

# VR Serious Games and Negative Schizophrenia Symptoms

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Schizophrenia is a chronic brain disorder that affects 1 in every 300 people worldwide. VR is an interesting tool that has started to be used in remediation therapies. Although it is typically used as an exposure technique for specific phobias, VR has been applied, with encouraging results, to the study and treatment of schizophrenia. It can offer the potential for a significant therapeutic benefit, since patients are more willing to enter challenging situations and experiment with alternative ways of responding.

Keywords: virtual reality ; game design ; serious games ; schizophrenia

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## 1. Introduction

One of the key characteristics of schizophrenia has been recognized as psychosocial impairment, which includes a deficit in social cognition and social behavior <sup>[1]</sup>. Symptoms such as depression, cognition, and even social functions have all been found to be influenced by the use of VR environments <sup>[2]</sup>. Thus, by using an immersive VR environment, it is possible to create realistic situations which could possibly trigger negative symptoms in patients but, in a secure simulation, enable users to build their confidence and cope with their struggles better.

VR is an interesting tool that has started to be used in remediation therapies <sup>[1]</sup>. Although it is typically used as an exposure technique for specific phobias, VR has recently been applied, with encouraging results, to the study and treatment of schizophrenia <sup>[3]</sup>. It can offer the potential for a significant therapeutic benefit <sup>[4]</sup>, since patients are more willing to enter challenging situations and experiment with alternative ways of responding <sup>[5]</sup>. Patients can put on a headset and be immersed in multiple situations ranging in difficulty, which may cause them to experience different levels of psychological distress <sup>[6]</sup>.

Individuals, not only in their own life activities but also in treatment, may be hesitant with respect to face-to-face engagement <sup>[7]</sup>. The causes of this anxious withdrawal may be many: social anxiety, negative self-image, panic attacks, and a lack of confidence <sup>[8]</sup>. Studies have shown that psychosocial interventions in schizophrenia have positive effects on disease symptoms, treatment compliance, quality of life, social cognition, social functioning, and employment <sup>[1]</sup>, generating positive perceptions and pleasant emotions. An improvement in relationships and peer motivation was reported <sup>[9]</sup> in group therapy sessions with digital games, where patients can play together. The power of VR interventions thus far has been most evident in the treatment of anxiety disorders <sup>[5]</sup>. Yet, some studies also noted an improvement in general psychopathology, negative symptomatology, and daily functioning <sup>[1]</sup>.

The success of a rehabilitation program depends on several factors <sup>[4]</sup>—not only is exposure to a troubling situation key for clinical change, but actively testing out fears with the dropping of defense behaviors is as well <sup>[5]</sup>. The sense of embodiment seems to be one of the key factors in a VR application, especially when it focuses on the increase in empathy. The user must feel self-located inside the virtual environment, perceive feedback from the environment as if it was from his own sensations, and recognize himself as the cause of the actions <sup>[9]</sup>.

VR therapy can be as effective, if not more effective, than treatments delivered in traditional formats <sup>[5]</sup>. Nonetheless, there is still an initial reluctance to use VR in working with patients with schizophrenia <sup>[1]</sup> due to the old misconceptions that games are only about having fun and cannot be used to develop practical skills. Consequently, the existing rehabilitation games lack the entertainment factor and should be updated to meet a greater number of key parameters, causing them to become more useful therapeutic instruments <sup>[4]</sup>. For instance, most VR therapy systems still require the presence of a therapist to administer the treatment, thereby restricting the treatment scalability <sup>[5]</sup>. Additionally, the effectiveness of computer games for rehabilitation could be enhanced by the incorporation of a social dimension <sup>[4][10]</sup>. Furthermore, to the best of researchers' knowledge, there has been no study published in which games use collaboration or competitiveness as a significant part of the schizophrenia rehabilitation process.

To conclude, there is still a long way to go in developing a solution for VR game therapies. The aim of the entry is to conduct a systematic review of the interventions based on VR targeted at patients with negative symptoms of schizophrenia and also of the characteristics of such interventions. From such an entry, an analysis of the presence or absence of key components of those interventions will be made.

## 2. Serious Games

Serious games are becoming a prominent study topic fueled by advancements in game production and computer graphics hardware, which are in turn fueled by the popularity of video games <sup>[4]</sup>. This has led to a view of games as educational technologies and, consequently, as having application beyond the realm of entertainment <sup>[11]</sup>. Although the term serious game still has a broad range of definitions, it is agreed that the main purpose of these games goes beyond mere entertainment <sup>[4][12][13][14]</sup>; they are designed to make players learn something and, if possible, have fun while doing it <sup>[14]</sup>. For the purpose of this entry, serious games are defined as digital games that, through some form of simulation, allow users to build knowledge and learn new skills in a more engaging and fun way.

Games provide powerful and meaningful contexts for learning <sup>[11]</sup>, as they can have positive impact on the development of different skills <sup>[14]</sup>. In addition, games have demonstrated that they help to enhance motivation in rehabilitation sessions, which is a big issue in treatment sessions due to the repetitive nature of the exercises <sup>[4]</sup>.

The fact that everything takes place in a simulation allows players to develop specific skills <sup>[12][13][14]</sup> and experience situations that are difficult to reproduce in the real world for reasons regarding safety, cost, and time <sup>[14]</sup>. When combined with immersive VR, serious games can easily computationally simulate realistic virtual environments in order to recreate scenes and situations experienced in everyday life <sup>[13]</sup>. These VR based-methods can offer patients immersive experiences that are engaging and rewarding for them <sup>[4]</sup>. The growing diffusion of serious games also expands the advances of VR to society by bringing applications that motivate the assimilation and construction of new concepts in contexts similar to those in the real world <sup>[13]</sup>.

## 3. Schizophrenia Symptomatology

There is recurring evidence substantiating the fact that negative symptoms are apart from positive symptoms. While positive symptoms are often the reason people get diagnosed with the illness, negative symptoms have been reported as among the most common early symptoms of schizophrenia, but they can occur at any phase <sup>[15]</sup>.

In comparison, positive symptomatology is characterized as an excess or distortion of normal function, and it can include, for example, delusions and hallucinations. On the other hand, negative symptomatology is characterized by a decline or absence of normal behaviors and can include a decrease in motivation and interest <sup>[15]</sup>.

In depth, according to Correll et al. <sup>[15]</sup>, the negative domain consists of five symptoms: blunted affect (a diminution in facial expressions), alogia (a decrease in the number of words spoken), avolition (a reduction in goal-oriented activities), asociality (poor relationship management), and anhedonia (a decreased experience of pleasure). This domain can also be subdivided into primary and secondary negative symptoms. However, these symptoms can be hard to distinguish, but recognizing the differences between the two is crucial for clinical trial design, and researchers need to know how to differentiate them. Fundamentally, primary symptoms are the ones intrinsic to the disease, and they usually cannot be managed with the currently available treatments; on the other hand, secondary symptoms are the ones that occur as a result of positive symptoms, affective symptoms, medication side effects, and other related factors <sup>[15]</sup>.

Finally, there is still a medical need for effective pharmacologic therapies to address negative symptoms. Thus, technologically advanced interventions aimed at addressing attitudes, behaviors, and psychosocial functioning can be beneficial when used in conjunction with the available treatments <sup>[15]</sup>.

## 4. VR Game Interventions Description

A total of 11 studies were included in the entry. The studies selected were analyzed according to what researchers considered to be key components in serious games. Some of the selected criteria followed the guidelines proposed in Rego et al. <sup>[16]</sup>.

From the analysis that was carried out, eleven parameters related to the testing trials and to the game therapies were selected for comparison purposes. The classification criteria for those articles include: sample (the number of subjects tested), duration (the duration of game testing in terms of sessions, weeks, and/or months), therapy target (the target skills the game is supposed to improve), interaction (the interaction modality), immersion (whether it is immersive or not), scenery (essentially the game environment, but also the genre and storyline), adaptation (game difficulty settings), progress monitoring (whether or not the system can collect performance data during gameplay), feedback (the game's response to user actions), portability (whether the game therapy can be administered outside of the health facility), and automation (whether or not the game is automated).

### 4.1. Social Skills Training VR (SST-VR) Role-Play

Conversation skills training, assertiveness skills training, and emotion expression skills training are the three types of skills on the basis of which each one of the tasks is chosen to be completed by the patient in role-playing games representing everyday situations. This intervention sample was divided into two groups: one that used immersive VR in the sessions

and the traditional group, which involved just the patient and the therapist role-playing. The main purpose was to find advantages of the use of VR in social rehabilitation compared to the traditional forms of rehabilitation [17].

#### **4.2. VR Vocational Training System (VRVTS)**

The vocational role-playing takes place in a virtual boutique [18]. This scenario was chosen for the study due to the identification of a salesperson as someone who requires social skills to interact with customers and to handle conflicts as well as problem solving skills. In order to level up in their position, the participants had to complete three levels of difficulty, all with a final competence test.

The purpose was to investigate the efficacy and effectiveness of VR for enhancing vocational traits. In this entry, the sample was divided into three training groups: VR, therapist administered, and conventional. Despite only one of these groups being digital-based, the content and structure were similar.

#### **4.3. Virtual City**

Patients and their matched controls completed the same eight individual tasks in the virtual city [19]. Four tasks tested their ability to find different targets around the city, and the other four tested their ability to return to a specific location. This way, the study aimed at developing a VR game to function as a meaningful measure of cognition and complement cognitive tests during clinical trials for schizophrenia treatments.

#### **4.4. Soskitrain**

This VR game consists of seven activities based on chosen targeted social interactions—namely: criticism, social assertiveness, confrontation expression, heterosocial contact, interpersonal warmth, conflict/rejection by parents, interpersonal loss, and positive expression [2]. Thus, the game allows users to practice social interactions with virtual characters, encourages the learning of social skills, and provides feedback on the user's actions. Additionally, in order to assess the performance of the patient, the game uses their committed errors, assertive behaviors, and time as the score.

It aimed at reporting the results achieved with their VR game when it was used to complement schizophrenia interventions, hoping that it would improve the social cognition and performance of patients.

#### **4.5. Virtual Morris Water Maze and Carousel Maze**

This VR game intervention was designed to demonstrate the deficit of spatial cognition in schizophrenia [20]. It contemplates two levels, the Stable arena and the Rotating arena, designed to make users navigate towards several hidden goal positions placed on the floor of the enclosed arenas. The Stable arena had a virtual four-goals navigation task that included finding and remembering certain positions using three orientation cues. The Rotating arena was like the previous one but with two frames—one in which both the arena and the player rotate and another in which there is a static room that moves according to the position of the player.

#### **4.6. VR Vocational Rehabilitation Training Program (VR-VRTP)**

Two workplaces, believed to be more likely to employ people with schizophrenia, were developed: a convenience store and a supermarket [21]. Before entering a specific scenario, patients received training in presenting a good image, including training in greeting posture, smiling, and common verbal greetings. Each trial included practical situations commonly encountered when working on the chosen field of work. The game provided feedback as well as scores to give a sense of accomplishment as the users progressed. Likewise, the VR-based vocational game was built so that schizophrenia patients could learn skills to be applied in a real-life context.

#### **4.7. Serious Game to Improve Cognitive Functions in Schizophrenia**

A virtual city inspired by Paris was developed as the scenery for this serious game [22]. The existing separate places—in locations that could easily be found, such as a bank, a supermarket, a restaurant, a pharmacy, and a park, among others—could be used as visual landmarks to orient their navigation. The patients were expected to cooperate by sharing strategies, solving problems, planning actions, and using the 2D and the 3D map to reach their common goal, depending on the instruction they had to follow. It implements a method that is expected to improve schizophrenia cognitive skills, especially memory, as well as planning and executive functioning tasks.

#### **4.8. Social VR Simulation**

The social interaction of this game consists of two tasks in a fixed order [23]. The first required that participants ask their virtual co-workers for help when handling a new program, while the second required the collection of money to buy a gift for the boss. It was necessary to interact with each one of the five coworkers twice—once to receive neutral/cooperative feedback and another time to receive negative/rejection feedback. Therefore, patients were matched with healthy controls to delineate psychological mechanisms for paranoid ideations and to test psychological interventions against paranoia.

#### 4.9. Virtual Supermarket Shopping Task (vSST)

Each round was divided into two stages: Acquisition, where players were given a shopping list to memorize during a certain amount of time, and Recall, where they were required to randomly pick up items from the supermarket list [24]. There were five consecutive rounds, each with increasing difficulty, as the number of items to memorize and collect increased. Completing the tasks successfully meant not making Intrusion errors, by picking up the wrong item, nor Omission errors, by missing some of the items from the list. The development of this virtual supermarket game is aimed at testing and training the memory and executive functions of patients with schizophrenia.

#### 4.10. Multimodal Adaptive Social Intervention in VR (MASI-VR)

Every game session required the participant to complete twelve social missions [25]. These were ordered by degree of difficulty (four easy, four medium, and four hard), which was determined by the number of conversational inquiries and responses required for mission completion. Once the missions started, the users were free to explore the virtual space and engage with the available avatars. Additionally, the players had to perform social interactions with no negative consequences; in other words, if they selected the wrong response, they would get feedback and the possibility to try again.

In this way, the study examined the feasibility and acceptability of improving social functioning in schizophrenia by making patients start conversations with strangers to ask for information.

#### 4.11. GameChangeVR Therapy

The VR therapy begins in the coach's room, where users meet their virtual automated coach [5]. All levels require the patients to carry out simple tasks such as ordering drinks, finding objects, and speaking to people. As the game progresses, the scenarios of the levels become busier and noisier, displaying anxiety-triggering elements such as Closed Circuit Television (CCTV) cameras, police officers, and people staring or standing in their way. In this way, it intends to test the fearful cognitions of patients while limiting their ability to use safety-seeking behaviors by challenging users to try to do something different.

It describes the process of developing an automated VR game therapy targeting the highly prevalent anxious avoidance of everyday situations by patients, with the use of a virtual coach who explains the psychological principles and guides the patient through the treatment.

**Table 1** illustrates the classification made for the selected VR therapies using the mentioned eleven parameters.

**Table 1.** The selected VR therapies classification.

Game Therapy Name	Authors, Year	Sample	Duration	Therapy Targets	Interaction	Immersion	Scenery	Adaptation	Progress Monitoring
SST-VR <sup>1</sup> Role-play	Park et al., 2011 [17]	91 inpatients from a mental health hospital	10 sessions, twice a week over 5 weeks	Behavioral	HMD, joystick, voice, and motion tracker	Yes	House, shop, and street	--	--
VRVTS <sup>2</sup>	Tsang et al., 2013 [18]	95 inpatients who attended a vocational rehabilitation program	10 sessions, once a week over 5 months, lasting for 30 min	Cognitive	Keyboard, mouse, and joystick	No	Shop	--	--
Virtual City	Zawadzki et al., 2013 [19]	33 patients from a mental health center	1 session	Cognitive	Joystick	No	City	--	Yes
Soskitrain	Calafell et al., 2014 [3]	12 outpatients from an adult mental health service	16 sessions, twice a week over 8 weeks	Behavioral	HMD, voice, and facial recognition	Yes	Shop and bar	--	Yes
Virtual Morris Water Maze and Carousel Maze	Fajnerova et al., 2015 [20]	29 first episode schizophrenia patients	1 session	Cognitive	Joystick	No	Maze	--	--

Game Therapy Name	Authors, Year	Sample	Duration	Therapy Targets	Interaction	Immersion	Scenery	Adaptation	Progress Monitoring
Social VR Simulation	Hesse et al., 2016 <sup>[23]</sup>	26 patients with psychotic disorders	2 sessions in 2 weeks	Cognitive	HMD, joystick, and voice	Yes	Office	--	--
VR-VRTP <sup>3</sup>	Sohn et al., 2016 <sup>[21]</sup>	11 outpatients from a mental health center	8 sessions, once a week over 8 weeks, lasting for 60 min	Behavioral	Keyboard, mouse, and voice	No	Convenience store and supermarket	--	Yes
Serious Game to Improve Cognitive Functions in Schizophrenia	Amado et al., 2016 <sup>[22]</sup>	7 patients with schizophrenia institutionalized for many years	12 sessions, once a week over 3 months, lasting for 90 min	Cognitive	Joystick	No	City	--	--
vSST <sup>4</sup>	Plechata et al., 2017 <sup>[24]</sup>	26 subjects without any neurological or psychiatric diagnosis	1 session	Cognitive	--	--	Supermarket	Configuration	Yes
MASI-VR <sup>5</sup>	Adery et al., 2019 <sup>[25]</sup>	17 outpatients from day facilities	10 sessions, twice a week over 5 weeks	Behavioral	Keyboard and mouse	No	Shop and bus stop	Configuration	Yes
gameChange	Lambe et al., 2020 <sup>[5]</sup>	11 patients with a lived experience of psychosis	6 sessions, lasting for 30 min	Cognitive	HMD	Yes	Shop, street, bar, bus, and doctor's office	Configuration	--

## 5. Conclusions

Currently, VR game therapies seem unable to fully replace traditional face-to-face therapies. However, when combined with regular therapy, VR systems can help to achieve much longer-lasting results and keep patients motivated. The studies reviewed showed improvement in both cognitive and behavioral social skills.

Despite all the recent developments in VR systems, there are still some limitations. For instance, when virtual characters are used to interact with the patient, it is necessary to program their animation in advance, which may restrain their behavior to unrealistic actions. Moreover, patients are always dependent on the required equipment, which can be as simple as a standalone VR headset or as complex as a desktop computer plus two joysticks, a VR headset, and a bunch of cables. When it comes to immersive systems, the required HMD can become a hassle, since it covers about half of the face of the patient, which can prevent a proper evaluation of facial expressions, and when there is a need for cables, these can interfere with the movement and posture of the patient and, consequently, its evaluation. Still, whether the game is immersive or has realistic graphics seems to have little impact on the performance of the patients, as long as they can stay engaged in the activities. Difficulty level adaptation is still either presented in the form of configuration or not presented at all; it would be more helpful if the game was able to adapt to the performance of the player, promoting an efficient learning experience.

Finally, from the obtained results, researchers were able to identify some interesting research opportunities. For instance, no study referenced the use of AI; however, this fast-growing technology has a lot of potential to be used to automate VR systems. In addition, it has been shown that group therapy can be beneficial for patients with anti-social disorders. Furthermore, the development of multiplayer serious games could provide a much better user experience without the need to make use of unnatural character interactions. Instead, they would interact with actual people, which can potentially help them to obtain the expected results faster. The problem of group therapy remains in the form of finding a way to conciliate patients with different illness severities who progress at different velocities. Finally, when verifying whether the selected game therapies had implemented researchers' selected key features, researchers realized that, frequently, those were not present.

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