# VIRTUE - Virtual Reality in Cognitive Stroke Rehabilitation

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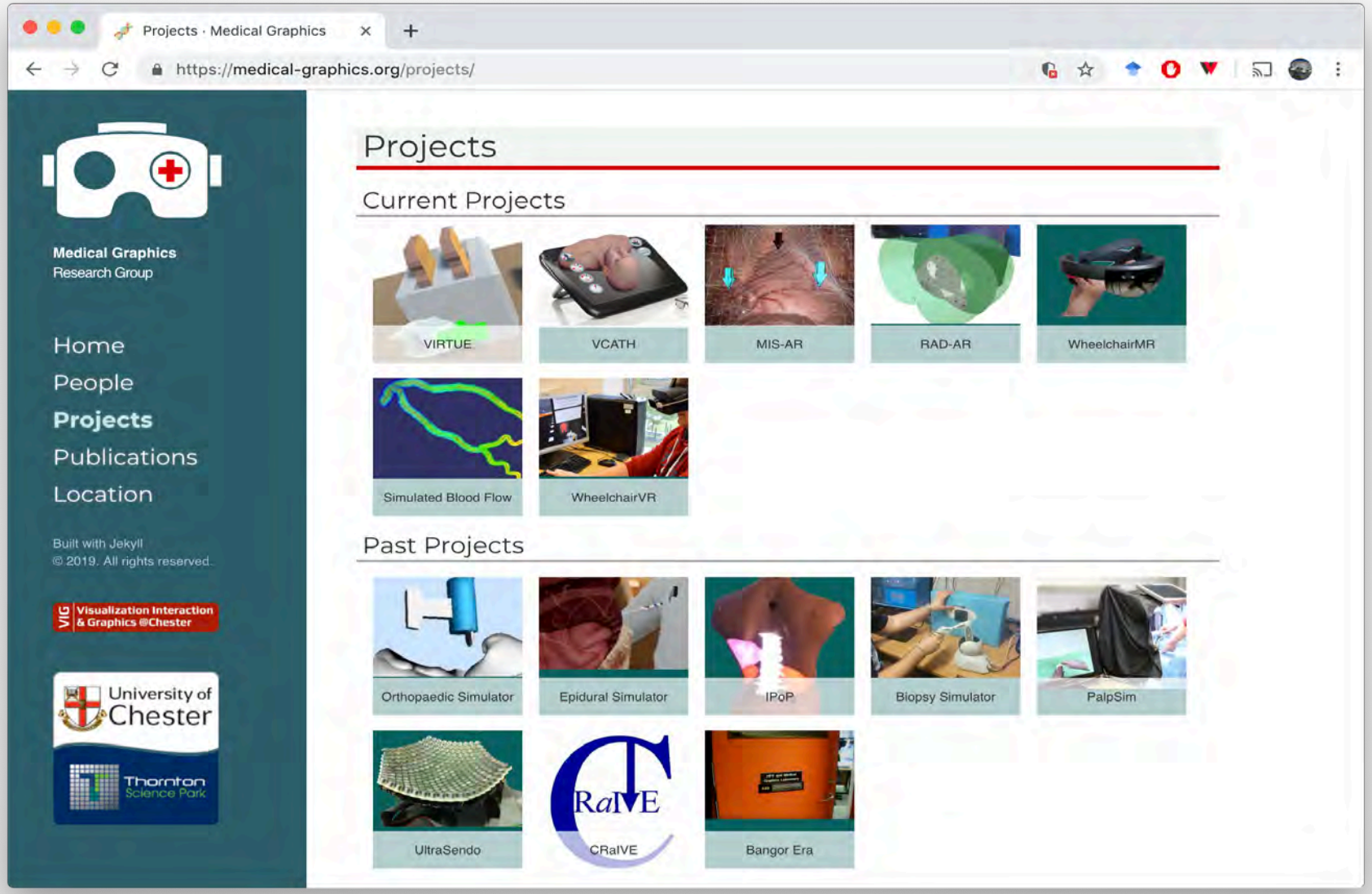
*Assistive Technology in Neurorehabilitation*
*Thursday July 18th 2019*

University of Chester

cadscan

Countess of Chester Hospital NHS
NHS Foundation Trust

# Medical Graphics Group



# Virtual Reality (VR)

A collection of technologies that allow people to interact efficiently with 3D computerised databases in real time using their natural senses and skills

VR has been fairly common since the 1980s, with the first devices produced in the 1960s.

Has a reputation for being expensive, cumbersome and/or delivering a low quality experience.

# VR in 2019 is Affordable

Oculus Rift, £400
360 degree positional tracking, integrated audio, touch controllers

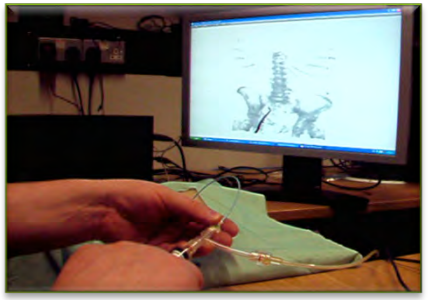
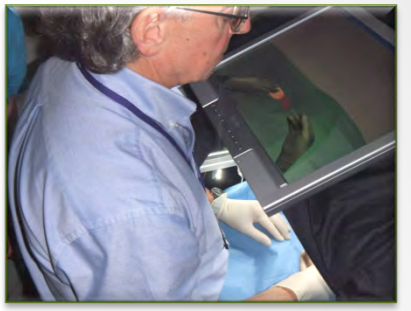
Oculus Go and Quest, from £399
Tetherless, Quest has two wireless controllers

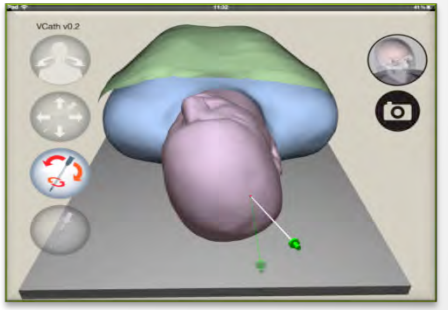
HTC Vive and Vive Pro, £499 / £1110
two wireless controllers, and room-scale motion tracking
Also has eye tracking option

HTC Vive Focus +, £639
Tetherless, two wireless controllers

# … and can be used for Healthcare

- VR can be used to help with
  - training medical procedures
  - retain skills
  - rehearal and planning of procedures
  - aid in the operating room
  - rehabilitate patients



# Stroke Survivors

A stroke is a life threatening condition that occurs when blood is cut-off from the brain causing brain damage. There are two main types of stroke:

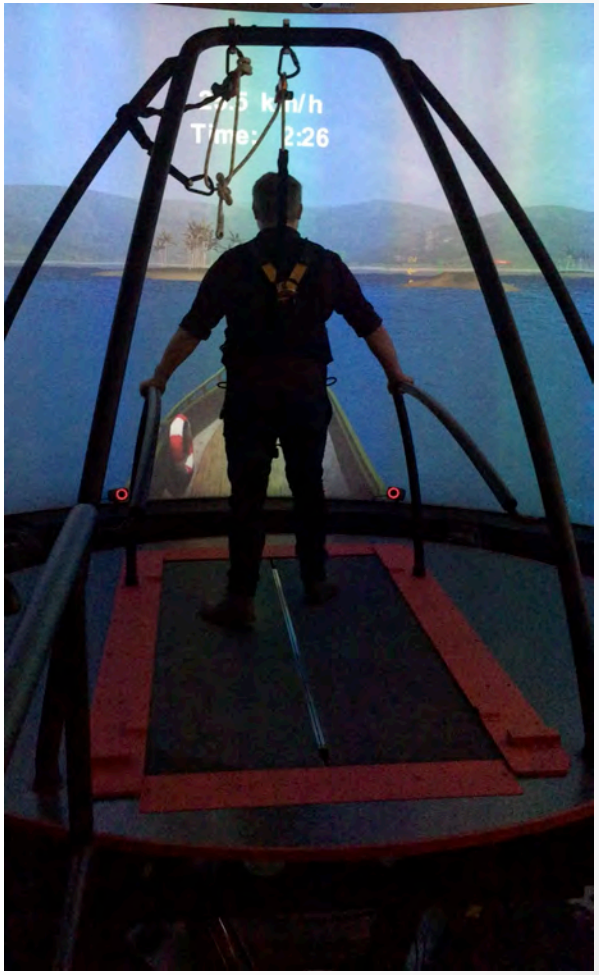
- Ischemic - Blood clot
- Haemorrhagic - Brain bleed

The symptoms of a stroke include a range of different conditions, such as:

- Hemiparesis - Paralysis on one side of the body
- Aphasia - inability to speak, read, or write
- Vascular Dementia - Issues with memory and task sequencing

# VR is already used for Physical Rehab following a Stroke

**Brain And Spinal Injury Centre (BASIC), Salford**



- Facilities include the CAREN (Computer Assisted Rehabilitation Environment)
  - mimics changes in terrain, encountered in the virtual environment, for example across the street or walking on uneven surfaces while in the safety of a harness
- But expensive to provide and maintain

# What about Cognitive Rehab?

The brain has the ability to form and reorganize synaptic connections, called neuroplasticity.

This process is triggered in response to different events such as experiences, learning, or following trauma.

# Activities of Daily Living (ADLs)

ADLs are tasks that form the daily routine of a normal person. These can include:

- Bathing,
- Cooking,
- Shopping

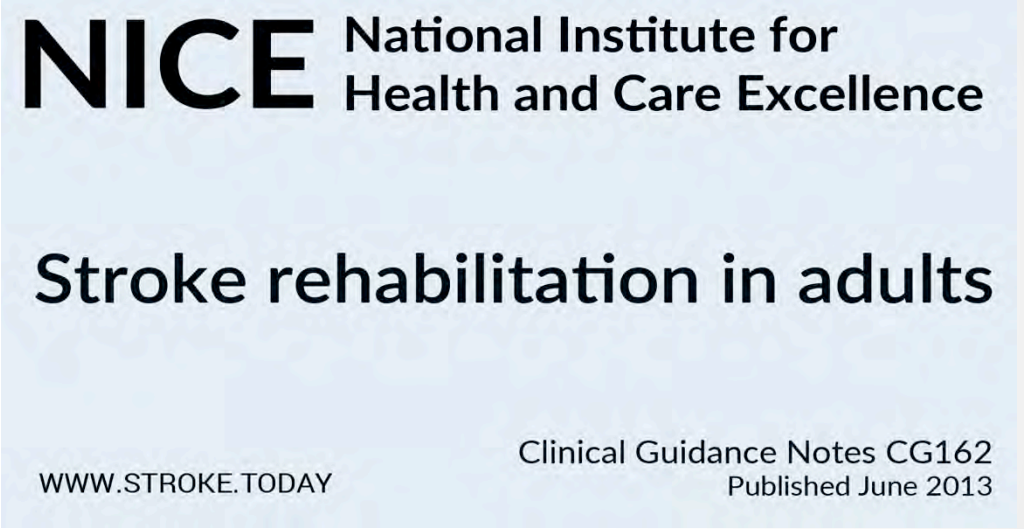
During normal therapy, patients practice ADLs to help trigger the neuroplasticity process and help them regain their ability to solve problems in a way that would seem familiar to them.

# Stroke Rehabilitation Guidelines

NICE Guidelines specify at least 45 minutes of therapy per patient, 5 days a week.

This is often a challenge to provide, and beyond this patients are usually sat in bed or on the ward with nothing to do.

VR has the potential to supplement normal therapy routines, providing a way of re-creating scenarios safely in a real-world situation.



# VIRTUE Project Aims

- Evaluate the efficacy of VR as a tool for Cognitive Rehabilitation
  - Practice Virtual ADLs
- Create an affordable commercially-viable product

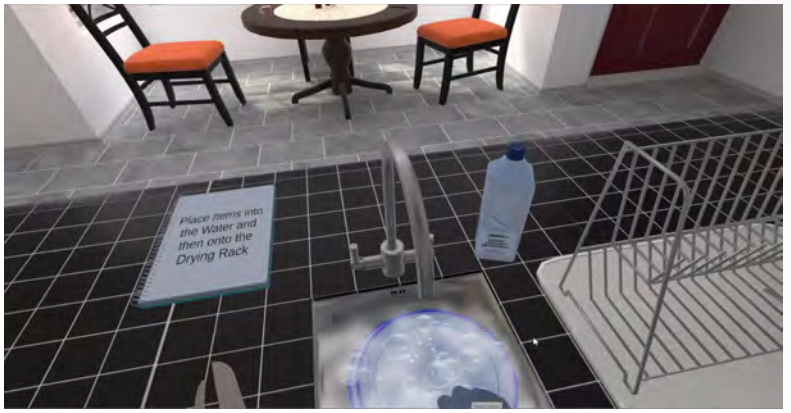
Funder: Innovate UK

Collaborators: cadscan, Countess of Chester Hospital NHS Foundation Trust, University of Chester

# Home Environment

VIRTUE immerses the stroke survivor in a home environment (bedroom, bathroom, kitchen, garden, etc) where they carry out basic tasks

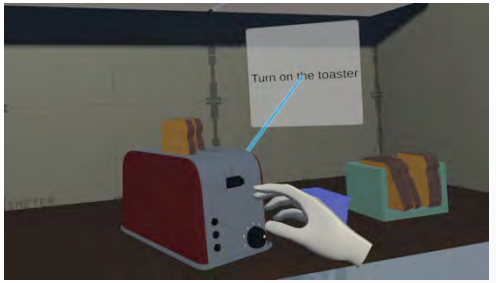
Each task has different levels of difficulty controlled by the therapist.



Place the Pillows
onto the Bed
Show Menu

# Hardware Options

- The system is able to work with a range of off-the-shelf Virtual Reality head-mounted displays including the HTC Vive (right) and Oculus Rift (left).
- These headsets provide an immersive way to interact with the virtual environments, and achieve a good sense of presence within the environment.
- The hand controllers allow for accurate interaction within the environment
    - They can map directly onto a computer graphics rendered hand in the virtual scene

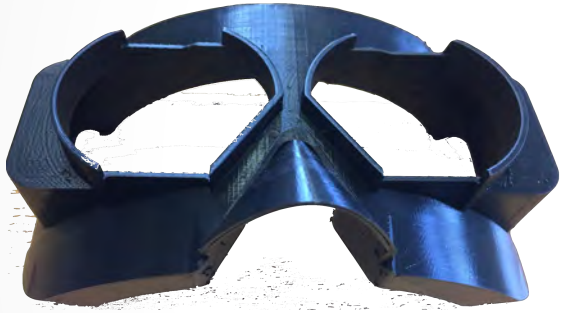


# Infection Prevention and Control

- As the headset is used by multiple patients, the device needs to meet the hospital's Infection Prevention and Control (IPC) guidelines
- The hand controllers are mostly smooth and can be cleaned using a combination of chlorine and alcohol based wipes
- The HMDs however are more problematic
    - Initially, a temporary solution enclosed the HMD inside a plastic bag, with disposable straps being used.
    - This solution was not ideal.

# Current Solution: “Batman” Interface

3D Print using anti-bacterial material



Slots into HMD cavity

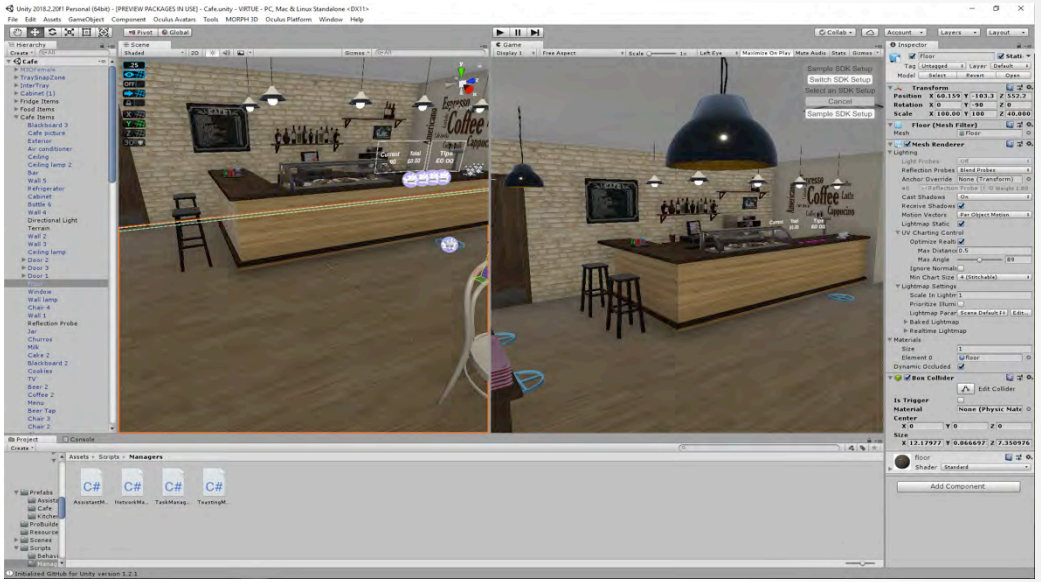
Additional strap mount

# Implementing the Tasks

Developed using the **Unity3D** Games Engine and the VRTK to provide support for a wide range of HMDs.

The Unity3D engine provides native support for VR application development and works with most modern VR HMDs.

A games engine was chosen as the development platform as we wanted to take advantage of the in-built physics support and games aspect to gamify the ADLs implemented in the application

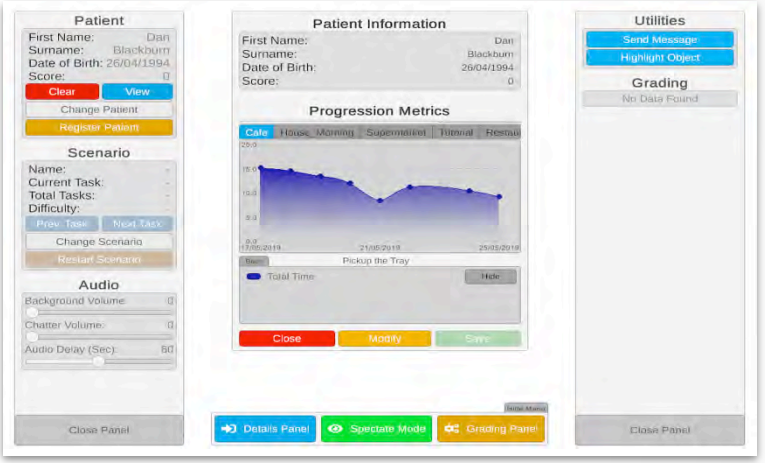


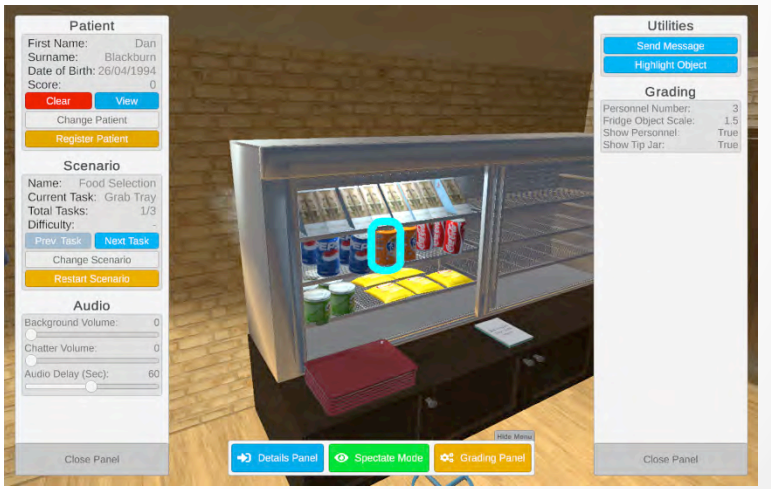
# Console Interface

A console interface is being developed to allow the therapist to control the VIRTUE application in real time.

It is designed to allow the therapist to see the patient's environment on the application PC and make changes, for example:

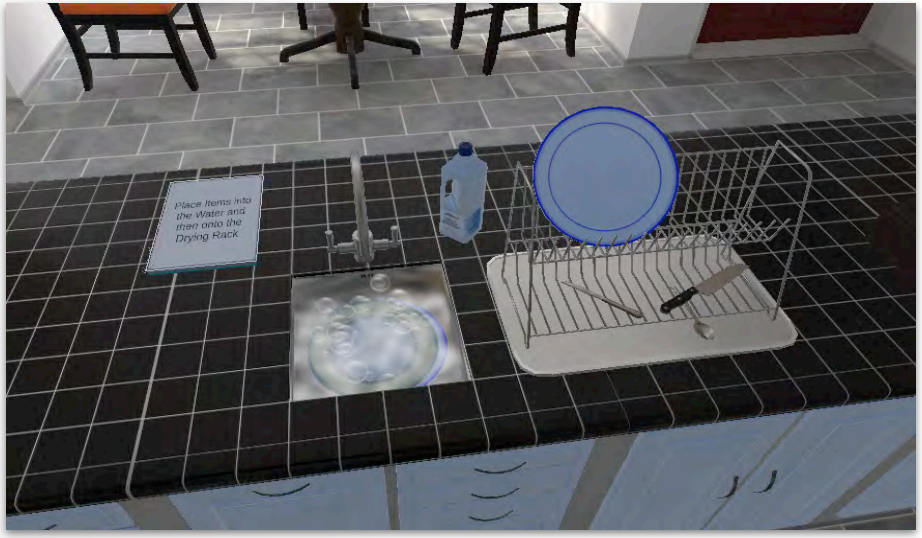
- Change the current scene or task
- Change the difficulty of the tasks
- Highlight in-scene objects
- Display Metrics

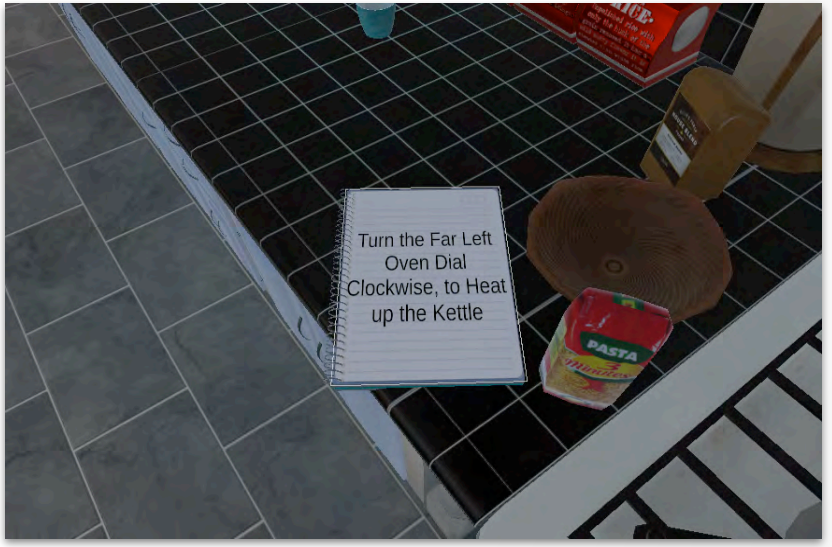


# Notepad

- Send messages and instructions to the patient
  - Message can be changed on the fly



# Café Environment

Basic Cafe Environment

Different cafe related tasks (ADLs)

- Grabbing items from a fridge
- Paying for items using exact cash amounts

Each task will have different levels of difficulty controlled by the therapist, such as increasing the number of items being purchased

OculusVR
Switch SDK Setup
Pringles
Coca-Cola

# Making a Payment

# Supermarket Environment

# Acceptability Study

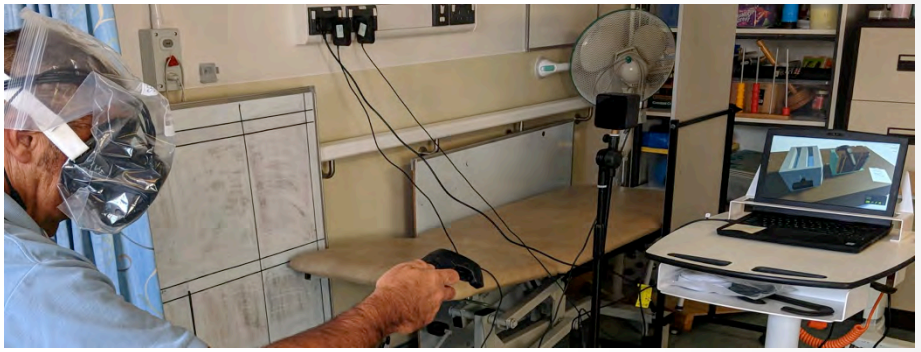
A study was conducted to determine whether patients over the age of 65 would accept VR as a rehab tool.

Demographic

- Age: 65+
- M-ACE Score: 15 - 25
- No history of mental illness

Single VR therapy session

Patients & Staff completed a questionnaire to determine their feeling towards the therapy



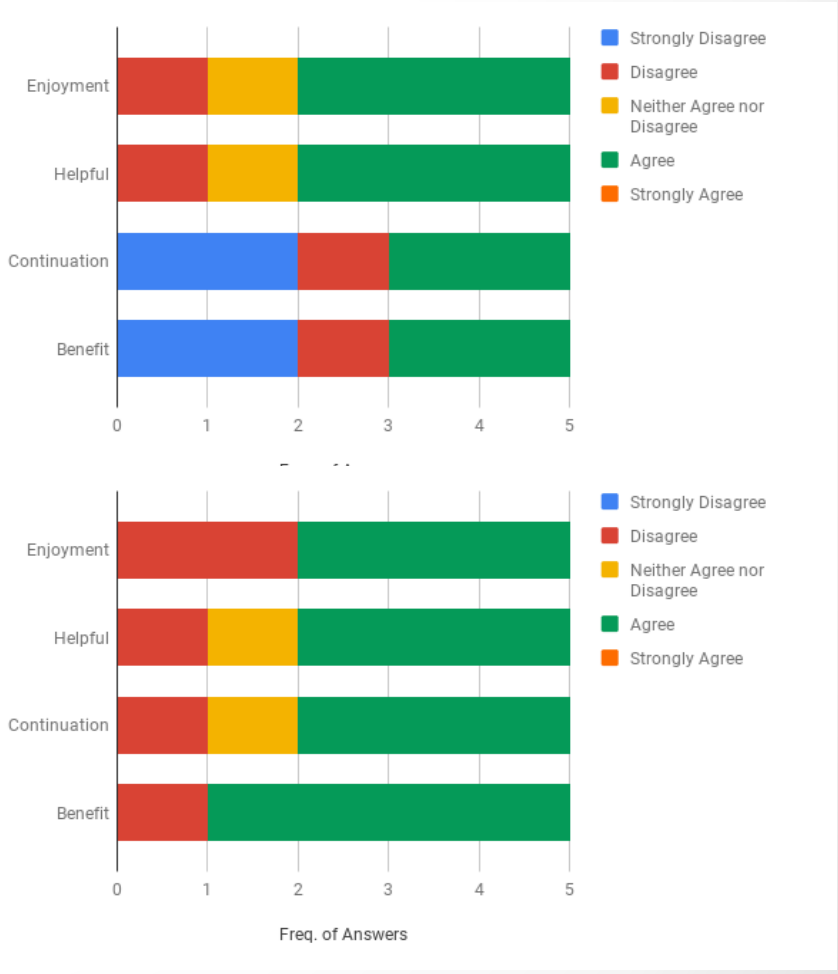
# Results

Patient Results

most of the patients found it enjoyable and helpful
mixed opinion over whether they would continue.

Staff Results

mostly agreed that the VR therapy would be beneficial and enjoyable for the patients.



# Pilot Study

- A year-long double-blind randomised controlled trial will start next month
  - Recruit 60 eligible patients in the first 3 weeks after stroke. Randomised into:
    - Active treatment group: will receive VIRTUE sessions at a different dose and duration, along with their regular therapy sessions.
    - Control group: receive a sham virtual reality based treatment for two weeks along with their usual therapy sessions.
  - Participants from both groups will be tested (using Cognitive Assessment of Minnesota and MoCA) on their cognitive function before the start and at the end of their treatment
  - Post study interviews will be used to assess acceptability
- The data gathered will be used to design a follow-on multi-site trial

# How much VR is tolerable?

- The study will include a dose escalation design
  - The first cohort (n=3) in the active treatment group will receive a VR treatment dose of 45 minutes, five days a week for 2 weeks
    - The dose will be deemed as beneficial if the total cognitive score is improved by at least 10%
  - If each participant in a cohort could not achieve the pre-prescribed 'target dose', the dose in the subsequent cohort will be reduced by 50%
  - If the target dose is tolerable and is found to be beneficial in all three participants, the total dose for the subsequent cohort in that stratum will be increased
    - The duration and frequency of the VR therapy will be adjusted from once to twice a day
  - If the target dose is tolerable but not found to be beneficial, the dose can be increased, or decreased if there is a reduction in benefit
  - If the target dose is reduced in a cohort and then found to be tolerable and beneficial, the target dose for the subsequent cohort will be increased

Colucci E, et al "A rule-based, dose-finding design for use in stroke rehabilitation research: methodological development" Physiotherapy. 2017 Dec;103(4):414-422.

# VIRTUE at Home

- The Oculus Quest provides a convenient platform for VR use at home
  - It is a tetherless headset and does not require a PC to run an application 👍🏽
  - We cannot use the console interface in this configuration, and the graphics performance is more limited. 👎🏽

  - We've brought one with use, so that you can try out some scenarios from VIRTUE

# Conclusions

- The flexibility of VR can facilitate personalised medicine without any limitation and this unique feature makes it different from other existing solutions in this area.
- VR can benefit the health service as it will accelerate patient recovery through intensive delivery of therapy with minimal supervision, shortening hospital stays and lowering costs.
- For clinicians, it will free up time for patients with more complex needs.
- For patients, recovery will be more effective because the therapy will be more engaging, delivered more often and can continue at home.

# Thank you

Any questions?

University of Chester