APPLICATIONS OF VIRTUAL REALITY TECHNOLOGIES FOR CLINICAL USE IN PAEDIATRICS

Dr Dido Green
Reader in Rehabilitation
Evolution of technology-mediated rehabilitation in childhood disability

Early approaches using video capture
Play based VR intervention
Tele-Rehab
Video games/game like systems
Virtual tutor (animation)
Pros and cons of off-the-shelf technologies like Nintendo Wii, etc.

For:
- Upper-limb and or lower-limb rehabilitation
- Physical fitness/balance
- Functional rehab – Cognitive Impairment
- Leisure and play
- Social interaction
- Self esteem and self empowerment
Evolution of technology-mediated rehabilitation in childhood disability

Early approaches such as Video capture technology eg. GestureTek Interactive Rehabilitation Exercise VR systems for children with cerebral palsy (CP) or acquired brain injury (ABI)

see Laufer & Weiss, 2011

“Mind Reading” computer program
Complex emotion recognition training
home + weekly group sessions
with a tutor Golan & Baron-Cohen, 2006
See Grynszpan et al 2014
Significant Effect of Group

ANOVA, $F(2,74)=5.64$, $p=0.005$

Effect size was high after treatment & remained medium at 6m; children receiving CIMT making more progress.
The Smallest (least) Detectable Difference

\[ 1.96 \times \sqrt{2} \times \text{SEM} \]

For the logit scale of the AHA

\[ 1.96 \times \sqrt{2} \times 0.733 \]

\[ \text{SDD} = 2.03 \]
Modified Constraint Induced Movement Therapy

Is the group mean meaningful $F(2, 74) = 5.64, p=0.005$?
Figure 5: Correlations between measures at onset and change in logits at 2- and 6-month assessments (a) for group receiving constraint-induced movement therapy, and (b) for control group. Correlations between age at onset and change in logits after 2- and 6-month assessment: (c) for group receiving CI therapy; and (d) for control group. ●, 2 months; ■, 6 months.
Table 3. Changes in Gross Motor Function Measure total and dimensional scores before and after the period of usual care, the general therapy program and the individualized therapy program.

<table>
<thead>
<tr>
<th></th>
<th>Usual Care Pre</th>
<th>Usual Care Post</th>
<th>p (within)</th>
<th>General Therapy Pre</th>
<th>General Therapy Post</th>
<th>p (within)</th>
<th>Individualized Therapy Pre</th>
<th>Individualized Therapy Post</th>
<th>p (within)</th>
<th>UC vs. UC</th>
<th>GT vs. IT</th>
<th>General Therapy Post</th>
<th>General Therapy Pre</th>
<th>p (within)</th>
<th>Individualized Therapy Post</th>
<th>Individualized Therapy Pre</th>
<th>p (within)</th>
<th>UC vs. UC</th>
<th>GT vs. IT</th>
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<tbody>
<tr>
<td>Total GMFM</td>
<td>94.5 (88.2–98.3)</td>
<td>94.5 (90.1–98.5)</td>
<td>0.173</td>
<td>92.2 (87.0–99.3)</td>
<td>92.5 (88.5–97.7)</td>
<td>0.333</td>
<td>93.2 (87.6–97.9)</td>
<td>95.5 (89.4–98.7)</td>
<td>0.065</td>
<td>0.173</td>
<td>0.917</td>
<td>0.441</td>
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<tr>
<td>GMRM-A%</td>
<td>100 (100–100)</td>
<td>100 (100–100)</td>
<td>1</td>
<td>100 (100–100)</td>
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<td>GMRM-B%</td>
<td>100 (100–100)</td>
<td>100 (100–100)</td>
<td>1</td>
<td>100 (100–100)</td>
<td>100 (100–100)</td>
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<tr>
<td>GMRM-C%</td>
<td>100 (96.4–100)</td>
<td>100 (96.4–100)</td>
<td>1</td>
<td>100 (82.1–100)</td>
<td>100 (85.7–100)</td>
<td>0.068</td>
<td>100 (84.2–100)</td>
<td>100 (89.3–100)</td>
<td>0.18</td>
<td>0.317</td>
<td>0.465</td>
<td>0.735</td>
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<tr>
<td>GMRM-D%</td>
<td>89.1 (70.8–100)</td>
<td>87.8 (73.1–100)</td>
<td>0.581</td>
<td>90.4 (83.0–100)</td>
<td>90.4 (82.1–100)</td>
<td>0.917</td>
<td>98.1 (84.0–98.1)</td>
<td>94.9 (82.1–100)</td>
<td>0.667</td>
<td>0.581</td>
<td>0.465</td>
<td>0.735</td>
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<tr>
<td>GMRM-E%</td>
<td>86.5 (72.7–98.6)</td>
<td>83.3 (75.9–97.6)</td>
<td>0.893</td>
<td>77.1 (65.8–96.0)</td>
<td>80.9 (67.5–92.0)</td>
<td>0.572</td>
<td>78.6 (65.8–89.9)</td>
<td>82.6 (68.6–93.4)</td>
<td>0.675</td>
<td>0.344</td>
<td>0.752</td>
<td>0.932</td>
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Diff change (pre-post); GMFM: Gross Motor Function Measure; GMRM-A: Gross Motor Function Measure dimension A; GMRM-B: Gross Motor Function Measure Dimension B; GMFM-C: Gross Motor Function Measure Dimension C; GMRM-D: Gross Motor Function Measure Dimension D; GMFM-E: Gross Motor Function Measure Dimension E; GT: period of general treatment; IQR: interquartile range; p (within): period of individualized, targeted treatment; p value for the within-group effects provided by the Wilcoxon Signed Ranks Test; p value (between): p value for the between-group effects provided by the Wilcoxon Signed Ranks Test; UC: period of usual care.
Interventions & Treatment Efficacy

AND:
++ Poor patient compliance - limits effects

+++ Poor generalisation to daily living skills

++++Questionable Treatment fidelity

What’s working?
How is it working?
When does it work?
What impact on psychosocial and overall wellbeing
Cortical reorganization induced by virtual reality therapy in a child with hemiparetic cerebral palsy

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Teresa Barrow, PhD, Assistant Professor, Communicative Sciences and Disorders, Hampton University, VA.
Mark Hallett, MD, Chief, National Institute of Neurological Disorders and Stroke (NINDS), Human Motor Control Section, Bethesda, MD, USA.

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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 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.

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 (Scheuer 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...
Workspace design – Upper limb function
RESEARCH ARTICLE

Use of virtual reality in rehabilitation of movement in children with hemiplegia – A multiple case study evaluation

Dido Green¹,² & Peter H. Wilson²

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Progress

Efficiency Data Ella - 4y 0m

Session number
Accuracy
Speed (secs)
Trajectory
Error average (x10)
Progress

Efficiency Data - Karen 10 years

Efficiency Data - John 15 years*

Efficiency data - John 5 y 3 m *

Efficiency data - Keith 4 y 7m* (LD/II and SI)

2 week holiday between 11 & 13
Workspace development – Upper limb function
Music project

Use of Computerised Music Games to develop

Individual Finger Movements for children with hemiplegia

Time Scales and Context of Learning
Individual motor profiles across 1 month training
(Holmström, Ullen, Green et al., in preparation)

Figure 1a 12 y male CVA, infarct aged 4
Figure 1b 7.5 y male MCA infarct trimester
Figure 1c 16 y female HCP Training and retention 1 month without system
Figure 1c 15 y male HCP Training and retention 1 month without system

Accuracy - Individual training

Accuracy - Day camp
• Bonferroni correction for Post Hoc tests

• A significant change in performance occurred within four days of training;

• Corresponding to 2h of active training and mean execution of 7267.94 (SD 3610.86) keystrokes had been performed within the game.

(Holmström, Ullen, Green et al., in preparation)
Follow up at 3 months (N=7)

No significant change in performance between Day 8 and 3 month follow-up

Mean Speed (No.Keystrokes 30s)

P=,528

Accuracy (All OK)

P=,116

(Holmström, Ullen, Green et al., in preparation)
Children with UCP allocated to the Mitii intervention achieved greater improvements in ADL motor and processing skills, goal attainment, and visual perception than the comparison group. ... n=102
Beit Issie Shapiro and iPads: Advanced technology, Advancing Communication

The first time one of the children at Beit Issie Shapiro brought his parents’ iPad to school and we saw how enthusiastically, skillfully and intuitively he was able to manipulate it, we realized that the time has come to move beyond the laminated flashcards currently used for alternative communication and to take advantage of new methods of communication for children with disabilities.
Using iPods® and iPads® in teaching programs for individuals with developmental disabilities: A systematic review

Debora M. Kagohara³, Larah van der Meer³, Sathiyaprapaksh Ramdossb, Mark F. O’Reilly², Giulio E. Lancioni², Tony N. Davisd, Mandy Rispoli³, Russell Langb, Se, Peter B. Marchik³, Dean Sutherland³,

Abstract

We conducted a systematic review of studies that involved iPods®, iPads®, and related devices (e.g., iPhones®) in teaching programs for individuals with developmental disabilities. The search yielded 15 studies covering five domains: (a) academic, (b) communication, (c) employment, (d) leisure, and (e) transitioning across school settings. The 15 studies reported outcomes for 47 participants, who ranged from 4 to 27 years of age and had a diagnosis of autism spectrum disorder (ASD) and/or intellectual disability. Most studies involved the use of iPods® or iPads® and aimed to either (a) deliver instructional prompts via the iPod Touch® or iPad®, or (b) teach the person to operate an iPod Touch® or iPad® to access preferred stimuli. The latter also included operating an iPod Touch® or an iPad® as a speech-generating device (SGD) to request preferred stimuli. The results of these 15 studies were largely positive, suggesting that iPods®, iPod Touch®, iPads®, and related devices are viable technological aids for individuals with developmental disabilities.
Innovative technology-based interventions for autism spectrum disorders: A meta-analysis

Ouriel Grynszpan¹,², Patrice L (Tamar) Weiss³, Fernando Perez-Diaz² and Eynat Gal³

Results: Evidence for overall effectiveness of technology-based training. Overall mean effect size for posttests of controlled studies of children with autism spectrum disorders receiving technology-based interventions was significantly different from zero and approached the medium magnitude, $d = 0.47$ (CI: 0.08–0.86).

Excluded:

1) single or multiple single-case designs,
2) those without external outcome measures;
3) use of AAC
An investigation of the impact of regular use of the Wii Fit to improve motor and psychosocial outcomes in children with movement difficulties: a pilot study

J. Hammond,* V. Jones,* E. L. Hill,† D. Green;‡ and I. Male§

Methods: Cross-over RCT
Intervention (n = 10) or comparison (n = 8)
Intervention: 10 min x 3 per week 1 month Wii Fit;
Comparison: regular Jump Ahead programme.

Results Significant gains in motor proficiency, child’s perception of his/her motor ability and reported emotional well-being for many, but not all children.

Conclusions This simple, popular intervention represents a plausible method to support children’s motor and psychosocial development.
Are children with DCD more or less active than their peers?

Does this matter?
The risk of reduced physical activity in children with probable Developmental Coordination Disorder: A prospective longitudinal study

Dido Green \(^a,\)\(^e,\)\(^*\), Raghu Lingam \(^b\), Calum Mattocks \(^c\), Chris Riddoch \(^c\), Andy Ness \(^d\), Alan Emond \(^b\)

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Evidence of Benefits of VR Technologies for Individuals or Groups

Do not rely on group means: Consider single-subject designs & learning profiles

Look beyond Systematic Reviews to identify factors that predict treatment response for individuals for applications of technologies

Be creative in considering the use of VR technologies across child development

¹Novak et al. 2013 DMCN

¹Damiano, 2014
Green, 2014 DMCN
THANK YOU FOR LISTENING
And to all the children and young people who inspire us

And to the team and our sponsors

Professor Peter Wilson
Professor Bert Steenbergen
Professor Ann-Christin Elliason
Dr Linda Homlstrum

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