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# VR SCENARIOS TO TREAT MENTAL HEALTH

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**Abstract.** Schizophrenia is characterized by delusions, hallucinations, anhedonia and apathy, and is a chronic mental illness, which still has no cure. It is diagnosed in three main groups, namely positive symptoms, negative symptoms, and cognitive symptoms, and affects the patient in major areas of life, such as work, interpersonal relationships, or self-care. The usual treatment is carried out with the help of antipsychotic medications, which mainly target the positive symptoms of the illness, but have little effect on the negative symptoms of schizophrenia. It is a disease that affects 1 % of the population, and while it is not the most common of other mental disorders, it can be the most disabling. Virtual reality (VR) is increasingly used as a powerful auxiliary tool in rehabilitation. It allows an immersive audiovisual environment with high clinical relevance and robust validity, modernizing rehabilitation interventions, leading to improved motor function and biomechanical or diagnostic ability better than traditional methods used to treat patients under cognitive health. In this context, this paper addresses the design of virtual environments and computer simulations, providing the patient with an experience close to the real world, and allowing intensive repetition of essential tasks during the mental health rehabilitation process, with real-time feedback in a controlled and safe environment. Virtual reality (VR) is increasingly used as a powerful auxiliary tool in rehabilitation.

**Keywords:** Virtual reality, schizophrenia, rehabilitation

## 1 INTRODUCTION

Schizophrenia is a psychiatric illness that, according to the World Health Organization (WHO), affects about 20 million people in the world population, and is the most common psychotic illness, and one of the most debilitating for humans [1]. Schizophrenia is characterized by behavioral, emotional and cognitive disturbances – including in social cognition. It can be described as a psychosis, which means that the person loses a sense of reality, not distinguishing it from the imaginary [2]. Although it is discussed as if it were a single disease, it corresponds to a group of disorders with heterogeneous etiologies and includes people with variable clinical presentations, response to treatment, and course of illness [3]. The Diagnostic and Statistical Manual of Mental Disorders [4] suggests that its diagnosis depends on at least two or more of the following symptoms, each for a significant portion over a period of 1 month (or less if successfully treated). At least 1 of these should be 1., 2. or 3.:

1. Delirium,
2. Hallucinations,
3. Disorganized speech,
4. Grossly disorganized or catatonic behavior,
5. Negative symptoms (e.g., decreased emotional expression or avolition).

The same manual suggests that, from the onset of the disorder and for a significant period of time, the level of functioning in one or more major areas, such as work, interpersonal relationships, or self-care, is markedly below the level previously achieved. The symptoms can be grouped into different groups:

1. Positive Symptoms: delusions, hallucinations, disorganized speech and behavior.
2. Negative symptoms: social isolation, difficulty showing emotions or even loss of interest, and poverty of dialogue.
3. Cognitive symptoms: altered attention, memory, intellectual, difficulty processing information to make decisions [5].

Schizophrenia goes through different phases: In the early stage the patient may have no symptoms or may have weakened social skills, mild cognitive disorganization, perceptual distortion, reduced ability to feel pleasure, and other generic impairments in the way he or she handles certain situations. In a secondary stage of the illness, subclinical symptoms may appear, which can be isolation of the person, as well as irritability, distrust, unusual thoughts, perceptual distortions, and disorganization. It is in this phase of the disease that delusions and hallucinations may also appear. At a more intermediate stage, sympathomimetic-tomatic episodes may become episodic or continuous, while the functional deficit tends to worsen at this stage. In the last stage, the pattern of how it manifests in the patient can be defined, at this stage, the deficits may also stabilize or even decrease [6].

Sixty years ago, the common alternative treatment for patients with schizophrenia was confinement in psychiatric hospitals, where most of them would remain for the rest of their lives. With traditional treatments, for example cognitive behavioral therapy, it is normal to try to treat the social-cognitive part of patients. However, these procedures can be painful and may require multiple patient therapy training sessions. The virtual reality application that is being developed aims to help these traditional methods by making it easier for the therapist to treat patients. Giving new tools and possibly decreasing the time in which positive effects appear in patients. Since these same applications ultimately bring real-time biofeedback from the patient to the therapist, we can help more effectively, opening a window to improve treatment.

### 1.1 Virtual Reality (VR) Viability and Efficiency

Virtual Reality (VR) is an environment generated by a computer with objects and attributes that make it look real by making users feel immersed in this reality. In 1961, two engineers from Philco Corporation built the first precursor to the Head-Mounted-Display (HMD), which was called Headsight, where it incorporated a motion tracking system.

Thomas Furness later directs (1986 and 1989) an American Air Force program called Super Cockpit where he makes use of an HMD to develop a system with the ability to project 3D maps, avionics data and a radar, all of this carried out in a virtual environment, where the pilot could hear and see in real time. The HMD had motion detection sensors, voice control, among others that made the pilot steer the plane, making use of gestures, eye movements or even speaking.

In the 90s, with the expansion of the video game market, there was a significant increase in the production of virtual reality products, in order to try to provide the user with a totally immersive experience, such as Sega VR (1991) and Nintendo Virtual Boy (1995). Unfortunately the technology that existed at that time was not very developed and since it was at that time that the growth of the Internet took place, there were many people who decided to focus on software for 3D design and not on hardware.

In the following years, with technological development and a great demand for the immersion provided by virtual reality, it returned with a new prototype, the

Oculus Rift, produced in 2009 by Palmer Luckey and in the following decades an outbreak of virtual reality occurred, which started with a simple flight simulator, became one of the most promising technologies [7].

Virtual reality is used in different applications such as simulation and training of airline pilots [8], in design and architecture, in the training of military personnel and also in the treatment of disorders and phobias, as we intend to do in this investigation. Nowadays, when we hear about virtual reality, we automatically associate it with video game industry, where it is applied using an HMD that has two screens, each screen corresponding to each eye. With the application of stereoscopy, two images are generated, one for each screen, and the brain interprets these same images as one, which causes the effect of depth, causing immersion. As its name implies, this will be the technology used to develop the application in mind, since the purpose of the application itself is to make use of virtual reality methods to help combat schizophrenia.

In 2013 in Hong Kong, Tsang and Man [9] conducted a study to investigate the effectiveness of virtual reality as a cognitive intervention to improve vocational outcomes, 95 patients with schizophrenia were hospitalized, 25 of whom underwent vocational training based on virtual reality (VRG). The rest with therapy sessions and a conventional group, the result was great because the patients at VRG performed much better than patients with therapy sessions.

Openmind 360 was founded in 2016. With the aim of eradicating and changing the stigmas created around mental disorders, educate and bring knowledge about them, the company organized several educational workshops for teenagers. According to the company, one in five adolescents go through some kind of mental illness and one in ten has thoughts suicidal, with only 20 % asking for help from psychologists. With this goal in mind, these innovative workshops are based on VR environments, where teenagers can open up and talk about their problems in an friendly environment [10].

In 2016, Oxford VR [11] created a treatment using immersive technology, presenting different scenarios that were personalized for each patient. This experience was carried out on people suffering from psychosis, anxiety and acrophobia where the patient can train their strategies to be able to apply in real-world situations. Some of the scenarios used was waiting in a line full of people. The results were very positive: patients with acrophobia had a 68 % reduction in their fear, with half of the patients reducing their fear by 75 %.

In 2018, the first GameChange project was created [12], with the purpose of helping to combat mental illnesses through the use of VR, specifically for patients with psychosis. Some of the environments that were implemented were taking a bus, going to the mall and talking to strangers among many other scenarios. In 2020, GameChange was developed with the aim of helping to combat mental illness through the use of automated VR cognitive therapy, anxiously avoiding everyday social situations. With six events, in six everyday scenarios: a street, a bus, a cafe, a bar, a doctor's waiting room and a shop. Possessing five levels of difficulty, each level provides an opportunity to test fear cognitions while limiting the use of safety-seeking behavior, allowing patients to gain confidence in coping skills. In each scenario, patients must perform important tasks, such as ordering a drink, finding items in the store, or calling someone across the room.

In this same year, virtual reality and non-invasive brain stimulation (NIBS) are innovative technologies that have potential in this area [13]. Current social cognition-related research suggests VR has potencial to facilite more direct translation of improvements from VR training to functional outcomes by immersing individuals in virtual enviromments that can feel like real-world encounters [14].

## 2 MENTAL HEALTH – VR APPLICATIONS

Most research conducted before 2012 focused on anxiety disorders [15], eating disorders [16], phobias [17] and post-traumatic stress disorder [18]. Sorkin et al. [19] in a study of 39 patients with schizophrenia and 21 healthy controls investigated the relationship of skill in navigating a virtual maze that required hypothesis generation and application, as well as rule shifting, to diagnosis and symptom ratings. Results of this study revealed that performance on the virtual maze accurately categorized 85 % of the sample with schizophrenia, and scores in the maze were linked to several items from a standardized symptom rating scale. In combination with results from the current study, these findings suggest that VR technology with schizophrenia may be used effectively for assessment of both neurocognitive and instrumental role functioning skills.

In 2014, Smith used VR to provide vocational or social skills training. The treatment was a scenario in VR in which the patient had to interact as if it were a job interview. The results were very positive, but there was a relatively high dropout rate, partly due to the participants finding the treatment to be very aggressive and partly due to the use of VR headsets that induce nausea and dizziness [20].

In 2018, du Sert et al. [21] used immersive virtual reality (VR), as the growing evidence suggests that greater immersion in an VR system increases both the sense of presence and the emotional excitement. The results propose that VR is a highly promising intervention for refractory auditory verbal hallucinations in schizophrenia. Nevertheless, the current trial has a few limitations that are worth being acknowledged, namely the non-blinding to treatment allocation of the evaluator performing the clinical assessments and the non-inclusion of the data from dropouts. The latter factor may have contributed to an over-estimation of treatment effect. The choice of treatment-as-usual as the control is another limitation that needs to be acknowledged, since treatment-as-usual is a comparison condition that only controls for the effect of time, and does not allow to directly compare VR to a proven efficient psychological intervention for treatment-resistant schizophrenia.

Powell et al. [22] explored two experimental studies: a pilot study consisting of three unique daily movements aimed at basic ROM and strength, and a revised study that incorporated four new movements aimed at ROM from perceptions obtained in the multimodal rehabilitation analysis of the pilot study. The results indicated that users were able to overcome the novelty effect of the iVR through prolonged exposure to gameplay for eight weeks. They also measured heart rate, galvanic skin response and electroencephalography while users played, which allowed them to understand their physical effort and emotional response during the game.

As we saw, VR has already been applied to the treatment of various pathological conditions. Several clinical studies have demonstrated its effectiveness in the treatment of post-traumatic stress disorder, anxiety disorder, and specific phobias. Actually, rehabilitation supported by digital technologies has thus emerged as a solution to support health professionals by providing high-intensity, repetitive, and task-specific exercises to improve the rehabilitation process [23].

Compared to traditional cognitive social therapies, which lasted an average of six months to show results, the use of VR in these interventions proved to be effective, since it only took five weeks to demonstrate positive effects [24]. The conclusion of all studies revised in this work, indicate that VR is a useful tool to evaluate and treat patients with schizophrenia. The reviewed studies covered three main areas: cognitive, social, and perceptual/sensory areas, classified into two main fields, namely evaluation of skills and symptoms ($n = 27$) and skill training ($n = 6$), as shown in Figure 1.

| Area | n | Domain | n | Objective | n |
|---|---|---|---|---|---|
| Cognitive | 15 | Evaluation | 13 | Executive functions | 10 |
| | | | | Atention | 5 |
| | | | | Spacial memory | 4 |
| | | | | Visual memory | 3 |
| | | Trainning | 2 | Cognitive skills | 2 |
| Social | 14 | Evaluation | 10 | Social interaction | 5 |
| | | | | Social perception | 3 |
| | | | | Emotional recognition | 2 |
| | | Trainning | 4 | Social skills | 3 |
| | | | | Comunication skills | 1 |
| Senso-perceptual | 4 | Evaluation | 4 | Reality perception | 2 |
| | | | | Sense of perception | 1 |
| | | | | Auditory hallucination | 1 |
| | | | | Delusion | 1 |

Figure 1. Summary of areas, domains and objectives of selected studies [24]

## 3 EXPERIMENTAL DESIGN – VR

This research will develop the VR environment by basically incorporating 3 key concepts that generate rehabilitative learning: repetition, feedback, and motivation. Since these factors are independent, when combined in an intelligent environment, they can achieve very promising goals. VR can promote better integration of cognitive and motor stimulation, contributing to more independent learning in everyday life, and can be very useful as a complement to existing therapies. Rehabilitation is comprised of interventions required when a person faces limitations in performing activities of daily living due to aging or due to acute or chronic pathologies, which may be manifested by difficulty in thinking, seeing, hearing, communicating, moving, interacting, or maintaining employment. Rehabilitation is an essential component of universal health coverage [25]. Mental health rehabilitation is a dynamic evidence-based model that provides comprehensive and continuous care plans focused on the person with severe and persistent psychiatric illnesses, closely linked to community integration and increased quality of life [26].

Mental health rehabilitation aims to help patients find a way to interact and function in society. Interaction with people and the experience of every day situations can contribute to this goal, thus allowing to control the experience in order to improve the effects of therapy. As a preparation and anticipation of some potential real-life circumstances during play, it is also the aim of this research to produce and test implementations of some VR scenarios, where the patient will be confronted with some simulated real-life condition, to be implemented in future activities. Some of these scenarios proposed to be developed are:

### 3.1 Metro Station Scenery

The first scenario we intend to implement is a metro ride: this scenario aims to reduce the symptoms of dialogue poverty and disorganized behavior. The idea in this scenario is that the patient communicates with other avatars present in the subway, while in progress with many people. In the virtual environment, the patient will appear at the entrance to the subway station, and there will be a small number of avatars, as shown in Figure 2.

To start the simulation, the user will have to enter the subway, and can choose to be seated or standing. The moment the choice is made, the metro will start the trip, and you can alternate between sitting or standing during the trip. When starting the simulation, the user will travel in an ambiguous metro with only a few passengers, as we can see in Figure 3.

The metro will stop at various stations from time to time, and whenever it reaches a stop, a number of passengers will get off and another will get on, but with the number of passengers increasing if there are no signs of stress and vice versa. During this trip, the user can also be approached by an avatar who wants to start a conversation with him. Here we can assess what the person's socio-cognitive skills are like, or even initiate training strategies for dealing with these

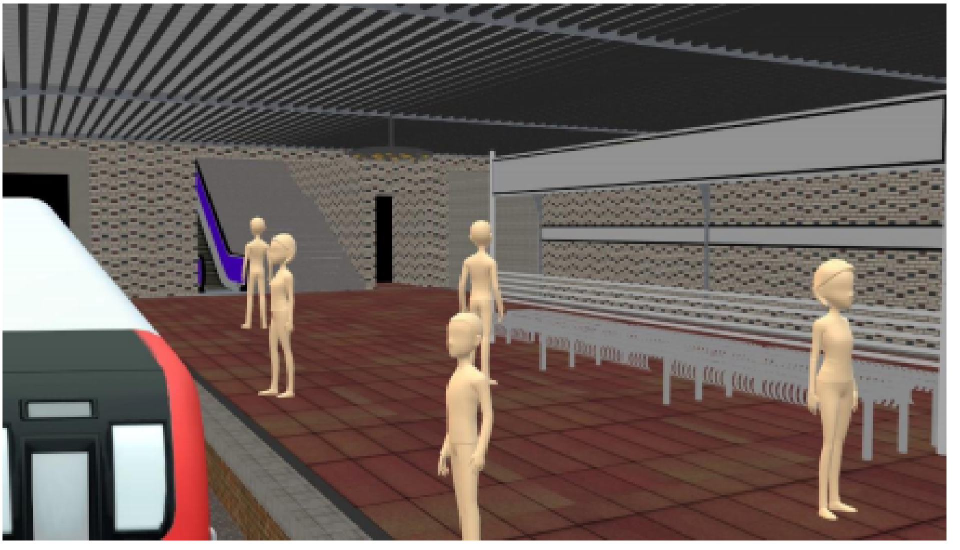

Figure 2. Metro station scenery

Figure 3. Metro interior scenery

kinds of events in the real world. The conversation created will be a short, simple conversation. If there are any signs from the patient that something is not right, the avatar himself can try to calm the patient down or even let him rest. It is important to note that the patient can leave the simulation at any time, as a stop button will also be implemented so that it will stop at a station within a few seconds and not start again, giving the patient time to get off the metro. The simulation ends the moment the patient leaves the metro and goes to the exit of the station, whether they exit via the emergency button or normally, like any other passenger.

### 3.2 Morning Routine Scenery

This second scenario will be the execution of a morning routine. This scenario aims to alleviate the symptoms of lack of interest in continuing actions and making decisions. We decided to create this scenario to represent a simpler everyday situation to test cognitive abilities. In addition to assessing cognitive abilities, it will also help the patient to overcome the symptoms of the positive and negative category, as they can generate disinterest by performing a simple activity, neglecting essential daily activities. In this virtual environment, as we can see in Figure 4.

Figure 4. kitchen scenery

The patient will find himself in the kitchen: initially, he will choose the food and utensils he needs to prepare it, with some breakfast options, which will be chosen by the patient when he enters the kitchen, being introduced to this range of choices through certain visual cues. If he feels any stress in the decision or does not know how to react, a hint will appear in the scenario that will take the patient to a post-it, which will allow him to choose the breakfast he can prepare, as we can see in Figure 5.

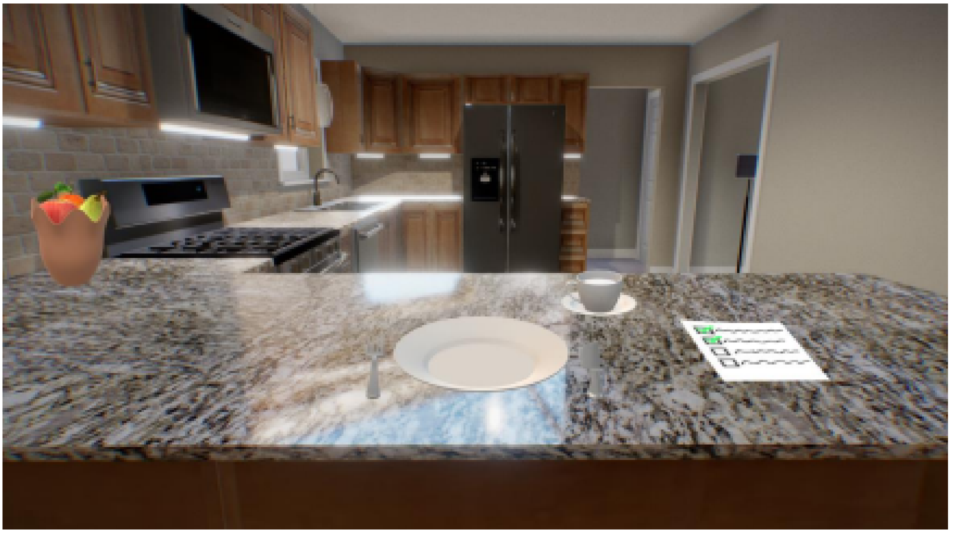

Figure 5. Postit with the options in the kitchen scenario

In case of any kind of panic, it may also be possible to get help from an avatar present in this kitchen, or from a voice of a member of the patient's family. If possible, after it is prepared, the patient has to eat it in this same environment, so that he can then wash the dishes, going through the water and, at the end, with a cloth. To finish the simulation, the patient only has to leave the kitchen through the front door.

### 3.3 Park Scenery

In the latter scenario, our goal is to reduce the symptoms of hallucinations and delusions. The patient will be sitting on a bench in the garden and should use the remote control that virtual reality has created to move by teleportation in this virtual world. In the virtual environment created, the user will be in a park surrounded by many people, as we can see in Figure 6, in which he will be able to interact with some objects, such as benches and/or drinking fountains, as well as with some animals that will be present there, such as dogs or cats and some avatars.

During the walk, other situations may arise and trigger some illusions and hallucinations. In order to determine if the patient is having some kind of delusions or hallucinations, the avatars' movements will already be predetermined, so that you

Figure 6. Park scenery

can effectively know if the user is going through a psychotic episode, and thus be able to calm the patient down and make sure that he is only having a hallucination. If the stress levels change too much, an emergency button will be available for the patient to exit the simulation, which in this case will be a cell phone, with the option to exit, as shown in Figure 7, just tap a button on the VR remote control and exit this phase.

All these prototype scenarios give an active role in the prescription, personalization and adaptation to the needs and context of the patients in their daily lives.

### 3.4 System Requirements

The proposed scenarios are designed to support the psycho-social rehabilitation of patients diagnosed with schizophrenia, namely targeting the negative and cognitive symptomatology. It integrates functionality that allows for greater flexibility and comprehensiveness of the rehabilitation experience, as well as consists of several hardware and software components, which support data acquisition, processing, storage, and visualization.

The system requirements will be based in a tool independent and completely autonomous from other rehabilitation or hospital systems. It needs a physical place to host the system that safeguards the user experience and safety. The caregiver will need a workstation, where he can monitor the dashboard with real time information about the rehabilitation session.


Figure 7. Scenery to leave the environment

In this context, the caregiver is a health professional, that will support the rehabilitation sessions. The patient will be immersed in a VR environment, so it is important to ensure a 4 m × 4 m area, free of objects and obstacles, for the patient to stand. Besides the computer system, the visualization and interaction with the system by the patient is done through a set of VR Head Mounted Display (HMD) and associated controllers.

It is through these that the player receives directions from the game and acts on the elements and objects represented therein. The communication between the HMD, the sensors, and the computer should be wireless, so as not to limit the patient's movements. This should also allow obtaining the patient's displacement in the room, in order to measure the translation and rotation movements to be replicated in the virtual environment. The availability of the physical area may incur in costs, depending on the facilities and infrastructure of the rehabilitation institution.

The interaction with the system will be performed through a serious game in VR that, simulating spaces and tasks of daily life activities, proposes problem-solving as the basis of psycho-social rehabilitation, with the aim of recovering autonomy and gaining quality of life. Therefore, the environment is anchored in three-dimensional spaces and objects with realistic proportions and color palette, and obeying the laws of physics, such as inertia, gravity, or light reflection. The area will be explored through a 1st person camera perspective. Figures 8, 9.

It is also intended to provide a platform for monitoring the rehabilitation session, through the representation in a dashboard of various values of performance and physiological condition of the patient. Finally, it is intended to store all the data

Figure 8. Developing scenery

Figure 9. Developing scenery

that, after processing, will be used by the medical team to evaluate the evolution of the rehabilitation process.

The medical staff will have access to a web-based application, similar to a dashboard, that will present various real-time data in visual format, that will help him manage the rehabilitation session. The data includes information related to the stress level, performance, and progress in the session, gathered by hardware and software probes. Finally, the medical team will have both read and write access to all the information, from the medical record and data obtained during rehabilitation sessions, as well as the ability to add recommendations, notes, and observations regarding each patient. The caregivers and medical staff use a regular computer, with keyboard, mouse, and monitor, to run web-based applications.

### 3.5 Sensors and Biofeedback Data

While conducting the simulation of this type of tests, the patient will be in a controlled laboratory environment, with plenty of space to physically simulate the movements according to the real world, and use several devices the least intrusive as possible to record the vital signals during the virtual environment simulation. In short, the patient will always be monitored and accompanied by a professional.

The sensors used to monitor the patients are described below:

**Haptic Vest [27]:** TACTOT is a wireless haptic vest that delivers feedback to the upper body in real-time for a more sensations experienced in virtual content. With a total of 40 individually controllable haptic motors sensors, TACTOT precisely replicates the various sensations experienced in digital content in a way which users can actually feel.

**Neulog GSR logger sensor NUL-217 [28]:** The NUL217 is a GSR logging sensor that measures the conductivity of the skin between the fingers. The logger connects to a USB-200 Module and records GSR in micro Siemens with a 10 nS resolution at a max sample rate of 100 Hz. The two finger electrodes were sterilized with saline wipes before gameplay.

**Polar OH1 – optical heart rate sensor [29]:** The Polar OH1 is a 6 LED optical heart rate sensor used with a cuff to record beats per minute as well and stress via Bluetooth at the sampling frequency of 1 Hz.

**Apple Watch Series 6 [30]:** The Apple Watch allows measure the level of oxygen in the blood through a revolutionary app and sensor, make an electrocardiogram and also measure the heart rate.

**Brain Sensing HeadBand [31]:** Muse 2 is a multi-sensor meditation device that can read your brain, heart, body and breath waves in real time and provide helpful feedback to improve meditation skills and get more relaxed. It is a research-grade EEG device that passively detects brain activity and translates it into guiding meteorological sounds to help keep you calm and focused.

The intention when using this sensors is to infer physical and mental state, analyzing potentials events, and record biofeedback data. These devices are easy to set up for a user under simulation, and are a more affordable solution compared to clinical grade sensors. The researchers and caregiver will always be present to monitor the user experience and followed a strict written protocol when interacting with patients. This ensures a consistent method of tracking progression and data acquisition, to be used in the module of profiling and real-time adaptation of the rehabilitation procedures.

### 3.6 Discussion

The main objective of the work described in this paper is the development of a rehabilitation system based on the scenarios presented above. Experience must not exacerbate symptoms and, as such, it was important to design the experiences that do not provide any unexpected stimuli or effects that can be misinterpreted as hallucinations. For example, there should not be a narrating voice to guide the patient, since it would seem as audio hallucinations, just as there should be no force-feedback device, since it could be mistaken for tactile hallucinations, or even placing arrows or other elements in the VR environment, for the same reasons. All of these scenarios presented were thought of by the medical team as by the developers of the scenarios, in order to help the patient in everyday situations that could happen.

The patient will be accompanied by a caregiver, who monitors the session and can intervene if necessary. The progress throughout the sessions is monitored by the medical team and to evaluate the appropriateness of the rehabilitation treatment and and possible adjustments.

## 4 CONCLUSION AND FUTURE WORK

As we mentioned earlier, there is a lot of evidence about how VR can improve the treatment of people with schizophrenia, showing that this tool has the potential to become an effective new way to treat symptoms. However, it is important to note that VR is only a complementary tool, which can integrate programs composed of other therapeutic approaches. This device gives the therapist not only a new tool, but also assigns an active role in prescribing and customizing the approach according to the user's needs and the context of their daily life, as well as in terms of stimulus presentation, monitoring and adjusting the process according to a safe environment.

The present document presents the study carried out for the development of both the scenarios and everything that involves their operation. In the future, we plan to implement all the above mentioned scenarios, develop the integration procedures to receive and store the sensor data, perform immersive and reactive VR testing of the prototypes of the associated scenarios to validate their implementations.

In recent years there has been a breakthrough in research to alleviate the symptoms of schizophrenia using VR, however, more studies are clearly needed to establish the reliability and validity of VR-based assessments, and issues with access to these resources and ethics require attention, thought and research as the field develops.

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