Parc de Salut MAR_group

Born in 1983 with the name of Institut Municipal d’Assistència Sanitària (IMAS), today it’s an comprehensive services company which make up a big Healthcare Park with over 2500 professionals.

Size of population served: 260.000
VIRTUAL REALITY BASED TRAINING (REHABILITATION GAMING SYSTEM) ON UPPER LIMB RECOVERY AFTER STROKE

Esther Duarte

Physical Medicine and Rehabilitation
PARC DE SALUT MAR. HOSPITALS DEL MAR I L’ESPERANÇA
initial hemiparesis: 85%  
Wade 1983

persistent functional deficit UL (3-6 m post-stroke): 55-75%

Nichols-Larsen 2005
Lai 2002
Studenski 2002

5-20% complete recovery at 6 mth
Kwakkel 2003
Learned Nonuse of paretic arm

- Chronic patients might tend not to use their paretic limb even though they would be able to perform the task with the paretic limb

- Learned nonuse is a subconscious adapting process

- Nonuse leads to additional loss of motor function
• An estimated 30-60% of adult patients after stroke do not achieve satisfactory motor recovery of the upper limb despite intensive rehabilitation (Lucca 2009).

• TRAINING: Task-oriented / repetitive / meaningful and challenging (Van Peppen 2004).

...the field of new technologies for upper limb rehabilitation is exploding...

Constraint-induced movement therapy
EMG triggered neuromuscular stimulation
Virtual reality (Action observation, Haptic feedback, Robotic interactive therapy)

Brochard S Curr Opin Neurol. 2010
Kalra L. Stroke 2010
How do we get to the source of the problem?

Peripheral manipulation of the skeletal-motor system is expensive, boring, treats the sequels but not the source of the problem...

The brain has the capability to reorganize itself in such a way that alternate brain areas take over other functions.

Karni et al. (1995) Nature
Action Observation:

- Activació del sistema motor por la simple observación de l’acció sense execució de moviment (MIRROR NEURON SYSTEM) 
  *Rizzolatti y Craighero 2004*)

LOC (MONOS): part post del cortex frontal inferior  
part anterior del lóbulo parietal inferior

ACTIVACIÓ: observació acció “intencionada”

Estudis electrofisiològics i de neuroimatge: evidència de l’existència de neurones mirall en humans al cortex premotor ventral, lòbul inf parietal i circunvolució frontal inferior

-MNS activ different body actions (hand, feet, mouth)  
-Meaningful / intentional actions > activation  
-Acquired motor skills of the observer

-MNS: Involvement in mediating empathy and social interaction (observing pain-related emotions in other individuals)

En ictus amb dèficit motor extremitat superior: beneficis de la observació de videus amb accions del braç (Ertelt 2007)

SNM: activació fMRI amb la observació d’agents artificials/robots (Gazzola, Rizzolatti 2007) moviment mà protèsica (Maruishi 2004), mà virtual (Adamovich 2009)

Major activació amb la observació desde la perspectiva de primera persona (Jackson 2006, Alaerts 2009, Lorey 2009)
• Several VR systems have been developed for the RHB of upper limb deficits following stroke (Cameirao 2008).

• VR promises the development of effective rehabilitation environments as it provides rich controllable multi-modal simulation and the possibility for individualization (Cameirao 2010).

• VR is a more effective approach than conventional interventions and achieved more improvement in arm function (Cochrane Database of Systematic Reviews 2011).
## European Commission research projects AAL-2008-1

Proyectos de Investigacion en Tecnologias Sanitarias y Servicios de Salud. **ISCIII Nov.2008**

### Rehabilitation Gaming System

<table>
<thead>
<tr>
<th>Participant no.*</th>
<th>Participant organisation name</th>
<th>Part. short name</th>
<th>Country &amp; Funding Agency*2</th>
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<tr>
<td>1 (Coordinator)</td>
<td>Universitat Pompeu Fabra</td>
<td>UPF</td>
<td>ES</td>
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<td>7</td>
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SPECS: Synthetic, Perceptive, Emotive, Cognitive Systems

Director: Prof. Dr. Paul Verschure

30 members: 6 Post-Doc Researchers, 10 PhD Students, Technical Coordinator, Technical Assistants, Project Management and Funding Development Coordinator, Project Manager Assistant, Administrator, Communication/Audiovisual Technician
• The **Rehabilitation Gaming System** (RGS) exploits the cognitive processes that mediate between perception of action / observation and its execution: this channel can be used to drive effective reorganization of the motor and premotor systems affected by stroke, by recruiting the mirror neuron system (Rizzolatti et al., 2009).

• RGS: bimanual task oriented action execution combined with the observation of virtual limbs that reproduce the executed movement in interactive game scenarios, allowing task-oriented, individual, specific, repetitive and challenging training (Cameirao 2010).

Neurorehabilitation using the Virtual Reality based Rehabilitation Gaming System. Methodology, design, psychometrics, usability and validation.

Cameirão M, Bermúdez S, Duarte E, Verschure P. Journal of Neuroengineering and Rehabilitation. 2010
The Rehabilitation Gaming System - Setup
Methods: Acute Phase

Protocol

- Baseline Evaluation
- Intermediate Evaluation
- Final Evaluation
- Follow-up Evaluation

- Intervention

- 5 weeks
- 7 weeks
- 12 weeks
Evaluation and clinical scales

- Barthel Index
- Motricity Index (upper extremities part), MRC
- Fugl-Meyer Assessment Test (upper extremities part)
- Chedoke Arm and Hand Activity Inventory (CAHAI)
- Modified Ashworth Scale
  - Nine Hole Peg Test
  - Box and Block Test
- RGS data
RGS group presented a steeper improvement and was significantly better than controls at the end of the treatment (week 12).

This effect was not significant at follow-up (week 24).

Cameirão M, Bermúdez S, Duarte E, Verschure P.
Virtual reality based rehabilitation speeds up functional recovery of the upper extremities after stroke: a randomized controlled pilot study in the acute phase of stroke using the Rehabilitation Gaming System
Restorative Neurology and Neuroscience 2011
The combined impact of virtual reality neurorehabilitation and its interfaces on upper extremity functional recovery in chronic stroke patients. We want to investigate the impact on chronic stroke rehabilitation of RGS coupled with different interfaces.

<table>
<thead>
<tr>
<th>Variable</th>
<th>RGS</th>
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<td>Barthel</td>
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<td>10.8±15.6*</td>
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<td>14.0±12.0**</td>
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<td>12.4±13.4**</td>
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<td>3.8±46.1</td>
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</table>

*p<.05, **p<.01, Wilcoxon Test
Current work

- Different interaction devices for chronic patients (n=30)
- 3 wk- period RGS training: better outcomes in motor function and arm activity at wk 12, sustained until month 6
- Comparing motor and functional upper limb time course of gains with RGS therapy in 2 groups of patients: <1 year and >1 year after stroke
  - sustained gains -6 months- in both groups
  - more acute patients present more change
- Home-experiments RCT (n=40)
  - RGS
  - Diagnostics
  - Brain imaging (gTMS) evaluation (before and after)
RGS-home experiments

RGS GROUP: 3 weeks-5 weekly RGS sessions of 20 minutes in home environment. Every session will include 7 min of hitting, 7 min of grasping and 7 min of placing activity.

CONTROL GROUP: patients are instructed to work at home with a standard occupational therapy

Outcomes..... In process

Navigated TSM Cortical mapping studies:

- Differences sound / paretic side
- Differences pre-post in both groups
- No differences RGS / control groups