Social Skills Acquisition in Virtual Reality-Based Interventions for People with Mental Health and Substance Use Disorders: A Qualitative Exploration

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Abstract

Background: People with concurrent mental health and substance use disorders (MHD and SUD) suffer from marginalization, leading to high levels of mortality and morbidity. Social participation requires certain social abilities, which are often inadequate in this group. Focusing on functional recovery and aiding people in the process of becoming active and participating citizens are thus key parameters in the recovery process for people with MHD and SUD.
Recent research on virtual reality-based interventions shows a particularly promising trans-diagnostic potential in improving social functioning and quality of life across the spectrum of neuropsychiatric disorders. However, research on digitalized cognitive remediation does not show generalization to everyday life. Key working mechanisms of the interactive, digital social environments in virtual realities have yet to be identified. We also lack understanding of how we can best design and structure immersive learning experiences to promote social skills acquisition and retention for people with mental health and substance use disorders.

Objective: The aim of this study was to explore how virtual reality-based interventions may be tailored to promote social skills acquisition and retention for people with concurrent mental health and substance use disorders.

Methods: Eight individual in-depth interviews with adults in recovery from mental health and substance use disorders were conducted in a mmedium-sized municipality in eastern Norway during the fall of 2022. The interviews were analyzed using template analysis in a process involving peer researcher collaboration

Results: The present study shows that human capacity to achieve sustained learning outcomes from multisensory perception in immersive learning experiences is limited in general. This study also shows that people with mental health and substance use disorders have particularly deficient immersive learning abilities, as well as disadvantageous social learning prerequisites.

Conclusions: Social skills acquisition and retention depend on restructuring dysfunctional cognitive schemas in the virtual reality user's long-term memory. Chunking VRI content into micro scenarios that may be repeated and structured according to individual learning prerequisites may enable the restructuring of a dysfunctional social schema and possibly ensure the storage of the new, repaired schema in the user's long-term memory. It is therefore suggested that virtual reality-based interventions for social skills training should be designed as short, focused micro scenarios, orchestrated in a sequenced or otherwise carefully and deliberately structured learning workflow. Clinical Trial: clinicaltrials.gov ref. NCT05653167

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Keywords:

mental health and substance use disorders; social participation; virtual reality-based interventions; social skills learning; template analysis.

Paper type

Original article

Introduction

People with concurrent mental health and substance use disorders (MHD and SUD) suffer from severe marginalization, which may lead to high levels of mortality and morbidity [1, 2]. Recognizing individuals with MHD and SUD as citizens with the right to live a life of dignity in the community, while mitigating their social marginalization, is fundamental for their recovery and community integration [3, 4]. However, social participation also relies on people's social performance and ability to cope with the responsibilities that come with citizenship [5, 6]. Social skills form the basis for social performance appropriate to the context and expectations of others [7]. Focusing on functional recovery and psychosocial rehabilitation is important to help poorly functioning individuals to develop the emotional, social, and intellectual skills needed to live, learn, and work in the community with minimal professional support [6, 8].

Virtual reality-based interventions (VRIs) for cognitive training and recovery are a rapidly growing field in mental health treatment. Recent research on VRIs shows a promising trans-diagnostic potential in improving social functioning and quality of life, across the spectrum of neuropsychiatric disorders [2, 9-15]. The concept of VRIs for mental health is to be understood as all kinds of interventions using VR technology (VRT) to promote psychological and/or behavioral change in order to achieve symptom reduction or improved psychosocial functioning. These interventions target common underlying mechanisms in disorders and are therefore amenable to use across a broad population, including people with MHD and SUD [16-19].

Research from a number of different disciplines using VR-based immersive learning shows that VRT is generally effective in recreating sufficient realism in simulations to provide emotional responses and adequate learning outcomes in experimental settings [12, 20, 21]. Immersive learning refers to all kinds of learning in virtual reality environments that provide a real sense of presence, presented as a digital simulation, serious games application or something in between [22, 23]. However, the extent to which users acquire skills from VR-based learning has been largely overlooked [24]. Focusing on genuine improvements in real world functioning is essential in developing new measures for addressing deficits associated with mental health disorders and substance use [18].

All learners are not equally capable of effective and efficient learning [25]. The characteristics of a population group targeted by digital interventions are important uptake determinants. These influence the impact that any digital intervention may have on their functional trajectories [26]. It is also vital to understand the target group's digital literacy and their perception of the use of digital interventions as these are key uptake factors for all types of digital interventions [26]. Further challenges when developing efficient VRIs are human limitations of transferring skills from virtual to real environments and long-term maintenance of VRI learned skills in real-world environments [10, 12, 27-31].

Challenges associated with human factors in immersive learning in general include health, physiology, adverse effects, cognitive load and compatibility [32]. Little research has been conducted on uptake factors for immersive learning or feasibility of VRIs among people with MHD and SUD [33]. Thus, the target group's uptake factors for digital interventions and immersive learning should be studied empirically. However, the key working mechanisms of social skills acquisition in the

interactive, digital social environments of virtual realities in terms of clinical outcomes and behavior change have yet to be identified [10, 34, 35]. There is also a persistent lack of theoretical conceptualization and understanding of the characteristics of effective digital recovery support interventions [15, 33, 36, 37].

Theoretical conceptualization

In order to explore our target group's determinants for immersive learning uptake, we needed to enhance our understanding of the general theoretical principles of immersive learning. Understanding both the target group's uptake factors and theoretical principles of immersive learning is vital for developing efficient learning experience design in VRIs. Learning experience design involves creating learning activities that induce an active process of constructing and retaining knowledge, in addition to orchestrating learning activities in a sequenced or otherwise carefully and deliberately structured learning workflow [25].

In immersive learning, the term "immersion" describes how technological affordances facilitate learning by inducing a sense of presence or co-presence in virtual environments. "Learning" refers to the response to immersive experiences in human perceptual and motor systems [38].

Just as in-vivo social skills training is predominantly based on learning experiences derived from basic principles of social learning [7], VRIs are learning-based interventions that build on immersive learning mechanisms. This indicates that a theoretical framework for the learning experience design in VRIs may be derived from basic principles of human learning.

The process from sensory perception to employing new behavioral repertoires in real-world situations in social learning is referred to as social skills acquisition [39]. The concept of social skills acquisition may be understood as a learning uptake. This is a two-phased process consisting of social learning and social performance. Learning deals with how people construct knowledge through mental information and how cognitive structures develop and change. Social performance is the process of retrieving social skills from the cognitive schemas in the long-term memory, and applying these skills to appropriate behaviors in relevant real-life settings [39, 40].

In the context of virtual reality learning environments, learning occurs when learners actively organize sensory input into coherent information and construct meaningful mental representations from the information presented in the VRI scenario. These processes include selecting relevant phrases and image sequences as well as organizing them into coherent internal causal chains of the steps in information processing. Finally, the processes include structuring and storing the processed information as cognitive schemas in the long-term memory. Such a process is called constructivist learning [40]. This description of social skills acquisition also explains the neurocognitive mechanisms of skills transfer from virtual realities to real-life settings. The theoretical principles of social skills acquisition and constructivist learning thus also explain the causal mechanism of the ecological validity of VRIs.

The ecological validity of VRIs refers to the extent to which VRI users improve functioning, daily life skills, compensatory strategies, social participation, and psychological well-being in real-life settings and situations [10]. According to constructivist learning theory [40], learning occurs when learners are able to build referential connections between corresponding aspects of the visual and verbal representations of the learning object.

Constructivist learning is fostered when the learner is able to hold a visual representation in visual working memory and a corresponding verbal representation in verbal working memory at the same time [40]. However, the constructivist learning model also implies that the cognitive load on the working memory acts as a major impediment to social skills learning in multisensory learning environments, such as the virtual reality scenarios in VRIs [40].

Apparently, the link between high scenario authenticity, real-life fidelity and ecological validity has been a dominating assumption in the field of simulation-based learning [41]. Learning tasks are

mainly designed on the basis of real-life problem solving with complex element interactivity, under the assumption that this leads to effective task performance in real-life settings [42]. According to cognitive load theory, this is contradictory to the functionality of human cognition. Cognitive overload in learning leads to a collapse in memory processing and thus also in skills acquisition. Cognitive load theory is based on an assumption that the human cognitive system has a limited working memory [41]. This assumption is derived from Atkinson and Shiffrin's [43] classical work on multimodal memory. Atkinson and Shiffrin [43] explain human memory as a multimodal system consisting of sensory memory, a transient short-term memory buffer, often referred to as working memory, and a long-term memory store [18, 43].

The working memory enables transient ongoing evaluation, manipulation, and synthesis of newly acquired information. The working memory operates within the short-term memory and is closely interrelated with and interacts with attention and executive function [18]. According to Atkinson and Shiffrin's theory, human working memory is unable to hold more than five to nine information elements and can actively process no more than two to four elements at the same time. Additionally, all unprocessed information in the short-term memory is lost in about twenty seconds when dealing with novel memory obtained by perceptual information processing. All input that exceeds the sensory buffer capacity will be overwritten by new sensory inputs and forgotten before this sensory information is passed on for further processing [41].

In contrast to processing sensory input, short-term memory has no known limitations when dealing with information retrieved from long-term memory. Only skills stored as cognitive schemas are available and sustainable in long- term memory [41].

The long-term memory holds cognitive schemas that vary in their degree of complexity and automation. These schemas can then be treated as a single element in short-term memory and thus greatly decrease cognitive load associated with the performance of later tasks. This cognitive information processing is also referred to as working memory. Therefore, practicing skills already stored in the long-term memory allows for a far higher task load than novel skills learning [41].

The theoretical construct presented here implies that cognitive capacity, memory and executive functioning are the most important uptake factors for immersive learning, and thus also key immersive learning prerequisites. Additionally, prior social modelling is a key factor for prior schema development. Hence, the VRI beneficiaries' previous life experiences and present cognitive schemas act as key preconditions for uptake of social skills learning, as these schemas determine whether the users need to learn novel skills or to practice skills already stored in their long-term memory. Understanding the presence of these uptake factors among people with MHD and SUD is crucial for tailoring VRIs to this group's learning prerequisites. This is therefore the aim of the present empirical inquiry.

Aim of the study

The aim of this study was to explore the target group's immersive learning uptake factors, in order to understand how we may tailor learning experiences in VRIs to promote sustained learning uptake among people with MHD and SUD. The research question in this study was twofold:

1) What are the uptake factors for digital interventions for people with MHD and SUD?
2) What are the prerequisites of people with MHD and SUD for social skills learning through immersive learning experiences?

Methods

Context and design

This qualitative study was conducted with people in recovery from MHD and SUD as participants. This is a retrospective study on data from eight in-depth interviews with adults in this group. Data were obtained in a medium-sized municipality in Eastern Norway during the fall of 2022. The present study is part of the project *"VR as a facilitator for participation in society among persons with MHD and SUD*". The overall aim of this project is to develop and evaluate a VRI paradigm to promote social participation among people with MHD and SUD.
Our project was designed in accordance with the recommendations for methodology and scientific rigor of virtual reality trials in health care (VR-CORE) [44]. The present study is part of the formative VR1 phase of the VRI development project, where the focus is on content design by working with service users and providers through principles of human-centered design [44].

Sampling and recruitment

Data were obtained from a convenience-based sample [45], where the researcher provided information on the research and potential participants decided whether to volunteer to participate or not. We recruited the participants from a low-threshold facility aimed at supporting people with MHD and SUD. Recruitment consisted of the first author informing about the project at the facility and inviting potential participants for individual interviews. These indicated their interest in participation to the head of the facility. After screening for inclusion criteria, the interviews were scheduled by the head in collaboration with the researchers. The inclusion criteria were a) adults aged 18 years and older, b) self-reported MHD and SUD, and c) capacity to fully understand study information and provide informed consent.

Participants

We recruited eight persons with self-reported MHD/SUD, three females and five males. The average age of the participants was 48 years, ranging from 42 to 61 years. One participant was an eastern European immigrant, and one participant was not a native Norwegian, but had grown up with Norwegian foster parents. The other participants were native Norwegians.
Seven participants started substance use in early adolescence with an average age of onset of 12 years. Six participants reported prior polysubstance use with opiate dependency, including amphetamines, cocaine, cannabis, benzodiazepines and alcohol. These participants were in opiate agonist treatment at the time of the interviews. One participant reported polysubstance use without opiate dependency, and one participant reported opiate dependency only. All participants reported MHD, including anxiety, depression, attention deficit hyperactivity disorder, post-traumatic stress disorder, and personality disorders. All participants reported prior severe **social marginalization due to MHD/SUD.** The participant demographics are presented in Table 1.

Table 1: Participant demographics

Participant	Gender	Age	ASU[a]	PSU[b]	SUT[c]
P 1	M	51	44	OPI[1]	
P 2	M	42	11	PSUO[2]	OAT[4]
P 3	F	50	11	PSU[3]	
P 4	M	44	12	PSUO	OAT
P 5	M	51	10	PSUO	OAT
P 6	F	43	13	PSUO	OAT

P 7	F	61	10	PSUO	OAT
P 8	M	45	14	PSUO	OAT

a) age of substance use onset b) prior substance use c) substance use treatment
1)Opiate use only 2)Polysubstance use including opiate addiction
3)Polysubstance use without opiate addiction 4)Opiate agonist treatment

Data Collection

The first author conducted the first three interviews independently, while the other five were co-moderated by the first and second author. The interviews lasted from 24 to 90 minutes and followed a semi-structured interview guide. The interview guide consisted of open-ended questions on how the participants perceived their opportunities and prerequisites for participating in work, education, and cultural life in mainstream society. In order to ensure a comfortable and safe setting for the participants, we conducted our interviews at the low-threshold facility where the participants were recruited. All the interviews were audiotaped and transcribed verbatim. The second author is a peer support worker who has lived experience of MHD and SUD. He was involved in developing the interview guide, conducting the interviews and collaborated in the analysis.

Analysis

Key uptake factors for immersive learning were derived from the present theoretical construct and used as a priori themes in a template analysis with a deductive approach. A priori themes are themes that are defined *prior* to the start of the analysis, structured in a thematic template [46]. A priori themes are often based on theoretical ideas that have guided a particular study, as in the present study [46]. The initial analysis template comprised three themes derived from the theoretical principles of social skills learning described in the introduction: 1) digital uptake factors, 2) immersive learning prerequisites, and 3) social skills learning prerequisites. The thematic template is presented in Table 2:

Table 2: Thematic template

	A priori themes	A priori sub-themes
1	**Digital uptake factors**	Digital literacy
		Digital intervention receptiveness
		VRI expectations
2	**Immersive learning prerequisites**	Executive functioning
		Memory processing
		Cognitive capability
3	**Social skills learning prerequisites**	Prior social skills modelling

In the first step of the template analysis, the first author familiarized himself with the data by exploring the verbatim transcriptions of the interviews and by reading the transcriptions afterwards. In the second step, the first and second author generated initial codes from empirical statements within and across the transcripts. The first author then presented the empirical statements and initial coding to the other authors in step three. In step four, the meaning and relevance of the empirical statements were discussed at both semantic and latent levels with all authors. Step five consisted of the first author interpreting the data using the template. The results were then discussed with the second and fourth author in step six. In addition, the empirical findings were presented and discussed with the

interview participants. The first author wrote up the analysis in step seven. The third and fourth authors edited the analytic description and the first author wrote the final report of the results.

Ethics

This study was approved by the Regional Committee for Medical and Health Research Ethics (ref. #421376), and the Data Protection Officer of Innlandet Hospital Trust (ref. 18197741). The study was also registered at clinicaltrials.gov (ref. NCT05653167). All participants signed an informed consent and were allowed to withdraw from the study at any time.

Results

Three main themes were derived from the analysis based on the a priori thematic template: 1) VRI receptiveness, 2) Deficient immersive learning abilities, and 3) Disadvantageous social learning prerequisites. The overall theme structure with a priori themes, final themes and the associated codes are presented in the final thematic map in Table 3.

Table 3: Final Thematic Map

	A-priori themes	Final themes	Codes
1	Digital uptake factors	VRI receptiveness	Familiar technology
			Various digital experiences
			A safe learning space
2	Immersive learning abilities	Deficient immersive learning abilities	Short attention span
			Poor memory processing
			Inhibiting substances
3	Social skills learning prerequisites	Disadvantageous social learning prerequisites	Relearning social skills
			Novel social skills learning

In the following, the main themes and the codes will be explained and related to empirical statements from the participants. These are presented in italics to show how the content appeared in the interviews. The statements have been translated from Norwegian with the original meaning preserved as far as possible.

Theme 1: VRI Receptiveness

This theme refers to the participants' digital intervention uptake factors. This includes experience with digital technologies in general and VRT in particular. In general, the participants reported various levels of digital literacy. Some participants reported very little experience with using computers and expressed a perceived lack of digital literacy in their daily living.
These participants reported difficulty in using banking apps and web portals for public services. They also lacked access to digital technologies:

"I haven't learned much computer stuff. I should though, otherwise you'll get stuck in today's society." (P 6)

Other participants used computers on a daily basis in work practice and reported average user competence. Others reported extensive experience with gaming and serious interest in digital technology:

"I spend much of my days on Netflix and gaming […]." (P 8)

With regard to VRT in particular, the participants reported having heard of VR and having understandings and opinions about VR and VRTs. They all had seen head-mounted VR displays, and some had experience of using recreational VR applications.

"I have those cheap VR goggles at home, which I can put my phone inside, then I sit at the bottom of the sea watching sharks and so on." (P 3)

This theme also accommodates the participants' attitudes towards meeting technology-based interventions instead of those delivered by humans in MHD and SUD treatment. The participants with little digital experience reported interest in the possibility of new kinds of digital interventions to promote their recovery. Some participants described how their social anxiety was triggered by human presence regardless of the situation and their relationship with the person present. One participant explained how she felt that digital interventions could create a safe social learning space to benefit people who struggle with social anxiety:

"Well, I think VR goggles would be really effective for me. So I can sit at home and practice social skills so that I don't have to think about what I'm doing and what I'm saying and how I'm standing, because then I can focus on the things I want to focus on and not all the nonsense that I constantly get hung up about. So actually, I think VR would be very effective for me." (P 6)

Overall, the participants expressed positive attitudes towards VRI, and were receptive to using VRIs as a tool for social skills learning.

Theme 2: Deficient immersive learning abilities

This theme is related to the participants' abilities for acquiring social skills through immersive learning experiences. The participants described a wide range of social and functional impairments in their daily living. Their difficulties varied, but they all reported problems with concentration and short-term memory to an extent that impaired their everyday functioning. Remembering appointments and messages was difficult for all the participants. They related many of their daily challenges to experiences they reported about difficulty in regulating attention, remembering things, or concentrating on tasks. They reported more profound impairments such as the inability to recognize people and retain knowledge. The participants narrated their everyday struggles in different ways:

"I cannot concentrate... I can't even read books, and I love to read." (P 1)

"Well, I forget things, like if I'm just going to get something from the kitchen, I have to go back because I forget what I was supposed to be doing." (P 3)

These quotations illustrate the participants' attention deficits and short-term memory. Several of them reported better functioning prior to starting serious substance use and elaborated on how their mental capacity had deteriorated due to excessive polysubstance use and possible hypoxic brain damage from multiple overdoses:

"[…] I reckon I've messed up quite a few things in my head because of my substance use, so I'm very forgetful." (P 2)

"I've had 36 overdoses when I was given an antidote, so I should have been dead a long time

ago." (P 8)

The participants claimed some improvement in their cognitive deficits after abstaining completely from substance use for an extended period. However, none of them had experienced full recovery of their cognitive abilities. Several of them talked about how they did not understand the impact of sobriety until they became entirely sober. They described how abstaining totally from substance use had been important for their functioning and well-being. They also reported that being clean was vital for benefiting from learning-based interventions. One of the participants expressed it in this way:

"You have to give up powder and cut out tablets, the most important thing is you have to abstain from substance use enough to get to a point where you're able to think." (P 7)

The participants also talked about how opioid agonist therapy affected them in their everyday functioning. One participant explained his situation as follows:

"I need to get off that methadone and all that stuff because it limits me so much in everything — I sweat and get tired and get totally worn out — just from washing up my dishes." (P 3)

Theme 3: Disadvantageous learning prerequisites

This theme describes the life experiences that have formed the participants' cognitive schemas for social skills, and which determine their social learning prerequisites. Some of the participants described adverse childhood experiences, such as neglect, domestic violence, substance use or lack of empathic responses from their caregivers. Others described warm relations with their parents and siblings, but harsh social treatment with bullying and exclusion among their peers and in school. One of the participants explained:

"We lived quite a sheltered life when I was little…until I started elementary school. There the whole school bullied me, and when I got home my father gave me a beating […] it was a lot like that." (P 3)

Additionally, the participants described many adverse experiences during their lives in substance use communities. Due to substance use onset early in their pre-adolescence, they were associated with their local substance use communities from a very young age. They described these scenes as harsh environments that exposed them to deviant behavior, such as violence, exploitation and intimidation:

"It's a kind of environment, on the streets, that comes with a lot of stuff…" (P 8)

Several of the participants also stated that when they came off substances, they found themselves at the same socio-emotional stage as when they started using them. They explained that they were still struggling with immature socio-emotional functioning and described a perceived lack of adult behavioral repertoires. One participant put it this way:

"[…] now I've just woken up from twenty-four years of substance use […] and I notice that I have the same mental problems I had when I was fourteen." (P 7)

The participants spoke about adverse school experiences. Several described learning difficulties and little help from teachers. They also talked of social exclusion and bullying in elementary school. They often skipped classes and most of them were early drop-outs. Overall, the participants expressed that they were missing much of the emotional and social skills they believed were required for appropriate adult functioning. The participants also perceived their current social abilities as unfit for participation in mainstream society among people they considered normal. One of them summed it up in this way:

"[….] you kind of have to learn everything all over again, learn to be human and relearn how to live." (P 6)

Discussion

This study sought to provide a better understanding of vital uptake factors for social skills learning through immersive learning experiences among people with MHD and SUD. The main findings in this study were that the participants had wide disparities in digital literacy, but that they were positive towards using VRIs to promote their social participation and functional recovery. However, this study also indicates that the prerequisites for social skills learning in VRIs of people with MHD and SUD are inferior to those of the population in general. The participants reported various levels of experience with digital technologies, but they all knew what virtual reality was. They were receptive to meeting technology-based interventions instead of human-delivered measures in in MHD and SUD treatment.

The participants also suggested that technology-based interventions could alleviate social anxiety in social skills training, as such interventions enable social skills learning without the presence of humans, which triggers social anxiety. Overall, this study suggests that VRIs may be acceptable and feasible to use with people with MHD and SUD.

This is in line with a systematic review on the feasibility of digital interventions among MHD and SUD populations, which shows that VRIs are feasible, but not consistently effective [33]. A study on the feasibility of VRIs for people who experience psychosis shows that they are feasible and are accepted by this patient group [12].

In regard to immersive learning abilities, the participants reported difficulty with attention, concentration, and memory, which affected their daily functioning. This concurs with previous research showing that MHD and SUD often consist of various combinations of mental health disorders, neurodevelopmental disorders, post-traumatic stress disorders and long-term substance use complications that in combination result in substantial cognitive impairment [19, 47, 48]. It has also been found that a majority of people with MHD and SUD struggle with impaired learning prerequisites in various forms and severities [19]. Executive functioning is the most common problem area observed in people with problematic substance use [49]. This includes difficulty with planning, memory, problem solving and self-regulation. All these factors affect daily functioning, including the capacity to understand concepts and skills learnt in an intervention and apply them to daily living [49].

Several of the participants in the present study reported a short attention span and problems with attention regulation. Short-term memory processing relies on attention, and is crucial for constructing and reconstructing cognitive schemas that can be stored in the long-term memory [41]. Attention is key to awareness and focusing on a stimulus, or a set of sensory stimuli. Attention is also key to the perception, selection, and filtering of sensory input [18]. Sustained attention is the capacity to maintain attention over an extended period, whereas selective, or focused, attention is the ability to preferentially attend to a subset of stimuli [18]. VRIs with head-mounted displays isolate the user from external distractions and are thus hence well suited for catching the VRI user's attention. However, the learning outcomes in VRIs also rely on divided attention.

The constructive learning process in VRIs stems from constant multisensory inputs that depend on the individual's capacity to respond to multiple stimuli simultaneously and requires executive shifts in focused attention according to the demands of the particular VRI scenario [18, 40]. Attention and short-term memory processing are thus paramount abilities for constructing sustainable learning outcomes from multisensory learning experiences in VRIs. Cognitive load theory indicates that in VRIs tailored to people with poor executive functioning, all sensory input that is not directly involved in the learning conveyed may worsen rather than promote the desired learning outcome

[42].

Hence, minimizing unnecessary cognitive tasks in VRI scenarios for social skills learning is vital for the transfer of skills from virtual to real environments. VRI scenarios that only expose the user to sensory input necessary to convey particular learning goals may therefore provide high learning precision and promote efficient learning uptake.

Another finding in the present study is the participants' descriptions of their childhood and adolescence. They reported multiple experiences of adverse life events from early childhood as well as exposure as adolescents to deviant social behavior in substance use environments. The participants' descriptions of their immature socio-emotional functioning may indicate both poor and deviant socio-emotional development. Additionally, several descriptions of school experiences indicate that they had missed much school-related social learning, as early school dropout or excessive truancy robs certain children of opportunities to practice both academic and social skills [50]**.** These are key findings in regards to the participants' social learning prerequisites.

Adverse childhood experiences include a set of highly correlated traumatic and negative events that include child maltreatment (e.g., sexual, physical, and verbal abuse) and household dysfunction (e.g., parental divorce, familial substance use, mental illness, and incarceration) [51]. Adverse childhood experiences are one of the most robust predictors of substance use and are commonly found among people with MHD and SUD [51, 52]. The participants' reports of violence and intimidation in substance use environments are also in line with previous research [53, 54]. It is also well known that adverse childhood experiences can disrupt physiological pathways and the development of body systems. Over time, this can lead to cognitive and emotional impairments that directly affect learning abilities through neurocognitive pathways [51].

The participants' descriptions of adverse life experiences are an essential finding in regard to the orchestration of the learning workflow in a VRI. Adverse childhood and other deviant social experiences heavily affect the development of individuals' cognitive schemas. The cognitive schemas for interpersonal relationships that specify what to expect from others and how to treat them are formed during pre-adolescence in particular. Young people living in stressful or harmful environments can form atypical schemas that enable them to survive adolescence, but lead to serious problems when they are applied to adult relationships later in life [55]. When the onset of substance use and mental illness occurs before adult social skills are learned through natural processes, such as our participants described, individuals will often form inaccurate and dysfunctional cognitive schemas for the requisite skills for independent functioning and personal coping. This is commonly found in people with MHD and SUD [55]. Dysfunctional schemas cannot be altered or adapted to new situations or new social contexts in the same way as functional schemas.

According to Young's [55] theory on early dysfunctional schema development, pre-adolescents exposed to stressful or otherwise difficult interpersonal environments where their emotional needs are not met develop dysfunctional beliefs about themselves and the world. With accumulated exposure to emotional stress and lack of empathic responses throughout the adolescent's development, these schemas become more abstract, complex, organized, dense and rigid. Hence, they also become increasingly difficult to change [55, 56]. This severely hampers the capability of developing social abilities and adapting them to new social circumstances, compared to people with functional and adaptive cognitive schemas. This presumably explains some of the problems the participants described with social participation in mainstream society. Hence, people with MHD and SUD often have serious difficulty in adopting appropriate social behavior in society at large. This is a key finding in regard to VRI learning experience design, as people's maladaptive cognitive schemas require a complete restructuring or overwriting in order to acquire and retain social skills [55]. Overwriting or restructuring old cognitive schemas or constructing new ones requires repeated practice and overlearning to ensure the assimilation and retention of social skills. Such learning is facilitated when errors are minimized and correct responses are strengthened with abundant positive reinforcement [7].

Strengths and Limitations

Lack of patient involvement, poor requirement definitions and lack of adaption to user feedback are some of the common factors that explain failures of digital interventions. Promoting empathy toward the design process involves carefully listening to and elucidating patients' perceptions, prerequisites and expectations, which is therefore important in VRI development [25, 44]. This is also important for user uptake, particularly for engaging traditionally hard to reach service user groups such as people with MHD and SUD [34, 57, 58]. Our human-centred design process and the peer worker collaboration throughout the research process were thus strengths of the present study. Our interviews with two interviewers, using a peer researcher as primary interviewer, also made a valuable contribution to the depth of our interviews and the richness of our data.

Convenience sampling involves both strengths and limitations. This study was aimed at a particularly vulnerable population which is traditionally hard to reach. Convenience sampling is a very considerate way of recruiting, and well suited for ensuring genuine voluntariness in vulnerable and hard to reach populations. This sampling method led to a sample of participants who were genuinely engaged in the interviews. Their willingness to share their experiences resulted in very rich data, considering the limited number of participants.

A limitation of this study is that our sampling did not encompass the full breadth of disparities in our multifaceted target group. Further, convenience sampling does not allow for generalization to other populations. As our study aims at developing interventions tailored to this particular target group, generalization is not relevant. Nevertheless, it is found that cognitive impairment affects daily and social functioning across the entire range of psychiatric diagnoses [18, 19]. The study may thus also be relevant for designing VRIs tailored to other populations.

Another limitation is the demographic context. This study was conducted in a Nordic welfare state. Thus, generalization to different demographic contexts may be limited, since social participation in society will always depend on civil rights and social opportunities as well as the individual's social abilities.

Conclusions and implications

In regard to uptake factors for digital interventions in people with MHD and SUD, this study showed wide disparities in digital literacy. However, the participants expressed receptiveness to VRIs, regardless of their digital literacy. As for the prerequisites for social skills learning through immersive learning experiences among people with MHD and SUD, we found that their capacity to achieve sustained learning outcomes from multisensory learning experiences in general is very limited. The present empirical data show that this group has deficient immersive learning abilities and disadvantageous social learning prerequisites.

Implications

The question that remains is how to design and orchestrate immersive learning experiences to promote sustained learning in people with MHD/SUD.

The findings in the present study indicate that people with MHD and SUD require precision learning, minimized cognitive load and spaced repetition to achieve social skills that are constantly relevant for use in real-world situations. Therefore, our VRI learning experience designs should be aimed at errorless learning structured in short scenarios that can be repeated until the desired learning outcome in each scenario is achieved. Minimizing cognitive load in the VRI scenarios and orchestrating the VRI scenarios in an appropriate learning workflow may be achieved by applying the principles of micro learning and spaced repetition to the learning experience design.

Micro learning involves a careful task analysis of the required VRI learning content in order to

identify specific learning units. When the required main learning units have been identified, the identified learning goals are broken down into short, focused units of learning content, called chunks or micro units [59]. These micro units constitute the learning goal of each scenario for learning social skills in the VRI. We conceptualize these VRI scenarios as micro scenarios, i.e., short, focused VRI scenarios aimed at learning one distinct social skill tailored to one micro unit of learning in a low fidelity environment with decreased element interactivity in order to minimize cognitive task load [42, 59].

Each micro scenario may be repeated according to the user's needs and wishes or according to the recommended principles of spaced repetition, based on Ebbinghaus' strategy to transfer acquired knowledge from short-term memory into long-term memory [60]. Ebbinghaus showed that rehearsals should be distributed over time to become more efficient. Instead of repeating a task many times in the same session, it is more efficient to reduce the number of repetitions and spread them over several sessions [60].
Chunking VRI learning goals into micro scenarios that can be repeated and structured according to individuals' learning abilities and prerequisites may enable the restructuring of maladaptive social schemas and promote the storage of repaired and new schemas in the VRI users' long-term memory. When the users have achieved their required social skills, they will be able to benefit from practicing these skills in more complex VRI scenarios, aimed at applying adequate social skills to relevant social situations simulated in high-fidelity scenarios with high-reality proximity.
This way of learning and practicing social skills may enable VRI users to further develop and adapt their new cognitive schemas based on real-world social experiences in the same manner as people with functional and adaptable cognitive schemas. Ultimately, this way of designing and structuring VRI learning experiences may enhance social performance and promote social participation of people with MHD and SUD in real-world settings.

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Data Availability

The anonymized transcripts used in this study are available from the corresponding author upon request.

Authors' Contributions

Conceptualization: JA, ML, and TS
Formal analysis: JA, FN
Writing, original draft: JA
Project administration: JA, ML
Funding acquisition: ML
Study design and data collection: JA, FN, and ML
Interpretation: JA, FN, ML, and TS
Writing, review and editing: JA, ML, and TS

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