tx of the same activity
    - Clumping
    - MP “tweaks” the existing motor schema, but there has to be one there!!
      - juggling
    - Polysensory
    - 1\textsuperscript{st} and 3\textsuperscript{rd} person

- Re-focus into room (2 min)
2. Maximize times when you could administer MP, thereby increasing practice attempts

- Home/homework
  - As an alternative to HEP
  - Shortage of clinical practice attempts
  - Develop a library of ADLs
- Internet
- When patient is waiting for tx
- In acute hospital (in bed)
Final thoughts…

**From a scientific/evidence perspective…**
- Several small RCTs from many groups now suggest MP + PP is superior to PP only in:
  - Increasing UE function
  - Reducing UE impairment, functional limitation
  - Increasing UE use
  - Improves UE kinematics during ADLs
- Optimal dosing now known (Page et al; ACRM, Toronto, next month)
- Neural mechanisms (and the fact that there are neural changes) are now known (Page et al; in press)
- MP can be used as an adjunct to certain therapies
  - mCIT (Page et al; in press); estim (Page et al; Manuscript in preparation)
- Works in the leg too, including home-based programs

**From a practical perspective…**
- MP is cost effective
- MP is non invasive
- MP doesn’t require exceptional personnel, set-up, or equipment
- MP is easy to do, easy for patients to follow, not tiring, etc
The end

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