# Transcendental Avatar: Experiencing Bioresponsive Avatar of the Self for Improved Cognition

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Figure 1: Avatars on three different backgrounds; full moon, galaxy and pink sunrise. In the case of the first graphic, we have a very calm avatar (blue color), then we have two examples of increasing emotional excitement, stress, or anxiety.

# ABSTRACT

Transcendental Avatar is a virtual reality (VR) system focused on stress relief to support relaxation techniques, using biofeedback, a well-known therapy technique to improve physical and mental health. Biofeedback as a method uses visual and audio feedback of one's physiology to reflect, recognize, and help one gain awareness of many physiological functions, improving their cognitive and emotional state. Yet, there has been little work on how this can be appropriately leveraged in virtual reality (VR). In Transcendental Avatar, we proposed a system that shows the personification of the avatar, reflecting in real-time user's biofeedback to enhance their cognitive and emotional state. In this study, we examine whether stress, and self-reported anxiety symptoms can be relieved or reduced by the proposed immersive experience.

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# **1** INTRODUCTION

According to a WHO scientific report, in the first year of the Coronavirus (COVID-19) disease pandemic<sup>1</sup>, global anxiety and depression increased by 25%. In addition, social isolation and restrictions

 $\label{eq:https://www.who.int/publications/i/item/WHO-2019-nCoV-Sci_Brief-Mental_health-2022.1$ 

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on people's capacity to work, visit relatives, and participate in social life had a negative effect on their mental state. To deal with the situation, therapies have become essential in caring for the mental state. One of the various therapeutic methods is biofeedback, which allows patients to re-experience their physiological state. Yu et al. 2018] They regulate and control their emotions by observing physiological signals. One of the platforms that supports biofeedback therapy is Virtual Reality. Virtual reality provides users with an enhanced sense of immersion in an alternate world, and previous research has used biofeedback for many applications. For example, researchers have also investigated its benefits, like agility transfer [Hajika et al. 2019], multi-sensory feedback [Morat et al. 2021], and more. When designing biofeedback therapy for self-reflection, it is essential to remember that current systems do not present methods including the avatar of the self. A similar work, Emotional Beasts, looked into showing users their physiological states via emotionaladaptive avatars [Bernal and Maes 2017]. However, the authors primarily focused on self-expression, whereas we emphasized our work as a self-support tool. Transcendental Avatar focuses on the user's understanding that the displayed avatar is their personification, reacting to biofeedback. In addition, the VR environment is related to nature to strengthen the user's feeling of being detached from reality and in a relaxation-related place.

# 2 DESIGN AND IMPLEMENTATION

## 2.1 Visual Feedback in VR

The Transcendental Avatar's VR experience design depends on two parameters; the user's avatar and the emotional triggers. To design the user avatar, we draw inspiration from an abstract personification of the user. Avatar reacts to physiological state, heart rate, and electrodermal activity by changing the velocity, shape, and color. The user can perceive the change in their self avatar when presented with an emotional stimulus and experience the difference in their avatar's appearance and presence. Biofeedback is a well-known

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therapy method where visual and audio feedback of one's physiology is used to reflect, recognize, and be aware of them to improve their cognitive and emotional state. We use Microsoft Azure Kinect sensors to transfer real-time user silhouette into depth maps and body motion tracking to Unity 3D. In addition, we used a plugin for Unity created by Keijiro Takahashi, which generates the visual effects that give avatars much more pleasant and stimulating looks, and the OscJackVS plugin, which allows transferring analyzed and prepared biofeedback data from TouchDesigner to Unity3D. Our prototype used Unity's High Definition Render Pipeline (HDRP) and Visual Effect Graph (VFX). HDRP is compatible with VR, optimized for single-pass rendering, and operates shaders and lighting units different from those in Unity's built-in render pipeline. Visual Effect Graph (VFX) is used to create one or multiple high-quality Particle Systems, affect effects at diverse rates, and accomplish stepby-step simulation. The conducted in July experiment helped us decide on colors, backgrounds, and animations inside the system. We tested 13 individuals. The PANAS questionnaire and an extensive interview were conducted after each experiment. Most users described the system as relaxing, sometimes similar to meditation, or making them sleepy and calm. In addition, some of them found the experience of seeing their emotions exciting and beneficial to relaxation and being more self-awareness. After successfully implementing the avatar, we looked into making it bioresponsive.

## 2.2 Physiological Sensing as Biofeedback

A bioresponsive avatar is an avatar that responds to the user's cognitive and emotional state. To achieve this, We used a custom, worn on the left-hand device based on ESP32. It collected two main physiological signals heart rate variability (HRV) and electrodermal activity (EDA). HRV is sensed through a plethysmograph (PPG) with a sampling rate of 50Hz, and the EDA signal was sampled at 4.545Hz. The data is streamed to the software, TouchDesigner, where we perform signal processing in real-time. Used by us signals have been proven to reflect user's cognitive load [Gupta et al. 2019] and emotional state [Gupta et al. 2021]. For the HRV signal, an increase in perceived cognitive load increases both the parasympathetic and sympathetic components, which is reflected in an increase in HRV [Solhjoo et al. 2019]. For EDA, we observe its phasic component, which directly correlates with emotional arousal [Caruelle et al. 2019].

#### **3 USER EXPERIENCE**

For our demonstration at Siggraph Asia, the participants will be able to experience the personification of their avatar that reflects the physiological state in real-time in Virtual Reality (we decided to use Oculus Rift S for our demonstration). Their avatar will reflect their actual emotional state, through various valence and arousal. For example, when the cognitive load level is heightened, and the emotional arousal is descending, the user's avatar materializes more peacefully and is less colorful, the main colors are blue and purple. Likewise, the avatar emerges more dynamic, fast, and full of color (red, pink or yellow) to show cognitive load and high arousal. The audience may try to interact with presented avatar's appearance and presence by focusing and regulating their cognitive and emotional state or experience the changes of the avatar freely based on their mental state from the stimulus. Furthermore, the participant can transfer to twelve different backgrounds related to nature. Their selection, as well as the avatar's color, is based on an earlier experiment and a survey concerning users' preferences in the context of relaxation and de-stress. In addition, they will have a possibility to interact with some 3D elements, e.g., flying around butterflies, fireflies, weather effects or observing small animations inside backgrounds, like clouds or stars. The entire experience will last about 7 minutes.



Figure 2: The Transcendental Avatar setup

# 4 CONCLUSION

The Transcendental Avatar is a concept that centers around stress relief to support relaxation techniques and manageable anxiety. This system allows users to observe and interact with a personification consisting of emotion-responsive particles in virtual reality. The audience can reflect, understand, and improve their cognitive and emotional states through a bioresponsive avatar. We hope that our VR experience in the future will be able to assist mental health and open the door to future avatar research.

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