ThinkTactic VR: A Co-Developed Cognitive Remediation Program in Virtual Reality for Individuals with Psychotic Disorders

Jasmin Yee, Hannah Matheson, Bryce J. M. Bogie, Émilie Du Perron, Alexandra Thérond, Maëlle Charest, Catheleine van Driel, Marika Goyette, Ya Ting Lei, Chelsea Noël, Kagusthan Ariaratnam, Greg Collins, Chris Gorman, Ana-Maria Cretu, Simon Tremblay, Marie-Christine Rivard, Catherine Cullwick, Crystal Morris, David Attwood, Alexandra Baines, Angela Stewart, Stéphane Bouchard, Christopher R. Bowie, Synthia Guimond

Submitted to: JMIR Mental Health
on: November 27, 2024

Table of Contents

ThinkTactic VR: A Co-Developed Cognitive Remediation Program in Virtual Reality for Individuals with Psychotic Disorders

Jasmin Yee[1, 2] BA; Hannah Matheson[3] MOT; Bryce J. M. Bogie[4, 1] MSc; Émilie Du Perron[1] MSc; Alexandra Thérond[5] MA; Maëlle Charest[6, 1] BA; Catheleine van Driel[7] MD; Marika Goyette[6, 1] BA; Ya Ting Lei[6] BA; Chelsea Noël[8] BA; Kagusthan Ariaratnam[1]; Greg Collins[1]; Chris Gorman[1]; Ana-Maria Cretu[9] PhD; Simon Tremblay[6]; Marie-Christine Rivard[6]; Catherine Cullwick[10] MOT; Crystal Morris[11] MOT; David Attwood[12] MD; Alexandra Baines[1, 12] MD; Angela Stewart[1, 12] PhD; Stéphane Bouchard[6] PhD; Christopher R. Bowie[13] PhD; Synthia Guimond[1, 14, 4, 6, 12] PhD

[1]University of Ottawa Institute of Mental Health Research at The Royal Royal Ottawa Health Care Group Ottawa CA
[2]Department of Occupational Science & Occupational Therapy University of Toronto Toronto CA
[3]Department of Cellular and Molecular Medicine University of Ottawa Ottawa CA
[4]Département de psychologie Université du Québec à Montréal Montreal CA
[5]Département de psychoéducation et de psychologie Université du Québec en Outaouais Gatineau CA
[6]Department of Psychiatry University Medical Center Groningen Groningen NL
[7]Department of Psychology Lakehead University Thunder Bay CA
[8]Département d'informatique et d'ingénierie Université du Québec en Outaouais Gatineau CA
[9]Professional Practice Royal Ottawa Mental Health Centre Royal Ottawa Health Care Group Ottawa CA
[10]Department of Mental Health Ottawa Hospital Ottawa CA
[11]Department of Psychiatry University of Ottawa Royal Ottawa Health Care Group Ottawa CA
[12]Department of Psychology Queen's University Kingston CA
[13]Department of Psychology Carleton University Ottawa CA

Corresponding Author:
Synthia Guimond PhD
University of Ottawa Institute of Mental Health Research at The Royal
Royal Ottawa Health Care Group
1145 Carling Ave
Ottawa
CA

Abstract

Background: Cognitive remediation improves cognition and psychosocial functioning in individuals with psychotic disorders. The use of virtual reality to deliver cognitive remediation in immersive environments that mimic real cognitively challenging situations has the potential to increase engagement to treatment and further enhance its impact on functioning.

Objective: In this project, we co-developed a cognitive remediation program in virtual reality with individuals with a psychotic disorder (n = 9) and healthcare professionals (n = 7) to identify and address their needs.

Methods: Individuals with lived experience met nine times and the healthcare professionals met three times. Participants discussed personal and professional opinions on the challenges associated with cognitive difficulties in individuals with psychotic disorders. They also provided feedback on the program development.

Results: We discerned four themes from the content expert working group: the need for a program to address cognitive impairments, the key program design elements to support cognitive rehabilitation, the importance of leveraging technology as an intervention tool, and the need to improve community functioning. Three themes were identified for the health care professionals: the need for a clinically significant program that addresses the research-to-practice gap, the need to improve patient engagement in services, and the need for a program that addresses the limited resources in healthcare. The needs of our end-user experts were placed at the center of the program development process. When possible, we also integrated their suggestions, like the incorporation of a virtual coach within the immersive environment.

Conclusions: Individuals with lived experience and healthcare professionals have distinct needs, which have informed the co-design of a novel cognitive remediation program in virtual reality, ThinkTactic VR. To our knowledge, ThinkTactic VR is one of the first co-designed and co-developed cognitive remediation program in virtual reality using an iterative, user-centered approach

with individuals with a psychotic disorder and health care professionals.

(JMIR Preprints 27/11/2024:69359)
DOI: https://doi.org/10.2196/preprints.69359

Preprint Settings

1) Would you like to publish your submitted manuscript as preprint?

✓ **Please make my preprint PDF available to anyone at any time (recommended).**
Please make my preprint PDF available only to logged-in users; I understand that my title and abstract will remain visible to all users.
Only make the preprint title and abstract visible.
No, I do not wish to publish my submitted manuscript as a preprint.

2) If accepted for publication in a JMIR journal, would you like the PDF to be visible to the public?

✓ **Yes, please make my accepted manuscript PDF available to anyone at any time (Recommended).**
Yes, but please make my accepted manuscript PDF available only to logged-in users; I understand that the title and abstract will remain v
Yes, but only make the title and abstract visible (see Important note, above). I understand that if I later pay to participate in <a href="http

Original Manuscript

Original Paper

Jasmin Yee[1,2], Hannah Matheson[2], Bryce J. M. Bogie[2,3], Émilie Du Perron[2], Alexandra Thérond[4], Maëlle Charest[2,5], Catheleine van Driel[6], Marika Goyette[2,5], Ya Ting Lei[5], Chelsea Noël[7], Kagusthan Ariaratnam[2], Greg Collins[2], Chris Gorman[2], Ana-Maria Cretu[8], Simon Tremblay[5], Marie-Christine Rivard[5], Catherine Cullwick[9], Crystal Morris[10], David Attwood[11], Alexandra Baines[2,11], Angela Stewart[2,11], Stéphane Bouchard[5], Christopher R. Bowie[12], & Synthia Guimond[1,2,3,5].

[1]Department of Psychology, Carleton University
[2]University of Ottawa Institute of Mental Health Research at The Royal, Royal Ottawa Health Care Group
[3]Department of Cellular and Molecular Medicine, University of Ottawa
[4]Département de psychologie, Université du Québec à Montréal
[5]Département de psychoéducation et de psychologie, Université du Québec en Outaouais
[6]Department of Psychiatry, University Medical Center Groningen
[7]Department of Psychology, Lakehead University
[8]Département d'informatique et d'ingénierie, Université du Québec en Outaouais
[9]Professional Practice, Royal Ottawa Health Care Group
[10]Department of Mental Health, The Ottawa Hospital
[11]Department of Psychiatry, Royal Ottawa Health Care Group
[12]Department of Psychology, Queen's University

Corresponding author: Synthia Guimond, Synthia.guimond@theroyal.ca

ThinkTactic VR: A Co-Developed Cognitive Remediation Program in Virtual Reality for Individuals with Psychotic Disorders

Abstract

Background: Cognitive remediation improves cognition and psychosocial functioning in individuals with psychotic disorders. The use of virtual reality to deliver cognitive remediation in immersive environments that mimic real cognitively challenging situations has the potential to increase engagement to treatment and further enhance its impact on functioning.
Objective: In this project, we co-developed a cognitive remediation program in virtual reality with individuals with a psychotic disorder (n = 9) and healthcare professionals (n = 7) to identify and address their needs.
Methods: Individuals with lived experience met nine times and the healthcare professionals met three times. Participants discussed personal and professional opinions on the challenges associated with cognitive difficulties in individuals with psychotic disorders. They also provided feedback on the program development.
Results: We discerned four themes from the content expert working group: the need for a program to address cognitive impairments, the key program design elements to support cognitive rehabilitation, the importance of leveraging technology as an intervention tool, and the need to improve community functioning. Three themes were identified for the health care professionals: the need for a clinically significant program that addresses the research-to-practice gap, the need to improve patient engagement in services, and the need for a program that addresses the limited resources in healthcare. The needs of our end-user experts were placed at the center of the program development process. When possible, we also integrated their suggestions, like the incorporation of a virtual coach within the immersive environment.
Conclusions: Individuals with lived experience and healthcare professionals have distinct needs, which have informed the co-design of a novel cognitive remediation program in virtual reality, *ThinkTactic VR*. To our knowledge, *ThinkTactic VR* is one of the first co-designed and co-developed cognitive remediation program in virtual reality using an iterative, user-centered approach with individuals with a psychotic disorder and health care professionals.

Keywords: virtual reality; cognitive remediation; user-centered approach; neurocognition; social cognition; community functioning

Introduction

Psychotic disorders, such as schizophrenia and schizoaffective disorder, are characterized by positive and negative symptoms, as well as cognitive impairments [1]. Neurocognitive impairments (e.g., attention and memory) and social-cognitive impairments (e.g., emotion regulation and theory of mind) are common in individuals with a psychotic disorder [2-4]. These impairments are associated with important challenges in community functioning and in performing daily activities [5, 6]. Although current pharmacological approaches successfully reduce positive symptoms, they do not have a consistent positive impact on cognitive functions [7]. This limitation has encouraged the

development of non-pharmacological interventions specifically targeting cognitive impairments in this population [8].

Cognitive remediation (CR) is a targeted approach that seeks to improve cognitive deficits and community functioning through cognitive exercises, strategies, and rehabilitative practices [9-12]. While the delivery method of CR differs, four core features of CR have been identified: 1) the presence of exercises to improve cognition, 2) the presence of a trained therapist, 3) the identification and development of cognitive strategies, and 4) the support for the transfer of skills to community functioning [9]. Studies have consistently provided evidence of the efficacy of CR in improving neurocognition and social cognition in psychotic disorders [12-14]. Despite increasing supporting evidence of CR, the transfer of learned skills and generalizability of skills to psychosocial functioning is more limited [12, 15, 16]. Furthermore, CR programs are sometimes accompanied by diminished motivation to continue with treatment, resulting in high dropout rates [16-18]. To address these limitations, one promising avenue is leveraging virtual reality (VR) to deliver CR interventions [19].

The Use of Virtual Reality as a Rehabilitation Tool

VR is a computer-generated technology that creates three-dimensional environments reminiscent of real-world scenarios, thus allowing for the presentation of more ecological stimuli [1, 20, 21]. The resulting increase in ecological validity provides a more realistic environment to learn and practice cognitive skills compared to traditional, computer-based CR modules [21]. VR is a powerful clinical tool that allows for the creation of experiences (e.g., public transportation, kitchen) that are difficult to replicate in a treatment setting [22-24]. In addition, the immersive aspect of VR programs can provoke cognitive and emotional responses similar to those experienced in real-world settings [25, 26]. Previous research has identified VR as a safe and effective method for individuals with psychotic disorders [19, 27-29]. Cognitive programs in VR have shown promising results to improve neurocognition and social cognition [19, 28]. However, these results are often based on

small samples and pilot studies [30].

To date, there are a limited amount of VR CR interventions available for individuals living with psychotic disorders [30], including interventions that target both neurocognition and social cognition. Moreover, most VR CR interventions have been developed with minimal direct input from end-users [22, 31, 32]. The few programs that have incorporated user feedback have done so to a limited extent, highlighting an area for potential improvement in the design and efficacy of these interventions [32]. A lack of user engagement during program development is one potential reason for program implementation failure [22]. As such, there is a need to co-develop a VR CR for individuals with psychotic disorders. Co-developing a VR CR program that includes scenarios that apply to real life and incorporates the key four elements of CR can address some of the current limitations commonly found in CR studies and can furthermore facilitate the transfer to community functioning [33].

Involving a Multidisciplinary Team in Program Design

To effectively co-develop a CR program in VR, Birckhead et al. [22] recommend that VR applications be co-designed with direct input from individuals who would use and benefit from these programs. Current research has indicated that incorporating ideas from individuals with lived experience of a psychosis-spectrum condition (i.e., content experts (CEs)) is integral for their symptom management and can improve their treatment motivation and outcomes [32, 34]. It is also vital to include input from healthcare professionals (HPs) in treatment design, given their expertise in providing care and understanding of psychosis-related symptomology and its impact on clinical and functional outcomes [22]. HPs can also identify potential facilitators and barriers to the clinical implementation of such treatment programs. Including CEs and HPs in the co-development process could improve engagement and adherence, as well as the content relevance of the program.

Aims and Objectives

The primary objective of this article is to report on the co-creation of a VR CR program

involving both CEs and HPs. To achieve this, we identified and addressed the specific treatment needs of these two distinct end user groups. We adopted an iterative development process, ensuring the VR program effectively met their needs. This article outlines the co-development process, from the initial concept to the creation of the finalized program.

Methods

Study Design

We followed two established frameworks: the recommendations for developing effective VR interventions [22] and the four core features recommended for CR programs [9]. During the study, working groups were conducted separately for CEs and HPs, during which participants discussed their needs and provided feedback on the VR program. Inductive thematic analyses were then performed for each group, and the feedback was incorporated into the development of the program after each session. This iterative process ensured that the evolving program effectively addressed the needs of both user groups.

This study received ethical approval from the Royal Ottawa Health Care Group Research Ethics Board (REB #2019016) and the University of Québec in Outaouais (REB #2022-1869). All participants provided written informed consent at the beginning of the study, and verbal consent to continue participating was obtained prior to every subsequent working group. Participants received $20 in cash or a gift certificate for each working group session they attended.

Participants

Context Expert (CEs) Group

Eleven CEs were recruited from the Royal Ottawa Mental Health Centre (ROMHC) and the local community in Ottawa, Canada. Participants were referred to the study by their clinician or self-referred after viewing flyers and brochures distributed in Ottawa. Five CEs withdrew from the study before the three years of development ended. Reasons for withdrawal included loss of interest (n = 1) and time constraints (n = 1). The three other participants did not provide a reason for their

withdrawal. Demographic information about the individuals included in our CEs group can be found in Multimedia Appendix 1.

Inclusion criteria were: (1) aged ≥ 18 years, (2) ability to read and speak fluent English, (3) diagnosed with a psychotic disorder, confirmed by the referring clinician or review of electronic medical records after consent, and (4) were on a stable medication regimen for at least one month before enrollment. Potential CEs were excluded if they (1) had vision problems without contact lenses or glasses that fit with the VR headset, (2) had significant neurological or medical disorders (other than a psychotic disorder) that may contribute to cognitive impairment, (3) had epilepsy or had a history of seizures, (4) had a recent history of substance abuse or dependence (within the past three months), (5) had a previous history of motion sickness or cybersickness (i.e., motion sickness related to virtual immersion), or (6) had decisional incapacity requiring a guardian.

Healthcare Professional (HPs) Group

Seven HPs consisting of psychiatrists (*n* = 2), clinical psychologists (*n* = 2), a neuropsychologist (*n* = 1), and occupational therapists (*n* = 2) were recruited from the ROMHC and collaborative institutions. Two collaborators from other institutions were invited to participate in the working groups due to their expertise in CR and VR psychological interventions. No HPs withdrew from the study.

HPs who met inclusion criteria (1) were a healthcare professional and (2) had two or more years of clinical experience with individuals with psychotic disorders or with VR interventions to ensure they had the necessary background experience. The same exclusion criteria for CEs were also applied for HPs.

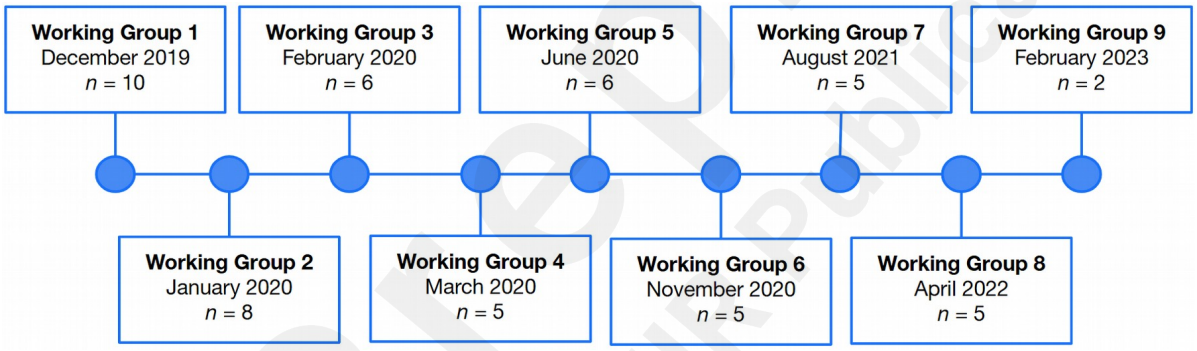
Procedure

Content Experts (CEs) Working Groups

CEs were invited to in-person or virtual Zoom meetings for an enrollment visit (*n* = 1) and working group sessions (*n* = 9; Figure 1). CEs working group sessions one to five were completed in

person at the ROMHC, while the rest of the sessions were facilitated through Zoom for Healthcare due to the COVID-19 pandemic. At the initial enrollment visits, CEs were individually interviewed by a trained research assistant. During this visit, a detailed description of the study and the role and responsibilities as research partners were discussed and informed consent was obtained. Additionally, initial testing of a VR environment prototype was completed. When participants completed initial prototype testing during their enrollment visit, the Simulator Sickness Questionnaire was administered to assess cybersickness (Kennedy et al., 1993; Multimedia Appendix 1). Afterwards, a discussion was initiated to explore the needs and collect initial feedback to gather initial reactions from CEs on the project. These activities ensured the participants had the necessary background information for the first working group and to establish rapport.

Figure 1. CEs working groups timeline.



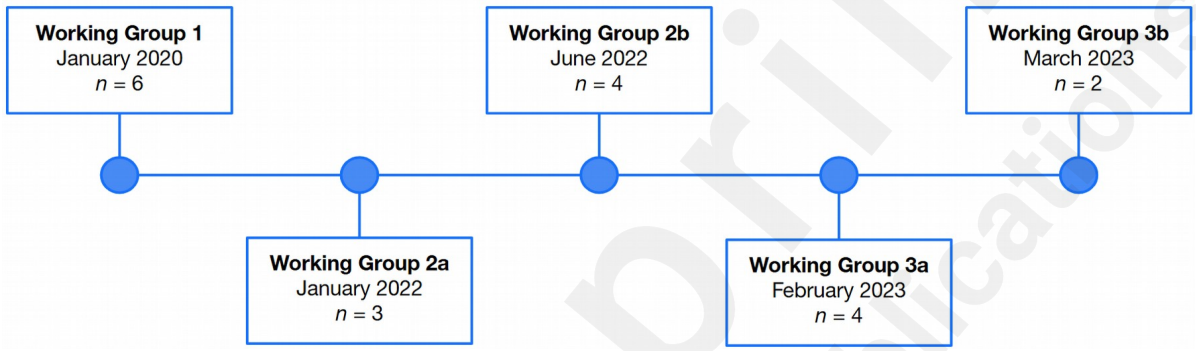
Note. n = number of participants attending the working group.

In the initial three working groups, two to three facilitators (SG, HM, AT) provided psychoeducation on neurocognition (working group one), social cognition (working group two), and community functioning (working group three). After presenting the topic, the facilitators led a semi-structured discussion to gather information from CEs about their personal experiences and opinions on the challenges associated with psychotic disorders related to the topic. These working groups were used to determine the needs of the CEs and the types of VR tasks to include in the training program. The remaining six working groups were facilitated by two study personnel (HM, AT, CN, or JY) who focused on gathering feedback on prototype versions of the program from CEs.

Healthcare Professionals (HPs) Working Group

The HPs working groups met three times between January 2020 and March 2023 (Figure 2). In each working group, two facilitators (SG, TR, or JY) facilitated a discussion where HPs shared their personal opinions on the challenges associated with living with a psychotic disorder and provided program feedback. The first working group was held in person at the ROMHC, with two participants joining virtually through Zoom. Due to the COVID-19 pandemic, the remaining working groups were facilitated virtually through Zoom.

Figure 2. HPs working groups timeline.



Note. The second and third HPs working groups were split into two separate sessions to accommodate participant availability. n = number of participants attending the working group.

In the first working group, informed consent was obtained from HPs, who then discussed their professional opinions on the treatment challenges associated with psychotic disorders. Afterwards, HPs tested an initial prototype of the VR program. In the remaining two working groups, HPs provided feedback on the other versions of the VR program.

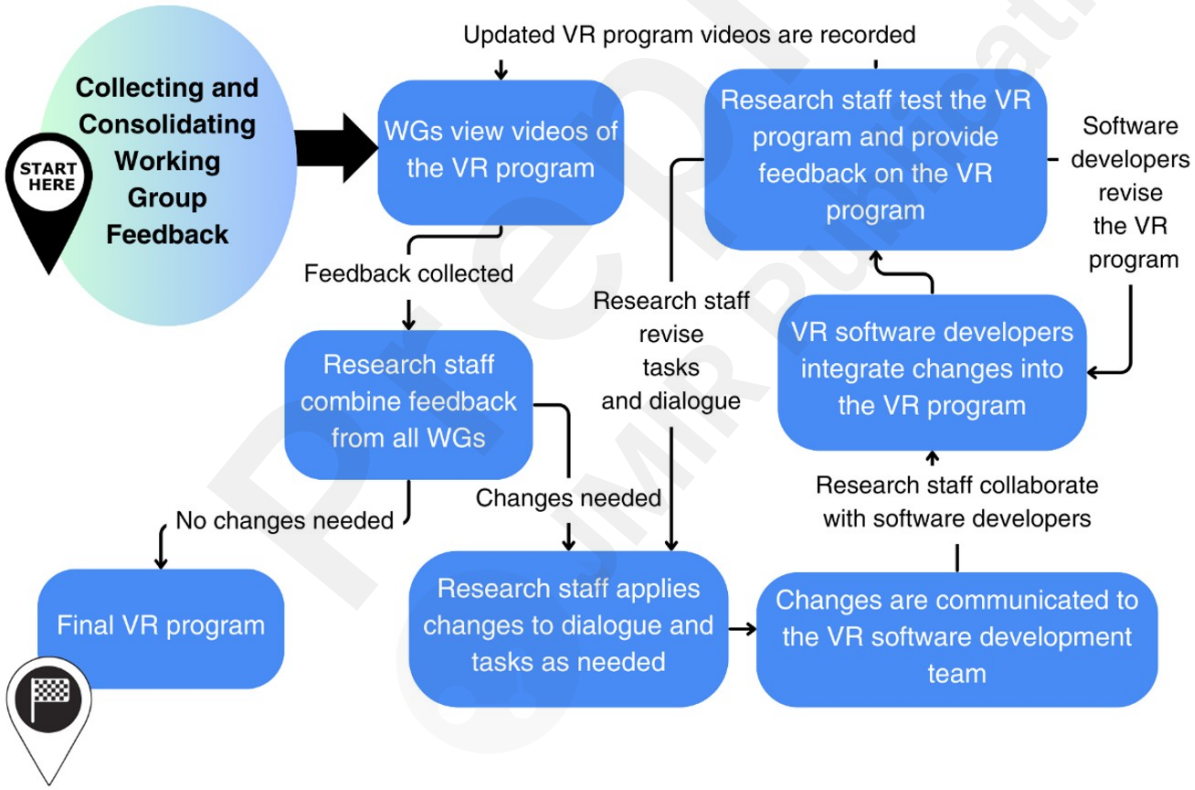
VR Design

User-Centered Iterative VR Program Development

The VR environments and tasks were developed following a user-centered design process and an iterative approach wherein the perspectives of CEs and HPs were integrated into all stages of the design process (Figure 3). At the end of the third working group, CEs brainstormed and identified potential VR environments and tasks. Based on the feedback collected, examples of VR

environments and tasks were showcased in the fourth working group. An iterative process subsequently followed where feedback was collected from CEs, which were later reviewed by the research team. When creating the VR environment, designs had to reflect the needs of CEs and HPs while adhering to the psychological principles of CR therapy. In collaboration with software developers, the proposed changes also had to abide by current technological parameters and VR design considerations (e.g., reducing the incidence of cybersickness). Research staff and software developers continuously tested and provided feedback on these changes. Once the research staff and software developers finalized the changes, the modified VR CR program was showcased at the subsequent working group, and new feedback was collected.

Figure 3. Iterative process to program development.



Note. WG = working group; VR = virtual reality.

Additionally, a VR coach was integrated into the VR program, providing VR navigation assistance (e.g., instructions on how to respond to a question or interact with objects in the environment), feedback on task performance, and CR strategies for a user. The CEs initiated the

development of the VR coach, and feedback was continuously provided during the development in the working groups. Research staff collaborated with software developers to create and modify the VR coach accordingly.

Software Development

Software development was carried out by the Cyberpsychology Laboratory at the University of Quebec in Outaouais, led by S.B. and M.C.R. Their team was composed of software developers who specialized in rehabilitative VR environments. Character animations were created based on previous VR simulations produced in the Cyberpsychology Lab, and the VR environments were also partly created using pre-existing environment design.

CR Therapy

The tasks within the VR modules were created by integrating and adapting strategies from CR manuals developed by Bellack et al., Friedberg et al., and Wykes & Reeder, and input from CEs and HPs [37-39]. Key strategies for treating social cognition, neurocognition, and community functioning in schizophrenia were identified from the above manuals. The script of the VR program development began after the fifth working group session with CEs. Initial drafts were completed through weekly meetings between HM and AT during which feedback from the working group sessions and CR manuals were used to help construct the environment. The VR CR program was revised after the ninth working group to refine the CR aspect further (JY, SG, BB, and CVD).

A similar approach was used to identify the CR strategies that the VR coach in the immersive environment should provide when an individual is having difficulties with a task in the VR program. This approach also supports the directive for the trained therapists to guide sessions and facilitate bridging discussions at the conclusion of each session.

Qualitative Data Analysis

A preliminary inductive analysis following the Braun and Clarke [40] model was conducted in March 2021 to identify and subsequently integrate central elements into the program using the

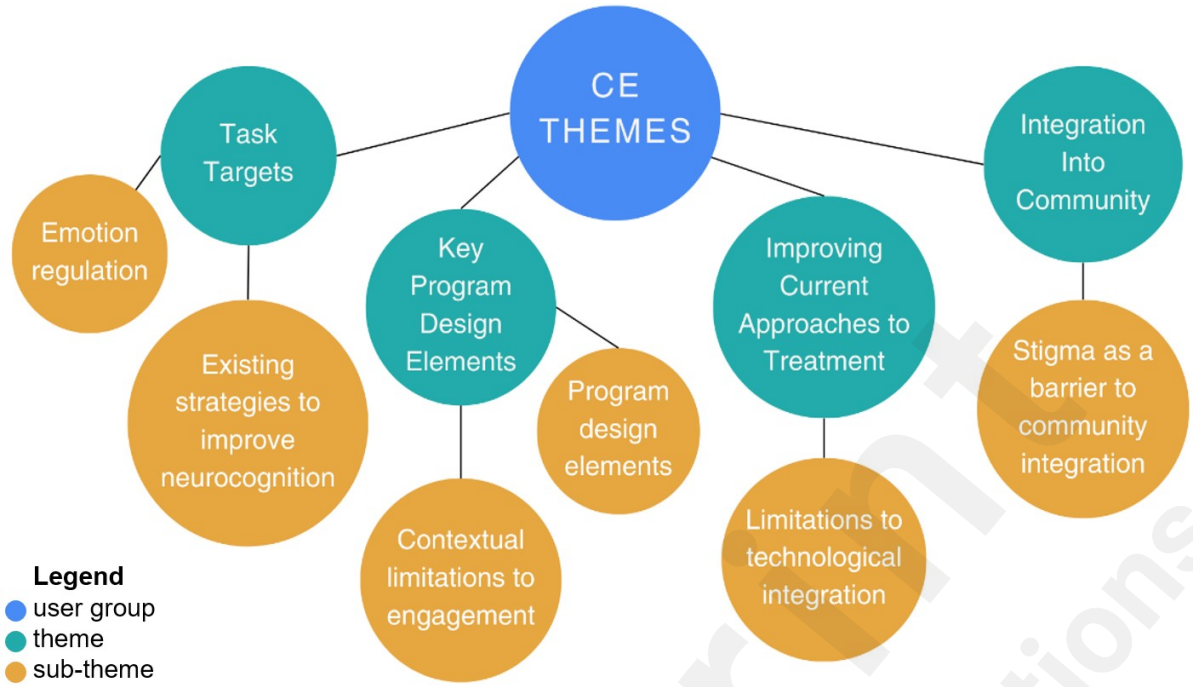
first seven CEs and the first HPs working groups (HM and CN). To mitigate bias, a team of research staff not involved in the preliminary analysis conducted the final inductive thematic analyses to identify the treatment needs of CEs and HPs. The remaining working groups were recorded and transcribed verbatim through Dragon Professional Individual (version 15; MC). Transcripts were then reviewed (MC) to apply syntactical corrections and redact identifiable information to safeguard participant anonymity (e.g., names of participants, occupation, and work location). Once the transcripts were finalized, the audio recordings were deleted.

Two separate inductive thematic analyses were conducted with CEs and HPs to acknowledge and isolate the different needs of the two participant groups. Nvivo (version 12.0, QSR) was used to facilitate familiarization, coding, and data organization. The CE analysis was conducted from December 2022 to May 2023 and in September 2023 as working group nine served as a debrief and presentation of the final VR program. Thematic coding was conducted independently (JY and EDP) for the first three working groups. Once no new codes emerged from the text, coders met to create an overall codebook to ensure text comprehension and consensus. The remaining six working group transcripts were then equally distributed between the two coders, who both used the final codebook to code the remaining transcripts. Themes were generated based on the codes. The themes were then refined by comparing initial themes to other themes and creating sub-themes with the help of external evaluators (CVD, AT, BB, and SG). Once themes were refined and finalized, their essence was defined. The identical process was completed for the HPs thematic analysis conducted between February 2023 and May 2023.

Results

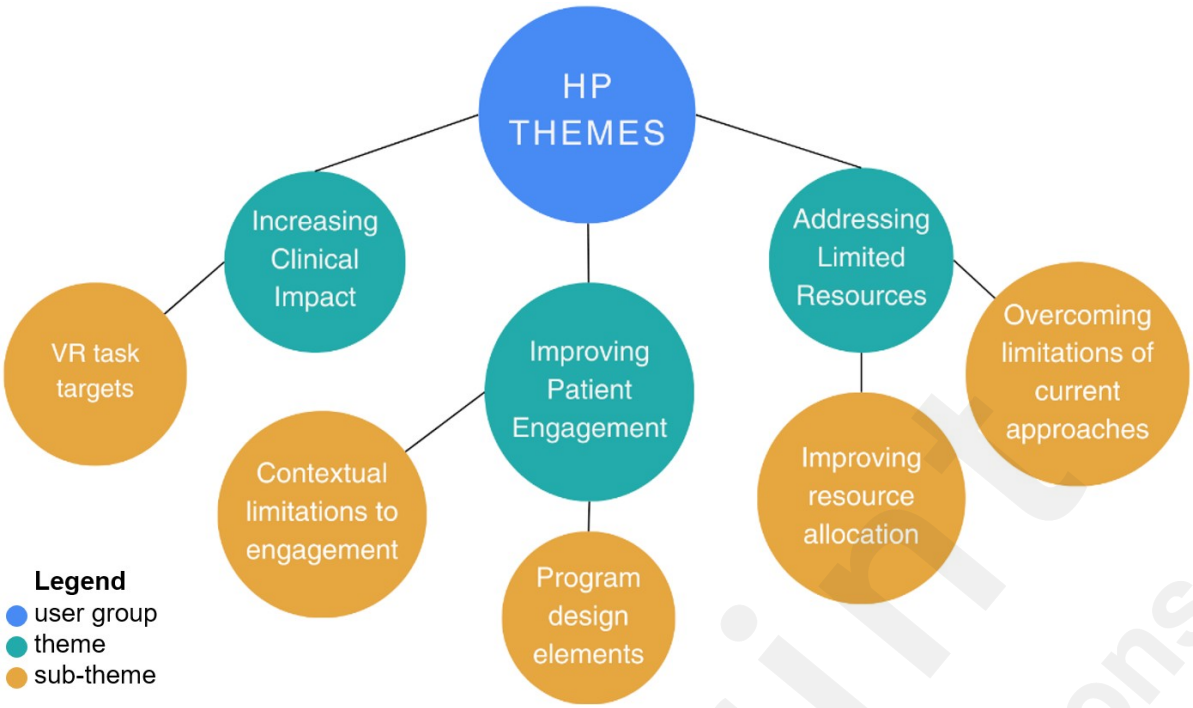
The thematic analysis identified four themes important for CEs: (1) the need for a program targeting cognitive functioning (task targets), (2) key program design elements, (3) improving current treatment approaches to increase efficacy, and (4) supporting community integration (Figure 4).

Figure 4. CEs thematic map.



The analysis also revealed three themes for HPs: (1) increasing clinical impact, (2) improving patient engagement, and (3) addressing limited resources (Figure 5). Together, these themes influenced the development of the program, ensuring perspectives and suggestions from the CEs and the HPs were considered at every step of its creation. Each of these themes and their associated subthemes are elaborated below with selected extracts from the narratives of participants illustrating them (a more comprehensive list of quotes can be found in Multimedia Appendix 2).

Figure 5. HPs thematic map.



CE Thematic Analysis

Theme 1: Cognitive Impairments to Target

One prominent theme that was mentioned during the focus groups was the task targets of an intervention, which include the different neurocognitive and social-cognitive domains in which CEs had difficulties, the strategies they tended to use, and what they would like to work on going forward (Table 1).

Table 1. CEs cognitive impairments to target quote exemplars.

Theme	Quotes
Cognitive impairments to target	• "I have difficulty with traveling [and] forgetting when to get off the bus." • "I was going to this gym, and I would say bye to the reception woman, and one day I asked about some workout tips, and she stopped saying bye and I tried to understand why she stopped, and I exhausted myself trying to understand."
Sub-Themes	
Impact of emotions and stress on cognition	• "The moment that my emotional state is not as well as it should be, like if you're not calm and capable for doing very well and performing the best, then I cannot remember nothing." • "I have this assignment that was due within a month, and it was for my course, and I set myself up earlier, I gave myself three weeks and started working on it even an hour a day but by the final week I stopped sleeping well and I wasn't able to focus."

Existing strategies to improve cognition	• "I write everything down. I note everything. I don't do anything with memory." • "The way that I used my phone at least I set up reminders so that I get a weekly reminder, two-day reminder, and then the day of the event."

CEs tended to tie their neurocognitive challenges, such as planning and attention deficits, to daily life tasks. A fair number of individuals also reported memory difficulties, such as remembering to eat or remembering the names of people. Additionally, CEs discussed social cognition challenges, such as trouble understanding why an acquaintance they frequently encounter in their daily life stopped acting friendly towards them despite there being no overt change in their past interactions. Others expressed difficulties communicating with others and regulating their emotions in stressful situations.

Sub-Theme: Impact of Emotions and Stress on Cognition

CEs explicitly mentioned how their emotional state or environment (e.g. the time of day, social context) influenced their neurocognitive and social-cognitive functioning. One CE shared that their memory tends to be poor during social situations, thus affecting their ability to remember faces and names. Another CE shared that their short-term memory was often influenced by their emotional state and affected their level of functioning at work (which in turn required them to rely more on compensatory strategies, such as asking their manager to write down their tasks).

Sub-Theme: Existing Strategies to Improve Cognition

For neurocognitive deficits, CEs highlighted their use of phones and note-taking. CEs equally discussed the benefits of using technology (e.g., using the "Reminders" function on their phone) versus more traditional external memory aids (e.g., a paper agenda). A few CEs focused more on behavioural or environmental modifications to help reinforce memory. One CE even mentioned they wanted to maintain their current level of memory performance and exclusively used their phone to write down appointments. In addition to memory aids, one CE mentioned they try not to over-complicate their life to avoid stress as it could affect their cognitive abilities. Engaging in social

interaction and asking friends for help was also repetitively suggested as a helpful tool. A few said they can complete tasks, such as writing an article or setting up a “game night” if they planned ahead. Aside from these strategies, CEs also mentioned the importance of psychoeducation in managing their difficulties better and suggested implementing it in VR.

Finally, CEs discussed their social cognition strategies but were less prolific compared to the discussion on neurocognitive approaches. One suggestion was to ask individuals how they were feeling and be more direct when interpreting the emotions of another individual. Other CEs had tips for reducing stress, which could ultimately help manage their cognitive difficulties.

Theme 2: Key Program Design Elements

CEs highlighted several key program design elements of an intervention to support rehabilitation (Table 2). Notably, CEs identified the importance of an immersive and interactive program environment. One CE highlighted that the immersive aspect was more important than the difficulty of the program due to the importance of translating the skills learned in the session to daily life. While CEs emphasized the importance of an immersive program, there was debate about the impact of multiple-choice questions on specific tasks on program immersion. One CE expressed that they liked this option as it allows users to learn from different approaches and see how choices affect later actions. Other CEs voiced that the multiple-choice questions could break the VR immersion.

Table 2. CEs key design elements quote exemplars.

Theme	Quotes
Key program design elements	• “It’s not a matter of harder or easier. It matters to be realistic and not complicated.” • “If you get off the bus or walk or you can choose to walk, if you have a time restriction you can still choose to walk or take the bus and then go grocery shopping for a list of things and manage the money…I just find it important to be able to make these things grounded in the reality context.”

CEs also discussed the importance and need of a program that promotes the translation of

skills and strategies learned in the session to daily life. One way to promote translation was to include tasks similar to those CEs encounter in their daily life. Another way to promote translation into reality was to incorporate environmental elements into the program. For example, one CE proposed that if a person forgot their destination while traveling on a bus, they could ask the driver for directions.

Two program design elements were also briefly discussed by the CEs, including having avatars from diverse cultural backgrounds and the ability to change the difficulty level of a program.

Theme 3: Improving Current Approaches to Treatment

CEs discussed the impact of pharmacological and psychotherapy interventions and voiced some of their limitations (Table 3). Such limitations included the negative impact of medication on their cognition and the sparsity of programs available.

Table 3. CEs improving current approaches to treatment quote exemplars.

Theme	Quotes
Improving current approaches to treatment	• "Especially for like thinking skills like memory attention and executive function is not something that you live with. It is not related with other symptoms, so we need those kinds of therapy." • "Taking medicine, it kind of dulls the mind."
Sub-Theme	
Limitations to technology integration	• "Not everyone can get data on their phone or has access to WIFI." • "When do you start introducing a back-and-forth aspect to a simulation? It opens the door for more back and forth just to keep things from getting confusing, and that might cause some issues later down the line for the programming."

CEs conversed about integrating technology into cognitive rehabilitation approaches to increase treatment efficacy, which was based on their prior experiences of smartphones as supportive devices. CEs shared how they relied on their phones to remember appointments; some participants identified a higher chance of forgetting appointments if it was not entered into their calendars when booked. Interestingly, there was greater emphasis on the role of technology in supporting social cognition development (rather than neurocognition development), where technology could enable

users to practice how to interact in social interactions.

Sub-Theme: Limitations to Technological Integration.

While CEs supported technology integration into treatment interventions, they also highlighted concerns. One such concern was that individuals may not have remote access to internet and mobile data, thus affecting the accessibility of internet-dependent interventions delivered through smartphones. Additionally, CEs emphasized two ways in which VR interventions are impacted by its equipment. First, VR interventions are constrained to computers that meet specific hardware requirements and are likely more difficult to access. Secondly, unfamiliar technology could negatively interact with the VR navigation experience; VR controllers differ from typical game controllers. As such, it could take time for a user to become accustomed to the VR interface, potentially affecting the depth of knowledge and strategies learned.

Theme 4: Integration into Community

CEs highlighted their need to socialize and the necessity for better community integration (Table 4). CEs emphasized the importance of interacting with others to improve their social skills and reduce isolation; a recurring topic was loneliness.

Table 4. CEs integration into community quote exemplars.

Theme	Quotes
Supporting community integration	• “I also think that the virtual reality should be fused with the community.” • “Something that those people, they need drastically. They need something interesting to be involved in their life. They need to socialize, they need to go out.”
Sub-Theme	
Stigma as a barrier to community integration	• “I explain to people that I have a long-term disability that could affect my cognition. Everyone has their struggles, and they would understand. I don’t give details that I have schizophrenia.” • “There is a lot of stigma and discrimination. Maybe they discriminate against you because they think that you are here, and you may be dangerous.”

While this need was emphasized, some CEs voiced challenges with social interactions,

including situations in which individuals wanted to socialize with others but would listen to their friends all night instead of saying anything. Other CEs specifically mentioned their difficulty in talking about themselves and elaborating on their hobbies, which were limited as they mostly spent their time at home “playing games” and “not being able to afford anything.” In addition to this need for social interaction, CEs expressed the importance of aiding disabled individuals with integration into the community. One CE mentioned programs that help disabled individuals integrate within the community and meet others with similar disabilities.

Sub-Theme: Stigma as a Barrier to Community Integration.

CEs disclosed how stigma increased the difficulty of integrating within the community and restricted their level of involvement. Many CEs shared past experiences of feeling stigmatized by other individuals due to their mental health conditions. One CE expressed that others may perceive them as “dangerous” and another participant shared that sometimes they feel like others make preconceptions about their behaviour. Considering these experiences, one CE suggested that a program could provide psychoeducation on navigating social situations where users encounter stigma and negative stereotypes being expressed by an avatar. Additionally, a program could include a task reflecting the above situation so that users can practice responding.

HPs Treatment Needs

Theme 1: Increasing Clinical Impact

HPs emphasized a need for more clinically significant programs targeted towards individuals living with a psychotic disorder (Table 5).

Table 5. HPs increasing clinical impact quote exemplars.

Theme	Quotes
Increasing clinical impact	• “In my sense this is bridging the gap (in psychiatric care) that we’ve been up against for 20 or 30 years.” • “I found there is a gap between the psychological and psychiatric world to the actual functioning. I think this would be very great for identifying what specific problem might be because we often are focused on is a task completed or not, but we don’t spend a lot of

	time discussing partially completed tasks and why the task broke down.”
Sub-Theme	
Cognitive impairments to target	• “We’re all clearly craving modules or elements in our clinical practice that help with social cognition? Because the social cognitive landscape for patients is where they grind to a halt.” • “From my point of view, which is a very practical point of view [is] from discharging people from hospital and can they navigate kind of basic tasks in the community.”

HPs identified a research-to-practice gap within the field, which could be lessened by integrating research into clinical practice. Clinical significance was conceptualized as the practical applications of a treatment. Participants conveyed a need for a program that improves neurocognition and social cognition within the context of the community functioning of their patients.

Sub-Theme: Cognitive Impairments to Target

HPs identified several domains of neurocognition that a program should target, notably memory and executive functioning. HPs also described a general need to enhance social cognition, but did not identify specific domains. A significant portion of the HPs working groups was spent discussing how a program should promote the transfer of learned skills and strategies to the daily lives of their patients. HPs described the impact of neurocognitive impairment on community functioning, which could affect their recovery and transition from inpatient to outpatient care.

Sub-Theme: Generalizability of the Program

Some HPs expressed that a program should be generalizable to clinical variations in a psychosis-spectrum disorder and other clinical populations. For instance, a VR CR program should consider the difference between active and chronic-stage psychosis. While the clinical significance of treatment is greater when it is generalizable, heterogenous expression of psychosis may ultimately hamper clinical impact if left unchecked. HPs also mentioned that when treating a psychotic disorder population, comorbid conditions (e.g., sleep apnea) should also be considered. Likewise, two HPs also highlighted the generalizability of a program to other populations marked by cognitive

impairment.

Theme 2: Improving Patient Engagement

The second theme reflected a need to improve patient engagement in treatment approaches (Table 6). HPs expressed a need for more patient engagement in the services offered by their clinics and, more broadly, on an institutional level. Motivation and contextual limitations were identified by HPs as critical factors that influence treatment engagement.

Table 6. HPs Improving patient engagement quote exemplars.

Theme	Quotes
Improving patient engagement	• "It is the same patients showing up for everything sometimes. We have full groups but it is the same 50 people doing all the groups. We have 1500 program patients, but really over 1000 of them the physician knows. Less than 500 are outpatients taking part in the program. And I don't think the 1000 patients not taking part in the program aren't doing so because they're doing so well."
Sub-Theme	
Contextual limitations to engagement	• "The question becomes, we would love to be spending more time on cognition but there is nasalism there, and we run into the problem of risk management, safety, medication, morbidity, illness morbidity, family needs, housing needs, issues of poverty." • "We have to be mindful that our medications that we prescribe are not pro-cognitive, they are de-cognitive, and it has changed the prescription culture that we prescribe medication that clearly deteriorates our mission."
Program design elements	• "I think finding a good land, or thinking about personalized medicine, or patient preferences is really important." • "We have a little more resource but we are also quite limited in terms of any real cognitive remediation. We can do a baseline neurocognitive assessment on almost everybody in this clinic but then from there, there is one kind of cognitive remediation group."

Sub-Theme: Contextual Limitations to Engagement

HPs listed several contextual limitations to engagement, such as lack of time, lack of social support, and socioeconomic background. For instance, their patients typically face challenges to satisfy basic physical needs, which can affect their ability to be physically and mentally present during appointments. HPs highlighted accessibility as a contextual limitation to engagement where their patients often encounter transportation issues traveling to and from appointments. Some HPs

discussed how medication side effects may negatively impact neurocognition. They also emphasized a lack of pharmacological approaches available to enhance neurocognition. Regarding the program specifically, HPs voiced that a prior negative VR experience may affect patient engagement; as such, a VR program should start with a practice portion to reduce the chance of cybersickness and to increase the amount of attention directed to the task.

Sub-Theme: Program Design Elements

HPs emphasized specific program design elements that could be incorporated into a program to improve engagement, such as the ability to personalize a program to a patient. HPs voiced that currently available cognitive rehabilitation programs lack the ability to tailor the program to the patient and their goals.

HPs identified two ways a program could provide a personalized approach. First, HPs mentioned how different approaches to CR may better suit certain patients, especially when considering the chronicity of their condition. The second method to provide a personalized approach was to change various program settings, such as the loudness of distractions. By changing various program design settings, HPs thought it would enable them to tailor the program to the level of cognitive functioning of their patients. Additionally, HPs expressed that providing a personalized approach would account for the heterogeneous presentation of psychotic disorders and comorbid conditions. For example, HPs described how a VR program should consider the difference between active and chronic-stage psychosis, as the treatment approach would differ. Two HPs also highlighted the generalizability of a program to other populations marked by cognitive impairment, such as mood disorders.

Finally, another integral program design element highlighted by HPs is integrating diversity and inclusivity into the program. HPs discussed how background avatars could be changed to reflect a greater inclusivity of racial backgrounds and how users themselves could change the coach avatar.

Theme 3: Addressing Limited Resources

A prominent theme throughout the HPs working groups was the limited resources available in healthcare and the need for a program to be effectively incorporated into a healthcare setting to mitigate these resource constraints (Table 7). HPs also highlighted current limitations in the diagnosis and treatment of psychotic disorders. Despite this negative lens, they also had suggestions on how to use current resources effectively.

Table 7. HPs addressing limited resources quote exemplars.

Theme	Quotes
Addressing limited resources	• "[There is] a massive drop off in resources. We have 1500 outpatients in the program. We have 1.4 OTs. We have two psychologists […], not just [for] our program, and we have 3.5 social workers and 3.5 nurses for our program." • "We have patients ready to go now and we submit a referral, and they have a wait and the waiting kills."
Sub-Theme	
Improving resource allocation	• "I could see this becoming part of OT. Like we see someone who is referred, and it is almost a year sometimes to see them so how can us as OTs get this going from the get-go?" • "I like the idea of thinking about potential of wait room intervention and how relatively brief interventions can be done while a patient is waiting to see the psychiatrist, nurse or social worker."
Overcoming limitations of current approaches	• "In a clinical interview, our patients usually over endorse their abilities…But looking at that functional endpoint and exploring how the person is actually performing in the task has always been the deficit that we've had clinically." • "The nasalism around how fixed are these cognitive deficits, particularly because it looks like most of these cognitive deficits occur before the first episode of early psychosis. So, we're showing up at the fire after the house has already burnt down."

HPs described what resources needed to be improved in their fields, including a lack of staff and availability. During the working group, healthcare practitioners mentioned being "stuck in terms of […] time." HPs mentioned that, despite their desire to try new approaches, they do not have the necessary staff to accommodate the substantial number of patients on their waitlists. In turn, this creates an uneven patient-to-healthcare provider ratio. In addition to staff shortages, patients are subject to long wait times due to, among other things, a long and arduous referral process. The terms

"expensive" and "cost" were also used a few times during these discussions.

Sub-Theme: Improving Resource Allocatio.

Despite the limited resources, HPs presented strategies to allocate available resources more efficiently and effectively. In response to staffing challenges, the HPs suggested delegating interventions, including VR training, directly to allied health professionals, such as occupational therapists (OTs). Several HPs in the working groups felt that a more interdisciplinary and holistic healthcare method would benefit patients more and create shorter wait times. They also suggested using clinic and hospital wait rooms to dole out brief interventions and reduce the need for multiple staff while "multipy[ing] your number of clients." Some HPs proposed that patients could complete a VR program in a wait-room setting or while waiting to access a service (referral or waitlist). In these settings, patients could start building on the skills and strategies they would later elaborate on with an OT. For instance, one HP expressed an interest in patients engaging in a public transportation-orientated module where they initially learn strategies for navigating public transportation before they go out in the community and practice with an OT. In response to the waiting room intervention idea, HPs raised the importance of embedding research and other multidisciplinary services (e.g., OTs) into a single clinic.

The keywords "quick," "brief," and "immediately" were mentioned a few times during discussions. HPs emphasized the need for quicker and easier measures, a speedier referral process, and brief but effective intervention methods, like using wait rooms to administer interventions.

Sub-Theme: Overcoming Limitations of Current Approaches

In addition to improving resource allocation, limitations in current approaches were brought up. One of the limitations of assessing neurocognition in psychotic disorders is the discrepancy often found between subjective and objective neurocognition. HPs discussed how patients may overestimate their cognitive abilities, especially if they perform relatively well on a simple cognitive test; however, this test may not accurately measure cognitive difficulties in daily life tasks. Coupled

with the need to measure neurocognition accurately, HPs discussed this need in the context of VR. While it was emphasized that the purpose of this program was for training purposes, HPs were excited about the prospect of VR assessments for neurocognition and community functioning. HPs were also concerned about whether training cognition is advantageous given the challenges to the schizophrenia algorithm. As cognition is often visibly affected before the first onset of psychosis, HPs wondered whether it is possible to train cognition to a pre-morbid state or whether such interventions are fruitless. Therefore, there is a need to define cognitive difficulties in psychosis better to determine which interventions offer more meaningful outcomes.

Resulting CR Program: ThinkTactic VR

The needs of CEs and HPs were placed at the center of the development process, where the VR environment and avatar design, tasks, and scripts were built based on the feedback provided by CEs and HPs (Table 8). For instance, the inclusion of an avatar that guides a user through the program and delivers CR strategies (i.e., the VR coach) was recommended by the CEs. Based on this feedback, research staff collaborated with the software developers in developing the initial prototype of the VR coach and presented videos of the VR coach in the subsequent working group. The iterative development approach of the entire program, including the VR coach, ensures that the program is continuously meeting the needs of CEs and HPs. CEs and HPs treatment needs and suggestions were incorporated to the best of our ability in the iterative program development process to create the final program: *ThinkTactic VR*.

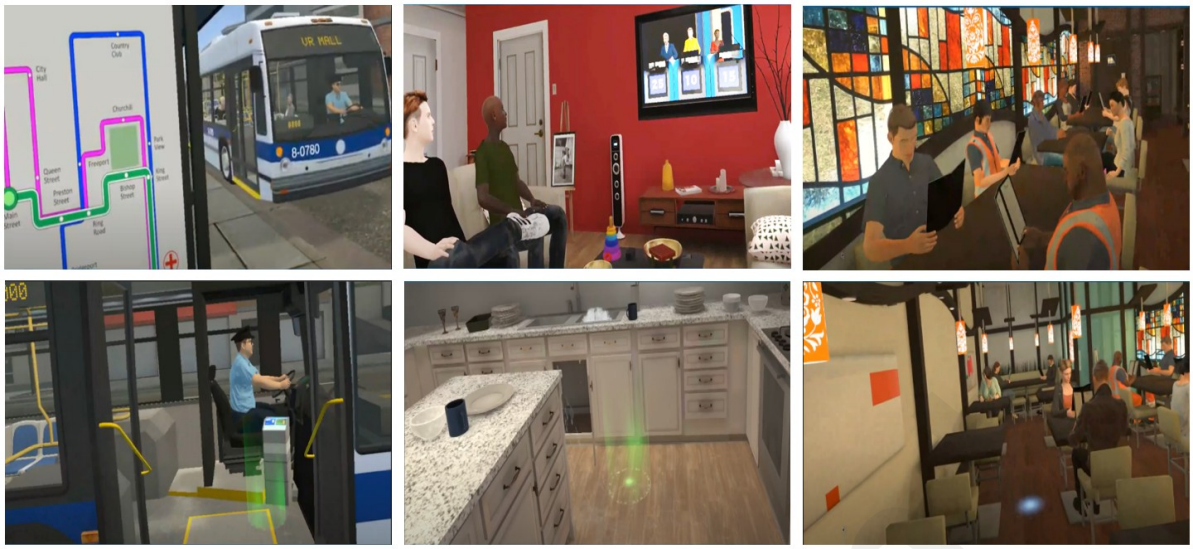
Table 8. Examples of user input integrated into ThinkTactic VR and noted for future iterations.

Incorporated into ThinkTactic VR	To be considered in future iterations of ThinkTactic VR
• Creating an interactive and realistic environment • Inclusion of a VR coach • Inclusion of memory aid • Psychoeducation on selecting balanced meals when heating up food	• Ability to customize the VR coach • Adding more tasks to the program • Cultural and gender diversity of the VR coach • Grocery store scenarios involving navigating around the store and

in the apartment module • Selection of the modules • Slower rate of speech from avatars and the VR coach • Tasks targeting neurocognition and social cognition simultaneously • Cultural and gender diversity of avatars	calculating prices • Purchasing an item from a store to receive change for a bus trip • Responding to a scenario that involves interacting with the police • Responding to a situation involving stigma

The final VR CR program includes three environments (i.e., modules): public transportation, apartment, and restaurant (Figure 6). Each module is composed of four levels where the first level serves as an introduction to how to navigate the environment and general tasks. As users progress through the module levels, environmental distractions (e.g., ambient noise) and task complexity increase. These neurocognitive and social-cognitive tasks are contextualized in situations an individual is likely to encounter in their life. If a user does not provide the intended answer during a task, they have the opportunity to repeat the task and practice CR strategies. These CR strategies are provided by a VR coach avatar integrated into the module. Users receive instant feedback from the VR coach after responding to a task. If a user is experiencing difficulty, the VR coach will provide CR strategies before the user reattempts the task (thus reinforcing the concept of errorless learning). If a user responds correctly to a task, the VR coach will reinforce CR strategies. This allows users to have repeated exposure and opportunities to practice CR strategies in cognitively challenging real-life scenarios in immersive environments. To support the transfer of learned skills and CR strategies to community functioning, *ThinkTactic VR* was designed to be accompanied by a trained therapist who also conclude each session with a bridging discussion.

Figure 6. ThinkTactic VR program photos.



Note. The public transportation module is featured on left, the apartment module in the middle, and the restaurant module on the right.

VR Module Descriptions

In the public transportation module, the user is instructed to select a bus route that will bring them to a destination in the shortest time and least number of stops (Table 9). Once the user selects the correct bus route, they board a virtual bus and must disembark it at the correct bus stop. Later levels build on this task to increase complexity, such as increasing the ambient noise and navigating a detour. The second module is situated in a home-based environment where users encounter situations, such as introducing oneself to a houseguest and responding to a flood in a kitchen. Finally, in the third environment, the user takes on the role of a server in a restaurant and is responsible for relaying food orders from customers to the kitchen. In later levels, the number of food items the user needs to remember increases. In all modules, there are four levels that feature tasks of increasing cognitive difficulty to increase psychosocial functioning.

Table 9. ThinkTactic VR example tasks.

Level	Task Description	Example Target Domains
Public transportation module		
Level 2	Selecting a bus route that brings a	Problem-solving,

	user to their destination in the shortest amount of time and stops	decision-making, attention
Level 3	Virtual avatars stare at the user as they onboard the bus	Emotion regulation, attribution bias, theory of mind, attention
Level 4	Remembering the order number of a grocery order at a store	Memory
Apartment module		
Level 2	Responding to a flood in the kitchen	Problem-solving, emotion regulation, attention
Level 3	Introducing oneself to an avatar	Emotion regulation, theory of mind
Level 4	Selecting takeout food from a series of options while keeping on budget	Problem-solving, decision-making
Restaurant module		
Level 1 to level 4	Recalling a food order from a table	Memory, attention

Discussion

Principal Results

The ThinkTactic VR CR program was co-developed with CEs and HPs through an iterative process. Both groups identified treatment needs and provided feedback, which directly informed the design of the program. Their input also highlighted the potential of VR interventions to facilitate transfer, generalizability, and engagement, reinforcing the value of integrating immersive technology into cognitive remediation. Both groups identified the need for a program addressing neurocognitive and social-cognitive deficits, highlighting the importance of real-world applicability. Each group also brought unique priorities: CEs mentioned the need for an immersive experience, while HPs focused on tailoring the program to individual clients. HPs also noted the importance of bridging the research-to-practice gap, improving patient engagement, and overcoming limited healthcare resources. CEs stressed the need for innovative treatments that integrate technology to enhance efficacy and support community integration.

Our results align with previous studies that involved user input during the development of cognitive remediation programs in virtual reality and identified similar needs, particularly regarding

the importance of exercises feeling immersive and representing real-life situations. One study adapted an intervention for social cognition in VR with individuals with early episode psychosis and highlighted the importance for the program to be immersive [40]. Interestingly, Hernandez et al. [31] conducted a similar study that analyzed the perspectives of individuals with mood disorders and HPs while developing a neurocognitive training program. Similar themes were identified, including the importance of an immersive aspect of a VR program, and contextualizing training in real-world scenarios to promote transfer [31]. Afterwards, Hernandez et al. [31] modified their prototype to reflect the feedback gathered and the treatment needs of their user groups. ThinkTactic VR is the first co-developed a program of CR that target both neurocognition and social cognition. Additionally, rather than modifying an existing VR program, our development approach involved creating a novel VR CR intervention from the ground up with input from those with lived experience and healthcare professionals.

ThinkTactic VR was developed according to a framework proposed for the development of VR interventions [22]. As recommended, the development process of ThinkTactic VR integrated empathy into its approaches and promoted inspiration by listening to the needs of CE and HPs. ThinkTactic VR also featured an extensive collaboration with CEs, HPs, software developers, and researchers where individuals brainstormed ideas for the program. Any ideas that were not feasible at this point of time due to resource and time constraints were noted down for future refinement of ThinkTactic VR (Table 8). Finally, an iterative, bottom-up process was used to design and develop ThinkTactic VR. The iterative approach to program development facilitated continuous user feedback loops that ensured any changes incorporated continued to integrate the needs of CEs and HPs.

ThinkTactic VR also incorporates the four essential components of a CR program identified in a working group [9]. First, a VR coach that provides CR was integrated into the program. The program is also designed for a user to be accompanied by a trained therapist. This therapist facilitates

engagement with the program and supports the user in identifying how CR can be applied to their functioning goals. Second, ThinkTactic VR features tasks that train neurocognition and social cognition in the context of cognitively challenging scenarios that resemble those encountered in daily life. Users engage in multiple repetitions of a task throughout four levels where the tasks increase in difficulty, providing continuous training. These tasks aid a user in developing problem-solving strategies and promote monitoring strategies, the third component of a CR program. Finally, delivering CR in VR may increase the transfer of learned skills and strategies that ultimately increase psychosocial functioning. Individuals get more exposure to cognitively challenging tasks they might otherwise avoid. They can also practice multiple times in a safe environment that resembles situations they may encounter in their life, allowing them to apply skills and strategies that facilitate generalization [41].

Initial pilot testing of a ThinkTactic VR module show it is feasible and acceptable for individuals with psychotic disorders [20]. A pilot randomized control trial (NCT05973110) is currently underway to evaluate the initial efficacy, feasibility, and acceptability of the full ThinkTactic VR program. The results of this trial will provide critical insights that will guide further revisions of the program.

Limitations and Future Directions

While we did our best to incorporate the suggestions of the participants, monetary and time restraints limited the full implementation of all suggestions (Table 8). The current study was also disrupted by the COVID-19 pandemic. Working groups were initially delivered in person (CE working groups one to five, HPs working group one) where participants could directly test the VR program and provide feedback. With the onsite restrictions introduced to reduce the transmission of COVID-19, all working groups were moved to an online format. Instead of immersing the participants in the VR program, participants watched pre-recorded videos of the program. Accordingly, there were limited opportunities to test the VR equipment (e.g., headset, controllers).

This switch to an online format may have changed the perceptions of the program, thus impacting the feedback provided. Finally, the sample size was relatively small, and the attendance of the CEs working groups fluctuated over time.

Conclusion

ThinkTactic VR is the first virtual reality cognitive rehabilitation program targeting both neurocognition and social cognition for individuals with psychotic disorders. It was co-developed with individuals with lived experience and healthcare professionals through an iterative process, incorporating feedback and suggestions from design to creation. The program was specifically developed to meet the needs of end-users. It aims to improve cognition through scenarios grounded in tasks that simulate daily activities, potentially leading to better community functioning. Future studies are needed to assess its efficacy and further refine its development to ensure implementation and scalability.

Acknowledgements

We would like to thank Sebastien Nadeau for their support in leading a CEs working group and their contribution to the modifications done to ThinkTactic VR. We greatly appreciate the support provided by Claire Mayaud and Abigail Bradley in the transcription process for the CEs and HPs working groups. Finally, we sincerely thank Dr. Kristelle Alumni-Menichini for their advice in the design, working group format, and analysis of the study.

This study was funded by the New Frontiers for Research Fund – Exploration (Tri-Council Agency); the Emerging Research Innovators in Mental Health (University of Ottawa Institute of Mental Health Research); and the Chercheur-boursier junior 1 (Fonds de Recherche du Québec – Santé).

Statement of Contributions

Conceptualization: Synthia Guimond.

Methodology: Synthia Guimond, Hannah Matheson, Alexandra Thérond, Stéphane Bouchard, and

Marie-Christine Rivard.

Software: Stéphane Bouchard, Simon Tremblay, Marie-Christine Rivard, Synthia Guimond, Jasmin Yee, Hannah Matheson, and Alexandra Thérond.

Formal analysis: Jasmin Yee, Bryce J. M. Bogie, Emilie Du Perron, Alexandra Thérond, Catheleine van Driel, Hannah Matheson, and Chelsea Noël.

Investigation: Hannah Matheson, Alexandra Thérond, Jasmin Yee, Synthia Guimond, Simon Tremblay, Marie-Christine Rivard, Ana-Marie Cretu, Maëlle Charest, Marika Goyette, Ya Ting Lei, Kagusthan Ariaratnam, Greg Collins, Chris Gorman, Stéphane Bouchard, Angela Stewart, Alexandra Baines, David Attwood, Catherine Cullwick, Crystal Morris, Christopher R. Bowie.

Data curation: Jasmin Yee, Maëlle Charest, and Synthia Guimond.

Writing – original draft: Jasmin Yee, Hannah Matheson, and Maëlle Charest.

Writing – review & editing: Bryce J. M. Bogie, Synthia Guimond, Jasmin Yee, Alexandra Thérond, Chelsea Noël, Émilie Du Perron, Catheleine van Driel, Ya Ting Lei, Maëlle Charest, Hannah Matheson, Marika Goyette, Alexandra Baines, Angela Stewart, Stephane Bouchard, Catherine Cullwick, Crystal Morris, David Attwood, Ana-Marie Cretu, Simon Tremblay, Marie-Christine Rivard, Christopher R. Bowie, Kagusthan Ariaratnam, Greg Collins, and Chris Gorman.

Visualization: Émilie Du Perron, Jasmin Yee, and Synthia Guimond.

Supervision: Synthia Guimond.

Project administration: Jasmin Yee, Hannah Matheson, and Alexandra Thérond.

Funding acquisition: Synthia Guimond, Stéphane Bouchard, and Ana-Marie Cretu.

Conflicts of Interest

AB has received an honorarium from Otsuka-Lundbeck in the past two years. Beyond the two years, AB has received honorariums from Otsuka-Lundbeck, Janssen, and HLS Therapeutics.

SB is the president and owner of Cliniques et Développement In Virtuo, a university spin-off that distributes virtual environments. The terms of these arrangements have been reviewed and

approved by the Université du Québec en Outaouais in accordance with its conflict-of-interest policies.

CRB receives in-kind research accounts from Scientific Brain Training and royalties from Oxford University Press. CRB is also the owner of Kingston Cognitive Fitness.

SG provides consulting services for Boehringer Ingelheim and receives financial compensation from the company.

Abbreviations

CEs: content experts
CR: cognitive remediation
HPs: healthcare professionals
VR: virtual reality

References

1. Jahn FS, Skovbye M, Obenhausen, Jespersen AE, Miskowiak KW. Cognitive training with fully immersive virtual reality in patients with neurological and psychiatric disorders: a systematic review of randomized controlled trials. Psychiatry Research. 2021;300:113928. PMID: 33857847
2. Crismon L, Argo TR, Buckley PF. Schizophrenia. In: DiPiro JT, Talbert RL, Yee GC, Barbara GW, Posey LM, editors. Pharmacotherapy: a pathophysiologic approach. 9th ed. New York, New York: McGraw-Hill; 2014. pp. 1019–1046
3. Kelly S, Guimond S, Lyall A, Stone WS, Shenton ME, Keshavan M, Seidman LJ. Neural correlates of cognitive deficits across developmental phases of schizophrenia. Neurobiology of Disease. 2019;131:104353. PMID: 30582983.
4. Fizdon JM, Fanning JR, Johannesen JK, & Bell MD. Social cognitive deficits in schizophrenia and their relationship to clinical and functional status. Psychiatry Research. 2014;205(1-2):25-29. PMID: 23017655.
5. Green MF, Horan WP, Lee J. Social cognition in schizophrenia. Nature Reviews Neuroscience. 2015;16(10):620-31. PMID: 26373471.
6. Higuchi Y, Sumiyoshi T, Seo T, Suga M, Takahashi T, Nishiyama S, Komori Y, Kasai K, Suzuki, M. Associations between daily living skills, cognition, and real-world functioning across stages of schizophrenia; a study with the schizophrenia cognition rating scale Japanese version. Schizophrenia Research Cognition. 2017;7:13-18. PMID: 28740824.
7. Leucht S, Cipriani A, Spineli L, Mavridis D, Orey D, Richter F, Samara M, Barbui C, Engel RR, Geddes JR, Kissling W, Stapf MP, Lässig B, Salanti G. Davis JM. Comparative efficacy and tolerability of 15 antipsychotic drugs in schizophrenia: a multiple-treatments meta-analysis. Lancet. 2013;382(9896):951-62. PMID: 23810019.
8. Bortolato B, Miskowiak KW, Köhler CA, Vieta E, Carvalho AF. Cognitive dysfunction in

bipolar disorder and schizophrenia: a systematic review of meta-analyses. Neuropsychiatric Disease and Treatment. 2015;11:3111-25. PMID: 26719696

9. Bowie CR, Bell MD, Fiszdon JM, Johannesen JK, Lindenmayer JP, McGurk SR, Medalia AA, Penadés R, Saperstein AM, Twamley EW, Ueland T, Wykes T. Cognitive remediation for schizophrenia: an expert working group white paper on core techniques. Schizophrenia Research. 2020;215:49-53. PMID: 31699627
10. Kurzban S, Davis L, Brekke JS. Vocational, social, and cognitive rehabilitation for individuals diagnosed with schizophrenia: a review of recent research and trends. Current Psychiatry Reports. 2010;12(4):345-55. PMID: 20574811
11. Matsuda Y, Makinodan M, Morimoto T, Kishimoto T. Neural changes following cognitive remediation therapy for schizophrenia. Psychiatry and Clinical Neurosciences. 2019;73(11):676-684. PMID: 31278805
12. Wykes T, Huddy V, Cellard C, McGurk SR, Czobor P. A meta-analysis of cognitive remediation for schizophrenia: methodology and effect sizes. American Journal of Psychiatry. 2011;168(5):472-85. PMID: 21406461
13. McGurk SR, Twamley EW, Sitzer DI, McHugo GJ, Mueser KT. A meta-analysis of cognitive remediation in schizophrenia. American Journal of Psychiatry. 2007;164(12):1791-802. PMID: 18056233
14. Lejeune JA, Northrop A, Kurtz MM. A meta-analysis of cognitive remediation for schizophrenia: efficacy and the role of participant and treatment factors. Schizophrenia Bulletin. 2021;47(4):997-1006. PMID: 33772310
15. Harvey PD, Bowie CR. Cognitive enhancement in schizophrenia: pharmacological and cognitive remediation approaches. The Psychiatric clinics of North America. 2012;35(3):683-98. PMID: 22929873
16. McCleery A, Nuechterlein KH. Cognitive impairment in psychotic illness: prevalence, profile

of impairment, developmental course, and treatment considerations. Dialogues in Clinical Neuroscience. 2019;21(3):239-248. PMID: 31749648

17. Glenthøj LB, Hjorthøj C, Kristensen TD, Davidson CA, Nordentoft M. The effect of cognitive remediation in individuals at ultra-high risk for psychosis: a systematic review. NPJ Schizophrenia. 2017;3:20. PMID: 28560266
18. Piskulic D, Barbato M, Liu L, Addington J. Pilot study of cognitive remediation therapy on cognition in young people at clinical high risk of psychosis. Psychiatry Research. 2015;225(1-2):93-98. PMID: 25467705.
19. Schroeder AH, Bogie BJM, Rahman TT, Thérond A, Matheson H, Guimond S. Feasibility and efficacy of virtual reality interventions to improve psychosocial functioning in psychosis: systematic review. JMIR Mental Health. 2022;9(2). PMID: 35179501
20. Bogie BJM, Noël C, Gu F, Nadeau S, Shvetz C, Khan H, Rivard MC, Bouchard S, Lepage M, Guimond S. Using virtual reality to improve verbal episodic memory in schizophrenia: a proof-of-concept trial. Schizophrenia Research: Cognition. 2024;36:100305. PMID: 38486790
21. Tarnanas I, Schlee W, Tsolaki M, Müri R, Mosimann U, Nef T. Ecological validity of virtual reality daily living activities screening for early dementia: longitudinal study. JMIR Serious Games. 2013;1(1). PMID: 25658491
22. Birckhead B, Khalil C, Liu X, Conovitz S, Rizzo A, Danovitch I, Bullock K, Spiegel B. Recommendations for methodology of virtual reality clinical trials in health care by an international working group: iterative study. JMIR Mental Health. 2019;6(1):e11973. PMID: 30702436
23. Brander M, Egger ST, Hürlimann N, Seifritz E, Sumner RW, Vetter S, Magnenat S. Virtual reality human-human interface to deliver psychotherapy to people experiencing auditory verbal hallucinations: development and usability study. JMIR Serious Games. 2021;9(2):e26820. PMID: 33769295

24. Rizzo AS, Koenig ST, Talbot TB. Clinical virtual reality: emerging opportunities for psychiatry. FOCUS The Journal of Lifelong Learning in Psychiatry. 2018;16(3):266-278. PMID: 31975921
25. Martens MA, Antley A, Freeman D, Slater M, Harrison PJ, Tunbridge EM. It feels real: physiological responses to a stressful virtual reality environment and its impact on working memory. Journal of Psychopharmacology. 2019;33(10):1264-1273. MID: 31294651
26. Nijman SA, Pijnenborg GHM, Vermeer RR, Zandee CER, Zandstra DC, van der Vorm D, de Wit - de Visser AC, Meins IA, Geraets CNW, Veling W. Dynamic interactive social cognition training in virtual reality (discovr) versus virtual reality relaxation (VRelax) for people with a psychotic disorder: a single-blind multicenter randomized controlled trial. Schizophrenia Bulletin. 2023;49(2):518-530. PMID: 36413388
27. Fornells-Ambrojo M, Barker C, Swapp D, Slater M, Antley A, Freeman D. Virtual reality and persecutory delusions: safety and feasibility. Schizophrenia Research. 2008;104(1-3):228-36. PMID: 18571899.
28. Rus-Calafell M, Gutiérrez-Maldonado J, Ortega-Bravo M, Ribas-Sabaté J, Caqueo-Urízar A. A brief cognitive-behavioural social skills training for stabilised outpatients with schizophrenia: a preliminary study. Schizophrenia Research. 2013;143(2-3):327-36. PMID: 23235141.
29. Sorkin A, Weinshall D, Modai I, Peled A. Improving the accuracy of the diagnosis of schizophrenia by means of virtual reality. American Journal of Psychiatry. 2006;163(3):512-20. PMID: 16513875.
30. Bell I, Pot-Kolder RMCA, Wood SJ, Nelson B, Acevedo N, Stainton A, et al. Digital technology for addressing cognitive impairment in recent-onset psychosis: a perspective. Schizophrenia Research Cognition. 2022;28:100247. PMID: 35281550
31. Hernandez ME, Michalak E, Choudhury N, Hewko M, Torres I, Menon M, Lam RW, Chakrabarty T. Co-design of a virtual reality cognitive remediation program for depression (bWell-D) with patient end users and clinicians: qualitative interview study among patients and

clinicians. JMIR Serious Games. 2023;11:e43904. PMID: 37027183

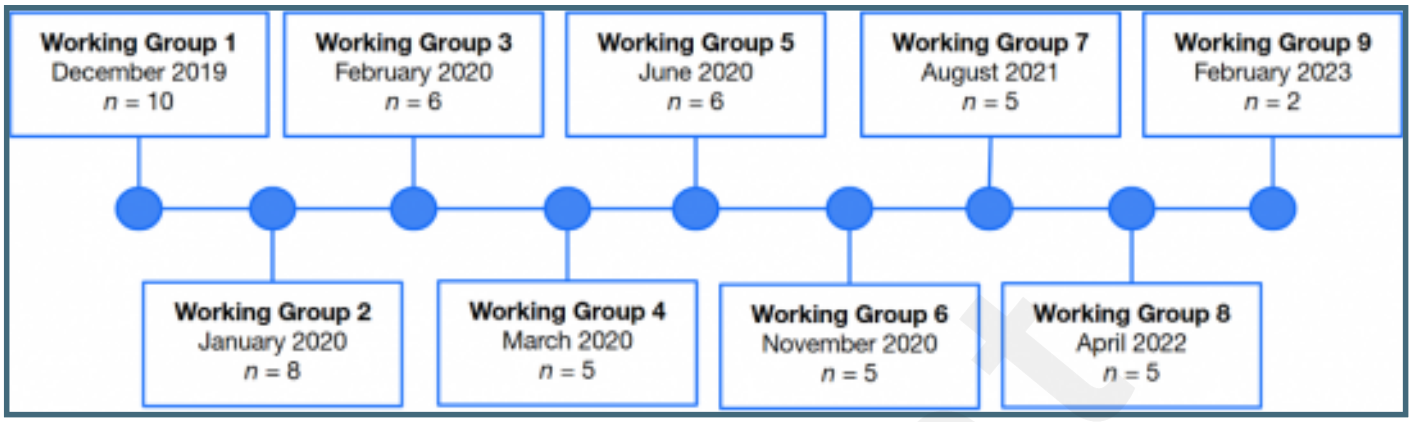
32. Mummah SA, Robinson TN, King AC, Gardner CD, Sutton S. IDEAS (Integrate, Design, Assess, and Share): a framework and toolkit of strategies for the development of more effective digital interventions to change health behavior. Journal of Medical Internet Research. 2016;18(12):e317. PMID: 27986647
33. Barlati S, Deste G, De Peri L, Ariu C, Vita A. Cognitive remediation in schizophrenia: current status and future perspectives. Schizophrenia Research and Treatment. 2013;2013:156084. PMID: 24455253
34. Lyon AR, Koerner K. User-centered design for psychosocial intervention development and implementation. Clinical Psychology Science and Practice. 2016;23(2):180-200. PMID: 29456295
35. Kennedy RS, Lane NE, Berbaum KS, Lilienthal MG. simulator sickness questionnaire: an enhanced method for quantifying simulator sickness. The International Journal of Aviation Psychology. 1993;3(3):203–220. https://doi.org/10.1207/s15327108ijap0303_3
36. Bellack A, Mueser T, Gingerich S, Agresta J. Social skills training for schizophrenia (2nd ed.). The Guilford Press; 2004. ISBN: 1-57230-846-X
37. Friedberg RD, McClure JM, Garcia JH. Cognitive therapy techniques for children and adolescents: tools for enhancing practice. Guilford Press; 2009. ISBN: 9781462520077
38. Wykes T, Reeder C. Cognitive remediation therapy: theory and practice. Routledge; 2005. ISBN: 9781583919712
39. Braun V, Clarke V. Using thematic analysis in psychology. Qualitative Research in Psychology. 2006;3(2): 77–101. https://doi.org/10.1191/1478088706qp063oa
40. Realpe A, Elahi F, Bucci S, Birchwood M, Vlaev I, Taylor D, Thompson A. Co-designing a virtual world with young people to deliver social cognition therapy in early psychosis. Early Intervention in Psychiatry. 2020;14(1):37-43. PMID: 30908854

41. Jespersen AE, Røen IS, Lumbye A, Nordentoft M, Glenthøj LB, Miskowiak KW. Feasibility and effect of an immersive virtual reality-based platform for cognitive training in real-life scenarios in patients with mood - or psychotic disorders: a randomized, controlled proof-of-concept study. Neuroscience Applied. 2023;2: 101120. https://doi.org/10.1016/j.nsa.2023.101120

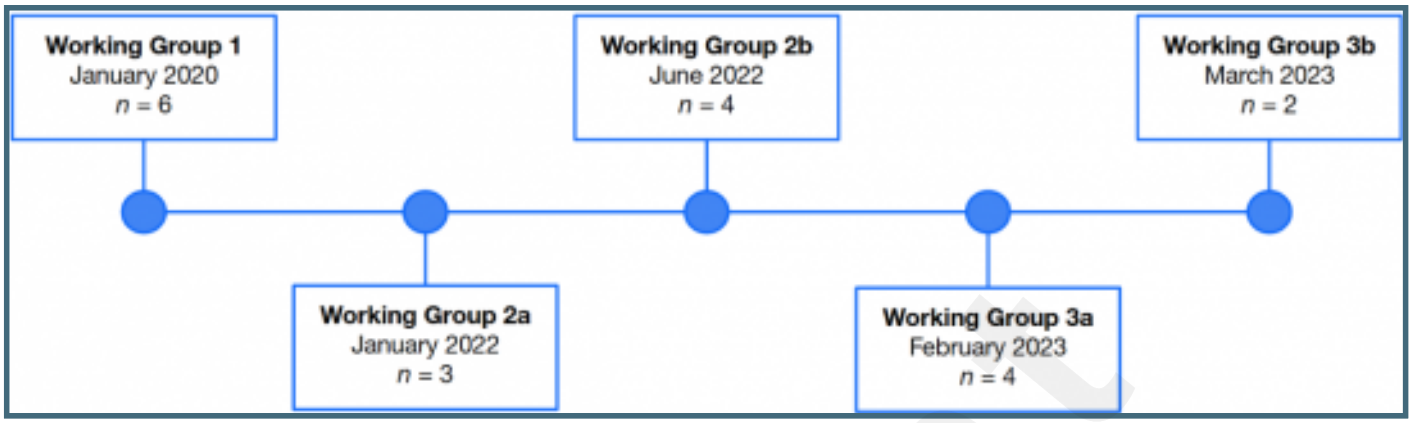
Supplementary Files

Figures

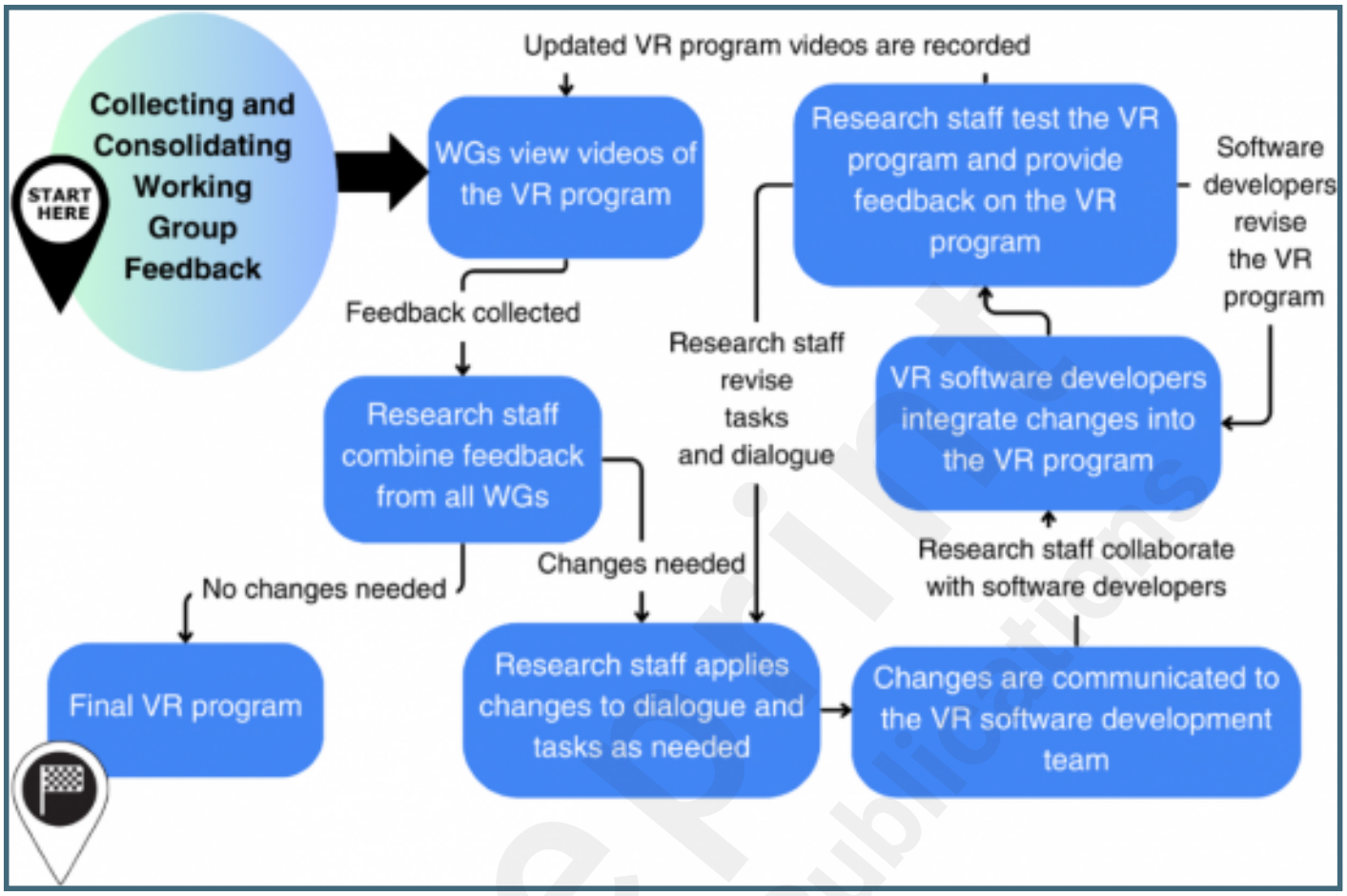
CEs working group timeline.



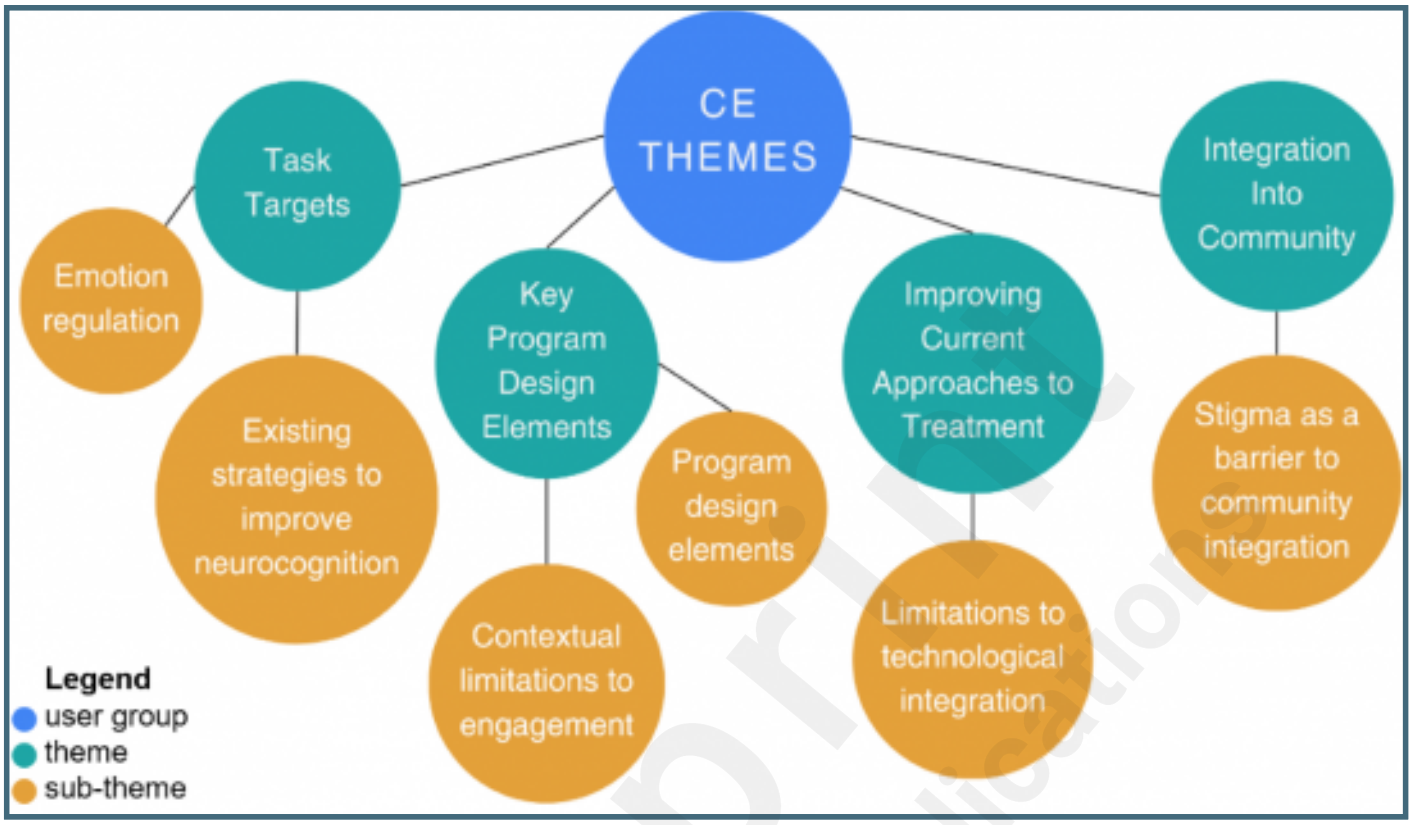
HPs working groups timeline.



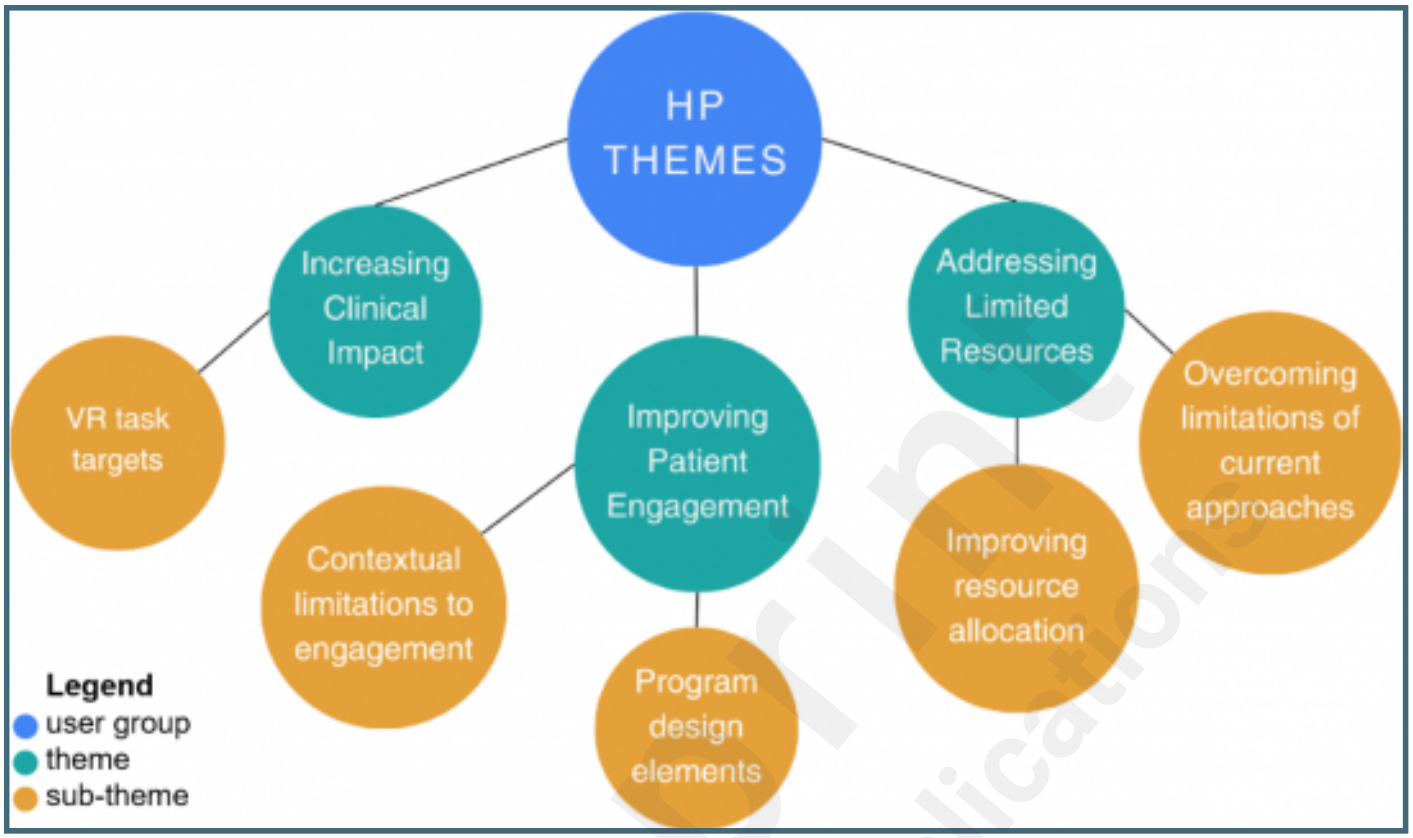
Iterative process to program development.



CEs thematic map.



HPs thematic map.



ThinkTactic VR program photos.

Multimedia Appendixes

CEs Demographic.
URL: http://asset.jmir.pub/assets/db417efbb47e9d0cb596ff8765c7ebba.docx

Thematic analysis quote exemplars.
URL: http://asset.jmir.pub/assets/f8c9cbe96812f22ce367f74a29847e67.docx