Mental Practice with Virtual Reality in Post-Stroke Rehabilitation

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Summary and goals

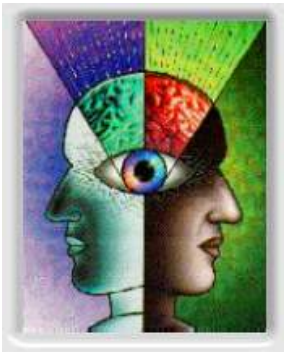
- *Goal*: to investigate the technical and clinical viability of using computer-facilitated mental practice in the rehabilitation of upper-limb hemiparesis following stroke
- *Design*: a series of single-case studies
- *Participants*: 6 patients with chronic hemiparetic stroke (Fugl-Meyer [FM] motor score 6 to 59)
- *Intervention*: 2 VR sessions per week for 8 weeks at the rehabilitation center, in addition to usual physical therapy

Hemiplegia

- hemiplegia is total paralysis of the arm, leg, and trunk on one side of the body
- traditional rehabilitation focuses on passive movement or on compensatory training of the non-paretic arm
- 5–52% of patients regain functional recovery of the upper extremity (Whitall et al. 2000).

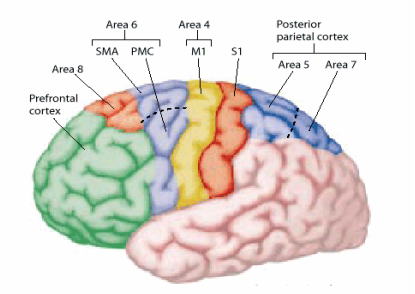
What is mental practice?

- Mental Practice (MP) with Motor Imagery (MI) is a training method that consists in mentally rehearsing a movement with the goal of improving performance
- Sport psychology studies show that combining mental and physical practice is more effective than physical practice alone (Driskell, 1994)



Evidence of functional similarity between imagined and executed actions

- fMRI shows similar cortical activity during real and imagined actions
- temporal correspondence between real and imagined actions (isochronic principle)
- vegetative responses vary in the same manner during both imagery and motor performance
- corticospinal excitability is similar during imagery and actual movement (Lacourse et al., 2004)



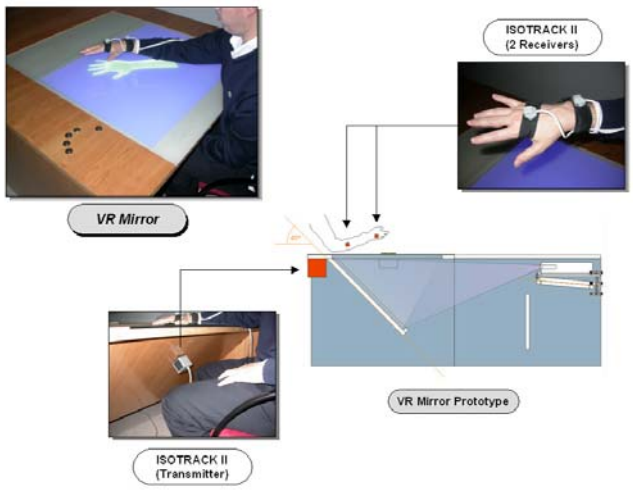
Motor imagery in rehabilitation

- pioneering clinical studies have described the contribution of motor imagery for improving upper limb motor function after stroke (Page et. al, 2002)
- one approach is to use a mirror to simulate the impaired limb moving about succesfully (Stevens et al, 2003)
- the goal is to engage compensatory networks to promote motor rehabilitation (Jackson et al. 2001)

The VR Mirror

1. The movement is recorded from the healthy arm
2. The movement is mirrored and displayed so that the patient can observe and see as if the impaired arm is performing the movement
3. The patient is instructed to mentally rehearse the movement he/she has just observed
4. The patient performs the movement with the affected arm

The VR Mirror: hardware architecture



Home rehabilitation

- patients were provided with a portable display device or a DVD storing pre-recorded movies, picturing the movements to be trained
- after viewing the movies, the patient is instructed to imagine the movement exercise
- exercises are performed on a daily basis

Inclusion criteria

- ✓ CVA onset between 1 and 6 years
- ✓ no cognitive deficits (Mini Mental Status Examination > 24)
- ✓ age 18-85
- ✓ no excessive spasticity or pain in the affected limb
- ✓ completely discharged from all forms of physical rehabilitation
- ✓ ability to image

Participants

- 6 patients with chronic hemiparetic stroke:

Patient	Gender	Age (y)	Time since onset (mo)	Type of stroke	Type of lesion	Motor Emisyndrome	Dominance
RG	M	68	25	ischemic	frontoinsulotemporal/right	left	right
MLR	F	61	27	ischemic	capsular/left	right	right
SS	M	57	20	ischemic	frontoinsulotemporal/left	right	right
LS	M	39	24	ischemic	frontotemporooccipital/right	left	right
GT	M	68	24	ischemic	frontoinsuloparietal/left	right	right
VP	M	46	13	ischemic	semioval centres/bilateral	right	right
Mean		56,5	22,2				
SD		11,8	5,0				
Range		46-68	13-27				

Neuropsychological assessment

Type of Test	Measure
Mini-Mental State Examination (Folstein et al. 1975)	Orientation, attention, immediate and short-term recall, language, and the ability to follow simple verbal and written commands
Vividness of Visual Imagery Questionnaire (Marks, 1973)	Visual imagery ability
Vividness of Movement Imagery Questionnaire (Isaac, Marks, & Russell, 1986)	Kinesthetic imagery ability
Mental Rotation test (Metzler and Shepard 1971)	ability to mentally rotate three-dimensional objects

Clinical protocol (+ 1 Mo home-rehab)

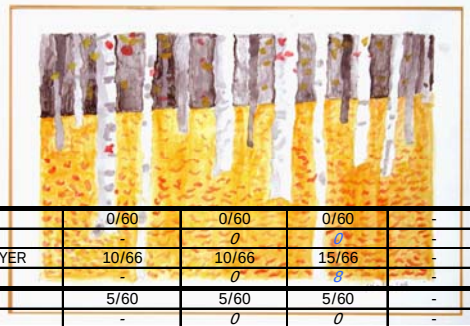
WEEK 1	WEEK 2	WEEK 3	WEEK 4
Session 1 Intervention: ½ hour physical practice; ½ hour VR-aided mental practice *Functional motor assessment*	*Session 3* Intervention: ½ hour physical practice; ½ hour VR-aided mental practice	*Session 5* Intervention: ½ hour physical practice; ½ hour VR-aided mental practice	*Session 7* Intervention: ½ hour physical practice; ½ hour VR-aided mental practice
Session 2 Intervention: ½ hour physical practice; ½ hour VR-aided mental practice	*Session 4* Intervention: ½ hour physical practice; ½ hour VR-aided mental practice	*Session 6* Intervention: ½ hour physical practice; ½ hour VR-aided mental practice	*Session 8* Intervention: ½ hour physical practice; ½ hour VR-aided mental practice *Functional motor assessment*
WEEK 5	**WEEK 6**	**WEEK 7**	**WEEK 8**
Session 9 Intervention: ½ hour physical practice; ½ hour VR-aided mental practice	*Session 11* Intervention: ½ hour physical practice; ½ hour VR-aided mental practice	*Session 13* Intervention: ½ hour physical practice; ½ hour VR-aided mental practice	*Session 15* Intervention: ½ hour physical practice; ½ hour VR-aided mental practice
Session 10 Intervention: ½ hour physical practice; ½ hour VR-aided mental practice	*Session 12* Intervention: ½ hour physical practice; ½ hour VR-aided mental practice	*Session 14* Intervention: ½ hour physical practice; ½ hour VR-aided mental practice	*Session 16* Intervention: ½ hour physical practice; ½ hour VR-aided mental practice *Functional motor assessment*

Testing of motor abilities

- Upper-extremity subsection of Fugl-Meyer Assessment of Sensorimotor Impairment (Fugl-Meyer et al. 1975)
- Action Research Arm Test (Lyle, 1981)
- patients were asked to keep a "Rehabilitation Diary" where they recorded open comments on their experience of care/quality of life during the treatment

Functional improvements after VR Mirror training

Patient	Assessment	Baseline	4 weeks	8 weeks	12 weeks	6 months
VP	ARA	12/60	26/60	29/60	-	-
	%					-
n=13	FUGL-M					-
	%					-
GT	ARA					-
	%					-
n=18	FUGL-M					-
	%					-
MLR	ARA					-
	%					-
n=13	FUGL-M					-
	%					-
LS	ARA	0/60	0/60	0/60	-	-
	%	-	*0*	*0*	-	-
n=16	FUGL-MEYER	10/66	10/66	15/66	-	-
	%	-	*0*	*8*	-	-
SS	ARA	5/60	5/60	5/60	-	-
	%	-	*0*	*0*	-	-
n=19	FUGL-MEYER	14/66	15/66	16/66	-	-
	%	-	*2*	*3*	-	-
RG	ARA	0/60	0/60	0/60	-	-
	%	-	*0*	*0*	-	-
*n=24**	FUGL-MEYER	6/66	7/66	7/66	-	-
	%	-	*2*	*2*	-	-



ARA = Action Research Arm Test
n = number of VR sessions

Discussion

- four out of six of the patients showed progressive reduction in impairment (as measured by the Fugl-Meyer Scale)
- three patients showed marked functional arm improvement
- no control condition to assess the single benefit of:
  - mental practice alone;
  - passive movement observation (Aziz-Zadeh et al. 2002; Loftus et al. 2005)
  - execution of bilateral movements (Lazarus et al. 1995)
  - repetitive training (Feys et al. 1998)

Conclusion and next steps

- VR-aided mental practice is technically feasibile and potentially effective

Why not using a simple mirror?

- VR mirror allows the patient to focus on the simulated movement
- performance feedback
- background images to enhance engagement

References

1. Altschuleret al, (1999) Rehabilitation of hemiparesis after stroke with a mirror, *The Lancet*
2. Garry M.I. et al. (2005) Mirror, mirror on the wall: viewing a mirror reflection of unilateral hand movements facilitates ipsilateral M1 excitability, *Experimental Brain Research* (online)
3. Jeannerod, M., Neural simulation of action: a unifying mechanism for motor cognition. *Neuroimage*, 2001. 14(1 Pt 2): p. S103-9.
4. Jackson, P. L., M. F. Lafleur, et al. (2001) Potential role of mental practice using motor imagery in neurologic rehabilitation. *Arch Phys Med Rehabil* 82(8): 1133-41.
5. Lacourse MG, Turner JA, Randolph-Orr E, Schandler SL, Cohen MJ. Cerebral and cerebellar sensorimotor plasticity following motor imagery-based mental practice of a sequential movement. *J Rehabil Res Dev.* 2004 Jul;41(4):505-24.
6. Page, S.J., et al., A randomized efficacy and feasibility study of imagery in acute stroke. *Clin Rehabil*, 2001. 15(3): p. 233-40.
7. Page, S. J., P. Levine, et al. (2001) A randomized efficacy and feasibility study of imagery in acute stroke. *Clin Rehabil* 15(3): 233-40.
8. Stevens, J. A. and M. E. Stoykov (2003) Using motor imagery in the rehabilitation of hemiparesis. *Arch Phys Med Rehabil* 84(7): 1090-2.
9. Traversa R, Cicinelli P, Bassi A, Rossini PM, Bernardi G. (1997) Mapping of motor cortical reorganization after stroke. A brain stimulation study with focal magnetic pulses. *Stroke*. Jan;28(1):110-7.
10. Whitall, J., S. McCombe Waller, et al. (2000). Repetitive bilateral arm training with rhythmic auditory cueing improves motor function in chronic hemiparetic stroke. *Stroke* 31(10): 2390-5.