Designing Virtual Restorative Environment With Generative AI: Hardware and Design Considerations

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Abstract
In today's fast-paced world, effective relaxation strategies are crucial for alleviating psychological stress and enhancing productivity. The theory of restorative environments is gaining acceptance, yet many, like those in high-stress jobs or with mobility issues, find it challenging to implement. To address the issue of accessibility, Virtual Reality Exposure Therapy (VRET) has been developed. This study identifies that current VRET applications, despite utilizing immersive technology to achieve virtualization and remote accessibility, still struggle with issues like unidirectional content and lack of personalization. To fill this gap, this study focuses on the capabilities of Generative AI, particularly in personalization, diversity, engagement, and inclusivity, showing significant potential in addressing cultural and aesthetic variety. Based on the foundation of Virtual Reality Exposure Therapy (VRET) and Restorative Environment Theory, this study aims to incorporate insights from experts and developers to establish the prerequisites, effectiveness, and design strategies for integrating generative AI in virtual restorative environments. The anticipated outcome is to fulfill more personalized psychological needs and create well-being for a broader audience.

Keywords: Restorative Environment Theory, Virtual Reality Exposure Therapy (VRET), Artificial Intelligence Generated Content (AIGC), Generative AI

Introduction

1.1 Contemporary Mental Health Needs

In contemporary society, workplace stress and psychological distress are widespread. The fast-paced and oppressive environment of urban life often leads to the accumulation of stress, which becomes a source of negative emotions. Living in a high-pressure urban environment, people often feel exhausted and hard to manage their stress, which have bad effect on their physical and mental health (Zhang & Guan, 2023). In response to this stress, many workplaces and companies are now exploring effective ways to take breaks, like space changing, short breaks, or practicing mindfulness (Espinoza et al., 2023; Yu et al., 2018; Liu et al., 2023).

1.2 Restorative Environment Theory

In the late 20th century, many scholars discovered that natural environments have a strong positive effect on people's emotional regulation. Contact with nature can enhance cognitive control, reduce stress, and relieve negative emotions (Kaplan & Talbot, 1983; Ulrich, 1991; Kaplan, 1995). This phenomenon has also gradually evolved into the Restorative Environment Theory (Kaplan & Talbot, 1983), which has been widely used in modern design considerations.

The impact of restorative environments can generally be divided into four key factors down below (Zhang & Guan, 2023):

1. Principle of Distance:
   A scene that diverts attention, let the body and mind be slightly away from the familiar environment, and experience things that are inaccessible and hard to try.
2. Principle of Richness:
   A scene that diverts attention, let the body and mind be slightly away from the familiar environment, and experience things that are inaccessible and hard to try.
3. Principle of Attractiveness:
   It can attract people's attention without much guidance, achieving the purpose of shifting attention and healing.
4. Principle of Compatibility:
   An ideal compatible environment adapts to the user, featuring beautiful and tranquil scenery that allows people to shift focus to the overall experience, achieving mental relaxation.

An appropriate environment can effectively help reduce stress, alleviate negative emotions, and restore mental fatigue (Figure 1). Providing a space that can rejuvenate users' physical and mental health, improve emotions, and induce self-healing has also become a focus of effort for designers and researchers.

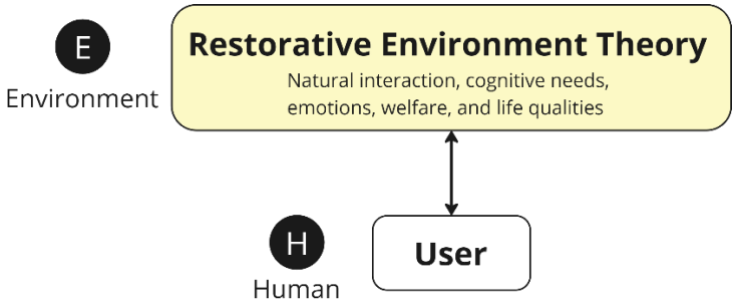

Figure 1: The Interaction Between People and Restorative Environments

1.3 Virtual Reality Exposure Therapy (VRET)

Although Restorative Environment Theory has gradually been recognized by everyone, there are still many peoples are difficult to benefit from this method. For example: patients with limited mobility, the elderly who require close medical care, workers find it difficult to leave their working environment, etc.

At the same time, technological advancements continue to become more progressive and widespread. This has led to the design of new types of interactive mechanisms and innovative interactive hardware, such as virtual reality equipment and wearable devices. These developments have also broken through the limitations of traditional interaction mechanisms and user interfaces (Espinoza et al., 2023).

To overcome the distance factor of restorative environments, Virtual Reality Exposure Therapy (VRET) has been gradually developed (Rothbaum et al., 2016). Advantages of VRET include the ability to control the scene, customize the environment, and provide a virtual environment without leaving the medical setting (Rothbaum et al., 2016).

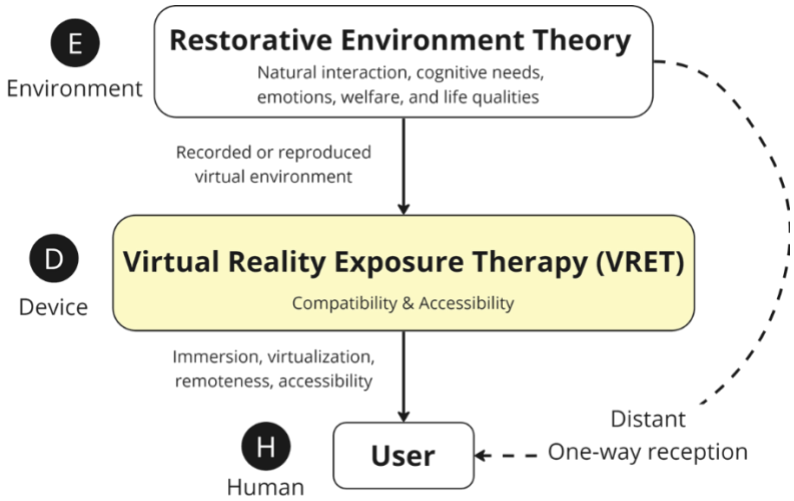

Figure 2: Experiencing Restorative Environments Through Technological Objects

In recent years, as technological capabilities have matured, many innovative research are using immersive technologies to create restorative environments.

For example, a Swiss research team (Jaquenod et al., 2023) proposed a method allowing elderly individuals with dementia to experience immersive travel within a safe, controlled medical environment. This non-pharmacological therapy fosters relationships between

caregivers and patients, using relaxing memories to alleviate the distress associated with dementia. Additionally, the use of head-mounted VR devices paired with virtual equestrian simulators (Ortet et al., 2023) allows the elderly to overcome fears of animals and the costs associated with traveling to equestrian centers. Liu et al. (2023) utilized VR to simulate natural environments for stress recovery among workers in isolated, confined, and extreme environments. These innovative attempts have allowed the Restorative Environment Theory become virtualized and remote (Figure 2).

1.4 Human-Centered AI & Generative AI

At this stage (Figure 2), VRET content is mostly pre-recorded images or artificially constructed virtual scenes, which still have limitations on users' individual emotional needs, content richness, and interactivity. In response to this situation, Pizzoli's research team (2019) proposed a "user-centered" VR experience that allows users to participate in events in the virtual space and create personalized experience content. The results also found that it was more effective in emotional regulation and relaxation.

Thanks to technological advancements, artificial intelligence is now considered one of the tools that can enhance human well-being (Garibay et al., 2023; Shneiderman, 2022). Scholars also suggest that technology can collaborate with people to improve adaptability, emotional quality, engagement, and connectivity (Riva et al., 2012; Calvo & Peters, 2014).

In current research trends, the ideal state of collaboration between humans and AI has been discussed as "Human-Centered AI (HCAI)." The relationship between humans and AI resembles a partnership or cooperation (Figure 3). Humans provide ideas to AI and evaluate the results. In particular, "Generative AI" can generate outputs based on the prompt from humans. Examples include the ChatGPT and image generation tools like Midjourney or Stable Diffusion, which are AI systems that the public can easily access.

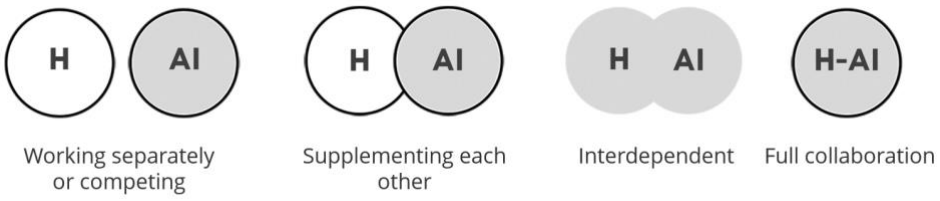

Figure 3: The levels of human-AI (H–AI) interactions (Sowa,et al.,2021）

This study explored the application of AI and mental health. We propose a new interactive model (Figure 4) that matches the advantages of generative AI in personalization, diversity, participation, and compatibility to meet users' emotional needs for the environment.

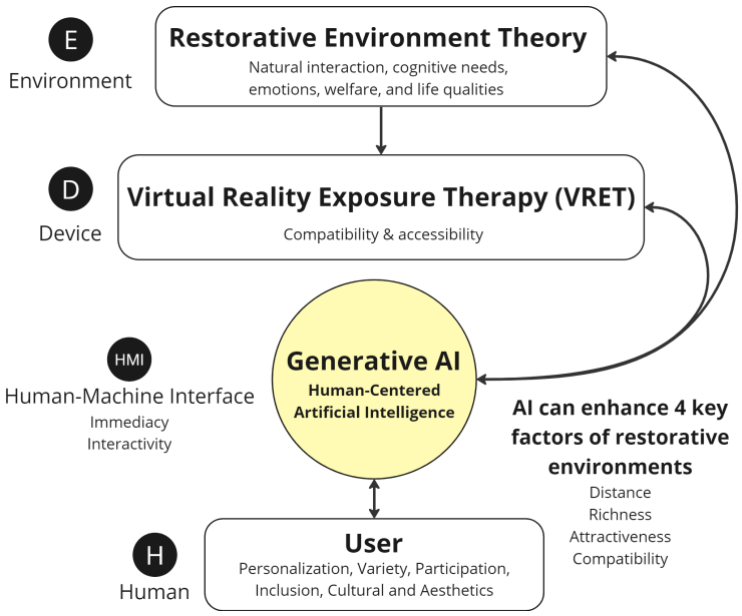

Figure 4: Potential Opportunities of Generative AI in VRET

Research Process and Method

The purposes of this research is to explore the potential of generative AI in virtual restorative environments, and propose the hardware and design considerations.

The experimental location was set in a spacious indoor area measuring 5 square meters, where the experiment was conducted for approximately one hour. The results were recorded using computer logging, paper questionnaires, and semi-structured interviews. The device used in this study was the Meta Quest Pro.

The participants recruited for the study were aged between 20 and 30 years old, and had experience in using or developing immersive devices. A total of 10 participants fully engaged in the entire experimental process.

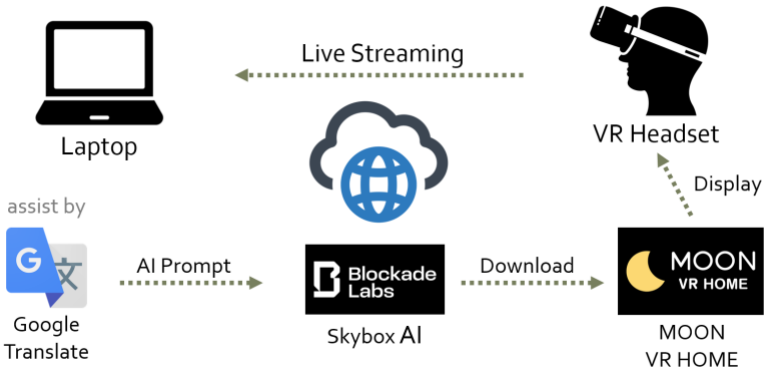

Figure 5: Experiment process

As shown in Figure 5, after providing an introduction to the participants, this study first engaged them in discussions about their stress relief methods and their ideal restorative environments. Subsequently, they were guided to use a generative AI platform called "Skybox AI" on a computer, which allowed them to create virtual environment images that matched their expectations through textual information. Since most of the participants were

not native English speakers, Google Translate was used during the experiment to help them determine the correct AI generation prompts.

Figure 6: Experimental site

Figure 7: Virtual perspective

After getting the ideal images, they were downloaded to the VR device via the internet. The final experience was conducted using a player called "Moon VR Home", which also streamed the visuals to a computer. The experimental site and viewing screen are shown in Figure 6, 7.

Figure 8: Walking mode

Figure 9: Walking mode

The experience was divided into two modes: walking mode and static mode. In walking mode (Figure 8, 9), participants could see the real environment, walk through a portal, and enter the virtual space. This is similar to a Mixed Reality (MR) experience. In static mode, participants sat in a swivel office chair to view surround imagery, providing an experience similar to the common VR presentation methods seen today.

At the end of the experience, participants were allowed to use the VR device to watch YouTube videos featuring 360-degree content related to the themes generated by the AI earlier. This allowed them to experience pre-recorded VR video sensations. Finally, a series of semi-structured interviews were conducted to gather feedback.

Results and Discussion

Through the experience process of this study, participants each created virtual restorative environments that met their personal expectations. The following are scenarios created by several test subjects:

Figure 10: Experimental results

prompt:
white sand, teal ocean waves lapping. shells scattered on the beach. Warm light-dappled textures, subtle gradient sky, fluffy clouds. On a beach with coconut trees, there are many people playing jet skis and parasailing on the sea.

Figure 11: Experimental results

prompt:
Buried deep in the clouds of Jupiter, Callisto, Ganymede, Io and Eupola in the sky, 8K volume clouds, thick hazy atmosphere, lightning, autumn season, lying on many clouds, next to There are the sun, moon, stars, birds, etc., and the weak sunlight shines on the clouds

Most of the subjects expressed high expectations for the process of AI generation. Based on the combined content of interviews and questionnaire surveys, this study has summarized the following findings:

1. Feelings about AI-generated restorative environments:
   Most people find the experience interesting, novel, and relaxing. AI prompts sometimes is difficult to produce the desired picture, but the uncertainty of the results brings unknown surprises, and also reduces stress.
2. Reasons to prefer walking mode
   Most participants preferred the walking mode because it offers an interactive process of switching spaces. The design of portal effectively transitions spaces while maintaining a sense of the real world.
3. Reasons to prefer static mode
   This mode is considered suitable for situations that do not require much movement. You can focus more on the presentation of the picture.
4. Visual problems
   AI still lacks a clear understanding of the scale of objects relative to the viewer. In walking mode, accurately determining ground level presents a challenge. Additionally, issues with the sensation of floating and the scale of displays during the experience diminish the overall realism (Figure 12-17).

Figure 12:
AI generated content (AIGC)

Figure 13:
Mapping on sphere

Figure 14:
What you actually see

Figure 15: Too small& floating

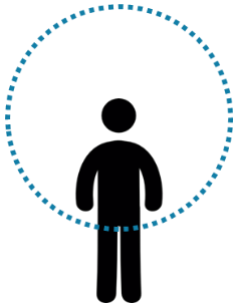

Figure 16: Too big

Figure 17: Fit size

5. AI prompts and generated content
   The test subjects hope that the AI generation process can more accurately match their ideas, and it is recommended to provide templates or formulas to help users better interact with AI.

Figure 18: Reference template for AI prompt

6. Advantages of generative AI
   Generative AI can be closer to the user's personal needs, and is more flexible than searching pre-recorded live videos.

Conclusion

In conclusion, generative AI offers more personalized content compared to live-action videos, which often can be predicted before viewing. Generative AI content surprises users with its novelty. Looking ahead, the future of AI technology should focus on enhancing interactivity, dynamic adjustment, and improving realism. This includes accurately understanding the scale of objects and generating corresponding sound effects. Furthermore, providing templates or formulas could reduce the cognitive load involved in human-AI interaction, thereby improving the overall relaxation experience.

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