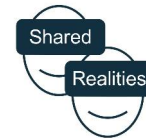


XR Mental Health

Dr David Roberts

Who am I



Founding CEO of Shared Realities Ltd

Earlier academic carrier

- 25 years as an Academic
- Universities of Reading and Salford
- Previous Leadership Roles at Salford
 - EPSRC National industrial Centre for Virtual Environments
 - Digital health
 - XR for health
- Professor
 - 10 years
 - Research professor 4 years



PhD in multi-user Virtual Reality

Publications

- h-index 51, > 9K citations (Google scholar)

Specialities

- Telepresence
- XR for mental health

Impact

- REF Impact statement awarded national exemplar for economic benefit of research by EPSRC/Royal Society

Learning Outcomes



Gain a basic understanding of:

The case for VR in mental health

Core qualities of XR and how these relate to mental health

Evidence of efficacy of virtual reality exposure therapy

The case for Mixed Reality in mental health

Balancing of engagement in exposure therapy through mixing reality & simulation

Neural Basis for XRET



Embodiment

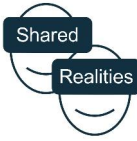
Changing perception of one's own body through a self avatar

Part I



VR for Mental Health

The principle of Virtual Reality



Immersion

Presence

React as if real

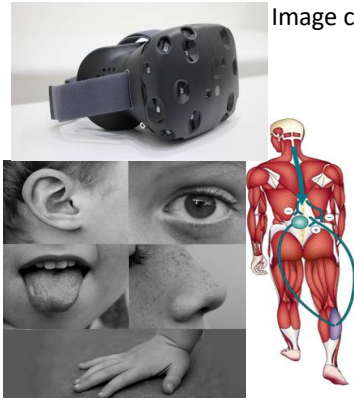


Image credit: HTC

Nature Reviews | Neuroscience

Image credit: Neuroscience reviews



Image credit: Landowska and Roberts et. al



Image credit: Sander and Roberts et. al

Technology Intervention

Neural response

Behavioural response

Objective

Subjective

VR immerses the senses, giving rise to a feeling of presence that results in reactions as if the stimuli were real

Relevance to Mental health



Psychological disorders cause people to respond differently to real world stimuli

A person's individual response to stimuli will likely be similar if that stimuli is real or virtual

Thus VR can evoke responses that are in part due to mental health and are indicative of how that person responds to the real world

These responses are both neural and behavioural

Applications of VR in Mental Health



Understanding,
Diagnosing,
Demonstrating,
Living with &
Treating a condition

Anxiety related disorders
Generalised Anxiety Disorder
Phobia
Post Traumatic Stress Disorder (PTSD)
Eating disorders
Body image
Dementia
Anti-social behaviour
Addiction
Schizophrenia
Obsessive Compulsive Disorder (OCD)

VR Reminiscence therapy



Calming people by giving them stimuli that evokes pleasant memories

Helping people to live with a condition



Image credit: carehome.co.uk

Virtual Reality Exposure Therapy



Technology intervention

Client immersed in a simulation that includes evocative stimuli

Simulation usually controllable



Image credit: OxfordVR

Offers

The feeling of being there

Controllability – a form of dosage control

Repeatability

Customization

Shared experience

(Client and therapist)

Potential for abstraction



Image credit: David Roberts taken at the Resilience Hub

VRET applications



Image credit: Bravemind from USC courtesy Albert (Skip) Rizzo



Image credit: Ahamba & Roberts



Image credit: Landowska & Roberts

Anxiety disorder

Generalised Anxiety Disorder (GAD)

Phobia

Acrophobia, agoraphobia, arachnophobia

Social Anxiety Disorder (SAD)

Public speaking

PTSD

War, terrorist attack

Obsessive Compulsive Disorder (OCD)

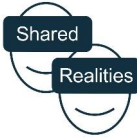
Addiction

Drugs, alcohol

schizophrenia

Hallucinations, illusions

Recent example publications



SAD - Rejbrand et al., 2023

Rejbrand C, Fure B, Sonnby K. Stand-alone virtual reality exposure therapy as a treatment for social anxiety symptoms: a systematic review and meta-analysis. *Ups J Med Sci.* 2023 Sep 14;128. doi: 10.48101/ujms.v128.9289. PMID: 37807998; PMCID: PMC10552696.

OCD - Lohse et al, 2023

Lohse, L., Jelinek, L., Moritz, S. et al. Efficacy of exposure and response prevention therapy in mixed reality for patients with obsessive-compulsive disorder: study protocol for a randomized controlled trial. *BMC Psychol* 11, 113 (2023).

Schizophrenia - Bisso et al, 2020

Bisso E, Signorelli MS, Milazzo M, Maglia M, Polosa R, Aguglia E, Caponnetto P. Immersive Virtual Reality Applications in Schizophrenia Spectrum Therapy: A Systematic Review. *Int J Environ Res Public Health.* 2020 Aug 22;17(17):6111. doi: 10.3390/ijerph17176111. PMID: 32842579; PMCID: PMC7504018.

Evidence of efficacy of VRET



5 meta studies point to efficacy similar to exposure therapy

Largest and most rigorous found that Effect size:

for treatment of PTSD lower than other anxiety related disorders;

& varies greatly across studies

While there has been hundreds of studies there has only been one large rigorous RCT for VRET treatment of PTSD

Neural biases of VRET demonstrated

RCT – Randomised Control Trial

Evidence of efficacy of VRET



Compressive meta study of VRET for anxiety disorders including PTSD - Carl et al., 2019

Virtual reality exposure therapy for anxiety and related disorders: A meta-analysis of randomized controlled trials. *J Anxiety Disord*, 61, 27-36. doi:10.1016/j.janxdis.2018.08.003

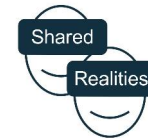
Large RCT for VRET treatment of PTSD - Reger et al., 2019

Reger, G. M., Smolenski, D., Norr, A., Katz, A., Buck, B., & Rothbaum, B. O. (2019). Does virtual reality increase emotional engagement during exposure for PTSD? Subjective distress during prolonged and virtual reality exposure therapy. *Journal of Anxiety Disorders*, 61, 75-81. doi:10.1016/j.janxdis.2018.06.001

Neural Bases of VRET - Landowska et al., 2018

- Landowska, A., Roberts, D., Eachus, P., & Barrett, A. (2018). Within- and Between-Session Prefrontal Cortex Response to Virtual Reality Exposure Therapy for Acrophobia. *Frontiers in Human Neuroscience*, 12(362). doi:10.3389/fnhum.2018.00362

Benefits and risks of VRET



Potential Benefits

- Dose control
- Engagement
- Familiar to some populations
- Feeling of being there
- Safety of not being there



Potential Risks

- Similar to any exposure therapy

 - Chance of retraumatisation

 - Particularly in early sessions

- Isolation from real world and therapist

 - Not yet proven to be problematic

VRET is a powerful tool that should be used with appropriate care

Engagement



Traumatized people may find it hard to engage in spoken/imaginal therapy

VRET seems more engaging to some resistant populations

Too much engagement can cause re-traumatization and dropout

VRET allows control of engagement in graduated therapy

But Traditional VRET replaces rather than complements traditional control of engagement

VRET PTSD

Potential to increase engagement

Military personnel are believed a particularly resistant group to exposure therapy

Drop out rates particularly high

Many veterans may not feel as comfortable engaging in imaginal exposure therapy

Yet most have experienced video war games and a great many play them post duty

Testimony from ex military PTSD sufferers

“It puts you back there”

“it makes you sweat”

Literature on graded therapy



Graded exposure therapy review- Heo et al 2022

Heo S, Park JH. Effects of Virtual Reality-Based Graded Exposure Therapy on PTSD Symptoms: A Systematic Review and Meta-Analysis. *Int J Environ Res Public Health*. 2022 Nov 29;19(23):15911. doi: 10.3390/ijerph192315911. PMID: 36497989; PMCID: PMC9735589.

Theoretical problem with traditional VR approach to grading therapy

Roberts, D. J., Barrett, A., & Landowska, A. (2018). Gradual and shared immersion in virtual reality exposure therapy. *Proc Int Conf Virtual Reality, Dissabilities and Associated Tech*.

Part II



Immersing in simulated stimuli without
losing grounding in reality

Dual awareness



Keeping people grounded in the real world while encouraging them to imagine what upsets them

- Core technique in imaginal therapy

- Championed by Rothchild

- Therapist manages the client's dual awareness making considerable use of non-verbal communication (NVC)

- e.g. therapist seeing client fixate might draw their attention to the safety of the clinical surroundings

Conventional VRET

- Hides the real world and most NVC

Mixed and extended reality



Augmented Reality



Image credit: Microsoft

Augmented Virtuality



Image credit: Meta

Virtual Reality



Image credit: HTC

Matrix

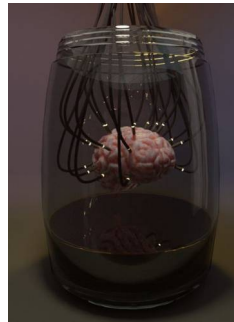
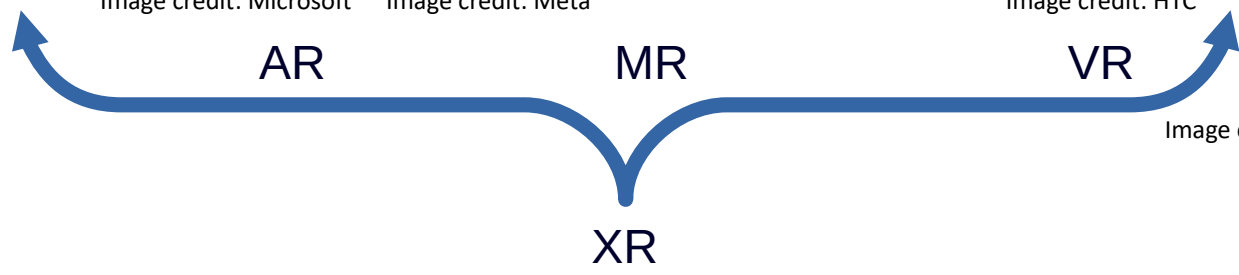


Image credit: Fernando Malhada (3D artist)



Relevance to Mental health



Mixed reality allows simulation to be mixed with real stimuli

Client and therapist can see each other, the real world and simulation situated within in

For example, therapist can see when a client fixates and guide their attention to the real world

Client and therapist together



Client and therapist share simulation and can both see aspects of the real world



Roberts, D. J., Barrett, A., & Landowska, A. (2018). Gradual and shared immersion in virtual reality exposure therapy. *Proc Int Conf Virtual Reality, Dissabilities and Associated Tech.*

Supporting Survivors of the Manchester Arena Bomb



Pictures by David Roberts taken at Resilience Hub

Helped the NHS to use a novel VRET to help survivors who wanted to return to the stadium



Logo: Resilience Hub



Picture by David Roberts taken at Resilience Hub



Novelty of intervention

Graduated immersion of interface

Keeping people grounded through sight of the clinical setting and therapist

360° video

Rapid content tailored creation

Low cost

High realism

Low cost phone based VR for PTSD treatment

Help given to the NHS



Worked with the Trust to understand their incentives and concerns about using VR therapy with vulnerable clients

Suggested the solution of combining 360 video with phone based VR

Provided a commodity off the shelf solution

Went with them to the scene of the attack and collaboratively captured relevant footage

Edited and stitched the videos

Co-developed a protocol for delivery

Trained clinicians and their leaders

Are now helping to validate

Capture of Content



360 still

Empty environment

Entrance Foyer

Just inside as if entering

Or next to where the explosion happened

360 video

Sparsely populated environment

Neutral environment

Picnic

Entrance Foyer

Just inside as if entering

180 video

walk through

Crossing the foyer

Approaching the doors that open to the bomb zone

Escape Routes



Image: Samsung

Stage 1: Low Immersion

Exploring 3D Video on phone

Finger used to pan around 3D Video of environment

Both Client and therapist see
Each other
The stimuli



Stage 2: Medium Immersion

Magic Window

Client pans the phone around her to look around the environment

Aimed at increasing feeling of being there without losing sight of the therapist



Stage 3: High immersion

When ready

Client puts on Head Mounted Display (HMD)

Strong feeling of being there

Putting it together and on them selves

Designed to increase feeling of control



Part III



The Neural Bases for XRET (PhD Studies supervised by Roberts)

Neural Basis for VRET



Fear response happens deep in the brain and thus cant currently be measured without lying in a tube



Image credit: Murray and Roberts. Simulation – Bravemind, Skip Rizzo.

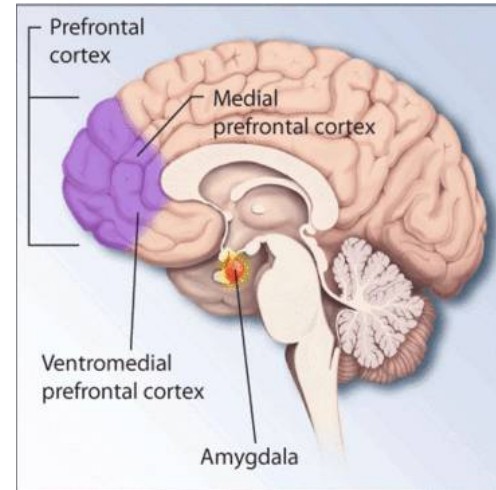


Image credit:
National Institute of Mental
Health

However, fear inhibition happens in the Prefrontal Cortex

We can measure this while people are in the kinds of VR that let them move around

Neural Learning During VR Exposure Therapy



Research questions

Does inhibitory learning take place within as well as between Virtual Reality Exposure Therapy?

Can we do VRET without isolating the client from the therapist?

Can fNIRS be combined with immersion projection technology?

Motivation

Understanding, diagnosing and treating anxiety related disorders. It was known that ET “normalises” pFC activation thought associated with inhibitory response. Jury out on whether learning takes place during ET session. pFC to VRET not measured. IR light and motion artefact might complicate things.

Contribution

First within session study of prefrontal response to virtual reality exposure therapy



PhD of Alex Landowska - Supervised by David Roberts and Pete Eachus

Experiments



Studies

“Healthy” subjects

Subjects with acrophobia

Apparatus

Display

Immersive projection technology (OcTAVE)

Stimuli

“Pit Room” from seminal presence experiment

Instruments

fNIRS neural imagining

Heart rate monitor

Video camera

Subjective Units of Distress questionnaire

- **Task**

- Participant gets used to VR in what appears a room in a small house. Walking through a door, they see a gaping hole in the floor looking down to the room below. They are asked to walk around the edge

- **Design**

- Block: Training room; neutral; Pit room

Findings



Study 1:

pFC activation indicative of inhibitory response when “healthy” subjects encounter the pit.

Study 2:

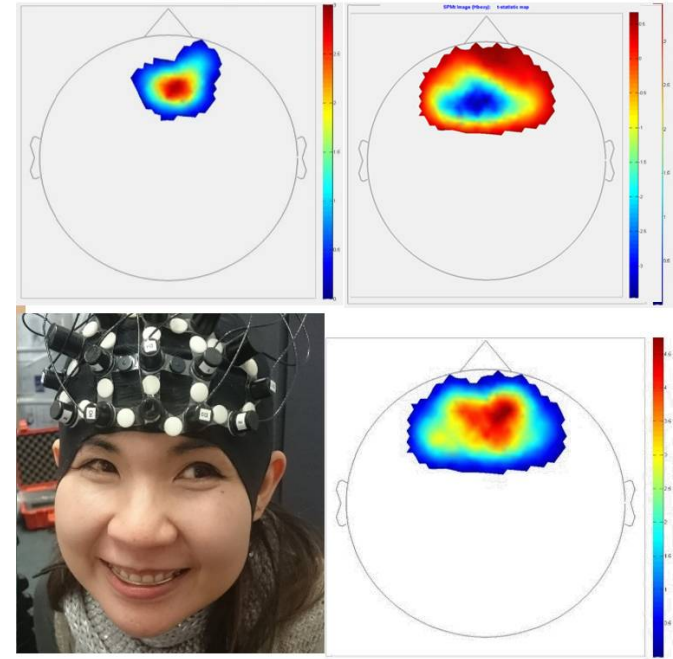
Learning during 3rd session

- Increase in pFC response

- Decrease in Subjective Units of Distress

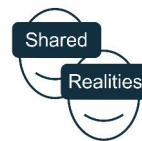
- Behavioural response

One participant got back in touch to say how she could now walk across a bridge near her house



Landowska, A., Roberts, D., Eachus, P., & Barrett, A. (2018). Within- and Between-Session Prefrontal Cortex Response to Virtual Reality Exposure Therapy for Acrophobia. *Frontiers in Human Neuroscience*, 12(362). doi:10.3389/fnhum.2018.00362

Virtual Humans in neuroscience & therapy



Research question

Can a virtual human evoke prefrontal cortex activity indicative of inhibitory response?

Secondary research question

What kind of VR display is best for combining with wearable neural imaging for measuring response to conversational interactions with virtual humans



Image credit: Ahamba, Roberts and Eachus.

PhD by Godson Ahamba Supervised by David Roberts and Pete Eachus

Study 1 – Headset: Method

Hypothesis

The annoying avatar will:

H1 – be disliked (Godspeed questionnaire);

H2 – evoke dorsolateral pFC activation;

H3 – evoke medial pFC activation. and

H4 – Prior experience of games/VR will impact.

Participants

N = 20 Neurotypical

2 groups: those with or without either gaming or VR experience



Image credit: Ahamba, Roberts and Eachus.

Variables

Dependent

Perceived likeability of virtual human; Activation of pFC

Independent

Friendliness of virtual human; Experience games/VR

Design

2x2 counterbalanced repeated measure

Materials

Oculus rift headset modified to fit fNIRS sensors

Instruments: fNIRS & Godspeed questionnaire

Image credit: The Brexit Experiment, Gibson, Roberts and Eachus.

Study 1 – Headset: Findings



Significant data loss from participants fiddling with headset as it pressed on sensors

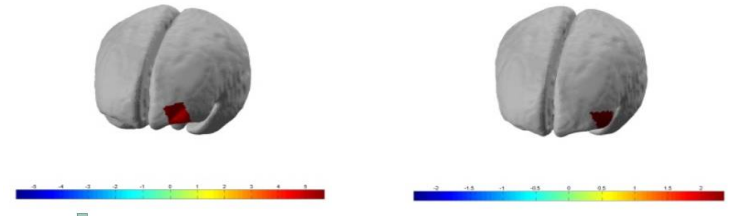
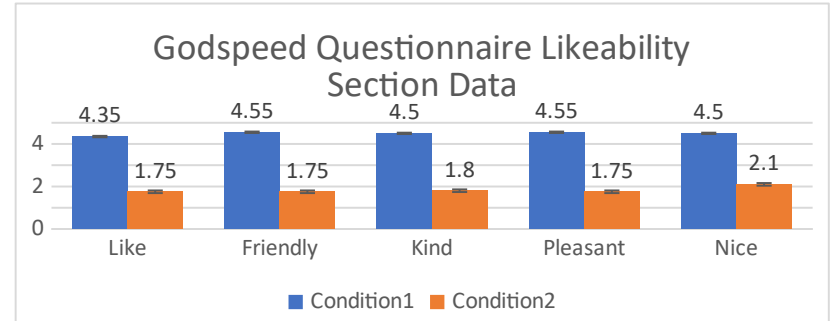
SPM Level 2 analysis across friendliness of virtual human & prior experience:

Gamers or VR

higher activation in medial prefrontal cortex (mpfc)

Non-gamers and no VR

higher activation in Dorsolateral pfc (dlpfc)



Images credit: Ahamba, Roberts and Eachus.

Study 2 - Large screen



Method

As previous experiment apart from:

Design

Within subject

Participants

N=10, (4F, 6M), 19-25 y/o, 6 with prior experience of games or VR.

Materials

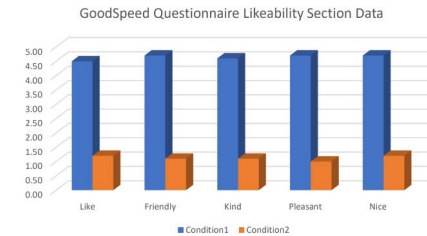
VR headset replaced by large (50") display monitor



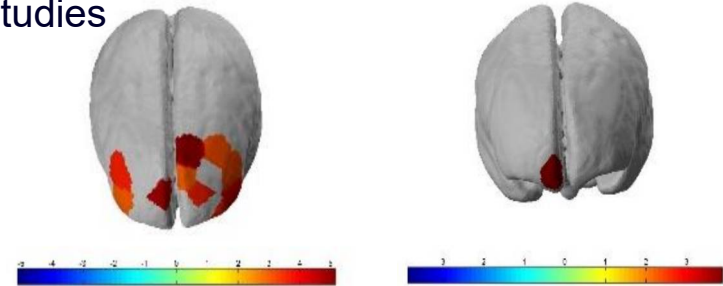
Images credit: Ahamba, Roberts and Eachus.

Findings

Very similar to previous study but much less data loss

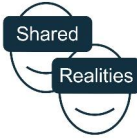


MANOVA showed little difference between studies



With (left) & without (right) VR or gaming experience

Study 3 - Surround Projection



Method

As previous experiment apart from:

Variables

Independent variables

Friendliness of virtual human (No grouping of participants)

Design

Counterbalanced within subject

Participants

N=14, (9F, 5M), 18-31 y/o

Materials

Display -projection onto surrounding walls and floor of a small room.

Analysis

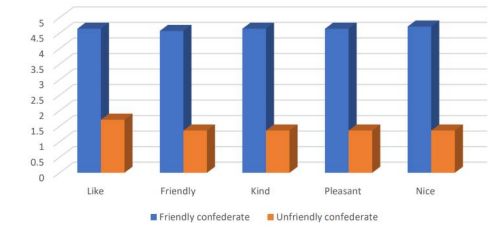
Better band filter



Image credit: Ahamba, Roberts and Eachus.

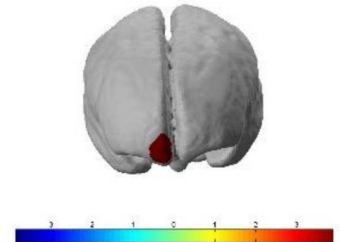
Findings

Godspeed Questionnaire Likeability Section Data



Increase in DLPFC when the virtual human was unfriendly

Low data loss.



Part IV



Changing perception of one's body through a self avatar

(PhD Study supervised by Roberts)

Manipulating Perception via Self Avatar



One's own avatar is known as a self avatar

In immersive VR is seen from first person perspective

A self avatar looking or behaving different to its owner can alter how they perceive themselves and others

A sense of **Embodiment** is that of having a body and consists of the senses of **Ownership**

feeling that a body is yours

Agency

feeling of control over it

Relevant literature



Embodiment – Longo et al., 2008

Longo, M. R., Schüür, F., Kammers, M. P. M., Tsakiris, M., & Haggard, P. (2008). What is embodiment? A psychometric approach. *Cognition*, 107(3), 978–998.

Embodiment in VR – Kilteni 2015

Kilteni, K., Groten, R., & Slater, M. (2012). The Sense of Embodiment in Virtual Reality. *Presence Teleoperators & Virtual Environments*, 21.

Impact of stroke on presence and embodiment – Borrego et al 2019

Borrego, A., Latorre, J., Alcaniz, M., & Llorens, R. (2019). Embodiment and Presence in Virtual Reality After Stroke. A Comparative Study With Healthy Subjects. *Front Neurol*, 10, 1061. <https://doi.org/10.3389/fneur.2019.01061>

Osimo et al., 2015 – a fun concept for self therapy via a recorded and changed self avatar

Osimo, S. A., Pizarro, R., Spanlang, B., & Slater, M. (2015). Conversations between self and self as Sigmund Freud - A virtual body ownership paradigm for self counselling. *Scientific Reports*, 5. <https://doi.org/10.1038/SREP13899>

Our following study - Hodrien et al, 2015

Hodrien, A., Galpin, A. J., Roberts, D. J., & Kenny, L. (2017). Exploring the impact of hand movement delays and hand appearance on myoelectric prosthesis embodiment using immersive virtual reality. *Annual Review of Cybertherapy and Telemedicine*, 15.

VR for understanding prosthesis acceptance

Research Question

What factors influence acceptance of prosthesis?
and Can VR help us understand this and specifically what are the roles
embodiment and agency?

Motivation

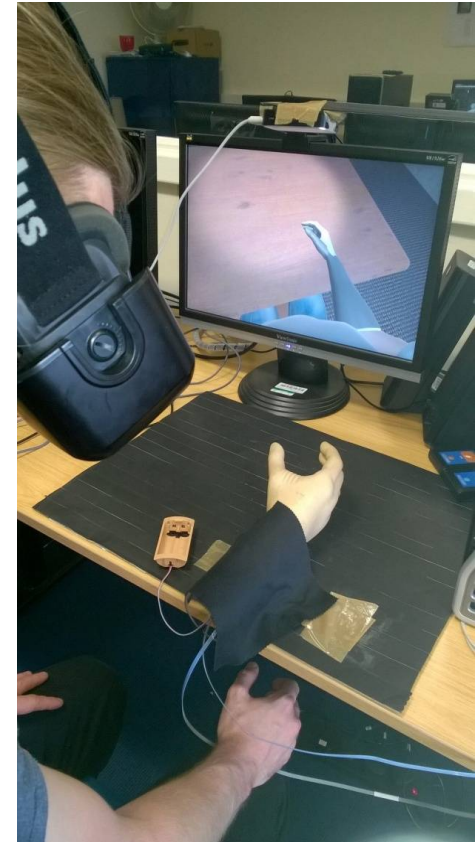
Individual differences in acceptance of prosthesis. Appearance, functionality/controllability, ownership and agency thought to be relevant. VR used in embodiment experiments and offers manipulation of appearance and behaviour, and eases recruitment by allowing subjects to appear to have a prosthesis in place of a limb.

Studies

Qualitative – Online questionnaire, not reported here.
Quantitative - VR experiment, reported here.

PhD of Andrew Hodrien

Supervised by Adam Galpin, Los Kenny and David Roberts



Method

Hypothesis

Ownership, agency, overall embodiment, SCR to a threat would be lower for EMG control than anatomical hand control of the virtual prosthesis.

Participants

N = 32 (17M + 15F)

“healthy” – intact limbs

Mean age 32.3

left-handed

12 experienced VR and 2 experienced controlling myoelectric prosthesis.

Design

Repeated measures

Variables

Dependent

Embodiment, ownership and agency; & SCR

Independent

Control of virtual prosthesis (via tracking of):
Myoelectric prosthesis; or real hand.

Materials

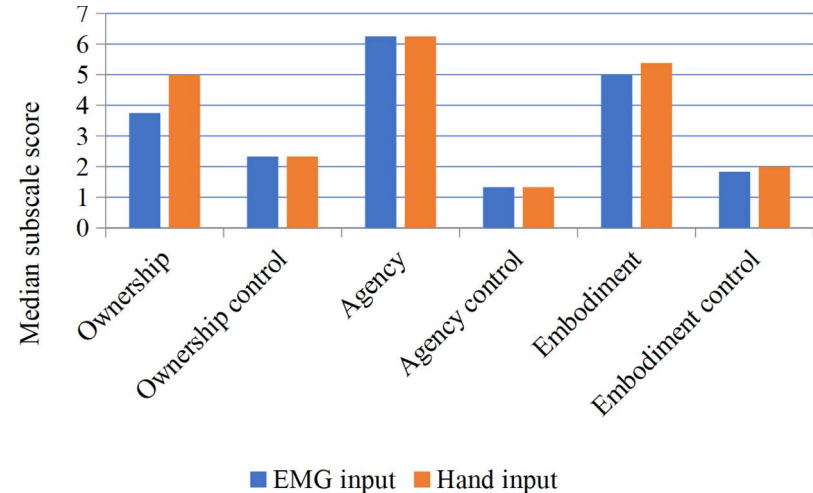
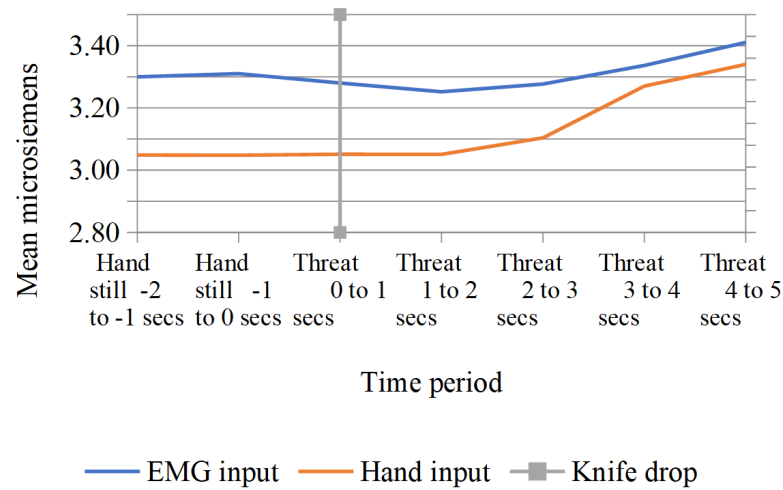
Myoelectric prosthesis (controlled by EMG sensors arm), passive finger tracker, VR headset & unity simulation

Instruments - Ownership and agency questionnaire adapted from Kalckert and Ehrsson (2012), including separate scores for ownership, agency, and embodiment; and SCR

Findings

Ownership was perceived and SCR sensitive to threat, across conditions

Ownership but neither agency or embodiment diminished by EMG prosthesis control



Thank you



Image credit: NBC News

The paradox of blurring boundaries of reality in people whose condition already blurs them

Don't let vulnerable people feel alone in something that they may falsely believe is real