Clinical Utility of Augmented Reflection Technology for Stroke Rehabilitation

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Outline

- Augmented Reflection Technology (ART)
  - The Augmented mirror box
  - AMB studies (non-clinical and cases)
  - TheraMem for physical rehabilitation
- Discussion
Mirror Visual Feedback

Augmented Mirror Box:: from optical to electronic


Early ART/AMB experimentation
Augmented Mirror Box::Working Prototype MkII.1.0
Augmented Reflection Technology
Augmented Mirror Box::Working Prototype MkII.2
Augmented Mirror Box::Working Prototype MkII.2
Augmented Reflection Technology

- Colour etc.
- Mirroring
- Size and Position
- 3D models
- 2D Backgrounds

View Manipulation:
- Left Camera
- Right Camera
- No Camera
- Mirror

Spatial Manipulation:
- Horizontal
- Vertical
- Zoom

Scene Manipulation:
- Grid Overlay
- Cube
- Cube Left
- Cube Right
- Transparency

Background Manipulation:
- No Texture
- Black
- Position Left Hand
- Position Right Hand
Study 1: Fooling effectiveness of ART vs. OMB
ART (above) and OMB (below) conditions

ART

Arbitrary
Symmetric
One Hand
Arbitrary
Symmetric
Two Hands

OMB
Fooled Identification of Hands
(i.e. right hand on left side was identified as left hand)
Study 2:
Advanced Mirror Manipulations

Interview by Clinical Psychologist

Forced Choice

<table>
<thead>
<tr>
<th>Left Side</th>
<th>N</th>
<th>Right Side</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Left Hand" /></td>
<td>L</td>
<td><img src="image2" alt="Right Hand" /></td>
</tr>
<tr>
<td><img src="image3" alt="Left Hand" /></td>
<td>L</td>
<td><img src="image4" alt="Mirrored Left Hand" /></td>
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<td><img src="image5" alt="Mirrored Right Hand" /></td>
<td>R</td>
<td><img src="image2" alt="Right Hand" /></td>
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<tr>
<td><img src="image5" alt="Mirrored Right Hand" /></td>
<td>R</td>
<td><img src="image4" alt="Mirrored Left Hand" /></td>
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Part A: Structured Interview

Participants **failed to report 28 times out of 30 (93%)** about the mirroring for all three mirroring conditions.

They were however always correct on the normal condition.
Part B: Forced Choice of Template

![Bar chart showing percentage of correct and wrong choices for templates B, L, N, and R.]

- **Wrong**
  - B: 80%
  - L: 70%
  - N: 10%
  - R: 70%

- **Correct**
  - B: 20%
  - L: 30%
  - N: 90%
  - R: 30%
Study 3: Ownership and Referred Tactile Sensation
Optical Mirror Condition

Participant observes mirror image of stimulated right hand
Replication in ART
ART advanced
Intensity of Referred Sensations

Mean +/- Std-Error

AVG nonzero

- OMB
- ART
- ART adv.
Ownership

![Bar chart showing ownership of "Not my hands" (1) to "My hands" (7) for ART and OMB participants.](chart.png)
Study 4: Limb Ownership in Virtual Environments
Results

![Graph showing means of agreement ratings for different questions related to ownership, spatial presence in VE, reality, and spatial presence in RE.](image)
Augmented Reflection Technology
TheraMem
TheraMem System
TheraMem Game Concept
Amplification Value 2.0 \[ s_{\text{new}} = s_{\text{ori}} \times (f+1) \]

Camera Video Stream (original movement)

User’s View (left hand with amplified movement)

1cm

3cm
TheraMem::Applicability Evaluation

Successful Evaluations:
- Empirical study with healthy participants
- Physio Students Lab week
- SoP Seminar & Neuro SIG meeting
- Interviews with physiotherapists
Clinical Feasibility Study
Patients and Sessions

6 chronic patients recruited from local stroke-club:

- stable motor deficits (> 5 years since stroke)
- different impairment severity (3 dependent, 3 independent)
- different range of impairments
- all having motor-deficits in their upper limb

4 sessions of 1h lead by a physiotherapist:

- Assessment of patient’s motor capabilities (first session only)
- 3- 5 patient tailored exercises
- Reassessment of patient’s motor capabilities (fourth session)
Clinical Setting

(a) Operator screen

(b) User screen

(b) ART boxes

(d) Physiotherapist
Administered Exercises
TheraMem
58 games of TheraMem were played by patients of which 56 were successfully completed.
Support Devices

3cm

1cm
Use of support devices

Moderate Impairment

Severe Impairment

- Use of Elbow Splint (alone)
- Pointing Device Device (alone)
- Amplification (alone)
- Elbow Splint & Pointing Device
- Elbow Splint & Amplification
- Pointing Device & Amplification
- Elbow Splint & Pointing Device & Amplification
Average Time for Completion

![Bar chart showing average time for completion](chart.png)
Average Tries for Completion

Number of tries

PT0  PT1  PT2  PT3  PT4  PT5

Average Tries for Completion
Feasibility Study::Conclusions

- The ART system is feasible for the use in clinical physiotherapeutic settings
- Patients are able to successful complete TheraMem
- Assistive devices might be required for patients with severe motor-impairments
- Patients were highly engaged in the exercises
- Patients liked the system and suggested it for further use

For details see:
Discussion
Collaborators & Contact

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Project Website (under construction):
http://www.hci.otago.ac.nz/research_ART.html