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# VIRTUAL REALITY IN THE PRACTICE OF MINDFULNESS IN PSYCHOTHERAPY: A NARRATIVE REVIEW

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**ABSTRACT.** The association between mindfulness (MF) and Virtual Reality (VR) is recent. MF has been used in psychotherapy due to the therapeutic effects reported. However, not all patients are able to obtain the benefits of this resource, and VR becomes a way to work with MF as it facilitates the sense of presence. This paper presents a narrative review of the literature about therapeutic uses of VR in the practice of MF. A total of 23 complete papers were analyzed, being the main research focuses: the improvement of immersive ecosystems and therapeutic resources in the context of MF in relation to the user experience; the development of economic technological resources; easy to handle material to facilitate the user experience. We concluded that VR can be a facilitator as a tool in the treatment of patients who could benefit from MF-informed therapy, although controlled studies are needed to understand the specificities of VR and the variables with therapeutic value.

**Keywords:** Mindfulness; virtual reality; narrative review.

# REALIDADE VIRTUAL NA PRÁTICA DE *MINDFULNESS* EM PSICOTERAPIA: UMA REVISÃO NARRATIVA

**RESUMO.** A associação entre *mindfulness* (MF) e Realidade Virtual (RV) é recente. O MF vem sendo utilizado na psicoterapia em razão dos efeitos terapêuticos observados. Entretanto, não são todos os pacientes que conseguem obter o benefício desse recurso, sendo a RV uma via para o trabalho com o MF por facilitar o sentido de presença. Este artigo teve como objetivo realizar uma revisão narrativa da literatura sobre a utilização terapêutica da RV na prática de MF. Foram analisados 23 artigos completos, sendo os principais focos de pesquisa: o aprimoramento dos ecossistemas imersivos e dos recursos terapêuticos no contexto do MF em relação à experiência do usuário; o desenvolvimento de recursos tecnológicos econômicos; material de fácil manuseio para facilitar a experiência do usuário. Concluímos que a RV pode ser facilitadora como ferramenta no tratamento de pacientes cujo perfil se enquadra em terapia mediada por MF, embora são necessários estudos controlados que permitam compreender as especificidades da RV e as variáveis com valor terapêutico.

**Palavras-chave:** mindfulness; realidade virtual; revisão narrativa.

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# REALIDAD VIRTUAL EN LA PRÁCTICA DEL *MINDFULNESS*: UNA REVISIÓN NARRATIVA

**RESUMEN.** La asociación entre *mindfulness* (MF) y Realidad Virtual (VR) es reciente. MF se ha utilizado en psicoterapia debido a los efectos terapéuticos observados. Sin embargo, no todos los pacientes pueden obtener el beneficio de este recurso, siendo la RV una forma de trabajar con el MF porque facilita el sentido de presencia. Este artículo tuvo como objetivo realizar una revisión narrativa de la literatura sobre el uso terapéutico de la RV en la práctica de MF. Se analizaron 23 artículos completos, siendo los principales focos de investigación: la mejora de ecosistemas inmersivos y recursos terapéuticos en el contexto de MF en relación a la experiencia del usuario; el desarrollo de recursos tecnológicos económicos; material fácil de manejar para facilitar la experiencia del usuario. Concluimos que la RV puede ser un facilitador como herramienta en el tratamiento de pacientes cuyo perfil encaja en la terapia mediada por MF, aunque son necesarios estudios controlados para entender las especificidades de la RV y las variables con valor terapéutico.

**Palabras clave:** mindfulness; realidad virtual; revisión narrativa.

## Introduction

This article presents a qualitative narrative review of the literature about the use of Virtual Reality (VR) in the practice of mindfulness (MF) in psychotherapy. The questions that motivated this review arose from observations of VR uses in a therapeutic context informed by mindfulness. VR was initially used in psychology for gradual exposure to anxiogenic situations (Gutiérrez, 2002; Maples-Keller, Bunnell, Kim, & Rothbaum, 2017). In our work with patients, we observed that some indviduals experienced changes in perspective regarding their therapeutic demands when becoming aware of inconsistencies in their usual narrative flows during immersion in environments recognized by them as synthetic. We asked ourselves if the context shift that VR provides could facilitate de-identification and metacognition, therapeutic axes sought in clinical work with mindfulness.

The interruption of habitual narratives is one of the processes through which mindfulness can generate therapeutic changes (Miró, 2013). Such an interruption can arise from contemplative observation of mental objects and narrative flows emerging in the field of consciousness and perception of the dynamic functioning of the attention system itself. Contemplative meditation, described in the literature as open field meditation, presupposes developing an 'observant self' (Chiesa & Malinowski, 2011) of one's own processes, an observant capable of a conscious observation by a subject immersed in the present. The present here is understood not as a temporal form, but as a space that contains the mental forms that arise and move at every moment (Borruso, 2010).

In our clinical work with VR, we observed that the inconsistencies experienced in triggering the usual narrative flows in the virtual environment generates an opening that can be exploited by the psychologist regardless of any specific theoretical framework.

We asked: (1) could immersion with VR - in virtual environments designed for mindfulness in psychotherapy - in the occurrence of interruptions in narrative flows, enhance communicative interactions and promote transformative experiences in first person? And, therefore, (2) could we understand that psychoeducational use and the delimitation of the attentional field have been the focus of mindfulness with VR?

The junction between mindfulness and VR in Psychology is recent, driven in part by the accessibility of mobile equipment. The number of papers reporting the development of VR systems for mental health is growing, and the scientific literature in this field is still young. Given this framework, we chose to conduct a narrative review to: a) outline a panorama of the field, b) map the needs that VR systems designed for mindfulness seek to cover, both for the patient and for the psychologist, c) and try to address our clinical questions formulated above.

## Mindfulness and Virtual reality as clinical tools

Mindfulness has been used both in medicine and in psychotherapy for the clinical and therapeutic effects observed in different contexts of intervention. However, the patient does not always tolerate mindfulness practice. In our daily work we corroborate the assumptions pointed out by the research that mindfulness is of great help to many patients and that the difficulty of its use with some individuals (e.g., in patients with dissociation, reactivity to interoception or hyperkinetic, who have experienced difficulties for an efficient attentional regulation) has created a therapeutic gap to be filled.

In Psychology, the word mindfulness is used to refer to meditation-based tools and also to a way of relating to one's own experience of the here and now. The practice of mindfulness assumes an experiential approach to the knowledge of oneself and the world, implying a psychological process that can be described as a conscious attention accompanied by an attitude of presence. As a clinical tool, it contributes to reduce stress and anxiety, prevent relapses into depression, reduce emotional reactivity to chronic pain and its intensity, facilitate attentional regulation and stimulate self-compassion (Chiesa & Malinowski, 2011). The embodiment of experience and the sense of presence are important axes in mindfulness, which includes sensory, behavioral, cognitive and affective aspects.

The use of VR in Psychology has been studied since 1980 with Schneider's precursor work in 1982 (Gutiérrez, 2002). In a systematic review of the literature covering the last 20 years on VR uses in mental health, Freeman et al. (2017) conclude that scientific works address treatments (n = 154), evaluations (n = 86) and theoretical development (n = 45). The disorders addressed were anxiety (n = 192), schizophrenia (n = 44), substance abuse (n = 22) and eating disorders (n = 18).

In a narrative review on the efficacy of the use of VR in mental health, Maples-Keller et al. (2017) indicate that VR is a promising approach for specific phobias, post-traumatic stress, social anxiety, panic disorder, generalized anxiety, schizophrenia, obsessive-compulsive disorder, acute and chronic pain, additions, eating disorders and autism.

In the literature on VR research, the sense of presence and embodiment are described as fundamental processes for immersion in virtual environments. The sense of presence – understood as the subjective experience of being in the virtual scene – generates the probability that the subject interacts in the virtual environment in an analogous way to what he would do in his daily life (Freeman et al., 2017). Within the field of clinical literature on mindfulness, the sense of presence refers to the awareness of being immersed in the intentional observation of mental, emotional, and proprioceptive processes, having the present moment as a space.

In this review we consider VR as a three-dimensional environment that allows interaction in real time, excluding the meanings of the word virtual associated with non-immersive environments.

## Development

## Method

**Search strategy:** the searches were carried out between May and October 2018 in BVS, without restricting databases, language or date, using words in English as recommended by the portal. The words used were: 'mindfulness' AND 'virtual reality'; 'mindfulness' AND 'VR'; 'meditation' AND 'virtual reality'; 'meditation' AND the 'VR'; 'DB' AND 'virtual reality'; 'DBT' AND 'VR'; 'compassion' AND 'virtual reality'; 'compassion' AND 'RV'. Records were located in Medline, LILACS and IDEC'S databases.

**Inclusion and exclusion criteria:** we included studies that consider mindfulness and VR as combined or complementary approaches, both in virtual environments designed for mindfulness practice and in interventions that use these two resources together. Articles that combine VR and the compassion construct in the context of mindfulness were included, as well as those that jointly deal with VR and specific elements of mindfulness, such as the meditative walk. We excluded articles that address mindfulness and VR as independent strategies in comparison studies.

**Selected jobs:** the search generated 60 records. Duplicate articles (n = 19) and those that did not meet the inclusion criteria (n = 29) were eliminated during the title and abstract analysis.

Articles listed in the references included in papers within the sample generated with the systematic search were included. In total, 23 complete articles were analyzed.

## Result

The following Table 1 gathers the articles analyzed:

**Table 1.** Papers analyzed and comments.

| Ref. | Type, population, sample | Comments |
|---|---|---|
| Amores & Maes (2017) | pilot comparative study; non-clinical; n = 12 | Viability of VR+NFB and olfactory necklace for MF. Physiological response measured with EEG compatible to subjective perception of relaxation. |
| Baños et al. (2011) | RCT; clinical; n = 39 | Significant differences (depression, relaxation and social interferences). Greater efficiency of the VR condition. |
| Botella et al. (2013) | pre-post pilot study, 6-month monitoring; clinical; n = 6 | Efficiency of adaptive virtual environment with TCC in fibromyalgia in group MF. Long-term benefits with significant decrease of pain and depression. |
| Bruggeman & Wurster (2018) | prototype | Describe a prototype of MBSR with VR and Biofeedback (breath). |
| Chen et al. (2018) | RCT; clinical; n = 180 | Effects of mindfulness-based relapse prevention (MBRP) + VRET. Ongoing during this review. |
| Cikajlo, Čižman-Štaba, Vrhovac, Larkin, & Roddy (2016) | controlled; clinical and non-clinical; n = 8 | The results in MF were obtained in less time than the traditional MBSR. |

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|---|---|---|
| Cikajlo, Čižman-Štaba, Vrhovac, Larkin, & Roddy (2017) | controlled; clinical and non-clinical; n = 8 | Viability of remote VRMF in brain injury. They reported vital satisfaction, better MAAS scores and movements decrease during VRMF. |
| Falconer et al. (2014) | pilot comparative study on conditions; clinical; n = 43 | VR as an embodiment technique as in the recipient position increases self-compassion in people high in self-criticism. |
| Falconer et al. (2016) | comparative; clinical; n=15 | Significant decreases on the severity of depression and self-criticism, increase on self-pity in 4 weeks. |
| Gomez et al. (2017) | single case; clinical; n = 1 | VRMF in DBT for emotional regulation in patient with severe burns. Decrease of negative emotions and increase of positive ones, good acceptance. |
| Kosunen et al. (2016) | Comparative; non-clinical; n = 43 | Neuroadaptive system combined with neurofeedback and VRMF. It is concluded that Relaword can provide deeper levels of meditation, relaxation and presence in VR+NFB condition. |
| Modrego-Alarcón et al. (2016) | Review; n = 10 | Analyses 10 articles on VR to enhance mindfulness. Pilot projects with small samples. |
| Navarro-Haro et al. (2017) | pilot; uncontrolled; non-clinical; n = 44 | Acceptability by experienced mediators and perception of benefits from VRMF to DBT. Satisfaction, improvement in MF condition and emotional condition. |
| Serra-Pla et al (2017 | comparative; clinical; n = 25 | Intervention to TDAH in adults based on VRMF seeking for treatment adherence and cost reduction. Ongoing during review. |
| Navarro-Haro et al (2016) | single case; clinical; n = 1 | Clinical potential of VRMF in Borderline Personality Disorder. VR can facilitate MF skills in DBT. Studies required on results durability and efficiency to TPL. |
| Prpa, Cochrane, & Riecke (2015) | prototype | Prototype of VRMF with biofeedback (SOLAR) considering non-identification, abstract visual elements, reward system and immersion. |
| Schroeder el tal. (2013) | protutype | Multimodal prototype of VR with haptic devices for chronic pain with sensorial feedback. It is viable to develop experiences by using low-cost VR. |
| Shaw, Gromala, & Song (2012) | discussion and prototype; non-clinical; n = 411 | VRMF+biofeedback system for chronic pain. It combines Jacobson relaxation and biofeedback. VR optimizes relaxation learning when physiological measures are observed. |
| Tarrant, Viczko, & Cope (2018a) | controlled pilot; non-clinical; n = 14 | Verify VRMF short session effect on moderate or severe generalized anxiety. The group with VR presented specific electrophysiological markers of anxiety reduction. |
| Tarrant & Cope, (2018b) | pre-post controlled pilot;non-clinical; n = 4 | Verify if low-cost wearable can be used with VRMF for NFB of frontal gamma asymmetry to generate positive states of mind. Results show possible VR specific effects on brain activity observed with QEEG and sLORETA. |

| | | |
|---|---|---|
| Tong, Gromala, Choo, Amin, & Shaw (2015) | RCT; clinical; n = 13 | Verify efficiency of immersive system with biofeedback based on MF for chronic pain. In VRMF condition with biofeedback for MBSR it was observed a significant decrease in pain perception. |
| Wood et al. (2007) | single case; clinical; n = 1 | Virtual-Reality Exposure Therapy with Arousal Control (VRET-AC) for EPT in warriors. Significant decrease on EPT symptoms, depression and anxiety. |
| Wood, Wiederhold, & Spira (2010) | case study; clinical; n = 30 | Controlled Virtual-Reality Exposure Therapy with Arousal Control (VRET-AC). VR is an effective treatment when associated with combat situations. |

Source: The authors.

### *Types of study and design*

We found one systematic review on mindfulness and VR (Modrego-Alarcón et al., 2016), covering 10 papers that use VR for mindfulness learning. The authors conclude that VR can facilitate the learning and practice of mindfulness in clinical and non-clinical populations, as well as signal the need for randomized controlled trials (RCT) and with larger samples. We did not locate any meta-analyses. Most articles present pilot studies with small samples. Three follow a randomized controlled design (one of them uses a sample of 180 subjects (Chen et al., 2018)). Others describe comparative studies of experimental conditions or design with a control group, but do not meet the RCT criteria. Others present single case reports or describe clinical practice-based studies investigating the effectiveness of treatments that include VR and mindfulness. We also analyzed articles on prototypes and architectures for mindfulness with VR (VRMF), and articles on theoretical development and construct validation.

### *Clinical conditions and interventions addressed*

The analyzed studies seek to verify the usefulness of VR to introduce mindfulness in the treatment of psychological disorders or other conditions accompanied by anxiety and stress, such as chronic pain. Papers that discuss adaptations of mindfulness with VR for specific psychotherapy interventions cover: mindfulness in dialectical behavioral therapy (Navarro-Hero et al., 2016, 2017; Gomez et al., 2017); the combination of exposure with VR (VRET) and MF for relapse prevention in addictive behavior (Chen et al., 2018), mindfulness-based stress reduction (Prpa, Cochrane, & Riecke , 2015; Tong et al., 2015; Cikajlo, et al., 2016, 2017; Bruggeman & Wurster, 2018; Wood et al., 2010); compassion-focused therapy (Falconer et al., 2014, 2016); mindfulness-based cognitive therapy (Wood et al., 2007; Baños et al., 2011; Botella et al., 2013; n = 2). According to DSM-V classification, the analyzed papers address substance-related disorders; trauma-related and stress-related disorders, highlighting the applications for the treatment of post-traumatic stress subtype and adaptation disorders, including chronic stress; anxiety disorders (especially generalized anxiety); depressive disorders; borderline personality disorder and attention deficit/hyperactivity disorder (ADHD) in adults.

In addition to the conditions named above, other analyzed papers address clinical problems such as chronic pain, fibromyalgia, brain trauma, and burns[4]. One of the papers (Navarro-Haro et al., 2017) addresses the acceptability of VR for mindfulness within Dialectical Behavioral Therapy among experienced meditators. This work is an approach to usability studies and differentiation of effects in expert and novice meditators, since a good part of mindfulness systems for VR seeks to facilitate the learning of mindfulness techniques. Regarding the effects of VR on proprioceptive consciousness with novice meditators, the work of Shaw et al. (2012) describes an open-label study with 411 non-clinical participants. The facility, Meditation Chamber, combines VR and biofeedback for an enhanced and augmented[5] experience geared towards learning mindfulness skills and experimenting its benefits such as reducing stress, anxiety, and pain.

## Discussion

### *Mindfulness and Virtual Reality joints*

The papers we analyzed present the junction between mindfulness and VR through (1) the comparison of the two modalities as different therapeutic strategies, (2) the use of both as complementary in the same treatment, and (3) the combined use in the same system/application, with mobile equipment or immersive environments such as basements and sensory chambers. Working with patients, we observed that such modalities, as strategies and tools, should be employed by the psychologist in line with the psychological theory underlying his clinical practice and meeting the patient's need for treatment, and not as mere intervention techniques.

### *Mindfulness and Virtual reality as complementary strategies*

When VR and mindfulness are approached in a complementary way, mindfulness is used to help the patient regulate psychophysiological activation and to face, with better resources, exposure with VR to anxiogenic and stressful situations.

One of the articles describes a mindfulness-based relapse prevention (MBRP) program combined with virtual exposure to scenes related to substance abuse behaviors in clinical subjects (Chen et al., 2018). In our clinical work, we found that exposure with VR requires the preparation of the patient and the attentive presence of the psychologist for a joint experience.

The degree of interaction between both during immersion may vary depending on the needs of support and regulation, always in a joint situation that benefits from the therapeutic bond.

[4] Although we did not find in this systematic search articles dealing specifically with mindfulness with Virtual Reality in cancer patients, this it is a junction that gathers together all the interventions based on mindfulness for pain and palliative care, with the use of Virtual Reality for pain, in response to the problem of chronic pain and the emotional state of a terminal illness, which has been used in both sections of the adults and pediatric patients (Contreras, Castañeda, Botella, & Becerra, 2017).

[5] The term 'augmented' is used here in general to refer to the expansion of the user experience through the modification that the information coming from the biosensors produces in the virtual environment and in the immersive experience. The in-depth discussion of the differences between the terms 'virtual reality' and correlates such as 'augmented reality', 'mixed/hybrid reality' and 'expanded reality' is beyond the scope of this work.

In this sense, VR systems that enable communication between the psychologist and the patient and that count on physiological data and flexible configuration parameters respond to real needs of clinical practice.

Two other papers combine mindfulness with VR for the treatment of post-traumatic stress in ex-combatants (Wood et al., 2010). They describe an architecture that combines combat scenes for exposure that can be alternated with scenes for control of psychophysiological activation (meditation and relaxation), as well as physiological data for monitoring patient activation. The treatment includes Mindfulness in the preparation for exposure, in the intermediate phases for the regulation of psychophysiological activation and at the end of the session, for integration. This architecture, in addition to providing the psychologist with biosensor information in real time, counts as the possibility of enabling the practice of MF in the virtual scenario, opening space for counterconditioning.

In our view, the use of VR in a mindfulness environment as a complementary therapy for coping with stressful situations becomes possible, primarily, by the bond stablished between psychologist and patient in the therapeutic process. It is up to the psychologist to decide the most favorable moment for the use of the virtual environment.

## *Ecosystems for mindfulness and Virtual Reality junctions*

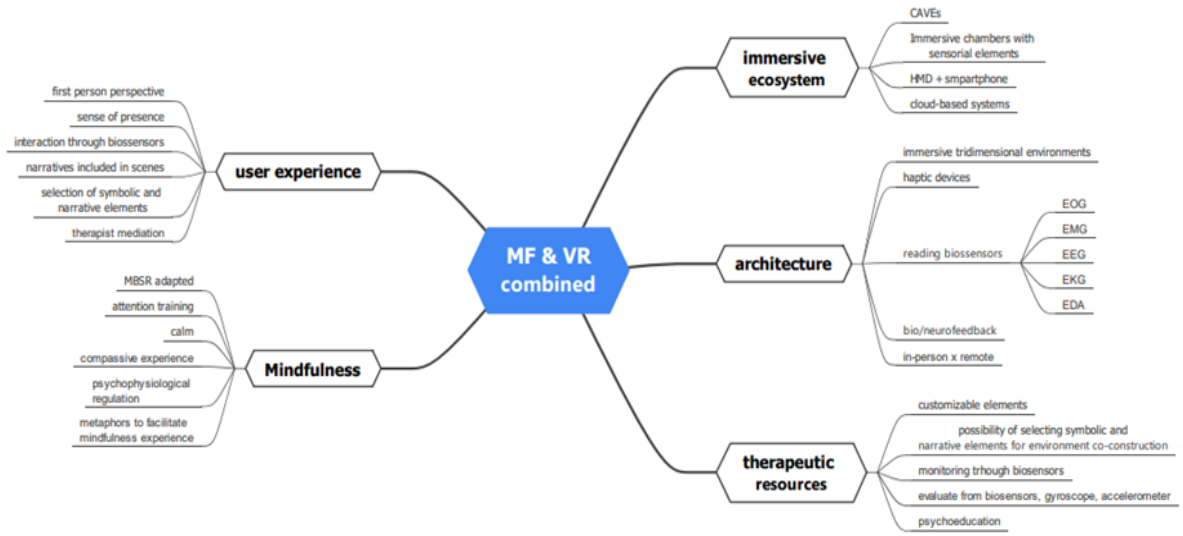
In the combined form of VR and mindfulness (VRMF), the analyzed papers cover the experimental use of a) three-dimensional environments designed for MF with VR; B) multimodal immersive environments with haptic devices that facilitate the sense of presence by providing sensory information; c) immersive environments with biosensors that facilitate proprioceptive awareness and d) use of bio and neurofeedback[6] sensors for interaction within the virtual scenarios from physiological parameters. Biofeedback as a data source that produces changes in scenes seeks a greater degree of interaction of the subject with the virtual environment. For the clinical work for attentional regulation, research shows that the interaction with physiological parameters in real time in the virtual environment facilitates the sense of presence, awareness and the state of mindfulness. However, such resources are still restricted to laboratories and are not usual in clinical VR systems available on the market. Figure 1 summarizes, in a cartographic manner, the results of the analysis performed.

The papers analyzed describe virtual environments for mindfulness developed for immersive rooms and for use with VR glasses and smartphone with the possibility of face-to-face or remote administration. EMMA's World Environment (Engaging Media for Mental Health Applications) follows a model in which immersion takes place in a room with projectors, audio, and a large screen. The software allows therapist and patient to choose together stimuli with symbolic value to compose the virtual world. The therapeutic system has been shown to be useful for the activation and processing of emotions in fibromyalgia, post-traumatic stress, pathological mourning, and adaptive disorders (Baños et al., 2011; Botella et al., 2013).

[6] Biofeedback is a therapeutic resource in which, through sensors that capture physiological activity, the patient learns to regulate the activation of the nervous system in real time. Biofeedback presupposes the existence of feedback: the sensor placed in the patient captures the physiological data, which is interpreted by software and translated in real time to the patient in the form of images and sounds. Through interaction with the audiovisual element the patient learns, with the help of the psychologist, strategies to regulate physiological responses. In the specific case of regulation of brain wave activity, electroencephalogram (EEG) sensors are used, and the process is called neurofeedback. The term biofeedback refers to other signs such as respiratory rate, heart rate, skin conductance, temperature.

Another approach addresses remote cloud systems to bring therapy to more people and patients with mobility limitations. Two of the papers analyzed (Cikajlo et al., 2016, 2017) present a prototype that includes a web interface for conducting real-time mindfulness sessions based on an MBSR program adapted for remote patients equipped with VR glasses and smartphone, individually or in a group. During remote sessions conducted in real time, the patient sees the therapist on the virtual scene.

**Figure 1.** Situational map constructed from the analyzed papers.




Source: The authors.

The other articles present VR systems developed for use with smartphones, some for autonomous use by patients in their homes (Schroeder et al., 2013) and others for use in the presence of the therapist. The different systems vary according to the psychological aspects they seek to potentiate, the metaphors and narratives in which the virtual environments are based, the combination with biosensors and the amount of information provided to the patient during immersion, the flexibility that each platform offers to the psychologist, with possibilities of setting stimuli and real-time evaluation. The articles analyzed reflect the search for formats, stimuli and variables that enable the junction of VR and mindfulness for the benefit of the patient.

From the analyzed papers we observed that systems designed to combine VR and mindfulness seek to meet specific clinical needs, such as learning the refocusing of attention in chronic pain or emotional reprocessing/regulation in patients with trauma, among others, as well as needs of the psychologist, including flexible platforms that allow (1) configure stimulation parameters in quantitative and qualitative (symbolic) terms, (2) obtain physiological information to evaluate and monitor the patient, (3) neurofeedback for training specific skills within the scene, (4) remote access to assign tasks to home between sessions and to attend patients with mobility limitations.

Combining the two modalities of intervention, VR and mindfulness, we have the possibility to meet clinical demands outlined in the diagnosis and treatment of different psychological conditions. Studies have shown greater efficacy for specific treatment

objectives as described above while pointing to a greater number of technological resources for monitoring this evolution.

### *Use of biosensors and haptic devices*

In our review, eleven (n = 11) papers describe systems that combine biosensors and haptic devices with VR for mindfulness. Haptic devices aim to produce an enriched immersive experience, potentiating for example the meditative walk for patients with pain (Schroeder et al., 2013); sensory elements aim to stimulate relaxation (Amores & Maes, 2017); and biosensors provide physiological data that allow greater interaction through biofeedback. New virtual glasses include biosensors to interact with scene elements through brain waves (Bernal, Yang, Jain, & Maes, 2018). While these systems are not commercialized, prototypes seek to include sensory devices and biosensors for an augmented and enhanced VR experience.

Several of the articles in this review include biofeedback, a form of training that allows the patient to modify physiological patterns with the help of biosensors. Biofeedback has been used to relieve symptoms associated with the regulation of the autonomic and central nervous systems such as stress, anxiety, depression, pain, hyperactivity, and epileptic seizures (Tan, Shaffer, Lyle, & Teo, 2016).

At the intersection with VR and mindfulness, biofeedback enables deeper meditation, with a greater sense of presence, relaxation, and connection. Neurofeedback, as a specific modality for brain wave training, has been explored in the practice of mindfulness with VR as a means to train attention and improve the experience of meditation and a lower physiological arousal, indicative of a meditative state from which it is possible to generate changes (Shaw et al., 2012).

The inclusion of haptic devices and biosensors seems to respond to the search for improved experiences, with greater sensory synergy, that facilitate awareness and learning of mindfulness and a greater appreciation of its benefits. On the other hand, the perception of deep calm associated with the regulation of the autonomic nervous system with meditation techniques has been sought through the inclusion of biofeedback sensors, mainly breathing, connected to elements of the scene.

### *Trends*

One of the relevant questions for research on VR uses concerns the possible specificities of VR interfaces and their therapeutic effects. This can be especially relevant for thinking interventions based on mindfulness, a practice based on introspection that seeks a proprioceptive awareness capable of integrating bodily sensations and perception of the mental field.

The inclusion of biofeedback opens a rich path in this direction by translating both to the psychologist and the patient his/her states into physiological data coming from the central nervous system and the autonomic nervous system. While commercialized systems do not integrate interaction with biofeedback, the psychologist relies on physiological data for monitoring and to facilitate metaconsciousness, even if observing the record with the patient after immersion, not in real time.

The work of Bernal et al. (2018) presents a VR platform for mental health supported by glasses equipped with biosensors. This work was not included in our sample because it presents a generic VR platform for mental health, both for evaluation and therapeutic

intervention, but does not address mindfulness. We chose to mention it here because it enriches this discussion with its system architecture perspective.

The architecture of the platform described adds machine learning and gamification to enhance mixed experiences, which implies that in addition to VR glasses, the user is connected to sensors that allow real-time monitoring of their physiological and cognitive states. Sensors in the glasses capture EKG (cardiac activity) and EDA (electrodermal activity) data, informing about psychophysiological activation and emotional reaction; EEG (electroencephalography) and EOG (electrooculography) sensors inform about attention and affective valence; EMG (electromyography) sensors inform about facial expressions and positive or negative valence. Neurofeedback is integrated into VR With Mindfulness for both evaluation and training.

Combining neurofeedback and VR, Tarrant et al. (2018a) researched the effect of a brief mindfulness session with VR on generalized anxiety. Both the experimental group with VR and the control group (Rest) reported decreased anxiety. Although both showed an increase in alpha wave power (consistent with greater relaxation), only the RV group showed a specific global electrophysiological change with a reduction in high-frequency Beta activity to low-frequency Beta after the intervention.

The study presents detailed analysis of the effects of mindfulness session with VR on specific regions of interest of the brain with sLORETA[7]. The authors observed a significant decrease in high-frequency Beta activity in the anterior cingulate cortex (the main mediator between the limbic system and the autonomic nervous system, associated with stress, worry, cognitive rigidity and obsessive thoughts). The results are relevant, as they suggest that meditation with VR produced a specific effect of reducing psychophysiological activation associated with anxiety not obtained with rest. Nevertheless, the results should still be interpreted with caution.

Through a case study, Tarrant and Cope (2018) also investigated the intersection between neurofeedback, VR, and compassion-based meditation (Open Heart), seeking construct validation. They sought to determine whether a consumer neurofeedback (MUSE) system used with VR environments (positivity by Healium) could focus on frontal gamma asymmetry, a reliable measure of changes in emotional states. They concluded that the intervention with VR presents therapeutic potential.

Using neurofeedback as a training element in the virtual environment, Bruggeman and Wurster (2018) proposed a study on mindfulness (MBSR) with individuals with low cognitive memory.

They introduced the Hiatus System, whose virtual experience is created so that the subject can reach and maintain his attention in meditative practice. They concluded that VR with breathing biofeedback is effective in teaching the patient to reduce stress.

About this, Tinga, Nyklíček, Jansen, Tycho, & Louwerse (2018) discuss the effectiveness of respiratory biofeedback to reduce activation in VR meditation for stress recovery. They used EEG and EKG measurements and concluded that, despite the subjective perception of reduced activation in both the experimental and placebo groups and without feedback, the reduction in activation was greater in the placebo group. With these findings, they suggest that VR may be effective in reducing activation, but that the use of respiratory biofeedback needs to be better understood. It would be necessary to ask if the respiratory feedback could suggest an active control of breathing, since the meditation

[7] Acronym for Standardized low Resolution brain Electromagnetic Tomography, software used to locate brain activity and functional connectivity.

guide described was based on breathing. Kosunen et al. (2016), when describing the prototype of the RelaWorld virtual environment, address the care and adjustments that were necessary for a good user experience with biofeedback and neurofeedback. Studies such as that of Tinga et al. (2018) indicate the importance of including measurements with biosensors and experimental control, and of identifying the specificities and mechanisms associated with each variable included. Considering our clinical experience, these results point to the importance that the psychologist can count on flexible clinical platforms that allow adjustments in biofeedback parameters and that are based on the mediation of the therapist. Mindfulness practices are a powerful tool for self-regulation, but in this learning process it is important that the patient learns to build regulation from the inside out, improving body and mind synchronization, suspending, and releasing the need for control and narrative processing.

It is important to note that the work with neurofeedback and biofeedback largely depends on the patient's ability to 'release' the search for control. In one session, the experienced therapist can carefully observe the patient and guide him to get carried away and allow the body (especially considering the autonomic and central nervous system) to learn to regulate itself from the information obtained through the sensors. The intention to interfere and control generates tension that hinders self-regulation, which can be part of the clinical picture as, for example, in anxiety disorders.

## Final considerations

The questions that guided us to this work emerged from our clinical practice where we used VR as a facilitator for mindfulness learning. The studies presented pointed to the use of new technologies as a facilitator for people who have some difficulty in immersion in mindfulness.

We understand that VR facilitates this learning by delimiting the focus of attention, reducing the interference of distractors from the natural environment. This contributes to providing a sense of presence in immersive environments designed to be engaging and interactive. VR, as an immersion technology and with environments designed for mindfulness, collaborates with awareness in the experience of mindfulness and with opening a facilitating path for its benefits.

In working with patients, we observed that the perception of inconsistencies within the narrative flows during meditation with VR generated a conducive space for psychotherapeutic intervention. This experience, corporally perceived, can promote the reorganization of the previously predominant narrative, facilitating the patient's first-person experience. We think that the bond and the attentive presence of the therapist are fundamental so that these perceptions can be used as openings for the therapeutic dialogue.

Regarding our question about the importance of the perception of the interruption of narrative flows during immersion with VR promoting transformative experiences, we found affirmative support in the review paper presented by Riva, Baños, Botella, Mantovani, & Gaggioli (2016) who conclude that VR is used for controlled exposure and to facilitate the embodiment of experience, signaling pathways for transformative experiences in first person.

Our questions led us to conduct a narrative review that delineated the intersection between VR and mindfulness-informed therapies. We prove that this is a recent association,

and that the indexed and reviewed literature does not yet collect the variety of experiences in development, and studies are necessary to provide a better understanding of the specifics of immersion with VR, its effects on the experience and the therapeutic openings that it can provide. Neurosciences have made advances in this direction, as well as works that conceive VR as a simulation and embodiment technology, which can interrupt predictive processing and, therefore, generate openings for reorganization and reprocessing (Riva, Wiederhold, & Mantovani, 2020). It is also worth mentioning efforts such as the three-step model for the development of treatments and clinical trials with VR, which starts from the principle that VR has specificities that require adaptations in protocols used in the biomedical sector (Birckhead et al., 2019).

Considering this scenario, it is possible to develop an interventional work with patients with different mental, physical and psychosomatic disorders, as we were able to follow in the analyzed studies. We understand VR as a tool that enables transformative experiences from a first person perspective (Riva et al., 2016, 2018, 2020; Gaggioli, 2020), with the potential to produce a de-identified and embodied observation of the psychological experience, leading to narrative reorganization from an experience that can facilitate a new sense of power when being the protagonist patient.

This review has limitations because most of the studies analyzed are still in early stages, and few studies meet the control criteria necessary to evaluate evidence-based efficacy. The narrative and qualitative review could provide, however, an overview of the current scenario. We conclude that most of the papers discussed here offer important information to map the paths for future randomized controlled studies that allow a greater expansion of treatment perspectives for patients whose profile falls within mindfulness-informed therapies and VR. Our gaze is on the patient who seeks help where in general so many other attempts have failed, and we believe that this is where we should pursue our future research.

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