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## ► To cite this version:

Claudia Krogmeier, Emma Tison, Justin Dillmann, Arnaud Prouzeau, Antoinette Prouteau, et al.. Leveraging Augmented Reality for Understanding Schizophrenia -Design and Evaluation of a Dedicated Educational Tool. ISMAR 2024 - IEEE International Symposium on Mixed and Augmented Reality, Oct 2024, Seattle, United States. hal-04699693

**HAL Id: hal-04699693**

**<https://hal.science/hal-04699693>**

Submitted on 17 Sep 2024

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# Leveraging Augmented Reality for Understanding Schizophrenia - Design and Evaluation of a Dedicated Educational Tool

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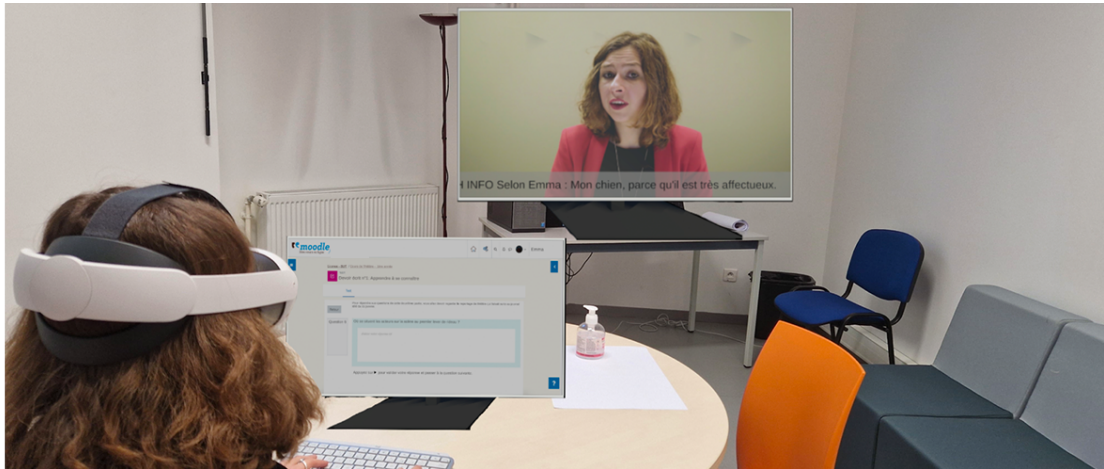


Figure 1: A participant interacting with the homework assignment in the simulation. She sees her responses broadcast on the TV in the background.

## ABSTRACT

Schizophrenia is a serious mental health disorder which may include symptoms such as hallucinations, delusions, and disorganized behavior. In addition to experiencing a diverse symptomatology, individuals with schizophrenia suffer from significant stigmatization which can interfere with effective treatment of the disorder among other issues. As a primary source of stigmatization comes from healthcare professionals, we were motivated to explore new ways in which to educate healthcare students about the symptoms of schizophrenia. Despite its potential to immerse users in new experiences within a real environment, little research concerning the use of augmented reality (AR) to simulate schizophrenia exists. In this paper, we present *Live-It*, a tool designed using recommendations from prior work as well as inspiration from lived experiences to educate mental health students about schizophrenia. The simulation uses the video passthrough capabilities of the Meta Quest 3 headset to simulate delusions, auditory hallucinations and additional symptomatology. Using thematic analysis, we evaluated our simulation with nineteen students and eighteen experts in healthcare to understand its ability to engage users and reliably represent symptoms of the disorder, as well as to determine how best to improve upon the design before the tool is widely deployed in mental health curricula.

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Our findings suggest that participants better understood symptoms of schizophrenia after experiencing the simulation, highlighting the potential of *Live-It* to be used as an educational tool. We present our design, provide a detailed analysis of our findings, and underline next steps in the development of our tool.

**Index Terms:** Human-centered computing, Augmented reality, Simulation, Schizophrenia, Education, Design.

## 1 INTRODUCTION

Affecting 24 million people worldwide, schizophrenia is a serious, chronic mental health disorder characterized by impairments in the individual's perception of reality. Symptoms of schizophrenia may include disorganized thinking and limited emotional expression in addition to psychotic symptoms such as hallucinations and delusions. Considered a significant mental health disorder, schizophrenia additionally affects the individual's social integration, as individuals with schizophrenia often suffer from stigmatization from the general public as well as from healthcare professionals who may not fully understand the disorder's complex symptomatology and the behavior it can elicit [1]. Individuals with schizophrenia are often seen as dangerous and unpredictable, despite only a very small percentage likely to be violent [38]. Such stigmatization may not only harm relationships and decrease opportunities for employment, but can impede timely treatment of the disorder.

One way in which to reduce stigma is through better education about the symptoms. While a standard educational approach may be effective for imparting knowledge about schizophrenia generally, it remains difficult for learners to fully grasp and understand symptoms through third person perspectives. Offering users a first-hand experience, virtual reality (VR) approaches are particularly relevant for schizophrenia education. According to Rodriguez et al (2022), technology-based interventions such as audiovisual simula-

tions [7], VR experiences [41], as well as video games [28, 10] have been generally effective in reducing public stigma towards various mental health disorders [30]. Concerning schizophrenia, previous studies have investigated simulations of auditory hallucinations [5, 9] as well as immersive experiences of schizophrenia using virtual environments [25, 37, 23]. Providing a safe environment in which to experience a variety of situations, VR additionally allows for the potential change of attitudes and beliefs [41] which can accompany learning in immersive, educational environments [24]. Promising results seen with VR simulations of various disorders [20, 32, 42] continue to propel its many applications in mental health. According to Tay et al (2023), AR/VR interventions have been beneficial for improving empathy towards people with mental illnesses as well as increasing knowledge of mental illness [36].

Although previous research has demonstrated the efficacy of VR in eliciting empathy towards stigmatized groups through perspective-taking [21], there exist multiple studies where simulations have also increased participants' desire for social distance from the stigmatized group [5, 30]. This paradox might stem from the intense nature of simulating extreme symptoms, such as visual hallucinations, which can be frightening for participants and inadvertently heighten perceptions of danger associated with schizophrenia. In contrast, social contact interventions—where individuals with mental illness share personal experiences—do not yield similar increases in social distance, suggesting that a more comprehensive representation of symptoms could bridge understanding more effectively [5]. Furthermore, while VR offers deep immersion, it can complicate participants' ability to distinguish between elements of their actual physical surroundings and those representing symptoms, as everything is simulated. In contrast, augmented reality (AR) offers a promising alternative by seamlessly integrating simulated symptoms with the physical world, providing a more grounded experience. Preliminary work by Silva et al. (2017) [34] has employed AR to simulate hallucinations. In this paper, we extend this approach by simulating a wider range of symptoms in AR. This method aims to enhance realism and empathy without increasing social distance, leveraging AR's unique capability to blend simulated experiences with actual physical environments for a more comprehensive educational tool.

In this paper, we present findings from an evaluation of *Live-It*, an AR educational tool for graduate-level healthcare students who may come in contact with individuals with schizophrenia in their future workplace. The name *Live-It* reflects the idea of *living* the experience of schizophrenia, in the hopes that such an experience may enhance understanding of the disorder and the individuals who experience it. This tool was designed in collaboration with an interdisciplinary team of experts in clinical neuropsychology, computer science, and human-computer interaction. We evaluate our simulation design with students and experts in healthcare and describe how themes extracted from related work apply to the design of our simulation. We analyze participant feedback in order to respond to three research questions:

- **RQ1:** Is the simulation able to reliably represent symptoms of schizophrenia?
- **RQ2:** How effective is the AR environment in providing an engaging user experience?
- **RQ3:** What is the potential of this tool to be used for educational purposes?

Our findings indicate that *Live-It* has significant potential to be used as an educational tool for training students (RQ3). Participants indicate that the simulation allows for a better understanding of symptoms and responses these symptoms can elicit (RQ1),

and provide generally positive feedback concerning their experience (RQ2). Based on feedback from participants, we plan to expand upon the simulation to incorporate additional symptoms and allow for a more seamless user experience. Findings from our work may additionally be used to inform future simulations which seek to use immersive technologies to educate users about symptoms across different mental health conditions.

### 1.1 Symptoms Included in *Live-It*

According to work by Prouteau et al (2011), symptoms of schizophrenia can be categorized into three subgroups: positive and negative symptoms as well as symptoms of disorganization [29]. Positive symptoms can include auditory, somatosensory, olfactory or visual hallucinations as well as delusions. Negative symptoms can include physical aenergy (lack of energy), avolition (inability to take action) and anhedonia (inability to feel pleasure), while symptoms of disorganization can include motor inconsistencies [29, 1]. In our simulation, we include several positive and negative symptoms. All symptoms present in the design of the simulation can be seen in Table 3 in Section 5.1.1. Symptoms included in the simulation include auditory hallucinations (hearing voices: Sym1, positive), delusions (fixed beliefs not based on facts: Sym2, positive), theft of thought (feeling that others are stealing your thoughts: Sym3, positive), self-care negligence (inability to take care of oneself: Sym4, negative), physical aenergy (lack of energy: Sym5, negative), and thought broadcasting (feeling that others are reading your thoughts: Sym6, positive). This is described in more detail in Section 3.

## 2 RELATED WORK

In this section, we discuss prior research investigating the simulation of a variety of mental health disorders including schizophrenia and psychosis. We detail previous VR and AR simulations and highlight recommendations from this prior work which have informed the design of the simulation. Similar to Hadjipanayi et al (2020) [20], we considered personal narratives essential in the design of the simulation, as subjectivity of those with lived experience is rarely represented in scientific literature. Therefore, we additionally consulted personal essays, youtube channels, reddit forums, educational material, works of art, blogs, as well as posts across various social media platforms created by individuals with experience of schizophrenia and/or psychosis. We highlight three themes which arise consistently throughout our exploration of both scientific literature and lived experiences, and describe how these are used to inform the design of our simulation. Lastly, we discuss the benefits and potential of using AR as an educational tool for schizophrenia.

### 2.1 Previous Simulations of Schizophrenia and Serious Mental Health Issues

Considering the prominence of stigma towards serious mental health disorders, there exist many simulations which seek to allow participants a better understanding of symptoms through firsthand experience. VR has previously been used to simulate a variety of different experiences such as drug usage [12], dementia [33, 3], Asperger's syndrome [20], being elderly [39], having a hearing [17] or visual impairment [2] as well as multiple other conditions including depression [41] and autism [32]. Perhaps one of the first simulations of schizophrenia was developed by Tichon et al (2003), which made use of an immersive environment with large screens and projectors to simulate visual and auditory hallucinations [37]. Work by Yellowlees et al (2006) designed a simulation of auditory and visual hallucinations using Second Life <sup>1</sup>, a screen-based online VR platform [40], which allowed users to better understand

<sup>1</sup><https://secondlife.com/>

hallucinations. Zare-Bidaky et al (2022) developed a VR 360 video simulation of psychosis in which participants experienced auditory hallucinations and delusions in which a TV appears to be speaking to the participant [42].

Although there exist many simulations of schizophrenia, results concerning stigma are inconclusive across many prior studies. Ando et al (2011) determined that while many simulations of schizophrenia have increased empathy, many have simultaneously increased desire for social distance from individuals with schizophrenia [5]. Kalyanaraman et al (2010) designed a VR simulation using auditory and visual hallucinations with the goal of educating healthcare professionals, and determined that their simulation actually increased participants' desire for social distance [23]. Similarly, work by Stelzmann et al (2021) revealed that stigma towards individuals with schizophrenia increased after viewing a 360 video presented in VR in which a young man tells the story of discovering his symptoms and experiencing schizophrenia throughout his daily life [35]. However, the authors determined that stigma only increased when participants did not find the man likable, whereas the simulation decreased stigma for participants who evaluated the man positively. Mixed results such as these appear to be true even in more recent work such as that by Libera et al (2023), in which users experienced auditory hallucinations within a 360 VR environment [15]. The authors determined that while their simulation increased empathy, it also increased stereotypes. Many previous hallucination simulations have failed to reduce stigma [8] or have had mixed results concerning their effectiveness [27], rendering their usage as a tool to educate users about schizophrenia unclear.

## 2.2 Designing Mental Health Experiences

Considering mixed findings from related studies, there exist multiple recommendations for future work which stem from previous simulations of serious mental health disorders and disabilities. Zare-Bidaky et al (2022) suggest focusing on the entire person who experiences symptoms rather than solely on symptom expression, and stress the importance of providing a neutral rather than dramatic environment, as the latter may unintentionally increase stigma [42]. Likewise, Ando et al (2011) recommend integrating the humanity of the person into the simulation regardless of the nature of symptoms depicted [5]. As increases in stereotypes may result from a better understanding of the limitations and difficulties associated with schizophrenia [15], it may be important to include aspects of hope such as coping strategies in order to show that recovery in the form of active symptom management is possible [17]. Instilling hope may not only counter stereotypes, but may facilitate a focus on the individual and their abilities rather than symptoms alone [8, 30].

## 2.3 Design Inspiration from Lived Experiences

To investigate personal narratives of schizophrenia, we explored multiple well-known social media channels such as Living Well With Schizophrenia<sup>2</sup> and xoradmagical<sup>3</sup>. We viewed material created by PositiveMinders<sup>4</sup>, an international organization which provides free training and resources in order to educate, spread awareness, and make mental health care resources accessible to everyone. Lastly, we explored artwork developed by Martin (2023) in collaboration with individuals with psychosis [26]. Across these various sources, individuals stressed the importance of remembering who they are even on bad days, the need to have and pursue goals, the difficulty taking care of oneself, as well as the desire to lead a meaningful life. In her essay "Recovery as a Journey of the Heart," Patricia Deegan, the creator of the Hearing Distressing

Voices simulation<sup>5</sup>, speaks from her own experience of schizophrenia, stressing the importance of recovery and hope for individuals living with serious mental illnesses [14].

## 2.4 The Need for Reliable Schizophrenia Symptom Representations

Concerning previous simulations of schizophrenia, accuracy of symptom representation is often unclear. While some simulations have used symbolic representations of symptoms such as fighting monsters to represent hallucinations [31], others have lacked sufficient details necessary to understand how symptoms are represented specifically [18]. Therefore, we provide detailed descriptions of all symptoms present in the design of our simulation.

## 2.5 Summary of Design Decisions

We identified three common themes based on recommendations from related work and lived experience of schizophrenia. These are Design Decision 1, DD1) Identity: the importance of showing the individual as an entire person with goals and a narrative. Design Decision 2, DD2) Recovery and Hope: the importance of instilling hope for the individual's situation, and Design Decision 3, DD3) Diverse and Accurate Symptom Representation: the importance of portraying a variety of symptoms as reliably as possible. In Section 3, we describe how these three design decisions are integrated into the simulation.

## 2.6 Using AR to Represent Schizophrenia

Constructivist methods of education, which suggest that students need to experience and feel what is being taught in order to make sense of new knowledge [18], paired with perspective-taking affordances of VR would seem to perfectly position VR to effectively simulate schizophrenia in order to educate students. Yet, mixed results from previous research concerning increases in both empathy and stigma render the efficacy of schizophrenia simulations unclear. Considering such contradictory findings, we were motivated to explore the use of AR as a tool to educate students about schizophrenia. As AR "supplements reality, rather than completely replacing it," [6, p.2] it may also be possible that by creating an experience which unfolds in the real world, participants may more easily be able to internalize and comprehend how new experiences for them are real experiences for other individuals.

## 3 SIMULATION DESIGN

In this section, we provide an overview of the scenario and its implementation. We discuss how design decisions (DD1; Identity, DD2; Recovery, DD3; Diverse symptoms) are applied to the simulation and describe which symptoms of schizophrenia are included in the design. Please see Section 8 for a video of the simulation.

### 3.1 Implementation

The simulation was developed in the Unity game engine and built as a standalone application. Participants wore the Meta Quest 3 VR Head-Mounted Display (HMD)<sup>6</sup> which has a resolution of 2064x2208 pixels per eye and a refresh rate of 120 Hz. We used the MetaXR All-In-One SDK 63.0.0. Participants were seated at a physical table in front of a virtual computer and physical keyboard. Participants used the physical Logitech MX Keys mini blue-tooth AZERTY keyboard<sup>7</sup> to complete a homework assignment displayed on the computer. The video passthrough feature of the headset allowed for the user to see the physical environment while wearing the device. The participant and the virtual computer screen

<sup>2</sup><https://www.youtube.com/@LivingWellwithSchizophrenia>

<sup>3</sup><https://www.youtube.com/@xoradmagical884>

<sup>4</sup><https://positiveminders.com/>

<sup>5</sup><https://www.patdeegan.com/hearing-voices>

<sup>6</sup><https://www.meta.com/fr/en/quest/quest-3/>

<sup>7</sup><https://www.logitech.com/fr-be/products/keyboards/mx-keys-mini.html>

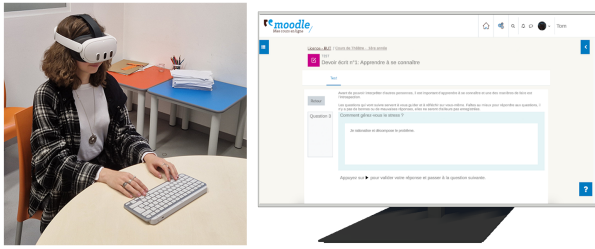


Figure 2: Left: A participant during the study. Right: the virtual computer screen seen within the environment.

can be seen in Figure 2. A virtual television was developed in order to allow for the simulation to be easily transportable. Transportability was essential in order for the simulation to be used as an educational tool within different locations. Using real televisions without the use of a headset would necessitate the need to conduct the training in the same location every time. Moreover, the use of an AR headset allows for a more scalable set-up as opposed to one which relies on a physical environment.

The television was positioned on a physical table in the background of the environment. Auditory hallucinations played through the HMD's speakers. Before the experiment, the researcher established the size and placement for both the computer and television within the real environment using the Meta Quest 3 controllers. These settings were locked and saved using Oculus spatial anchors, allowing for both the computer screen and the television to remain in place across all participant sessions. AR spatial anchors were placed in reference to the headset. Source code for the simulation can be found here <https://github.com/bivwacInria/LiveIt.git>

### 3.2 Scenario

In the simulation, users complete a homework assignment displayed on the virtual computer while a virtual television plays in the background. The homework assignment, auditory hallucinations, and TV broadcast all contribute to the narrative basis of acting. This narrative was selected as it allows ample opportunity for incorporating ideas of being watched and being famous, two common delusions in schizophrenia. Additionally, this narrative was developed in order to give the participant the identity of a theater student with the goal of completing a related homework assignment (DD1; Identity). Titled "Getting to Know Yourself, Introduction to Acting," the assignment follows a free response format in which the user responds to questions such "How do you manage stress?" A view of the environment can be seen in Figure 1.

Our study involved a pretesting phase which was conducted in order to ensure that the simulation effectively elicited anxiety without being overly distressing, as simulations which are too distressing can be harmful [17] and may elicit reactive responses from users. Pretesting was conducted with a small group of participants who were prompted to comment on the simulation's emotional nature. Through these conversations, we determined that the simulation made participants feel anxious and interested in the experience of individuals with schizophrenia. The pretest indicated its current duration of 8 minutes was appropriate for an evaluation of the simulation, and would be an appropriate duration for use in an educational setting. No participant thought the simulation was upsetting or distressing.

### 3.3 Symptoms Represented within Auditory Hallucinations

Auditory hallucinations were developed based on descriptions from individuals with lived experience of schizophrenia as described in

Section 2.3, and were verified by experts in neuropsychology. During the simulation, five different voices (Sym1) comment on the user's inability to concentrate, mocking the user for being unable to finish their work and instructing them to look at the television. Both derogatory statements such as "She always fails," and less negative statements such as "She just needs to rest," are included. Multiple statements suggest that the user is being watched and observed, and that their thoughts could be recorded by an unknown group (Sym3), while others such as "She's the best actress the world has ever seen," allude to delusions of grandeur (Sym2). Statements such as "She really needs a shower" suggest an inability to take care of themselves (Sym4). "She is too tired to concentrate," and similar statements allude to lack of energy (Sym5). At the end of the stimulation, the voices instead highlight the fact that recovery is possible with statements such as "Think of the future" (DD2; recovery) as individuals with lived experience additionally stress the importance of remembering one's identity on bad days (DD1; identity). We included both positive symptoms, and negative symptoms using auditory hallucinations (DD3; diverse symptoms). The voices were recorded by the researchers in a soundproof chamber. Volunteers at Inria were recruited as voice actors, and were directed by experts in neuropsychology and filmmaking.

### 3.4 Symptoms Represented Using the Television

The virtual television present in the background of the environment plays three different broadcasts throughout the simulation, beginning with a report about birds while the user familiarizes themselves with the task. Next, a daily news report plays, providing an overview of current events. Throughout this broadcast, the news reporter emphasizes certain statements such as "Pay attention, while driving in this weather," which, while subtle, correspond to voices which mock the user's difficulty concentrating. A scrolling banner at the bottom of the television includes expected information such as "Watch out for black ice," as well as statements such as "We're watching you" (Sym2).

In order to simulate thought broadcasting, or the fixed belief that one's thoughts can be read by others, some of the user's responses to the homework assignment were broadcast on the scrolling banner of the TV screen (Sym6). The third broadcast depicts a rehearsal for a play, and includes footage of actors looking directly into the camera and moving across the stage in slow motion, making this broadcast appear dream-like and unnerving. The broadcasts can be seen in Figures 3 and 4. The news report was filmed by the researchers, while the following reports on birds and the theater rehearsal were edited from footage available at [pexels.com](https://pexels.com)<sup>8</sup>, which was free to use and modify without attribution.

## 4 EVALUATION

### 4.1 Participants and Procedure

We evaluated the simulation with nineteen graduate students in Neuropsychology (12) and Psychology (7) programs (Age range 21-31, M=25; 12 Female, 4 Male, 3 Other), and eighteen experts in healthcare (Age range 28-53, M=39; 12 Female, 6 Male) which included nurses (4), one social worker, occupational therapists (5), one psychologist, medical secretaries (3) and neuropsychologists (2). The simulation was additionally evaluated by two professional peer helpers, professionals who use their personal experience of mental health disorders to assist others in their recovery journey. We wanted to include both future users of the tool (students) as well as participants who could comment on the accuracy of symptom representation (experts) in order to represent both groups in our study. A majority of both students and experts reported limited prior experience using VR/AR technology. In total, 37 participants

<sup>8</sup><https://www.pexels.com/>

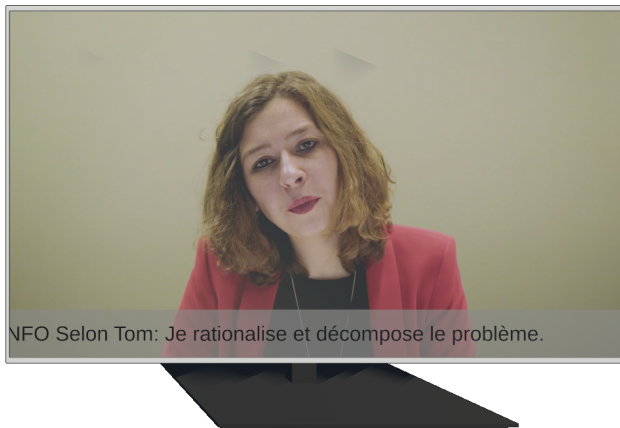


Figure 3: The news report the participant sees on the television. The scrolling banner shows a participant's response to the question: *How do you deal with stress?* The response reads: *According to Tom, I rationalize and break down the problem.*

took part in our study. The gender distribution in the study is representative of both mental health students and mental health professionals [16]. The age distribution is indicative of both the age of mental health professionals [16], as well as the age of Master's level students in France according to the French Ministry of Higher Education and Research in 2023.

Our study received ethics approval from Inria's ethics review board. The researcher instructed participants to respond to homework assignment questions they would see on a virtual screen in front of them using the physical keyboard. The researcher also informed participants of the TV's presence in the environment. Participants were told they would experience symptoms of schizophrenia, and that they could end their participation at any time. The researcher then fitted the headset to the participant and started the application which began with an introductory screen on the virtual computer. Participants first selected their pronouns and entered their name using the keyboard. In this way, hallucinations which spoke about the participant in third person were matched to the participant, and the participant's name was seen at the top of the homework assignment on the screen, allowing for a more personalized experience. After participants entered their name and pronouns, participants experienced the 8 minute simulation in which they responded to a homework assignment. After eight minutes, the simulation terminated. Once the simulation terminated, the researcher helped the participant remove the headset. The participant then filled out the questionnaire. All participants completed the entire experiment. TV assets were downloaded from the Unity asset store, while all other elements of the simulation were developed by the team, including the functionality of the keyboard and the introductory screen where the participant enters their name and pronouns. The Unity scene size was 105 Kb.

## 4.2 Methodology

The questionnaire that participants filled out after the simulation was designed to probe a variety of topics in order to respond to our three primary research questions and gain additional feedback about the experience. We explored symptom recognition, usability, personal attitudes, feelings of surveillance and anxiety as well as feedback concerning the homework assignment and television in the environment among other variables. In addition to free response questions, we explored certain variables using Likert scales. Immersion in AR was measured using questions inspired from work by Georgiou et al (2017) [19], while AR simulator sickness was

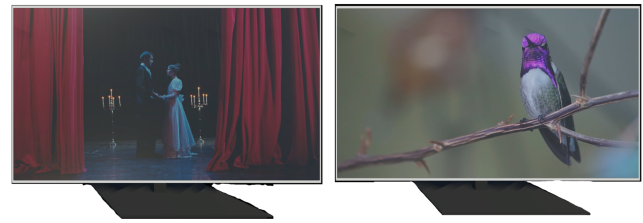


Figure 4: Two additional news reports that the participant sees during the simulation. The left screen shows the play rehearsal while the right screen shows the report on birds.

measured using the questionnaire designed by Hussain et al (2023) [22]. To evaluate the potential of our simulation as an educational tool, we investigated utility, feasibility, and accessibility of the simulation using free response questions inspired by work by Chen (2010) which explored the evaluation of programs related to health promotion and social improvement [11]. Our questionnaire can be found in our Supplementary Materials (Section 8).

Analysis of free response questions was inspired by the six-step guidelines for thematic analysis from Braun and Clarke (2017) [13]. The goal of thematic analysis is to find repeated patterns of meaning within a dataset through a process of searching, combination of important data features, and identification of themes. According to Braun and Clark (2017), "a theme captures something important about the data in relation to the research question..." [13, p.82]. In order to identify patterns in participant feedback, we first started by familiarizing ourselves with the data through repeated readings (step 1). Next, we generated codes for segments of data in order to extract features from the data (step 2). Extracts were tagged as either "Student" (S) or "Expert" (E) feedback. We then identified patterns, and combined codes in order to generate themes (step 3).

At this stage, we had four themes. We reviewed these four themes (step 4) and decided to merge "Advantages of the Simulation" and "Current Issues" into one theme called "The User Experience," as the two themes alone did not have enough content to be supported individually. We then defined and named the three final themes (step 5): 1) Fidelity of Symptoms through Embodied Knowledge, 2) The User Experience, and 3) Implications for Healthcare. Lastly (step 6), we selected examples for each theme and produced a report of the analysis.

## 5 RESULTS

In this section, we report results from our thematic analysis. Following the thematic analysis, we report relevant descriptive statistics in a separate section. All quotations have been translated to English. Responses from a total of 37 participants were included in the thematic analysis. Each participant responded to twelve open response questions, for a total of 444 questions possible (37 x 12). With an 80% response rate, 359 responses were available for analysis.

### 5.1 Fidelity of Symptoms through Embodied Knowledge

Although information about schizophrenia and its diverse symptomatology exists in textbooks and in the classroom, there is a difference between being able to imagine symptoms versus being able to experience them personally. E18 explains that the simulation "allows you to embody what you already know but only on an intellectual level," which is echoed by S17, who mentions the simulation as: "a real bonus in terms of understanding disorders... it illustrates much better than descriptions." Specifically,

experiencing symptoms of schizophrenia from a first person perspective contributes to making information about the disorder feel more real. Many participants stated that the first person experience enhanced their ability “to be able to feel the effects of the disorder” (S8). “Having a foothold in the real...” (S1) and “Experiencing things from a different point of view,” (S9) contributes to “a different approach and different view of what patients may be going through.” (E8). Concerning the fidelity of symptoms included in the simulation, E5 stressed how the simulation upheld what patients have reported, stating “...I was also very impressed by the fact that the simulation brought back elements that had already been described by the people I worked with.” E1, a professional peer helper, confirms that the simulation “brought me back to the idea that I myself can have parasitic ideas.”

Being able to experience the reality of symptoms from a first person perspective may additionally allow for a better understanding of the behaviors these symptoms can elicit. E12 specifically mentions the interest of “being able to put yourself in someone else’s shoes to understand and grasp certain behaviors and reactions.” E18 also reflects on the impact of symptoms on thoughts and behavior, stating “[The simulation] was relatively close to what I imagined would be the experience of someone suffering [from schizophrenia], but I could embody and understand how much it impacted me (mainly concentration, but also ideas, thoughts, etc).” Embodiment of such knowledge can influence thoughts about the disorder, making typically intellectual knowledge more personally relatable.

### 5.1.1 Understanding the Impact of Auditory Hallucinations

Concerning auditory hallucinations, participants expressed a better understanding of the difficulties and feelings which can be elicited in response. S14 states that the experience “allows me to get closer to what people are going through, it gives me a better understanding of how people can be bothered when voices become intrusive,” citing voices as a primary cause of lack of concentration, while S19 states that “we underestimate the cost of continuously divided attention...” Participants further reflected on the impact that symptoms could have on individuals with schizophrenia, mentioning the “discomfort experienced in daily life” (E3) and “the cognitive load that people can go through to ignore hallucinations” (S2).

### 5.1.2 Design Effectively Simulates Ideas of Delusion

Multiple aspects of the simulation design effectively allowed participants to feel as though they were being watched and observed, a common delusion in schizophrenia. Participants described feelings of both anxiety and surveillance that they experienced during the simulation. Hearing voices was particularly anxiety-inducing for participants, especially voices which attacked self-esteem (S18), were negative (E9) and (S5) “said I was going too slow [with the task.]” Many participants specifically reported that seeing their responses to the homework assignment broadcast on TV was disturbing (S5, S6, E3, E13), surprising (S7, E14, E17, E18), and generated feelings of being watched. S3 states that seeing their responses on TV “[gave] the impression that they were reading in real time what [I was] thinking.” S5 states “I ignored the television a little while I was answering the questions. But then I saw one of my answers on the screen and it was a bit disturbing, as if everyone could see my answers,” while S17 states “the most anxiety-provoking part was seeing your own answers broadcast “publicly” on a TV screen.”

## 5.2 The User Experience

Participants provided positive feedback on their experience during the simulation, and reported feeling both positive and negative emotions. Participants described the simulation as interesting (S1, S7, S8, S9, S16, S18, E12), immersive (S10, S17, E16), fun (S16, E6), intriguing (S17), engaging (S19), motivating (S19), enriching

(E5), enjoyable (E16), and as one that awakens curiosity for what could happen next (S19). Considering the design of the simulation, the experience was also considered stressful (E1, E10, S14), anxiety-inducing (S11, S5, S9, S16), overwhelming (S15), and disturbing/unsettling (E9, S1, E1, E9), in general indicating a dynamic user experience by design. Participants highlighted both the realism of the simulation, as well as difficulties associated with completing the task as contributing factors in their user experience. In total, 22 participants reported feeling watched during the simulation.

### 5.2.1 Realism of the Simulation

Many participants considered their experience in the simulation realistic. Voices were considered especially realistic (S5), and real enough to cause stress at times (S14). S3 mentions specifically that it “really felt like the voices were in my head.” While the TV was generally perceived as less disturbing than the voices, it effectively induced anxiety and feelings of surveillance as mentioned previously. Concerning the realism of the TV, many participants were satisfied, stating “the TV news was well done,” (S3), “the image was very clear,” and that “it simulated a newscast quite well” (S17). However, certain aspects of the simulation contributed to a lower sense of realism. For example, two participants did not recognize the TV in the environment as a television (S2, S11).

### 5.2.2 Difficulties from the Simulation

Participants indicated that difficulty in completing the homework assignment was due to both design of the simulation and perceived issues with the AR environment. The homework assignment was primarily considered difficult as hearing voices made it hard to concentrate. Negative, intrusive auditory hallucinations in combination with the reflective nature of the homework assignment made the task especially difficult for certain participants. Issues related to the AR environment also contributed to task difficulty. In particular, participants reported blurry vision (S3, S15, S16, S19), difficulty using the keyboard (S11), as well as heaviness of the headset (E14). Certain participants did not appreciate the homework assignment, considering the task uninteresting. S14 suggests “[placing] the person in a context that makes more sense in terms of the task to be performed, so as to perceive a minimum of interest.” However, S18 notes “it’s good to ask about the things you’re bad at. It makes sense and reinforces the impact of hallucinations.”

## 5.3 Implications for Healthcare

Having a first person experience of schizophrenia in which participants can feel the impact of the symptoms in a real way may help reduce stigma in healthcare professions. S1 mentions that the simulation helps to “objectify what is happening in people with [schizophrenia].” Being able to experience schizophrenia in this way shows promise for reducing judgement from healthcare professionals. E5 explains that the simulation may “enable healthcare professionals to stop thinking that people do things on purpose (e.g. forget an appointment)...[and] understand the level of fatigue felt by people who experience [these symptoms] on a daily basis.” Participants expressed enthusiasm at the simulation’s potential to educate and sensitize people about the disorder. S10 describes the simulation as having “very good immersion, it’s a great tool for raising awareness of the symptoms of schizophrenia.”

### 5.3.1 Reducing Stigma

A better understanding of symptoms and their behavioral consequences could additionally reduce negative biases and stereotypes towards patients with schizophrenia. S17 states specifically that the simulation could be useful for “[reducing] the prejudice that patients “exaggerate” their disorders or don’t make enough effort to do things/get better.” The simulation may also be useful for reducing stigma associated with violence. S18 highlights a potential

Facilitators	# Participants
Quick	15
Few Resources/Simple/Easy Usage	11
Playful	10
Modern/New	5
Useful for Training	4
Transportable	4
Clinical Implications/Practical	3
Facilitates Understanding	3
Triggers/Responds to Curiosity	2

Table 1: Facilitators to Implementation as Training Tool

reduction in “stereotyped beliefs specific to the dangerousness of individuals,” while E3 further underlines the potential of the simulation “to reduce the stigma attached to psychiatry in general, since it is often associated with schizophrenia and dangerous people.” The simulation “allows for empathy” (E9) and could play a significant role in improving training for both healthcare professionals and students. E5 describes it as “very relevant for better understanding [symptoms] and for adjusting [our approach] as health professionals.”

Obstacles	# Participants
Cost/Material	21
Time Required to Run Simulation	9
Interest in Subject	4
Willingness of Institution	4
Personnel Training	3
AR Reluctance/Difficulty	2
Anxiety	2

Table 2: Obstacles to Implementation as Training Tool

### 5.3.2 Obstacles and Facilitators to Feasibility

Participants were asked to list both obstacles and facilitators concerning feasibility of the simulation’s implementation as an educational training tool in an academic setting. These responses are provided in Table 1 and Table 2. Concerning perceived usefulness of the simulation, participants underlined first person understanding of symptoms, ability to educate and sensitize the public, and potential to reduce stigma as primary contributors. Concerning accessibility, participants primarily mentioned fear, anxiety, stereotypes and false beliefs as reasons that students might refuse to participate in the simulation. Participants expressed different opinions concerning the utility of AR for simulating schizophrenia. While E15 highlighted the fact that AR “allows you to experiment with exceptional situations without risk,” S10 expressed concern, stating that AR “.. is innovative, but I think that the enthusiasm generated by testing it may affect awareness of the experience of a person with schizophrenia.”

## 5.4 Descriptive Statistics

In this section, we report relevant descriptive statistics which may further inform themes identified in our thematic analysis.

### 5.4.1 AR Simulator Sickness & Immersion

While a majority of participants reported low levels of AR simulator sickness, seven mentioned moderate to high levels which included ocular fatigue and general discomfort. Participants were asked to assess their levels of immersion during the simulation using two seven-point Likert scales. The first scale ranged from a fictitious activity (1) to a completely real activity (7) for which participants reported ( $M = 4.46; SD = 2.03$ ). The second scale ranged from something I was doing (1) to something I was experiencing (7) [19], for which participants reported ( $M = 4.78; SD = 1.40$ ).

### 5.4.2 Feasibility, Utility, Accessibility

Participants used seven-point Likert scales to rate feasibility, utility and accessibility [11] of the simulation as an educational tool. Specifically, participants rated how useful they thought the tool might be for reducing stereotypes towards individuals with schizophrenia ( $M = 5.59, SD = 1.57, Range : 1 - 7$ ), reducing negative emotions such as fear and anxiety towards these individuals ( $M = 5.43, SD = 1.52, Range : 1 - 7$ ), and reinforcing positive emotions such as compassion and serenity ( $M = 6.00, SD = 0.97, Range : 3 - 7$ ). Participants also rated how useful the tool could be for reducing discriminatory behavior towards people with schizophrenia ( $M = 5.30, SD = 1.41, Range : 1 - 6$ ), and if the tool could be useful for improving support for people with schizophrenia ( $M = 6.05, SD = 1.15, Range : 2 - 7$ ). Lastly, participants rated feasibility of the simulation to be implemented in an academic setting ( $M = 5.92, SD = 0.89, Range : 4 - 7$ ) and accessibility concerning the ability of students to become involved with the simulation ( $M = 6.24, SD = 1.14, Range : 1 - 7$ ).

### 5.4.3 Understanding Symptoms of Schizophrenia

Using two seven-point Likert scales, participants were asked to rate both if they felt they better understood symptoms of schizophrenia, as well as if they better understood what individuals with schizophrenia may experience. As questions for professional peer helpers were different, we report these statistics separately. Participants reported a mean score of  $5.56 (SD = 1.16)$  for understanding symptoms, indicating a high level of understanding. For understanding the experience of individuals with schizophrenia, the mean score was slightly higher at  $5.85 (SD = 0.99)$ .

Professional peer helpers (2) responded to similar questions with slightly different wording: *Does what you experienced in the simulation correspond to what a person suffering from schizophrenia might experience in everyday life 1) ...concerning the symptoms? and 2) ...concerning emotions/sensations?* In terms of symptoms, professional peer helpers rated 6 and 7 on a seven-point scale, indicating significant correspondence between symptoms depicted in the simulation and symptoms experienced by individuals with schizophrenia. In terms of emotions/sensations, professional peer helpers rated 4 and 6 on a seven-point scale, indicating medium to high correspondence between emotions/sensations in the simulation and those which can be experienced by individuals with schizophrenia.

### 5.4.4 Recognizing Symptoms of Schizophrenia

Participants were asked to list symptoms of schizophrenia that they recognized in the simulation. These can be seen in Table 3.

ID	Symptom	# Participants
Sym1	Auditory Hallucinations	36
Sym2	Delusions	16
Sym3	Theft of Thought	2
Sym4	Self-Care Negligence	1
Sym5	Physical Aenergy	0
Sym6	Thought Broadcasting	0

Table 3: This table shows all symptoms included in the design, and how many participants recognized these symptoms in the simulation.

Participants also reported associated features such as anxiety (2 participants), negative thoughts (2), self-deprecation (7), paranoia (3) and cognitive issues (5) as symptoms. Although these are not considered symptoms in and of themselves, many of these aspects were intentionally included in the design of the simulation. Additionally, participants reported feelings of influence (3), and visual hallucinations (18), which are both symptoms of schizophrenia, but were not intentionally included in the design of the simulation.



## 6 DISCUSSION

We designed and evaluated *Live-It*, an AR educational tool to teach students about schizophrenia. Nineteen students and eighteen experts in healthcare took part in the study and provided feedback. Our results suggest that *Live-It* allows for first person, embodied knowledge of schizophrenia which can help participants better understand how symptoms may influence feelings and behaviors.

### 6.1 First Person Understanding of Symptoms

Being able to experience symptoms from a first person perspective allowed them to feel real and personally relatable for participants. Participants recognized many symptoms present in the design of the simulation, highlighting its ability to allow for a glimpse into the reality of an individual with schizophrenia. Concerning the reliability of the simulation to represent symptoms of schizophrenia (RQ1), our findings are encouraging. Almost half of the participants recognized delusions, and 22 participants reported that they felt they were being watched at some point during the simulation. Participants also self-reported that they were generally better able to understand both symptoms and experiences lived by individuals with schizophrenia. Additionally, professional peer helpers reported that the symptoms depicted in the simulation corresponded well with symptoms of schizophrenia.

Concerning theft of thought, self-care negligence, physical aenrgy, and thought broadcasting, few to no participants recognized these as symptoms in the simulation. Although thought broadcasting was not reported, one participant specifically alludes to this symptom as they describe their experience “*the [phrases on TV] gave me the feeling that I was being watched and listened to more than I was. It worried me that I had been “betrayed” and that my answers were in fact being recorded and read*” (S18).

One important aspect of the tool which may have contributed to the impression of experiencing symptoms is the personalization of the simulation. This approach, inspired by experiences such as the VR application *Goliath: Playing with Reality*<sup>9</sup>, in which a recording of users’ names is used in the experience, suggests that a deeper connection to the narrative can be forged through personalized content. In future work, we would like to further explore the role of personalization within the simulation.

### 6.2 An Engaging Experience

Participants commented on the realism of the experience and reported relatively high levels of immersion, overall providing for an engaging user experience (RQ2). Although AR simulator sickness was overall very low, we plan to investigate ways in which to improve the AR environment in order to further decrease discomfort and increase immersion. Considering most participants had limited experience with this sort of technology, it is possible that an uncontrolled novelty effect of the experience contributed significantly to the engagement or enjoyment of the simulation [4].

Participants indicated that realism of the simulation intensified their sensation of being under surveillance. Key elements contributing to this effect included hearing voices and the broadcasting of homework responses on TV within the simulation. The portrayal of these elements in a realistic manner, especially the TV acting as a central medium for creating a sense of observation and anxiety, was particularly impactful. The authenticity of the news report, the nature of the homework assignment, and the disembodied voices were highlighted as factors that not only disrupted participants’ concentration but deepened their experience of being monitored.

Furthermore, we decided to use AR instead of VR for this simulation in order to provide a more grounded experience with the physical world. AR’s unique ability to blend digital elements

<sup>9</sup><https://about.meta.com/community/vr-for-good/goliath-playing-with-reality/>

with physical spaces might significantly affect the participant’s immersion and emotional responses, potentially differing from those elicited by fully immersive VR environments. However, a blending not well done may decrease the realism of the simulation, perhaps even provoking feelings related to the uncanny valley effect. Therefore, investigating differences in how AR and VR enhance usability and realism is a compelling direction for future work.

### 6.3 A Tool for Schizophrenia Education

Participants reported the potential of the tool to be used in healthcare settings to reduce stereotypes and prejudice towards patients, mentioning the short duration, transportability, and simplicity of the simulation as key points which could facilitate its use for training. Specifically, participants indicated a high potential of the tool to reduce discriminatory behaviors and increase support for individuals with schizophrenia. Therefore, our findings support the potential of the tool to be used for educational purposes (RQ3).

Our system differs from previous VR simulations of schizophrenia by focusing specifically on training. To the best of our knowledge, only one simulation of schizophrenia has previously explored the use of AR. Our work also differs from previous studies by simulating a broader range of schizophrenia symptoms and employing a participative methodology with expert feedback. *Live-It* thus adds to the body of knowledge on simulating schizophrenia symptoms using creative technologies like AR. Considering the novelty of this approach, it was crucial for us to first investigate the research space and assess the suitability of our system as a training tool before directly addressing stigma. Having conducted an evaluation of the system to examine the user experience and the tool’s potential to enhance understanding of diverse symptomatology, we will conduct additional studies specifically targeting stigma in the future.

## 7 CONCLUSION

We designed an AR simulation of schizophrenia and evaluated it with healthcare students and experts. Through embodied knowledge of schizophrenia, *Live-It* allows for a real way in which to experience symptoms through a first person perspective. Participants reported that *Live-It* not only has significant potential as a tool to educate about schizophrenia, but also to reduce stigma in healthcare. We plan to expand upon the simulation, incorporating additional symptoms and exploring new methods to represent symptoms which were not recognized. We will investigate the usage of eye gaze data and facial tracking in our future work as well, as metrics such as these may better inform how visual cues, such as homework responses broadcast on TV, play a role in eliciting feelings of surveillance. As technology continues to improve, we will examine the potential of using a different headset which may not only be more comfortable but allow for higher resolution video passthrough. We hope that the design and evaluation of our tool will generate ideas for other researchers seeking to use immersive technologies to simulate experiences that are difficult to imagine and, therefore, understand.

## 8 SUPPLEMENTARY MATERIAL

Supplementary files can be found at the following link [https://osf.io/7myxq/?view\\_only=e9da009e3155499982ccb7cf94ae11bf](https://osf.io/7myxq/?view_only=e9da009e3155499982ccb7cf94ae11bf).

## REFERENCES

- [1] Schizophrenia. <https://www.who.int/en/news-room/fact-sheets/detail/schizophrenia>. Accessed: 2024-01-31.
- [2] R. Addison. Detour: brain deconstruction ahead. *IEEE computer graphics and applications*, 15(2):14–17, 1995.
- [3] A. Adefila, S. Graham, L. Clouder, P. Bluteau, and S. Ball. myshoes—the future of experiential dementia training? *The Journal of Mental*

- Health Training, Education and Practice*, 11(2):91–101, 2016. doi: 10.1108/JMHTEP-10-2015-0048
- [4] M. Akçayır and G. Akçayır. Advantages and challenges associated with augmented reality for education: A systematic review of the literature. *Educational research review*, 20:1–11, 2017. doi: 10.1016/j.edurev.2016.11.002
- [5] S. Ando, S. Clement, E. A. Barley, and G. Thornicroft. The simulation of hallucinations to reduce the stigma of schizophrenia: a systematic review. *Schizophrenia Research*, 133(1-3):8–16, 2011. doi: 10.1016/j.schres.2011.09.011
- [6] R. T. Azuma. A survey of augmented reality. *Presence: teleoperators & virtual environments*, 6(4):355–385, 1997.
- [7] S. Brown. The effectiveness of two potential mass media interventions on stigma: video-recorded social contact and audio/visual simulations. *Community mental health journal*, 56(3):471–477, 2020. doi: 10.1007/s10597-019-00503-8
- [8] S. A. Brown. Do simulations of psychosis lower stigma toward individuals with schizophrenia? a randomized controlled trial. *Psychiatry Research Communications*, 1(1):100001, 2021. doi: 10.1016/j.psycom.2021.100001
- [9] S. A. Brown, Y. Evans, K. Espenschiede, and M. O'Connor. An examination of two brief stigma reduction strategies: filmed personal contact and hallucination simulations. *Community mental health journal*, 46:494–499, 2010. doi: 10.1007/s10597-010-9309-1
- [10] A. J. Cangas, N. Navarro, J. M. Parra, J. J. Ojeda, D. Cangas, J. A. Piedra, and J. Gallego. Stigma-stop: a serious game against the stigma toward mental health in educational settings. *Frontiers in psychology*, 8:1385, 2017. doi: 10.3389/fpsyg.2017.01385
- [11] H. T. Chen. The bottom-up approach to integrative validity: a new perspective for program evaluation. *Evaluation and program planning*, 33(3):205–214, 2010. doi: 10.1016/j.evalprogplan.2009.10.002
- [12] M. Christofi, D. Michael-Grigoriou, and C. Kyrlitsias. A virtual reality simulation of drug users' everyday life: the effect of supported sensorimotor contingencies on empathy. *Frontiers in psychology*, 11:1242, 2020. doi: 10.3389/fpsyg.2020.01242
- [13] V. Clarke and V. Braun. Thematic analysis. *The journal of positive psychology*, 12(3):297–298, 2017. doi: 10.1191/1478088706qp063oa
- [14] P. Deegan. Recovery as a journey of the heart. *Psychiatric rehabilitation journal*, 19(3):91, 1996. doi: 10.1037/h0101301
- [15] C. Della Libera, M. Goosse, F. Larøi, and S. Willems. Examining the impact of experiencing auditory verbal hallucinations from a first-person perspective on the degree of empathy and stigmatization in a group of psychology students: A study using 360° immersive videos. *Comprehensive Psychiatry*, 123:152379, 2023. doi: 10.1016/j.compsych.2023.152379
- [16] d. l. e. d. s. DREES Direction de la recherche, des études. Démographie des professionnels de santé. 2021.
- [17] L. Embøl, C. Hutter, A. Junker, D. Reipur, A. Adjorlu, R. Nordahl, and S. Serafin. Hearmevirtual reality: using virtual reality to facilitate empathy between hearing impaired children and their parents. *Frontiers in Virtual Reality*, p. 77, 2021. doi: 10.3389/frvir.2021.691984
- [18] N. J. Formosa, B. W. Morrison, G. Hill, and D. Stone. Testing the efficacy of a virtual reality-based simulation in enhancing users' knowledge, attitudes, and empathy relating to psychosis. *Australian Journal of Psychology*, 70(1):57–65, 2018. doi: 10.1111/ajpy.12167
- [19] Y. Georgiou and E. A. Kyza. The development and validation of the ari questionnaire: An instrument for measuring immersion in location-based augmented reality settings. *International Journal of Human-Computer Studies*, 98:24–37, 2017. doi: 10.1016/j.ijhcs.2016.09.014
- [20] C. Hadjipanayi and D. Michael-Grigoriou. Conceptual knowledge and sensitization on asperger's syndrome based on the constructivist approach through virtual reality. *Heliyon*, 6(6), 2020. doi: 10.1016/j.heliyon.2020.e04145
- [21] F. Herrera, J. Bailenson, E. Weisz, E. Ogle, and J. Zaki. Building long-term empathy: A large-scale comparison of traditional and virtual reality perspective-taking. *PLoS one*, 13(10):e0204494, 2018. doi: 10.1371/journal.pone.0204494
- [22] M. Hussain, J. Park, and H. K. Kim. Augmented reality sickness questionnaire (arsq): A refined questionnaire for augmented reality environment. *International Journal of Industrial Ergonomics*, 97:103495, 2023. doi: 10.1016/j.ergon.2023.103495
- [23] S. Kalyanaraman, D. L. Penn, J. D. Ivory, A. Judge, et al. The virtual doppelganger: Effects of a virtual reality simulator on perceptions of schizophrenia. *The Journal of nervous and mental disease*, 198(6):437–443, 2010. doi: 10.1097/NMD.0b013e3181e07d66
- [24] G. Makransky and G. B. Petersen. The cognitive affective model of immersive learning (camil): A theoretical research-based model of learning in immersive virtual reality. *Educational Psychology Review*, pp. 1–22, 2021. doi: 10.1007/s10648-020-09586-2
- [25] A. J. Marques, P. Gomes Veloso, M. Araújo, R. S. de Almeida, A. Correia, J. Pereira, C. Queiros, R. Pimenta, A. S. Pereira, and C. F. Silva. Impact of a virtual reality-based simulation on empathy and attitudes toward schizophrenia. *Frontiers in Psychology*, 13:814984, 2022. doi: 10.3389/fpsyg.2022.814984
- [26] C. Martin. Art and empathy: five lived experiences of psychosis. *The Lancet Psychiatry*, 10(1):9–10, 2023. doi: 10.1016/S2215-0366(22)00364-9
- [27] A. J. Morgan, N. J. Reavley, A. Ross, L. San Too, and A. F. Jorm. Interventions to reduce stigma towards people with severe mental illness: Systematic review and meta-analysis. *Journal of psychiatric research*, 103:120–133, 2018. doi: 10.1016/j.jpsychires.2018.05.017
- [28] D. Mullor, P. Sayans-Jiménez, A. J. Cangas, and N. Navarro. Effect of a serious game (stigma-stop) on reducing stigma among psychology students: A controlled study. *Cyberpsychology, Behavior, and Social Networking*, 22(3):205–211, 2019. doi: 10.1089/cyber.2018.0172
- [29] A. Prouteau. *Neuropsychologie clinique de la schizophrénie: Enjeux et débats*. Dunod, 2011.
- [30] M. E. Rodríguez-Rivas, A. J. Cangas, L. A. Cariola, J. J. Varela, and S. Valdebenito. Innovative technology-based interventions to reduce stigma toward people with mental illness: systematic review and meta-analysis. *JMIR Serious Games*, 10(2):e35099, 2022. doi: 10.2196/35099
- [31] M. E. Rodríguez-Rivas, A. J. Cangas, A. Martin, J. Romo, J. C. Pérez, S. Valdebenito, L. Cariola, J. Onetto, B. Hernández, F. Ceric, et al. Reducing stigma toward people with serious mental illness through a virtual reality intervention: A randomized controlled trial. *Games for Health Journal*, 2023. doi: 10.1089/g4h.2023.0118
- [32] M. A. Sarge, H.-S. Kim, and J. A. Velez. An anti-sim intervention: The role of perspective taking in combating public stigma with virtual simulations. *Cyberpsychology, Behavior, and Social Networking*, 23(1):41–51, 2020. doi: 10.1089/cyber.2019.0678
- [33] X. Shen, Y. S. Pai, D. Kiuchi, K. Oishi, K. Bao, T. Aoki, and K. Minamizawa. Dementia eyes: Perceiving dementia with augmented reality. In *SIGGRAPH Asia 2021 XR*, pp. 1–2. 2021. doi: 10.1145/3478514.3487617
- [34] R. D. d. C. Silva, S. G. Albuquerque, A. d. V. Muniz, S. Ribeiro, P. R. Pinheiro, V. H. C. Albuquerque, et al. Reducing the schizophrenia stigma: a new approach based on augmented reality. *Computational intelligence and neuroscience*, 2017, 2017. doi: 10.1155/2017/2721846
- [35] D. Stelzmann, R. Toth, and D. Schieferdecker. Can intergroup contact in virtual reality (vr) reduce stigmatization against people with schizophrenia? *Journal of clinical medicine*, 10(13):2961, 2021. doi: 10.3390/jcm10132961
- [36] J. L. Tay, H. Xie, and K. Sim. Effectiveness of augmented and virtual reality-based interventions in improving knowledge, attitudes, empathy and stigma regarding people with mental illnesses—a scoping review. *Journal of Personalized Medicine*, 13(1):112, 2023. doi: 10.3390/jpm13010112
- [37] J. Tichon, J. Banks, and P. Yellowlees. The development of a virtual reality environment to model the experience of schizophrenia. In *Computational Science—ICCS 2003: International Conference, Melbourne, Australia and St. Petersburg, Russia June 2–4, 2003 Proceedings, Part III 3*, pp. 11–19. Springer, 2003. doi: 10.1007/3-540-44863-2\_2
- [38] K.-M. Valery and A. Prouteau. Schizophrenia stigma in mental health professionals and associated factors: A systematic review. *Psychiatry research*, 290:113068, 2020. doi: 10.1016/j.psychres.2020.113068
- [39] N. Yee and J. N. Bailenson. Walk a mile in digital shoes: The impact of embodied perspective-taking on the reduction of negative stereotyp-

ing in immersive virtual environments. *Proceedings of PRESENCE*, 24:26, 2006.

- [40] P. M. Yellowlees and J. N. Cook. Education about hallucinations using an internet virtual reality system: a qualitative survey. *Academic Psychiatry*, 30:534–539, 2006. doi: 10.1176/appi.ap.30.6.534
- [41] A. S. Yuen and W. W. Mak. The effects of immersive virtual reality in reducing public stigma of mental illness in the university population of hong kong: randomized controlled trial. *Journal of medical internet research*, 23(7):e23683, 2021. doi: 10.2196/23683
- [42] M. Zare-Bidaki, A. Ehteshampour, M. Reisaliakbarighomi, R. Mazinani, M. R. Khodaie Ardakani, A. Mirabzadeh, R. Alikhani, M. Noroozi, F. Momeni, A. D. Samani, et al. Evaluating the effects of experiencing virtual reality simulation of psychosis on mental illness stigma, empathy, and knowledge in medical students. *Frontiers in Psychiatry*, 13:880331, 2022. doi: 10.3389/fpsy.2022.880331