A MEMORY PALACE FOR BRAIN ANATOMY AND FUNCTION REPRESENTED IN VIRTUAL REALITY

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ABSTRACT

Memory palaces are effective tools for learning vast amounts of information in a canonical order using mnemonics. However, our review of the literature revealed a lack of implementation and user study of memory palace in Virtual Reality (VR) for neuroscience education. VR technology enables us to build highly interactive virtual learning spaces that are engaging and interesting. As a result, we implemented a web-based version of VR (known as WebXR) to help students about brain regions for the first time including the name, function, and location of each brain part.

KEYWORDS

Memory Palace, Mnemonics, Virtual Reality, Neuroscience Education, Brain VR

1. INTRODUCTION

Memory palaces are a technique that takes advantage of the brain's natural impressive ability to use spatial information to recall complex information (Burgess, 2008). In a memory palace, a list of things that are difficult to remember are encoded as images that are easy to remember. These images are placed in locations in the memory palace in the learner's imagination. The learner memorizes the palace and can imagine walking through it, decoding the mnemonics into the target information (Qureshi et al, 2014). A mnemonic is an abbreviation of a more complex idea through symbols, letters, or images (Carney, 2011), e.g., ROY-G-BIV to remember the colors of the rainbow.

Each location must be rehearsed in the same order every time. The stronger the individual's presence within the memory palace and association of the mnemonics with the location, the stronger the recall (Qureshi et al, 2014).

Suppose a learner wishes to remember that they need to buy milk and set up an appointment to groom their dog. The two familiar locations in their memory palace are their wardrobe and bathroom. These locations in the real world are familiar, as the individual always visits their wardrobe in the morning to get dressed first, then always goes to the bathroom to brush their teeth second. In this way, a canonical order of the memory palace is established. As a mnemonic, a scene of a carton of milk is imagined in the wardrobe, and a wet dog with an overgrown coat is imagined in the bathroom. They rehearse moving from the wardrobe to the bathroom in their imagination. When they get home, they can remember the mnemonics and decode them into the tasks they wanted to remember.

Memory palaces are typically modeled on locations well-known to the learner. Someone might make 30 canonical locations in the imagined version of their childhood home. Then, when they populate the locations, mnemonics are created and placed, in order, in these locations. It takes effort to create the palace locations, remember the correct order, create effective mnemonics, and rehearse the palace so that it is remembered when needed. This effort can make this memory tool less viable for many people. It could be that providing a palace for learners, rather than requiring them to design one themselves, will reduce this burden.

ISBN: 978-989-8704-43-6 © 2022

Virtual reality (VR) is an experience of a computer-generated world (Mandal, 2013). Even abstract information is more easily understood and recalled when experienced through a virtual lens. This is because immersion leads to more interaction with the data (Huttner & Robra-Bissantz, 2017). It is plausible that the learning of a memory palace could be enhanced if it is done through VR.

Brain areas and functions are commonly taught across a wide array of disciplines, including cognitive science, psychology, and neuroscience. An effective tool for enhancing memorization would be useful for neuroscience education, and VR is a promising avenue to explore (Radianti et al, 2019). Examples of virtual reality brain projects can be found so far in a few impressive brain systems: The Neuro explorer (Gamehearts, 2018), the "Giant Walkthrough Brain" (Ingram & Day, 2015), "UW Virtual Brain Project™" (Rokers & Schloss, 2021) and "A Journey into the Brain" (Unimersiv, 2017). These projects aid in the visualization of the brain but often fail to distinguish brain parts in the visual presentation and often do not show brain function.

The UW Virtual Brain Project ™ is a system that was advertised as an interactive walkthrough of the brain through 3D narrated diagrams. It was created by the Neuroimaging Center at NYU Abu Dhabi (NYUAD) and Wisconsin Institute for the Discovery at University Wisconsin-Madison (Rokers & Schloss, 2021). Using their system, they ran a similar experiment to compare the effectiveness of headset VR compared to its desktop VR counterpart. Results of that study showed that students did not have significant improvements in memory retention. Although not significantly more effective, they did also show that VR was far more enjoyable for students as a learning platform. They note that their findings support the idea that as of right now, VR cannot be a replacement for classroom learning but rather an effective tool to make the classroom more dynamic (Rokers & Schloss, 2021).

While no difference was found in the UW Virtual Brain Project ™ experiment, prior literature indicates that the addition of a memory palace format within our Experiments should prove to be another distinction from what has currently been researched. Therefore, compared to the neuroscience tools currently available, our Brain VR memory palace is the first to explicitly be designed for the purpose of learning brain region names, functions, and locations using mnemonic imagery in a memory palace.

To investigate and answer the above questions we designed and created a memory palace that was coded into a 3D VR model. It was created to address the neuroscience education tool gaps mentioned above. Most notably, it makes use of the memory palace tool that was not part of the design of previous systems. Our visually engaging module depicts the brain as a series of floating islands at different elevations. This enables islands to represent the brain's gross anatomy without overwhelming detail. The island positioning mirrors the relative placement of the parts in real brains.

Each island is named with a welcome arch leading to mnemonic scenes that represent key parts within those main brain areas. Each scene has two image elements: the foreground represents the function, and the background represents the name of the part. Each mnemonic is distinct and easily recognizable as its own scene, spatially separated from others. An example is provided below of the Cerebellum (Figure 1).

Information about function is represented by having a pedestal for each scene that explains the mnemonic, as opposed to presenting the brain without learning aids. Each pedestal explains the name, function, their respective mnemonics, both in text and with a voice recording.

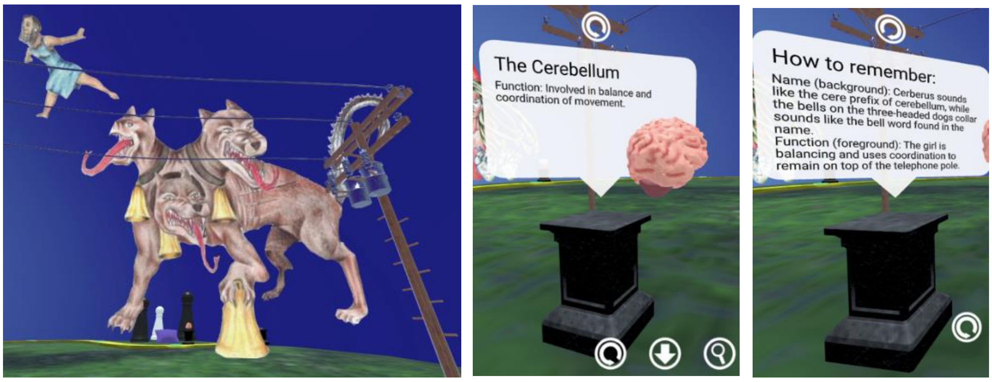

Figure 1. The girl in the foreground balancing on a telephone represents that the cerebellum oversees balance and coordination. The background is of the mythical Greek creature Cerberus with giant bells on its collar to help remember the name mnemonic of the brain part being Cere-bell-um. Desktop VR (DVR) and Headset VR (HVR) stimuli (left) with associated pedestal front (middle) and back (right)

2. THE BRAIN VR MEMORY PALACE

The memory palace is designed as a series of islands, representing gross brain regions, populated with scenes, which represent specific brain areas. The memory palace is represented in three ways: as a text document, as a series of still images, and as an immersive 3D VR model, which can be experienced through a desktop or head-mounted display interface

The first island, representing the brainstem, has one scene: the brainstem (Figure 2). The second island, representing the hindbrain, contains three brain areas: the cerebellum, the medulla oblongata, and the pons (Figure 2). The third island consists of two sub-islands, visually represented as platforms (Figure 3). The first sub-island has 4 scenes: the tegmentum, the tectum, the red nucleus, and the periaqueductal grey. The second sub-island represents the basal ganglia's three brain parts: the basal ganglia scene itself, the striatum, and the globus pallidus. The last island is the forebrain area. It contains nine scenes separated again into two sub-islands (Figure 3). The first sub-island contains the insular cortex, the pituitary gland, the corpus callosum, and the olfactory bulb. The second sub-island of the forebrain represents the limbic system, and it had scenes for itself (the limbic system), the hypothalamus, the thalamus, the amygdala, and the cingulate cortex.

Figure 2. Overview sketch of the Brainstem Island (1 scene: The brainstem scene (left)) and of the Hindbrain Island (3 scenes: cerebellum, medulla oblongata, and the pons scenes (right))

Figure 3. Overview sketch of Midbrain Island. (7 scenes: sub-island 1-tegmentum, tectum, red nucleus, and periaqueductal grey scenes; sub-island 2-basal ganglia, striatum, and globus pallidus scenes. (left)) and Overview sketch of Forebrain Island. (9 scenes: sub-island 1-insular cortex, pituitary gland, corpus callosum, and olfactory bulb scenes; sub-island 2-limbic system, hypothalamus, thalamus, amygdala, and cingulate cortex scenes.)

3. CONCLUSION

Although memory palaces are proven to be effective learning tools, students often do not make the effort to create them on their own. Because brain anatomy and function are challenging to learn, creating mnemonic tools for students might facilitate learning about the brain. In this paper, we present a memory palace created for learning basic brain anatomy and function. The effectiveness of this tool still needs to be tested. We are currently conducting an experiment to test its efficacy.

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