Emerging Therapies – Use of Virtual Reality to improve upper-limb function

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for
HemiHelp
23 October 2008
Peterhouse College, Cambridge

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Minimising impact of brain injury/ disease – Can we improve hand function of children with hemiplegia?

Background

The effects of brain pathology/injury during infancy & childhood create:

- **profound developmental consequences for the child,**
- a significant **health and socio-economic burden**,
- Pose a **significant therapeutic challenge** for movement therapists.

Interventions

Treatment Efficacy

Traditional rehabilitation:

- Focuses on **distal movement** problems
- **Minimizing effects** of one-sided weakness

through:

- **Compensatory techniques** or
- **Reducing effects of muscle weakness,stiffness, ROM, atrophy**

Eg. Casting, splinting, BTX

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Interventions Treatment Efficacy

Few methods developed:

- **target** central control of movement/Cognition,
- specifically **treat hand function** and/or
- consider **visual-spatial orientation** & **action prediction**
- consider **anticipatory postural adjustments**

And:

++ Poor patient compliance - limits effects
+++ Poor generalisation to daily living skills
++++Questionable Treatment fidelity – what's working?

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Prospective f/u (Fedrizzi et al 2003)

31 children (16 males, 15 females) with hemiplegia

Comparison of <4 years to > 11 years

Assessments:

Spontaneous use of affected hand

Stereognosis for older children

Grip

- 1cm
- 2.5cm
- 4cm

0= inability

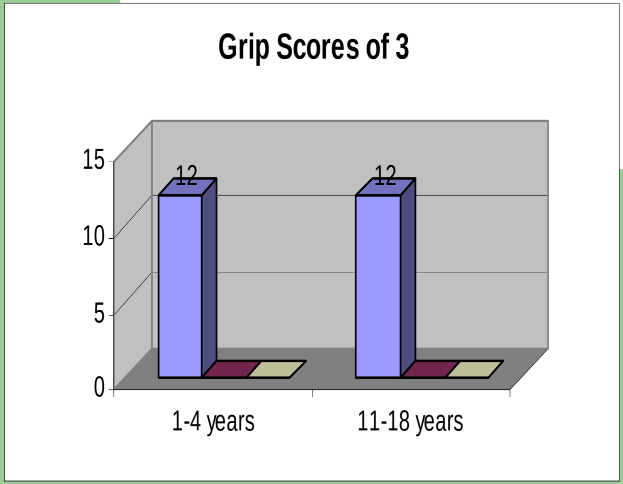
1= whole-hand/stereotyped

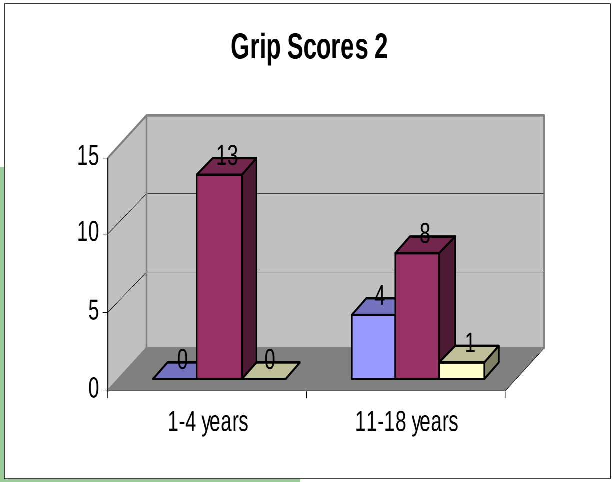
2= radial 3 fingers/impaired manipulation

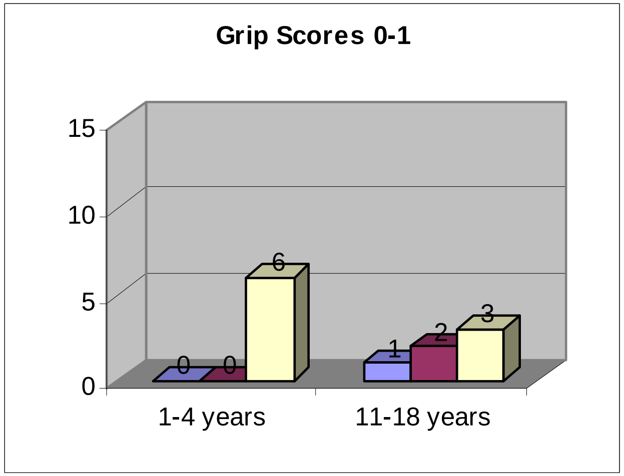
3= pincer/manipulation

Rehabilitation

Prospective f/u (Fedrizzi et al 2003)
Grip Use over time







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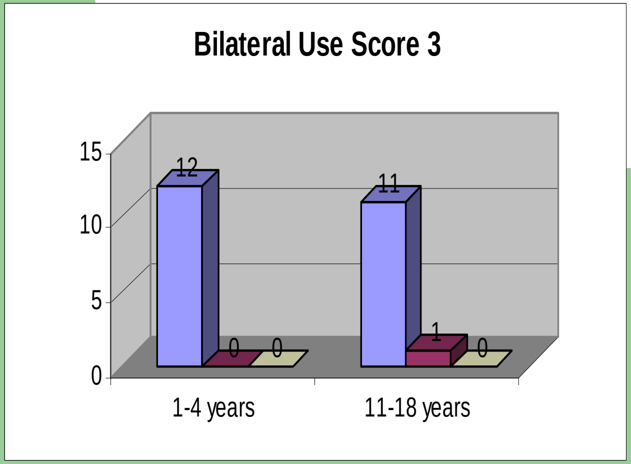
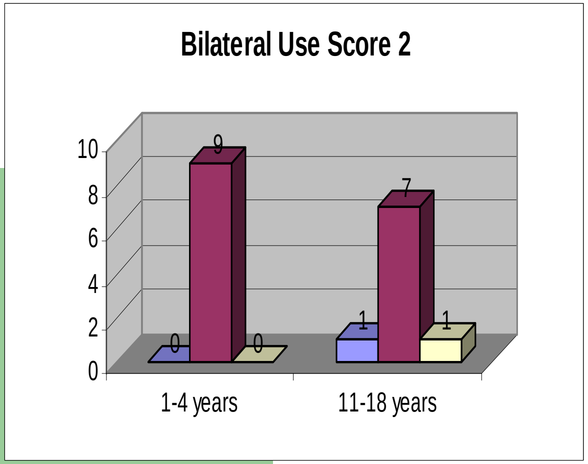
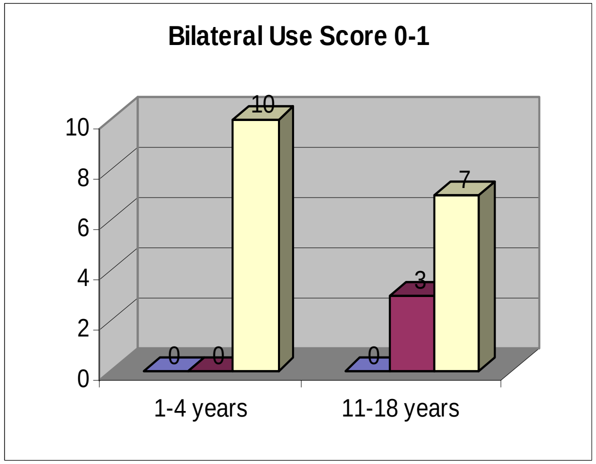
Prospective f/u (Fedrizzi et al 2003)

Spontaneous Hand Use over time







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Prospective f/u (Fedrizzi et al 2003)

Results:

Grip – non significant improvement

Low scores at outset, improvement more marked in grip than spontaneous hand use;occurring mainly in early years

Spontaneous use AH – remained stable

All but one of the children with relatively good grip and sp-use at first Ax maintained this **provided they had treatment**!

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Prospective Rx study (Corry et al., 1997, DMCN, 39 185-193)

14 children with hemiplegia
Randomised, double blind
BTX-A into multiple spastic arm muscles

Investigated: MAshworth, Active ROM, grasp& release empty capsule and transfers of coins

Improvements in:

Range, tone, grasp and cosmetic appearance

Decreased ability:

To pick up coins and No 'functional' benefit

Prospective Rx study (Pearse, Gibson & Eyre, 2008)

50 children with hemiplegia

Randomised, double blind **(BTX-A or Placebo)**

BTX-A into biceps brachii + Occupational Therapy

Outcomes:

Melbourne

Nine Hole Pegboard

COPM

grip strength

Improvements:

Significant for both groups across measures over 6 m

Rate of increase:

Greater in BTX-A group in Melbourne and Pegboard

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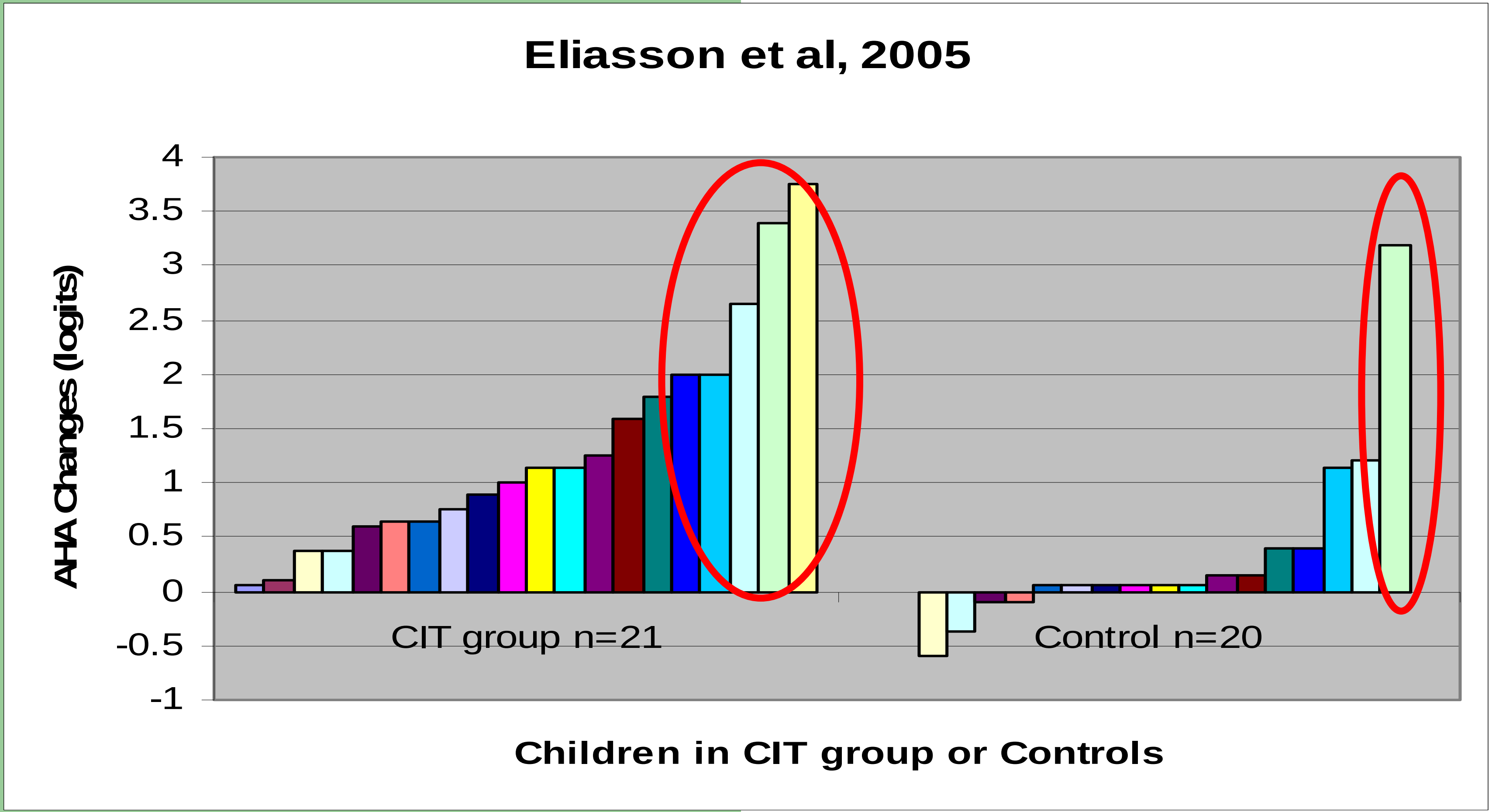

F (2,74 = 5.64, p=0.005

Upper Limb Rehabilitation at ECH

Offered:

BTX injections, serial casting, splinting and/or

Intensive treatment programmes:

Intensive bimanual, MULE and/or CIMt Or DBS/ITB

These interventions are either:

invasive, uncomfortable

repetitive therefore reduced compliance

expensive/scarce resources or **labour**.

Carry inherent risk of reduced progress

Progress does **not generalise to ADL**

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New Interventions for UL function

Engagement
Enjoyable
Targeted
Based on sound theories of motor learning
Include sensory-perceptual components
Require anticipatory planning
Develop cognitive aspects of motor planning for action prediction

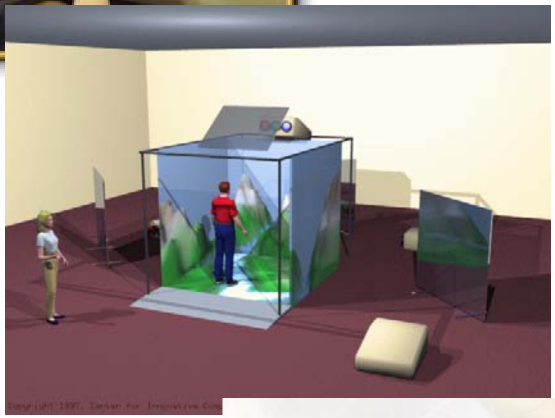
New Interventions for UL function

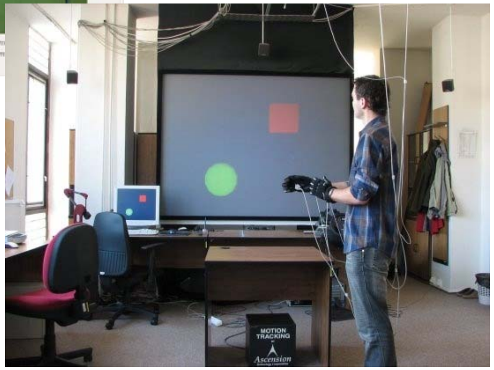
Computerised Music Games
‘Magic’ Hand tricks in UL rehabilitation
Virtual Reality Augmented workspace

Enjoyable
Engagement
Targeted - inter-joint coupling – reach and grasp
Based on sound theories of motor learning
Includes sensory-perceptual challenges
Augments feedback to enhance action prediction
Shapes movement direction and timing
Develops cognitive aspects of motor planning for action prediction

Virtual Reality (VR) has many faces

Virtual Reality (VR) has many faces **(cont.)**





VR is more than head-mounted displays and shoot-’em-up games!

Journal of NeuroEngineering and Rehabilitation
Review **Open Access**

Video capture virtual reality as a flexible and effective rehabilitation tool

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Published: 20 December 2004

Journal of NeuroEngineering and Rehabilitation 2004, **1**:12 doi:10.1186/1743-0003-1-12

This article is available from: http://www.jneuroengrehab.com/content/1/1/12


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Figure 2 Individual with a stroke performing the Wishy Washy application using the Sony EyeToy system.

Cortical reorganization induced by virtual reality therapy in a child with hemiparetic cerebral palsy

Case report

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Virtual reality (VR) therapy is a new, neurorehabilitation intervention aimed at enhancing motor performance in children with hemiparetic cerebral palsy (CP). This case report investigated the effects of VR therapy on cortical reorganization and associated motor function in an 8-year-old male with hemiparetic CP. Cortical activation and associated motor development were measured before and after VR therapy using functional magnetic resonance imaging (fMRI) and standardized motor tests. Before VR therapy, the bilateral primary sensorimotor cortices (SMCs) and ipsilateral supplementary motor area (SMA) were predominantly activated during affected elbow movement. After VR therapy, the altered activations disappeared and the contralateral SMC was activated. This neuroplastic change was associated with enhanced functional motor skills including reaching, self-feeding, and dressing. These functions were not possible before the intervention. To our knowledge, this is the first fMRI study in the literature that provides evidence for neuroplasticity after VR therapy in a child with hemiparetic CP.

See end of paper for list of abbreviations.

Hemiparetic cerebral palsy (CP) is a common neurological condition associated with sensorimotor function and development in children (Ashwal et al. 2004). It often leads to delay in motor development or deconditioning of the affected limbs because of the affected individual's tendency to compensate with the intact limbs rather than attempt to use the involved limbs (Held 2000). Non-intervention or intervention that emphasizes compensatory or a reflex inhibition mechanism contribute to never-learned-to-use (NLTU) or underutilization of the impaired limb (DeLuca et al. 2003) respectively. This may result in suppression of development of cortical representation of the affected limb and further inhibit its functional use (Cicinelli et al. 1997, Liepert et al. 2000).

To help children with hemiparetic CP overcome NLTU or underutilization, various neurorehabilitation therapies have been used including neurodevelopmental treatment (Butler and Darrah 2001), neuromuscular electrical stimulation and dynamic bracing (Scheker et al. 1999), and constraint-induced movement therapy (Liepert et al. 2000, Page et al. 2002), but outcomes have been variable (Butler and Darrah 2001, Page et al. 2002). Of these treatments, constraint-induced movement therapy was found to produce measurable functional motor improvement in a child with hemiparetic CP (DeLuca et al. 2003) and in adults with chronic hemiparesis (see Liepert et al. 2000, Page et al. 2002), but its cost-effectiveness, safety, and issues of compliance (Page et al. 2002) call into question its


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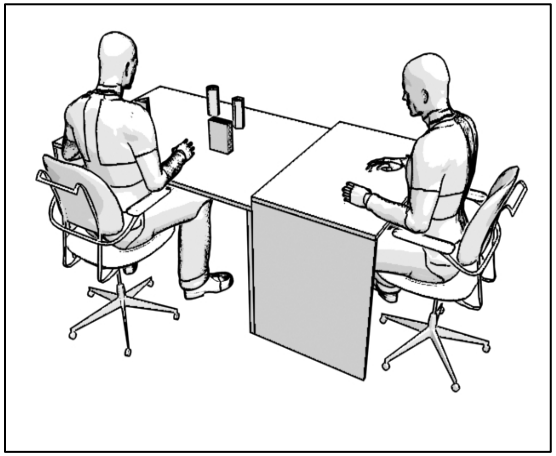
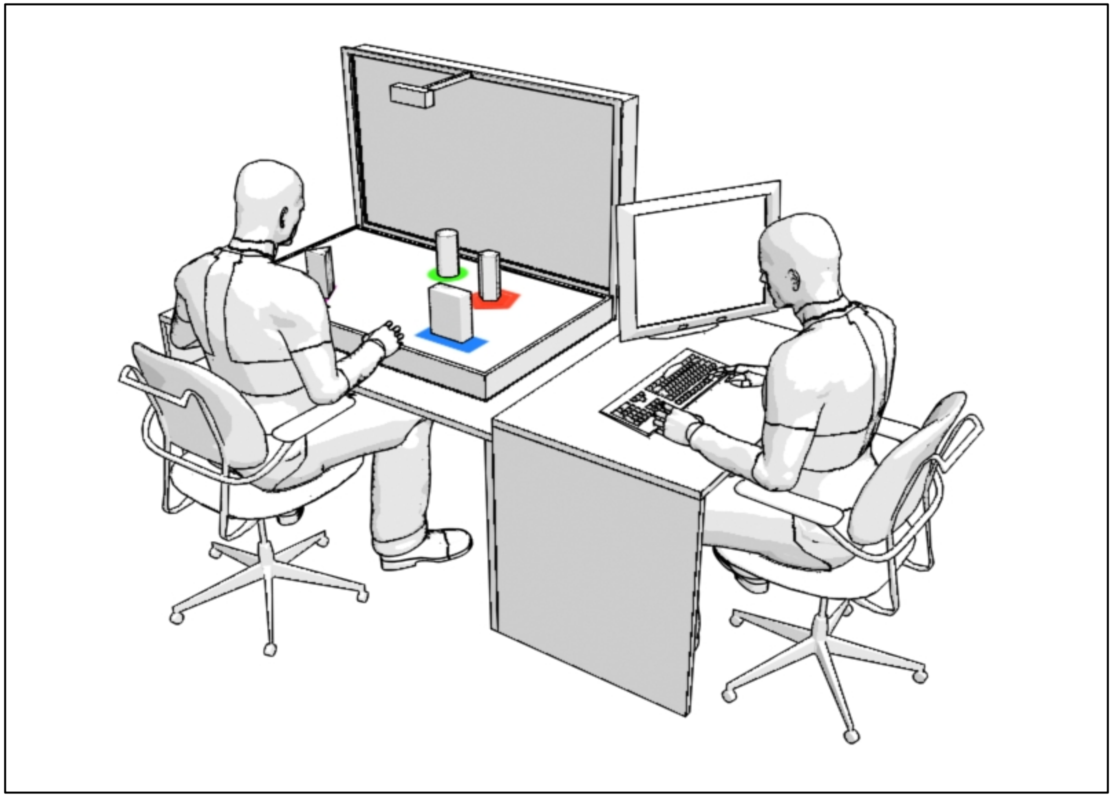
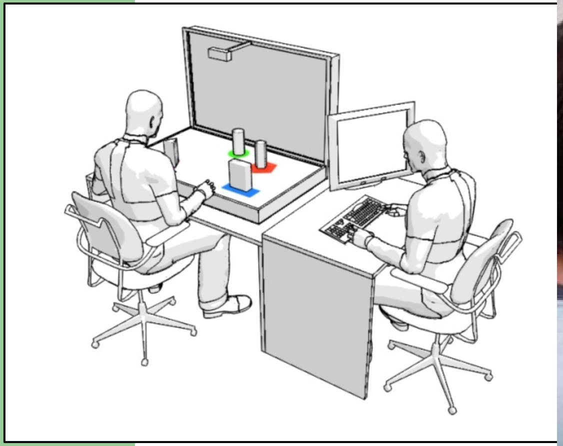
Workspace design – Upper limb function





Workspace design – Upper limb function



In Summary

The rehab systems and options we are developing will:

- **Provide affordable options to augment current therapy practice**
- **Benefit from the clinical and academic expertise of scientists and researchers at ECH and RMIT;**
- **Will use affordable materials or utilise available hardware and may be replicated easily and at relatively low cost for distribution across NHS.**
- **Further developments may allow for remote delivery of upper-limb rehabilitation, as well online administration of training tasks.**

The Future

Following these development and feasibility studies we hope to build on the outcomes of the current submission to:

Explore other forms of interaction,

Evaluate the systems/approaches in clinical trials and

Explore neuroplastic changes following intervention to provide a greater understanding of the mechanisms of change.

Consider novel means for service delivery using remote access

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The Problems?

Not Fun, Not Engaging, Not Robust

Systems don’t work
Ineffective outcomes
Access and affordability
IT solutions complicated

Any further thoughts/questions will be REALLY welcome in helping us design a system that works to improve function for children with hemiplegia!

Thank you for listening

And thanks to the NIHR GSTT/KCL Biomedical Research Centre and Guy's and St Thomas' Charity for funding and support for this project.

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