
Holger Regenbrecht
Information Science
University of Otago
University of Otago, Dunedin

- New Zealand's oldest university (1869)
- approx. 20,000 students
- 3,700 staff
Department of Information Science

- 18 faculty (academic staff)
- 4 research and teaching fellows, 7 technical and admin staff
- about 50 postgraduate students (30 PhD, 10 Masters, 10 Hons/PGDip)
Our academic staff are involved in a wide variety of research areas (http://www.infosci.otago.ac.nz/research/):

- Business Intelligence / Decision Support
- Software Agents and Modelling
- Health Informatics
- Mobile Computing & Wireless Networking
- Human-Computer Interaction (HCI)
- Computer Vision & Image Analysis
- Information Assurance & Security
- Data Management

We offer a wide ranging PhD Programme. PhD Scholarships and topics available.
HCI::Three Main Research Themes

- Mixed Reality and Therapy
- Mobile Augmented Reality
- Videoconferencing
Brain-related Research at Otago's Computer-Mediated Realities Lab

Research questions regarding

• sensory (in particular visual) illusions and neuroplasticity; Augmented Reflection Technology (ART)
• sense of presence and virtual rehabilitation, Mixed Reality experiences
• translational research utilising ART, in particular post-stroke rehabilitation and pain management
• CMR-based psycho- and physiotherapy, e.g. Virtual Reality Exposure Therapy
• novel technologies to measure brain-related activities and to provide new stimuli
Brain-related Research at Otago's Computer-Mediated Realities Lab

collaborative Mixed Reality Exposure Therapy (here arachnophobia)  Virtual Reality Exposure Therapy (here claustrophobia)  Virtualised Nine Hole Peg Test for motor rehabilitation

ART-based TheraMem game for post-stroke rehabilitation  Evaluating affordable EEG measurements with ART system  "Fooling the brain" with Augmented Reflection Technology
Stroke Facts (New Zealand)

• About 9500 New Zealanders every year have a stroke
• Stroke is the third largest cause of death in New Zealand
• Stroke is the major cause of serious adult disability
• In 2010 the costs of stroke were estimated to be close to $1 billion only in New Zealand
  • of which about $590 million was attributed to the cost of primary health care
• There are an estimated 60,000 stroke survivors
• Many are disabled and need significant daily support
• About 2/3 of survivors have upper limb deficits
• Stroke recovery can continue throughout life

www.stroke.org.nz/node/16
www.gw.govt.nz/physical-inactivity-costs-almost-one-percent-of-gdp/
Stroke Rehabilitation Possibilities

**Drugs**

**Transcranial Stimulation**

**Physical Therapies**

**Central Sensory Stimulation**
Bimanual Coupling

(Franz & Ramachandran, 1998)
Fooling the Brain with a Mirror

When using a mirror, the circle drawings of both hands became more alike

(Franz & Packman, 2004)
Rehabilitation after stroke with a Mirror

<table>
<thead>
<tr>
<th>Patient number</th>
<th>Age, sex, handedness</th>
<th>Side of CVA, severity, time since CVA</th>
<th>Rehabilitation focus</th>
<th>First four weeks</th>
<th>Second four weeks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>59, M, R</td>
<td>RCVA, mild, 2-3 years</td>
<td>Hand, wrist, elbow</td>
<td>C +1 +0.5</td>
<td>M +1 +1</td>
</tr>
<tr>
<td>2</td>
<td>55, M, R</td>
<td>RCVA, severe, 1 year</td>
<td>Shoulder, elbow</td>
<td>C 0 0</td>
<td>M +1 +0.5</td>
</tr>
<tr>
<td>3</td>
<td>53, F, R</td>
<td>RCVA, extremely severe, 1-5 years</td>
<td>Shoulder</td>
<td>M +0.5 0</td>
<td>C 0 0</td>
</tr>
<tr>
<td>4</td>
<td>55, M, R</td>
<td>RCVA, extremely severe, 6 months</td>
<td>Shoulder</td>
<td>M +1 0</td>
<td>C 0 0</td>
</tr>
<tr>
<td>5</td>
<td>54, F, L</td>
<td>RAVM, severe, 20-25 years</td>
<td>Shoulder, elbow</td>
<td>C 0 0</td>
<td>M +1 0</td>
</tr>
<tr>
<td>6</td>
<td>60, F, R</td>
<td>RAVM, severe, 4-7 years</td>
<td>Shoulder, elbow</td>
<td>C 0 0</td>
<td>M +1 0</td>
</tr>
<tr>
<td>7</td>
<td>53, F, R</td>
<td>RCVA, moderate-severe, 2-25 years</td>
<td>Shoulder, elbow</td>
<td>M +0.5 0</td>
<td>C 0 0</td>
</tr>
<tr>
<td>8</td>
<td>73, M, R</td>
<td>RCVA, severe, 4-5 years</td>
<td>Shoulder, wrist</td>
<td>C 0 0</td>
<td>M +1 +0.5</td>
</tr>
<tr>
<td>9</td>
<td>62, M, R</td>
<td>LOVA, moderate, 8 months</td>
<td>Shoulder, elbow, wrist</td>
<td>M +1 +0.5</td>
<td>C 0 0</td>
</tr>
</tbody>
</table>

All patients had severely decreased to absent proprioception in the affected limb.
CVA=cerebrovascular accident (R=right; L=left); AVM=arteriovenous malformation; G=grader; M=mirror; C=control (transparent plastic).

Patient characteristics

(Altschuler et al., 1999)
Action execution, mental simulation and observation activate similar areas

(Grèzes & Decety, 2001)
Neurophysiological Correlates

In the mirrored condition, activation in the visual cortex was lateralized contralateral to the seen hand

(Dohle, Kleiser, Seitz, & Freund, 2004)
Also with patients who suffered a stroke

Increased activity as a result of the mirror illusion during bimanual movement in two areas: the precuneus (B) and the posterior cingulate cortex (A)

(Michielsen et al., 2011)
Mirror therapy improves motor function after stroke – Cochrane Review

<table>
<thead>
<tr>
<th>Study or subgroup</th>
<th>Experimental N</th>
<th>Mean(SD)</th>
<th>Control N</th>
<th>Mean(SD)</th>
<th>IV(Random,95% CI)</th>
<th>Weight</th>
<th>IV(Random,95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All studies with post-intervention data</td>
<td>20</td>
<td>3.65 (1.3)</td>
<td>20</td>
<td>2.75 (1.3)</td>
<td>9.4%</td>
<td>0.68 [0.04, 1.32]</td>
<td></td>
</tr>
<tr>
<td>Acerca 2007</td>
<td>24</td>
<td>-1.5 (0.7)</td>
<td>24</td>
<td>-3.4 (0.9)</td>
<td>8.6%</td>
<td>2.32 [1.57, 3.06]</td>
<td></td>
</tr>
<tr>
<td>Cacchio 2009a</td>
<td>8</td>
<td>-2.2 (0.7)</td>
<td>16</td>
<td>-3.65 (1.23)</td>
<td>7.3%</td>
<td>1.28 [0.35, 2.22]</td>
<td></td>
</tr>
<tr>
<td>Cacchio 2009b</td>
<td>18</td>
<td>13.36 (3.16)</td>
<td>18</td>
<td>12.72 (3.33)</td>
<td>9.3%</td>
<td>0.19 [-0.46, 0.85]</td>
<td></td>
</tr>
<tr>
<td>Dohle 2009</td>
<td>39</td>
<td>31.41 (2.06)</td>
<td>63</td>
<td>31.61 (2.63)</td>
<td>11.2%</td>
<td>0.00 [-0.40, 0.39]</td>
<td></td>
</tr>
<tr>
<td>Jitswaart 2011</td>
<td>20</td>
<td>43.5 (1.4)</td>
<td>20</td>
<td>36.6 (1.42)</td>
<td>9.5%</td>
<td>0.48 [-0.15, 1.11]</td>
<td></td>
</tr>
<tr>
<td>Michielsen 2011</td>
<td>19</td>
<td>17.6 (1.05)</td>
<td>21</td>
<td>17.9 (0.89)</td>
<td>9.6%</td>
<td>-0.03 [-0.65, 0.59]</td>
<td></td>
</tr>
<tr>
<td>Seok 2010</td>
<td>20</td>
<td>3.6 (0.8)</td>
<td>20</td>
<td>3 (0.7)</td>
<td>9.4%</td>
<td>0.65 [0.01, 1.29]</td>
<td></td>
</tr>
<tr>
<td>Stbreyaz 2007</td>
<td>9</td>
<td>11.89 (6.23)</td>
<td>6</td>
<td>6.33 (5.2)</td>
<td>6.3%</td>
<td>0.89 [-0.20, 1.99]</td>
<td></td>
</tr>
<tr>
<td>Tekuka 2006</td>
<td>17</td>
<td>2.62 (1.23)</td>
<td>19</td>
<td>2.79 (0.99)</td>
<td>9.1%</td>
<td>0.73 [0.05, 1.41]</td>
<td></td>
</tr>
<tr>
<td>Yavuzer 2008</td>
<td>40</td>
<td>16.47 (6.83)</td>
<td>20</td>
<td>16.2 (4.1)</td>
<td>10.2%</td>
<td>0.04 [-0.49, 0.58]</td>
<td></td>
</tr>
</tbody>
</table>

**Subtotal (95% CI):** 234 247

Heterogeneity: Tau² = 0.31; Chi² = 39.46, df = 10 (P = 0.00002); I² = 75%

Test for overall effect: Z = 3.07 (P = 0.0022)

(Thieme et al. 2012)
Optimal Rehabilitation / Neuroplasticity

1. Treatment **frequency** and **intensity** correlate with recovery (Kwakkel et al., 2004; Sonoda, Saitoh, Nagai, Kawakita, & Kanada, 2004).

2. Movement **practice** and **repetition** play a fundamental role in recovery (Karni et al., 1995).

3. **Specificity** of rehabilitation training with respect to the deficits and required functional outcomes has an impact on recovery (Krakauer 2006).

(Bermudez i Badia, 2013), (Takeuchi & Izumi, 2013)
Rehabilitation

Rehabilitation has been defined by the World health organization (WHO) as a coordinated process that *enhances activity* and participation.

Rehabilitation is a process of education the disabled person in order to support him/her coping with family, friends, work and leisure as independently as possible.

Broeren, 2007
ART was created to

Exploit the current technological capabilities, both experimentally and therapeutically, to foster the brain’s ability to heal itself and give patients after a stroke an opportunity to regain their quality of life.
Augmented Reality (AR)

- Real-world view augmented by 3D virtual information, which is computer-generated in real-time.
- The goal is to create the impression that the virtual objects are part of the real environment.
Augmented Reflection Technology
Presence: Teleoperators and Virtual Environments (2011)
Augmented Reflection Technology
Augmented Reflection Technology
Augmented Reflection Technology

Operator (experimenter, therapist)  User (participant, client, patient)
Augmented Reflection Technology

- Colour etc.
- Mirroring
- Position
- Size
- 3D Models
- 2D Backgrounds
TheraMem Game
3D Scene Construction

video planes for hands

Scene marker

Tape 1 Time: 6
ART::TheraMem Software Architecture (simplified)

- Render Left
- Render Right

3D Scene

- Amplification Ctrl
- Fingertracking
- Bgr Subtraction
- Video Left
- Video Right

- 3D environment
- 3D objects (plants)
- Interaction/Logic

3D environment

- 3D objects (plants)

Interaction/Logic
Studies

Fooling effectiveness of ART (compared with Optical Mirror Box)
(Regenbrecht, Franz, McGregor, Dixon, & Hoermann, 2011)

Limb Ownership and Referred Tactile Sensations in OMB and ART
(Hoermann, Franz, & Regenbrecht, 2012)
(Regenbrecht, Hoermann, Ott, Muller, & Franz, 2014)

Limb ownership & presence in virtual environments in ART
(Regenbrecht, Hoermann et al., 2012)

ART-TheraMem’s usability and utility
(Regenbrecht et al., 2011)

Evaluation of advanced User Interfaces
(Allen, Hoermann, Piumsomboon, & Regenbrecht, 2013)
(Regenbrecht, Collins, & Hoermann, 2013)
(Collins, Hoermann, & Regenbrecht, 2014)

Clinical feasibility of ART for rehabilitation of patients with chronic motor impairments after stroke
(Hoermann, Hale, Winser, & Regenbrecht, 2012)
Clinical Feasibility - Setting

(Hoermann, Hale, Winser, & Regenbrecht, 2012)
Various Exercises in ART
ART-TheraMem

(Hoermann, Hale, Winser, & Regenbrecht, 2012)
In Summary: With ART we can combine

**Optimal Rehabilitation practice**

**Latest Neuroscientific Evidence**

**Cutting-Edge Technology**

**Engaging User Experience**
Ongoing Study - NeuroART

**Controlled Pilot Intervention Study with ART for upper limb motor rehabilitation in early phase after stroke**

**Aim:** evaluate the clinical feasibility of ART as an adjunct upper limb rehabilitation intervention for patients in their early phase after stroke

**Measures:** Upper limb function measured by validated instruments

**Population:** Adults in their early phase after (< 6 months) stroke with unilateral impairments of the upper limb

**Sample:** 12 participants (6 in intervention and 6 in control group)

**Sessions:** Up to 5 sessions a week for 4 weeks, as tolerated during inpatient rehabilitation

**Duration:** ~30 minutes exercise per session, 45 minutes per session including breaks

**Location:** ISIS Rehabilitation Ward & Dunedin Hospital
ART in Clinics (research and intervention)

- Dunedin Hospital
- Wakari Hospital
- Otago School of Physiotherapy
- Median-Kliniken/Charité, Berlin, Germany

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www.igroup.org/regenbre/publications.html

with

Dr Simon Hoermann (Medicine and Information Science)
Prof Elizabeth Franz (Psychology),
A/Prof Leigh Hale (Physiotherapy)
Dr Nick Cutfield (Medicine)
Selected Publications


References


