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The VR Therapy platform for social anxiety treatment

Abstract. During the period of online learning related to the pandemic situation, a co-operation was established between the Institute of Computer Science and the Institute of Pedagogy at Siedlce University of Natural Sciences and Humanities to create a therapeutic environment in virtual reality for the treatment of social anxiety or shyness. Anxiety disorders are classified as the most common mental disorder in children and adolescents, their prevalence is estimated at 2-10 percent of the population. The phenomenon has increased due to the pandemic situation. The aim of the project is to develop a low-cost and user-friendly technological solution using virtual reality and biofeedback elements for social anxiety therapy, dedicated to children and adolescents aged 12 to 19.

Keywords: Social anxiety disorders, Virtual reality therapy, Biofeedback.

1   Introduction

The period of the coronavirus pandemic has contributed to an increase in the number of people struggling with interpersonal communication problems [12]. This particularly affected people who were starting a new chapter in their lives by changing their educational institution. Getting used to participating in classes remotely and then returning to the stationary mode led to the formation of social phobias among pupils and students. This problem was noticed by many psychologists and it was clear that it needed to be solved. However, this could not be done in an irresponsible way, by leaving a person with social phobia syndromes alone, but by controlled introduction of this person into the environment of interpersonal interactions. Virtual reality in this case turns out to be a technology with a great potential. Currently, virtual reality devices are used by the computer games industry, film and series distributors in order to provide a better computer entertainment experience. These devices are also practical in fields such as medicine, psychology, and heavy industry. For the dynamically developing branch of psychology, in connection with medicine and the computer games industry, new solutions for virtual reality are created, helping people affected by fears, phobias and traumas. The use of an artificially generated interaction environment allows for simultaneous introduction of the therapy participant to social activities, leaving the therapist with full control over the course of treatment. That is why the idea of creating an extensive platform for managing therapeutic sessions was born. The working name of the platform is VR Therapy.

In the following sections we will describe related existing solutions, the architecture of our platform and the functionality and implementation of its three main components: Therapy Desktop, Therapy Web and the application for VR headset.

2   Related VR treatment solutions

Social anxiety disorder (SAD) is currently, i.e. in the DSM-IV, defined as "a marked and persistent fear of one or more social or performance situations in which the person is exposed to unfamiliar people or possible scrutiny by others" [10]. Virtual reality exposure therapy (VRET) has become an important therapeutic tool for mimicking social situations that are relevant in a therapeutic context [11], [14], [15]. The most commonly reported fear relates to public speaking or speaking up in a meeting. For this reason, research related to SAD often focuses on this problem [13], [16], [17], [19], [20].

A number of virtual reality treatment environments have been developed in recent years. Some of them will be presented in this section.

Replika [5] in an application to treat anxiety by interacting with artificial intelligence. It allows one to conduct video calls, coaching, simulating a conversation with a partner. It provides an activity log, machine learning based on conversations, augmented reality along with AI. The application is available on Android, iOS and Oculus by subscription. It does not use feedback sensors, nor does it allows for remote session management.

Virtually better [6] is a range of products for use in behavioural health therapy, including exposure therapy for various phobias (bridges, heights, flying), substance use disorders (bars, restaurants, parties), post-traumatic stress disorder, as well as various relaxation protocols (meditation, deep breathing, guided relaxation, muscle relaxation, olfactory sensations, visualization of sounds). The software is available with dedicated equipment.

oVRcome [18] is a mobile health application for treating various types of phobias, with a VR set included as part of the subscription. It provides therapies for children, adolescents, and adults (fears of bridges, heights, flying, speeches, darkness, animals, insects, tight spaces, driving, vomiting), and allows for communicating with the therapist. There are no additional feedback sensors, data collection, or remote session management.

The PsyTech [3] offers a wide range of solutions in the field of VR therapy, including treatment of anxiety, phobias, emotional control exercises, relaxation exercises using artificial intelligence. It is available on Oculus and other VR devices in a monthly subscription model. Several scenes are provided as part of this solution: anger management, relaxation, fears (bridges, heights, flying, speeches, storms, darkness, animals, insects, cramped spaces, blood draws, confined spaces), PTSD, neural stimulation, obsessive compulsive disorder.

The Amelia VR platform [8] has over 100 virtual environments and scenes. It supports professionals who deal with various disorders to adapt and apply many techniques. It offers therapies for fears (public speaking, flying, confined spaces, heights), and scenarios for social situations, relaxation, feeding, and mood improvement. The platform is available for Android and iOS as well as other VR devices.

VirtualsSpeech [7] allows one to train soft skills by simulating situations such as a press conference or a TV show. It uses ChatGPT services for some of its functionality. It is available for Oculus and other VR devices with a monthly/annual subscription. The application requires additional hardware acceleration, does not support additional feedback sensors and remote session management.

Relax VR [4] is a relaxation app that supports guided meditation, binaural sound and natural landscapes as well as fragrance oils. Available for Oculus and other VR devices, software purchase with hardware. No virtual characters, It does not provide feedback sensors and remote session management.

Deep [1] is an anxiety management game in which the player explores an underwater world using breathing to move. Requires software purchase and is available on dedicated VR device. It provides relaxing scenery, that can be customized. The app requires an internet connection.

Cognihab [9] provides healthcare solutions for stroke rehabilitation, spinal cord injury, cerebral palsy, autism, cancer, visual impairment. Provides assistance of specialists and training, delivery of all equipment. It is available on Oculus and dedicated hardware.

Metaverse [2] is a virtual reality therapy system used to treat various anxiety disorders such as agoraphobia, social phobia, public speaking and performance anxiety. It provides cooperation with the medical, educational and corporate sectors. It offers following scenarios: Meta-campus, Meta-school.

3   The VR Therapy platform

The proposed solution is intended to provide the ability to conduct therapy sessions for elementary and secondary school students with social phobias in an easy and intuitive way. This should allow as many users as possible to use the tool without the need for additional training. In addition, it is expected to allow for cost savings by being able to use already available hardware, without having to purchase additional, specialized and expensive software and equipment. The functionality offered consists of:

1. management of users and their roles,
2. management of phobias, therapy protocols, therapies and individual sessions,
3. collection of data from sessions and their subsequent analysis,
4. integration of biofeedback devices,
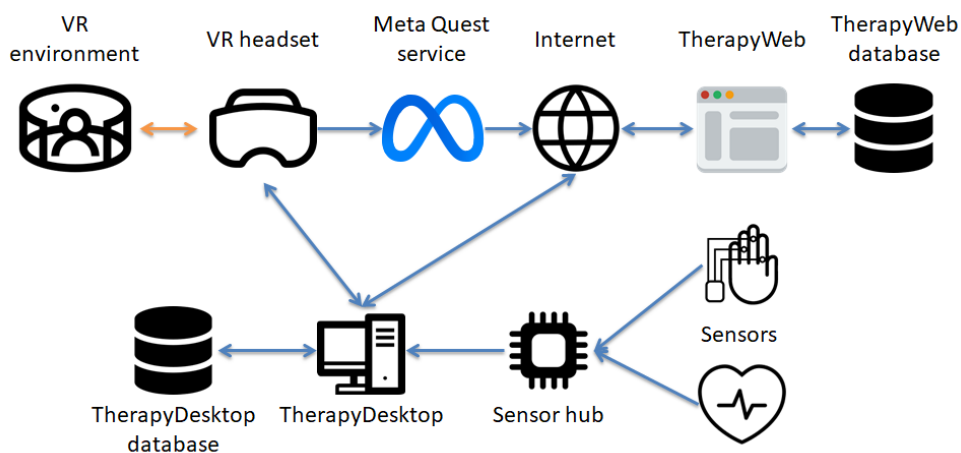5. therapist control over the course of sessions.

Figure 1. The VR Therapy platform architecture. Source: own elaboration

The result of the work is a platform consisting of three applications: desktop app, web app, VR headset app, and biofeedback devices (see Fig. 1). The desktop application, together with the application for VR headset, allows one to conduct a session. The session begins with proper preparation of the participant (plugging in the biofeedbacks and giving instructions), selecting a phobia and a scenario (therapy protocol). The scenario is a collection of scenes, actions and breaks (an example of a scenario is presented in the section 6). Three-dimensional scenes with environments, characters, animations and interactions are created in the Unity graphics engine. A set of actions is available for each scene, through which the session facilitator can influence what the participant sees and hears. The therapist, based on the measurements of the biofeedback devices displayed live, can decide to reduce or increase selected stimuli, for example, to increase the number of students in the class, to reduce the level of volume of conversations. In the scenes created, cartoonish graphic styling is used, so that the participant can more easily overcome his fear of the person, thing or situation represented in this way. The appropriate use of these two elements (action and stylized graphics) should increase the quality of the sessions carried out and the speed with which positive results are achieved compared to the use of static, photo-realistic images alone (see SpeakApp-Kids [21] for reference). The web application allows the collection of the results of all sessions recorded by therapists. The materials collected in this way make it possible to analyse the entire therapy history of a given participant, as well as their groups. The results of such analysis can be used to improve the process of conducting sessions, make changes in scenarios, as well as introduce partial

automation. It can, for example, consist in adding artificial intelligence mechanisms to support decision-making at the stage of diagnosis and evaluation of therapy results.

4   TherapyDesktop application

The desktop application allows the therapist to manage the course of a treatment session. Each session is associated with a participant and a phobia. One person may participate in many sessions related to more than one phobia, if necessary. During the session, the application records data from physiological sensors. The data is sent through a network connection from the device directly handling the sensors. This approach allows the user to change sensors (e.g. for more accurate or to other types) without making changes to the TherapyDesktop application itself. In addition, a device handling sensors can use a wireless connection which increases the comfort of the therapy participants. Before starting the session, the sensor set must be
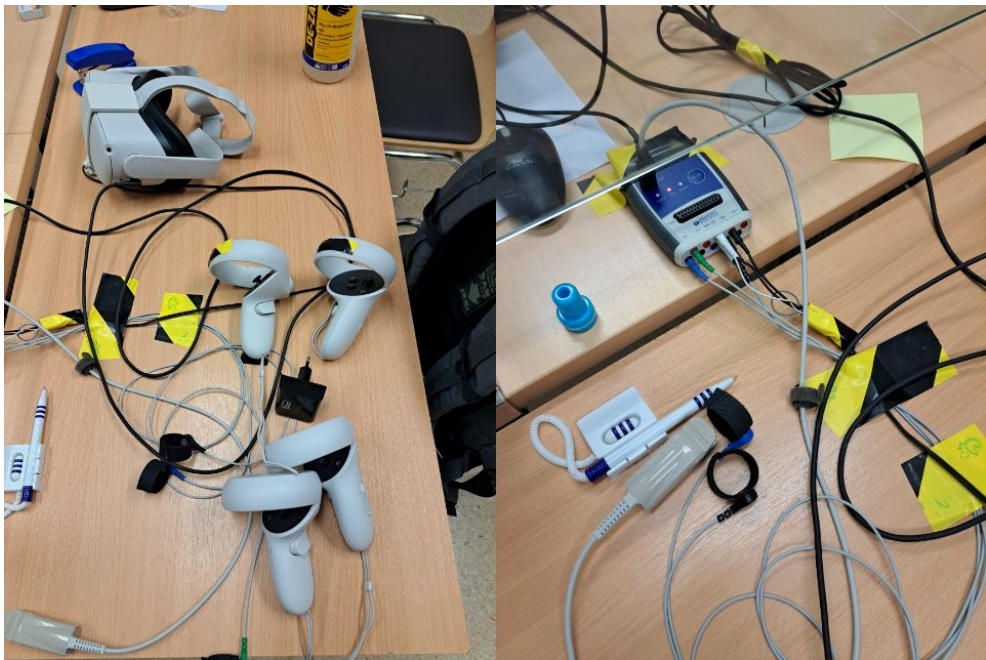

Figure 2. Hardware components of the platform. On the left is the Oculus Quest headset, and on the right is the Optima+ device with sensors connected. Source: own elaboration

properly prepared. The details of implementing this procedure will depend on the devices used. In the initial stages of the platform's development, galvanic skin response (GSR) and heart rate (ear clip) sensors were used. These sensors were connected to Espressif's ESP8266 chip. Currently, a Neurobit Optima+ 4 USB device is being used, with sensors for GSR, Blood Volume Pulse (BVP) and respiration (temperature sensor under the nose). Fig. 2 shows the devices currently in use. There have also been tests of EMG (electromyography) sensors and breath measurement using a chest belt.

Measurements stored in the TherapyDesktop database include information about the type of sensor, the state of the sensor during the measurement and a timestamp. Possible sensor states are: normal, no signal, out of range, loss of signal and undetermined. This additional information allows better filtering of signal artifacts during later analysis. During the therapy
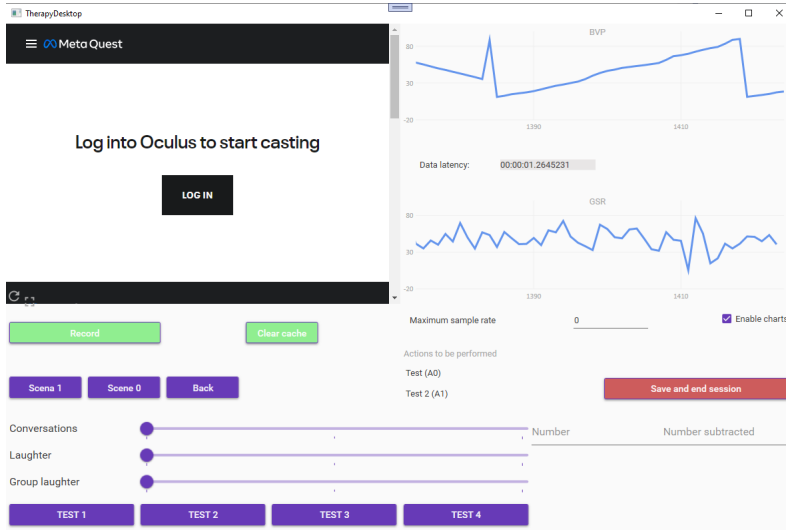

Figure 3. TherapyDesktop graphical interface during a therapy session. Source: own elaboration

session, current sensor readings are also presented in graphs in the TherapyDesktop app. This makes it possible to observe the therapy participant's reactions in real time, as well as to detect sensor malfunctions and quickly take action to solve the problem. As a result, only a portion of the data will be lost during the session, provided spare sensors are available or the resulting problem can be easily solved, such as by correcting the sensor mounting. During the session, the TherapyDesktop application opens a special window with controls for managing the session (see Fig. 3). An important element here is the "actions to be performed". The possible actions are defined within the therapy scenario for each of its phases. Once the session is over, the data can be transferred to TherapyWeb app for further analysis.

5 TherapyWeb application

TherapyWeb is designed to interact with therapy participants and provide additional tools for therapists. The application offers a functionality for managing users, planning therapy sessions and analysing the session data.

The components of the TherapyWeb application are shown in Fig. 4. Due to the functionality of displaying session recordings, which entails transferring large files, Azure Blob Storage and Azure Service Bus were used.

The TherapyWeb database stores following data: user profiles, information about treated phobias, treatments performed, sensor data recorded during therapy sessions, as well as additional information about the course of the session (triggered events and links to recordings).
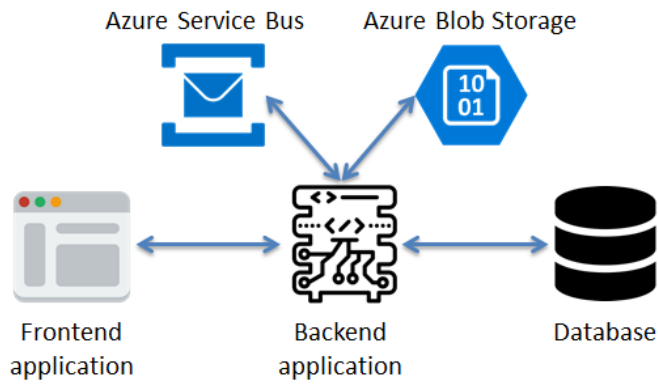
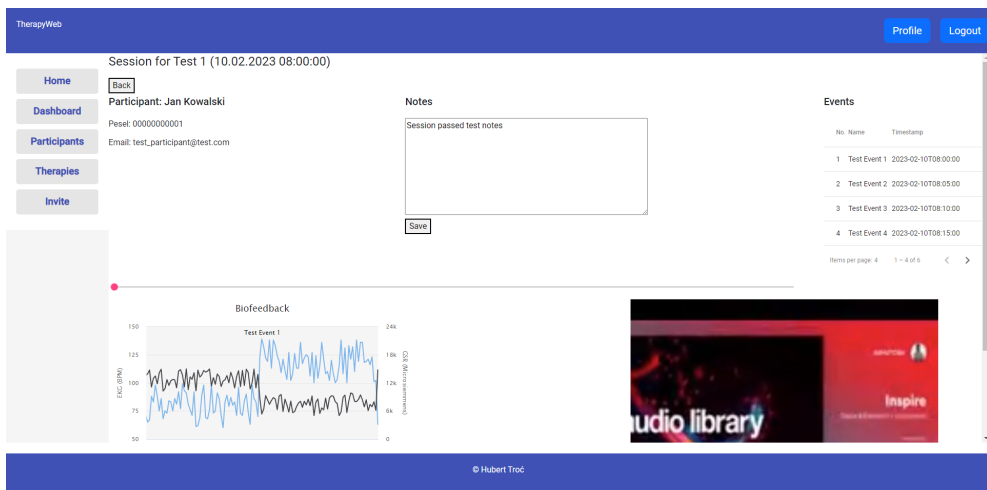**Figure 4.** TherapyWeb application components. Source: own elaboration

Figure 5. The session management panel interface available for the therapist. Source: own elaboration

After a session is performed, the desktop application sends therapist's notes, identifier of the video, a list of triggered events and biofeedback data. This data can be further analysed in the session panel (see Fig. 5). The panel contains detailed information about the course of the session: the participant and the therapist data, editable notes available to the therapist, a list of events triggered by the therapist from the level of the desktop application, graphs of readings from biofeedback devices and session recordings.

Recordings and graphs have been synchronized with each other, i.e. the graph shows the measurements from the currently viewed fragment of the recording. This was achieved by reading the values of two sliders - visible above the graph and created by the video element.

6   Application for VR headset

The virtual reality application will be used by therapists to conduct therapeutic sessions with participants in a safe and effective way. It contains a set of simulations and therapeutic exercises, as well as the ability to manage the presented environment from the desktop application. The app is available on VR platforms such as Meta Quest and Meta Quest 2.

Initially, the target device was the Oculus Quest. During the implementation phase of the project, access was obtained to the Oculus Quest 2 version, which had the appropriate hardware and system fixes compared to its predecessor, as well as offering higher performance.

The application for VR goggles was implemented using the Unity platform. The VR device is handled based on the OpenXR plugin created directly to support programming for the Oculus Quest in the Unity environment. Unity is equipped with many game development tools, such as a scene editor, motion and physics mechanisms, management of advanced animation and much more. It is popular due to being easy to use and accessible to creators of all levels of experience. The wizard offers writing scripts responsible for the game logic in C#and JavaScript programming languages.

The platform also offers a store with resources (prefabs) available directly from the program interface. Unity also has a system that allows one to properly configure the game for distribution on any supported platform.

In order to maintain a high level of immersion, a VR application must properly present scenes to the user. For this purpose, appropriate resources should be prepared: textures, three-dimensional models and elements supporting their interactions. In addition to the independent preparation of resources, publicly available databases and tools were used. The most important of these are Mixamo, ReadyPlayer Me, and Sketchfab.

Mixamo (`https://www.mixamo.com`) is a website that provides 3D animation technology for game and movie creators and other content. It offers services such as animating character models, 3D models, etc. Mixamo provides the ability to use the same skeleton for many character models, thanks to which one animation can be duplicated by many characters. This saves time when creating applications.

ReadyPlayer Me (`https://readyplayer.me`) offers users to create a personalized 3D avatar model. The user can create his avatar from scratch or through an uploaded photo. The tool is easy to use and also offers the option to export the model in a suitable format to help the development of the application.

Sketchfab (`https://sketchfab.com/`) is a service that allows one to share, download and view 3D models. There we will find thousands of different models, including architecture,

furniture, tools, etc. In addition, Sketchfab also offers tools for editing and animating 3D models.

The scenes in Unity3D are the main focus of the application. They are very important, because they will be used to simulate various stressful situations involving the user in virtual reality (see Fig. 6).

Figure 6. VR Therapy project – the scenery of the classroom. Source: own elaboration

The VR app connects to the desktop app and executes the appropriate scenarios. The application supports controllers, however, due to the type of therapy performed, their functions have been disabled, and to ensure better immersion for the tested user, the model of hands representing gestures based on pressed keys has also been hidden. In therapy scenes, there is static displacement, i.e. the placement of the character is managed by the therapist. This is to reduce the risk of causing an accident while wearing goggles and incorrect readings from heart rate monitoring devices.

The application has a demo version, showing an example virtual environment without the use of applications and external tools of the platform, such as: TherapyDesktop or biofeedback sensors. The demo includes a separate user model control system that takes full advantage of the existing buttons on both controllers and helps to familiarize users with the operation of the virtual reality device.

The VR application project consists of a total of 22 characters, of which 16 are student models and the remaining 6 are teachers. There are also items in the scenery - models that the user can grab and throw, and if necessary, reset their position using the function assigned to the controller button.

Changes in lighting, teacher model, and the appearance of the class can be done by pressing the appropriate button. The user can also reset his/her position to the original one.

The lighting configuration consists in turning off the lighting in the classroom and turning on the projector light, which gives an aesthetic visual effect and additionally ensures the functionality of displaying the presentation on the board (see Fig. 7).

Figure 7. Light on and off effects. Source: own elaboration

There is also a model of the user's hands in the demo scene. The model of hands has animations that are triggered when the appropriate buttons on the controller are pressed.

6.1   The VR app during therapy session

The application is launched by the user on the Oculus device by entering the application panel. One can also do this through Unity while in Oculus Link mode (Oculus device connected to a computer). When the application is launched, the avatar of the VR goggles user is placed in a predetermined location in the scene. During this time, the user is able to lean, turn around and listen freely. His/her displacement is controlled by a therapist using a desktop application. Submitted messages with information about the scene to be displayed and other actions are processed on an ongoing basis. The message contains the appropriate elements of the action table that are executed according to the script of the scene. During the execution of the action, character animations are also performed in the classroom scenery.

Each character has a behaviour tree that defines the sequence and conditions that must occur for a given animation to run. Teacher and student selection is managed via scripts. Each character has configured animations that trigger periodically. Each of the animations has a unique repetition time, and student characters call them until they are interrupted by another animation, e.g. an animation triggered by the therapist's action, or until the animation lasts.

The assumption of this work was to create three basic scenes that are most needed in therapeutic sessions for the target group of people under 24 years old. In order for the scenes to be as close to the assumptions as possible, their proposals were consulted with Andrzej Sędek, PhD, from the Institute of Pedagogy at the University of Natural Sciences and Humanities in Siedlce, who focuses his scientific interests on issues related to social, historical and educational psychology. Two main scenes were chosen: the classroom and the auditorium/gymnasium. An introductory scene was also created: the "Intro" office, where the therapist can see how the participant reacts to various frustrating tasks before starting the session.

The main goal for the classroom scene was to create a scenery that most accurately reflects a real classroom from an elementary/secondary school. One of the problems that was encountered at the beginning of the designing phase was the fact that most schools for young

people have different rooms depending on the subject that is taught in them. For this reason, it was necessary to create an appropriate script that would allow the therapist to choose the basic appearance of the room, for example, a math, history or geography classroom.

The scenes presented in VR headset seem small, but they contain complex objects. This makes the rendering process demanding. During the implementation and testing of the application phase, numerous optimization improvements were made. They ensured that the application works smoothly and provides the right level of immersion.

Character animations simulating specific behaviours are triggered by scripts at the appropriate time of the session. Using a given script, the teacher is able to perform the following animations: pointing at a student, pointing at a student in anger, pointing at a student with a thumb, arguing, talking to a student, talking to a student while facing him/her. To ensure the impression of interaction of characters with other elements of the scene, it is possible to set the direction of their eyes, including the appropriate rotation of the head (see Fig. 8).

Figure 8. Students facing teacher model (left side) and students facing user's avatar (right side). Source: own elaboration

For student models, the available animations are: clapping, cheering, screaming, laughing, showing disappointment, and fist-cheering. Animation combinations with sounds in the classroom are also available. As an example, class laughter with different levels of intensity can be used.

6.2 The course of an exemplary therapeutic scenario

The current version of the platform has a ready prototype of a therapy session scenario, which is to be used by the therapist to collect preliminary results regarding how a given participant reacts to stress, whether he has problems with performing irritating tasks under time pressure or whether he has any disturbing levels of stress during public performances. These results are collected using special sensors that monitor basic life functions such as breathing or skin-galvanic reaction. The main purpose of the script implementing the discussed scenario is to properly manage the scene objects in such a way as to instruct the participant in a controlled way how to go through the successive stressful tasks. The whole thing is based on displaying the appropriate text on a virtual screen in a specific time frame. In addition, there is a transfer between previously created scenes and playing at the right moment the annoying sound of a ticking clock.

The course of the scenario presented in stages (the therapist instructions, the participant actions, and breaks are marked with different text styles):

1. Waiting for the therapist to start
2. A short break
3. Instructions for reading the colours of words aloud
4. **Reading the colours of words aloud - the Stroop effect**
5. A short break
6. Instructions on how to subtract out loud
7. **Subtracting a specific number from another large number aloud**
8. A short break
9. Instructions on answering the question asked by the therapist
10. **The participant's answer to the question asked by the therapist**
11. A short break
12. Instructions for moving to the desk in the classroom scene
13. **Staying at the desk in the classroom scene**
14. A short break
15. Instructions for moving to the classroom scene at the blackboard
16. **Stay in the classroom scene at the blackboard**
17. A short break
18. Thanks for participating in the study - end of the scenario

Each of the tasks presented in the scenario has a specific time frame for its execution, and after a certain number of seconds has elapsed, the application will proceed to the next stage in the scenario. In this case, each task had a fixed time of 60 seconds. While waiting for the next stage of the scenario, the participant is shown the message "Break. . . " on the screen.

The execution of each task, including the countdown timer and ticking clock sound, begins when an action is received from the therapist initiated in the TherapyDesktop application.

7 Summary

A platform for therapy in a virtual reality environment called VR Therapy was presented. Its components allow users to plan, conduct and analyse therapeutic sessions. In the TherapyWeb application, a therapist can schedule a visit or a series of therapy visits. The VR headset app allows a user to participate in a diagnostical or therapeutical session. The therapist uses the TherapyDesktop application to prepare and conduct scheduled sessions. The collected data is transferred to the TherapyWeb application, where it can be analysed in more detail. By using scripts and scenes combined with virtual reality, we are able to simulate specific stressful situations for the therapy participants and prepare them to cope with their phobias in a controlled environment. In addition, during the session the therapist is able to determine whether the participant is actually stressed and how he reacts to specific situations based on the measurements from biofeedback devices shown in real-time. The prototype version of the platform as well as the first scenario on public speaking at school has been developed. We are conducting a pilot study to determine the psychometric properties of our solution. We plan to implement next therapeutic scenarios such as: telephone conversation, attending remote lessons, shopping, or even a job interview.

References

1. Deep vr. `https://www.exploredeep.com/`, [Accessed 30-07-2023]
2. Metaverse software - virtual reality solutions. `https://www.metaverse.com.tr/en/`, [Accessed 30-07-2023]
3. PsyTech VR | Mental Health and Wellness system for Meta Quest, PICO and HTC — psytechvr.com. `https://www.psytechvr.com`, [Accessed 30-07-2023]
4. Relax VR | Virtual Reality Treatment for Spas. `https://www.relaxvr.co/`, [Accessed 30-07-2023]
5. Replika — replika.ai. `https://replika.ai/`, [Accessed 30-07-2023]
6. virtuallybetter.com. `https://virtuallybetter.com/`, [Accessed 30-07-2023]
7. VirtualSpeech - Soft Skills Training with Practice Exercises and VR. `https://virtualspeech.com/`, [Accessed 30-07-2023]
8. VR for Psychotherapy | Amelia Virtual Care. `https://ameliavirtualcare.com/virtual-reality-solution-psychology/`, [Accessed 30-07-2023]
9. VR Solutions for Healthcare - Cognihab. `https://www.cognihab.com/`, [Accessed 30-07-2023]
10. Diagnostic and statistical manual of mental disorders, 4th ed. American Psychiatric Publishing, Inc., Arlington, VA, US (1994)
11. Abramowitz, J.S., Deacon, B.J., Whiteside, S.P.: Exposure therapy for anxiety: Principles and practice. Guilford Publications (2019)
12. Babicki, M., Mastalerz-Migas, A.: The occurrence of anxiety disorders among poles during the covid–19 pandemic . Psychiatria Polska **55**(3), 497–509 (2021). https://doi.org/10.12740/PP/OnlineFirst/126230
13. Boetje, J., van Ginkel, S.: The added benefit of an extra practice session in virtual reality on the development of presentation skills: A randomized control trial. Journal of Computer Assisted Learning **37**(1), 253–264 (2021)
14. Diemer, J., Mühlberger, A., Pauli, P., Zwanzger, P.: Virtual reality exposure in anxiety disorders: Impact on psychophysiological reactivity. The World Journal of Biological Psychiatry **15**(6), 427–442 (2014)
15. Emmelkamp, P.M., Meyerbröker, K., Morina, N.: Virtual reality therapy in social anxiety disorder. Current psychiatry reports **22**, 1–9 (2020)
16. Hinojo-Lucena, F.J., Aznar-Díaz, I., Cáceres-Reche, M.P., Trujillo-Torres, J.M., Romero-Rodríguez, J.M.: Virtual reality treatment for public speaking anxiety in students. advancements and results in personalized medicine. Journal of personalized medicine **10**(1), 14 (2020)
17. Kahlon, S., Lindner, P., Nordgreen, T.: Virtual reality exposure therapy for adolescents with fear of public speaking: a non-randomized feasibility and pilot study. Child and adolescent psychiatry and mental health **13**(1), 1–10 (2019)
18. Lacey, C., Frampton, C., Beaglehole, B.: ovrcome–self-guided virtual reality for specific phobias: A randomised controlled trial. Australian & New Zealand Journal of Psychiatry **57**(5), 736–744 (2023)
19. Lindner, P., Dagöö, J., Hamilton, W., Miloff, A., Andersson, G., Schill, A., Carlbring, P.: Virtual reality exposure therapy for public speaking anxiety in routine care: a single-subject effectiveness trial. Cognitive Behaviour Therapy **50**(1), 67–87 (2021)
20. Palmas, F., Cichor, J., Plecher, D.A., Klinker, G.: Acceptance and effectiveness of a virtual reality public speaking training. In: 2019 IEEE international symposium on mixed and augmented reality (ISMAR). pp. 363–371. IEEE (2019)
21. Sülter, R.E., Ketelaar, P.E., Lange, W.G.: Speakapp-kids! virtual reality training to reduce fear of public speaking in children–a proof of concept. Computers & Education **178**, 104384 (2022)