Fantastic Voyage 2021: Using Interactive VR Storytelling to Explain Targeted COVID-19 Vaccine Delivery to Antigen-presenting Cells

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ABSTRACT

Science storytelling is an effective way to turn abstract scientific concepts into easy-to-understand narratives. Science storytelling in immersive virtual reality (VR) can further optimize learning by leveraging rich interactivity in a virtual environment and creating an engaging learning-by-doing experience. In the current context of the COVID-19 pandemic, we propose a solution to use interactive storytelling in immersive VR to promote science education for the general public on the topic of COVID-19 vaccination. The educational VR storytelling experience we have developed uses sci-fi storytelling, adventure and VR gameplay to illustrate how COVID-19 vaccines work. After playing the experience, users will understand how the immune system in the human body reacts to a COVID-19 vaccine so that it is prepared for a future infection from the real virus.

Keywords: Virtual reality, storytelling, immersion, interactivity, education.

Index Terms: Human-centered computing – Human computer interaction (HCI) – Interaction paradigms – Virtual reality; Human-centered computing – Human computer interaction (HCI) – Interactive systems and tools

1. INTRODUCTION

Educators have used stories in science teaching to make subjects accessible to novice learners. Studies have shown that storytelling in science education promotes students' understanding of complex science concepts [1, 2]. Cinematic immersive storytelling in VR, either based on 360-degree videos or full computer animations, has been embraced by many content creators since 2014 as a new trend in immersive storytelling [3]. However, although those immersive VR storytelling experiences provide a great potential for training and education, most of them are passive with limited interactive options for users (e.g., allowing the users to change viewpoints or interact with characters in the scene). If a user is exposed to the medium very often or for a long time, he/she may lose engagement with the experiences. Therefore, we propose the design of immersive VR storytelling with high interactivity for science education.

During the COVID-19 pandemic period, science education on virus-related information for the general public plays an important role in guiding people to take correct and appropriate steps for virus prevention. Vaccination will be an effective way to protect healthy people against infection of the highly-contagious COVID-19 virus and should curb its fast spread within communities [4]. However, despite the proven effectiveness and high safety of approved COVID-19 vaccines, many people are unwilling to take them due to safety concerns and general distrust [5] that may arise from a lack of understanding of how the vaccine works in the human body.

We believe that understanding the science behind a vaccine's working mechanism and how it affects the human body is a necessary step for a person to make decisions on whether or not to take the vaccine. A highly interactive and immersive VR storytelling experience can well serve this purpose. In our interactive VR storytelling prototype, we took information on COVID-19 vaccines and their working mechanisms, integrated it with research information from targeted immunotherapy, and created a compelling VR experience that was inspired by a classic work of science fiction: *Fantastic Voyage*. The 3D user interfaces (3D UIs) in the prototype are custom designed to provide users with a novel interactive experience that supports their learning.

2. EXPERIENCE DESIGN

2.1 The Story

The story centers on currently approved COVID-19 vaccines, which have been developed using the new mRNA manufacturing method by extracting messenger RNA genetic information from the virus's spike proteins and packing it into vaccine particles. Vaccines developed with such a method are unstable in the human body and break down quickly once injected [6]. On the other hand, research in targeted immunotherapies shows that vaccine delivery directed to antigen-presenting cells (APCs) like dendritic cells has a potential to maximize the effectiveness of the vaccine because APCs play a critical role in activating other immune cells and triggering an immune response in the human body [7].

Figure 1. A nanobot travels inside the human body tissues

Therefore, the user in our VR experience is assigned a fictional top secret mission to drive a nanobot ship loaded with COVID-19 vaccine particles inside the human lymphatic system, search for dendritic cells, and deliver the vaccine to them once they are found and identified. The user has to complete the mission under a time constraint due to the short shelf-life of the vaccine. Once the mission is accomplished, the user has to find a way to exit the lymphatic system without being detected by activated immune cells and attacked by antibodies.

2.2 Implementation

To create a highly interactive and immersive storytelling experience in VR, we took advantage of some new cinematic and

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animation tools available in the game engine Unity since its 2017.2 version and customized them to meet our design needs. Specifically, we used the Timeline tool in Unity to sequence all audio and dialogue in the experience. We then used Timeline Signals to trigger interaction events whenever we wanted, either during an audio clip that is playing or after it is played. Once an interaction event meets a certain condition, it can be scripted to trigger Timeline audio so that the Timeline resumes playing and the story progresses. Such a design setup allows us to create a system that responds precisely to the user's interactions and provides quick feedback to user activities, thus optimizing the VR learning experience.

2.3 3D UI Design

The designs of our custom 3D UIs are based on three main criteria:

- Interactivity should support the conveyance of immunology information embedded in the story.
- Interactivity should have novelty to engage users into interactions.
- Interactivity should be easy to learn and use.

2.3.1 Travel

Our solution is primarily a seated VR experience. A nanobot is used to locomote the user in the virtual environment. We designed two modes of locomotion. One is system controlled, in which the nanobot carries the user and moves along a predefined path. The other is user controlled, in which the user is allowed to use the controller to move the nanobot around with four degrees of freedom (DoF). As such, we were able to grant users freedom of exploration while still guiding them through the story [8].

2.3.2 Antigen-presenting Cell (APC) Identification

We created a 3D UI to help the user identify a certain type of APC (the dendritic cell), in the lymphatic system based on the procedure of immunophenotyping (a process to identify blood cell types using antibodies and laser beams) from microbiology labs. The 3D UI allows the user to shoot antibody particles to immune cells, scan them for cells with specific antibodies bound to their surfaces, and then label them as targeted APCs.

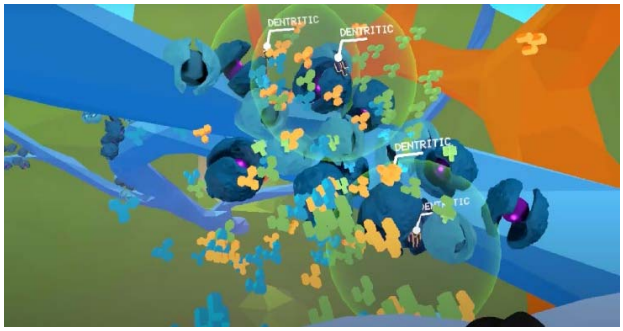

Figure 2. The identified APCs are labeled upon being scanned.

2.3.3 Vaccine Delivery to APCs

After the APC cells are successfully identified and labelled, the user needs to deliver the vaccine particles directly to the APCs. To make the delivery a more playful experience, we integrated a 3D UI resembling a slingshot in the nanobot. The slingshot can be activated by pressing a button on the controller. Users can pull the controller to drag the slingshot and shoot the vaccine particles at the identified APCs. The predicted trajectory is visualized in front of the slingshot to help users target the right location.

Figure 3. The slingshot 3DUI for vaccine delivery

2.4. Camera View Switching

The use of film cuts or camera shot transitions is a powerful technique in traditional film-making to guide the viewers' attention throughout the story [9]. However, using such a technique in VR storytelling needs special setup and planning in order to reduce user disorientation. We provided three points of view (POVs) throughout the user experience, the main 1st person POV and two 3rd person POVs from the left and right back quarter. The POVs are controlled by the system depending on which stage of the storyline the user is going through. Adding the 3rd person POVs allows the user to be more aware of the surrounding environment and strengthens the storytelling experience.

3. Conclusion

We created a novel educational VR storytelling experience with high interactivity by putting a user inside the lymphatic system of the human body and walking him/her through the process of how the COVID-19 vaccine works with human immune cells to build up immunity against the virus. Our goal is to help science education on COVID-19 related information for the general public. Our design explored a technical setup in Unity that seamlessly blends narratives and user interactions to create an optimal learning experience for the user. The 3D UIs in the experience engage the user with interactions and should effectively support the learning of abstract immunology concepts.

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