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Review

Temporality in Virtual Reality Interventions for Depressive Episodes. A Scoping Review

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Highlights

What are the main findings?

- The temporal dimension in VR-based interventions for depression is underrepresented in the literature.
- Two features are considered essential in supporting the reorganization of time perception in depression through VR: generating immersion and scaffolding vivid imagination through visualization.
- VR's capacity to generate experiences otherwise inaccessible in real life, such as shifting between perspectives and enabling interaction with abstract constructs, remains underrated.

What are the implications of the main findings?

- Since all analysed studies are exploratory they require further research on how therapeutic interventions influence temporal experience within VR.
- VR interventions may benefit from engaging individuals more actively and drawing on VR's underrated features.
- More coherent frameworks for VR interventions are needed.

Abstract

Background/Objectives: People living with depression often experience consistent disruptions in the experience of time, which contribute to their suffering, and are considered a diagnostic indicator. We present a scoping review on virtual reality (VR)-based interventions for depression addressing temporal processing or subjective experiences of time. The paper aims to explore the extent to which therapeutic interventions using virtual reality target the temporal dimension of patients' experiences.

Methods: We conducted a scoping review, using the PRISMA 2020 standard. The literature search was extended using Research Rabbit and reference list searches. Seventeen papers were selected for final analysis. **Results:** Our scoping review indicates that the topic of time in VR-based therapeutic interventions for depression remains underrepresented. Of the seventeen papers reviewed, only two explicitly deal with this issue, while the rest touch upon it briefly or implicitly. The studies suggest that VR's main advantage in modifying the experience of time in depression is its potential to generate immersion and to scaffold imagination through visualization. The main limitations are methodological: most of the research is exploratory, reports short-term effects and utilizes a wide variety of empirical designs and therapeutic approaches.

Keywords: temporality; virtual reality; depression; mental health

1. Introduction

The World Health Organization states that globally, an estimated 5.7% of adults suffer from depression [1]. Even less than half receive mental health support and treatment. This highlights the need for innovative, cost-effective, and accessible interventions.

The body of research has pointed to virtual reality (VR) as one of the promising technologies in mental health care [2–4]. VR is defined as a computer-generated, three-dimensional environment that provides multisensory input and enables users to interact directly with virtual objects [5]. Unlike traditional media, VR enables immersive engagement, eliciting a sense of presence and agency within a simulated environment. The feeling of immersion makes VR a valuable therapeutic tool. It allows the therapists to create realistic and safe scenarios, where patients can confront distressing experiences, relive positive or negative memories, and practice a variety of coping strategies. Additionally, VR makes it possible to simulate experiences that are not attainable in real-world settings.

According to the DSM-5-TR, depression involves symptoms spanning three core domains: emotional (e.g., persistently low mood), cognitive (e.g., difficulty in concentrating or making decisions) and somatic or psychosomatic (e.g., insomnia, changes in appetite, or chronic fatigue). Although the DSM-5-TR does not explicitly mention temporal disruptions as diagnostic criteria, alterations in the subjective experience of time are significant and well-documented aspects of depressive disorder within phenomenological psychiatry [6–9]. Depressed individuals report a slowing of time, an overwhelming sense of the past, a frozen experience of the present and future that feels closed off.

VR therapy seems particularly well suited to deal with the distorted temporality in depression, because it allows to create temporal experiences that may be impossible to achieve in the physical world, and adapt them to individual needs. Whereas an increasing number of studies explore the use of VR in the treatment of mental disorders [10,11], including depression, little attention has been devoted to its potential to modulate the perception of time. To date, no systematic review has examined this issue.

Our scoping review seeks to address this gap by organising and critically analysing existing research. We will describe the scope of the gaps in the literature, and organise existing studies according to the time dimensions to which they refer. We will present the mechanisms considered to be essential to supporting the reorganization of time perception in depression through VR. Finally, we will highlight the limitations of existing studies, and suggest directions for future research.

2. Experience of Time, Depression and VR Interventions—An Overview

2.1. Experience of Time in Depression

Ratcliffe aptly describes first-person experience of time in depression as follows: “When depressed, time seems to slow down, and at a certain point can become irrelevant. It is easy to lose track of days without realising it” [12] (p.175). The experience of time in depression is characterized by a deceleration of temporal flow [13–15]. Changes in the subjective experience of time are corroborated by empirical findings, which show that patients with depression tend to overestimate time intervals in objective temporal judgment tasks [16–18]. The past also takes on particular significance. Depressed individuals often experience the dominance of the past, with its losses and failures, over the future and its possibilities [8]. As Gallagher [14] indicates, individuals with depression are frequently preoccupied with past experiences while showing diminished engagement with the present and the future. The past is characterized as unchangeably negative [6], overwhelming and discontinuous, where perception of linear time is blocked [19]. The present moment is experienced as meaningless and reduced to repetitive circling and time in the present feels suspended [6]. For instance, Fusar-Poli et al. found that the patients typically declare that they “can’t remember days because time has stopped” [9] (p. 357). Moreover, the present is experienced as stagnation, whereas the future appears to be “impossible” or predetermined [12,20]. It carries hopelessness, and no possibility of change. To speak in Minkowski’s words, “the future orientation,

which gives meaning and direction in life, is missing” [21] (p. 301). In depression, individuals experience loss of goal-directedness and drive, which leads to a slowing down, and, eventually, a “freezing” of lived time.

2.2. VR Therapy for Depression

A systematic review of VR interventions in emotional disorders [22] highlights that Cognitive Behavioural Therapy (CBT) and its sub-type exposure therapy are the leading methods of VR therapy for depression. The frequency of appointments and the duration of VR use depends on the needs of the person, typically starting with a 20–90 minutes session [23]. On average, patients receive eight weekly sessions [24]. Prior to the session, the therapist provides the patient with an explanation of the VR intervention, and following the session, they discuss the patient’s experience.

Lindner et al. [25] showcase how psychoeducation, behavioural activation, social skills training, cognitive restructuring, avatar therapy and virtual gardening can be integrated with CBT-VR. Freher et al. [11] indicate that VR therapy can enhance positive affect, mental imagery, and improve cognitive functioning of depressive patients. VR can also be used as neurofeedback game [26], VR group therapy for depression [27], or VR intervention simulating the phenomenological aspects of psychedelic and mystical experiences [28]. VR technologies can further address depressive symptoms through gaming interventions. The narrative and point-collection aspect of the games fostered sensorimotor activation and positive emotions [29].

There is much less research on using VR for depression compared to research on VR for post-traumatic stress disorder (PTSD) and anxiety disorders [30,31]. The majority of research on VR for depression is individually designed, which suggests that this field remains relatively underdeveloped [11,22].

2.3. VR Interventions and Time Experience

VR technology is a promising tool to investigate factors influencing subjective time perception. The advantage of VR lies in its capacity to create simulated spaces and regulate sensory output. Under typical conditions, use of VR headsets leads to faster subjective passage of time in comparison with non-VR conditions [32,33]. Time experience can be manipulated in VR through visual and auditory means. For instance, Rogers et al. [34] showed that music in VR correlates with underestimation of the time spent in VR. The degree of avatar representation in VR (so-called “VR embodiment”) also played a role in subjective time experience [35,36]. Conditions of lower levels of embodiment (no avatar) resulted in the experience of slowing down the passage of time in comparison to partial and full-body representations [37–39]. The negative effects associated with experiencing VR, such as simulator sickness, dilated subjective time and lead to an overestimation of temporal intervals [40].

A body of research explored how the motion of virtual objects and the illusion of self-motion influences temporal perceptions [40–42]. The studies employed the so-called “virtual zeitgebers” or chronometers, which are external cues that aid in the tracking of time. Examples of zeitgebers include a pendulum or the movement of the Sun [41]. For instance, Schatzschneider et al. [41] found that a static virtual sun caused distortion of time estimation, whereas natural or accelerated motion improved temporal accuracy. Ozyurt & Ikhwan [42] demonstrated that scaling up grid patterns in virtual landscapes significantly decreased the subjective passage of time. Smaller spatial scales intensified the sense of self-motion and produced a faster perception of time flow. Taken together, these findings demonstrated that VR provides a useful tool for manipulating subjective time perception, and has the potential to inspire therapeutic approaches for depression.

3. Materials and Methods

This study applied the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 methodology to explore research on VR-based interventions for depression that addressed subjective experience of time.

We proceeded in three steps. First, we defined three inclusion criteria for the study selection. During each stage of the search and screening process, texts were selected for further analysis if they satisfied one or more of the following criteria:

- 1) address the modulation of time perception through VR interventions and directly or indirectly refer to episodes associated with depressive disorders;
- 2) address the use of VR interventions for individuals with depressive disorders and directly or indirectly refer to aspects of time perception or lived temporalities;
- 3) address the temporal experience in the context of depressive disorders and directly or indirectly refer to the application of VR technologies.

Second, we conducted a systematic search of the Scopus and PubMed databases following the PRISMA guidelines. In order to ensure the alignment with field-specific terminology, we used the following keywords: "Virtual Reality" (VR), "extended reality", "VR intervention", and "VR therapy", as well as "Depression*" (depressive disorder; melancholia), and "Time" (time experience*; time perception*; lived time; subjective time; temporality; temporal experience; time disturbances). We expanded the search by combining these core terms with supplementary descriptors such as "treatment", "first-person", "qualitative*", and "phenomenology*". There were 189 combinations of keywords. The review included publications available in English up to August 2025. The selection process is illustrated in Figure 1.

In the initial stage, we identified 3 546 records (2 087 from Scopus and 1 459 from PubMed). After removing duplicates and irrelevant records, 846 articles remained. Subsequently, the records were screened by title and abstract according to the predefined inclusion criteria. At this stage, 812 articles were excluded as they did not sufficiently correspond to the research focus, resulting in 34 articles retained for full-text review. Upon closer examination, 22 studies were excluded, as they did not fully meet any of the predefined inclusion criteria. Consequently, twelve articles were identified from Scopus and PubMed databases as relevant and included in the review.

Third, as the PRISMA search resulted in relatively small number of largely overlapping studies, we decided to supplement it using the Research Rabbit literature-mapping tool and with a standard review of the reference lists of relevant papers. Unlike PRISMA, Research Rabbit allows key-words free search to consider a broader research context. We used the twelve previously selected papers (through the PRISMA procedure) as a basis for the Research Rabbit exploration of connected papers. This resulted in the selection of an additional fifteen records. Out of the fifteen, we chose two articles that supplemented the PRISMA-based dataset. Additionally, a bibliography review of the collected papers identified three additional studies. Ultimately, 17 papers were included in the final analysis (see Figure 1).

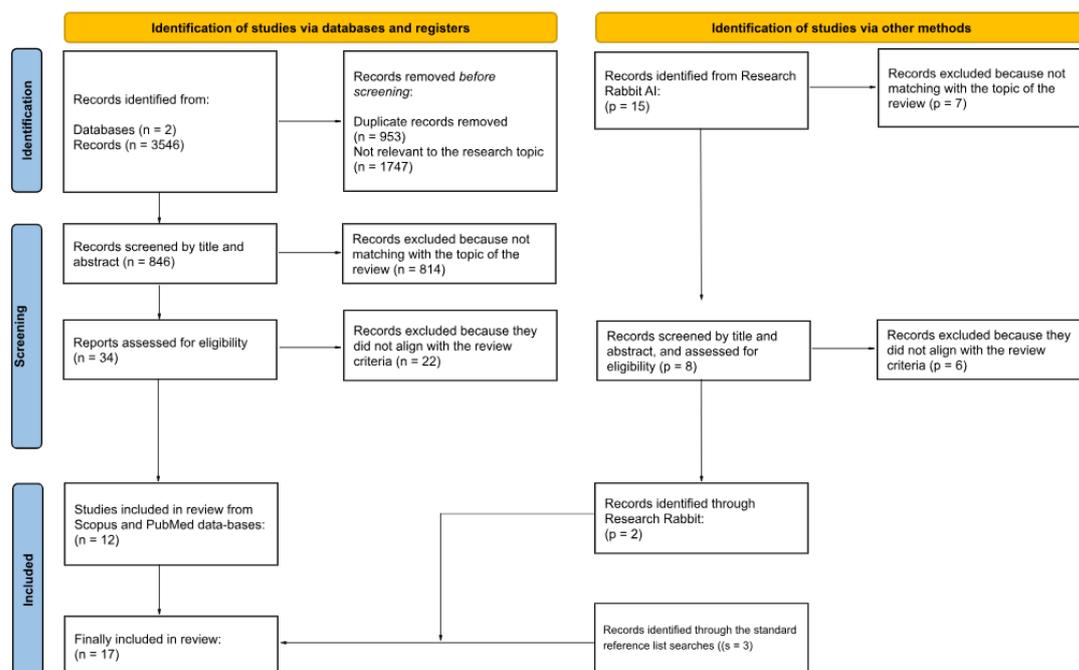


Figure 1. Selection process for the scoping review.

4. The Research Landscape

In order to organize the collected material, we used a grounded theory to develop bottom-up analytical categories [43] (pp. 315-318, 405-406). Through systematic reading and an analysis conducted by two independent coders, we identified three basic overarching thematic clusters focusing on the aspects of time experience in VR-based interventions for depression. The first cluster comprises four studies of VR-based therapeutic interventions that support patients' engagement with the present (4.1). The second cluster included four studies concerned with VR-based interventions that also engaged patients in the present but helped them in redefining their attitude toward the future (4.2). The largest cluster of studies comprised nine papers focused on ways of manipulating the experience of time through VR technology. These studies explored how virtual environments can accelerate or decelerate time perception, justifying their importance by reference to possible therapeutic application for depressive disorders (4.3). Table 1 below organizes the collected studies according to the clinical condition, therapeutic strategy, intervention characteristics, temporal framework, and time-related outcomes.

Table 1 shows that eight papers were concerned with various forms of depressive disorder, while the remainder focused on manipulating time through VR. This cluster of research mentioned the therapeutic use of VR as the rationale for the research. Consequently, no therapeutic methods were assigned to this cluster of research in table 1. The remainder of the studies varied significantly in the way the therapeutic interventions were designed. We use the classification of therapeutic intervention methods proposed by Freher et al. [11] to show that none of them were dominant.

Table 1. Studies characteristics and psychological effects regarding time in papers, included for analysis.

Author	Clinical condition	Therapeutic strategy	Description of VR intervention	Time dimension	Psychological effects regarding time
Buele et al. (2024)	Geriatric depression and mild cognitive	Skills training Enhancing cognitive	Real life motor training supported by VR-based cognitive training involving simulated daily life tasks.	Present	Improved executive functions, spatial and temporal orientation.

	impairment	functioning			
Colombo et al. (2022)	MDD	Behavioural activation Psychoeducation	Behavioural activation (BA) protocol using VR. Subjects participated in favourite activities through Google Earth VR.	Present Future	Moderate to large increase in the time spent planning and engaging in the activities scheduled during the intervention.
Fernandez-Alvarez et al. (2021)	MDD	Mental imagery	Participants recalled positive autobiographical memory using Google Earth VR app.	Present Past	VR used to provide a spatial reference and evocative environment for recalling positive memories, reducing rumination.
García-Gutiérrez et al. (2025)	MDD and social phobia	Cognitive restructuring	Participant used EYME digital platform in VR to visualize and imagine personal cognitive schemas and shape self-perception.	Present Future	Enhancing positive future oriented imagining.
Huang et al. (2022)	MDD	Enhancing cognitive functioning	Working Memory Training (WMT) through VR app (e.g. supermarket shopping, flowerpot replenish).	Present Future	VR-based working memory training indirectly boost event-based prospective memory performance
Igarzábal et al. (2021)	None	None (Time perception manipulation)	Participants waited for 7.5 minutes in a VR room.	Present	Participants in VR were more bored and experienced a slower passage of time compared to the real waiting room scenario.
Ke et al. (2024)	None	None (Time perception manipulation)	Participants performed a cycling task while exposed to surrounding exercising avatars in a VR gym.	Present	Faster self-motion in VR and higher exercise intensity of avatars accelerated subjective passage of time and, to a certain extent, time duration judgments.
Landek et al. (2023b)	None	None (Time perception manipulation)	Participants were exposed to objects displaying different motion types (e.g., pendulum).	Present	Effects of the motion of virtual zeitgebers on time duration estimation and subjective passage of time.
Landek et al. (2023a)	None	None (Time perception manipulation)	Participants were exposed to the motion of the virtual tunnel.	Present	Effect of the density and speed of a virtual tunnel on the illusion of self-motion and the perception of time.
Landek et al. (2024)	None	None (Time perception)	Participants were exposed to virtual zeitgebers (clock and orbit pendulum).	Present	Effect of different types of motion (slow/medium/fast and regular/irregular) of virtual zeitgebers on time duration estimation and subjective passage of time.

		manipulation)			
Mao et al. (2024)	Depression, anxiety, and cancer-related fatigue	Skills Training	Mindfulness Training in VR app that supported a personalized course, intelligent monitoring, emotion tracking, and games.	Present	Multisensory VR scenarios with meditative music enhanced immersion, helping patients focus on the present moment and expand body awareness.
Miller et al. (2023)	Depression	Psychoeducation Behavioral activation Skills training	Self-guided VR-CBT application supporting behavioral activation, mood tracking, mindfulness and activity scheduling, problem-solving and continued activity	Present Future	Mood tracking and activity scheduling via VR app increased sense of control, emotional regulation and time structuring. Activity scheduling helped to impose structure on time.
Olasz et al. (2024)	Anxiety	Skills Training	Mindfulness session on a VR beach with voice-guided breathing, body scan, and visualization to engage imagination.	Present	VR-mediated mindfulness exercises accelerated the perceived passage of time. The effect of acceleration is linked to immersion and flow state.
Rutrecht et al. (2021)	None	None (Time perception manipulation)	Participants played a fast-paced game <i>Thumper</i> in both VR and desktop versions. Difficulty progressively increased.	Present	The flow state generated faster subjective perception of time, but did not significantly influence the underestimation of time duration.
Unruh et al. (2024)	None	None (Time perception manipulation)	VR used to elicit an Out-Of-Body experience. Participants experienced a transition from the first- to third-person perspective in VR.	Present	Disembodiment and transition from first- to a third-person perspective affect time duration estimations and subjective experience of time passage.
Unruh et al. (2021)	None	None (Time perception manipulation)	Waiting in a real room vs. a VR room (avatar and no-avatar conditions).	Present	Effect of virtual embodiment on time duration estimation and subjective passage of time.
Wang et al. (2025)	None	None (Time perception manipulation)	1-minute VR scenes featuring either evocative or conventional content.	Present	Evocative VR environments lead to faster experienced passage of time.

Moreover, the data in Table 1 demonstrate that all interventions related to the present. The studies supported the patients through generating meaningful and pleasant moments, and modifying the pace of their experience of time. Five studies used positive experiences in the present to alter patients' attitudes towards the past or future. These effects were achieved thanks to the three main features of VR: immersion, sense of presence, and physical interaction capabilities. While all VR interventions were constructed to create a sense of immersion and presence, designs based on VR's

interaction possibilities are rather scarce. Immersion and sense of presence are used to evoke positive emotions that aim to strengthen patients' motivation to take action and encourage regular participation in therapy. Only six studies have employed the VR's capacity to facilitate direct interaction with virtual objects (e.g. by whole-body or hand movements). Three interventions used interactive features of VR to a minimal extent (e.g., guided meditation, or exploring a 3D landscape with VR controllers). The remaining studies applied exposure or waiting scenarios and did not take advantage of VR's interactive capabilities.

4.1. Engaging the Present

The four studies below show the capacity of VR to support patients in focusing on the present, maintaining positive experiences, and enhancing imaginative vividness of memories. In particular, VR mindfulness and cognitive training increased positive mood and motivation with reduction in anxiety and rumination levels.

Mao et al. [44] explored how VR-based mindfulness training helps patients with depression, anxiety, and patients undergoing chemotherapy with cancer-related fatigue. 48 participants completed four weeks of VR-based mindfulness training. The personalized course comprised seven submodules, including mindfulness breathing, awareness of thoughts, perception of sound, body scanning, immersive stress reduction, and deep relaxation. The results indicate that one week intervention reduced anxiety and depressive symptoms. This study is relevant for lived experience of time, as VR-based mindfulness encourages patients to focus on the present moment.

Olasz et al. [45] compared the effectiveness of a mindfulness exercise, delivered via VR and a tablet device. The Guided Meditation VR™ application delivered a 20-minute relaxation program set in a virtual beach environment without background music. According to Olasz et. al. [45], both VR and tablet interventions were equally effective in reducing anxiety. However, participants in the VR condition perceived the sessions as shorter than their actual duration, compared to the tablet condition. Research suggest that this effect may be due to the state of immersion and flow induced by the VR, as indicated by other studies in our review [46,47]. Experiencing the flow state also facilitates the adherence to therapeutic practice, offering indirect benefits for dealing with chronic disorders, such as depression. Mindfulness training has been shown to increase awareness of the present moment, thereby reducing distress.

Buele et al. [48] designed a study to assess efficacy of dual intervention (motor training and VR-based cognitive exercises) for 34 elders (aged 65 and above), with mild cognitive impairment and depressive symptoms. The research utilized a pre-test/post-test randomized controlled trial design. An experimental group was engaged in VR-based cognitive training, while a control group executed conventional cognitive training. Training in VR simulated routine tasks, such as searching for ingredients in a virtual kitchen. It was designed to target memory, attention, executive functions, and time-space orientation. After six weeks and twelve sessions with motor and cognitive training, there was an improvement in cognitive abilities, and depressive symptoms were reduced in both the experimental and in the control groups. No advantage of VR over traditional cognitive training was observed. The experimental group exhibited higher motivation and a completion rate compared to the control group. Temporal orientation has been mentioned as one of the indicators of enhanced cognitive abilities, but it has not been examined as an independent factor.

Fernandez-Alvarez et al.'s [49] study showed how VR can support autobiographical memory and emotion regulation in patients with major depressive disorder (MDD). The study used single-case multiple baseline design. Eighteen adults, during two sessions in Google Earth VR, visited previously identified places associated with their pleasant experiences (e.g., a beach or a park). While in VR, the participants were asked to verbalize their memories associated with the scenery. Immersion in the virtual environment not only enhanced the recall of positive memories, it made them more imaginatively vivid and detailed in the moment of the VR experience. Participants reported an increased positive mood, as well as reduced rumination. However, this effect gradually faded after about a week. Reviving positive memories in the present was intended to help patients

re-establish new relation to their past. The authors of the study indicated that a similar procedure could be applied when working with the future, for instance, by creating a space that allows individuals to future-oriented imagining or engage in planning. This approach was employed in the studies described in the next section as well.

4.2. *From Engaging the Present to Orienting Toward the Future*

The four studies below focus on the role of VR interventions in allowing the patients diagnosed with depression to focus on the present moment and future-oriented imagining: planning, prospecting and imagining future self.

Colombo et al. [50] performed an exploratory study with VR supported behavioural activation (BA). The aim was to enhance engagement in meaningful daily activities among seven participants with a depressive disorder. The study applied a single-case experimental design with multiple baselines. During a two-week intervention, patients benefited from four sessions with Google Earth VR, where they visited personally significant places, associated with pleasant experiences (e.g., a park). They imagined, visualised, planned, and rehearsed future activities in an immersive VR environment, guided by designed therapeutic narration. Results showed gradual improvements in daily activity, planning, savouring, and mood. The intervention influenced participants' lived temporalities by fostering positive attitudes toward the present and imagining hopeful future. The authors reported that the sense of presence and immersion offered in VR, which supported the patients' motivation and emotional engagement, enabled their vivid imagination of the future joyful activities.

Miller et al. [51] evaluated the feasibility and efficacy of a self-guided CBT-based digital intervention, by combining a mobile app with VR experiences for adolescents with depressive symptoms. 30 participants completed five modules over five weeks at their own pace. Each module included app components accompanied by a VR experience, such as immersive educational videos on depression and behavioural activation, mindful breathing, and guided meditations on problem-solving and relapse prevention. Participants reported that the program helped them to structure time for their activities, make choices, plan, and imagine enjoyable future actions. Both quantitative and qualitative data supported the intervention's acceptability and efficacy for delivering self-guided therapeutic content; significant reductions in depressive symptoms were observed.

Huang et al. [52] explored how VR-based working memory training (WMT) could improve event-based prospective memory. Their study involved the present and future dimensions of time. 46 participants with MDD were divided into experimental and control group and compared with 41 healthy individuals. Participants in the VR group completed 20 sessions of VR-based WMT. The VR-based program consisted of five memory tasks (e.g., memorizing a shopping list, or remembering the positions of flowerpots). The findings indicated that VR-based WMT enhanced event-based memory of intentions directed towards the future.

García-Gutiérrez et al. [53] presented a case study involving ten therapeutic sessions (one hour a week), using a VR platform Explore Your Meanings (EYME), to support identity reconstruction for a 21-year-old woman with MDD and social phobia. The EYME enabled users to visualize, imagine and interact with different dimensions of self-identity. The intervention implicitly involves lived temporality by addressing the tension between the patient's present and ideal future selves, and enhancing her optimism toward the future. Users could define the present self ("Who am I?"), the ideal self ("Who would I like to be in the future?"), and their relations with significant others. Using EYME, patients' created a three-dimensional graphical "map of meanings" that they could engage with directly. VR-based EYME made abstract concepts, such as "identity" and "personal meanings", more concrete and manageable. During therapy, the patient demonstrated significant improvement, even though six months later a follow-up check indicated a recurrence.

4.3. Modulating Time Experience in VR

The following number of studies are not specifically focused on the future or the past, but on how the experience of the present can be modulated through VR. Many of the studies do not involve patients with depression, but are part of the VIRTUALTIMES project [36,37,47,54,55] which aims to develop VR environments that use time manipulation to support treatments for psychological disorders such as depression. Moreover, they justify investigating time modulation in VR by its potential application to the treatment of depression.

Igarzábal et al. [47] investigated how people experience time in waiting situations. They hypothesized that boredom, thinking about time, and a slower perceived passage of time will take place in both offline and the VR waiting rooms. Since VR is typically associated with entertainment and flow states, the authors expected the time in VR to be experienced as running faster. The study involved 83 healthy students. After entering a VR waiting room, participants were told the experimenter needed to configure the system elsewhere and were asked to remain seated with the headset on. They waited for 7.5 minutes. Contrary to the authors' expectations, the participants in the VR condition reported greater boredom, more time-related thoughts, and a slower passage of time than in the real waiting room settings.

Unruh et al. [37] also investigated how people experience time, while waiting in VR. They examined the relationship between virtual embodiment and time perception. The study compared offline and VR conditions, with the latter divided into avatar and no-avatar conditions. The VR waiting room was a digital reproduction of the real room used in control condition. It involved 105 participants. The experimental design was analogous to that used in the Igarzábal et al. [47]. This time, the offline condition did not differ significantly from the VR conditions, in either duration estimation, or the feeling of time passage. As predicted, participants in the avatar condition experienced a faster passage of time and were less focused on time passage as compared to the offline waiting scenario.

Another Unruh et al. [56] study examined how out-of-body experiences in VR affected time perception. 44 participants were examined in two virtual disembodiment conditions (looking at their own avatar from behind or from the front). Time duration estimates were significantly shorter in the disembodied condition, when participants looked at their own avatar from the front, than in the embodied condition, where the participants had a first-person perspective.

Landeck et al. [36] explored how the density and motion speed of a virtual tunnel generated the illusion of self-motion (vection) and modulated time perception in both the desktop and in the VR settings. The study involved 132 participants in the desktop condition and 42 in the VR condition. Participants watched a moving virtual tunnel either on a computer screen or in VR. The tunnel varied along three parameters: speed (fast vs. slow), duration (20, 30, or 40 seconds), and density of tunnel sections (low vs. high). Accelerated passage of time was experienced in both VR and screen conditions. Overall, participants underestimated the actual elapsed time, with greater underestimation in VR. The illusion of self-motion correlated positively with the perceived passage of time and was stronger under high-density and fast-speed conditions.

Another Landeck et al. [54] study explored how virtual objects displaying different types of motion affected time perception. They used seven types of virtual zeitgebers [41]. Landeck et al. [54] employed zeitgebers that exhibited rotary motion (e.g., a clock), irregular motion (e.g., a Newton pendulum), and linear motion (e.g., a tunnel). In a similar study, Landeck et al. [55] developed earlier work to compare a clock and an orbital pendulum. The first study [54] involved 60 participants and the second study 32 participants [55]. In both experiments, participants were exposed to all zeitgebers for 30 seconds. In the 2024 [55] study each object was additionally presented under three speed conditions (slow, normal and fast). Both papers indicated that zeitgebers with more visible changes (e.g., irregular motion of the pendulums) led to an accelerated feeling of time. This effect was stronger in fast conditions, as indicated by the results of the 2024 study. However, significant differences were found only between the slow vs. the normal, and the slow vs. the fast conditions

[55]. Participants underestimated duration when observing zeitgebers that had irregular and dynamic motion.

Then, Ke et al. [57] explored the relationship between surrounding avatars and time perception in a VR gym. The experiment incorporated three independent variables: the motion speed of surrounding avatars performing squats (slow, medium, and fast), the intensity of the exercise surrounding avatars (low: only the barbell; high: barbell with weights), and the participants' bodily movement (sitting or cycling on a stationary bike). The study involved 24 participants. Subjects underestimated time duration in all experimental conditions. Interestingly, the exercise intensity did not affect underestimation. However, the subjective feeling of time passage differed significantly depending on the exercise intensity and motion speed of surrounding avatars. The faster the motion or exercise intensity was, the faster was the experience of the passage of time. The authors suggested that their findings could be applied to alleviate depressive symptoms associated with the sensation of being "stuck in time" or a slowed subjective passage of time.

Moreover, Rutrecht et al. [46] used the game *Thumper* to investigate time perception in a flow state. The study involved 100 participants divided into experimental (VR condition) and a control group (desktop condition). The *Thumper* is a rhythm-based video- and VR-game, with clear goals and increasing challenges. The game successfully induced a flow state, with higher flow in the VR group. A higher-level of flow was correlated with an accelerated passage of time and reduced time awareness. However, the study did not demonstrate significant underestimation of time duration dependent on the flow state. The authors suggested that games capable of inducing a flow state could help alleviate depressive symptoms related to the subjective slowing of time experience. The *Thumper* also shares several characteristics with the game *Boson X* [58], which has been connected to a reduction in ruminative thinking.

Finally, Wang et al. [59] examined how evocative VR content modulated time perception. Participants were exposed to 1-minute VR scenes featuring either evocative or conventional content. The evocative VR included three animations: lightning and thunder, a Christmas tree with flickering lights, and a moving cat. After each exposure, participants estimated the perceived duration of time. The authors highlighted the relevance of their study for interventions addressing depression or anxiety, as the evocative content modulated time perception to promote the feeling of comfort.

5. Results

Our scoping review indicates that the theme of temporality within VR-based interventions is wide, but remains underexplored for depression. Among all studies selected for the review, only two papers explicitly addressed how VR interventions change attitudes to time in depressed patients. Colombo et al. [50] designed a VR-supported BA scheme to mitigate negative expectations, an intervention that facilitated imagination and visualisation of pleasurable future activities, supported planning, and enhanced the capacity for savouring. Fernández-Alvarez et al. [49] also addressed depressed patients directly, and demonstrated that a VR-supported intervention facilitated the retrieval of their vivid and emotionally positive autobiographical memories, thereby reducing symptoms like rumination, and enabling their positive experiences in the present.

The remaining studies addressed either the experience of time, or the potential therapeutic use of VR, briefly or implicitly. Nine studies summarised in Section 3.2.3 focused on investigating the experience of time in VR, invoking its potential therapeutic use for depression as a rationale for designing a research schema focused on time acceleration or deceleration [36,37,46,47,54–57,59]. While these works suggest that altered time perception produced in VR may offer benefits for patients with depression, they fell short in providing detailed guidance on how to design specific interventions. Six further papers only implicitly mentioned time experience in VR therapy for patients with some form of depressive disorders [44,45,48,51–53]. There is a need for further research that can implement the theoretical assumptions made in these studies and their empirical findings into an actual therapeutic practice.

In order to organise the collected material, we applied the framework proposed by Montesano & Seinfeld [60], which classifies therapeutic interventions in VR along three dimensions: the strategy of the intervention (exposure, training, or exploration), the focus of the therapeutic process (symptoms, attitudes, or identity exploration and flourishing), and the patient's perspective in VR (first-, second-, third-person, or multi-perspective). Seven of the analysed studies applied an exposure-based strategy [36,37,47,54,55,57,59], while four adopted a skill training [44,45,48,51]. In addition, one study implemented a mixed exposure and training design [46]. Two further studies allowed participants to freely explore a virtual environment [49,53]. The studies employing exposure strategy did not explicitly aim to modify symptoms, attitudes, or self-identity, except for the one of Wang et al. [59]. Among the remaining studies, five sought to alleviate depressive symptoms [44,48,49,51,52], and one pursued both symptom reduction and attitude change [51]. The rest focused on identity exploration and personal flourishing [45,53]. Nearly all interventions, except for two, utilized a first-person perspective. García-Gutiérrez [53] and Unruh et al. [56] applied mixed-perspective designs. The former combined first- and second-person views, whereas the latter integrated first- and third-person perspectives.

The studies highlighted the psychological mechanisms that make VR an effective therapeutic tool and the practical reasons that support its integration with standard therapy. Among the reviewed studies, six papers emphasized the potential of VR to generate a state of immersion by facilitating positive engagement in the present [48–53]. This contributes to reframing the individual's cognitive and emotional relation with the past or future events. Through immersive multimodal experiences that re-anchor attention in the present, VR offers a possibility to disrupt entrenched patterns of relating to time.

Supporting mental imagery through the use of VR is another recurring theme across studies. VR was seen as a tool that increased vividness of imagination, therefore enhancing patients' positive attitudes towards past, present, or future [49,50,53,59]. The potential of VR to enhance one's imagination supports its capacity to afford interaction with abstract entities such as time, social relations, or personal identity [53].

Four of the seventeen analysed studies emphasized that VR-based interventions yielded practical benefits. VR is a relatively low-cost technology that enhances the accessibility of healthcare, particularly in regions where access to mental health professionals is limited [44,48,50,51]. Several studies indicated that VR systems can be flexibly adapted and personalized to meet individual patients' needs, and could be implemented in home settings [44,49,50,53]. This could reduce the risk of stigma associated with receiving therapy at medical facilities, as well as reducing the stress associated with face-to-face interactions [37,44,49,51]. In all seventeen studies, VR interventions have been considered as complementary to other methods (e.g. standard psychotherapy, BA, tablet applications) rather than a stand-alone psychological intervention.

The analysis of the methodological aspects of the collected research reveals moderate to low reliability of their findings. We assessed the studies according to the following criteria: (a) whether the results supported the original hypotheses; (b) whether the study employed a control group; (c) whether statistically significant differences were observed between experimental and control groups; (d) whether the outcomes sustained over time; (e) whether the study was exploratory, descriptive or explanatory. Among the collected studies three reported outcomes that contradicted the original hypotheses [45,47,48]. Majority of the remaining studies did not use a control group in their study design [44,45,49–51,53,55–57,59]. Sixteen papers indicated only short-term effects except for the study by Miller et al. [51] that indicated effects that sustained over time. All the studies had exploratory aims, with conclusions highlighting the need for future confirmation as shown in table 1. There is a significant variation among methods and therapeutic approaches with no coherent framework for studying and designing VR-based interventions addressing lived temporality or time experience in depression.

6. Discussion and Future Directions

As the results of our scoping review indicate, VR-based interventions explicitly targeting temporal experience consist of a novel and largely unexplored area. Most of the studies have examined how VR-based interventions can help to influence the perception of time, rather than directly addressing temporality as a therapeutic focus. Many studies have highlighted the potential of using VR in therapeutic interventions to modify the perception of time, as well as its practical advantages. All analysed studies had an exploratory character and their results require better empirical grounding.

In view of the limitations observed, it is worth considering the possibilities for further development of research on VR-based interventions focusing on the experience of time in depression. For instance, Cavaletti [61] analysed the use of VR in chemotherapy. Her conclusions are consistent with the studies by Landeck et al. [36,55] and Unruh et al. [37] which is that VR can produce a duration compression effect. This can be applied in working with depression, by creating a dynamic temporal experience. Equally important may be the choice of an interactive VR experience that actively engages the individual. In case of depression, this is achievable, unlike in chemotherapy, where physical movement may be restricted. In this way, a person's activity in VR can potentially alter the subjective experience of time and enhance the overall sense of agency and the capacity to change one's environment. Both are diminished in depression.

Cavaletti [61] highlights that VR is well suited to work with the experience of temporal flow or dissolving its passage. In a flow state, not only the sense of self but also worries and concerns temporarily disappear. As indicated in the analysed studies, the sense of immersion and presence in VR foster generation of flow states [45,46]. The higher the immersion and presence in VR, the stronger the flow experience. This applies not only to action games, but also applications that require a higher level of reflection, such as those focused on therapeutic interventions of time and identity.

According to Fuchs [62], the subjective experience of time in depression is characterized by standing still, whereas the "world-time" passes by. This discrepancy leads to the desynchronization between the patient's lived temporality and the world. Fuchs [8] proposed five principles for resynchronizing therapy as a strategy to address temporal disturbances in depression. The studies we analysed show a clear alignment with some of the Fuchs' guidelines. Moreover, the stages identified by Fuchs offer a valuable framework that can inform both the design and the implementation of future therapeutic interventions, which we will present now.

The first stage in Fuchs' [8] resynchronizing strategy is a recovery period, or the so-called "timeout", that allows the patient to gradually readapt to social rhythms with minimal pressure. The examined body of research shows that in the "timeout" period VR interventions can offer therapeutic benefits either through evoking a state of flow, temporarily increasing the internal pace of time [36,46,47] or through delivering personalized mindfulness exercises [44,45,51]. A possible extension of these strategies involves creating a personal safe space in a drawing app like OpenBrush, allowing individuals to define, visualize, imagine and revisit their safe space in VR. Another option is to use existing calming 360° YouTube videos or meditation apps like Maloka, or Flowborne VR, with biofeedback.

The second set of guidelines for resynchronization emphasizes the need for regularities and rhythms in everyday life that help to tune up distorted lived temporality with the external timing. The reviewed studies indicate that VR supports patients with scheduling activities and enhances their time orientation [48,50,52]. VR can support scheduling practice by encouraging patients to engage in activities within comfortable, immersive environments, or participating in shared activities such as virtual group therapy offered on platforms like Innerworld.

The third phase of the resynchronization supports future orientation. Patients are encouraged to define and start working toward achievable goals. Findings in our scoping review (see Section 3.2.2) demonstrate that VR supports simple actions, helping patients expand their sensorimotor space, and visualize and imagine hopeful future [50,51,53]. VR environments enable not only the

observation but also the interaction with desired future scenarios. Additionally, flexible perspective shifts in VR enhance patients' sense-making and self-reflective capacities[53,56].

During the fourth step in the resynchronization process, the patient receives personalized stimulation suited to their current state. Several reviewed studies highlight the potential of VR to create personalized interventions that calibrate the intensity of the VR experience to patients' needs [44,49,51]. For instance, therapy may begin with non-interactive 360° immersive videos and gradually progress toward higher levels of interaction or task engagement.

Finally, Fuchs recommends restoring disrupted temporal and social rhythms to help patients in acute depression and grief regain future orientation, a sense of continuity by re-establishing meaningful social connections. Although VR experiences can clearly accompany this process, none of the studies we reviewed specifically addressed grief and only one focused on acute depressive disorder [52]¹. A possible VR application at this stage could be a non-interactive psychoeducational experience visualizing stages of grief to support patients' readjustment process. Another option is an active VR experience in which individuals create personal narratives of grief, using images or photos from its stages to reflect on their transformation.

6. Conclusion

Our scoping review reveals that the view of VR as a time-manipulating device is empirically sound. Also, many studies highlight that disordered time perception is a key feature of depression. Surprisingly, studies directly examining the capacity of VR to modulate time perception in depression remains scarce. Among the 17 papers gathered for analysis, only two explicitly tackled the issue of time. Nevertheless, lived temporalities and the time experience are often implicitly dealt with in VR interventions for depression. We identified three categories of research according to the dimension of time that were either explicitly or implicitly addressed: interventions supporting engagement with the present (n=4), interventions fostering orienting towards the future (n=4), and modulating time experience in VR (n=9).

Analysed studies suggest that the effectiveness of VR in enhancing patients restore a healthy relation to time stems from its capacity to generate immersive experiences and scaffold vivid imagination through visual means that helped in recalling positive memories and anticipating the future with hope. VR technology enables experiences otherwise inaccessible in real life. It allows users to shift between first-, second-, and third-person perspectives. While this appears to be a promising strategy, only two studies in the reviewed sample applied such designs. Similarly, although VR affords interaction with abstract constructs, including time, social relations, or personal identity, this path was applied in one study.

Although many studies indicate that VR is well suited to alter the perception of time, they offer limited guidance for the design of specific therapeutic interventions. Moreover, our analysis suggests that the results of the studies are of moderate to low reliability. The majority of the research was exploratory, with temporary effects. Considerable methodological diversity further hinders meaningful comparison across studies. This gap may stem from limited collaboration between theorists and practitioners, and from the novelty of VR technologies. The absence of standardized therapeutic frameworks further constrains its consistent application. More research is needed to enhance dialogue between theorists and practitioners that could establish coherent design principles, integrating diverse methodologies and theoretical perspectives.

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¹ In Huang et al. (2022) study patients received average 22 in Hamilton Depression Rating Scale.

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Abbreviations

The following abbreviations are used in this manuscript:

VR	Virtual Reality
MDD	Major Depressive Disorder
DSM-5-TR	Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition, Text Revision
CBT	Cognitive Behavioural Therapy
PTSD	Post-traumatic stress disorder
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
BA	Behavioural Activation
EYME	Explore Your Meanings
WMT	Working Memory Training

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