CyberPsychology & Behavior
Volume 12, Number 6, 2009
© Mary Ann Liebert, Inc.
DOI: 10.1089/cpb.2009.0192

Emotional Response to Virtual Reality Exposure across Different Cultures: The Role of the Attribution Process

Alessandra Gorini, Ph.D. (C),[1,2] José Luis Mosso, M.D.,[3,4] Dejanira Mosso,[3] Erika Pineda, M.D.,[4] Norma Leticia Ruíz, M.D.,[4] Miriam Ramíez,[3] José Luis Morales,[3] and Giuseppe Riva, Ph.D.[1,5]

Abstract

Many studies have shown the ability of media—television, movies, and virtual reality (VR) experiences—to elicit emotions. Nevertheless, it is still unclear how the different factors involved—user related and medium related—play a role in producing an emotional response during a VR experience. We investigate this issue, analyzing the role played by the cultural and technological backgrounds of the users in the emotional responses to VR. Specifically, we use the "core affect" model of emotions developed by Russell (2003) to explore how these factors influence the way in which participants experience virtual worlds. Our sample includes 20 Mexican participants: 8 living in El Tepeyac, a small rural and isolated Mexican village characterized by a very primitive culture, and 12 high civilized inhabitants of Mexico City. The "Green Valley," a noninteractive, relaxing immersive environment showing a mountain landscape around a calm lake, was used to induce relaxation in the two groups during an ambulatory surgical operation. To investigate the effects of VR on the relaxation process, we measured participants' physiological (heart rate) and emotional (VAS-A) responses before, during, and after the operation. The results show that VR significantly modified the core affect (reduced arousal) in all participants but that the final emotional response produced by this change was influenced by the attribution process: the civilized inhabitants of Mexico City, who were able to attribute the reduced arousal to the VR experience, reported a significant reduction in the self-reported level of anxiety, while people from El Tepeyac showed a reduction in their physiological reactions but not in their perceived anxiety.

Introduction

Many studies have shown the ability of media—films, TV programs and virtual reality (VR) experiences—to elicit emotions.[1–7] In particular, the characteristics of a VR experience—the high level of control of the interaction and the enriched experience provided to the user—transform it in an advanced imaginative system,[8] an experiential form of imagery that is as effective as reality in inducing emotional responses. This feature has been extensively used for clinical purposes.[9,10] For example, it has been used as a new medium for exposure therapy in the treatment of anxiety disorders.[9] The rationale is simple: in VR, the participant is intentionally confronted with the feared stimuli while allowing anxiety to attenuate. Avoiding dreaded situations that reinforce specific phobias, a series of controlled exposures reduces the anxiety through the processes of habituation and extinction. VR has been also used as a distraction technique in different clinical contexts in which the participant's attention to the medical procedures can increase his or her stress level and/or the perceived pain.[11–13] As demonstrated by different experimental studies, VR has a positive effect in attenuating pain[14–24] and anxiety[14,25,26] before and during various medical interventions.

Recently, Riva and colleagues[5] affirmed that virtual environments can be considered "affective media," being effective in inducing moderately to intense emotional, behavioral, and physiological responses coherent with the contents of the experienced environment and providing a good context for assessing those dynamic changes in emotional responses. Nevertheless, even though some authors suggest possible "recipes,"[27,28] it is still unclear how the different factors involved[29–31]—user related and medium related—play a role in producing an emotional response during a VR experience.

[1]Applied Technology for Neuro-Psychology Lab, Istituto Auxologico Italiano, Milan, Italy.
[2]Research Institute Brain and Behavior, Maastricht University, Netherlands.
[3]Panamericana University, Mexico City, Mexico.
[4]Regional Hospital No. 25 of the IMSS, Mexico City, Mexico.
[5]Psychology Department, Catholic University of Milan, Milan, Italy.

We investigate this issue, analyzing the role of the cultural and technological backgrounds of the users in the emotional responses to VR. Specifically, we explore how these factors influence the way in which the users experience virtual worlds. As a starting point of our analysis, we use the "core affect" model of emotions developed by James Russell[32] (Table 1). This theory refuses the traditional dichotomy that accepts the existence of only emotions and nonemotions. It considers the complexity of the human experiences, as well as the individual and cultural differences, in the creation of different prototypical emotional episodes. According to Russell, the core affect is a neuropsychological category corresponding to the combination of valence and arousal levels that endow the emoters with a kind of "core knowledge" about the emotional features of objects and events.

The core affect can be experienced as freefloating (mood) or attributed to some cause (and thereby begins an emotional episode). In this view, an emotional response is the attribution of a change in the core affect given to a specific object (affective quality).

The main hypotheses behind this study are (a) the VR experience is able to modify the core affect, and (b) the final emotional response produced by this change is necessarily influenced by the attribution process. In particular, we expect that the attribution process, being related to the previous knowledge of the users, will be different in different cultures.

To test these hypotheses, we investigated the differences in the core affects and emotional episodes produced by the immersion in a distracting virtual world. To verify the role played by culture, we selected two samples of participants undergoing ambulatory surgery. The two groups of Mexican participants differed in cultural background: the first consisted of inhabitants of El Tepeyac, a small rural and isolated Mexican village characterized by a very primitive culture; the second sample consisted of inhabitants of highly civilized Mexico City.

El Tepeyac is located about 7280 feet (2,220 meters) above sea level, 12 hours by car from Mexico City. Its inhabitants belong to the Tlapanecos community, a large and very poor community of indigenous Mexican people who live on the mountains northeast of Acapulco. In El Tepeyac, there are five families, for a total of 200 persons. They live in a very marginalized condition without any kind of integration with the rest of the civilized world, and they speak only a local dialect called Tlapaneco. They rely on subsistence-based production (based on pastoral, horticultural, and/or hunting and gathering techniques) and a predominantly nonurbanized society. Only small and uncomfortable roads connect this region to other Mexican areas. A very basic level of education (primary school) is provided to the children. Even in the school, the official language is Tlapaneco, and education is only oral. Their most advanced technological equipments are two-way radio and closed-circuit television transmitting only local information between villages but no news about the rest of the world. Regarding health services, a few years ago they built a small clinic in which a local nurse delivers basic medications. Medical services are provided only occasionally by a voluntary medical doctor (J. L. M.) who comes from Mexico City to performs medical and ambulatory surgical operations.

Materials and Methods

Participants

Eight residents of El Tepeyac (ET), 5 females and 3 males, aged between 33 and 77 years ($M = 50.75 \pm 16.30$), were involved in the study. Each underwent an ambulatory surgical operation under local anesthesia to remove a lipoma (3 cases) or a cyst (5 cases). Operations were performed in a small operating room in El Tepeyac, fully equipped with all medical materials needed for surgery.

The recorded physiological and psychological measures were compared with those obtained in 12 patients living in Mexico City (MC), 7 females and 5 males, aged between 19 and 74 ($M = 49.08 \pm 16.57$), who underwent removal of a lipoma (5) or a cyst (7) by the same surgeon at the General and Regional Hospital No. 25 of the IMSS in Mexico City (see Table 2 for details).

All the operations were ambulatory interventions performed under local anesthesia and lasted about 90 minutes. From the beginning to the end of the surgical procedure, patients were asked to wear a head-mounted display (HMD) and headphones that allowed them to be fully immersed in a relaxing virtual environment.[33]

All participants were asked to sign an informed consent.

Technical equipment

The PlayStation Portable (PSP), a Sony handheld game console that measures approximately $17 \times 7.3 \times 2.2$ cm ($6.7 \times 2.9 \times 0.9$ in.) and weighs 280 g (9.88 oz) was used to run the

Table 1. Main Features of "Core Affect" Model

Term	*Definition*
Core affect	A neurophysiological state that is consciously accessible as a simple, nonreflective feeling that is an integral blend of hedonic (pleasure–displeasure) and arousal. Core affect responds to virtual reality experiences.
Affective quality	The ability to cause a change in core affect.
Attributed affect	Core affect attributed to an Object. This process, that is isolated from any judgment of the reality of the Object, is typically quick and automatic but can be deliberate.
Affect regulation	Action aimed directly at altering core affect. This process does not rely on the Object.
Object	The person, condition, thing, or event at which a mental state is directed. An Object is a psychological representation, and therefore mental states can be directed at fictions, the future, and other forms of virtual reality.

Adapted from Russell JA. Core affect and the psychological construction of emotion. Psychological Review 2003; 110:145–72.

Table 2. Demographic Data, VAS-A Scores, and Heart Rate Values of Each Participant at T0, T1, and T2

Group	*Gender*	*Age*	*VAS_T0*	*VAS_T1*	*VAS_T2*	*HR_T0*	*HR_T1*	*HR_T2*
ET	Male	46	5	2	3	90	92	84
ET	Male	45	10	10	8	70	72	67
ET	Female	42	1	2	3	75	76	75
ET	Female	73	1	1	1	78	78	75
ET	Female	36	1	1	1	82	80	60
ET	Female	54	1	1	1	78	80	60
ET	Male	77	1	1	1	60	62	60
ET	Female	33	1	4	1	100	85	85
Mean		50,75	2,63	2,75	2,38	79,13	78,13	70,75
SD		16,30	3,29	3,11	2,45	12,14	8,85	10,53
MC	Male	45	9	7	2	88	85	80
MC	Male	53	6	3	1	64	67	72
MC	Male	43	4	7	1	80	69	68
MC	Female	44	5	3	2	66	93	70
MC	Male	74	6	4	1	72	70	70
MC	Female	19	5	1	1	95	95	93
MC	Male	33	1	1	1	60	65	61
MC	Female	66	7	2	1	75	77	75
MC	Female	65	5	1	1	88	80	80
MC	Female	68	4	1	1	72	87	85
MC	Female	34	7	1	1	66	74	67
MC	Female	45	8	2	1	77	75	76
Mean		49,08	5,58	2,75	1,17	75,25	78,08	74,75
SD		16,57	2,11	2,22	0,39	10,84	10,04	8,75

noninteractive VR environment (see below). The PSP was connected to the Vuzix iWear AV 920, a high-resolution HMD, in order to allow participants a 3D immersion in the virtual environment. The iWear weighs only 2.9 ounces, pivots up to 15 degrees for comfortable viewing angle, and has integrated speakers that allow user to plug in his or her own headset.

The Green Valley,[34] a noninteractive, relaxing environment showing a mountain landscape around a calm lake, was presented to the participants together with relaxing music and soft sounds (birdsongs, flowing water, etc.) (Fig. 1). Having the impression of walking around the lake, participants could observe nature and virtually sit on a comfortable deck chair in order to become easily relaxed.

All participants were exposed to the virtual environment for the entire length of the operation.

Experimental procedure

All participants were asked to wear the HMD and headphones connected to the PSP a few minutes before the anesthetic injection. The total length of the virtual relaxing session

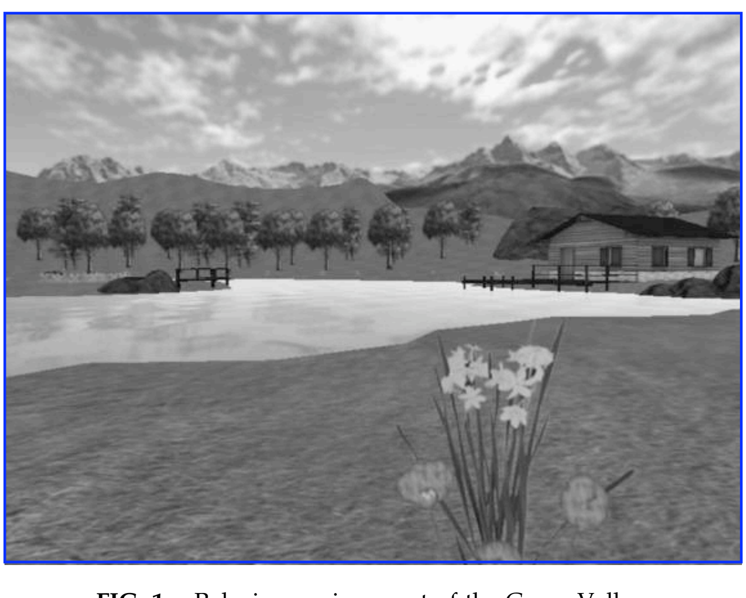

FIG. 1. Relaxing environment of the Green Valley.

lasted about 90 minutes, corresponding to the duration of the intervention.

Subjective measure of anxiety. Participants gave their ratings using the visual analog scale for anxiety (VAS-A), a widely used anxiety measurement with well-established validity and reliability.[35–39] The VAS-A is a 100-mm vertical line with end points anchored as *no anxiety* at the bottom of the scale and *anxiety as bad as it could possibly be* at the top; scores range from 0 to 10. Among the numerous tools available for assessing anxiety, direct scaling procedures, such as the VAS, are popular because of their simplicity, versatility, relative insensitivity to bias effects, and the assumption that the procedures yield numerical values that are valid, reliable, and on a ratio scale.[37] All these attributes make the VAS a very good instrument to measure discomfort even in individuals with very basic education. Ratings were administered immediately before (T0), in the middle (T1), and immediately after (T2) the operation. Measurement at T1 was taken during a brief (~2 min) pause in operation.

Physiological measurements. Heart rate, considered one of the best physiological indexes of stress, was recorded for each patient at T0, T1, and T2.

Questionnaire. After T2, only participants from El Tepeyac were asked to orally answer the questions reported in the Table 3.

Results

Data were entered into Microsoft Excel and analyzed using SPSS version 16. Due to the small number of participants, we analyzed the data using nonparametric statistic tests. Two-tailed p values of less than 0.05 were considered to be significant. Age and gender of the two groups were statistically comparable (see Table 2 for details).

Subjective measure: VAS-A scores

ET group. Regarding the VAS-A scores, there were no significant differences between T1 and T0 ($z = -0.272$, N ties $= 3$, $p = 0.785$), T2 and T1 ($z = -0.736$, N ties $= 4$, $p = 0.461$), and T2 and T0 ($z = -0.577$, N ties $= 3$, $p = 0.564$).

MC group. Unlike what we found in the ET group, in the MC group we observed significant differences between T1 and T0 ($z = -2.502$, N ties $= 11$, $p = 0.012$), T2 and T1 ($z = -2.384$, N ties $= 7$, $p = 0.017$), and T2 and T0 ($z = -2.946$, N ties $= 11$, $p = 0.003$) (Fig. 2).

Comparing the difference between the VAS-A values calculated from the beginning to the end of the operation (T0, T1, T2), we found a significant difference between the two groups ($U = 4.500$, $N_1 = 8$, $N_2 = 12$, $p = 0.0001$), indicating that the difference in the VAS-A scores between T0 and T2 was greater in the MC group than in the ET group.

Physiological measure: Heart rate values

ET group. Regarding heart rate, there were significant differences between T2 and T1 ($z = -2.371$, N ties $= 7$, $p = 0.018$) and between T2 and T0 ($z = -2.207$, N ties $= 6$, $p = 0.027$) but not between T1 and T0 ($z = -0.526$, N ties $= 7$, $p = 0.599$).

MC group. In the MC group, we observed no significant differences in heart rate between T1 and T0 ($z = -0.713$, N ties $= 11$, $p = 0.476$), T2 and T1 ($z = -1.893$, N ties $= 10$, $p = 0.06$), and T2 and T0 ($z = -0.357$, N ties $= 11$, $p = 0.721$) (Fig. 3).

Comparing the difference between heart rate values calculated from the beginning to the end of the operation (T0–T2), we found a significant difference between the two groups ($U = 30.000$, $N_1 = 8$, $N_2 = 12$, $p = 0.049$), indicating that the difference in heart rate values between T0 and T2 was greater in the ET group than in the MC group.

Table 3. Oral Questionnaire Administered to El Tepeyac Participants

	Questions	*Participant answers*		
1	Do you watch television?	Yes (6)	Less than 2 hours per week (1)	No (1)
2	Have you ever played with videogames before?	Yes		No (8)
3	Have you heard about virtual reality before this experience?	Yes		No (8)
4	Are you worried/scared about technology?	Yes (1)	A little	No (7)
5	Wearing the HMD, did you realize you were undergoing an operation?	Yes (7)	A little	No (1)
6	Did you feel pain during the operation?	Yes	A little (1)	No (7)
7	Did you feel anxious during the operation?	Yes	A little (2)	No (6)
8	Were you interested in the virtual landscape we showed you?	Yes (8)	A little	No
9	While there, did you fall asleep?	Yes (1)	A little	No (7)
10	Would you propose a different type of virtual environment?	Yes (8)	Don't know	No
11	Would you repeat the virtual experience if necessary?	Yes (8)	Don't know	No
12	Were you relaxed during the immersion in the virtual environment?	Yes (8)	A little	No
13	Are you going to recommend VR to other patients?	Yes (8)	A little	No
14	Do you think VR is a useful tool to reduce anxiety and discomfort during a surgical operation?	Yes (8)	A little	No

Note: Parenthetical numbers indicate the number of patients who chose the corresponding answer.

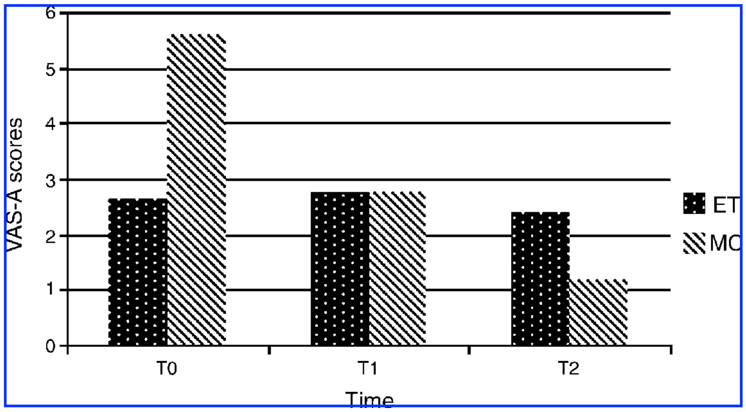

FIG. 2. VAS-A scores in the two groups of patients from the beginning (T0) to the end of the operation (T2).

Questionnaire. Because one of the goals of the study was to investigate the effect of VR on people without any previous experiences with technology, we proposed the questionnaire presented in the Table 3 only to the ET group. Questions and answers were given orally.

What we noticed from their answers is that seven out of eight experienced closed-circuit television before; none of them played with videogames before; and none had ever heard about VR. Only one declared being worried about technology. One patient was so absorbed by VR that he said he did not realize he was undergoing an operation, and the majority of ET participant said they did not feel pain and anxiety during the operation. All participants answered that they were interested in the virtual landscape, that they would like to repeat the experience with VR, and that they would recommend the VR experience to others. They did not passively observe the virtual environment, as suggested by the fact that they also suggested how to modify it: some of them expressed the desire to see animals moving around, one said she would like to see a seaside landscape populated by fishes and dolphins, and another would to include landscape of the region in which they live as well as pictures of his family.

In particular, the answers to question 10 demonstrate that after the experience, participants clearly understood the VR concept: a virtual environment is "a place" that can be modified on the basis of the user's needs and tastes. This is exactly the desire that in the last decades has moved technological societies to the creation of "virtuality."

Discussion

Our data show that from the beginning to the end of the operation, there was a significant decrease in the level of perceived anxiety in the MC group but not in the ET group and, conversely, a significant decrease in heart rate in the ET group but not in the MC group. The decreases in VAS-A and heart rate were significantly different in the two groups, indicating that the VR exposure had a significant relaxing effect on both groups, but in one case (MC), the effect caused a reduction in the perceived anxiety, while in the other (ET), it resulted in a decreased heart rate, which is the arousal component of the core affect theory. A possible explanation of these results is that an emotion directed to an object (VR in this case) is not a primitive element but a complex event characterized by different components[40] such as autonomic and psychological factors. According to Russell's theory, core affect automatically responds to the contents of consciousness whether based on reality or fiction. So, our relaxing environment activated a relaxation state in all the patients, regardless of their cultural background or their confidence in technology. On the contrary, culture and participants' previous experiences altered their attribution process. Specifically,

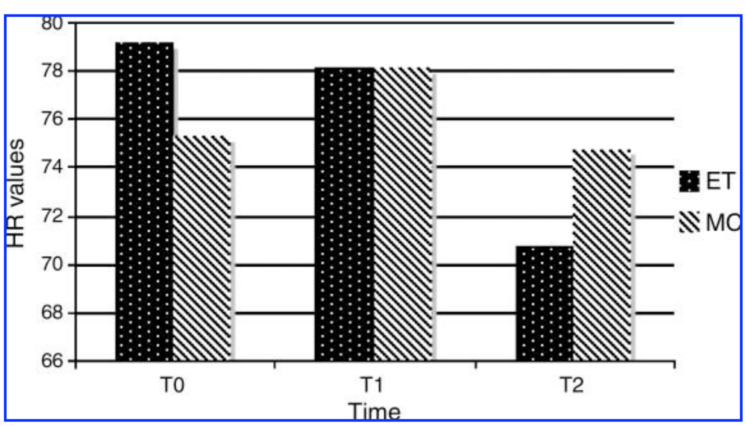

FIG. 3. Heart rates in the two groups of patients from the beginning (T0) to the end of the operation (T2).

the lack of a significant reduction in the VAS-A found in the ET group does not necessarily mean they did not benefit from the VR relaxing experience but that they were unable to attribute the modifications in their physiological response (core affect) to it. In this view, these data are an empirical demonstration that the traditional sharp boundary between emotions and nonemotions can be changed in favor of a model in which each of the components that concur in creating a complex emotion can also occur alone.

Nevertheless, because the level of perceived anxiety experienced by people from El Tepeyac was relatively low even at the beginning of the operation, two alternative culture-related explanations to the lack of reduction in the VAS-A score in this group of patients are possible. First, the total lack of medical knowledge that characterizes people from El Tepeyac could be a factor that significantly limits their worries about the possible negative consequences of the operation and the illness itself. Second, before they completed the VAS-A, we tried to explain to the ET group what anxiety is. It is possible that they incorrectly interpreted our meaning. If this was the case, the VAS-A did not really measure what we intended to evaluate. All these explanations are possible and congruent with the very different cultural background that characterizes the two participant groups.

The main limitation of this study is that the sample is small: as clearly stated in the introduction, El Tepeyac is a very isolated place with no stable medical services. Unfortunately, testing a larger number of participants would require a number of years, so we started to collect and analyze data from a small sample assumed to be representative of the entire population, with the intention to collect more data in the future. The consequence of such a small number of participants is the lack of a control experimental condition, such as the lack of treatment or the administration of a different relaxation technique not based on VR.

The strength of this study is that it represents the first attempt to analyze the effects of VR exposure in two samples of participants characterized by a vastly different cultural and technological background: the few available cross-cultural studies on VR investigate how the user's character and cultural background influence the sense of presence[41,42] in two different cultures (i.e., Dutch and Chinese) but with similar experience in the use of interactive media and technology.

This study shows that VR exposure to a relaxing environment has different physiological and psychological effects according to the cultural and technological background of the users. In particular, we interpret the different emotional responses between the two groups with a difference in participants' attribution process mainly caused by their different cultural backgrounds. Further research is needed to investigate the effects of other, possibly more interactive VR systems in rural, isolated populations.

Disclosure Statement

No competing financial interests exist.

References

1. Lang PJ. The emotion probe: studies of motivation and attention. American Psychologist 1995; 50:372–85.
2. Lang PJ. Negative video as structure: emotion, attention, capacity and memory. Journal of Broadcasting & Electronic Media 1996; 40:460–77.
3. Lazarus RS, Speisman JC, Mordkoff AM, et al. A laboratory study of psychological stress produced by a motion picture film. Psychological Monographs. 1962; 76:1–122.
4. Gross JJ, Levenson RW. Emotion elicitation using films. Cognition & Emotion. 1995; 9(1):87–108.
5. Riva G, Mantovani F, Capideville CS, et al. Affective interactions using virtual reality: the link between presence and emotions. Cyberpsychology & Behavior 2007; 10:45–56.
6. Botella C, Garcìa-Palacios A, Villa H, et al. Virtual reality exposure in the treatment of panic disorder and agoraphobia: a controlled study. Clinical Psychology & Psychotherapy 2007; 14:164–75.
7. Han K, Ku J, Kim K, et al. Virtual reality prototype for measurement of expression characteristics in emotional situations. Computers in Biology & Medicine 2009; 39:173–9.
8. Vincelli F. From imagination to virtual reality: the future of clinical psychology. CyberPsychology & Behavior 1999; 2:241–8.
9. Gorini A, Riva G. Virtual reality in anxiety disorders: the past and the future. Expert Review of Neurotherapeutics 2008; 8:215–33.
10. Riva G. Virtual reality in psychotherapy: review. CyberPsychology & Behavior 2005; 8:220–30; discussion 31–40.
11. Levandovski R, Ferreira MB, Hidalgo MP, et al. Impact of preoperative anxiolytic on surgical site infection in patients undergoing abdominal hysterectomy. American Journal of Infection Control 2008; 36:718–26.
12. Muglali M, Komerik N. Factors related to patients' anxiety before and after oral surgery. Journal of Oral Maxillofacial Surgery 2008; 66:870–7.
13. Rubin GJ, Hardy R, Hotopf M. A systematic review and meta-analysis of the incidence and severity of postoperative fatigue. Journal of Psychosomatic Research 2004; 57:317–26.
14. Gold JI, Belmont KA, Thomas DA. The neurobiology of virtual reality pain attenuation. Cyberpsychology & Behavior 2007; 10:536–44.
15. Sharar SR, Carrougher GJ, Nakamura D, et al. Factors influencing the efficacy of virtual reality distraction analgesia during postburn physical therapy: preliminary results from 3 ongoing studies. Archives of Physical Medicine & Rehabilitation 2007; 88:S43–9.
16. Sharar SR, Miller W, Teeley A, et al. Applications of virtual reality for pain management in burn-injured patients. Expert Review of Neurotherapeutics 2008; 8:1667–74.
17. Hoffman HG. Virtual-reality therapy. Scientific American 2004; 291:58–65.
18. Hoffman HG, Doctor JN, Patterson DR, et al. Virtual reality as an adjunctive pain control during burn wound care in adolescent patients. Pain 2000; 85:305–9.
19. Hoffman HG, Patterson DR, Seibel E, et al. Virtual reality pain control during burn wound debridement in the hydrotank. Clinical Journal of Pain 2008; 24:299–304.
20. Hoffman HG, Patterson DR, Soltani M, et al. Virtual reality pain control during physical therapy range of motion exercises for a patient with multiple blunt force trauma injuries. Cyberpsychology & Behavior 2008; 12:47–9.
21. Hoffman HG, Richards TL, Bills AR, et al. Using fMRI to study the neural correlates of virtual reality analgesia. CNS Spectrums 2006; 11:45–51.

22. Hoffman HG, Richards TL, Van Oostrom T, et al. The analgesic effects of opioids and immersive virtual reality distraction: evidence from subjective and functional brain imaging assessments. Anesthesia & Analgesia 2007; 105:1776–83.
23. Hoffman HG, Seibel EJ, Richards TL, et al. Virtual reality helmet display quality influences the magnitude of virtual reality analgesia. Journal of Pain 2006; 7:843–50.
24. Hoffman HG, Sharar SR, Coda B, et al. Manipulating presence influences the magnitude of virtual reality analgesia. Pain 2004; 111:162–8.
25. Schneider SM, Prince-Paul M, Allen MJ, et al. Virtual reality as a distraction intervention for women receiving chemotherapy. Oncology Nursing Forum 2004; 31:81–8.
26. Gold JI, Kim SH, Kant AJ, et al. Effectiveness of virtual reality for pediatric pain distraction during IV placement. Cyberpsychology & Behavior 2006; 9:207–12.
27. Freeman D. (2003) *Creating emotion in games. The craft and art of emotioneering*. Indianapolis, IN: New Riders.
28. Fogg BJ. (2003) Persuasive technology: using computers to change what we think and do. San Francisco, CA: Morgan Kaufmann.
29. Botella C, Quero S, Banos RM, et al. Virtual reality and psychotherapy. Studies in Health Technology & Informatics 2004; 99:37–54.
30. Riva G, Molinari E, Vincelli F. Interaction and presence in the clinical relationship: virtual reality (VR) as communicative medium between patient and therapist. IEEE Transactions on Information Technology in Biomedicine 2002; 6:198–205.
31. Riva G, Waterworth JA, Waterworth EL. The layers of presence: a bio-cultural approach to understanding presence in natural and mediated environments. Cyberpsychology & Behavior 2004; 7:405–19.
32. Russell JA. Core affect and the psychological construction of emotion. Psychological Review 2003; 110:145–72.
33. Riva G, Gaggioli A, Villani D, et al. NeuroVR: an open source virtual reality platform for clinical psychology and behavioral neurosciences. Studies in Health Technology & Informatics 2007; 125:394–9.
34. Grassi A, Gaggioli A, Riva G. The Green Valley: the use of mobile narratives for reducing stress in commuters. Cyberpsychology & Behavior 2009; 12:155–61.
35. Abu-Saad H, Holzemer WL. Measuring children's self-assessment of pain. Issues in Comprehensive Pediatric Nursing 1981; 5:337–49.
36. Downie WW, Leatham PA, Rhind VM, et al. Studies with pain rating scales. Annals of the Rheumatic Diseases 1978; 37:378–81.
37. Price DD, McGrath PA, Rafii A, et al. The validation of visual analogue scales as ratio scale measures for chronic and experimental pain. Pain 1983; 17:45–56.
38. Reading AE. A comparison of pain rating scales. Journal of Psychosomatic Research 1980; 24:119–24.
39. Vessey JA, Carlson KL, McGill J. Use of distraction with children during an acute pain experience. Nursing Research 1994; 43:369–72.
40. Oatley K, Johnson-Laird PN. Towards a cognitive theory of emotions. Cognition & Emotion 1987; 1:29–50.
41. Chang T, Wang X, Lim KJ. Cross-cultural communication, media and learning processes in asynchronous learning networks. 35th Annual Hawaii International Conference on System Sciences. Maui, Hawaii, 2002:113–22.
42. Hu J, Bartneck C. Culture matters: a study on presence in an interactive movie. Cyberpsychology & Behavior 2008; 11: 529–37.

Address correspondence to:
Alessandra Gorini
Istituto Auxlogico Italiano
Via Pelizza da Volpedo, 41
20149 Milano
Italy

E-mail: alessandra.gorini@gmail.com