Initially, we planned to build an AED (Automated External Defilabrator) simulator. There is a general lack of awareness of AEDs among the public. In this scenario we planned for users to be placed in a realistic SCA (Sudden Cardiac Arrest) scenarios whereby the user is tasked with finding the AED (in the train station scenario) and operating it on the casualty. The purpose of this VR application was to supplement classroom training for first aid trainers, refresh existing first aid skills for users and to increase the awareness of AEDs.

However, this project was discontinued because we realised that we needed high quality assets that were not available on the asset store and would have to be created manually. Our team doe not have the artistic skills to build models from scratch. Moreover, a large virtual environment would be required for the user to move in as well as the current issue of trying to make users movement natural.

We then decided to take advantage of the pain-relief aspect of VR (VR has a proven track record in pain relief) and apply this to exercise pain and endurance. We hypothesised that the user should be able to have a longer endurance when exercising, less exercise pain and ultimately an increased motivation to exercise.

The types of exercise we decided to target in this timeframe were ideally safe bodyweight exercises such as push-ups, star jumps etc. The scenarios would have been the user cycling through clouds, or push-ups in a relaxing scenery. It had to be a mobile VR application, as this is the lowest entry barrier to VR. The problem with mobile VR is that full tracking is not currently available. Head tracking is essential, we designed methods to use a smartphones gyroscope to calculate pitch but this would require using hacks - this is not feasible, so the project was scrapped.

We decided to keep the pain relief aspect of VR and apply this to fear reduction and pain relief during acute wound treatment in A&E. Normally, if you get an open wound from an accident. In A&E, they will clean and cover the wound, before you can be transferred to another specialist nurse. This procedure of cleaning the wound, moving the limb and removing debris as well as covering the wound is painful and it is not possible to provide any painkillers. Moreover, some patients have a fear of blood and open wounds, not everyone has the same pain tolerance. It is more distressing for the patient if they are a child or a vulnerable person.

We designed a mobile VR app in which the patient can use while their wound is being treated. In the VR experience they can either be transported into a peaceful, calm natural environment (such as a toon-like forest) or play a relaxed game with a mobile VR controller.

The patient should feel less pain and be calmer (possibly no pain – its unlikely this has been tested before on A&E patients). Currently, medical staff cannot provide painkillers, so this VR experience would be better than the current situation facing patients.

No navigation was to be needed inside the VR experience, the patient would normally be sitting or lying down when receiving treatment.

From feedback and experience from other group members, we decided to focus on a specific problem facing patients and that was Trypanophobia (fear of medical procedures involving injections or hypodermic needles) We suspect that the fear and anxiety associated with injections could prevent people from receiving medical treatment, especially with children.

Anxiety can also lead to more needle attempts if the patient does not remain calm, (the patient keeps moving about) as well as discourage people from donating blood, stem cells etc.

Our solution was to build a low-entry barrier mobile VR experience aimed at adults and children, providing a distraction for a short period of time. The experience was designed as an animated environment, a colourful toon-like forest (almost like an aquarium) – distracting without the cost of a controller.

To ensure a low entry barrier the experience was designed for the Google Cardboard, most doctors, nurses and medical professionals as well as patients have a smartphone, the Google Cardboard can easily be made or printed out.

We initially scrapped the interaction aspect of the experience as all studies carried out with pain relief/anxiety in VR were games (except for Forest of Serenity by Holosphere), increased level of interaction (plausibility) can increase the distraction thereby reducing the anxiety and pain.

Currently, no researcher has attempted to use a solely animated environment as the experience, so the animated environment concept has not been explored, could place illusion be enough to reduce anxiety? Animated environments do have a lower risk of motion sickness. We cannot afford good enough and cheap enough interaction with mobile VR, the Google cardboard is the cheapest possible entry into VR.

We researched as much as we could on the effects of VR on pain relief and anxiety especially in a medical setting.

https://www.jpain.org/article/S1526-5900(05)00240-3/fulltext - VR distraction during blood draw in children:

“Children in the VR HMD group reported a lower frequency of moderate-to-severe pain intensity levels compared with the other three groups”

https://www.researchgate.net/publication/7141575_Effectiveness_of_Virtual_Reality_for_Pediatric_Pain_Distraction_during_IV_Placement - IV placement for an MRI scan (injecting a dye into blood for detection in MRI):

“While children in the control condition had a fourfold increase in pain ($p < 0.01$), children in the VR condition reported no significant changes in pain intensity between pre- and post intravenous placement. Furthermore, children, caregivers and nurses were more satisfied with the use of VR for pain management during the procedure.”

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3138477/ - from here we also find out that VR can provide the same level of pain relief in every use, no-wear out.

Moreover there were other projects we found that were similar to our concept such as SnowWorld https://www.bbc.co.uk/news/health-12297569 and Gardens of serenity http://www.holosphere.co.uk/case-studies/forest-of-serenity/

One of the theories behind why the pain relief works is that you have a limited capacity of attention and you must notice or focus on a painful stimulus in order for it to be perceived as painful. So, if you focus on something else, you will perceive the painful stimulus to be less intense. We believe this could also be applied to anxiety.

We first implemented our first prototype demo without any interaction, from feedback it became clear that it would be better to have user interaction, this would increase distraction and hopefully a stronger place illusion. The problem we faced is that we could not use a controller as this would go against our main goal of having a low entry barrier as well as the fact that the patient would be having an injection, so they should not be moving their arms.

There are controllers on the market for mobile devices, but they are not standardised, we looked into the prospect of using the PaperStick controller (a VR controller printed from paper with a QR sticker, smartphone camera can track controller) but there was no SDK available. https://sites.google.com/site/gameplusvr/

So, we overcame this problem by using the users gaze/HMD rotation as input for interaction.

Firstly, we built the animated environment, the whole environment consists of 3D assets from the unity asset store, all the models were either low-poly or hand painted textures. Hand-painted textures create a toony colourful playful look, a complete contrast to the current environment the patient is in.

Low-poly butterflies were animated and follow a random path around the player using a waypoint system. We found that low-poly models that are relatively smaller to hand-painted texture models can blend into the environment without ruining plausibility.

Implementing user gaze/HMD rotation as input was the most difficult part of the project. We tried using the API of the HTC Vive unity plugin as well as Steam VR both were outdated, so unity had to update the api causing further conflicts further into the project. We were using the latest version of unity for development.

Normally, implementing gaze-based interaction would require using the VREyeRaycaster script as part of the VR sample provided by unity, but this did not track where the user was looking at. The Vive official plugin also had an outdated API and had the same problems. We also used the VRTK asset which had an simulator and that also did not work.

So, I tried to track the camera position and shoot a invisible ball from the user was looking at (via the rotation of the camera), if ball collides with an object, it means the user's gaze is on the object, I therefore can make the collided object interactive. Through this attempt, I found a better way of doing this by using the built-in unity Physics.Raycast class, this required less resources and performed better, this made into a script which is attached to the main camera.

The next problem was making the animated environment interactive using gaze mechanism that now worked. If the user were to play notes by looking at a tree, (there are 23 trees in the environment) then this should be provide enough interaction to be distracting. We chose an xylophone as this generally a positive and calming sound.

When the user, looks at a tree the trunk changes into a random colour (via changing the emission setting in the standard shader), when the user looks at a mushroom, a loop will play to complement the xylophone sound of the trees.

Also, bubbles which now have collisions as well as random speeds rain onto the user, further distracting the user. The idea is to immerse the user in a distraction long enough for the medical procedure to be carried out.

For the scope of this project, we were planning to use a Oculus Go as the demo and standardised prototype, then optimise and scale down to a google cardboard, if we have enough time. We were aiming for mid to high budget smartphones released since 2016 as the hardware for the Google Cardboard. We don't want to target a specific smartphone brand HMD as this would limit the number of people who could use the experience.

However, this did not go to plan. It was difficult to get the SDK of google Oculus Go to work as well as with the Google Cardboard, instead we developed the demos on the HTC Vive which worked on the unity. The unity scene could always be exported onto the Google Carboard outside the scope of the project. (we were always keeping in mind tris counts when developing)

Plausibility illusion: Mixture of passive and active interaction, trees change colour when users looks at them and play different notes, bubbles will bounce off a user if it touches as well as bounce of other however the butterflies have random pattern of movement, some events occur in relation to the user. All interaction is based on magic interaction, its non-realistic. It is a fantasy environment, so it is not credible and not fully plausible, but the user is only expected to be in the environment for less than one minute. The HMD provides the only input in the VR world.

Place illusion, is limited by the fact that the user cannot by design move around in the environment (there receiving an injection), it is a fantasy environment. The user can move there head naturally in the in the environment but there is no embodiment (designed as mobile VR), the user does not have a body, when they look down they do not see a body

Member contribution:

Liban and Imran: main programming and research.

Responsible for bringing the designed interaction to reality. Also, searched for assets needed for the environments.

Selina: level designer, initial idea, research

Designed and directed the multiple environments, later we focused on one single environment. Trypanophobia was her idea and provided background research.

Laith: project management, asset finding

Insured each environment was built on time, directed their issues to me, general help to all team members. Also assisted in finding assets.

Hussein: Project leader and firefighting

I lead the whole project, evaluated which environments to carry on with. Had to help with technical issues relating to assets and APIs.

References:

Assets used in final demo

https://assetstore.unity.com/packages/3d/environments/hand-painted-forest-environment-free-sample-35361

https://assetstore.unity.com/packages/tools/integration/steamvr-plugin-32647

https://assetstore.unity.com/packages/3d/vegetation/plants/glowing-stylized-mushroom-56048

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https://soundpacks.com/free-sound-packs/xylophone-samples-pack/

Background research

Snowman https://www.bbc.co.uk/news/health-12297569

Doctor https://www.fau.edu/newsdesk/articles/virtual-reality-study.php

Gardens of serenity http://www.holosphere.co.uk/case-studies/forest-of-serenity/

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