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Review Article

# Virtual reality–based cognitive remediation in severe mental illness: Current evidence from a narrative review

Andrea Fiorillo [a,*], Stefano Barlati [b,c], Matteo Di Vincenzo [a], Umberto Albert [d,e], Giuseppe Carrà [f], Bernardo Dell'Osso [g,h,i], Giovanni Martinotti [j], Mario Luciano [a], Antonio Vita [b,c]

[a] Department of Psychiatry, University of Campania "Luigi Vanvitelli", 80138, Naples, Italy
[b] Department of Clinical and Experimental Sciences, University of Brescia, 25123, Brescia, Italy
[c] Department of Mental Health and Addiction Services, ASST Spedali Civili of Brescia, 25123, Brescia, Italy
[d] Department of Medicine, Surgery and Health Sciences, University of Trieste, 34129, Trieste, Italy
[e] Unità Clinica Operativa (UCO) Clinica Psichiatrica, Azienda Sanitaria Universitaria Integrata Giuliano-Isontina (ASUGI), 34128, Trieste, Italy
[f] Department of Medicine and Surgery, University of Milan Bicocca, 20126, Milan, Italy
[g] University of Milan, Department of Mental Health, Department of Biomedical and Clinical Sciences Luigi Sacco, 20157, Milan, Italy
[h] "Aldo Ravelli" Center for Neurotechnology and Brain Therapeutic, University of Milan, 20142, Milan, Italy
[i] Department of Psychiatry and Behavioral Sciences, Bipolar Disorders Clinic, Stanford University, CA 94305-5723, USA
[j] Department of Neurosciences, Imaging and Clinical Sciences, Università degli Studi G. D'Annunzio, 66100, Chieti, Italy

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ABSTRACT

Cognitive impairment is a pervasive feature across severe mental illnesses (SMIs), including schizophrenia spectrum disorders (SSDs), major depressive disorder (MDD), and bipolar disorder (BD), and is associated with poor functional outcomes and reduced quality of life. Cognitive remediation (CR) is an evidence-based psychosocial intervention aimed at improving cognitive functioning and daily functioning in individuals with SMI. In recent years, virtual reality (VR) has emerged as a promising modality for delivering CR in a more immersive, engaging, and ecologically valid manner. This narrative review synthesizes the current literature on the effectiveness of fully immersive VR-based CR interventions in SMI populations. Preliminary findings suggest that VR-CR may enhance treatment engagement, facilitate transfer of cognitive gains to real-life functioning, and support remote delivery. Although early results are encouraging, most available studies are limited by small sample sizes, short follow-up periods, and lack of standardized outcome measures. Further large-scale randomized controlled trials are needed to establish the long-term effectiveness, generalizability, and cost-efficiency of VR-CR approaches.

## 1. Introduction

Cognitive impairment represents a multifaceted and pervasive feature across all severe mental illnesses (SMIs). In schizophrenia spectrum disorders (SSDs), cognitive impairment is considered a core clinical characteristic (Vita et al., 2024a). More than 80% of affected individuals exhibit overall cognitive performance at least one standard deviation below the general population (Harvey et al., 2022; Mucci et al., 2018). These deficits present from the very beginning of the illness (Catalan et al., 2024; Fusar-Poli et al., 2012), involve both neurocognitive domains and social cognition (Green et al., 2019), and are strongly associated with poor psychosocial functioning and unfavorable real-world outcomes (Vita et al., 2024a; Galderisi et al., 2014; Harvey and Strassnig, 2012; Tandon et al., 2024; Vita et al., 2023a; Starzer et al., 2023).

Cognitive impairment also represents a significant issue in other severe mental disorders, including major depressive disorder (MDD) (De Houwer and Koster, 2023; Fusar-Poli et al., 2023), where moderate impairments in cognitive functioning have been found since the first depressive episode (Ahern and Semkovska, 2017; Hammar and Ronold, 2022; Tran et al., 2021; Varghese et al., 2022; Dotson et al., 2020; Semkovska et al., 2019), bipolar disorder (BD), in which deficits are comparable in severity to those observed in SSD (Kurtz and Gerraty, 2009; Miskowiak et al., 2016; Atay et al., 2024; Bortolato et al., 2015), and other psychiatric conditions to a lesser extent (Bozzatello et al., 2023; Gvirts et al., 2012; Judd, 2005; McClure et al., 2016; Vita et al.,

* Corresponding author at: Department of Psychiatry, University of Campania "Luigi Vanvitelli", Largo Madonna delle Grazie 1, 80138, Naples, Italy.
*E-mail address:* andrea.fiorillo@unicampania.it (A. Fiorillo).

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2018; Leichsenring et al., 2024; Loyer Carbonneau et al., 2021; Onandia-Hinchado et al., 2021; Rubia, 2018; Corsi et al., 2021).

Improving cognitive performance with the aim of producing noticeable gains in psychosocial functioning and in real-world outcomes has increasingly become an essential treatment goal in modern psychiatry and in psychosocial rehabilitation practice (Pingani et al., 2013; Fiorillo et al., 2020; Menon, 2020; Vita et al., 2022a).

Psychopharmacological drugs show limited efficacy in treating cognitive impairment across psychiatric disorders (Emsley, 2023). Recent guidelines recommend second-generation antipsychotics over first-generation ones for their more favorable cognitive profile and suggest minimizing anticholinergic burden (Vita et al., 2024a; Vita et al., 2022a; Baldez et al., 2021; Clissold and Crowe, 2019; Désaméricq et al., 2014; Feber et al., 2025; Ohi et al., 2022). Still, these drugs do not directly enhance cognition. Several molecules are under investigation (Veselinović and Neuner, 2022; Vita et al., 2024b; Keshavan, and Eack, S.M., 2023), but none has been approved or specifically recommended.

On the contrary, specific psychosocial interventions are associated with significant improvements in cognitive functioning, that can be reliably transferred to patients' everyday life. According to the definition proposed by the Cognitive Remediation Experts Working Group (Bowie et al., 2020), cognitive remediation (CR) is a behavioral training-based intervention specifically targeting cognitive impairment (e.g., deficits in attention, memory, executive functions, social cognition and metacognition), based on the scientific principles of learning in order to improve functional outcomes (Bowie et al., 2020; Wykes et al., 2024). It has been tested in large multicentric RCT trials and can be considered an evidence-based psychosocial intervention in patients affected by a wide range of different severe mental disorders.

CR can be easily and effectively implemented in real-world (Dark et al., 2024; Montemagni et al., 2021; Nibbio et al., 2020) and low-resource settings, including low-income countries such as India (Hegde, 2017), Iran (Hatami et al., 2021), Togo, and Benin (Deste et al., 2024; Vita et al., 2023b), and being effective in various psychiatric conditions, such as SSD (Vita et al., 2022a; Dark et al., 2024; Taylor et al., 2025; Barlati et al., 2024; Vita et al., 2024c; Lejeune et al., 2021; Solmi et al., 2023; Wykes et al., 2011; Yeo et al., 2022; Vita et al., 2023c; Vita et al., 2024d; Corbera et al., 2024; Vita and Barlati, 2019), MDD (Goldberg et al., 2023; Legemaat et al., 2022; Sociali et al., 2022; Thérond et al., 2021) and BD (Bellani et al., 2019; Samamé et al., 2023). However, CR requires high levels of motivation and sustained engagement from patients, and results may not be easily translated in real-life contexts.

Although cognitive remediation is an evidence-based and potentially implementable intervention, its limited uptake in routine clinical practice highlights the need for complementary delivery modalities, such as virtual reality (VR), aimed at improving scalability, patient engagement, and real-world transfer rather than replacing established approaches.

VR can be defined as an immersive and interactive environment generated by a computer, displayed as a three-dimensional simulation; a display presents sensory information aiming to create an immersive stereo scene, while a tracker provides feedback regarding the user's position, orientation and movement to the computer in order to update the scene in a synchronous manner (Moro et al., 2023). While the first VR hardware technologies already emerged in the 1980s, the development of novel head-mounted displays, generating two high-definition images – one for each eye – and including stereo speakers, the implementation of small movement tracking devices and the possibility to run VR software on portable devices have been associated to a consistent increased interest toward this technology (Slater and Sanchez-Vives, 2016). In fact, the possibility to interact in an immersive simulation that is designed as a controlled environment but is perceived through natural sensorimotor contingencies has already been recognized as a promising opportunity in the field of mental health, both for assessment and treatment purposes (Emmelkamp and Meyerbröker, 2021; Freeman et al., 2017; Torous et al., 2023).

The present review aims to provide an updated synthesis of the available evidence on the effectiveness of VR-delivered CR interventions in patients suffering from SMIs, in which prior evidence already demonstrated the effectiveness of paper-and-pencil- and computer-based interventions. In this regard, we adopt the definition of SMI commonly used in psychiatric research and public health frameworks, which primarily includes SSD, BD and MDD with significant functional impairment. This conceptualization is based on the chronic course of illness, the associated disability, the high service utilization, and the robust evidence supporting the presence of clinically meaningful cognitive impairment in these conditions (Zumstein and Riese, 2020).

The objective of the present work is not to draw definitive conclusions regarding the effectiveness of VR-CR in SMI, but to provide a structured overview of the existing studies, critically discuss their methodological limitations, and identify gaps and directions for future research. In emerging and rapidly evolving fields such as the implementation of VR-based interventions in CR, narrative reviews can play a valuable role in contextualizing early evidence and guiding the design of more rigorous and systematic investigation in the future.

## 2. Materials and methods

To identify studies exploring the effectiveness of VR-delivered CR interventions in SMIs, where cognitive impairment has been extensively found to correlate with worsening functional outcomes, we performed a literature search in PubMed, Scopus and PyscINFO from inception to June 30, 2025 with the following search strategy: “virtual reality” AND “cognitive remediation” AND (“schizophrenia” OR “major depressive disorder” OR “bipolar disorder” OR “severe mental illness”). A further manual search was conducted in Google Scholar using the same keywords.

Virtual reality (VR) technologies are broadly classified into three main categories based on immersion level: non-immersive, semi-immersive, and fully immersive systems (Table 1). Non-immersive VR typically refers to desktop-based simulations or “serious games” viewed

**Table 1**
Categories across the reality-virtuality continuum. Adapted from Moro et al. (2023).

| Type of Virtual Reality | Description | Devices/ Technologies Used | Clinical Applications in Mental Health |
|---|---|---|---|
| Non-Immersive VR | Computer-based environments accessed via standard screens, with minimal immersion. | Desktops/ laptops, monitors, keyboards, mice | CBT psychoeducation, cognitive training, anxiety reduction |
| Semi-Immersive VR | Partial immersion via large screens or projections; retains awareness of real world. | Projection systems, large displays, basic tracking | Mindfulness, stress management |
| Fully Immersive VR | High immersion with head-mounted displays and multisensory feedback. | VR headsets, haptic/ physiological devices | VRET for anxiety, PTSD, phobias, social anxiety; treatment-resistant hallucinations |
| Augmented Reality | Virtual overlays on real-world view without full immersion. | Smartphones, AR glasses, tablets | Emotion regulation, prompts during daily activities |
| Mixed Reality | Blends real and virtual with real-time interaction and spatial mapping. | MR headsets with depth sensors, motion-tracking systems | Social cognition rehabilitation, interactive therapeutic settings |

VR: Virtual reality; CBT: Cognitive Behavioral Therapy; VRET: Virtual Reality Exposure Therapy; PTSD: Post-Traumatic Stress Disorder.

on monitors, which allow interaction using standard input devices like keyboard and mouse. Semi-immersive VR integrates more enveloping environments – such as large screens or partial projection systems – that increase presence without full sensory isolation. Fully immersive VR involves head-mounted displays (HMDs) or multi-projector environments, often including motion tracking and handheld controllers, which completely occlude the real world to place users inside a digital environment. Additionally, within the broader reality-virtuality continuum, related modalities include augmented reality (AR) – which overlays virtual content into the real world – and mixed reality (MR) – which merges and enables interaction between real and virtual objects in real time. For the purpose of the present review, we included only studies adopting fully immersive VR (Moro et al., 2023).

Both original studies and reviews were considered of interest for the purpose of the present work. Literature emerging from the searches was assessed by at least two investigators for inclusion in the review. References of interest emerging from the citations of included works were also taken into account for inclusion. Since we did not adopt a systematic procedure, given the structure and the aims of the present review, the studies included in the review do not represent the totality of the works investigating the explored topic.

We focused specifically on schizophrenia spectrum disorders, major depressive disorder, and bipolar disorder, consistent with widely used definitions of SMI in epidemiological and clinical research, which emphasize persistent disability, need for long-term treatment, and substantial cognitive impairment.

The database search yielded a total of 96 hits; after removal of duplicates, 60 articles were screened for inclusion in the present review. Combining the result of the database search with those of the manual search of Google Scholar and of the reference lists of included studies and reviews, a total of 11 individual papers were included in the present review.

## 3. Results

Cognitive remediation (CR) emerges as one of the therapeutic interventions that could benefit most of a virtual reality delivery. Treatment engagement represents an important moderator of response in CR interventions, and better treatment engagement produces substantially increased gains in all outcomes, including long-term functional outcomes (Altman et al., 2023; Evans et al., 2023; Saperstein et al., 2020; Thibaudeau et al., 2024). As such, increasing engagement in CR represents an important therapeutic challenge in clinical practice and identifying facilitators that improve engagement is of significant clinical value (Taylor et al., 2025; Altman et al., 2024; Trapp et al., 2022). By providing an immersive environment, VR facilitates more direct and intuitive interaction with cognitive exercises, which may in turn enhance engagement and support the effectiveness of CR interventions.

Since the improvement of functional outcomes represents the ultimate goal of CR (Bowie et al., 2020; Wykes et al., 2024; Barlati et al., 2024), the approach should include dedicated bridging sessions to translate cognitive performance gains into real-world functioning, and it should be delivered in the context of structured psychiatric rehabilitation programs, potentially combined with other evidence-based interventions focused on psychosocial functioning. The relevance of this integrated approach has been well documented, with positive results in functional outcomes (Vita et al., 2022a; Vita et al., 2024c), such as community and work activities (Lejeune et al., 2021). In this regard, VR technology allows to design ecologically valid exercises that, with the support of a trained therapist, could be easily translated into real-world tasks. As regards social cognitive training, the VR environment could present several scenarios as well as role-play exercises to improve the transfer of social cognitive gains into social skills and, ultimately, into interpersonal skills.

Assessing cognitive performance represents an essential element of CR programs, both to evaluate patients' participation, to better personalize the intervention and to monitor participants' improvements (Calzavara-Pinton et al., 2024; Vita et al., 2022b). VR software could integrate assessment tools into the cognitive exercises, enabling precise tracking of participants' progresses (Verdejo-Garcia et al., 2024).

Finally, VR technology could facilitate the remote delivery of CR interventions, consistently improving treatment accessibility, adherence and attendance. While remote and digital delivery of CR interventions is already tested in several studies and in several clinical practice contexts independently from VR technology, with good feasibility, acceptability and responses (Cella et al., 2024; Jagtap et al., 2022; Medalia et al., 2021; Parri et al., 2024; Taylor et al., 2024), VR could further facilitate remote delivery of CR programs while enhancing engagement and ecological validity.

The potential of VR to enhance the effectiveness of CR interventions has already been recognized, with feasibility studies being already available (Table 2). In particular, one single-arm study conducted in France including eight participants with SMIs and providing CR through a series of exercises where participants were tasked with navigating a virtual urban environment, found preliminary positive effects on attention, processing speed and memory tasks (Amado et al., 2016). Moreover, Chan et al. (Chan et al., 2010) conducted a RCT trial in Hong Kong providing 10 sessions of a VR program including two activities drawn from a program dubbed Interactive Rehabilitation Exercise System (IREX). The authors found a significant improvement in overall cognitive function and in the repetition and memory subscales of the neurobehavioral cognitive status.

Two non-randomized controlled trials conducted in Italy compared 10-weekly 90-min sessions of a VR attention training comprising three different VR environments with 10-weekly Integrated Psychological Treatment CR sessions combined with other nonspecific rehabilitation activities in community centers in patients with schizophrenia. One trial included 6 participants in the control group and 6 in the experimental VR treatment group (La Paglia et al., 2013), while the other study included 9 participants in the control group and 6 in the experimental VR treatment group (La Paglia et al., 2016). In both trials, the VR approach was superior in global cognitive performance measured with the Mini Mental State Examination, in executive functions measured with the Tower of London Test and in sustained attention measured with the Trial Making Test part A.

A case series involving two individuals diagnosed with schizophrenia and exhibiting deficits in social cognition, treated in France, reported the outcomes of a virtual reality-based cognitive remediation program focused on social cognition, consisting of 10 weekly sessions and known as RC2S. Assessment included a comprehensive battery of social cognition measures, covering domains such as emotion recognition, Theory of Mind, attributional style, social perception, and empathy. Both participants showed notable improvements, particularly in the theory of mind and attributional style domains (Peyroux and Franck, 2016).

A single arm study conducted in Israel included 31 participants diagnosed with schizophrenia recruited in an acute mental health inpatient setting. The ecological VR-based training consisted of the Functional Brain Trainer (FBT) program, simulating different real-life environments and daily tasks, and was delivered in eight 20-min sessions, conducted 2–3 times per week. Twenty-three participants completed the intervention, reporting high rates of satisfaction; significant improvements were reported in processing speed, cognitive flexibility, verbal fluency, and visual-motor organization domains test, functional capacity, clinical symptoms and diversity of participation in everyday activities (Komemi et al., 2016).

More recently, randomized controlled trials of more structured and comprehensive CR programs delivered through VR, with larger samples and more extensive cognitive and functional assessments, have begun to emerge. A randomized controlled trial with a cross over design conducted in Italy included 50 participants with BD and compared a VR-based CR intervention to a waiting list. The VR-CR intervention consisted of the program CEREBRUM, containing 52 exercises, 22 in the

**Table 2**
Included studies investigating the effectiveness of VR-CR in patients with SMI.

| Authors, Country and Year | Sample | Methods | Outcomes | Results | Limitations |
|---|---|---|---|---|---|
| Chan et al. Hong-Kong 2010 (Chan et al., 2010) | $N = 27$ older patients with schizophrenia: $N = 12$ allocated to the experimental and 15 to the control group | Two-arm RCT; 10-session intervention using the Interactive Rehabilitation Exercise System (ball and bird; shark bait) | Orientation, attention, calculations, constructions, memory, language, and reasoning | Significant improvements in overall cognitive functions, repetition and memory | Small sample size; single site |
| La Paglia et al. Italy 2013 ( La Paglia et al., 2013) | N = 12 patients with schizophrenia: $N = 6$ allocated to the experimental and 6 to the control group | Non-randomized controlled trial; 10-weekly 90-min sessions of a VR attention training comprising 3 different VR environments compared with 10-weekly IPT CR sessions combined with other nonspecific rehabilitation activities | Global cognitive performance, executive functions and sustained attention | VR approach resulted significantly superior | Small sample size |
| Imado et al. France 2016 (Amado et al., 2016) | $N = 8$ patients with schizophrenia | One-arm pilot study; 3-month program consisting of weekly sessions of a virtual game in imaginary town | Attention, visual scanning abilities, speed processing, verbal and visual working memory verbal learning, executive functioning, visuo-spatial abilities, retrospective and prospective memory, autonomy | Improvements in attention, working memory, prospective and retrospective memory; gaining in autonomy | Small sample size; diversity in assessment; different pharmacological treatments (compounds and dosages); condition of institutionalization |
| La Paglia et al. Italy 2016 ( La Paglia et al., 2016) | $N = 15$ patients with schizophrenia: N = 6 allocated to the experimental and 9 to the control group | Non-randomized controlled trial; 10-weekly 90-min sessions of a VR attention training comprising 3 different VR environments compared with 10-weekly IPT CR sessions combined with other nonspecific rehabilitation activities | Global cognitive performance, executive functions, sustained and divided attention, planning, short- and long-term memory, cognitive flexibility | The VR experimental group showed reduced time of execution, reduced needs of assistance and therapist's intervention, reduced number of omissions and improvement in sustained attention | Small sample size |
| Peyroux and Franck France 2016 (Peyroux and Franck, 2016) | N = 2 patients with schizophrenia and social deficits | Two case-studies, consisting of 3 baseline sessions, 14 treatment sessions and follow-up sessions of RC2S program focused on social cognitive remediation | Attention, working memory, cognitive flexibility, social functioning | Significant improvements in the targeted social cognitive processes, particularly in the Theory of Mind and attributional style. Positive changes in functioning in the long term | Case study design, very small sample size |
| Jaspersen et al. Denmark 2023 ( Jespersen et al., 2023) | $N = 40$ patients with mood or psychotic disorder: $N = 20$ allocated to the experimental and 20 to the control group | Randomized controlled proof-of-concept study, investigating the feasibility and the pro-cognitive effects of the administration of two 90-min sessions of VR-CR in one week. | Verbal memory, executive functions, processing speed, working memory and sustained attention, verbal learning, verbal fluency | After one week, improvements in the global cognition composite score, in the processing speed domain and a trend-level positive effect on verbal learning and memory | Moderate learning effect due to the repetition of the same assessment one week later the baseline, unblinded allocation of participants |
| Perra et al. Italy 2023 ( Perra et al., 2023) | $N = 64$ patients with bipolar disorder: $N = 39$ allocated to the experimental and 25 to the waitlist group | Randomized controlled cross-over clinical study. Experimental condition consisted of providing fully immersive VR recovery-oriented cognitive remediation (CEREBRUM, including 52 exercises) in 24 45-min sessions, divided into two sessions per week over three months alongside conventional care. Waitlist group received conventional care and after three months began the experimental trial. | Visuospatial, attention, memory, verbal and semantic fluency, executive functions | Significant improvements in memory, attention, verbal fluency, executive function | High drop-out rates |
| Komemi et al. Israel 2024 ( Komemi et al., 2016) | $N = 31$ inpatients with schizophrenia | Pre-post 1-arm design; 8 VR-CR sessions lasting 20 min delivered across 4 weeks alongside therapy as usual | General cognitive functions (inhibition, persistence, spatial memory, shifting-matching) | Significant improvements in the intervention engagement, general cognitive functioning, functional capacity and diversity of participation in everyday activities | Absence of control group, small sample size, lack of long-term follow-up |
| Primavera et al. Multisite 2024 ( | $N = 21$ older patients (58–75 years old) with bipolar disorder: N = 15 allocated to the | Secondary analysis of Perra et al. (Perra et al., 2022) including older participants. | Visuospatial functions, attention, memory, language and executive functions | No statistically significant improvements were observed between experimental group and control group | Small sample size |

(*continued on next page*)

**Table 2** (*continued*)

| Authors, Country and Year | Sample | Methods | Outcomes | Results | Limitations |
|---|---|---|---|---|---|
| Primavera et al., 2024) | experimental and 6 to the control group | | | | |
| Damgaard et al. Denmark 2025 ( Damgaard et al., 2025) | N = 31 patients with mood or psychotic disorder: *N* = 18 allocated to the experimental and 13 to the control group; *N* = 28 healthy controls | Randomized controlled trial, investigating the neural correlates of cognitive improvement after four-week VR-CR treatment | fMRI analysis: "global cognition composite" resulted from standardized and average neuropsychological test raw, based on comparison with healthy controls | Increase of encoding-related neural activity in the left dorsal prefrontal cortex, bilateral occipital cortex, left inferior temporal gyrus, left frontal pole, and intracalcarine cortex. Increased activity in prefrontal and occipital cortex correlated with treatment-related cognitive improvement at the end of the treatment and at 3-months follow-up | Small sample size, participants were mostly young |
| Perra et al. Multisite 2025 (Perra et al., 2025) | *N* = 34 patients with bipolar disorder | Secondary analysis of Perra et al. (Perra et al., 2022). Assessment at 6- to 12-month follow-up. | Visuospatial function, attention and immediate recall, memory, language, executive functions | Significant improvements were found with regards to language. | Lack of comparison with control group due to crossover design, feasibility study |

Abbreviations: CR: Cognitive Remediation; fMRI: Functional Magnetic Resonance Imaging; IPT: Integrated Psychological Treatment; RCT: Randomized Controlled Trial; VR: Virtual Reality.

Memory and Learning Module, 10 in the Cognitive Estimates Module, and 20 in the Attention and Working Memory Module, and was delivered for 24–45 min sessions, divided into two sessions per week over three months. After accounting for the cross-over procedures and drop-outs, the authors compared 39 subjects in the VR-CR arm and 25 in the waiting list group. Participants receiving the experimental intervention reported improvements in several cognitive domains, including memory, attention, verbal fluency and executive functions, and emotional awareness, as well as in clinical outcomes such as depressive symptoms, and showed more stable circadian rhythms (Perra et al., 2022; Perra et al., 2023). Post-hoc analyses reported that younger participants (≤58 years of age) improved more in complex task such as the Digit Span Backward and Digit Symbol tests, while older participants (≥59 years of age) improved more in simple tasks such as the Frontal Assessment Battery, the Matrix test and Test of Tale (Primavera et al., 2024). Thirty-four participants also completed the 6- and 13-months follow-up observations, with most cognitive variables showing a trend toward stability or even further improvement over time (Perra et al., 2025).

A randomized controlled proof-of-concept study conducted in Denmark included 10 participants with SSD and 10 participants with MDD in an immersive VR-CR program and 10 diagnosis-matched participants in a treatment-as-usual control group. Participants in the active treatment group received two 90-min sessions in a VR scenario based in an immersive, interactive kitchen environment that included the Cognition Assessment in Virtual Reality (CAVIR) scenario (Jespersen et al., 2025). Sessions were conducted with a trained therapist, and participants were also assigned cognitive exercises homework; assessments were carried out at baseline and after one week with both the CAVIR and other validated neuropsychological tests. All participants completed the training session, and the VR-CR sessions provided improvements in the global cognition composite score, in the processing speed domain and a trend-level positive effect on verbal learning and memory (Jespersen et al., 2023). Following the results of this proof-of-concept study, a randomized controlled trial was then carried out. Outcomes included cognitive performance measured with the CAVIR and other neuropsychological tests, measures of daily life functioning, subjective cognitive difficulties and quality of life, and neurobiological correlates using functional Magnetic Resonance Imaging (fMRI) (Jespersen et al., 2024). Data on a subsample of 31 participants, 18 treated with VR-CR and 13 in the VR control group, with complete fMRI data, have already been published: the active treatment group showed increased encoding-related neural activity in the left dorsal prefrontal cortex, bilateral occipital cortex, left inferior temporal gyrus, left frontal pole, and intracalcarine cortex, suggesting a neurobiological effect related to pro-cognitive effects (Damgaard et al., 2025).

Other studies are currently undergoing and are available as protocols or as interventions tested in nonclinical participants. For instance, one study based in Canada aims to assess the effectiveness of a VR-CR intervention including theory-based gamification for people with MDD, dubbed bWell-D, and the feasibility and acceptability of the program in a sample of 20 nonclinical participants showing satisfactory results (Hewko et al., 2025).

## 4. Discussion and conclusions

Cognitive impairment in patients with SMIs has been increasingly recognized as a pervasive and stable feature, from acute episodes to stable phases of various psychiatric disorders. These deficits affect multiple domains, including attention, memory, executive functioning, and social cognition, and contribute significantly to poor functional outcomes, regardless of clinical symptom improvement (Dam et al., 2021; Nord et al., 2025; Salehinejad et al., 2021; Barlati et al., 2022; Ronold et al., 2020; Sampogna et al., 2021; Clark et al., 2016; Sumiyoshi et al., 2021; Di Vincenzo et al., 2022; Gillissie et al., 2022; Burdick and Millett, 2021; Depp et al., 2012; Maj et al., 2021; McCutcheon et al., 2023). Immersive virtual reality (VR) could represent a promising and innovative approach to cognitive remediation in psychiatry. By simulating realistic, interactive environments, immersive VR allows patients to engage in cognitive tasks embedded in ecologically valid contexts, enhancing both motivation and transferability of cognitive gains to everyday functioning. VR-based CR can replicate real-world scenarios, hereby training executive functioning, memory, attention, and problem-solving in daily context. Moreover, VR offers significant advantages in terms of adaptability and personalization. Tasks can be dynamically adjusted to individual performance levels, ensuring an optimal challenge and promoting skills acquisition through real-time feedback. It also enables the safe replication of complex social situations, thus providing opportunities for social cognition training that would be difficult to reproduce in traditional CR settings.

Preliminary evidence suggests that VR-based cognitive training may be at least as effective as traditional CR, with enhanced user engagement and lower dropout rates. VR systems can also collect precise behavioral

and performance data, enabling fine-grained analysis of cognitive functioning and treatment progress. While the field is still emerging, early applications in schizophrenia and mood disorders have shown encouraging results, and ongoing studies aim to establish its efficacy, feasibility, and cost-effectiveness in broader clinical settings. Integrating VR into CR protocols may help overcome some of the current limitations of standard interventions, bridging the gap between cognitive performance improvements and real-world functional recovery.

Available evidence highlight that VR is a suitable, well-accepted, and engaging modality for delivering CR interventions. Moreover, studies suggest that CR delivered through VR appears to be effective on cognitive outcomes in patients with different severe mental illnesses. However, current evidence must still be considered preliminary and cannot allow to draw definitively conclusions. Moreover, preliminary findings should be considered in light of several well recognized pros and cons, which are summarized in Table 3.

Most available studies were feasibility trials and did not include control groups allowing to compare treatment benefits with placebo or with active approaches. Randomized trials included small samples, with even smaller proportions of specific diagnoses, contributing to the uncertainty of observed results. Most studies used validated neuropsychological assessment tools to assess cognitive performance, but did not include comprehensive, validated and internationally recommended assessment batteries, such as the MATRICS Consensus Cognitive Battery, the Brief Assessment for Cognition in Schizophrenia (BACS) (Vita et al., 2022b), or the Brief Assessment for Cognition in Affective Disorders (BAC-A) (Keefe et al., 2014). Moreover, most available studies did not encompass measures of functional capacity, psychosocial functioning or real-world functional outcomes, and did not include patient-reported outcome measures. Finally, only one randomized controlled trial including patients with BD provided follow-up results, investigating the long-term effect of the approach.

Therefore, while available results are promising and encouraging, these should be considered as preliminary and more research is needed to establish the effectiveness of VR-delivered CR, particularly as regards functional outcomes and long-term effects. Larger randomized controlled trials, with rigorous design and long follow-up observations, will provide more clear evidence, allowing to develop explicit recommendations on the potential benefits of VR-CR.

Some doubts about the usefulness of this approach still persist. It could be argued that VR technology has an elevated cost, with a limited dissemination of VR-CR interventions. However, given the recent technological developments and commercial interests, VR hardware will probably become accessible at more contained prices in the near future (Torous and Blease, 2024). Moreover, the development of VR-CR should not hamper the dissemination of traditional CR interventions in clinical settings and should therefore not limit the accessibility of already established and recommended evidence-based treatment. Thus, to clarify this issue, more cost-effectiveness studies are needed.

Furthermore, the superiority of VR approaches toward traditional CR modalities remains to be more explored: if VR consistently emerges as superior to pencil-and-paper or computerized CR in relevant outcomes, this could warrant further investments, even if it is less cost-effective, in high resources contexts or in selected cases and situations. On the contrary, if its effectiveness is equal to traditional CR, resources would be more appropriately allocated in fostering a more widespread dissemination of traditional CR interventions in mental health services, for example by training more mental health professionals.

Finally, while different studies are available or are being conducted in severe mental illnesses (Dellazizzo et al., 2020), novel trials should also assess the effectiveness of VR-CR in other mental disorders frequently burdened by cognitive difficulties including, but not limited to, borderline personality disorder, eating disorders, autism spectrum disorders and attention deficit-hyperactivity disorder (ADHD) (Vita et al., 2018; Meneguzzo et al., 2021; Tchanturia et al., 2014; Thorsrud et al., 2024; Dinu and Dark, 2023; Pascual et al., 2015; Reeder et al., 2014; Hanssen et al., 2023; Stevenson et al., 2002).

Moreover, available preliminary evidence suggests promising results in terms of improvements in positive symptoms, as well as social and vocational skills in patients with psychosis (Bisso et al., 2020; Gillouin et al., 2024; Hoşgelen et al., 2024; Schroeder et al., 2022; Wiebe et al., 2022). Anxiety disorders represent another field with consistent evidence on the effectiveness of VR approaches (Carl et al., 2019; Chesham et al., 2018; Kampmann et al., 2016; Parsons and Rizzo, 2008; Shahid et al., 2024; Tan et al., 2025).

The current study presents several limitations that should be acknowledged. First, as a narrative review it was not designed to provide an exhaustive or systematic coverage of all available evidence regarding the effectiveness of VR–based interventions within CR. Consequently, the inclusion of studies may be subject to selection bias, and the absence of a formal systematic search strategy prevented quantitative assessment of study quality and effect sizes. Second, publication bias cannot be excluded, as studies reporting null or negative findings may be underrepresented in the published literature, potentially leading to an overestimation of treatment effects. Third, the marked heterogeneity in study designs, intervention characteristics, outcome measures, and clinical populations limits the possibility of direct comparisons across studies and precludes definitive conclusions regarding the efficacy. Therefore, such limitations highlight the need for future systematic reviews and meta-analyses to more rigorously evaluate the effectiveness of VR–based CR interventions.

In conclusion, VR represents a very promising tool to deliver CR interventions in severe mental illnesses; available literature, although preliminary, confirms that VR-CR could provide substantial benefits to mental health services' users in everyday clinical practice. However, more research is needed to further understand the generalizability, durability and cost-effectiveness of this approach before providing clear clinical recommendations on its use.

**Table 3**
PROs and CONs of the use of virtual reality (VR) in cognitive remediation interventions.

| PROs | CONs |
|---|---|
| – High patient acceptance and engagement: mental health professionals report that VR enhances engagement, safety awareness, and treatment control (Dellazizzo et al., 2020) | – High cost: hardware, software development, and clinician training needed for effective implementation |
| – Effective clinical outcomes: meta-analyses support the use of VR in different mental disorders (Dellazizzo et al., 2020) | – Cybersickness (nausea, dizziness, disorientation): these are very common and may hinder the treatment (Perra et al., 2023) |
| – Flexible, customizable scenarios: interchangeable virtual environments enable tailored exposure and training ( Perra et al., 2022; Perra et al., 2023; Primavera et al., 2024; Perra et al., 2025) | – Privacy and data concerns: VR collects sensitive biometric/user data and regulatory compliance is required |
| – Transferability to real life: VR exposure therapy shows transfer of coping skills to real-world settings (Amado et al., 2016) | – Limited evidence for some uses: breathing exercises and non-exposure interventions show no significant benefit over traditional methods |
| – Potential for scalable self-guided therapy: self-guided VR shows promising engagement and retention in anxiety disorders (Carl et al., 2019; Chesham et al., 2018; Kampmann et al., 2016; Parsons and Rizzo, 2008; Shahid et al., 2024; Tan et al., 2025) | – Implementation and clinician barriers: lack of equipment, training, workload, and alignment with traditional therapy models remain challenges |

## CRediT authorship contribution statement

**Andrea Fiorillo:** Writing – review & editing, Writing – original draft, Validation, Supervision, Resources, Project administration,

Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Stefano Barlati:** Writing – original draft, Validation, Software, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Matteo Di Vincenzo:** Writing – original draft, Software, Investigation, Formal analysis, Data curation. **Umberto Albert:** Writing – review & editing, Validation, Supervision, Methodology, Investigation, Conceptualization. **Giuseppe Carrà:** Writing – review & editing, Validation, Supervision, Methodology, Investigation, Conceptualization. **Bernardo Dell'Osso:** Writing – review & editing, Validation, Supervision, Methodology, Investigation, Conceptualization. **Giovanni Martinotti:** Writing – review & editing, Validation, Supervision, Methodology, Investigation, Conceptualization. **Mario Luciano:** Writing – original draft, Validation, Software, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Antonio Vita:** Writing – review & editing, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Formal analysis, Conceptualization.

## Declaration of competing interest

The authors report no conflicts of interest.

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