Virtual reality in emotion regulation: A scoping review

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Abstract

Academic research investigating virtual reality (VR) is growing rapidly; as a result of VR becoming more easily accessible, it has become a more viable tool for helping individuals regulate their emotions. This research aims to provide an overview of the field and the contexts in which VR has been implemented to facilitate emotion regulation. Results indicate that although VR has been used to facilitate ER for over two decades, empirical research in the field has remained somewhat static until 2018. Furthermore, the contexts in which it has been employed have remained narrow with more than half of all included publications utilising VR to administer exposure therapy. While the recent increase of published works in the field, combined with more varied uses of VR, indicate a broadening of the field this work highlights several gaps in the extant literature, identifying a series of potential avenues for future research.

Keywords

Immersive VR, emotion regulation, technological affordances, human-computer interaction, scoping review

1. Introduction

Virtual Reality (VR) is an immersive, multisensory medium which provides the user with the experience of being in, and interacting with, an environment other than that in which they are physically present[1]. As affordable VR hardware has become more widely available, the number of studies investigating VR, spanning fields from psychology to human-computer interaction, is growing rapidly. As such, there is an increasing need to understand and study the technology and its affordances.

Since the early days of VR, it has been utilised in simulation training and therapeutical contexts to help people deal with challenging, stressful, and anxiety-inducing situations in safe and controlled environments[2]. Reviews and meta-analyses have provided evidence of VR's usefulness in treating diverse clinical conditions[3].

VR holds much promise as a tool to deliver both therapy and training; in addition to offering safe and predictable environments, it can be adapted to individual user needs[4]. Furthermore, it provides opportunities beyond simple simulation or replication; by exploiting the technological and gameful affordances of VR, novel and innovative techniques can be developed to provide more meaningful and affective experiences[5].

Recent years have seen an increasing degree of academic attention paid to the topic of emotional regulation (ER); indeed, it has become one of the most studied concepts within the field of psychology during the past two decades[6]. ER is defined as "processes by which individuals influence which emotions they have, when they have them, and how they experience and express these emotions"[7]. These processes or regulatory strategies can be conscious or subconscious, and be used to increase, decrease, or maintain one or more components in emotion generation.

While interest in both VR and ER has grown in parallel with one another, it is only relatively recently that they have begun to coalesce. As a result of technological developments VR headsets are becoming both easier to use and more affordable, as such the use of VR technology and

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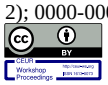

virtual environments to help users regulate their emotions is a more viable prospect[4].

Two main approaches exist to promote relaxation, stress reduction and ER in virtual environments: the first uses content derived from classical relaxation techniques as a means to enhance users' well-being at a specific moment, while the second engages the user in emotional and behavioural learning processes through more customisable virtual environments. While the majority of studies utilise one or the other, greater potential is offered if they considered in conjunction with one another, thereby providing more effective approaches. See, e.g., Pizzoli et al.[8]

Whilst the evidence of the usefulness of VR in treating diverse clinical conditions have been provided by reviews and meta-analyses[3], the purpose of this scoping review is to identify how VR technology and its particular affordances have been used to facilitate and promote ER strategies. Indeed, the use of VR to elicit changes in the emotional state of users has often focused on the short-term effects, for example as an analgesic[9], or its potential to alter individual moods[10]. Such approaches cannot be considered as constituting ER as they do not engage users in emotional and behavioural learning processes which promote long-term change. Therefore, such works are not within the scope of this review.

The focus of this work is on experimental and empirical research investigating both the VR manipulations employed in treatment and their context of use. The review aims to provide an overview of the field and to identify any gaps which currently exist in the field and the possible future research avenues in this increasingly significant field of research.

2. Method

This research used the PRISMA checklist adapted for scoping reviews[11] to guide the process of data collection, and reporting. The initial search was conducted in February 2021 in the Scopus database, one of the largest, multidisciplinary databases. Conducting the searches in as few comprehensive databases as possible instead of several different ones is preferable for purposes of rigor and clarity[12]. To achieve the objectives the literature search in the Scopus database was conducted using the following search query:

TITLE-ABS-KEY ((VR OR "virtual reality") AND (emotion*) AND (train* OR regulation OR management OR treatment))

The search string used in the query was composed of three sections: one describing *virtual reality*, the second describing *emotion*, and the third describing the *management*. These sections were built using multiple related terms and employing wild cards for a comprehensive search where appropriate. All results were assessed using the inclusion and exclusion criteria presented in Table 1. These criteria were developed to address the aims of the research, as such only studies which specifically promoted long-term ER for users were included. Additionally, given that this work is concerned with the use of VR to evoke and assess ER, publications presenting conceptual or theoretical research were excluded. Similarly, given the potential for confounding issues to affect small samples, any study with less than 10 participants was excluded. Finally, to ensure consistency, only one type of VR hardware was included: immersive, Head-mounted Displays.

Table 1
Inclusion and Exclusion Criteria

Inclusion criteria	Exclusion criteria
Considers VR as immersive VR (HMD)	Considers VR as mobile VR, CAVE, or other
Promotes user emotion regulation	User is not active in emotional regulation
Promotes long-term skill development	Focuses on short-term effects
Reports on manipulation outcomes	Presents only a design for a future study
Includes 10 or more participants	Includes less than 10 participants
Peer-reviewed	Published on pre-print server or other non peer-reviewed forum
Written in English	Written in any other language

Legend: VR = Virtual Reality; HMD = Head-mounted display; CAVE = Cave Automatic Virtual Environment

The initial search produced 1074 hits, after exclusion of review papers, conference reviews, editorials, books and letters 909 results remained. Further screening excluded all non-English publications, leaving 883 publications.

Subsequent screening removed all duplicate publications; abstracts of remaining publications were screened to identify publications addressing the main research question. All publications were first screened by one author, then reviewed by a second author; any conflicting or unclear interpretations were marked for review, discussed and reconciled by the authors to ensure consistency and conceptual clarity. Of the initial results, 16 were retained. Backwards and forwards searches were conducted on the

remaining publications. A further 183 potential publications were identified, these were screened to ensure they met the same inclusion criteria as in the initial round, leaving 20 publications. A second search on Scopus database was conducted in December 2021 using the identical search query as before. This was done to ensure that all the relevant papers published since the initial search were included. This search produced 149 (additional) hits, after exclusion of review papers, conference reviews, editorials, errata and letters 118 results remained. All non-English publications were also excluded from the search results, leaving 113 publications, of these five publications met the inclusion criteria. Backwards and forwards searches were conducted on the five additional publications, providing a further eight publications which met the inclusion criteria. In total, 49 publications were included, see fig. 1.

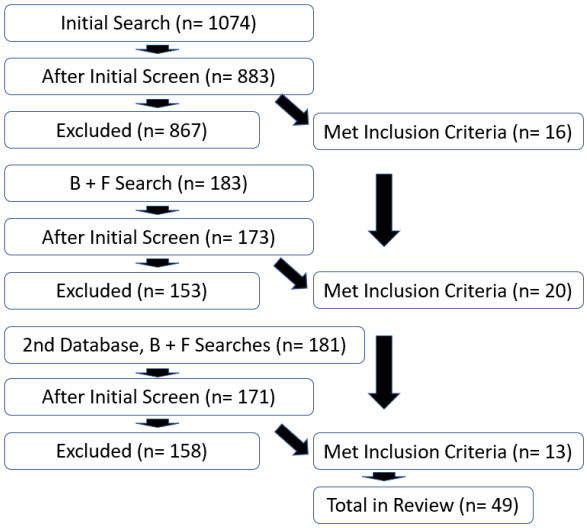

Figure 1: Publications Included in Review

3. Results

A concept matrix[13] was used to conduct the analysis and all publications meeting the inclusion criteria (N=49) were individually coded according to the following pre-defined concept matrix:

1. publication type, field & year
2. context of use & target behaviour
3. study design
4. virtual reality utilisation

The concept matrix above was developed prior to the review in order to capture the information required to achieve the aims of the research[11]. During the review process it was adapted in order to fully reflect the nature of the included publications. For example, context of use was expanded to incorporate both primary and secondary elements (see Table 2.).

3.1. Publications

Recent years have seen a marked upturn in published works, with the number of publications rapidly increasing from 2019 onwards. It is worthy of note that the first publication included in this review was published in 1995, yet none were published from 1996 to 1999, or in either 2004 or 2013, see fig. 2. Of these publications, the overwhelming majority, 47 of 49, were journal articles with the remaining two publications being a book chapter and an article published in conference proceedings.

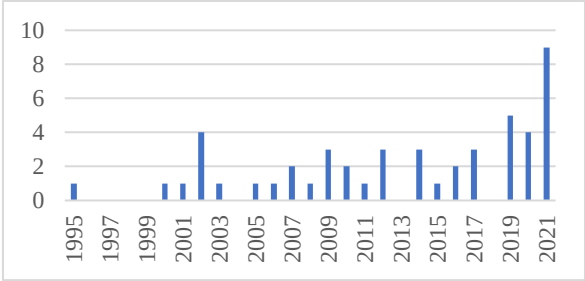

Figure 2: Publications by Year

The use of VR as a tool for teaching emotional management is an inherently multidisciplinary topic. With this in mind, the field of study was extracted from the publication venue rather than from the publications themselves. In order to ensure consistency of approach the disciplinary fields of each venue were extracted from the MinEdu database established and maintained by the Finnish Ministry of Education and Culture. MinEdu defines scientific fields by combing classifications used by the Scopus and Web of Science databases, Norwegian and Danish rating systems, and those of the European Reference Index for the Humanities (ERIH). While some publication venues have a single classification, others can have upto four separate classifications, as such the cumulative figures below exceed the total number of papers included in this review.

Given that this work is concerned with the subject of VR and emotional management, it is unsurprising that the most referenced fields are *Psychology* (32 hits), *Neurology and Psychiatry* (16 hits), and *Computer and Information Science* (13 hits). There is great diversity evident in the publication venues, however, with referenced fields including *Nursing* (7 hits), *Sociology* (6 hits), and *Educational Sciences* (1 hit). Table 2

provides a full list of scientific fields served by the publications included in this review.

Table 2
Scientific fields represented

MinEdu Classification	# of hits
Psychology	32
Neurology and psychiatry	16
Computer and information sciences	13
Nursing	7
Media and communications	6
Sociology	6
Biomedicine	5
Public health care science, environmental and occupational health	4
Agronomy	2
Biochemistry, cell and molecular biology	2
Gynaecology and paediatrics	2
Health care science	2
Others	2
Educational sciences	1
Medical and health sciences	1
Neurosciences	1
Other engineering and technologies	1
Philosophy	1
Statistics and probability	1
Visual arts and design	1

Legend: MinEdu = Finnish Ministry of Education and Culture Database

3.2. Context of use and targeted behaviours/conditions

The majority of studies included in the review utilized VR in therapeutic contexts (41 publications), exposure therapy (ET) being by far the most common field (29 publications). VR was used extensively as part of the treatment for post-traumatic stress disorder (PTSD) (e.g. P4, P28, P34), but also for several phobia: aviophobia (P30, P40), arachnophobia (P6), acrophobia (P25) and panic disorder with or without agoraphobia (P33). VR was also applied in exposure therapies targeting social anxiety disorder (SAD) (P17), public speaking anxiety (P46) and exam anxiety of university students (P5).

VR was also used as part of cognitive behavioural therapy (CBT) by replacing the in vivo exposures and behavioural experiments with VR equivalents. VR-CBT was utilised in treating gambling disorder (P3), morbid obesity (P22) and paranoid symptoms in psychotic patients (P11).

Table 3
Use contexts and fields of application

Primary UC	Secondary UC	Target Behaviour/Condition	Publication
Therapy	Exposure Therapy	PTSD	P4, P7, P18, P27, P28, P29, P34, P35, P36, P37
		Aviophobia	P30, P38, P40, P41
		Arachnophobia	P6, P10, P14
		Panic Disorder w/wo Agoraphobia	P1, P33
		Acrophobia	P8, P25, P39
		Exam Anxiety	P5
		PSA	P13, P20, P46
		SAD	P17, P19, P49
	CBT	Gambling Disorder	P3
		Morbid obesity	P22
		Paranoia	P11
		PSA	P43, P48
		SAD	P2
	Psychodynamic therapy	Depression & anxiety	P45
	Body Exposure Therapy	Anorexia Nervosa	P32
	Mindfulness Skills	GAD	P31
	Relaxation Therapy	Depression & anxiety	P15, P16, P42
Stress Manage-ment	CBT	Stress	P9
	Relaxation Training	Obesity	P23, P24
		Mood Disorder	P44
		Stress	P47
	Stress-coping skills	Stress	P21
Psycho-education	ER skills building	Adolescent risk behaviour	P12
	Cognitive reappraisal	Borderline Personality Disorder	P26

Legend: CBT = Cognitive Behavioural Therapy; ER = Emotional Regulation; GAD = Generalised Anxeity Disorder; PSA = Public Speaking Anxiety; PTSD = Post-Traumatic Stress Disorder; SAD = Social Anxiety Disorder; UC = Use Context; w/wo = with or without

In addition to exposure therapy and CBT, VR was used to create environments for Ericksonian psychotherapy and relaxation therapy targeting depression and anxiety of the elderly (P16), patients with cardiovascular disease (P15) and chronic obstructive pulmonary disorder (P42). VR was also employed in body exposure therapy treating anorexia nervosa (P32) and in a form of therapy promoting mindfulness skills in patients with generalized anxiety disorder (P31).

Other than therapy, VR applications were employed in studies implementing stress management protocols and psychoeducation. VR offered environments for relaxation training for subjects suffering from obesity (P23), mood disorder (P44) and psychological stress (P47). A VR game promoting stress-coping skills, aiming at altering a negative stress mindset of a patient population was also investigated (P21).

In the area of psychoeducation, a VR game was also utilized to help young patients with borderline personality disorder (P26). Another interactive VR platform was also used for role-play, supporting adolescents' ER skills building in situations potentially leading towards risk behaviours (P12). Table 3 provides a full list of primary and secondary use contexts (UC) and the specific behaviours and conditions which were targeted with the use of VR.

3.3. Study design

The focus on empirical works, rather than theoretical or conceptual pieces, resulted in a situation in which every single publication featured in this review took the form of quantitative, experimental research. However, there was notable diversity in the design of the experimental approaches. First, recruitment ranged from convenience-samples among the general population (P17), university students (P19), or in-patients (P44), to targeted recruitment of individuals who were thought to benefit from new approaches to the management of emotions (P27). The nature of the studies, their application and context of use (section 3.2), largely defined the recruitment of participants, for example requiring active service members diagnosed with combat-related PTSD (P34) or individuals affected by anorexia nervosa (P32). Given the specific nature of both conditions, it is unsurprising that the samples were dominated by males and females, respectively. However, in many other studies investigating more generalised disorders, such as Public Speaking Anxiety, females dominated the samples, with only four non-PTSD studies using samples where the number of males exceeded females (P8, 45.45% female; P11, 31%; P39, 40%; P46, 48%).

Second, a number of studies used only a single condition, adopting an AB design in order to assess differences between baseline and post-experiment measures (P44), while another study adopted a 2x3 design in which a group of healthy controls and affected individuals were each assigned to one of three treatment conditions (wait-list control, standard treatment, and VR-enhanced treatment) (P14). The most common approaches, however, used either a two-group or three-group design where VR-enhanced approaches were compared to either a control group (wait-list, standard treatment, or healthy individuals) or a combination of control and standard treatment. The prevalence of studies utilising control groups in preference to an AB design ensure more robust conclusions can be drawn from the work.

The overwhelming majority of works (21 of 49) incorporated two measurement points, baseline (pre-experiment) and post-experiment, a further 16 incorporated three measurement points, baseline, post-experiment and follow-up (ranging from one week to one year). While within-subjects analysis exceeded between-subjects analysis, 18 and 11 respectively, the majority of works, 20, used both approaches in order to measure individual changes as a result of treatment and changes between treatment groups. Approaches to measurement were evenly distributed between the studies: 13 employed both self-reports and physiological measures, 14 employed self-reports only, and 15 employed both self-report measures and clinical assessments. Only five studies employed clinical assessments, physiological measures and self-reports; two studies used clinical assessments only.

3.4. Virtual reality utilization

Virtual reality was predominantly used to create practice environments promoting ER which were safer, more controllable (whether by the therapist or the users themselves), and recently, more cost-effective. VR was utilised in the majority of the studies included in this review as part of existing therapeutic protocols, e.g. ET and CBT, functioning as an alternative to in vivo exposure. With the rise of low-cost consumer hardware, the possibility of also using VR for self-guided exposure has emerged (P49). For this reason, most VR applications used in the studies aimed to simulate real-life scenarios, either to expose and desensitize users or to allow certain skills could be practiced via role-play. In several cases VR was featured as an alternative to visualisation (P17, P18), an aid for concentration (P24) or an addition to more traditional treatment protocols for relaxation training (P24, P36).

A limited number of implementations went beyond the "real" and utilised the affordance of VR technology in order to create more fantastical and gameful environments. For treating depression and anxiety in patient populations, the Virtual Therapeutic Garden offered an interactive, multisensory (visual, auditory and kinesthetic) environment, where users could bring a grey, untidy garden back to life by tending it through completing therapeutic tasks. In this way, the gradually increasing colour palette and growth of plants both served as a reminder of their progress and symbolised their own recovery (P15, P42).

These more playful and, indeed, more gameful approaches are also reflected in the emergence of environments which have been created to alter a) stressful mindsets, and b) cognitions about the flexibility of emotions. In "Stressjam" heart rate variability (HRV) biofeedback was used to provide participants (both healthy controls and patient population) information about their capacity to cope with stress, i.e. their "superpower" in the game. They used this skill to advance in the game: exploring, finding and applying effective mechanisms in their bodies to generate stress or to remain calm. (P21). The educational game "InMind" was employed by researchers to enable adolescents diagnosed with Borderline Personality Disorder to modify beliefs about their ability to affect their own emotions. During the game participants took charge of changing emotions within the brain by "firing" red neurons and transforming them to green, in this way they were able to reduce the intensity of an emotion, this process being analogous to reducing the intensity of an emotional experience by adopting an alternative approach. Adopting an active role in game encouraged the participants to believe that self-directed emotional change was a realistic and achievable goal (P26).

Employed as a means of delivering Body Exposure Therapy for patients with anorexia nervosa, a VR environment was used to manipulate the body image of the study participants. They were first exposed to a virtual body with their real-size silhouette and body mass index (BMI) which was gradually manipulated by applying small BMI increases to the body over successive sessions. This continued until the healthy BMI target was reached. The aim of each session was also to reduce the participant's initial (body related) anxiety level by 40%. To induce full body illusion (FBI) over the virtual body, visuomotor and visuo-tactile stimulation was conducted in the beginning of each session. (P32).

Multisensory experiences with auditory, olfactory, tactile and vibrotactile cues were often utilised in exposure settings to augment the immersive qualities of VR. By increasing the felt presence of participants, and by creating more authentic environments, treatment efficacy was improved. Simple props were already utilised in the early studies alongside VR, e.g. a furry toy spider or real railing used to create tactile experiences for arachnophobes (P10) and acrophobes (P39), or real aeroplane seats with vibrating sensations for patients dealing with aviophobia (P40). The more current platforms, such as "Virtual Iraq" employed in multitude of studies (e.g., P18, P27, P34) targeting combat-related PTSD in active-duty military personnel, are highly adjustable with combat-related features and can be customised to suit user needs.

Biofeedback (BF) was used to communicate with the VR environment in only one study included in this review. As discussed previously, the "Stressjam" game environment used HRV biofeedback to provide participants in-game information about their stress-coping capacity during an interactive VR experience (P21).

4. Discussion

To our knowledge, this scoping review is the first attempt to outline how immersive VR technology and its affordances have been utilised to facilitate ER. Immersive VR and ER have seen academic attention grow in parallel, yet this review reveals a notable increase in published studies combining both areas only recently. ER has been one of the most studied topics in psychology over the past two decades, as such it is unsurprising that studies investigating VR's potential in this area are largely from this field.

This review highlights many benefits afforded by VR in the promotion of ER. The most obvious advantage of VR relates to its customisability; many publications utilising platforms which could be adapted to the specific needs of individual users. Second, it is a safe, stable, and predictable environment, a particular asset when used to address phobias or traumatic experiences. Finally, VR was also often found to be a useful alternative for subjects having difficulties engaging in the visualization-based practices often required when using different therapeutic techniques.

As a result of this scoping review several gaps in the existing literature have been identified. This is to be expected as, although publications

included in this work span 25 years, until 2018 publications averaged 1.1 per year before jumping to 6 per year between 2019 and 2021. Those issues and areas felt to be fruitful avenues for further research are discussed below.

The use of VR as a means of delivering exposure therapy dominated the reviewed literature, appearing in over 50% of publications, albeit the range of specific phobias or disorders addressed via exposure therapy was reasonably broad. However, this situation indicates that the potential of VR is far from being realized. It is the context of psychoeducation which offers the most scope for growth with only two identified works in that area being published in the previous two years. Indeed, the use of VR for psychoeducation-based training is not limited to clinical settings; research integrating ER and psychoeducation into other forms of workplace training, for example, affords many possibilities. Such an approach would build on work which is beginning to utilise VR when, e.g., training emergency personnel.[14 15]

Closely connected to the above point, the majority of research featured virtual environments which were designed simply as a direct replication of in vivo treatments, or as simulations of the real-world. While the environments featured degrees of customization and user-centred adaptability unavailable in vivo, they did not exploit the affordances of the technology. Further work is needed to expand upon pilot studies which use VR to tailor scenarios according to individual responses, such as with anxiety disorders[16]. Interestingly, studies utilizing VR technology's affordances more widely, of going beyond the "real", have all been published since 2019. The emergence of research which highlights gameful affordances of VR in facilitating ER provides an example of a promising avenue for future research combining VR, psychoeducation, emotional management, and gamification[17].

Interestingly, despite the widespread use of physiological measures our search results featured very few studies utilizing biofeedback (BF) technology alongside VR. No doubt, this is associated with the available technologies given that several early studies incorporated a range of multisensory aids to augment VR. Indeed, BF in VR has increasingly been studied in relation to, for example, relaxation[18], mindfulness[19], and as a game mechanic[20].

A particular issue of interest is that regarding drop-outs or non-completers; while some studies found that VR encouraged participation, for example when using psychoeducation to address adolescent risk behaviours, those treating combat-related PTSD observed the opposite. Both context of use and target population, therefore, are particularly important and it cannot be assumed that the benefits of VR can be equally applied to all. More research is needed featuring participants drawn from representative, non-clinical samples.

The latest research, and the rapid growth of work in the area, utilising VR technology in the facilitation of user ER indicate the broadening of the field and the emergence of new systems and designs. In addition to more fruitful exploitation of the affordances of the technology, the future of VR as a tool for ER lies in highly personalised, customisable and adaptive implementations[3 21].

Standard limitations apply to any review, and this work is no exception. The most notable being that when investigating a multidisciplinary field, particularly one associated with a developing technology, it is unlikely that all relevant publications will be identified despite all best efforts when constructing the search. This issue is somewhat mitigated by the fact that backwards and forwards searches were conducted on all included hits, indeed these searches returned more relevant results than the initial searches. Second, the pre-defined inclusion criteria necessarily shaped the publications selected for inclusion, while this is not a limitation in itself, the need to focus on a specific type of publication, in this case empirical studies, meant that conceptual or theoretical works are not featured in this work.

5. Conclusion

This work provides an overview of the field and contexts in which VR has been implemented to facilitate ER. Results indicate that until recently, empirical research in the field has remained somewhat static with a relatively narrow scope, although the recent increase of published works, combined with more varied uses of VR and its' affordances, suggest a broadening of the field.

6. Acknowledgements

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