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Affective Interactions Using Virtual Reality: The Link between Presence and Emotions

GIUSEPPE RIVA, Ph.D.,[1,2] FABRIZIA MANTOVANI, Ph.D.,[1–4]
CLARET SAMANTHA CAPIDEVILLE, Ph.D.,[2,3]
ALESSANDRA PREZIOSA, M.S.,[1] FRANCESCA MORGANTI, Ph.D.,[1]
DANIELA VILLANI, M.S.,[1,2] ANDREA GAGGIOLI, Ph.D.,[1,2]
CRISTINA BOTELLA, Ph.D.,[5] and MARIANO ALCAÑIZ, Ph.D.[6]

ABSTRACT

Many studies showed the ability of movies and imagery techniques to elicit emotions. Nevertheless, it is less clear how to manipulate the content of interactive media to induce specific emotional responses. In particular, this is true for the emerging medium virtual reality (VR), whose main feature is the ability to induce a feeling of "presence" in the computer-generated world experienced by the user. The main goal of this study was to analyze the possible use of VR as an affective medium. Within this general goal, the study also analyzed the relationship between presence and emotions. The results confirmed the efficacy of VR as affective medium: the interaction with "anxious" and "relaxing" virtual environments produced anxiety and relaxation. The data also showed a circular interaction between presence and emotions: on one side, the feeling of presence was greater in the "emotional" environments; on the other side, the emotional state was influenced by the level of presence. The significance of these results for the assessment of affective interaction is discussed.

INTRODUCTION

ALTHOUGH EMOTIONS are present in almost all events in our lives, they are probably one of the least understood aspects of human experience. In particular, the role of emotions in mediated experiences has not been systematically researched yet, in spite of the important role that emotions play in how people attribute meanings to their experiences and to what extent they can feel present in mediated environments.

On one side, many studies have already confirmed the ability of films, TV programs and imagery techniques, as well as still slides of emotional scenes, to elicit emotions.[1–7] Recently, Mauss et al.[8] confirmed that movies are effective in inducing moderately intense emotional, behavioural, and physiological responses coherent with the context of the movie being viewed, and they provide a good context for assessing those dynamic changes in emotional responses. On the other side, even if some authors suggested possible "recipes,"[9,10] it is

[1]Applied Technology for Neuro-Psychology Laboratory, Istituto Auxologico Italiano, Milan, Italy.
[2]Interactive Communication and Ergonomics of new Technologies Laboratory, Università Cattolica del Sacro Cuore, Milan, Italy.
[3]Faculty of Communication and Arts, UNA University Centre, Lourdes, Brazil.
[4]CESCOM, University of Milan Bicocca, Milan, Italy.
[5]Department of Basic and Clinical Psychology and Psychobiology, Universitat Jaume I de Castellón, València, Spain.
[6]Medical Image Computing Laboratory (MEDICLAB), Universitat Politècnica de València, València, Spain.

less clear how to manipulate the content of interactive media to induce an emotional response.[11–13] In particular this is true for advanced interactive media, including Virtual Reality (VR).

Since 1989, when Jaron Lamier used this term for the first time VR has been described as a computer simulated environment with, and within which, people interact. Using visual, aural and haptic devices, the user can experience the environment as if he/she was part of the world. Further, because input devices sense the user's reactions and motions, the computer modifies the synthetic environment in real time, creating the illusion of interacting with, and thus being immersed within, the virtual world.

Even if VR is usually described as a particular collection of technological hardware, it is also possibile to describe virtual reality in terms of human experience, using the concept of presence[14,15]: VR is the medium able to induce the experience of "presence" in a computer-generated world. Presence is usually defined as the "sense of being there"[14] or the "feeling of being in a world that exists outside the self."[16,17]

Lombard and Ditton[18] describe presence as the "perceptual illusion of nonmediation", a level of experience where the technology and the external physical environment disappear from the user's phenomenal awareness: the term *perceptual* shows that the illusion involves continuous (real time) responses of the human sensory, cognitive, and affective processing systems to objects and entities in a person's environment. And, what's more, a subject experiences an *illusion of nonmediation* when he or she fails to perceive or acknowledge the existence of a medium in his/her communication environment and responds as he/she would if the medium were not there. There is consensus that the experience of presence is a complex, multidimensional perception, formed through an interplay of raw (multi-) sensory data and various cognitive processes.[19–23]

Starting from the above theoretical background this study analyzed the possibility of using VR as an *affective medium*: a medium able to elicit different emotion through the interaction with its contents. Within this general goal the study also analyzed the relationship between presence and emotions. More in detail, the main hypotheses explored by the research were:

- *The possibility of affective media*: interactive media, and in particular VR, may be developed to induce specific emotions in their users;
- *Emotional state will be influenced by the sense of presence*: If the virtual environment is able to produce in users the feeling of presence, this environment will be able to elicit emotions;
- *Sense of presence will be greater in the "emotional" environments*: It is more likely that an environment that is able to elicit anxiety, relaxation, etc. could make users feel more present in that environment.

To verify the above hypotheses we used three VR environments (virtual parks) developed by the University Politecnica de Valencia, Valencia, Spain, within the activities of the European funded "EMMA" (IST-2001-39192) project.[24–27] All the three parks share the structure and include the same objects (trees, lamps, summer cinema, band stand, etc). However, the developers modified the experience associated to the three parks by manipulating sound and music, shadows, lights and textures. In particular, the audio-visual features of two parks were manipulated to induce two specific emotional states: anxiety and relaxation (Figs. 1 and 2).

The third one (neutral) was used as control group. A detailed description of the features of the parks is included in the paper by Baños et al.[24] In a preliminary study, Baños et al. verified significant differences between the emotional and the neutral environments.[28]

METHODS

Sample

Sixty-one undergraduate students of Psychology from the Catholic University of Milan took part in the experiment. There were 35 females and 26 males aged 19–25 years (M = 21.45; SD = 2.91). Participants with history of neurological disease, head injury, learning disability, psychological disorders, usage of any medication for psychological or emotional problems, or those who scored 18 or higher on the Beck Depression Inventory questionnaire[29] were excluded from the experiment. Students were volunteers and did not receive any payment or credit for their collaboration. All participants experienced all virtual environments (anxious, relaxing and neutral parks), in a randomized order.

Experimental design and materials

In order to study the efficacy of VR as affective medium, each subject experienced all the three virtual parks (repeated-measures design): anxious, relaxing, and neutral. The sample was randomized to the various sequences of treatments. For two experimental treatments (A and B), and a control treatment (C), there are six possible sequences: A-B-C, A-C-B, B-C-A, B-A-C, C-A-B, and C-B-A.

FIG. 1. The anxious park.

The virtual environments were run on a portable computer (Sony Vaio Notebook PCG-GRT 996ZP, Pentium-4 3.20-GHz), with Microsoft Windows XP Professional and a graphic card NVIDIA GeForce FX Go5600 with 3D performance and 64 MB of VRAM. Environments were visualized using an immersive Head Mounted Display (800 × 600 resolution) with head tracking. Navigation and movements within the environment were possible through the use of a wireless joystick (Logitech Wingman Cordless Rumblepad Gamepad). Voices and music during the exploration were played by two external amplifiers and speakers (Star SP-160B).

Measurements

For each participant, two different types of self-report measures were used: (1) paper-and-pencil questionnaires for emotional and presence assessments and (2) emotional and presence ratings during the VR experience.

Paper-and-pencil materials consisted of:

- **One questionnaire used for exclusion criteria evaluation**: *Beck Depression Inventory (BDI)*.[29] This instrument assesses main cognitive aspects of depression, and it has become the most widely used

FIG. 2. The relaxing park.

self-report instrument for measuring depressive symptom severity in both research and clinical settings. It consists of 21 items. For each question, the participant is required to choose the statement that best describes his/her mood state, from among four possible answers.

- **Three questionnaires for mood evaluation before and after VR experiences:** (1) *Visual Analogue Scale (VAS).*[6] Participants are required to indicate how they feel at a specific moment in time with reference to each of seven visual analogue scales measuring Happiness, Sadness, Anger, Surprise, Disgust, Anxiety, and Quietness. (2) *Positive and Negative Affect Schedule* (*PANAS*).[30] This measure is composed of a list of 20 adjectives used to describe 10 positive emotions (which compose the global Positive Affect Score) and 10 negative emotions (which compose the global Negative Affect Score). Respondents are required to indicate the extent to which they feel the emotions included on the schedule "at this moment" on a five-point scale (where 1 = very slightly or not at all, to 5 = extremely). (3) *State Trait Anxiety Inventory (STAI).*[31] This measured the level of anxiety. Respondents indicate how much each statement reflects how they feel on a 0–3 scale. It has two versions, asking participants "how they feel right now" (state version), or "how they generally feel" (trait version). Only the state version was used because it is sensitive in revealing changes in anxiety pre- and post-mood induction.
- **Two questionnaires for presence evaluation:** (1) *UCL Presence Questionnaire*.[32] This is a post-experience subjective measure of presence. Respondents are required to provide ratings on a 1–7-point Likert scale on three questions: Q1—*"Rate your sense of being in the virtual environment."* Q2—*"To what extent were there times during the experience when the virtual environment was reality for you?."* Q3—*"When you think back to the experience, do you think of the virtual environment more as images that you saw or more as somewhere that you visited?"* (2) *Independent Television Company Sense of Presence Inventory (ITC-SOPI).*[33] This post-exposure presence measure is divided into two parts. Part A is composed of six items and refers to a respondents' impressions/feelings after a media experience has finished. Part B consists of 38 items and refers to a respondents' impressions/feelings during a media experience. A consistent scoring mechanism (1–5-point Likert scale, from Strongly Disagree to Strongly Agree) is used for both parts. Factor analysis of this 44-item questionnaire showed that it measures the following dimensions of presence: (a) Sense of Physical Space, (b) Engagement, (c) Ecological Validity, and (d) Negative Effects.

Emotional and presence ratings during the VR experience were carried out by questions within the environment. With respect to emotions, participants were asked to rate on a 10-point scale their level of sadness, happiness, anxiety, and relaxation, answering the questions:

- EQ1—*"To what extent do you feel sad at this moment?";*
- EQ2—*"To what extent do you feel happy at this moment?"*
- EQ3—*"To what extent do you feel anxious at this moment?"*
- EQ4—*"To what extent do you feel relaxed at this moment?"*

For presence they had to use the same scale to respond the questions:

- PQ1—*"Do you feel you are here, in this park?"*
- PQ2—*"Do you feel this park is real, is it a place you are visiting?"*

Procedures

Participants were seated in a swivel armchair in front of a computer and were tested once per session. At the beginning of the session, they provided their informed consent and received a set of instructions about the experiment. The experiment was divided into two main phases: baseline and navigation.

Baseline phase. In this phase, participants were requested to previously complete the VAS, PANAS, STAI, and BDI questionnaires in order to assess their baseline emotional state. At the end of this phase, participants were instructed about the use of the equipment and how to explore the virtual environments.

Navigation phase. This phase was divided into three parts in which, according to the randomized order, the three virtual parks were presented to all participants. The navigation in each environment was free and lasted about 3 min. In all environments participants had to answer questions concerning their emotional state (EQ1, EQ2, EQ3, and EQ4) and sense of presence (PQ1 and PQ2), which appeared on the display at the beginning and at the end of the experience.

At the end of each part, participants completed the VAS, PANAS, STAI, UCL, and ITC-SOPI questionnaires in order to assess their emotional state

TABLE 1. EMOTIONAL RATINGS BEFORE AND AFTER THE EXPLORATION OF THE "ANXIOUS" VIRTUAL ENVIRONMENT

Questionnaire	*Item*	*Baseline*	*After the exploration of the anxious environment*	*Significance*
VAS questionnaire	Sadness	M = 2.02 (SD = 1.15)	M = 2.59 (SD = 1.37)	$F_{1,60} = 8.55$; $p < .005$
	Happiness	M = 4.18 (SD = 1.04)	M = 3.21 (SD = 1.23)	$F_{1,60} = 32.32$; $p < .001$
PANAS questionnaire	Positive affect	M = 31.37 (SD = 4.60)	M = 27.55 (SD = 5.74)	$F_{1,60} = 36.54$; $p < .001$
Emotional questions inside the environment	EQ1 (sad)	M = 1.38 (SD = 1.45)	M = 1.98 (SD = 1.65)	$F_{1,60} = 10.98$; $p < .005$
	EQ3 (anxious)	M = 1.98 (SD = 1.72)	M = 3.18 (SD = 2.33)	$F_{1,60} = 22.24$; $p < .001$
	EQ4 (relaxed)	M = 4.25 (SD = 1.98)	M = 3.08 (SD = 2.05)	$F_{1,60} = 19.04$; $p < .001$

and sense of presence elicited by the navigation in the virtual environments. Finally, after all three environments had been experienced by the subjects, a debriefing phase concluded the session.

Statistical analysis

Our analyses proceeded in two steps. We first used a repeated-measure one-way analysis of variance (ANOVA) to evaluate the efficacy of the virtual environments in eliciting emotions that were coherent with their contents. We then analyzed the link between presence and emotions. We used ANOVAs, correlation analysis, and multiple regressions to evaluate their reciprocal influence. In our statistical analyses, we used SPSS 13 (SPSS Inc., Chicago, IL) software.

RESULTS

Virtual reality as affective media

Before beginning analyses of the treatment effects, pretreatment characteristics of groups were compared. As a check on the random assignment to conditions, ANOVA*s* of the pretreatment differences between the affective and the neutral parks were carried out on the measured variables. None of the tests were significant at $\alpha = 0.05$.

Then, a repeated-measure ANOVA was carried out in order to investigate the differences of in the emotional states before (baseline) and after the exploration of environments. Separate analyses were performed on data from anxious, relaxing, and neutral parks. The data showed different significant changes in the expected direction. The experience of the anxious park reduced happiness and positive affects, and increased sadness and anxiety (Table 1).

The experience of the relaxing increased quietness and happiness, and reduced anger, sadness, anxiety, and negative affects (Table 2).

No significant changes were found after the exploration of the neutral park. We then used a between-conditions one-way ANOVA to verify the existence of significant differences in the emotional levels measured after the exploration of the three parks. Differential effects of the treatments were determined using post-hoc analyses. In particular, to reduce the risk of type I errors, we used the LSD post-hoc procedure with an adjusted experimentwise

TABLE 2. EMOTIONAL RATINGS BEFORE AND AFTER THE EXPLORATION OF THE "RELAXING" VIRTUAL ENVIRONMENT

Questionnaire	*Item*	*Baseline measurement*	*Relaxing environment*	*Significance*
VAS questionnaire	Quietness	M = 4.36 (SD = 1.16)	M = 5.21 (SD = 0.90)	$F_{1,60} = 32.56$; $p < 0.001$
	Anger	M = 1.32 (SD = 0.77)	M = 1.00 (SD = 0.00)	$F_{1,60} = 10.121$; $p < 0.005$
	Anxiety	M = 3.17 (SD = 1.33)	M = 1.64 (SD = 0.88)	$F_{1,60} = 113.10$; $p < 0.001$
PANAS questionnaire	Negative affect	M = 15.54 (SD = 4.29)	M = 11.96 (SD = 2.78)	$F_{1,60} = 49.99$; $p < 0.001$
STAI questionnaire	Total score	M = 37.16 (SD = 8.66)	M = 31.69 (SD = 8.00)	$F_{1,60} = 22.54$; $p < 0.001$
Emotional question inside the environment	EQ1 (sad)	M = 1.23 (SD = 1.15)	M = 0.77 (SD = 0.94)	$F_{1,60} = 10.54$; $p < 0.005$
	EQ2 (happy)	M = 3.92 (SD = 2.03)	M = 4.54 (SD = 1.88)	$F_{1,60} = 11.61$; $p < 0.001$
	EQ3 (anxious)	M = 1.61 (SD = 1.55)	M = 0.98 (SD = 1.12)	$F_{1,60} = 10.41$; $p < 0.001$
	EQ4 (relaxed)	M = 4.44 (SD = 2.11)	M = 5.49 (SD = 1.78)	$F_{1,60} = 22.27$; $p < 0.001$

TABLE 3. DIFFERENCE IN THE EMOTIONAL RATINGS BETWEEN THE THREE VIRTUAL ENVIRONMENTS

	Anxious environment	*Relaxing environment*	*Neutral environment*	*Significance*
VAS questionnaire				
Sadness	M = 2.59 (SD = 1.37)	M = 1.74 (SD = 0.93)	M = 1.98 (SD = 1.12)	$F_{2,114} = 16.96$; $p < 0.001$
Anxiety	M = 2.80 (SD = 1.59)	M = 1.65 (SD = 0.88)	M = 1.90 (SD= 1.08)	$F_{2,112} = 22.60$; $p < 0.001$
Happiness	M = 3.21 (SD = 1.23)	M = 4.34 (SD = 1.17)	M = 3.70 (SD = 1.38)	$F_{2,114} = 22.56$; $p < 0.001$
Quietness	M = 3.85 (SD = 1.21)	M = 5.21 (SD = 0.90)	M = 4.52 (SD = 1.21)	$F_{2,114} = 36.35$; $p < 0.001$
PANAS questionnaire				
Positive affect	M = 27.55 (SD = 5.74)	M = 29.73 (SD = 6.26)	M = 27.13 (SD = 6.48)	$F_{2,114} = 6.503$; $p < 0.005$
Negative affect	M = 17.47 (SD = 6.21)	M = 11.96 (SD = 2.78)	M = 12.98 (SD = 3.76)	$F_{2,114} = 47.686$; $p < 0.001$
STAI questionnaire				
Total score	M = 39.31 (SD = 8.78)	M = 31.69 (SD = 8.00)	M = 34.56 (SD = 8.00)	$F_{2,114} = 31.885$; $p < 0.001$
Questions inside the environment				
EQ1 (sad)	M = 1.98 (SD = 1.65)	M = 0.77 (SD = 0.94)	M = 1.26 (SD = 1.24)	$F_{2,114} = 19.24$; $p < 0.001$
EQ2 (happy)	M = 3.36 (SD = 1.73)	M = 4.54 (SD = 1.88)	M = 3.75 (SD = 2.09)	$F_{2,114} = 15.25$; $p < 0.001$
EQ3 (anxious)	M = 3.18 (SD = 2.33)	M = 0.98 (SD = 1.12)	M = 1.52 (SD = 1.42)	$F_{2,114} = 36.89$; $p < 0.001$
EQ4 (relaxed)	M = 3.08 (SD = 2.08)	M = 5.49 (SD = 1.78)	M = 4.26 (SD = 2.19)	$F_{2,114} = 40.21$; $p < 0.001$

error rate (EER): 0.05 for each variable in a three-group analysis and 0.025 for each variable in a four-group analysis.[34]

Here again, as expected, post-hoc analyses showed significant differences related to the characteristics of the parks (Table 3): the anxious park was more anxious than both neutral and relaxing parks (this one was the less anxious); the relaxing park induced more happiness and quieteness than both neutral and anxious parks (this one with the lowest levels).

Emotion and presence

After finding that virtual parks were able to induce the expected emotional states, we started to explore the link between presence and emotion.

First we used a between-conditions one-way analysis of variance (ANOVA) to investigate if the level of presence was different in the three park. The data (Table 4) showed that the level of presence was significantly higher in the anxious and in the relaxing parks than in the neutral one. In general the highest level of presence was found in the relaxing park, but post-hoc analyses showed that this difference was significantly different from the anxious one only in the first item of the SUS questionnaire.

To better explore the possible link between emotion and presence, we analyzed in both the affective parks the correlations between the level of presence (ITC-SOPI questionnaire) and the emotional level experienced after the virtual experience. In the anxious park, positive correlations emerged between presence and negative emotions, and negative correlations emerged between presence and positive emotions. Also we found a positive correlation between affects and presence independently from their valence (Table 5).

In the relaxing park, we found positive correlations between presence and positive emotions, and negative correlation between presence and anxiety. Moreover, we found a positive correlation between positive affects and presence (Table 6).

These data suggest that the link between emotion and presence is not directly connected to a

TABLE 4: DIFFERENCE IN THE LEVEL OF PRESENCE BETWEEN THE THREE VIRTUAL ENVIRONMENTS

	Anxious environment	*Relaxing environment*	*Neutral environment*	*Significance*
ITC-SOPI Questionnaire Negative effects	M = 1.79 SD = 0.61	M = 1.51 SD = 0.50	M = 1.73 SD = 0.71	$F_{2,112} = 3.735$; $p < 0.05$
SUS questionnaire Question 1	M = 3.95 SD = 1.56	M = 4.23 SD = 1.51	M = 3.75 SD = 1.50	$F_{2,112} = 3.93$; $p < 0.05$
Questions inside the environment				
PQ 1	M = 4.16 SD = 2.10	M = 4.57 SD = 2.09	M = 4.08 SD = 2.03	$F_{2,112} = 26.21$; $p < 0.001$
PQ 2	M = 3.92 SD = 2.19	M = 4.44 SD = 2.19	M = 3.48 SD = 1.78	$F_{2,112} = 12.92$; $p < 0.001$

specific emotional state but it is influenced by the overall characteristic of the experience. However, from correlations we don't have any data about the possible direction of this link.

To overcome this limitation we carried out a series of Multilevel (hierarchical) Linear Regression Analyses (MLRAs). In the first group of analysis we used emotional indexes to predict the level of presence measured by the ITC-SOPI; in the second one we used the indexes of presence (ITC-SOPI scores) to predict the emotional level. In both cases, we used a two-stage least-squares regression.

Standard linear regression models assume that errors in the dependent variable are uncorrelated with the independent variable(s). When this is not the case, as in this specific study where emotion and presence are correlated, linear regression using ordinary least squares (OLS) no longer provides optimal model estimates. MLRA uses instrumental variables that are uncorrelated with the error terms[35] to compute estimated values of the problematic predictor(s) (the first stage), and then uses those computed values to estimate a linear regression model of the dependent variable (the second stage). Since the computed values are based on variables that are uncorrelated with the errors, the results of the MLRA model are optimal.[36]

In the first group of analyses, presented in Table 7, all the presence factors resulting from the ITC-SOPI questionnaire were significantly predicted by some emotional indexes. In particular, the PANAS "Positive Affect" score was included in all the significant models with the only exception of the "Negative Effect" ITC-SOPI scale.

In the second group of analyses, presented in Table 8, significant regression models were found for the anxious park only. In general, the "Negative Effect" ITC-SOPI score was present in all the models. Moreover, the "Engagement" ITC-SOPI score a significant predictor of the level of "Positive Affect" measured by the PANAS questionnaire.

DISCUSSION

This study has some caveats. First, the size of the experimental sample was limited. So, for some analyses—especially for the multilevel linear regression analyses—the statistical power was low.

Second, we measured emotional states using self-report questionnaires only. Even if the assessment tools used were validated and effectively tested in different contexts, the use of physiological indexes may help in obtaining a more complete picture of the emotional response of the user.

Third, we tested only two emotional states—anxiety and relaxation—whose main difference is in the level of activation. We need new studies to verify if it is possible to induce emotional states characterized by different levels of valence and if, in these states, the link between presence and emotions follows the same direction.

Nevertheless, this study also provided clear answers to the different questions raised in the introduction. The first goal of this study was to test the possibility of developing affective media: interactive media able to induce specific emotions in users. To verify this hypothesis we used three VR environments (virtual parks) developed by the University Politecnica de Valencia, Valencia, Spain, within the activities of the European funded "EMMA" (IST-2001-39192) project. All the three parks shared the same structure but were different in the aural and visual experience provided to their

TABLE 5: CORRELATION BETWEEN PRESENCE AND THE EMOTION IN THE "ANXIOUS" VIRTUAL ENVIRONMENT

Anxious Environment	*Item*	*VAS anxious*	*VAS quietness*	*STAI*	*PANAS positive affect*	*Emotion PANAS negative affect*	*Emotion question 1 (sad)*	*Emotion question 2 (happy)*	*Emotion question 3 (anxious)*	*question 4 (relaxed)*
ITC-SOPI questionnaire	Sense of physical space	0.155	−0.198	0.159	0.341**	0.305*	0.361**	−0.207	0.483**	−0.283*
	Engagement	0.113	−0.083	0.126	0.370**	0.235	0.056	−0.132	0.300*	−0.098
	Ecological validity	0.125	−0.116	0.143	0.182	0.277*	0.339**	−0.253*	0.349**	−0.262*
	Negative effects	0.116	−0.402**	0.450**	−0.210	0.427**	0.242	−0.318*	0.351**	−0.392**

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 (2-tailed).

TABLE 6: CORRELATION BETWEEN PRESENCE AND THE EMOTION IN THE "RELAXING" VIRTUAL ENVIRONMENT

Relaxing Environment	*Item*	*VAS anxious*	*VAS quietness*	*STAI*	*PANAS positive affect*	*PANAS negative affect*	*Emotion question 1 (sad)*	*Emotion question 2 (happy)*	*Emotion question 3 (anxious)*	*Emotion question 4 (relaxed)*
ITC-SOPI questionnaire	Sense of physical space	0.183	0.138	−0.120	0.443**	−0.002	0.009	0.235	−0.082	0.270*
	Engagement	−0.061	0.370**	−0.188	0.515**	−0.025	−0.070	0.235	−0.305*	0.356**
	Ecological validity	0.204	0.096	−0.158	0.263*	−0.070	0.053	0.134	−0.052	0.192
	Negative effects	−0.004	−0.110	0.236	−0.047	0.270*	0.029	0.114	0.123	−0.108

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 (2-tailed).

TABLE 7: MULTILEVEL LINEAR REGRESSION ANALYSIS: WE USED EMOTIONAL INDEXES TO PREDICT THE LEVEL OF PRESENCE MEASURED BY THE ITC-SOPI

ITC SOPI questionnaire						
Predicted variable	*Predictor variable*	*B*	*SE*	*Beta*	*t*	*Sig.*
Sense of physical space (model 1—anxious environment)	Positive affects	0.06098	0.11	−0.374	−3.050	0.004
	Q1 emotion	0.09322	0.042	0.237	2.238	0.029
	Q2 emotion	−0.129	0.037	−0.341	−3.480	0.001
	Q3 emotion	0.170	0.036	0.611	4.739	0.000
Sense of physical space (model 2—relaxing environment)	Positive affect	0.04881	0.013	0.443	3.795	0.000
Engagement (model 3 anxious environment)	Positive affect	0.05399	0.012	0.497	4.644	0.000
	Q2 emotion	0.0996	0.040	−0.300	−2.501	0.015
	Q3 emotion	0.07160	0.027	0.290	2.631	0.011
Engagement (model 4 relaxing environment)	Positive affect	0.05399	0.012	0.497	4.644	0.000
	Q3 emotion	−0.165	0.065	−0.271	−2.536	0.014
Ecological validity (model 5 anxious environment)	Positive affect	0.04823	0.019	0.331	2.526	0.014
	Q2 emotion	−0.185	0.063	−0.382	−2.917	0.005
Negative effects (model 6 anxious environment)	Vas anxiety item	−0.170	0.060	−0.440	−2.848	0.006
	Vas quietness item	−0.139	0.068	−0.276	−2.048	0.005
	STAI total score	0.02289	0.009	0.329	2.615	0.011
	Q3 emotion	0.117	0.039	0.444	3.014	0.004

user. Our data showed the efficacy of the affective parks—the anxious and the relaxing ones—in eliciting specific emotional states. These states were coherent with the contents of the parks and produced after a short 3-min VR experience. No emotional induction was provided by the neutral park (control condition).

This result suggests that VR is an effective mood induction medium, opening its possible use in different applicative areas ranging from the well-being industry to clinical psychology. Moreover it also suggests that presence is not influenced only by the environment's graphic realism, display dimension, and other technological features, but to a great degree by the characteristics of the experience, including the emotional ones, provided by the technology.

The second goal of the study was to analyze the possible link between emotions and presence. A previous study suggested that affective contents have an important effect on the sense of presence experienced within a VR experience.[24] This result was confirmed by our study: the level of presence was significantly higher in the anxious and in the relaxing parks than in the neutral one. Nevertheless, our data showed a bidirectional relation between

TABLE 8: MULTILEVEL LINEAR REGRESSION ANALYSIS: WE USED THE INDEXES OF PRESENCE (ITC-SOPI SCORES) TO PREDICT THE EMOTIONAL LEVEL

Predicted variable	*Predictor variable*	*B*	*SE*	*Beta*	*t*	*Sig.*
VAS questionnaire						
Vas quietness item (model 1 anxious environment)	Negative effects	−0.796	0.236	−0.402	−3.374	0.001
PANAS questionnaire						
Positive affect (model 1 anxious environment)	Negative effects	−3.371	1.121	−0.359	−3.006	0.004
	Engagement	4.799	1.191	0.481	4.031	0.000
Questions inside the environment						
Q2 emotion (model 1 anxious environment	Negative effects	−0.903	0.350	−0.318	−2.580	0.012
Q4 emotion (model 1 anxious environment)	Negative effects	−1.317	0.402	−0.392	−3.274	0.002

emotions and presence: at least for the anxious park, the level of presence was also a significant predictor of different emotional variables.

Even with the limitations stated before, our study is surely relevant to improve the evaluation of affective interactions. Our results suggest the importance of the sense of presence as mediating variable between the media experience and the emotions induced by it. In particular our study suggests that if a medium is not able to induce a feeling of presence, the affective responses might be low independently from the emotional content provided by it. So, assessing this variable may help researchers in better understanding the meaning of the affective responses collected during the interaction with a medium.[37]

Results provided by this study also confirm the importance of thoroughly investigating cognitive factors, when thinking about and designing interactive media. Further studies are necessary to evaluate the influence of cognitive and technological factors on emotions and presence and to find more elements that can contribute to them.

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Address reprint requests to:
Dr. Giuseppe Riva
Università Cattolica del Sacro Cuore
Largo Gemelli 1
20123 Milan, Italy

E-mail: auxo.psylab@auxologico.it