Virtual reality and emotion regulation:
a systematic review

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Abstract

The attention to the emotion dimension, in the context of interventions aimed at promoting psychological wellbeing as well as the treatment of some psychopathological conditions, allowed the development in recent decades important studies and reflections both from the point of view of theoretical scientific knowledge and therapeutic implications.

Starting from the awareness of the important functions that emotions perform in intra and interpersonal dynamics, the question of emotion regulation becomes central, as a complex and dynamic psychic activity that allows the achievement of individual well-being and good social functioning.

Experiments and therapeutic interventions based on virtual reality (VR) in recent years have opened new scenarios and led to new knowledge regarding emotion regulation in both normotypic and pathological samples.

The aim of the following paper is to offer a review of the scientific literature of the last 10 years regarding the use of virtual reality in the context of emotion regulation.

Keywords 1
Emotion, Emotion regulation, VR, New Tech

1. Introduction

A number of theorists, starting with Tomkins [1] and Plutchick [2], referring to Charles Darwin's theory, have postulated the existence of some primary or basic emotions that have developed in order to regulate behavior and favor the survival of the species, considering them as evolutionarily adaptive responses to situational needs. Primary emotions are defined by Ekman [3] on the basis of certain characteristics: they are short-lived, they manifest involuntarily, the cognitive evaluation of the event that triggers it leads to an almost immediate automatic recognition of the stimulus, the antecedents are universal, the sensation is accompanied by precise physiological mechanisms and is characterized by universal signals recognizable in the form of particular expressive manifestations (facial expressions and specific behaviors).

Although there is not yet full agreement among scholars, we can nevertheless estimate about five primary emotions by relying on scientific evidence [3] fear, anger, disgust, happiness and sadness.

The Emotion Regulation (ER) is one of the most important emotion capacities and, when it is dysfunctional, it is implicated in a series of problems that can also cause more or less serious disorders [4] [5] [6]. For this reason it is a central and widely debated topic in the clinical and rehabilitation field, especially as regards the improvement of possible treatment programs [7].

In support of this thesis, recent research finds identifying in a good interpersonal regulatory competence a protective factor against psychopathology [8] and, moreover, people suffering from psychological disorders have greater difficulties than healthy individuals [9] [10].

Defining emotion regulation is not a simple task, in fact, literature provides various theoretical definitions of the construct precisely because of the multiplicity of processes and functions underlying the various regulation strategies, as well as the lack of concrete and agreed theoretical systems [10].

Virtual reality (VR) can be described through an analysis that takes into consideration purely the technological aspect, for which it is defined as "computer-generated simulation of a real or imaginary environment" [10].

The essential aspects, from a technical point of view, that define a virtual reality technology are: a computer capable of supporting real-time animations, controlled by a series of position trackers; a set of input information that must be integrated and used to provide the user with an image modification, possibly in a rapid time to the point of creating an illusion of concomitance; a stereoscopic headset (head-mounted-display-HDM) for visual output [11].

Despite the importance of this description, it would be simplistic to consider virtual reality as a simple sum of technologies, its founding element and what makes it such an important scientific frontier is that it allows a new type of human-machine interaction [12] able to convey experience and knowledge [13].

1.1 Emotion regulation in virtual reality

The impact of emotion regulation interventions on well-being has been extensively documented in the literature and the positive changes with respect to this process have also been important with regard to mental health and relationship satisfaction [14] [15]. Despite this, it is only in recent years that virtual reality technologies have been incorporated into the design of such interventions, both in the clinical and non-clinical settings, as a means to facilitate and increase the positive outcomes of ER [16] [17].

The application of virtual reality in psychology has a great advantage as it allows researchers and doctors to create realistic experiences but in a safe environment, such as in the laboratory or in the clinical setting [13]. Thanks to this, it is possible to measure in real time the cognitive, emotion, physiological and behavioral responses with respect to different "real life" situations while maintaining experimental control [18]. The VR system, therefore, has the possibility of creating a rapprochement between laboratory and daily operation, establishing itself as an environmentally valid environment [18].

Through virtual reality it was possible to improve the subjects' abilities to recognize and control their emotions. Lorenzetti et al. created a virtual environment in which it was possible to experience a game through which participants received sensory feedback in real time whenever they felt tenderness, distress or neutral emotion states in progress [19]. The neurofeedback system was based on BCI (neuronal interface based on EEG) for which neuronal activity was connected to the color of the virtual environment which changed according to the fluctuation of the emotion state experienced by the subject. In this way, the participants were instructed to feel tenderness or anguish as intensely as possible and to voluntarily increase the intensity of their emotions in the sense of increasing their neural activity while experiencing complex emotions [19].

Over the years, some researchers have also investigated the issue of the use of VR in pathological samples, with the aim of monitoring its effectiveness and usability in therapy [17] [20] [21].

This article offers a review of the last 10 years regarding the use of VR in emotion regulation in different contexts and with heterogeneous samples.

2. Method

The literature analysis was carried out using the main search engines PubMed and Google Scholar. Advanced searches were carried out which allowed to direct the bibliographic search towards results that presented the main keywords "virtual reality" and "emotion regulation" combined with the words "emotion", " psychological disorders", "gad", "anxiety disorders ", "borderline" emerged after the bibliographic searches. The words have been searched in the title section and, where possible, among the key words. The search was carried out in July 2020, including articles published over a period of time ranging from 2010 to 2020.

Exclusion criteria: No VR studies

3. Results

The results of *Table 1* show that virtual reality is a valid tool for implementing treatments aimed at improving emotion regulation strategies in patients and healthy subjects.

The studies by Lorenzetti et.al, Weerdmeester et al., investigated the use of biofeedback and neurofeedback within VR and found an improvement in the regulation of the emotion and physiological response and awareness through these techniques.

Konrad et al. and Bosse et al. both conducted two studies on non-clinical subjects and had satisfactory results with respect to the possibility of using virtual reality systems in order to generate learning of more adaptive ER strategies.

A series of VR interventions, carried out by Tarrant et al., Navarro-Haro et al. on the other hand, were found to be effective in subjects with generalized anxiety disorders by improving the conscious control of their anxious response using both relaxation techniques and meditation.

A single study was conducted by Navarro-Haro et al on borderline disorder. From this intervention, through VR, an improvement was seen with respect to the negative emotions generally experienced by BDP subjects.

With respect to phobic disorders, a review of nine studies presented by Wechsler et al. suggests that VR exposure shows a greater potential and is no less effective than in vivo exposure in specific phobia andagoraphobia.

Ultimately Wrzesien et al. they focused their intervention on the possibility of learning emotion regulation through the use of self-similar avatars in a virtual environment and the results indicate an improvement in emotion regulation through model observation (VRS).

Table 1
Table title

Authors	Year	Sample Characteristics	VR activities	Evaluation of the ER	Outcomes
Tong et al. (articles)	2015	13 patients with chronic pain	Immersive environment stereoscopic VR display	Numerical Rating Scale (NRS) for Self-Report Pain Levels (values 0–10)	These findings indicate that the VMW (VR paired with biofeedback for MBSR training) was significantly more effective than MBSR alone at reducing reported pain levels among participants
Weerdmeester et al. (articles)	2017	72 healthy adults	Virtual reality video game based on biofeedback	Trier Social Stress Test	Learning to manage physiological activity
Konrad et al. (articles)	2016	128 healthy adults	Non immersive web-based VR	SHS, SWLS, RPWB	Generation of more adaptive ER strategies
Bosse et.al (articles)	2014	34 healthy adults	Virtual scenario with induction of negative emotions	subjective emotion ratings	Strengthening or weakening of emotion responses to negative stimuli
Navarro-Haro et al. (articles)	2019	42 patients with GAD	DBT immersive virtual reality	GAD-7 HADS FFMQ DERS MAIA	Improvement of awareness and anxiety response
Navarro-Haro et al. (articles)	2016	1 borderline patient	Vr DBT	DBT diary card	Reduction of negative emotion and increase of awareness
Wrzesien et al. (articles)	2014	22 teenagers	Vr with self-like avatars (VRS)	VAS and SAM EGG	Improvement of emotion regulation through model observation (VRS)

Wechsler et al. (articles)	2019	371 phobic disorder pat.	Exhibition in VR	Hedges' g effect sizes	VR exposure shows a greater potential and is no less effective than in vivo exposure in specific phobia and agoraphobia.
Tarrant et al. (articles)	2018	14 patients with GAD	VR and meditation	Physiological measurement with EGG	VR intervention led to a physiological reduction in anxiety.
Bornioli et al. (articles)	2019	384 healthy adults	Non-immersive laptop	UWIST MACL scale, PRS scale	Results show the crucial features that make walking positive for psychological wellbeing
Rodriguez et al. (articles)	2015	24 healthy adult	VR and Emotiv EPOC-based EEG	Visual-Analogue Scale (VAS) and PANAS	activation in several relevant brains regions that are associated with sadness induction and that are associated with the application of emotion regulation strategies
Lorenzetti et al. (articles)	2018	8 healthy adults	Exposure to the natural environment and Neurofeedback	Emotion Regulation Questionnaire (ERQ)	Participants were instructed to control the intensity of emotions

4. Conclusion

The results of this systematic review show that VR should be a valid tool for improving the ability of individuals to manage emotions by allowing the learning of more adaptive emotion regulation strategies to the context.

The use of this innovative technology in this sense is promising because it allows to recreate realistic digital environments within which VR interventions can, for example, inspire new actions, increase the awareness of subjects regarding their emotions, allow the modification of the emotion response through the re-evaluation of emotion stimuli and, subsequently, memorize the re-evaluated experience.

These results are relevant both for health promotion and prevention treatments for the onset of disorders, both for the treatment of subjects who already have more or less serious pathologies, as in the case of anxiety or borderline disorders.

It has also been shown that the effectiveness can be better than non-VR treatments and that adherence to the treatment was, in some cases, greater.

It has also been shown that the effectiveness can be better than non-VR treatments and that adherence to the treatment was also, in some cases, greater.

Considering, therefore, the different advantages of VR exposure and its high potential, its diffusion should be emphasized and a deeper investigation of what are the relevant operating mechanisms is necessary in order to develop improvements in technology and procedures that they could produce even greater effects in the future.

Research should aim to investigate the mechanisms and underlying factors that may contribute to the effectiveness of biofeedback systems when using VR interventions for ER in order to maximize their positive therapeutic outcomes, and furthermore, it would be interesting again, to be able to understand how way avatars and embodiment in virtual bodies can enhance the learning of emotion regulation strategies in a more engaging way.

As the introduction of avatars into mental health applications is relatively new, a deeper understanding of their influence on user behavior is of great importance.

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