Interactive Virtual Reality Scenarios for Treating Phobias: Enhancing User-System Interaction in Mental Health

George-Gabriel Constantinescu
Faculty of Computer Science
"Alexandru Ioan Cuza" University
Iasi, Romania
georgegabrielconstantinescu@gmail.com

Adrian Iftene
Faculty of Computer Science
"Alexandru Ioan Cuza" University
Iasi, Romania
adiftene@gmail.com

ABSTRACT
In the context of immersive technologies in healthcare, virtual reality (VR) has been identified as a promising tool for treating phobias through controlled and interactive exposure scenarios. This paper presents various VR-based approaches for addressing specific phobias by simulating real-life situations in safe and user-friendly environments. Using interactive design techniques and natural user-system interaction models, such as gaze-based triggers, hand-based interactions, and scenario adaptation, our study enhances the therapeutic experience. It aims to reduce patients' anxiety responses over time. The system enables repeated gradual exposure and dynamic difficulty adjustment, making therapy more accessible, customizable, and engaging. Our research emphasizes the role of VR as a complementary tool in mental health care, capable of preparing users to better manage different phobias in everyday life. The study further highlights the potential of user-centered interactive technologies to support long-term behavioral improvements in clinical and home-based therapeutic contexts.

Author Keywords
Virtual Reality (VR); Phobia Treatment; Exposure Therapy; User Experience (UX); Human-Computer Interaction (HCI); Interactive Scenarios; Mental Health; User-System Interaction

ACM Classification Keywords
H.5.1 & H.5.2. Multimedia Information Systems – Artificial, augmented, and virtual realities

General Terms
Design; Experimentation; Human Factors; Measurement; Usability

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INTRODUCTION

Virtual Reality (VR) has become more popular in recent years, with many applications in areas such as education, training, and healthcare. One of the most promising uses of VR in medicine is in the treatment of phobias. With the help of immersive technologies, patients can face their fears in a safe and controlled environment, without needing to be exposed to real-life situations.

This method is known as **Virtual Reality Exposure Therapy (VRET)**. It allows people to gradually get used to the things they are afraid of—such as heights, flying, or small spaces—by using virtual scenarios that can be repeated and adjusted over time. Many studies have shown that this approach can be just as effective, or even more effective, than traditional therapy methods [1, 2]. In most cases, these VR therapies show the user a situation they fear, and they just have to watch and wait for their anxiety to reduce. However, recent research has shown that making the experience more **interactive** can lead to better results [3, 4]. For example, if users can move around, interact with objects, or control how the scene changes, they may feel more involved and benefit more from the therapy.

Our study explores how interactive VR scenarios can be used to treat phobias more effectively. We focus on simple, natural ways for users to interact in VR—such as using their hands or head movements—to control the scene. These interactions help create a more engaging and realistic experience, which may improve the way people react to their fears in real life. This paper describes how we designed and implemented our VR solutions, the types of interactions we included, and how users responded during testing. Our goal is to show how interactive VR experiences can be a useful tool in the field of mental health, especially for people who struggle with phobias. Unlike previous studied VR exposure systems, our framework integrates both natural interaction methods (hand-tracking and gaze-based selection) and a modular scenario design with progressive intensity and gamified elements. This combination provides a more adaptable framework that can be extended to different types of phobias and allows personalized exposure based on user comfort and therapeutic needs.

Fig. 1: Example of XR application architecture [5]

ARCHITECTURE

In developing our VR-based systems for phobia treatment, we focused on creating a safe, immersive, and interactive environment that supports gradual exposure through user-controlled experiences. The architecture combines modular scene design, adaptive difficulty systems, intuitive interactions, and real-time feedback mechanisms, all supported by modern VR hardware and development frameworks.

Unity Game Engine

We used the Unity game engine (**LTS 2021.3.31f1 & LTS 2022.3.14f1**) as the core development platform, along with C# scripting via Visual Studio 2022. The project architecture integrates Unity's XR Plugin Management, XR Interaction Toolkit, OpenXR Plugin, and Oculus XR Plugin, ensuring compatibility with a range of VR headsets and robust support for interaction mechanisms such as teleportation, grabbing, and object manipulation. The system is modular, allowing for the integration of various fear-related environments, each designed as an isolated VR scene. Scenes are loaded dynamically and can be customized based on user feedback or therapeutic needs.

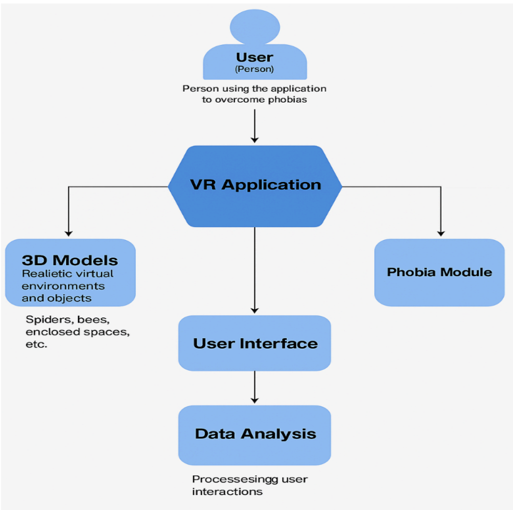

Fig. 2: Example of C4 diagram architecture for VR solution

Interaction Design

User interaction is a central element of the system. Interaction methods include:

- Hand tracking and controller input enable users to interact with virtual objects naturally.
- Gaze-based selection, used for non-intrusive menu navigation and decision-making.
- Trigger-based mechanics, where proximity or specific actions activate scene changes, object behaviors, or intensity levels.

These elements allow for both active exploration and structured progression, adapting to the user's comfort level.

Hand Tracking and Gesture Input

To support a more intuitive interaction model, we incorporated hand tracking and gesture-based input within the VR environment. This approach allows users to naturally engage with digital objects using their hands, helping them feel more immersed and connected to the virtual space.

Immersion and Feedback Components

To enhance immersion and ensure realism:

- **Environmental audio** is spatialized using Unity's audio engine to simulate realistic ambient conditions.
- **Lighting and particle systems** are used to dynamically reflect the emotional tone of the environment.
- **User guidance elements**, such as visual cues or narrative voice prompts, provide instructions and context without disrupting immersion.

The system includes a **feedback mechanism** at the end of each scenario, allowing users to reflect on their emotional state and provide a self-assessment. This feedback loop supports progress tracking and potential therapy adjustments.

Hardware Platform

The application runs on the **Meta Quest 2**, selected for its wireless operation, integrated hand tracking, and portability. Being standalone makes the experience more accessible to users in both clinical and home environments, while still supporting high graphics and interaction features.

Adaptability and Customization

Each VR scenario includes **multiple intensity levels**, which can be adjusted manually. These levels affect elements such as sound intensity, lighting, object behavior, and user distance from stimuli. The adaptability of the system allows it to suit a wide range of user needs, anxiety levels, and therapeutic goals.

IMPLEMENTATION

Designing and implementing a VR system to **support phobia treatment** involves combining immersive technologies with user-friendly interaction techniques and psychological exposure methods. This section describes the main components of our implementation and how they were developed to create an engaging and effective therapeutic experience.

Application Focus: Exposure Therapy for Phobias

The main goal of our VR solution is to support exposure therapy through a controlled and customizable environment. Users are placed in simulated scenarios that reflect common fears, such as spiders (arachnophobia) or bees (apiphobia). Each scenario is structured in three intensity levels, allowing users to progress gradually as they become more comfortable.

To make the therapy more effective and user-centered, each level includes:

- **Ambient changes** (sound effects, lighting)
- **Adjustable** proximity and movement of fear stimuli.
- **Interaction elements** (e.g., "exit" triggers, calming tools, or intensity modifiers)

These techniques aim to maintain **immersion** while respecting the user's comfort and therapeutic pace.

VR Interface and Environment

The system was built using the Unity Game Engine, combined with Oculus XR Plugin and XR Interaction Toolkit to enable seamless integration with Meta Quest 2. This platform provides full support for hand tracking, controller input, and spatial movement, offering users an intuitive and responsive experience. Each fear scenario is designed as an isolated scene that can be loaded from a central menu. The User Interface is minimalist and relies on:

- **Gaze-based selection** for navigation.
- **Hand interaction** for manipulating virtual objects.
- **Visual cues** to guide the user without breaking immersion.

The entire interface is optimized for standalone VR use, without requiring external controllers or sensors.

Modular Design and Scenario Management

All fear simulations are implemented as **modular environments**. Each module contains:

- **3D assets and animations** specific to the phobia.
- Scripts that **control scene logic**, intensity levels, and triggers.
- Audio files and **environment** lighting settings.
- **Interaction zones** with defined responses.

This modular approach allows for easy updates and scalability. New phobia scenarios can be added by simply creating a new module that follows the same structure.

Interaction Techniques

User interaction is handled via the **XR Interaction Toolkit**, which supports both **action-based** and **device-based** input. The system includes:

- **Teleportation** and **continuous movement** options for navigation.
- **Interactables**, such as calming items or tools to manipulate the environment.
- **Triggers** based on proximity or gaze to advance exposure phases.
- **Dynamic feedback** (visual and audio) based on user actions.

This ensures that the therapy is not passive, but **active and participative**, improving engagement and learning through direct experience.

Voice and Audio Components

Spatial audio was integrated into the system to increase realism. Each fear scenario uses:

- **Directional audio** for stimuli (e.g., buzzing bees, crawling spiders),
- **Environmental sounds** to simulate real-world conditions,
- **Soothing background** audio in safe zones to reduce anxiety.

Additionally, for a specific scenario for phobia of social anxiety, **voice narration** using a virtual agent provides instructions or encouragement during critical phases. The voice system uses basic TTS (Text-to-Speech) for flexibility in scenario development.

User Feedback and Data Processing

At the end of each session, users are invited to:

- Rate their level of discomfort or anxiety,
- Reflect on their progress,
- Choose whether to repeat or increase difficulty.

This feedback is stored locally and used to track progress over time. It also allows therapists or system administrators to evaluate the session's effectiveness.

SOLUTIONS

The virtual reality prototypes developed in this project focus on exposing users to fear-inducing scenarios through carefully designed, interactive experiences. Rather than presenting static or passive environments, each solution integrates game mechanics, narrative elements, and adaptive systems to ensure engagement while maintaining psychological safety.

Exposure Rooms and Scenario-Based Chambers

Users begin their experience in a central hub from which they can select specific phobias to explore. Each phobia is structured as an isolated, immersive room designed using escape-room logic. Within these rooms, users are given short objectives or challenges—such as solving a puzzle, locating an item, or surviving a situation—while simultaneously facing stimuli related to their fear. For instance, users may be required to:

- Cross narrow bridges between tall buildings (**acrophobia**).
- Reach into snake-filled containers to retrieve a key (**ophidiophobia**).
- Explore pitch-dark caves with limited light sources (**nyctophobia**).

Fig. 3: The user selects the type of phobia scenario

The design encourages **light problem-solving and task focus**, helping distract from the intensity of the fear stimulus and fostering repeated, goal-oriented exposure.

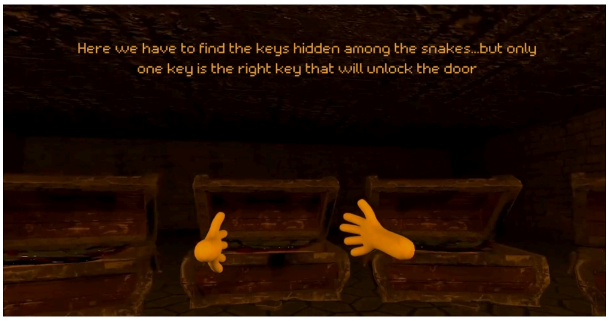

Fig. 4: Ophidiophobia scenario

Gamified Board Mechanics with Randomized Events

Another core feature is the integration of a virtual board game format, where the player advances based on dice rolls and lands on randomized tiles. Each tile corresponds to a different type of experience:

- Safe tiles that allow forward movement without consequence,
- Challenge tiles involving logic puzzles or coordination games,
- Phobia tiles that transport users to thematic mini-scenarios where they face spiders, snakes, insects, or other stimuli.

Fig. 5: Users select the type of phobia scenario

This combination of unpredictability and progression encourages emotional regulation through repetition, novelty, and reward-based incentives. It also introduces natural breaks between exposure sessions, helping users recover and reflect before the next challenge.

Fig. 6: Arachnophobia scenario

Different Difficulty and Layered Intensity

Each phobia scenario supports multiple levels of difficulty, structured into three distinct layers. As users progress, they may encounter:

- Increased **visual realism** and **proximity of feared elements**,
- More **dynamic or unpredictable behaviors** (e.g., sudden movement or increased sound),
- **Environmental stressors** like darkness, noise, or time pressure.

Despite the added challenge, all scenarios are designed to maintain full user control. Players can access calming tools (such as interactive objects or environmental modifiers), exit the experience at any time, or rate their discomfort after each session.

Interaction and Feedback Mechanisms

Users interact using intuitive gestures (hand tracking, grabbing, pointing) and gaze selection. Scenes are enriched with immersive sound design and ambient feedback, which help reinforce presence and emotional engagement. In certain scenes, collecting virtual objects or solving tasks serves both as a distraction technique and as a way to measure progress over time. At the end of each session, users are encouraged to complete a **feedback screen**, where they can evaluate:

- Their emotional state (e.g., anxious, neutral, confident),
- The perceived difficulty of the session,
- Whether they would like to repeat or move forward.

This information is saved locally and can be used to guide future sessions or inform therapists about a user's evolution. Interactions go beyond passive observation: users can approach, manipulate, or avoid phobia-related objects (e.g., moving a virtual spider or crossing a virtual height edge), which enhances realism and immersion compared to visual exposure.

Balancing Therapy and Enjoyment

While the primary goal is exposure and desensitization, the applications also include **non-phobic experiences**, such as relaxing mini-games or visually rich environments. These provide emotional relief and help users rebuild a sense of control. For example, fishing, matching games, or calm underwater exploration serve as interludes between intense moments, creating a **balanced therapeutic rhythm.**

Fig. 7: Interacting with bees in a VR environment

EVALUATION OF USABILITY TESTS

To assess the effectiveness, accessibility, and emotional impact of our VR-based phobia exposure applications, we conducted a series of structured usability tests with participants (students) from the Faculty of Computer Science. The goal was to evaluate how well users could interact with the system, tolerate phobic stimuli in a controlled virtual environment, and provide meaningful feedback regarding their experience.

The evaluation process was divided into two main stages to ensure both familiarity with the system and authentic engagement with the phobia scenarios. *Initially*, participants attended short briefing sessions, where they were introduced to the concept of virtual exposure therapy and given instructions on using the Meta Quest 2 headset. A brief tutorial within the application helped users understand navigation, interaction mechanics (hand gestures, gaze selection), and the structure of exposure scenarios. This phase ensured that users felt comfortable before engaging with more emotionally intense content. *In the second phase*, participants were invited to explore several phobia scenarios using our applications. These included rooms simulating fear of spiders, darkness, heights, bees, and snakes. Each scenario was presented in progressive intensity levels, and participants had full control to exit, adjust, or skip levels based on their comfort. Following the sessions, users completed questionnaires that captured both objective usability metrics and subjective emotional feedback.

Methodology

Our methodology followed a three-step process:

- **Introduction and Onboarding** – Users were guided through the interface, controls, and goals of the application via voice prompts and an interactive tutorial.
- **Scenario Engagement** – Participants explored one or more phobia environments using the Meta Quest 2 headset. They progressed through different difficulty layers at their own pace.
- **Feedback Collection** – A post-session questionnaire gathered data on usability, discomfort, immersion, and perceived emotional progress.

Participants & Performed Tasks

The evaluation process involved a group of **30 to 40 students** from the Faculty of Computer Science. These participants were not only testers but also contributors to the development of the VR applications. As part of their coursework and research projects, they actively participated in the design, implementation, and refinement of the phobia scenarios. The group included students with varying experience in XR, from beginners to those with advanced skills in VR and interaction design. This diversity provided valuable feedback and allowed for realistic usability testing from both developer and end-user perspectives. Participants engaged with all the implemented applications during the development cycle. They tested different phobia exposure environments, including:

- Climbing and crossing structures at height (**acrophobia**),
- Interacting with swarms of bees and spiders (**apiphobia, arachnophobia**),
- Exploring dark, enclosed spaces (**nyctophobia**),
- Solving escape-style puzzles in **fear-themed** rooms.

Each participant went through the full experience flow: selecting scenarios, interacting with environment-specific elements, and completing follow-up reflections. They also contributed to iterative improvements by reporting bugs, identifying UX breaking points, and suggesting enhancements to the intensity progression system. To complement subjective feedback, we also measured basic performance and interaction metrics during testing: average frame rate (~70-80 frames per second), system latency (50 ms), and average time per scenario, between 3 to 4 minutes.

Remarks

Feedback from the student participants was overall highly positive. Many expressed interest and enthusiasm in both the technical and psychological aspects of the VR experiences. Because they were involved in the project's lifecycle, their observations often went beyond basic user impressions, providing deeper insights into scene logic, performance, and interaction consistency.

Some reported emotional responses when facing phobia content, especially in later intensity levels—suggesting that even within an academic context, **immersive exposure had a real impact**. Most participants appreciated the balance between tension and control, noting that the option to modify intensity or exit at any point made the scenarios feel **safe but still challenging**. We acknowledge that the participants were students, some of whom contributed to the development of the system. This may introduce positive bias and limit the final overview of the findings.

CONCLUSION AND FUTURE DIRECTIONS

This article explored the development of virtual reality applications focused on supporting exposure therapy for individuals with specific phobias. By designing interactive, customizable, and immersive environments, we aimed to create a system where users can gradually face their fears in a safe and controlled manner. The use of hand tracking, gesture-based input, environmental adaptation, and modular scenario design allowed us to offer users both challenge and comfort, enabling personalized progress through structured VR experiences. The feedback collected from testing sessions, involving students with diverse technical backgrounds, confirmed the usability and impact of the system. Participants found the scenarios both engaging and emotionally stimulating, with many highlighting the importance of control, pacing, and the balance between tension and relief. Their insights were essential in refining the exposure logic, interaction models, and feedback mechanisms of the system.

Looking ahead, the next stages of development will focus on deepening the level of interaction and realism. Potential improvements include the integration of biometric feedback (such as heart rate sensors), adaptive scenario pacing based on user responses, and enhanced haptic feedback to simulate tactile sensations. These additions aim to increase emotional immersion while maintaining psychological safety. We also plan to explore the integration of AI-driven agents to act as virtual therapists or companions, capable of reacting contextually to user behavior and guiding them through exposure experiences. This direction aligns with the broader vision of making digital therapies more adaptive, accessible, and scalable.

As a **future objective**, we hope to **collaborate with medical professionals** from local healthcare institutions in order to evaluate and adapt these VR applications for use in real clinical contexts. Testing the systems with individuals diagnosed with specific phobias will allow us to better understand their therapeutic impact and make the transition from research prototype to practical treatment tool.

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