

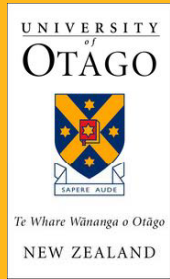


The Augmented Mirror Box Project

H. Regenbrecht, L. Franz, B. Dixon, G. McGregor + S. Hoermann

Outline

1. Virtual and Augmented Reality supported Therapy and Rehabilitation
2. Mirror-Box Therapy
3. Augmented Mirror Box – current implementation
4. First User Studies



VR/AR Therapy and Rehabilitation

INFORMATION SCIENCE
&
PSYCHOLOGY

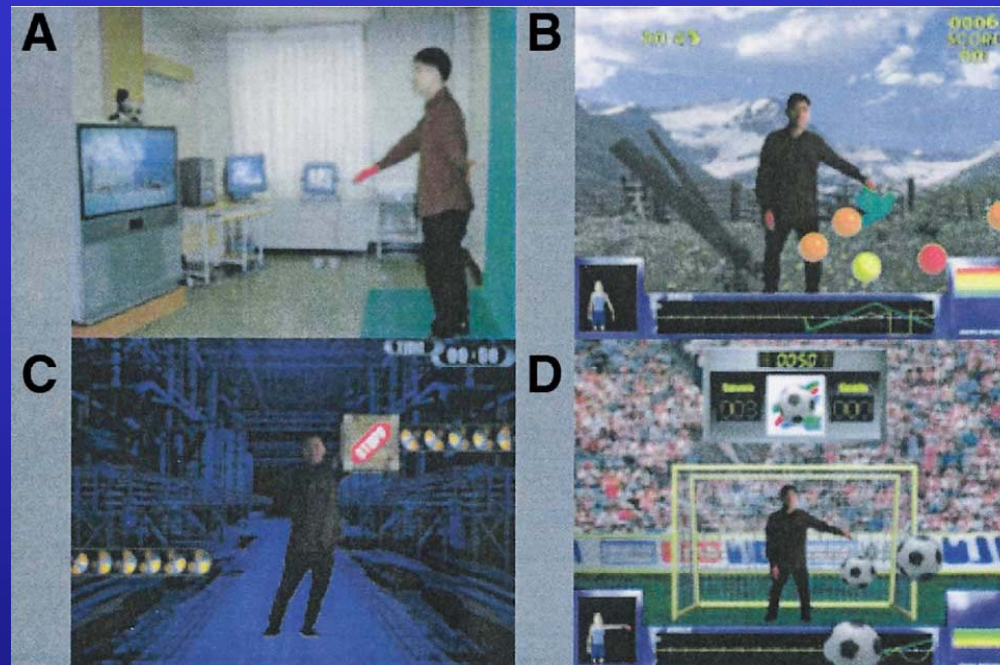
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april 2010

CS/IS Seminar

regenbrecht et al.

VR/AR therapy::Examples



(A) VR exercise setup, (B) birdball exercise game, (C) conveyor exercise game, and (D) soccer exercise game

Jang et al. (2005). Cortical Reorganization and Associated Functional Motor Recovery After Virtual Reality in Patients With Chronic Stroke: An Experimenter-Blind Preliminary Study. Arch Phys Med Rehabil Vol 86, November 2005

VR/AR therapy::Examples



Figure 1. The Rehabilitation Gaming System. A subject faces a display with the arms resting on a table. The arm movements are tracked by a camera positioned on top of the display. The tracking system detects in real-time the position of the color patches located on the wrists and elbows. Data gloves are used to detect finger movements. This way, on the display two virtual arms reproduce the movements of the subject's arms.

Cameirão, Bermúdez i Badia, Oller & Verschure (2008)

[Abstracts from CyberTherapy 2008, June 23-25, 2008 San Diego, CA, USA]

VR/AR therapy::Examples



Multiplexed Telerehabilitation (after stroke) in Virtual Reality project at Rutgers

VR/AR therapy::Examples



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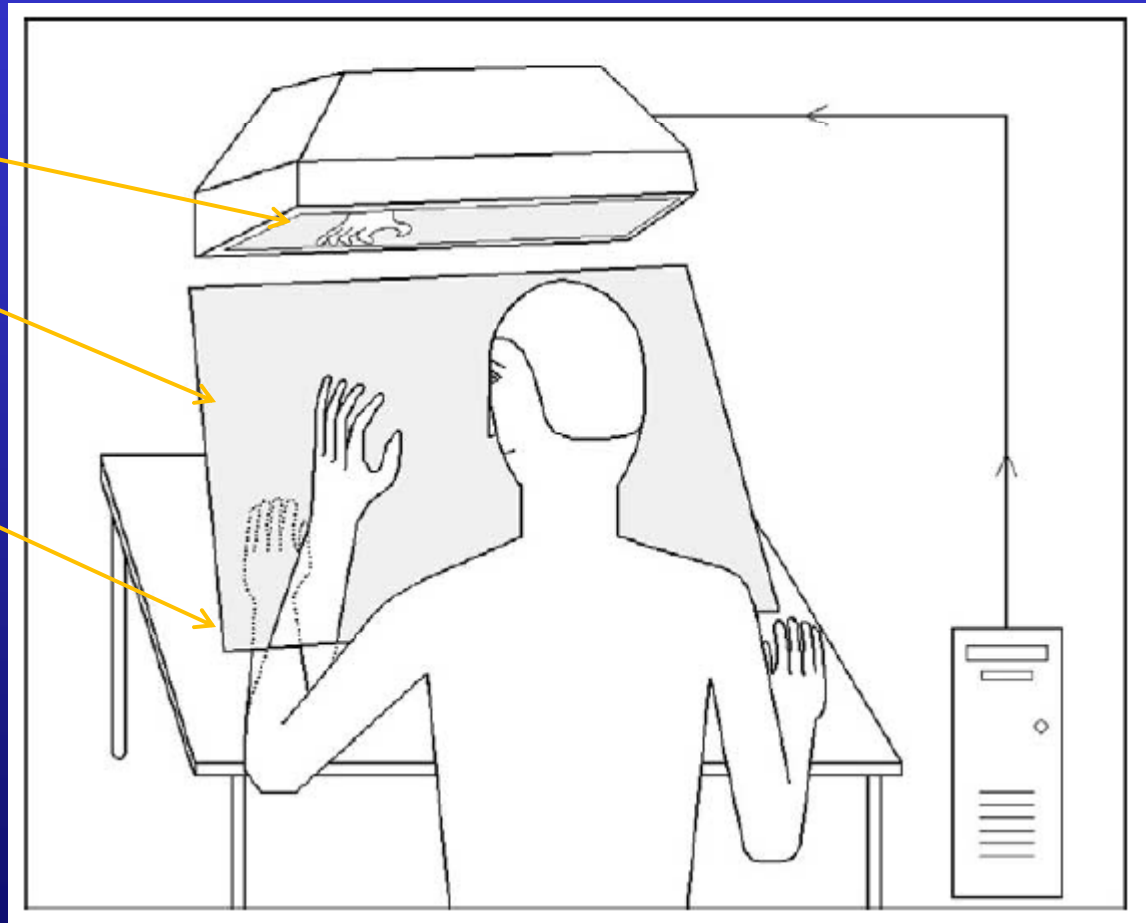
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VR/AR therapy::Examples

pre-recorded
hand

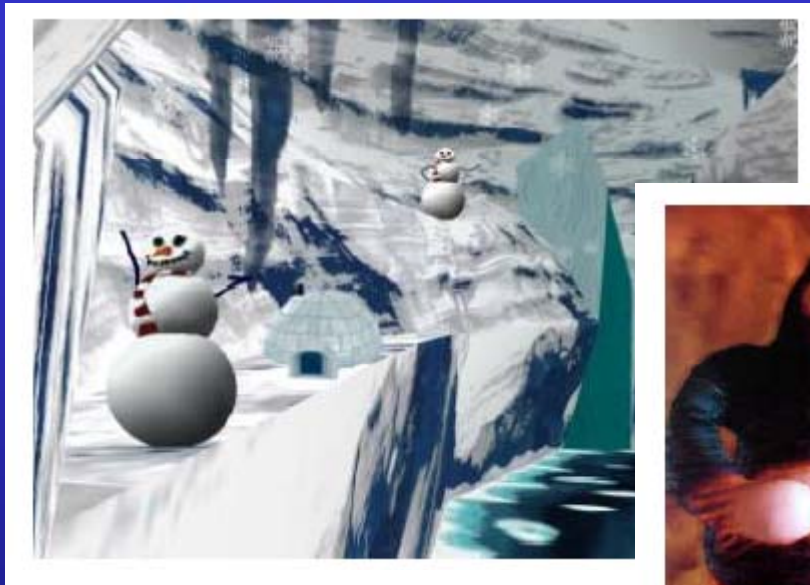
mirror

impaired
hand



Giraux, & Sirigu (2003). Illusory movements of the paralyzed limb restore motor cortex activity. Neurolmage 20 (2003) S107–S111

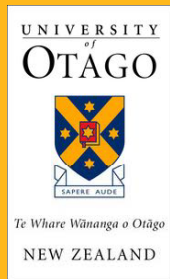
VR/AR therapy::Examples



Using Virtual Reality for after stroke pain
management (hot/cold stimuli: Snow World and
Dante's Canyon)

Shahrbanian, Maureen & Simmonds (2008)

[Abstracts from CyberTherapy 2008, June 23-25, 2008
San Diego, CA, USA]



Mirror-Box Therapy

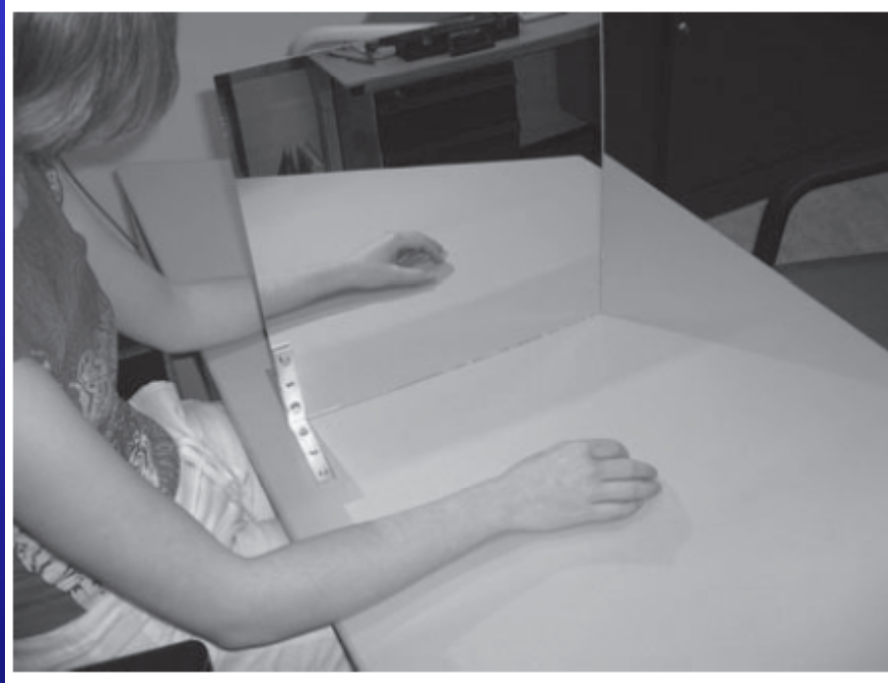
Mirror Box therapy::Optical Mirror Box



Fig. 6 The mirror box. A mirror is placed vertically in the centre of a wooden or cardboard box whose top and front surfaces have been removed. The patient places his normal hand on one side and looks into the mirror. This creates the illusion that the amputated hand has returned.

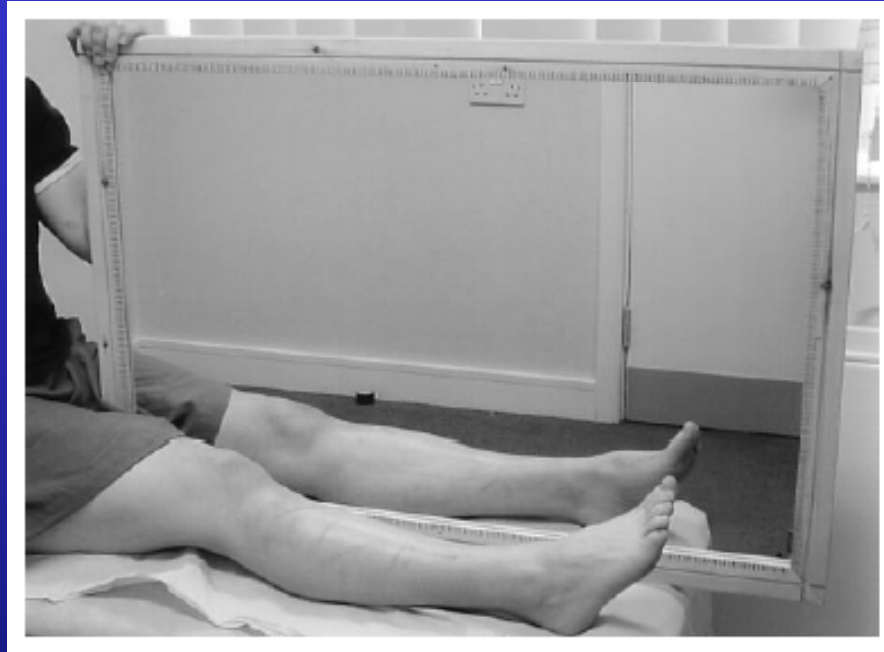
Ramachandran, V. S. & Hirstein, W. (1998).
The perception of phantom limbs: The D.O. Hebb lecture., *Brain* 9 (121), 1603-1630.

Mirror Box therapy::Examples



Selles, Schreuders, & Stam (2008). Mirror Therapy In Patients With Causalgia (Complex Regional Pain Syndrome Type II) Following Peripheral Nerve Injury: Two Cases. *J Rehabil Med* 2008; 40: 312–314.

Mirror Box therapy::Examples

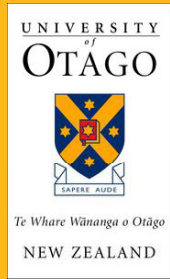


McCabe, Haigh, Ring, Halligan, Wall, & Blake (2003). A controlled pilot study of the utility of mirror visual feedback in the treatment of complex regional pain syndrome (type 1). *Rheumatology* 2003;42:97–101

Mirror Box therapy::Examples



Yavuzer, G., Selles, R., Sezer, N., Sütbeyaz, S., Bussmann, JB., Köseoglu, F., Atay, MB., & Stam, HJ. (2008). Mirror Therapy For Hand Rehabilitation Poststroke. Arch Phys Med Rehabil Vol 89, March 2008

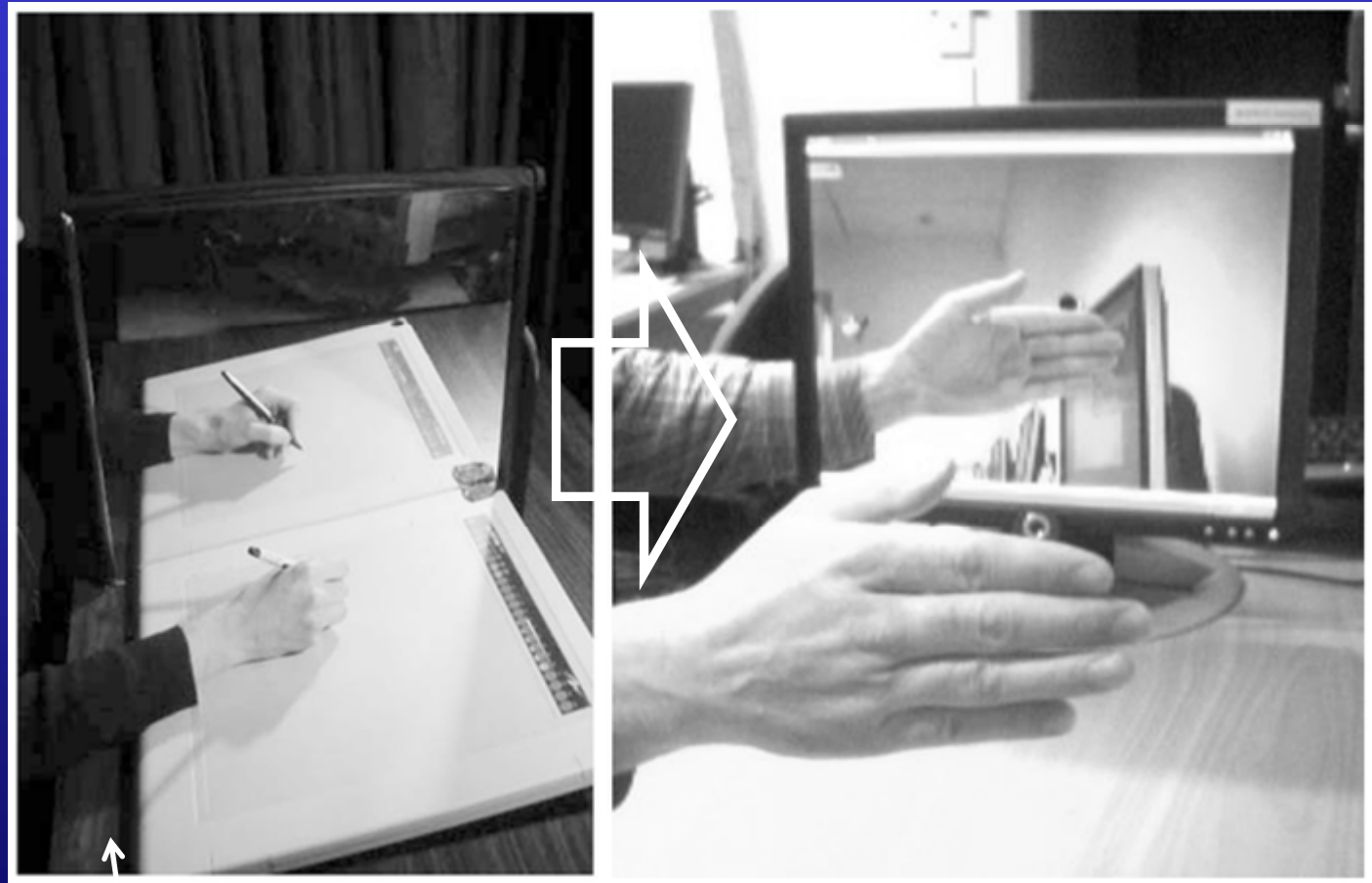


Augmented Mirror Box

Augmented Mirror Box::Replication of “traditional” optical mirror box

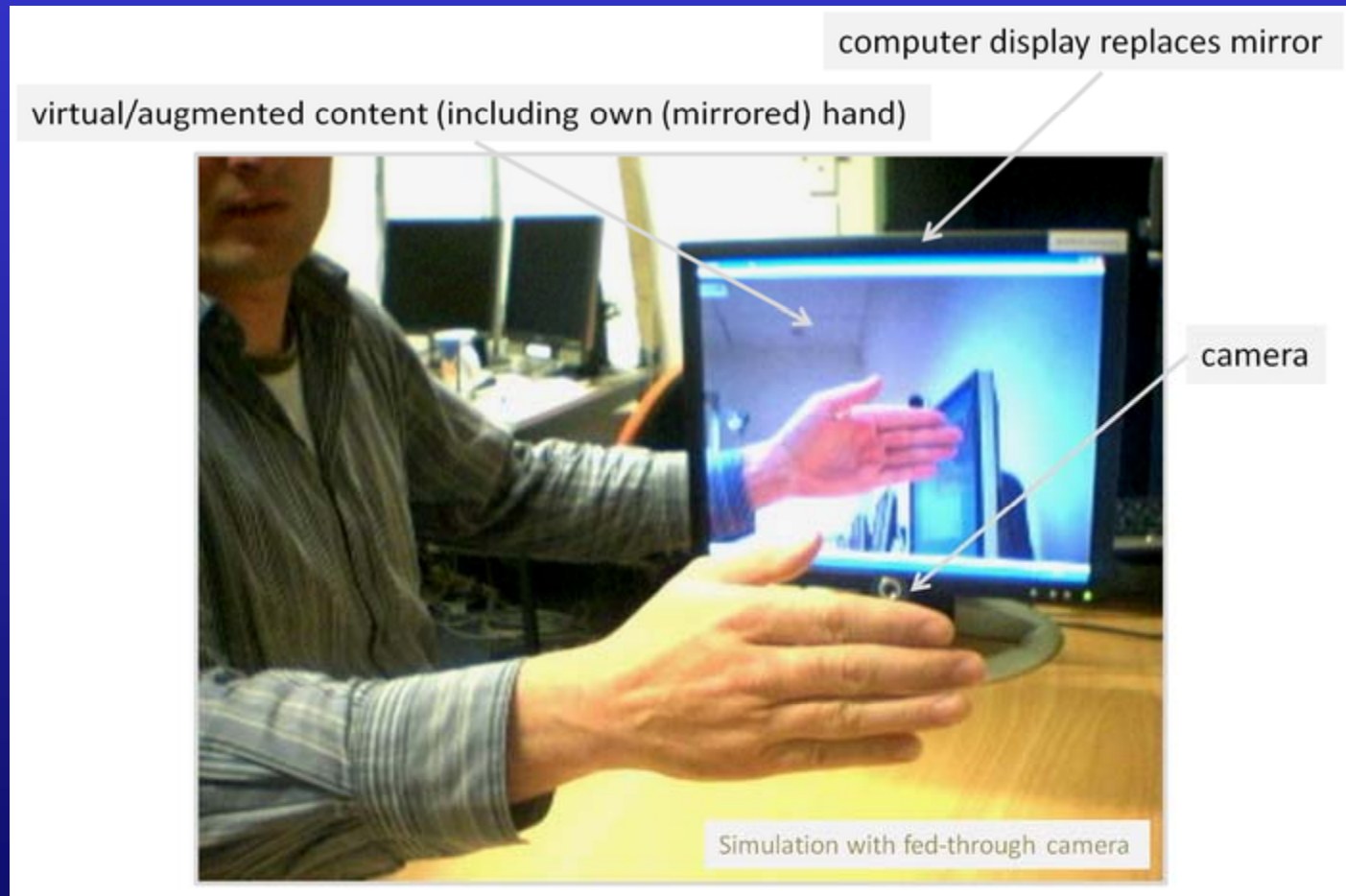


Augmented Mirror Box::from optical to electronic



Franz, E. & Packman, T. (2004). Fooling the brain into thinking it sees both hands moving enhances bimanual spatial coupling. *Exp Brain Res* (2004) 157: 174–180.

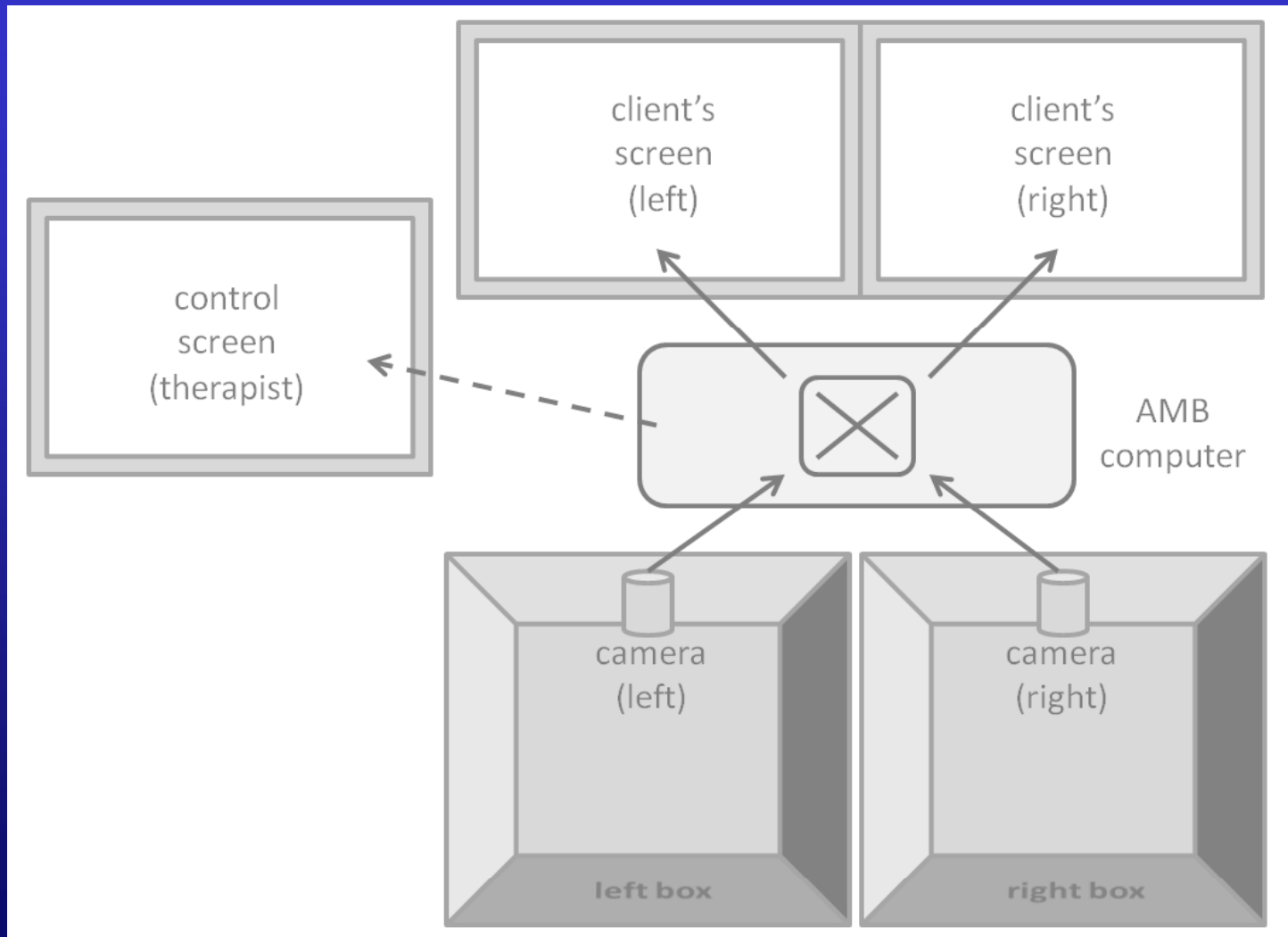
Augmented Mirror Box::Demonstrator AMB Mk.I



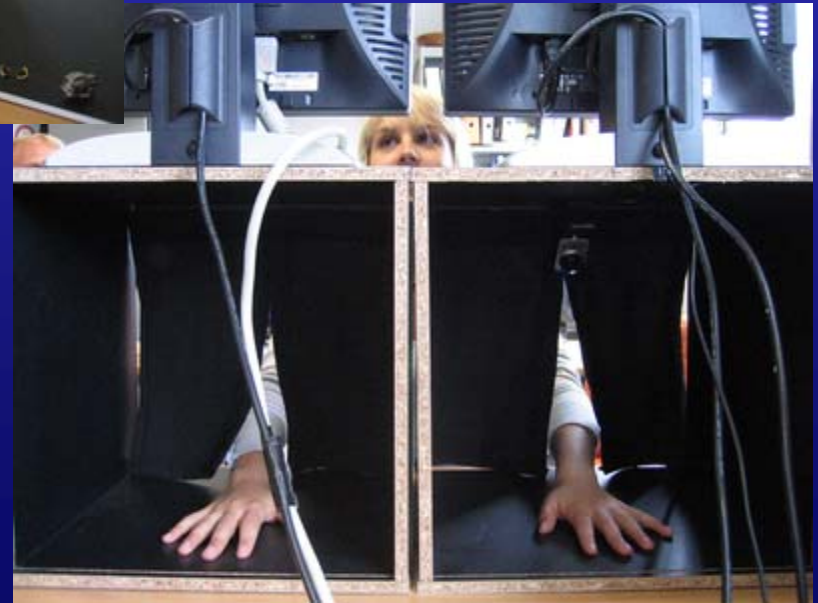
Augmented Mirror Box::Objectives

- ❑ Providing more therapeutic control in mirror-box applications using Augmented Reality technology
- ❑ Possible use of similar technology in different therapy/rehab areas, e.g. preventive (occupational) healthcare
- ❑ Research on experienced sense of presence / motor control of real and imagined scenes: embodied interaction, affordances, possible actions, ...
- ❑ Provision of a system (mature prototype) actually usable in practitioners' office
- ❑ Potential amendments to original mirror box:
 - ❑ Decoupling of limbs and display
 - ❑ Manipulation of spatial and temporal parameters
 - ❑ Changing the limb's surrounding environment
 - ❑ Adding virtual (animated, interactive) objects to environment (e.g. Rehabilitation training)
 - ❑ Adding tangible objects to environment (e.g. tactile augmentation)

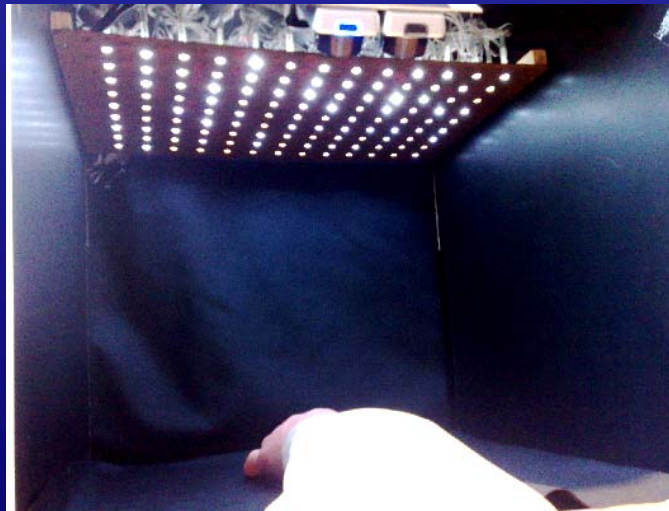
Augmented Mirror Box::Schematic



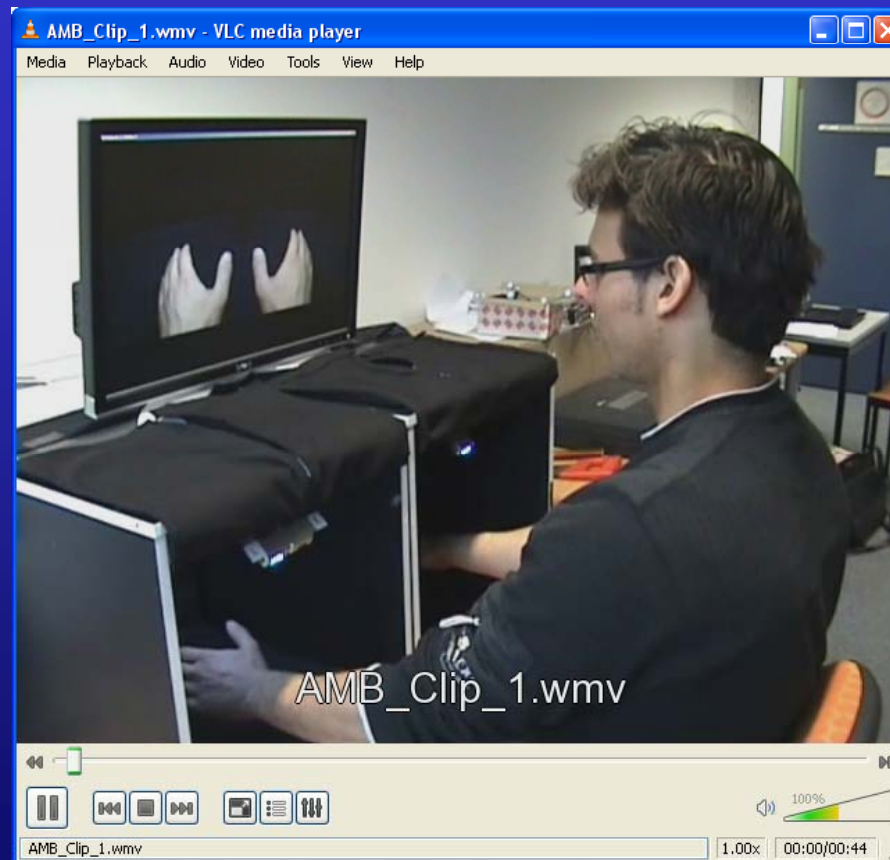
Augmented Mirror Box::Working Prototype MkII.1



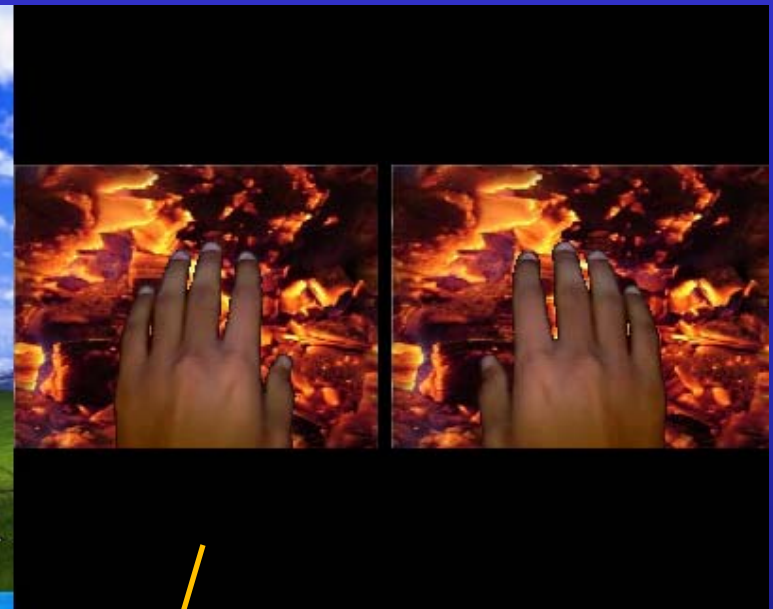
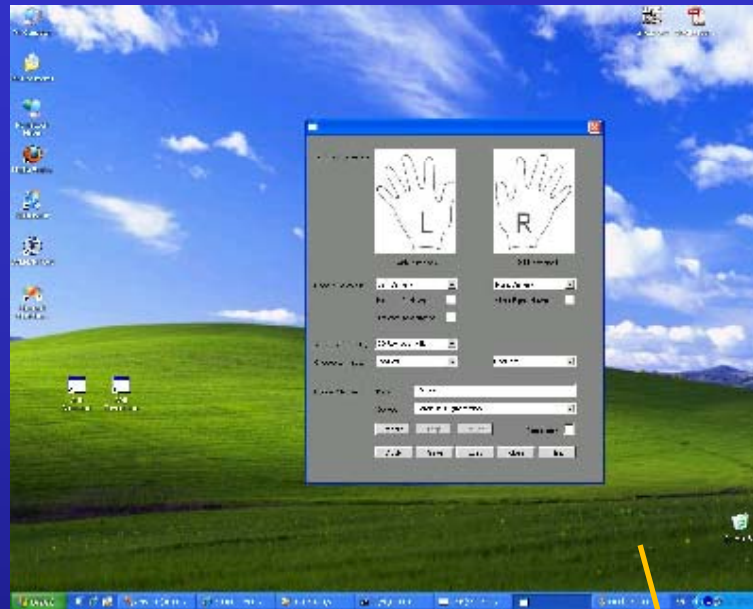
Augmented Mirror Box::Working Prototype MkII.2



Augmented Mirror Box::Working Prototype MkII.2



Augmented Mirror Box:: AMB software



Operator (experimenter, therapist)

User (participant, client, patient)

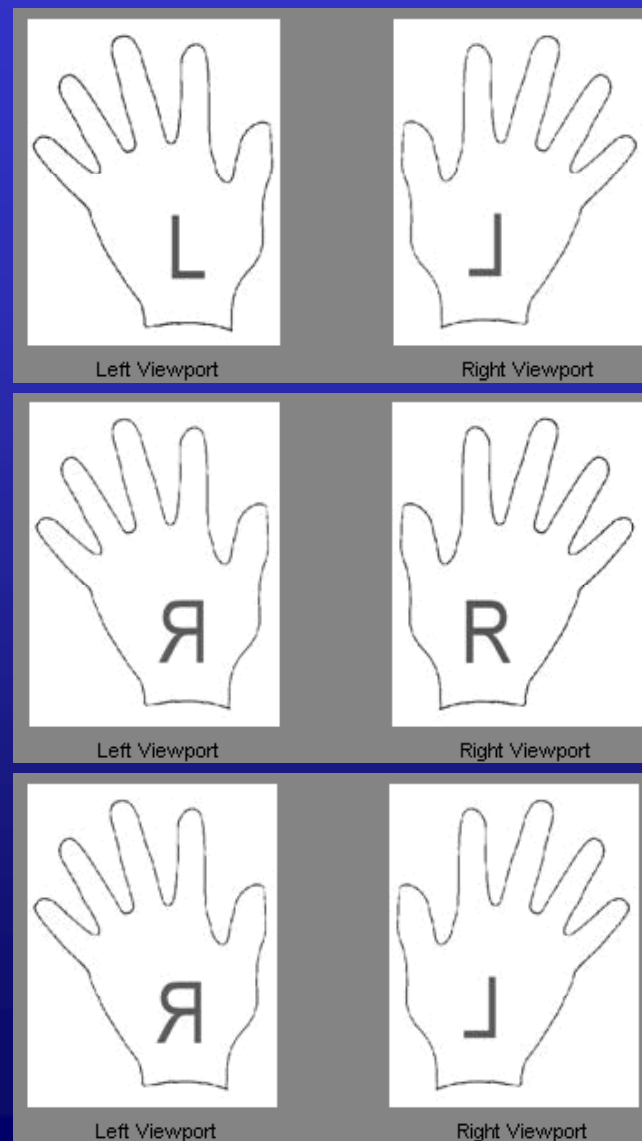
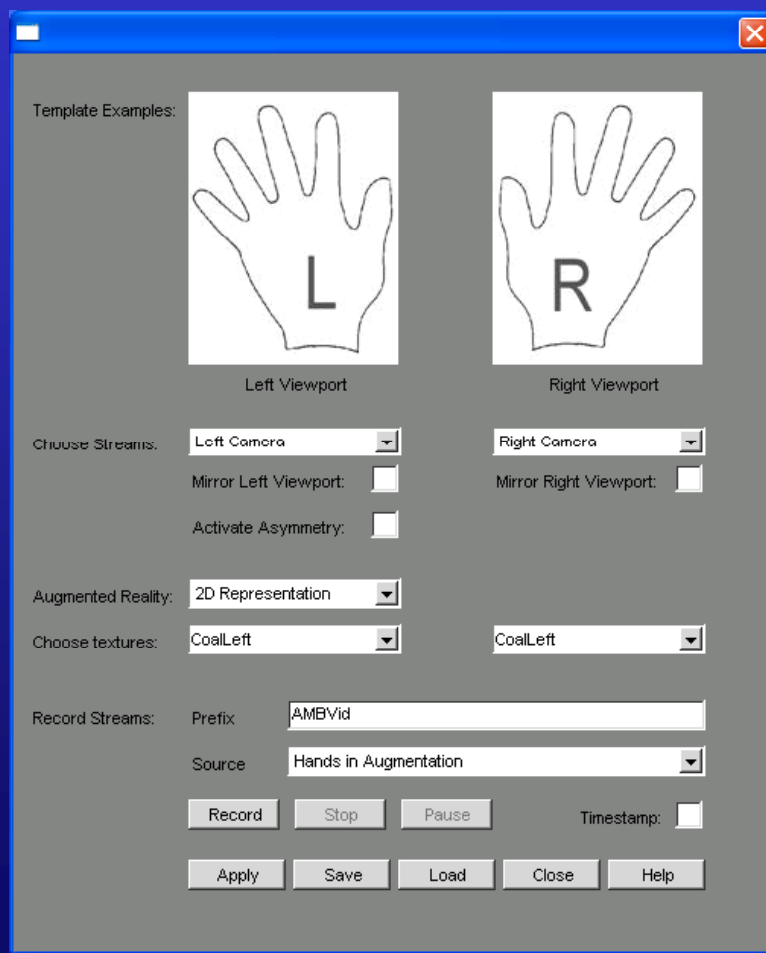


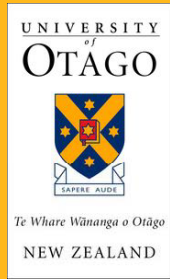
Augmented Mirror Box:: AMB software



Augmented Mirror Box:: AMB software

Functionality





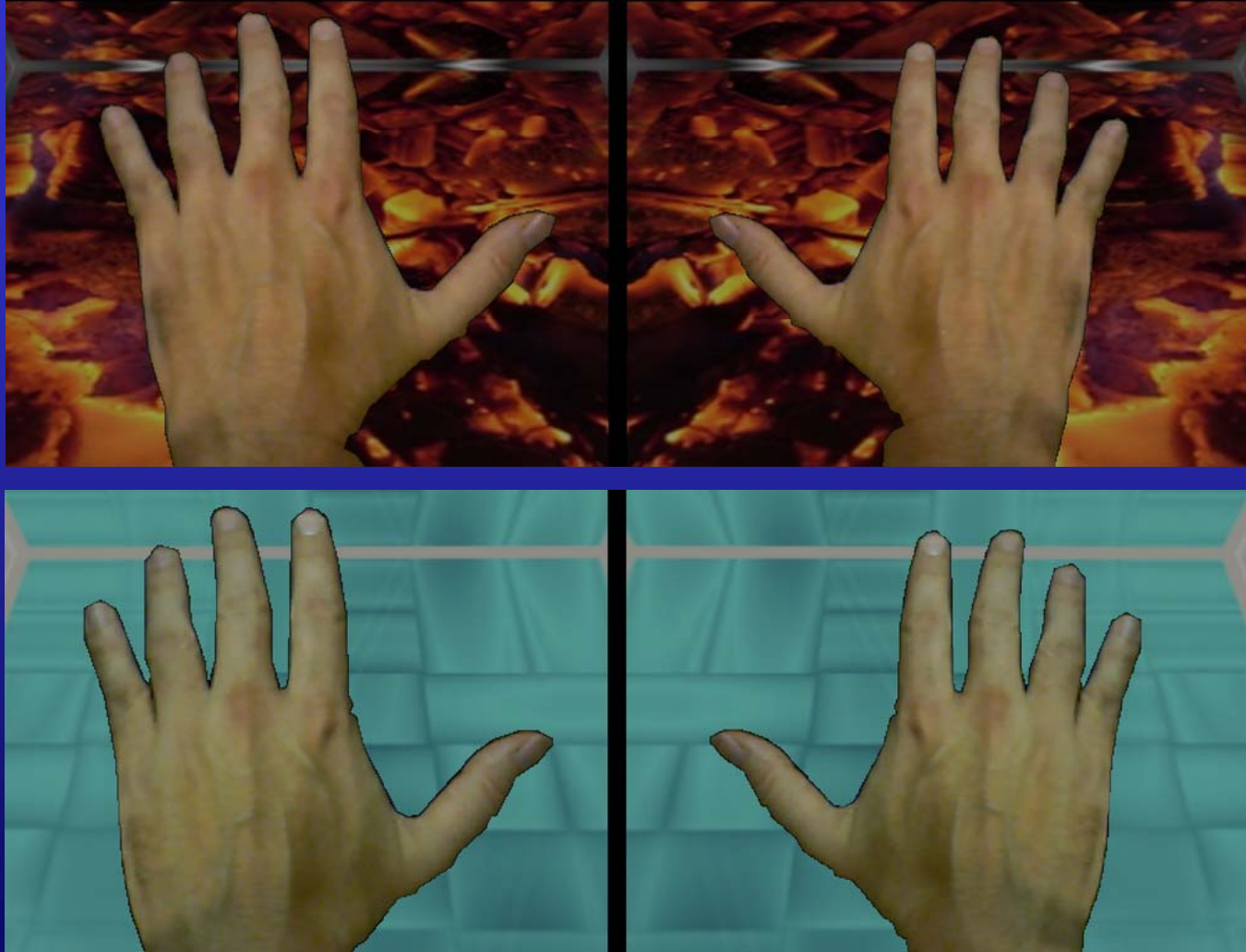
First User Studies

User Studies::Play with virtual ice and fire

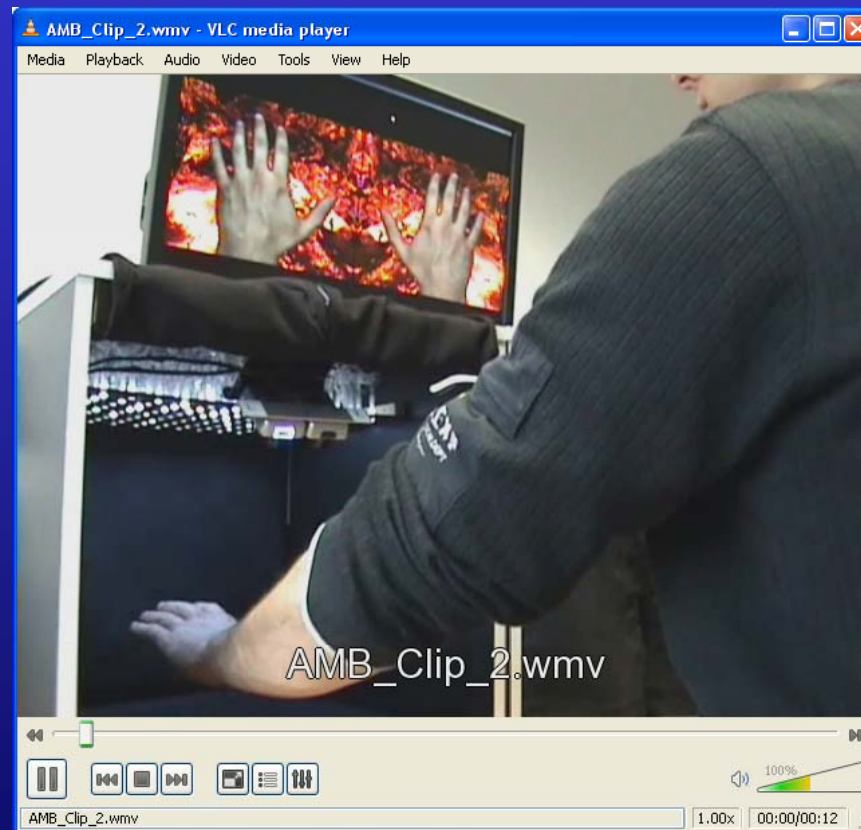
- ❑ Left hand mirrored on right screen.
- ❑ Use of therapeutic task of simultaneous movements
- ❑ Two conditions with different environments: ice cube and coal burning
- ❑ We hypothesized that
 1. the participants would notice the mirrored conditions, but
 2. they are unable to tell what exactly is happening. Also, we hypothesized that
 3. there will be a difference in temperature perception for the two (cold, hot) environments presented, even if the actual temperature was always the same.



User Studies::Play with virtual ice and fire



User Studies::Play with virtual ice and fire



User Studies::Play with virtual ice and fire

- ❑ 32 Participants
- ❑ Laboratory study
- ❑ Randomised order for hot/cold conditions
- ❑ The majority of the subjects felt that the hands displayed on the monitor were their own hands ($m=1.97$, $s.d.=1.1$).
- ❑ Nine subjects reported that they noticed that the hands were mirrored (ratings of 1,2 or 3 on a -3 - +3 likert-like scale)
- ❑ but only 4 participants recognized that the left hand was mirrored.
- ❑ This finding can be supported by our observations: even if people try to find out they usually don't know – also reported by 24 subjects choosing “don't know” in the last item, when asked which hand was mirrored.
- ❑ A perceived temperature difference was not reported.

User Studies::Play with water

- ❑ Right hand mirrored on left screen.
- ❑ Hands in (real) water set to certain temperatures
- ❑ Within-subject 3x2 conditions:
(mirrored, vision, no vision) x
(same or different temperature)
- ❑ We hypothesized that
 1. Subjects believe that the hand(s) shown are their own
(mirrored and non-mirrored conditions)
 2. The mirror effect works.
 3. There will be a perceived temperature transfer from one
hand to the other.

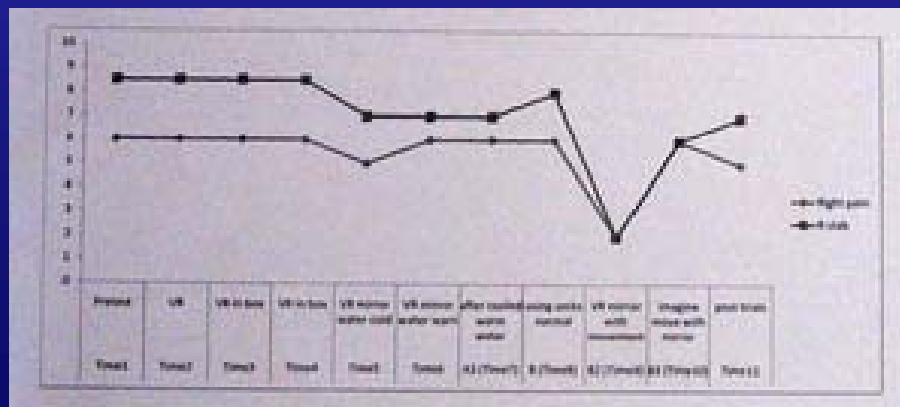


User Studies::Play with water

- 22 Participants, all right handed, laboratory study
- Visual condition in order non, vision, mirror
- Temperature counterbalanced
- Measurements of perceived temperature, non-specific psychological distress (K10), individual's current level of general well-being (Affectometer), Oral questions on perception/belief what was happening.
- Oral answers reported knowledge about what was happening in the experiment was significantly larger than zero.
- Only one participant realised what actually happened, half of the participants did not notice anything, 9 thought they know but were wrong or only partially correct.
- Three realised (some sort of) mirroring.
- All perceived the system as realistic / believable.
- Some minor effects on interactions between conditions.
- A perceived temperature difference was not reported.

User Studies::Initial Therapeutic Case Study

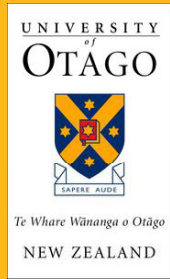
- ❑ Participant suffering from Complex Regional Pain Syndrome in foot
- ❑ Participant did not believe in / accept ownership of mirrored limb but pain levels dropped nevertheless!
- ❑ Current setup suitable for hands, but probably too small for feet (but still working)
- ❑ Display placement deserves more consideration in foot condition



User Studies::Conclusions

- ❑ Participants believe to see their hands
- ❑ Mirror effect seems to work – initial proof of concept
- ❑ Temperature effects could not be measured
- ❑ Augmentation still too weak
- ❑ Hardware system design acceptable but room for improvement
- ❑ Therapeutic application path promising, more studies needed though





Future Work

Augmented Mirror Box::Future Work

- Development of a reliable and robust “shipping” version of the AMB software: clinical trials and therapy
- Development of a new experimental version of the AMB software: further studies and experimentation
- Development of extended research version: further experimentation
- Further improvement of AMB hw (in particular lighting)
- Different 3D models for scientific and therapeutic purposes
- Improvement on effect measurements (video analysis)
- Virtual (and real) models in AMB environment (also phantom model and semi-transparent display)
- Stereo camera approach (depth of hands in boxes): depth-correct augmented reality application
- Exploration of other applications areas

Augmented Mirror Box::Future Work (cont.)

- ❑ Current final proof-of-concept study on mirror effect (N=30); finishes on Monday
- ❑ Next study: different factors affecting presence and believability
- ❑ Focus on primary application fields (unilateral impairments)
 - ❑ Stroke and brain injury rehabilitation
 - ❑ Complex Regional Pain Syndrome
 - ❑ Phantom Limb Pain Management
- ❑ Clinical study with volunteers (N≈10)
- ❑ Clinical therapy studies (single cases, N≈5)
- ❑ Also conceptually develop AMB technique as a diagnostic tool and use of AMB to help understanding the underlying (perceptual / neuropsychological) processes

- ❑ Funding proposal development
- ❑ Collaboration opportunities

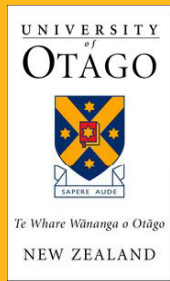
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on behalf of
Augmented Reflection Technology Group

*Thanks to
Danielle Windfuhr, Alexander Wollert, Hussam Al-Mahoozi*



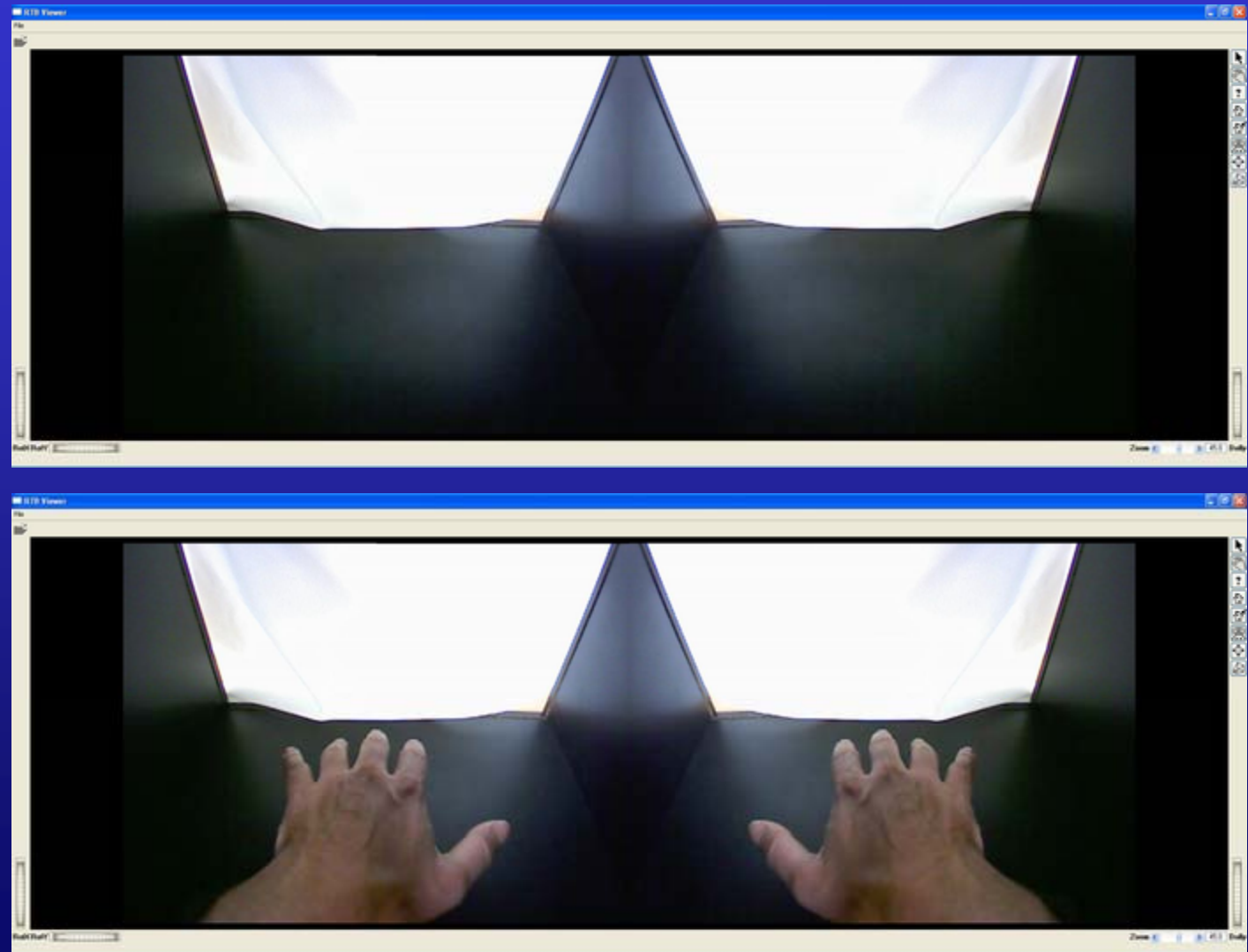
Miscellaneous

Augmented Mirror Box::Possible Future Work Simon's PhD work

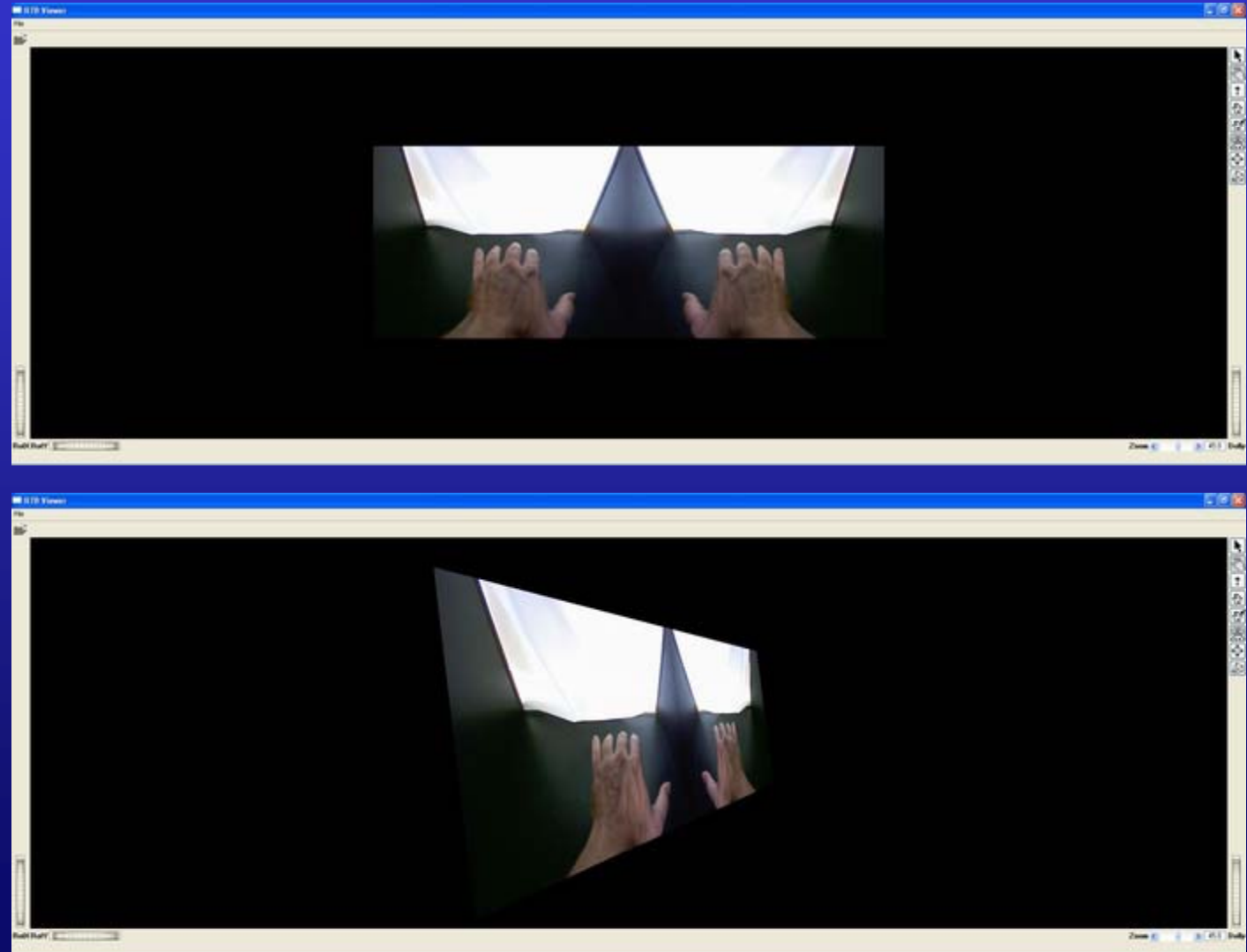
Aspects to be manipulated:

- ❑ Mirror: none, left, right, both
- ❑ Size: environment or limb
- ❑ Position: x, y, z
- ❑ Movement: amplitude, pace (also shake/jitter)
- ❑ Timing: slow down, speed up, delayed
- ❑ Appearance: colour, visibility
- ❑ Touch: virtual or tactile (being touched or touch)
- ❑ Temperature (real, perceived)
- ❑ Grasp: virtual or real (being grasped or grasp)
- ❑ Immersion: resolution, fps, latency
- ❑ Foreign limb vs. own limb

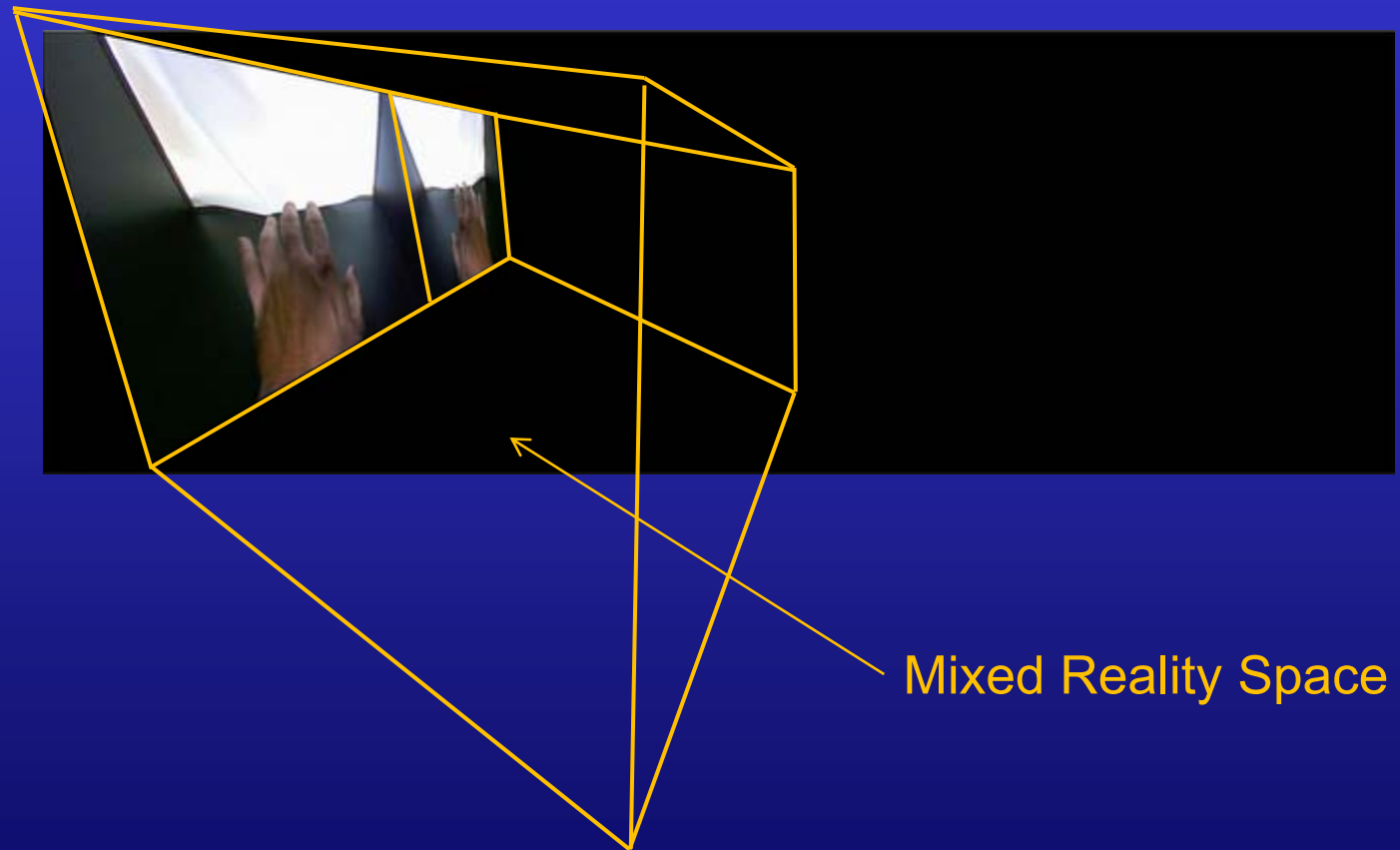
Augmented Mirror Box:: Working Prototype.Perceived Screen(s)



Augmented Mirror Box:: Working Prototype.Actual 3D environment



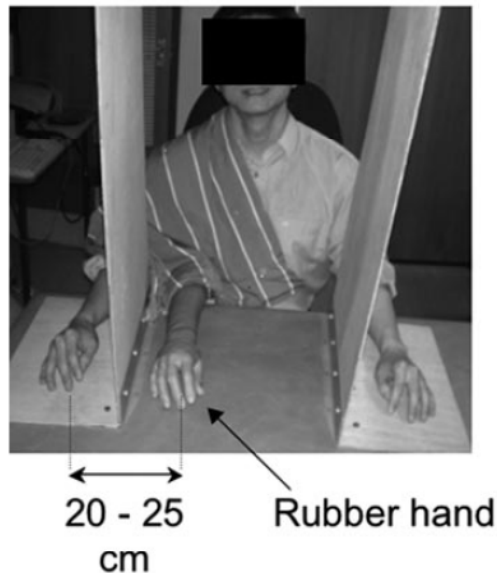
Augmented Mirror Box:: Working Prototype.Virtual and real space to be used



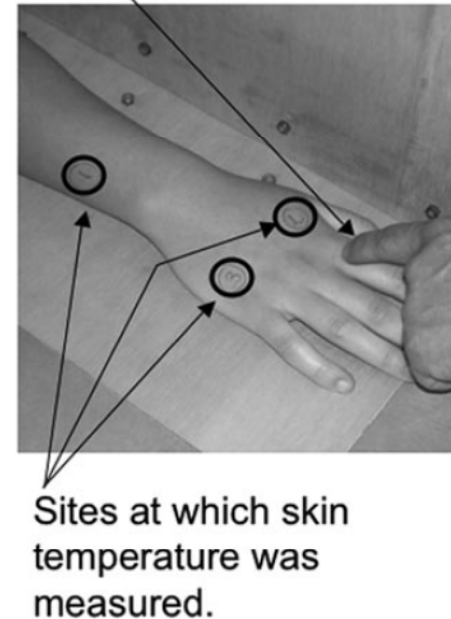
Mixed Reality Space

VR/AR therapy::Examples

A Participant's hands placed behind screens. Opposite hand visible for Experiment 1.



B Synchronous manual brushing of real hand and rubber hand.



Moseley, Olthof, Venema, Don, Wijers, Gallace, & Spence (2008). Psychologically induced cooling of a specific body part caused by the illusory ownership of an artificial counterpart. PNAS September 2, 2008 vol. 105 no. 35 13169–13173

VR/AR therapy::Examples

