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Towards evidence based motor system regeneration

Arm rehabilitation using combined technologies: Experiences with stroke, potential for use with MS?

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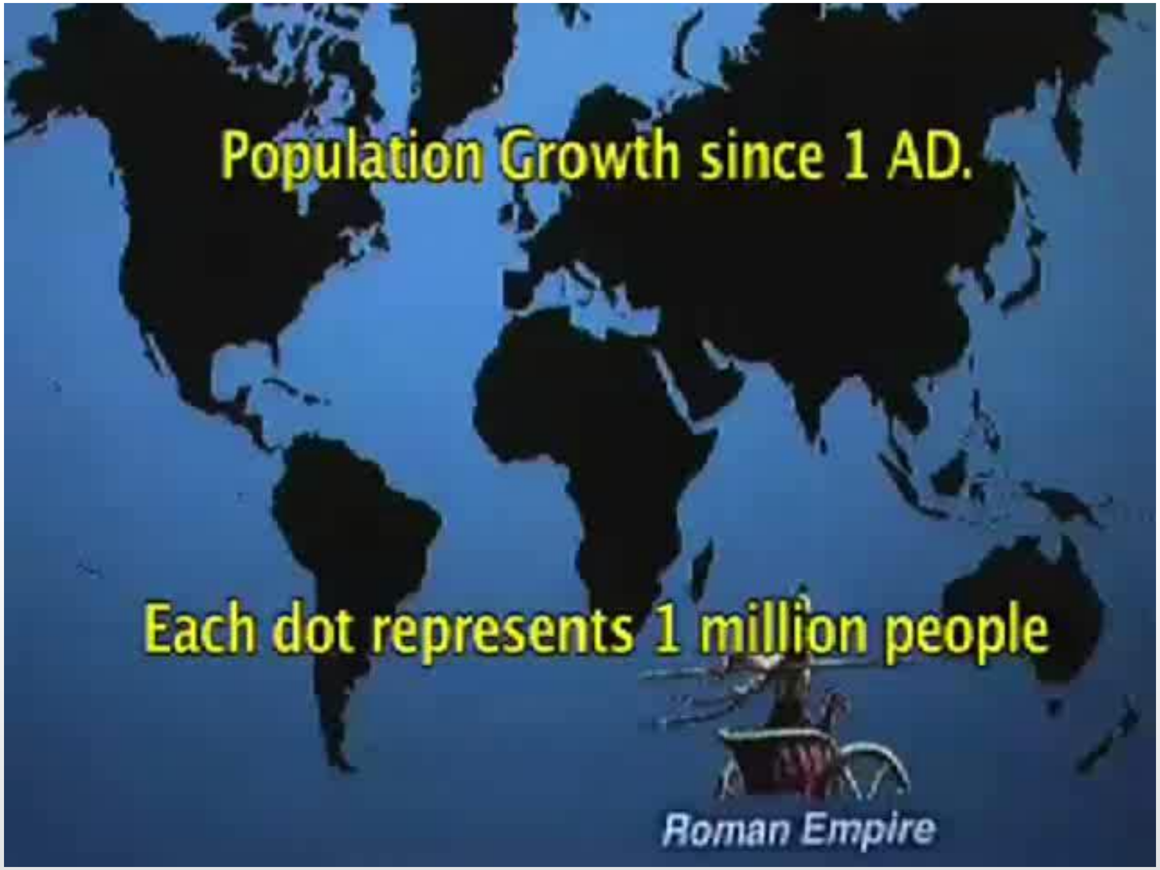
June 2nd 2012 1400-1430

Introduction

- Drivers for technology based rehabilitation
- Rehabilitation – recovery and compensation
- Combined technologies – current studies
- Lessons
- References

Drivers for technology based rehab (1)



Population Connections

Drivers (2)

- Economic costs
- Intensity of practice
- Maximising transfer of skills
- Legislation and guidelines

MS resembles stroke

- Movement deficits can be stable for months–years;
- There is no standard treatment for the movement deficit that follows MS.
- Medical therapy for MS involves medications that control the frequency and severity of MS recurrences, but not specific signs and symptoms
- Recovery from MS – principles are to promote neuroplasticity

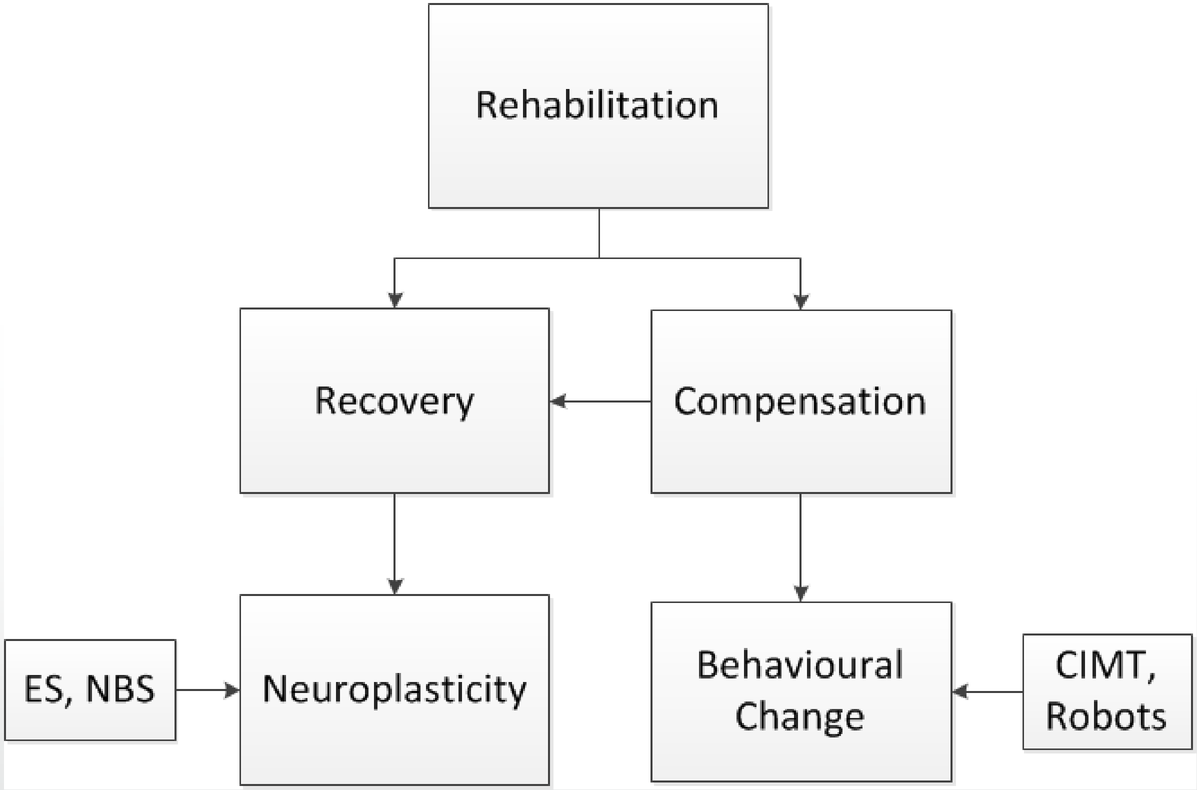
Recovery vs. Compensation

Following an injury a motor task may be performed in:

exactly the same way – RECOVERY (occurs through neuroplastic changes through neuronal activity or connectivity changes).

a different way – COMPENSATION (occurs through abnormal muscle / movement synergies which may or may not enhance function, or lead to behavioral changes, which may also promote neuroplasticity)

How therapies affect rehabilitation



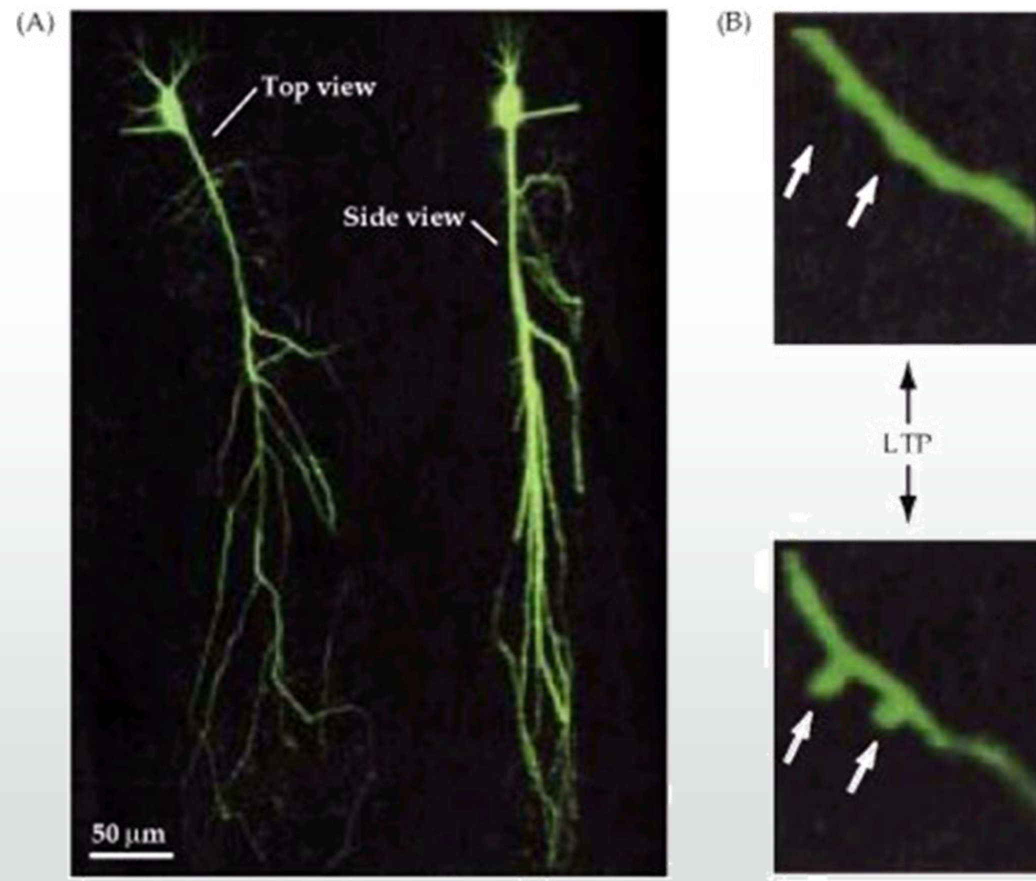
ES – Electrical Stimulation, NBS – Non invasive brain stimulation, CIMT – Constraint induced movement therapy

Neuroplasticity in response to ES

- Axonal and dendritic sprouting and synaptogenesis may provide potential for recovery

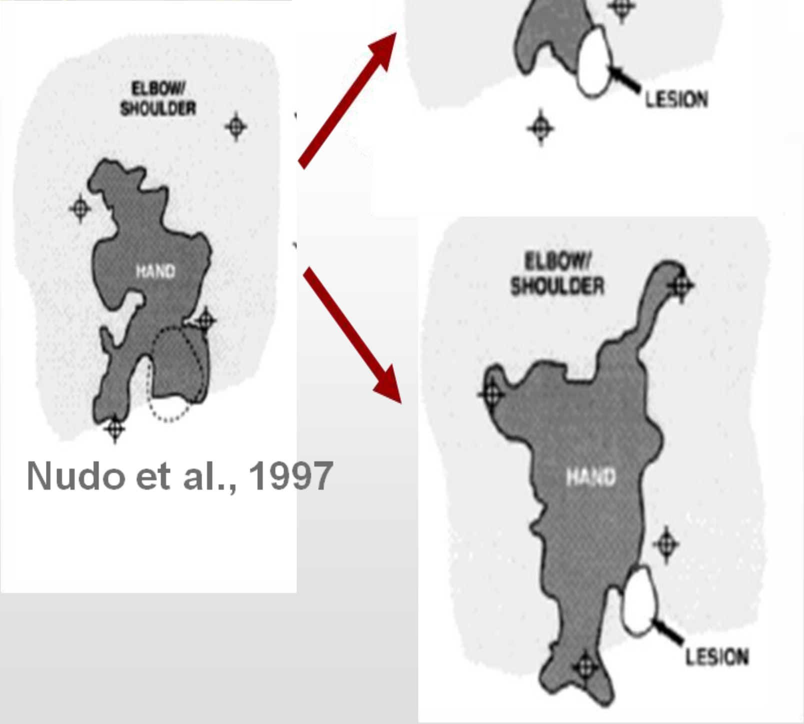
- Functional activities are are required for useful neuroplastic changes to occur

New post-synaptic dendrite spines appearing one hour after stimulation – accompanying synaptic efficiency



Behavioural factors

- To acquire a skill requires:
  - Varied, goal orientated practice
  - Feedback
  - Attention and motivation
- Cortical changes are associated with skill acquisition



Nudo et al., 1997

1. Plautz et al., 2000
2. Nudo,2003

Nudo, 1997

Principles of rehabilitation

- Active role of the patient
- Active problem solving
- Relevance to the individual's problems and goals
- Defined and measurable outcomes

For a technology to be useful in rehabilitation all of the above need to be considered

Robots / ES / TdCS

Evidence - Robots and ES

Robots

- Stroke: Kwakkel et al 2008, Mehrholz 2009
- MS – Carpinella el al 2009, Gijbels et al 2011

ES

- Stroke – Glanz et al 1996
- MS – FES for fatigue, Chang et al 2011

FES for foot drop, Barrett et al 2011

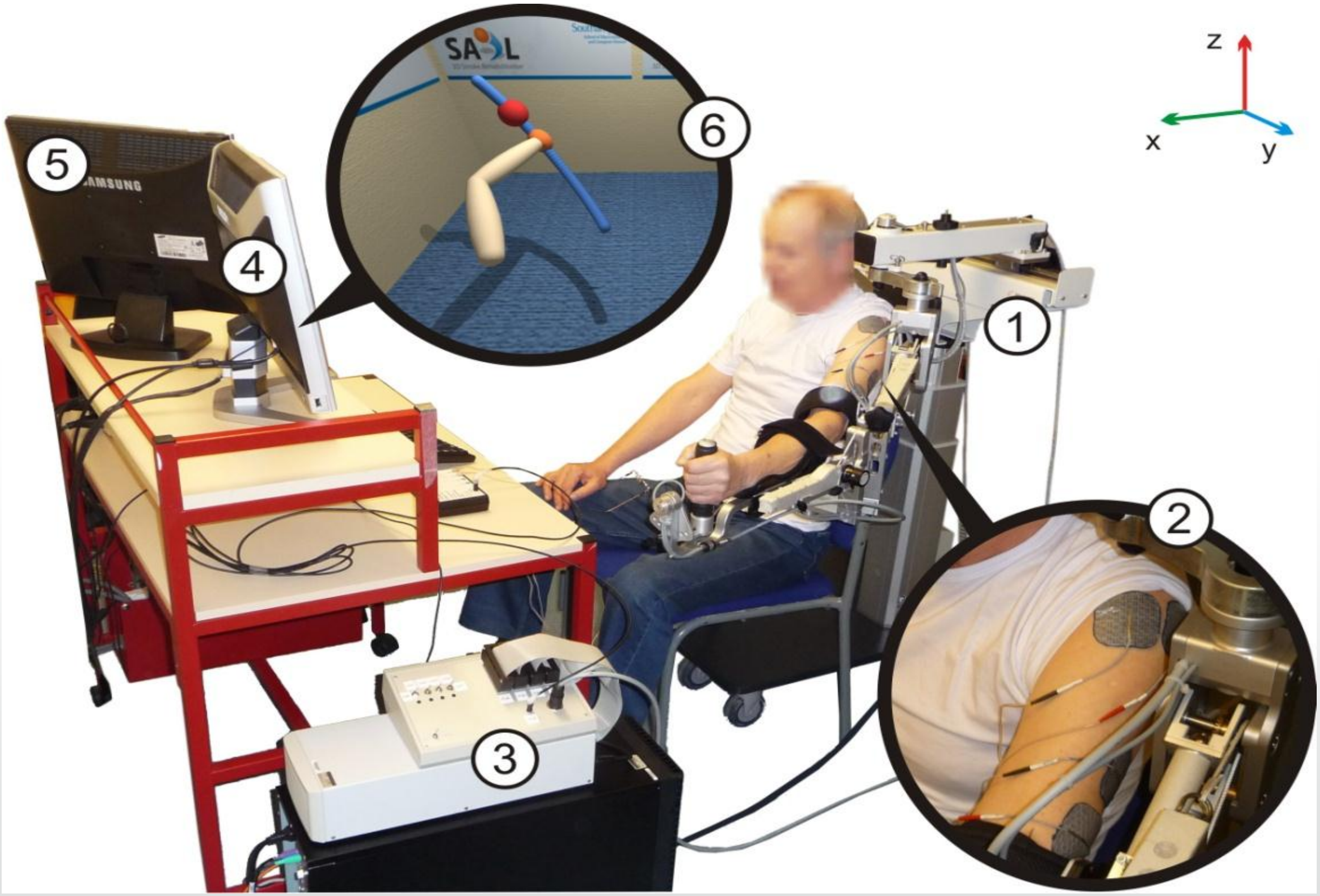
Combining Robots, ES and Iterative Learning Control

- Robot therapy is as effective as intensive therapy (Lo et al 2010)
- ES is most effective when it enhances voluntary effort (de Kroon et al. 2005). However current systems fail to exploit this
- In this study ES was mediated by iterative learning control (ILC) during the performance of VR tasks in an arm robot

SAIL clinical trials (2011)

- Clinical trials with 5 chronic stroke patients comprised 18 treatment session of 1 hour duration over 6-8 weeks
- Outcome measures applied pre and post intervention:
  - Fugl-Meyer and ARAT
  - unassisted tracking for 4 tasks
  - eye-movement monitoring to check for neglect
- Patient perceptions paper to investigate users' views on the system

Meadmore, K L, Hughes, A-M, Freeman, C T, Cai, Z, Tong, D, Burridge, J H and Rogers, E (2012) Function Electrical Stimulation mediated by Iterative Learning Control and 3D robotics reduces motor impairment in chronic stroke. *Journal of Neuroengineering and Rehabilitation*
Meadmore. K., Hughes, A. M., Freeman, C., et al. (2012) Participant Feedback driving change in the design of Stroke Rehabilitation Technologies. *Trans Neural Systems Rehabilitation Engineering*. Submitted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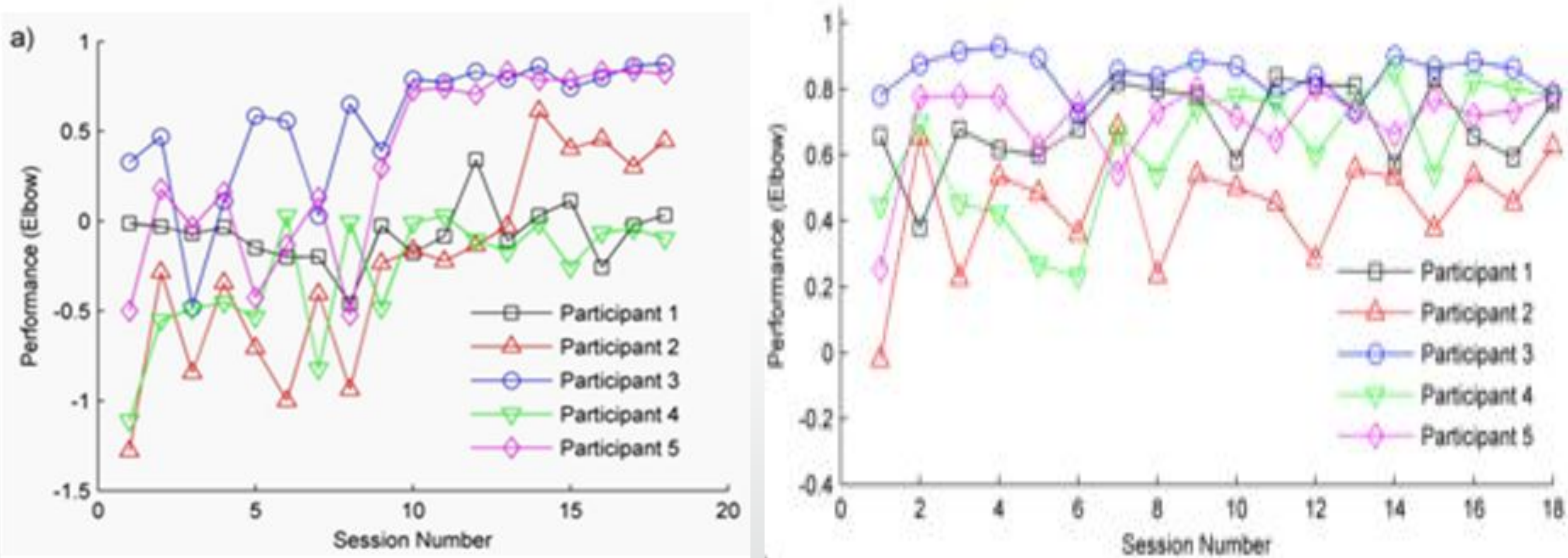
Results: changes in unassisted (a) and assisted (b) tracking



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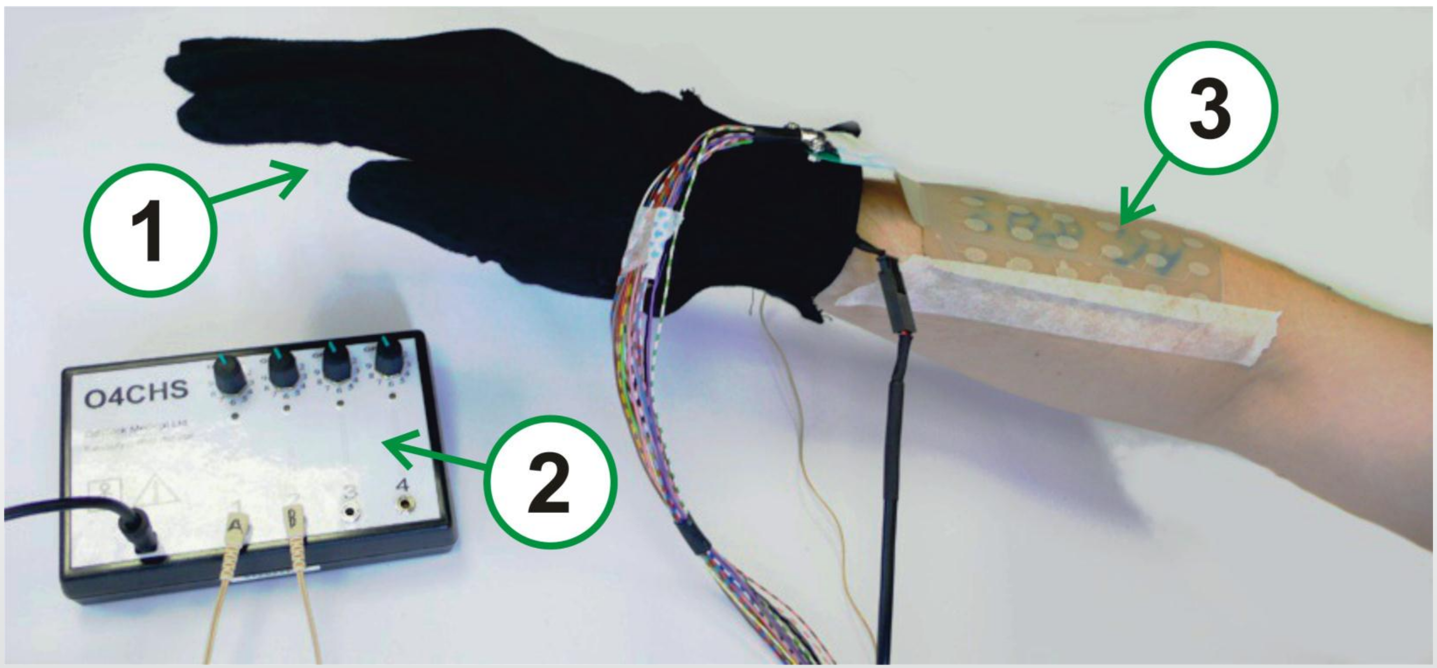
Current pilot work

Real time hardware: 1) data glove, 2) FES stimulator, and 3) electrode array (containing 24 electrode elements)



Transcranial Direct Current Stimulation with MS patients

- Effects of Anodal Transcranial Direct Current Stimulation on Chronic Neuropathic Pain in Patients With Multiple Sclerosis (Mori et al 2010)

tDCS

tDCS with robot therapy

- Double blinded RCT
- Robot therapy / tDCS (Anodal stimulation to affected hemisphere)
- 18 sessions of 20 min tDCS / sham to affected hemisphere during robot training – 1hr 3xweek
- Outcomes: short and long-term changes in cortical excitability, impairment and function

tDCS

tDCS with robot therapy

Inclusion Criteria
Age: 18-80
Time: 2 weeks to 3 months

Number of sites = 7

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Brain-sight – location of the precise area for TMS

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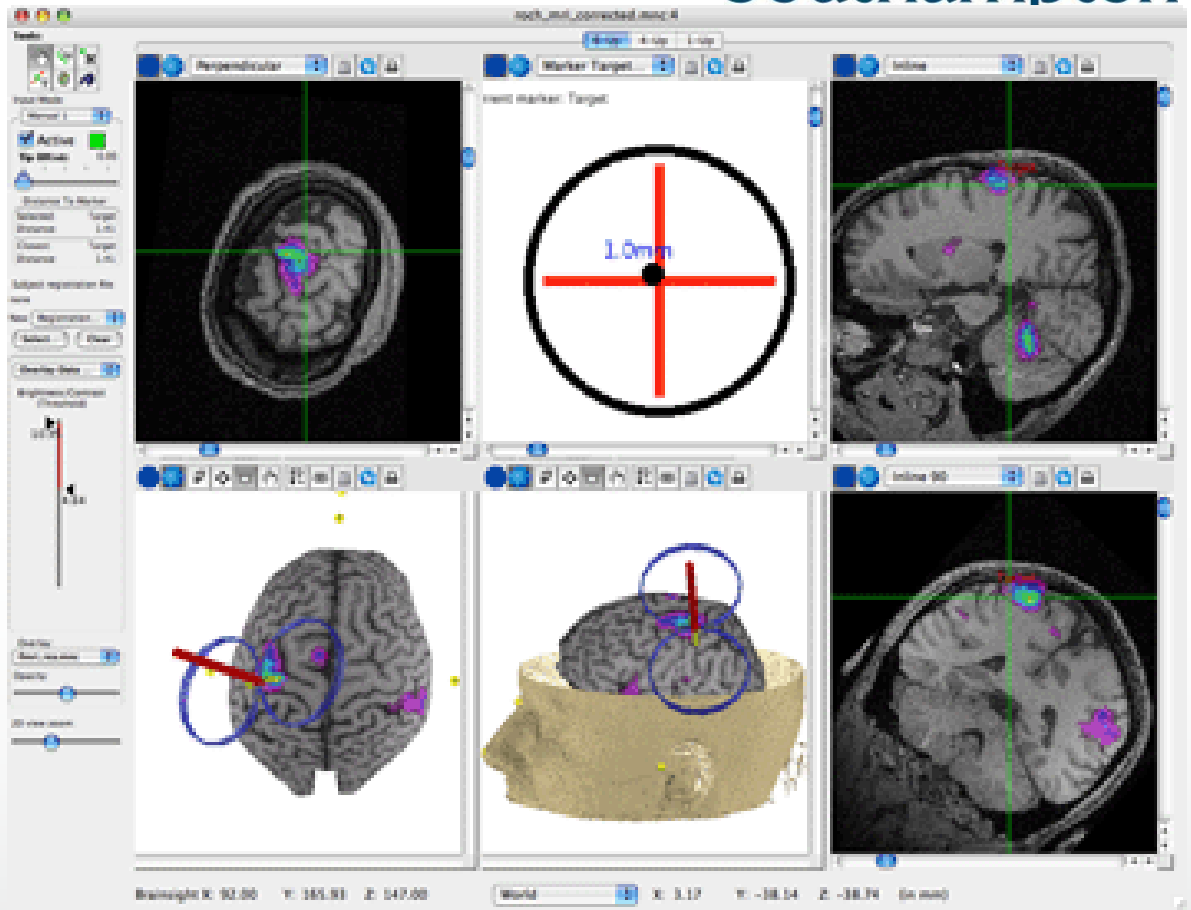
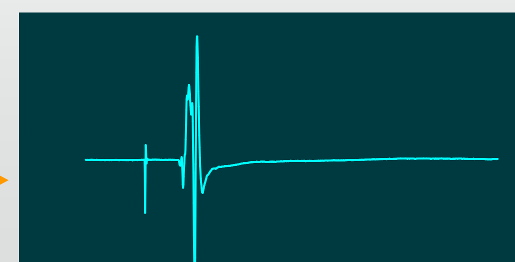
TMS

Images courtesy of Mike Grey





Evidence - CIMT

Stroke: Constraint-induced movement therapy for the upper paretic limb in acute or sub-acute stroke: a systematic review (Nijland et al, 2011)

MS: CIMT can improve hemiparetic progressive multiple sclerosis (Mark et al, 2008)

Methods: 5 progressive MS patients had 30 hours of repetitive task training and shaping over 2-10 weeks
Results: Significantly improved limb use at post-treatment and 4 weeks post-treatment, improved fatigue ratings and maximal movement ability

Improving Hand Use in Multiple Sclerosis

- CIMT vs a set of Complementary and Alternative Medicine (CAM) treatments (yoga, relaxation exercises, aquatherapy, massage
- Feb 2010 – Mar 2014
- Intervention for 2 consecutive weeks, 3.5 hours per day (Monday–Friday), under the direct supervision of a specially trained therapist.
- ClinicalTrials.gov identifier: NCT01081275
- Contact: Victor Mark, MD vwmark@uab.edu

LifeCit

Motivational tool

- Development phase 1 – 6 patients – completed
- Development phase 2 – 12 patients – in progress
- RCT over 9 sites, 40–60 patients – Start July 2012
- Mitt 6–7 hours per day
- Outcome measures: Wolf Motor Function Test

Welcome to LifeCIT

If this is your first time on the LifeCIT website then click this button:

Register

If you already registered with LifeCIT then click this button:

Login

If an existing LifeCIT user has given you a user name and password to view their progress, click this button:

Login

Question 1 of 10

Can you turn a light switch on with your stroke hand?

Please click on yes or no

Yes

No

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Question 1 of 10

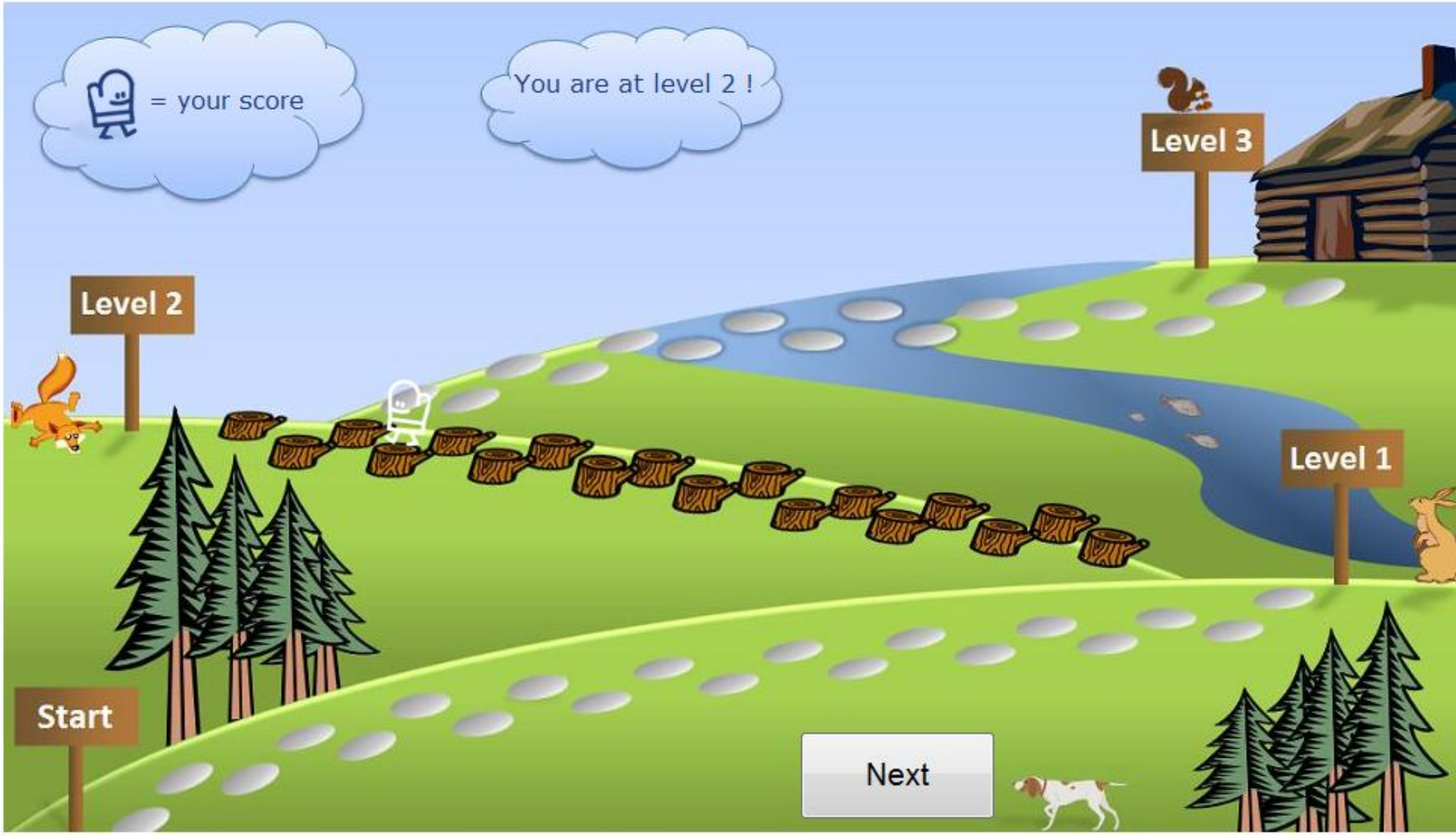
That's great!

How well can you turn a light switch on with your stroke hand?

Click on the ◯ symbol next to the best answer

- ◯ Very slowly, with difficulty
- ◯ Slowly, with some effort
- ◯ Almost normally
- ◯ As well as before my stroke

Back   Next


= your score
You are at level 2 !
Level 3
Level 2
Level 1
Start
Next

For yourself

Select as many activities as you like, from any level, by clicking on the small grey square.
You can de-select an activity by clicking on the grey square again.

Level 1

- ☐ Wash hair
- ☐ Brush hair
- ☐ Apply cream/moisturiser
- ☐ Eat a meal/snack with fingers

Level 2

- ☐ Brush teeth
- ☐ Style hair
- ☐ Pour a cold drink
- ☐ Drink from glass/cup
- ☐ Eat a meal/snack with cutlery
- ☐ Make a phone call

Level 3

- ☐ Shave
- ☐ Put makeup on
- ☐ Prepare a simple meal/snack
- ☐ Open a letter
- ☐ Write a few sentences

Next

Your list of activities for today (06 Dec 2011):

- File bills
- Apply cream/moisturiser
- Eat a meal/snack with cutlery
- Prepare a simple meal/snack
- Dust furniture
- Go food shopping with someone's help
- Unload dishwasher
- Play dominoes
- Go out to play bingo
- Throw and catch a ball

Have you selected enough activities to be busy for 3-4 hours today?

Click here to add more activities: Go back

Print list (if you have a printer)

Email list (if you have an email address)

Text list (if you have a mobile phone)

Open new window (to open a copy of the list to keep for reference)

Click here to continue: Next

Enter your progress

- [x] File bills
- [ ] Apply cream/moisturiser
- [x] Eat a meal/snack with cutlery
- [ ] Prepare a simple meal/snack
- [x] Dust furniture
- [ ] Go food shopping with someone's help
- [x] Unload dishwasher
- [x] Play dominoes
- [x] Go out to play bingo
- [x] Throw and catch a ball

Tick all the activities you have completed today

Next

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Enter your progress

Today I wore the mitt for	0	1	2	3	4	5	6	7	8	9	hours
and	0	10	20	30	40	50					minutes.
Time for activities (with mitt on):	0	1	2	3	4	5	6	7	8	9	hours
and	0	10	20	30	40	50					minutes.

Please type any additional comments about your day here (optional):

Had a good day today - I was able to prepare a sandwich on my own!

Next

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Send a message of encouragement (optional)

Type your name in this box:

Sarah - your therapist

Type your message to zz in this box (4 lines maximum):

Well done for wearing the mitt all week! Keep going!
I'll see you on next Wednesday for your outpatient appointment.
Best wishes,
Sarah

Click here to continue:

Next

Wearable sensor platform with expansion modules

Arm rehabilitation technologies

- Co-designed with patients, carers and clinicians- participant database useful at all stages of research
- Need to be reliable, simple to use, clinically and cost effective
- Driven by an understanding of neuroscience
- Capable of measuring changes and provide feedback
- Enable an increase intensity of practice, whilst being motivating - fun - challenging - sociable
- Need to understand what works for whom, when and why

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- LifeCit: Clare Meagher, Sebastien Pollet, Lucy Yardley

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