



## Research report

## Virtual reality and stimulation of touch and smell for inducing relaxation: A randomized controlled trial

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## ABSTRACT

The aim of this study was to test the efficacy of a mood-induction procedure in a Virtual Reality (VR-MIP) environment for inducing relaxation and generating sense of presence, and to test whether the stimulation of the senses of touch and smell improves the efficacy of this VR-MIP. A controlled study was carried out with four experimental conditions. All of them included the VR-MIP to induce relaxation, but varying the senses stimulated. The sample consisted of 136 participants randomly assigned to one of the four experimental conditions. Emotions and sense of presence were evaluated. The results showed statistical differences before and after mood-induction and a high sense of presence in all groups. However, no statistical differences were found among the four groups on emotions and sense of presence. The results showed that the VR-MIP was effective; however, the stimulation of the senses of touch and smell did not show significant improvement of the mood-induction or the sense of presence. It was identified a trend in favor of the groups where the sense of touch was stimulated, they seemed more relaxed and the sense of presence was higher. We hypothesized that the stimulation of sense of touch, could improve the efficacy when using VR-MIP because it provides more sensory information.

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## 1. Introduction

Virtual Reality (VR) allows the simulation of real-life situations in a tridimensional computer-generated environment where the user can interact with the environment as if he/she were in the real world. In VR it is possible to interact in real time with different objects and experience a sense of presence, -the illusion of “being there”- (Baños, Botella, & Perpiñá, 1999). Since its emergence, VR has diversified its application areas, with the most common being: architectural design, user-oriented design, marketing, military training, surgery simulation, medical training, education, physical rehabilitation, and psychological treatments.

This technology enables users to interact and immerse themselves in an environment through the stimulation of different senses. In 1957, Morton Heilig designed the first approximation of a virtual environment (VE) to stimulate various senses. This system was called “Sensorama”, and it consisted of a display enriched with

objects from the physical world (e.g., images, sounds, odors). It tried to provide the illusion of reality by using a 3D motion picture with smell, stereo sound, and seat vibration, or increasing the sense of movement by blowing air into users' faces. Despite this initial system, the most common senses stimulated in VE have been sight (using 3D images) and hearing (using computer-generated sounds). In recent years, the possibility of using strategies to stimulate smell, touch or taste has been considered, with the purpose of improving sensory experiences in VE. For instance, Dinh, Walker, Hodges, Song, and Kobayashi (1999) analyzed the possibility of stimulating different senses in order to enhance the VR experience. They evaluated the effects of smell, touch, sight and hearing on the sense of presence and memory. They used stimuli associated with specific objects in the VE (scent of coffee for smell, specific sounds for hearing, a real fan to provoke the sensation of air on the participants' skin, or a light lamp to produce the feeling of the sun on the skin to stimulate touch). Their results showed that the more senses stimulated, the higher the sense of presence, specifically when hearing and touch were introduced. Hoffman, Hollander, Schroder, Rousseau, and Furness (1998) also found evidence of the role of tactile sensations. In their study, participants could interact with

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physical objects by means of tactile augmentation. While a virtual hand was exploring a virtual object, the real hand was exploring the real object at the same time. The authors suggest that adding physical objects that provide tactile feedback for actions increases the sense of presence in VEs. Other studies have focused on olfactory stimulation. For example, Tortell et al. (2007) associated scents with specific objects in a VE to assess their influence on memory.

Other studies used tactile or olfactory stimuli with the specific purpose of improving the sense of presence in VEs in the treatment of specific phobias (Carlin, Hoffman, & Weghorst, 1997; Hoffman, García-Palacios, Carlin, Furness, & Botella, 2003) or posttraumatic stress disorder (Rizzo et al., 2010; Rothbaum, Rizzo, & Difede, 2010), and they concluded that by adding other sense stimuli, the effectiveness of VR exposure therapy for the phobia increased.

One of the applications of VE in the field of psychology has been to induce various moods and emotions, as a “mood-induction procedure” (VR-MIP). For instance, (Baños et al., 2013) used VEs to induce positive emotions (joy and relaxation) in a specific population (adult hospitalized patients with metastatic cancer). The participants used the VR-MIP in four sessions lasting 30 min each for one week. Results showed an increase in positive emotions and a decrease in negative emotions (sadness and anxiety). In a recent pilot study (Baños et al., 2014), participants (pre-graduate students) received a VR-MIP to induce relaxation and joy in six sessions over a period of two weeks. Results showed an improvement in joy and relaxation after using the VR-MIP. Another recent study (Herrero, García-Palacios, Castilla, Molinari, & Botella, 2014) evaluated the efficacy of using a VR-MIP (in a group session) to induce positive emotions in patients with fibromyalgia syndrome as a component of their psychological treatment. Results showed significant increases in positive emotions (joy, surprise, calmness, and vigor), as well as in motivation and self-efficacy.

Several studies have found that the use of emotional VE helps to increase the sense of presence. For instance, Baños et al. (2004b) studied the effectiveness of a VE (a virtual park) in inducing sadness, joy, relaxation and anxiety, and they concluded that emotional VE increased the participants’ sense of presence compared to non-emotional (neutral) VE. In a further study, Baños et al. (2008) found a relationship between the intensity of positive emotions (relaxation and joy) and a strong sense of presence. Riva et al. (2007) also used VE to induce relaxation and anxiety, and their results also confirm the bidirectional relationship between emotions and sense of presence.

However, although there is evidence of the use of VE to induce emotions, and of the relationship between emotions and sense of presence, all of these studies used only sight and hearing stimuli. In fact, as mentioned above, research in VR using other senses such as touch or smell is very limited, even though some studies have emphasized the importance of improving VR experiences and suggested that including other stimuli (e.g. olfactory) could produce more immersive experiences, as long as the stimuli are consistent with the VE (Tortell et al., 2007). Other studies have proposed that using olfactory stimuli in VE could evoke certain emotions, which would have a direct impact on behavior (Baus & Bouchard, 2010). Along these lines, a recent review (Aiken & Berry, 2015) highlights the potential role of olfactory stimuli for improving VR exposure therapy, especially in the treatment of posttraumatic stress disorder, as smell can influence emotion and affective response, facilitate recall, or increase sense of presence.

We developed and tested a VR-MIP (“House of Relaxation”) in a pilot study, and the results showed that it was effective in inducing relaxation and sense of presence (Serrano, Botella, Baños, & Alcañiz, 2013). However, this non controlled study had several limitations, such as the small number of participants and the fact that only two senses (sight and hearing) were stimulated. The present study tries

to advance in this line of research by using the same VR-MIP (“House of Relaxation”) along with the stimulation of the senses of sight, hearing, touch, and smell.

The possibilities of VR for inducing emotions and its efficacy demonstrated in several studies is first introduced and motivated. In addition the possibility of improving these mood-inductions with the stimulation of the senses of touch and smell is exposed. Then, the main objectives and hypotheses to be evaluated in this study are specified. Subsequently the details of the experiment to test the hypothesis are described; including participant characteristics, the description of the measures, the specifications of the VR environment and tactile and olfactory stimuli, and the details of the procedure that guided the experiment. Next, the results found are described, and finally the conclusions and limitations found are exposed, as well as the recommendations for future studies in this research are specified.

The main objectives of this study are to test, in a controlled study, the efficacy of this VR-MIP to induce relaxation and sense of presence, and to analyze whether the stimulation of the senses of touch and smell improves the efficacy of this VR-MIP in inducing relaxation and sense of presence.

### 1.1. The following hypotheses are tested

**H1.** The relaxation scores will increase significantly in participants after the VR-MIP.

**H2.** The stimulation of the senses of touch and smell will enhance the relaxation experience. Statistically significant differences between groups will be observed in this direction: the groups in which these senses were stimulated will be more relaxed.

**H3.** Participants will report a high sense of presence after the VR-MIP.

**H4.** The stimulation of the senses of touch and smell will enhance the sense of presence. Statistically significant differences between groups will be observed. It is expected that the groups in which these senses were stimulated will experience a greater sense of presence.

## 2. Material and methods

### 2.1. Participants

The sample was composed of 136 participants (84 women and 52 men) whose ages ranged from 18 to 63 years ( $M = 27.05$ ,  $SD = 8.01$ ). Participants were recruited using different strategies, and they received a financial reward of 12€. The inclusion criteria were: being between 18 and 65 years old and not having any clinical symptoms of anxiety and/or depression. All the participants were evaluated using first a *Clinical Assessment Questionnaire* designed for this study, and then the *Beck Depression Inventory II* (Sanz, Perdígón, & Vázquez, 2003) and the *State-Trait Anxiety Inventory* (Spielberger, Gorsuch, & Lushene, 1986) to identify clinical symptoms. Participants were allocated to each of the four experimental groups by the Random Allocation Software (Saghaei, 2004).

### 2.2. Measures

*Clinical Assessment Questionnaire.* It is a brief 12-item questionnaire developed specifically for this research; its aim was to identify anxiety and/or depression symptoms in order to decide if it was necessary to perform a more specific assessment of depression and anxiety.

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