

Immersive Virtual Reality Serious Games for Schizophrenia Negative Symptomatology

Beatriz Miranda

ADiT-Lab

Instituto Politécnico de Viana do Castelo

Viana do Castelo, Portugal

beatrizmiranda@ipvc.pt

Paula Alexandra Rego

ADiT-Lab

Instituto Politécnico de Viana do Castelo, Viana do Castelo,

Portugal

LIACC, Universidade do Porto, Porto, Portugal

paularego@estg.ipvc.pt

Luís Romero

ADiT-Lab

Instituto Politécnico de Viana do Castelo

Viana do Castelo, Portugal

romero@estg.ipvc.pt

Pedro Miguel Moreira

ADiT-Lab

Instituto Politécnico de Viana do Castelo, Viana do Castelo,

Portugal

LIACC, Universidade do Porto, Porto, Portugal

pmoreira@estg.ipvc.pt

Abstract — Studies have shown that Virtual Reality (VR) games can be used to address negative symptoms of schizophrenia. Yet, while the traditional forms of treatments have been validated for years, treatments that use VR are still quite recent and require a lot of testing and improvement before they achieve the same level of validation. A VR serious game was developed to assess the development, usage and validity of these systems. Twenty-one healthy subjects participated in the trials of the developed game. The positive results obtained reinforce the belief that this type of system has a strong potential as a complement to the current, more traditional, forms of therapy. The application of these kinds of systems may increase substantially the distribution of therapy, as well as decrease its costs, allowing more people to gain access to it.

Keywords — serious games, schizophrenia, virtual environments, virtual reality

I. INTRODUCTION

The use of VR technology in serious games has opened a new frontier in the field of healthcare. VR technology offers immersive and interactive features that have the potential to enhance the effectiveness of healthcare applications [1], particularly in the areas of cognitive-behavioral therapy and rehabilitation [2, 3]. This has made VR a promising approach for addressing a range of mental health conditions and other healthcare-related issues, such as schizophrenia [4, 5, 6]. While this technology has shown great potential for use in healthcare, it is still a relatively new and a developing technology [3, 7]. Therefore, VR treatments still need to be thoroughly tested and validated through clinical trials and other scientific studies to ensure their safety, effectiveness, and suitability for use in a clinical setting [8]. These studies are necessary to establish evidence-based guidelines for the use of VR in healthcare and to ensure that patients receive the best possible care [4].

Schizophrenia is a mental disorder that affects a person's perception of reality, thinking, emotions, and behavior [9]. Its symptoms consist of two main categories, the positive and the negative. While positive symptoms consist of delusions, hallucinations, disordered thinking, and abnormal behaviors that often make it difficult for individuals to distinguish

between what is real and what is not [10], negative symptoms refer to a decrease or loss of normal functions and behaviors that are present in healthy individuals [11]. The latter may include reduced emotional expression, social withdrawal, lack of motivation (avolition), decreased speech output, and a decreased ability to experience pleasure (anhedonia) [10]. Negative symptoms can be particularly debilitating for individuals with schizophrenia, as they can lead to a loss of interest in daily activities, social isolation, and difficulties with employment or academic performance [4, 5]. Negative symptoms can also be challenging to treat, as they are often less responsive to medication than positive symptoms [3]. However, recent research has shown that certain types of psychosocial interventions, such as cognitive-behavioral therapy, can be effective in improving negative symptoms, overall quality of life for individuals with schizophrenia [12] and their psycho-social integration [13].

In this context, the use of VR in serious games for healthcare applications has become an active area of research, aiming to create effective and accessible solutions for patients and professionals. Likewise, this study aims to test the usability of an immersive VR serious game targeted at the treatment of negative symptoms and to study its results to contribute to the validation of the use of this technology in cognitive-behavioral treatments.

The article is organized in the following manner. Section II presents a brief state-of-the-art of existing similar studies. Section III outlines the material and methods used to achieve the study outcomes. Section IV presents the obtained results, while Section V analyses these results. Lastly, in Section VI, significant conclusions are drawn, and potential avenues for future research are proposed.

II. STATE-OF-THE-ART

In terms of related work, numerous studies developed VR games that aim to help patients with schizophrenia to improve their social and functional skills. For instance, in [2] the game makes players act as a salesperson and use their skills to manage a store efficiently. Also, the games have varying scenarios, ranging from a house [6], boutique store, a bus stop, a bar [4], a cafeteria, a grocery store [1], and a

market [11]. The difficulty level of the games increases as the patient progresses [1, 2, 3, 4], and each game has different tasks that aim to improve different social skills, such as facial emotion recognition [3], interacting with customers [2, 3, 11], maintaining a conversation [1, 3, 6], as well as, emotion regulation [6]. Some of them also provide feedback on the patient's performance and allow for better control over challenges and skills to train [2, 3, 4]. In [11], for example, players can check their performance and scores at the end of each game session. Lastly, all of these games aim to improve the patient's social functioning and clinical outcomes in a safe, stress-free, and immersive environment.

In a previous study we made a revision of interventions involving patients with negative symptoms of schizophrenia that use VR games in order to identify relevant features of such games such as: interaction modality, immersion, adaptation, among others. The review showed that VR systems, when combined with regular therapy, can help to achieve much longer-lasting results and keep patients motivated [14].

III. MATERIAL AND METHODS

This study was a single nonrandomized control trial used to assess the usability, efficacy and safety of creating a VR game therapy to be used in the treatment of negative symptoms of schizophrenia.

A. Sample

Twenty-one healthy individuals were included in this early stage of trials. To be accepted subjects had to meet the following inclusion criteria:

- Between 18 and 60 years old;
- Have completed at least middle school;
- Not have a medical history of schizophrenia or any other related mental disorder;
- And be capable of giving written informed consent.

Being a preliminary trial using the first version of the game, the sample could not be the intended target audience, since patients would require it to have been previously tested and approved to assure its safety. Therefore, participants were volunteers who worked and/or studied in fields of interest such as healthcare, computer science and design.

Hence, as described in Table I, subjects were mostly male, with an average age of 27.2 years old and an average of 15.7 years of education, in other words, in average they had completed at least up until a bachelor's degree. Of the twenty-one participants, only two worked in the field of healthcare. The remaining participants were mostly from the field of informatics. And in terms of relevant related experience, the majority of participants claimed to have a high level of computer experience, meaning that they use computers on a daily basis to execute advanced tasks. In the case of experience with VR, the sample was more heterogeneous. About half of the participants said they had never experienced immersive VR, while the other half said they had some or a lot of experience, either experienced it less than five times or above that.

B. Game Description

The developed game consists of an immersive VR simulation game that aims to help patients with avolition regain their independence, by providing them with a

platform to practice basic daily activities such as cooking or cleaning. The game is designed to replicate real-life scenarios and provide patients with a safe and controlled environment to practice their skills. Yet, concepts are simplified, designed to contain enough information so that the player can recognize each interactions one of his daily life, while executing them in a more engaging way.

TABLE I. SAMPLE DESCRIPTION

Gender (females; males)	Age (mean; S.D.)	Education (High School; BSc; MSc; PhD)	Field of work (healthcare; other)	Computer skills (low; medium; high)	VR skills (low; medium; high)
6; 15	26.4; 9.9	10; 8; 1; 2	2; 19	1; 2; 18	10; 7; 4

To start off, players are provided with a brief in-game tutorial that covers the basic mechanics of the game. This tutorial helps patients understand how to interact with the virtual environment and perform different actions such as picking up objects, opening drawers, and turning on appliances.

After completing the tutorial, players are then directed to the kitchen, where they can select either a breakfast or lunch meal to prepare. Fig. 1 displays the kitchen area where most of the game takes place. After choosing their meal, they must follow a series of steps to cook and serve the selected dish. Each step is displayed in a board and the player is instructed to follow them in order. If one step is executed correctly, the step is automatically marked as correct in the board and an affirmative sound is played. These steps are designed to be realistic and progressively more challenging, allowing patients to gradually build their skills and confidence, yet manageable for patients with schizophrenia. The level of difficulty of each task was measured by:

- If the step requires the player to find an object, how easily can it be found;
- The presence of explicit sub-steps within a step description;
- The presence of implicit sub-steps within a step description;

Overall, this immersive VR simulation provides players with a sense of accomplishment as they progress through the cooking process and ultimately serve their finished dish. This sense of achievement can help to build confidence and motivation, which are crucial factors in cognitive-behavioral treatment.

C. Procedures

All trial sessions consisted of an initial introduction to the research, followed by the signature of the written informed consent. While the researcher takes notes on the performance, subjects are prepared to complete the tutorial plus the two game levels, breakfast and lunch in this exact order. Then, subjects completed the survey on the overall user experience (UX). And finally, if the subjects' occupation were related to the field of healthcare, for instance a doctor, they would also complete an interview

about their professional view of the game and the possibility of it being applied in real treatment sessions.

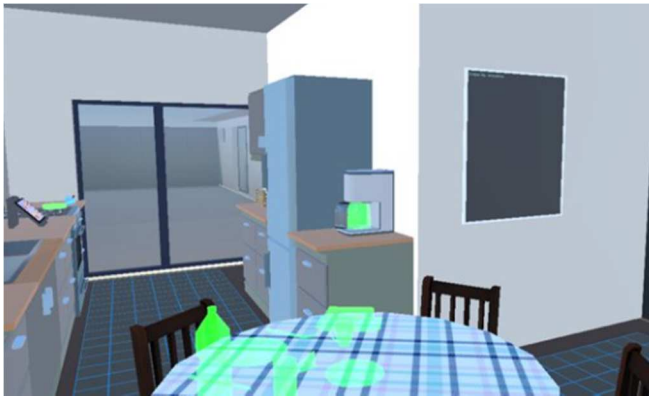


Fig. 1. The main game area - kitchen

D. Instrumentation

1) Immersive VR Game Therapy

To test the game usability, subjects had to complete two Tasks, A and B, consisting of the preparation of two meals, one of easy difficulty and one hard. The difficulty of each Task was measured by how many steps it had and how difficult each step was. The purpose behind the completion of each Task is to see if, the players can understand and do what the game requests, if there was any progress in the participants' skills over time and to see how participants would react to different levels of difficulty. As they completed both Tasks, the researcher recorded the Task completion time, requested assistances, the number of times participants requested help to proceed with the game, mistakes made, the number of times that they struggle to understand what they had to do, errors committed, the number of wrong attempts at completing game actions, and Task efficacy, the percentage of completion of a level.

2) Survey

Also, to test the usability, subjects answered a survey divided into four sections:

- **Personal information:** including information such as gender, age, education and occupation;
- **User Experience (UX):** including ten selected questions related to different game components of interest, such as to get their view on the level of immersivity and difficulty;
- **Satisfaction:** based on the ten questions of the System Usability Scale (SUS) [15] to measure the subject's satisfaction with the system. The resulting score obtained ranges from 0 to 100. To be considered acceptable the system needs to get a score above 71 and above 85, to be considered excellent;
- **Suggestions:** with an optional open answer question for subjects to leave their personal opinion on the game and their suggestions for improvement.

3) Interview

To test the efficacy and safety of the game, an interview was conducted only with the two subjects whose occupation

was in the healthcare field. Although they were not specialized in schizophrenia symptomatology, they both have had contact with schizophrenia patients in the past.

The interview consisted of a conversation with questions aimed at getting their medical opinion on the game about its benefits, difficulty, safety and automation. Thus, those individuals were interviewed on the following subjects:

- Overall opinion on the system;
- System's benefits on cognitive treatments;
- System's level of difficulty;
- Presence of any dangerous component;
- And the need for therapist assistance.

IV. RESULTS

A. Tests

Out of the total number of participants, only four were unable to complete both Tasks successfully, each due to one of several reasons such as exceeding the time limit (set to 20 minutes), giving up during Task B, and encountering a bug in the game. The completion time was on average below 10 minutes in both Tasks which indicates that players did not struggle too much to complete them, taking a reasonable amount of time to complete all the steps required. Table II displays the results for Task A and B side by side.

TABLE II. USABILITY TEST RESULTS

	Task A		Task B	
	Mean	SD	Mean	SD
Task effectiveness	99.0%	4.4%	95.5%	11.6%
Completion time	6 min 47 sec	4 min 10 sec	9 min 14 sec	3 min 49 sec
Errors	2.2	2.2	9.8	7.6
Mistakes	0.8	1.1	2.3	1.2
Assists	1.7	2.4	3.0	3.2

In terms of errors and mistakes, errors were more frequent since they were recorded by the game itself every time a participant attempted an action incorrectly. Mistakes were only taken into account by the test administrator if it was perceived as the participant was confused about how to complete one of the steps of a Task. Hence, the most common errors and mistakes were caused due to struggles to find the correct objects, failed attempts at guessing what the next step would be and difficulty understanding how to complete certain steps. Frequent mistakes would often lead to requests for assistance. As for those, only 8 participants completed Task A without assistance, and only 2 of those participants completed both tasks without assistance. It was speculated that participants would request some assistance while playing, so the low mean number of assistances in Task A and B, shows that the game could be able to guide players well enough that they would not need therapist assistance to play it.

Overall, most participants completed the Tasks easily despite potential struggles caused by bugs, stress, and time constraints. And, even though participant performance results got worse in Task B, it indicated that the Task

presented a bigger challenge to them, as planned. Therefore, the test results were mostly positive.

B. Survey

According to the selected survey responses presented in Table III, it was found that the level of graphic realism in the game might affect how immersive the game felt to the subjects. While it was initially expected that the level of graphic realism would not impact the level of immersion, the responses from the subjects were varied and not unanimous. While some ($n = 6$) agreed that the level of graphic realism did not affect the level of immersion in the game, others ($n = 9$) disagreed and believed that it did. And others ($n = 6$) were neutral about the affirmation, meaning that they felt like the concepts were not dependent on each other.

TABLE III. SURVEY ANSWERS FROM USABILITY TESTING

	UX results ($n = 21$)		
	Disagree	Neutral	Agree
I think the game would feel more immersive if the graphics were more realistic.	6	6	9
I think the game gave me enough tips so that I could understand what I had to do.	0	1	20
I think that Task A was easier to complete than Task B.	4	4	13
I manage to execute the Tasks more efficiently at the end rather than at the beginning of the game.	1	3	17
	SUS results ($n = 21$)		
	Disagree	Neutral	Agree
I think that I would like to use this system frequently.	0	4	17
I think that I would need the support of a technical person to be able to use this system.	19	0	2
I would imagine that most people would learn to use this system very quickly.	0	0	21
I felt very confident using the system.	0	1	20

In addition, Task B was designed to be more challenging than Task A, and most subjects ($n = 13$) agreed with this. However, some subjects ($n = 4$) felt that as they became more skilled in the game, Task B became less challenging. Despite this, the results in Table II showed that the level of difficulty did not decrease, indicating that even though subjects felt more comfortable with the game, they still struggled more as they progressed.

Also, subjects felt confident while playing the game ($n = 21$) and found it engaging and suitable to be played regularly ($n = 17$). The tutorial was found to be helpful enough that players felt that they might not require constant assistance during gameplay ($n = 20$). Even subjects with little to no experience with computer and VR technology were able to quickly learn how to play the game.

Overall, the survey responses were mostly consistent with expectations. Also, the SUS evaluation scored 88.7 out of 100, which is considered an excellent grade.

C. Interview

During the interview, the researcher and healthcare professionals discussed their views on the game. According to the professionals, the game was considered to have a small learning curve while still being engaging and challenging to play. Besides an initial struggle to learn the game controls everything was easy to understand and the need for game assistance was low, especially after playing for a while. They also considered the game beneficial to cognitive-behavioral treatments and of major help for patients' daily life.

In fact, in terms of outcomes, as can be seen in Table IV, they mostly resulted as expected. Subjects agreed that the game shows potential benefits to schizophrenia treatments. They also agreed that there was no component too difficult to understand. And, also agreed that there was no need for a therapist to be always present during gameplay besides at an initial stage, when they are learning to play the game. Only when questioned if there was any potentially dangerous component, one of the participants said that mostly no, but maybe the interaction with hot food (which was made without any kitchen utensils) could lead patients to act the same way in real life, which can have serious repercussions.

TABLE IV. INTERVIEW ANSWERS

Questions	Expected	S1 ^a	S2 ^a
1. Could the game be beneficial to cognitive-behavioral therapy?	Yes	Yes	Yes
2. Was any component too difficult to understand?	No	No	No
3. Was any component potentially dangerous?	No	No	Yes
4. Is the presence of a therapist always necessary?	No	No	No

^a Subject 1 and 2 (S1 and S2) correspond to the two healthcare professionals that participated in the interview

V. DISCUSSION

The study revealed that VR can be utilized as a modern approach for cognitive-behavioral treatments for mental health conditions, including schizophrenia. The immersive feature of VR makes it more engaging, leading to an increase in attendance rate. The use of immersive VR creates a realistic and intuitive way of interacting with games, allowing patients to participate in roleplay in a more natural way. The game's target was to treat negative symptoms of schizophrenia, in particular the symptom of avolition, which significantly affect the daily life of patients. Thus, the portrayal of day-to-day situations, such as daily kitchen activities, was found to be the most effective approach. Additionally, features like tutorials helped players get used to the game mechanics more quickly and independently.

During the testing phase, participants seemed to have enjoyed playing with the prototype, found it easy to play, yet challenging, and understood well what they had to do. These assumptions were validated by survey responses. The analysis of the interview leads to a belief that the serious game developed would be effective and safe to be used in therapy sessions. But it suggests that some alterations should be made to the game actions to assure the patient's complete

safety. The data obtained was then positive and contributed to a clearer understanding that such systems can be used in the treatment of mental health disorders, such as schizophrenia.

Moreover, obtained results build on existing evidence that VR systems can be used as an additional treatment to complement conventional forms of mental health therapy and pharmacological treatments. The validation of these types of systems helps standardize them, make them more effective and make them more suitable to be used as an addition to therapy. Overall, the results of this study suggest that immersive VR-based games have significant potential in the treatment of negative symptoms of schizophrenia.

While this study provides valuable insights into the topic under investigation, there are several limitations that need to be acknowledged. First, the duration of our study was relatively short, and there was only time for one stage of implementation and testing, which limits our ability to draw conclusions about long-term effects and make improvements on what was developed. Second, the sample size of our study was relatively small, which limits the generalizability of our findings to larger populations. Lastly, our study was limited to a specific demographic group, which was not representative of our target group, people diagnosed with schizophrenia. Yet, the sample had healthcare professionals, who can also validate the study. Future studies should aim to include a more diverse sample of patients and healthcare professionals to better understand the generalizability, effectiveness and safety of our findings.

VI. CONCLUSION

To conclude, this study aimed to accelerate the testing, development and adaptation of treatments for schizophrenia using modern technologies, such as immersive VR. By integrating serious games and VR into the treatment of schizophrenia, existing treatment techniques can be updated and automated. As such, these technologies can play a significant role in improving treatment outcomes for individuals with schizophrenia. Ultimately, the integration of technology into schizophrenia treatment could lead to more effective and efficient care for patients.

Furthermore, based on the study's results it is expected a refinement of the developed game, so that it can better represent an actual therapy session in terms of effectiveness. This would also allow for further trials to test the new features and even to test with the target audience, people diagnosed with schizophrenia.

ACKNOWLEDGMENT

This work was funded by the European Regional Development Fund (ERDF) through the Regional Operational Program North 2020, within the scope of Project GreenHealth: Digital strategies in biological assets to improve wellbeing and promote green health, Norte-01-0145-FEDER-000042.

REFERENCES

- [1] L. H. Adery, M. Ichinose, L. J. Torregrossa, J. Wade, H. Nichols, E. Granholm, N. Sarkar and S. Park, "The Acceptability and Feasibility of a Novel Virtual Reality Based Social Skills Training Game for Schizophrenia: Preliminary Findings," *Psychiatry Research* 270, pp. 496-502, 2019.
- [2] M. M. Y. Tsang and D. W. K. Man, "A virtual reality-based vocational training system (VRVTS) for people with schizophrenia in vocational rehabilitation," *Elsevier journal: Schizophrenia Research*, pp. 51-62, 2013.
- [3] M. R. Calafell, J. G. Maldonado and J. R. Sabaté, "A virtual reality-integrated program for improving social skills in patients with schizophrenia: A pilot study," *Journal of Behavior Therapy and Experimental Psychiatry*, pp. 81-89, 2014.
- [4] S. Lambe, I. Knight, T. Kabir, J. West, R. Patelf, R. Lister, L. Rosebroocka, A. Roviraa, B. Garnishf, J. Freemanf, D. M. Clark, F. Waitea and D. Freeman, "Developing an automated VR cognitive treatment for psychosis: gameChange VR therapy," *Journal of Behavioral and Cognitive Therapy*, pp. 33-40, 2020.
- [5] M. H. Lim and D. L. Penn, "Using Digital Technology in the Treatment of Schizophrenia," *Schizophrenia Bulletin*, pp. 1-2, 2018.
- [6] K. Park, J. Ku, S. Choi, H. Jang, J. Park, S. I. Kim and J. Kim, "A virtual reality application in role-plays of social skills training for schizophrenia: A randomized, controlled trial," *Psychiatry research*, pp. 166-172, 2011.
- [7] F. S. Jahn, M. Skovbye, K. Obenhouse, A. E. Jespersen and K. W. Miskowiak, "Cognitive training with fully immersive virtual reality in patients with neurological and psychiatric disorders: A systematic review of randomized controlled trials," *Psychiatry Research*, vol. 300, pp. 1-11, 2021.
- [8] D. Freeman, P. Haselton, J. Freeman, B. Spanlang, S. Kishore, E. Albery, M. Denne, P. Brown, M. Slater and A. Nickless, "Automated psychological therapy using immersive virtual reality for treatment of fear of heights: a single-blind, parallel-group, randomised controlled trial," *Lancet Psychiatry*, vol. 5, pp. 625-632, August 2018.
- [9] M. J. Park, D. J. Kim, U. Lee, E. J. Na and H. J. Jeon, "A Literature Overview of Virtual Reality (VR) in Treatment of Psychiatric Disorders: Recent Advances and Limitations," *Frontiers in Psychiatry*, pp. 1-9, 2019.
- [10] C. U. Correll and N. R. Schooler, "Negative symptoms in schizophrenia: a review and clinical guide for recognition, assessment, and treatment," *Neuropsychiatric disease and treatment*, vol. 16, pp. 519-534, 2020.
- [11] B. K. Sohn, J. Y. Hwang, S. M. Park, J. S. Choi, J. Y. Lee, J. Y. Lee and H. Y. Jung, "Developing a Virtual Reality-Based Vocational Rehabilitation Training Program for Patients with Schizophrenia," *Cyberpsychology, Behavior, and Social Networking*, pp. 686-691, nOVEMBER 2016.
- [12] P. F. Sotos, A. F. Caballero and R. R. Jimenez, "Virtual reality for psychosocial remediation in schizophrenia: a systematic review," *The European Journal of Psychiatry*, pp. 1-10, 2020.
- [13] M. Macedo, A. Marques and C. Queirós, "Virtual reality in assessment and treatment of schizophrenia: a systematic review," *Jornal brasileiro de psiquiatria*, vol. 64, pp. 70-81, 2015.
- [14] B. Miranda, P. A. Rego, L. Romero and P. M. Moreira, "Therapeutic use of VR serious games in the treatment of negative schizophrenia symptoms: a systematic review," *Healthcare*, vol. 10, p. 1497, 2022.
- [15] A. Bangor, P. Kortum and J. Miller, "Determining what individual SUS scores mean: adding an adjective rating scale," *Journal of Usability Studies*, pp. 114-126, 2009.