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Emotions and the Emotional Valence Afforded by the Virtual Environment

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1. Introduction

For decades, researchers have been concerned about the effectiveness of traditional tools used by clinicians to treat mental disorders and have been trying to develop more and more innovative techniques. The emergence of virtual reality presents new clinical and experimental opportunities in psychology. Virtual reality, as defined as "an application allowing a user to navigate and interact in real time with a computer-generated three-dimensional environment" (Pratt et al., 1995, p.17), can be distinguished from other media by the real-time interaction with synthetic stimuli. The potential of virtual reality has encouraged more scientific research exploring the mechanisms involved in the efficacy of using virtual environments.

Various applications to mental health problems have been the subject of virtual reality experiments. Virtual reality's usefulness in inducing anxiety for curative purposes has been reiterated many times (Robillard et al., 2003; Moore, Wierderhold et al., 2002), and the effectiveness of this tool for psychological treatment of certain anxiety disorders is documented by numerous studies (Bouchard et al., 2006; Côté & Bouchard, 2008; Gerardi et al., 2010; Weiderhold & Weiderhold, 2005).

It may seem astonishing that virtual reality would put an end to phobic avoidance even though virtual scenarios are not totally realistic. The feeling of presence gives users the subjective impression that the virtual environment in which they are immersed really exists. Seven dimensions may modulate presence: the realism of pictograms and images, social interactions in the environment, the ease of interactions, the user's power or perception of control, the duration of exposure, social factors such as relationships with others and, finally, characteristics related to the virtual reality system (Stanney & Sadowski, 2002). In addition, some variables such as the participant's propensity to be absorbed in an activity, the tendency to concentrate and to dispose of distractions (Witmer & Singer, 1998) and, certain data even suggests, the ability to be hypnotized could be involved in an increased feeling of presence (Wiederhold & Wiederhold, 2000). Ijsselsteijn and Riva (2003) asserted that the effectiveness of virtual immersion is partly attributable to the degree of presence felt by the immersed user. Similarly, Wiederhold and Wiederhold (1999) suggested that the degree of presence could be related to the success of the treatment.

The relationship between the feeling of presence and the intensity of the emotions felt in a virtual environment is especially relevant for clinicians using VR with people suffering from emotional disorders. Robillard et al. (2003) reported a significant correlation ($r = .74$, $< p$ .001) between anxiety and the feeling of presence. To assess the direction of the relationship between anxiety and presence, Bouchard, St-Jacques, Robillard and Renaud (2008) manipulated anxiety while participants suffering from a phobia of snakes were immersed in virtual reality, then evaluated the impact of anxiety on the feeling of presence. The results showed that the feeling of presence was significantly higher when the researchers induced anxiety. Changes in the level of anxiety felt and in the feeling of presence were also strongly and significantly correlated. Using multilevel hierarchical linear regression analyses, Riva et al. (2007) suggested the existence of a bidirectional relationship between emotions and presence. Based on these sophisticated analyses, their study suggests that anxiety is not only a predictor of presence, but the level of presence is also a significant predictor of the level of anxiety. Such a bidirectional relationship has been confirmed by an experimental study (Michaud et al., 2004) where presence was manipulated in a sample of 33 heights phobics. When the immersion in the virtual environment was conducted in a high-presence setting, the level of anxiety was significantly higher than when the immersion was conducted in a low-presence setting. These results all confirmed that emotions, at least anxiety, felt during an immersion have an impact on the feeling of presence.

Theoretically, one may wonder why the fact of feeling anxiety more intensely would make a person feel more present in the virtual environment. Can the causal relationship between emotions and presence be explained simply by a non specific emotional arousal, or does the emotion has to be consistent with the experience felt during the immersion? Feeling an emotion while immersed could validate the user's impression of the realism of the virtual stimuli. Post immersion, users of virtual reality systems sometimes say, "I fell from the balcony and was so surprised and nervous that it shows how much your virtual environment is realistic and how much I felt really there". Their feeling of being present appears to be strengthened by the emotional arousal. But what if that arousal was not confirming the realism of the virtual stimuli? Such as being anxious in a relaxing environment, or depressed in a joyful environment? Would a dissonance destroy the illusion and perceived realism of the immersion? There is a need to clarify whether people immersed in a virtual situation feel more present merely because they are feeling an emotion, or because the emotion feel is congruent with what is to be expected to felt in the virtual environment (i.e., which emotional valence is afforded by the virtual environment). In order to sort out the role of emotions and of the message they transmit to the user immersed in virtual reality, it would be necessary to induce emotions that do not match the virtual environment. If a user feels an emotion that is not supposed to be felt during the immersion, we can determine whether it is the emotional arousal itself that foster presence or if the meaning of the emotional arousal is important as well.

It is worth noting how emotions have been manipulated in previous studies on presence. In some cases, the virtual environments were carefully designed to induce emotions (Banos et al., 2004; Robillard & al., 2003). It is hard to see how an experimenter could create a mismatch between an emotion and the expected valence of a virtual environment by using procedures from Banos al (2004) or Riva et al. (2007) who used the virtual environment to induce the emotion. The alternative strategy is to induce the mood prior to the immersion, as Bouchard et al. (2008) did. However, their strategy was applied with phobics, who are people already sensitized to react very strongly to specific frightening stimuli. No study has attempted to induce positive and negative emotions in non-clinical participants without manipulating the virtual environment.

This chapter reports on two experiments examining the impact of inducing emotions on the feeling of presence among non-clinical samples. The objective of the studies consisted of verifying whether feeling an emotion that doesn't match with what the virtual environment is expected to induce leads to less presence than feeling an emotion that does match the emotional contents afforded by the environment. In the first experiment, a virtual environment judged *a priori* to be pleasant was used to evaluate the impact of positive and negative emotions on the presence felt by participants. Given the results, a second experiment was designed with a virtual environment that has a more saddening content.

2. Experiment 1

In order to examine the match between emotions felt by the user and those that should be induced by the virtual stimuli, the emotions have to be induced experimentally *in vivo*. The *in vivo* method means that the emotions will be induced in the user before the latter is immersed in virtual reality (*in virtuo*). Although the emotion of anxiety is quite easy to induce intensely among subjects suffering from anxiety disorders (e.g., Bouchard et al., 2008; Robillard et al., 2003), one may wonder whether it is possible to induce other types of emotions as intensely as anxiety. For this study, it was decided to induce positive and negative emotions among healthy subjects during immersion in an attractive virtual environment.

2.1 Sample and procedures

Twenty-eight adults participated in the study (18 women and 10 men). The non-clinical sample was made up of subjects varying in age from 19 to 53 (M = 28.54, sd = 10.36). The participants were recruited by ads posted on the university's campus. The inclusion criteria required that participants never had a virtual reality experience before and be 18 years of age or older. A telephone prescreening form was used to exclude participants suspected of epilepsy, having a physical condition that could exacerbate simulator sickness (diseases of the inner ear), cardiovascular problems, high blood pressure or diabetes.

The equipment used in the study included an IBM computer (Pentium IV™ with an ATI Radeon 128 MB graphics card) and a CY-Visor virtual headset (field of vision of 31 degrees, 800 x 600 resolution). An Intersense Intertrax^2 tracker (3 degrees of liberty, angular resolution of .02 degrees, latency of 4 ms) was attached to the virtual headset. The virtual environment was an adaptation of the level the Temple of Horus from the game "Unreal Tournament: Game of the year edition®", where the user walks in pyramids and into a mythical temple located in the Egyptian desert. The adaptation was limited and consisted in removing the violent content of the game, enabling the motion tracker to emulate the mouse of the player and using the headset to display the images to the user. The environment was chosen because of its availability and *a priori* positive features.

The participants who met the study selection criteria were invited to participate in the experiment and randomly assigned either one of the following conditions: (1) positive emotion (joy) induced or (2) negative emotion (sadness) induced. Each participant filled in the consent form, was advised of the nature of the research and the overall course of the experiment. Two pre-test questionnaires ("Immersive Tendencies Questionnaire" and "Simulator Sickness Questionnaire") were completed to assess and control for predisposition to feel present and to develop simulator sickness. This step was followed by a first 5-minute immersion in a neutral / irrelevant virtual environment in order to familiarize the participant with how to navigate in virtual reality and appraise the concept of "being there" in a virtual environment. After inducing emotions experimentally and taking measures with the Brief Mood Introspection Scale, the participant was immersed in the positive environment for seven minutes. This experimental immersion was followed by the completion of a battery of questionnaires. Finally, subjects had to wait fifteen minutes before leaving the lab to make sure that no significant simulator sickness was induced by the immersions.

The experimental manipulation of emotions consisted of inducing emotions *in vivo* prior to the experimental immersion. The effectiveness of various techniques for inducing emotions (music, films, facial expressions, autobiographical memories, etc.), including Velten's technique, varies between 50 and 75% (Gerrards-Hesse et al., 1994; Martin, 1990; Westermann, Spies, Stahl, & Hesse, 1996). Among these techniques, the procedure developed by Velten (1968) was used given its popularity and effectiveness (Gerrards-Hesse et al., 1994; Martin, 1990). The procedure consists of reading short statements that include emotional dimensions with positive, or negative, valence. Thus the participant had to read 25 short statements developed by Velten (1968) and expressing an emotional state of joy or depression/sadness. The person had to try to adopt the emotional state suggested by the statement. Each statement, written on a card, was read silently at the participant's own pace.

2.2 Measures

The Brief Mood Introspection Scale (Mayer & Gaschke, 1988) measures the intensity of various 16 emotions. The emotions are divided into two sub-scales and items are rated on a scale from 1 to 9 (1: does not correspond at all; 9: corresponds perfectly). The first sub-scale measures the strength of positive emotions (happy, calm, cheerful, etc.) and the second sub-scale measures the intensity of negative emotions (e.g., melancholy, depressed, sad, angry, etc.). This measure was used to check for the impact of the manipulation.

The Immersive Tendencies Questionnaire (Witmer & Singer, 1998) measures to what point the individual succeeds in cutting off outside distractions and concentrating on different tasks (i.e., watching a video) and thus provides an indication of a subject's capacity to feel immersed in a virtual environment. It consists of 18 items rated on a Likert scale (1 "never", 7: "often") assessing four domains: (1) focus: (degree of concentration, capacity to cut off distractions); (2) involvement: (feeling of being "absorbed" in a task); (3) emotions: (intensity of emotions, for example, during or after seeing a film); (4) play: (how often the person plays video games). The ITQ is used to control for potential pre-experimental differences among participants randomized in the two conditions.

The Simulator Sickness Questionnaire by Kennedy, Lane, Berbaum and Lilienthal (1993) is composed of 16 items. It measures on a 4-point scale (0 "not at all" to 3 "severely") the degree of discomfort felt by the individual (nausea, vertigo, eyestrain, etc.). The questionnaire includes three dimensions: (1) nausea; (2) oculomotor problems and (3) disorientation. It should be administered once before the immersion to enable excluding symptoms that are present before the experiment. This measure is used to document the potential side effects of the experiment and control for differences in side effects generally experienced during the study.

A Brief Measure of Presence was used to quantify the feeling of presence using one item and a rating scale of 0 to 100 by answering the question: “On a scale of 0 to 100, how much did you have the impression of really being *there* in the virtual environment?” The sensitivity of this brief measurement to changes and experimental manipulations was validated by Bouchard, Robillard, St-Jacques, Dumoulin, Patry and Renaud (2004). This measure represents one of the two dependent variables and is used to compare the scores in the neutral and the experimental immersions.

The Presence Questionnaire (Witmer & Singer, 1998) uses a 7-point Likert scale (1 “not at all” to 7 “completely”) to measure the following dimensions: (1) realism (extent to which virtual environments appear natural or can be confused with reality); (2) possibility of action (active exploration and control of events); (3) quality of the interface (delay or awkwardness of the device); (4) possibility of examination (observation of objects from different angles); (5) self-evaluation of performance (feeling of competence and adaptation related to carrying out tasks); (6) auditory and (7) haptic (possibility of touching certain objects). This measure of presence relates more to the properties of the hardware and the software to induce presence than it related to the subjective experience of the user (Stanney & Sadowski, 2002). This is the second dependent variable and is used to compare the scores after the experimental immersion.

2.3 Results

The descriptive statistics show that scores on the Immersive Tendencies Questionnaire are comparable to the normative samples (M = 64.11, sd = 13.11), indicating that the participants seemed adequately predisposed to feel “absorbed” in the virtual environment (M = 66.43, sd =13.39). No differences were found between the two conditions. No difference was found on side effects of the immersion, although participants felt mild simulator sickness during the neutral immersion (M = 124.56, sd = 151.66) and intensity of the side effects increased at the second immersion (M = 256.97, sd = 224.47).

The manipulation check (see Figure 1) showed important findings on the Brief Mood Introspection Scale. As detailed in Table 1, repeated measures ANOVAs on the positive emotions revealed that a positive mood was induced with success in participants in the condition where joy was induced. Consistently, the negative mood in that group of participants was low and remained as such after the experimental immersion. However, among participants where sadness was induced, the level of positive mood was low post induction and increased significantly during the experimental immersion. The level of negative mood was moderate post induction but decreased significantly after the experimental virtual immersion. The induction procedure was therefore successful in inducing the expected emotions, but the immersion in the virtual environment was powerful enough to counter the negative mood.

As shown by the average scores on the dependent measures of presence (see Table 2) and results of the statistical analyses (see Table 1), the experimental manipulation of mood did not have a statistically significant effect on presence. The effect-sizes observed for the interaction on the Brief Measure of Presence (η^2 = .006) and between the conditions on the Presence Questionnaire (η^2 = .02) were minimal, suggesting that the lack of a significant difference is probably not explained merely by the size of the sample.

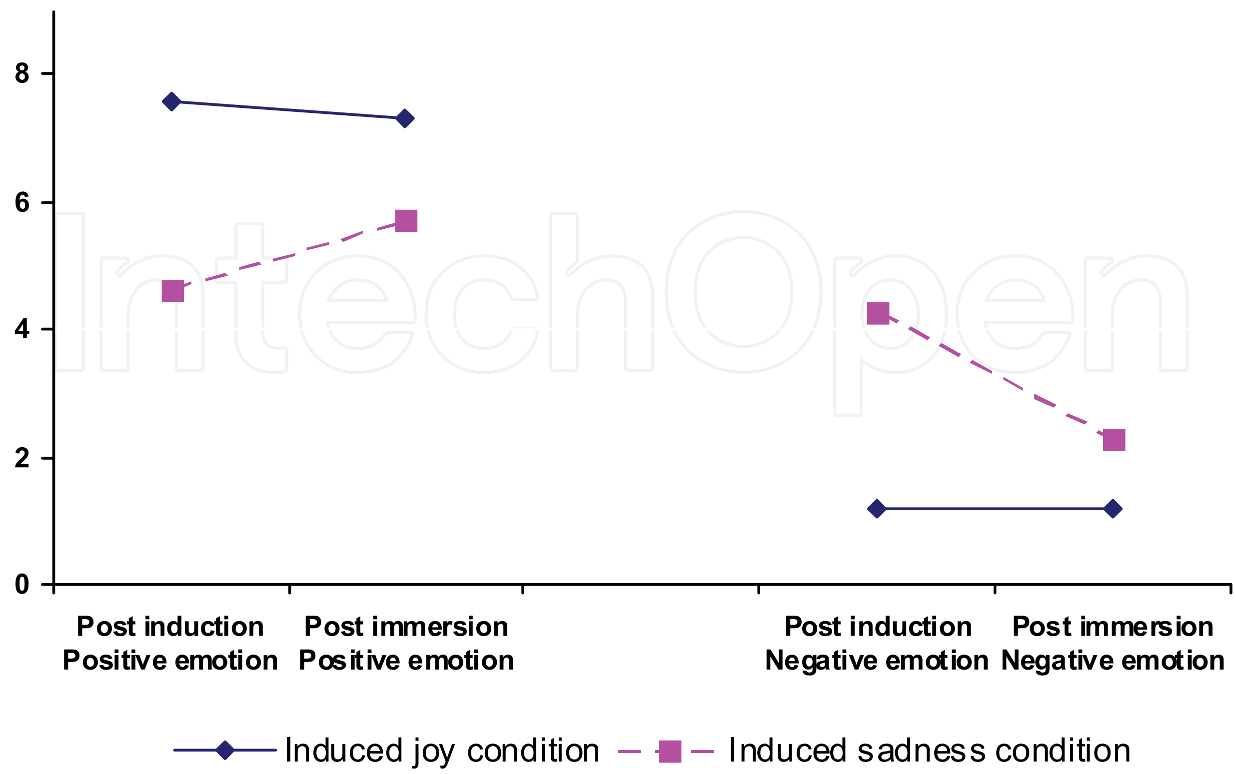

Fig. 1. Positive and negative mood after the induction and the immersion in a virtual environment with a positive valence.

	Condition main effect	Time main effect	Interaction main effect
Brief Mood Introspection Scale			
Positive emotions	32.36***	4.30*	8.20***
Negative emotions	26.28***	8.09**	8.09**
Brief Measure of Presence	.02	18.06***	.16
Presence Questionnaire	.52		

Note: Repeated measures ANOVAs were performed for the first two instruments and a two-way ANOVA was performed with the Presence Questionnaire. * $p < .05$, ** $p < .01$, *** $p < .001$

Table 1. Statistical analyses for mood and presence in a virtual environment with a positive valence.

	Conditions	
	Induced Joy	Induced sadness
Brief Measure of Presence – post immersion in the neutral / irrelevant environment	37.14 (26.01)	39.86 (33.22)
Brief Measure of Presence – post experimental immersion	50.71 (26.52)	51.07 (35.04)
Presence Questionnaire – post experimental immersion	100.79 (19.75)	94.36 (26.83)

Table 2. Mean (and standard error) for the measures of presence in Experiment 1.

2.4 Discussion for experiment 1

The objective was to verify whether feeling an emotion that matched the valence of a virtual environment induces a greater feeling of presence than feeling an emotion that does not match the emotional valance afforded by the same virtual environment. The hypothesis advanced was that inducing a negative emotion in a virtual environment that was expected *a priori* to be attractive would disturb and decrease the feeling of presence. The results first confirmed that the experimental manipulation was effective: the expected mood state of joy and sadness were induced. However, the valence of the virtual environment seemed positive enough to reduce the saddening effect of the mood induction. In addition, the manipulation did not produce the expected effect on the presence measures and the hypothesis cannot be confirmed. The effect-sizes suggest that the kind of emotions induced had no influence on the level of presence during virtual immersions. However, the induction of emotions in general, no matter whether the valence fits or not with the virtual environment, was associated with a significant increase in presence on the Brief Measure of Presence.

The weak level of negative mood reported after the experimental immersion among participants in the sadness condition may explain the results on the presence measures. The discrepancy between the emotional valence of the virtual environment and the induced negative mood was not that strong. Maybe a stronger discrepancy between mood and valence of the virtual environment would have had a significant impact. To reach that goal, the use of a negatively valence environment and the induction of positive emotion may be more fruitful than trying to induce more sadness in participants.

One possible explanation for the observed decrease in negative mood among participants where sadness was induced may be the inherent attractiveness of the virtual environment used for the immersion. Visiting a mythological Egyptian temple may represent a positive experience for most participants in the sample. It is important to point out however that virtual environments used by other researchers to induce positive mood (Banos et al., 2004; Riva et al., 2007) were especially designed to have a strong positive valence. No such efforts were invested in the current environment and, therefore, it was not expected to have such a soothing effect. Since the attractiveness of the environment chosen for the experiment may be blurring the results, and given the difficulty to induce a very negative mood that would be incongruent with the valence of the environment, a second experiment was designed with a virtual environment that has a negative valence, with the hope to verify whether a positive emotion which doesn't match the valence of a virtual environment would decrease the feeling of presence.

3. Experiment 2

This experiment used the same design and procedure for inducing emotions as Experiment 1, but a virtual environment depicting a grayish virtual city with dark building and broken-down cars was chosen. As well, some additional questions were added to complement the single-item measure of presence. The hypothesis was still that an emotion that does not match the virtual environment's affective valence would lead to a poorer feeling of presence than a matched emotion.

3.1 Sample and procedures

The sample was composed of 31 adults (19 women and 12 men) from a non-clinical population. Three participants were excluded because of excessive simulator sickness during the experiment. The 28 completers' age varied from 18 to 62 (M = 30.55, sd = 11.79). The recruitment procedures and selection criteria were identical to those described in the previous experiment.

The computer used was the same as in Study 1, except for the VR equipment. The use of a high-end headset (nVisor Sx from NVIS; visual field 60 degrees, resolution 1280 x 1024) and more precise tracker (Inertia cube^2 from InterSense; 3 degrees of liberty, angular resolution .05 degrees, latency of 8 ms, angular extent of 360 degrees) were expected to provide a better immersive experience. The virtual environment used for the experiment was a virtual city adapted from the 3D game Max Pain and used to treat height phobia (Bouchard et al., 2008). A pilot study was done to verify the valence of the virtual environment. In total, ten people who were not part of the experimental groups evaluated on a scale from 0 to 10 the valence of the Temple of Horus environment (see Experiment 1) and the virtual city. They confirmed that the virtual environment used in Experiment 2 did indeed had a more negative valence ($t_{(9)} = 4.54$, $p < .001$) than the Egyptian desert.

As in the previous experiment, emotions were induced using Velten's technique (1968). The experimenter explicitly reminded participants to try to hold their emotion during the experimental immersion. Also, participants were requested to complete the Brief Mood Introspection Scale not only after the emotions were induced but also before the mood induction, when they arrived at the lab. The addition of a baseline for their mood state was expected to allow confirming that the mood induction was indeed the cause of their mood state. The same measures were used in the experiment. Three items were added post-immersion to broaden the assessment of the subjective feeling of presence. One positively worded item assessed the perceived realism of the virtual environment and two items were negatively worded (reverse scoring) to document to what extent the user was aware that the virtual environment was created artificially and that he or she was in an office and not "there" in the virtual environment. An average score was calculated for this Gatineau Presence Questionnaire.

3.2 Results

The mood of participant was induced with success (see Figure 3 and Table 3). The scores on the negative emotion scale revealed a significant interaction effect. A more specific repeated-measures Condition X Time interaction contrast revealed a significant increase in negative mood from the baseline to after the sadness induction ($F_{(1,26)}$ = 16.09, $p < .001$). The mood state during the experimental immersion was consistent with the mood induction, with a significant repeated-measure Condition X Time interaction contrast ($F_{(1,26)}$ = 5.09, $p < .05$) on the negative mood scale. Therefore, a stronger negative mood was reported in participants where a sad mood was induced, and the virtual environment had a saddening effect on the mood of those where a joyful mood was induced. The effectiveness of the mood induction was also confirmed with similar repeated measures Condition X Time interaction contrast on the positive mood scale. A stronger positive mood was reported from baseline to post-induction in participants where joy was induced compared to those where sadness was induced ($F_{(1,26)}$ = 37.74, $p < .001$). The saddening effect of the virtual environment on the positive mood scale was not limited to participants where joy was induced, as revealed by the significant Time effect detected for that contrast ($F_{(1,26)}$ = 18.66, $p < .001$) and the lack of statistical significance of the repeated measures Condition X Time interaction contrasts between post-induction and post-immersion ($F_{(1,26)}$ = 4.90, ns).

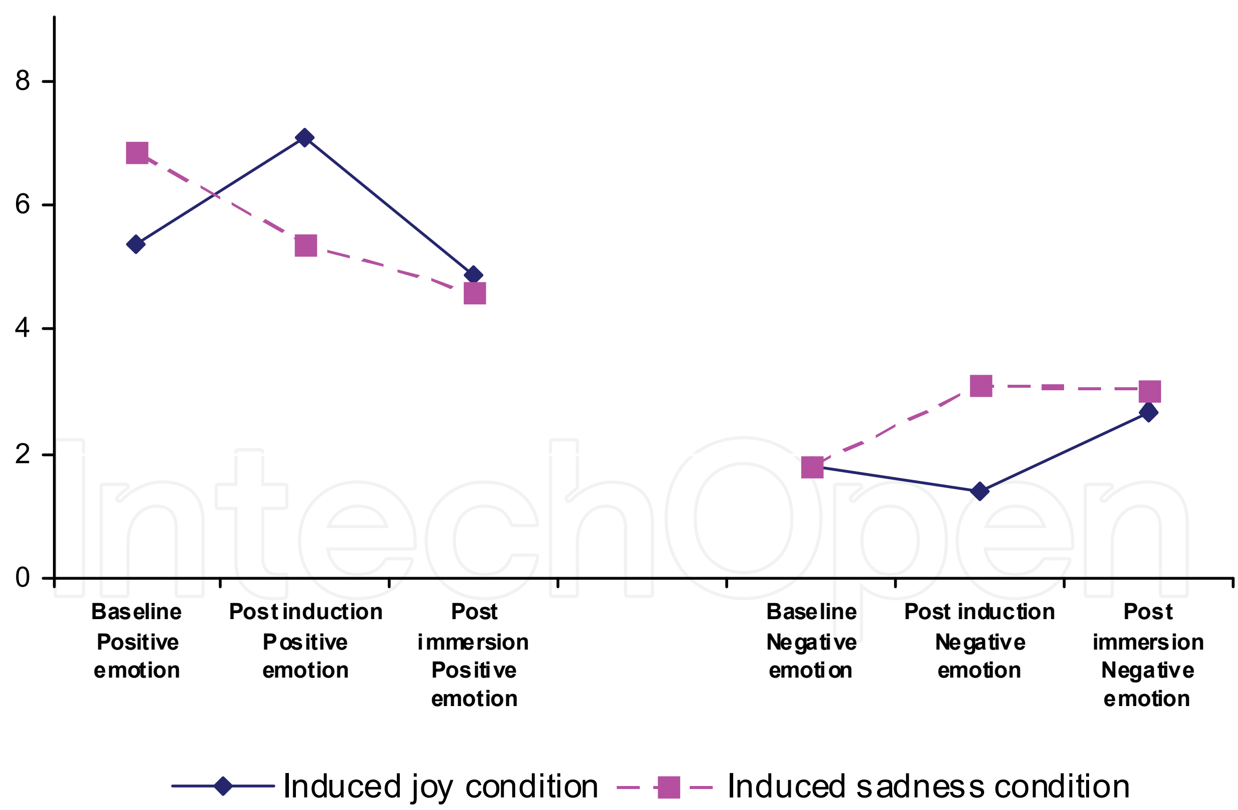

Fig. 2. Positive and negative mood at baseline, post induction and post immersion in a virtual environment with a negative valence.

Tables 3 and 4 show descriptive statistics and results of the analyses for the presence measures. The experimental manipulation had no significant impact on presence, even when measured only with one item, with all four items of the Gatineau Presence Questionnaire and with the Presence Questionnaire. The effect sizes were all small ($\eta^2 < .015$). Finally, let's mention that participants felt mild simulator sickness during the neutral virtual exposure (*M* = 30.29, *sd* = 23.55), that the intensity of the sickness increased during the second virtual immersion (*M* = 40.59, *sd* = 25.73) and that immersive tendency was good (*M*= 70.03, *sd*= 17.11) for both conditions.

	Condition main effect	Time main effect	Interaction main effect
Brief Mood Introspection Scale			
Positive emotions	.4	16.42**	8.39***
Negative emotions	2.45	6.77**	5.19*
Brief Measure of Presence	.00	.8	.00
Gatineau Presence Questionnaire	.34		
Presence Questionnaire	.19		

Note: A 2 X 3 repeated measures ANOVA was performed for measure of mood, a 2 X 2 repeated measures ANOVA was performed for the Brief Measure of Presence and two-way ANOVAs were performed for the remaining two instruments. * p < .05, ** p < .01, *** p < .001

Table 3. Statistical analyses for mood and presence in a virtual environment with a negative valence.

	Conditions	
	Induced Joy	Induced sadness
Brief Measure of Presence – post immersion in the neutral / irrelevant environment	63.82 (21.33)	63.18 (18.61)
Brief Measure of Presence – post experimental immersion	67.0 (22.03)	66.82 (23.23)
Gatineau Presence Questionnaire - post experimental immersion	51.74 (20.53)	46.52 (27.06)
Presence Questionnaire – post experimental immersion	86.94 (14.62)	84.36 (16.54)

Table 4. Mean (and standard error) for the measures of presence in Experiment 2.

3.3 Discussion for experiment 2.

The results of this second experiment suggest, as does the data from the first experiment, that effectively inducing emotions was possible but it did not has an impact on presence. The participants were able to use Velten's technique (1968) for inducing a positive or negative mood, but the immersion counteracted the effect of the positive mood induction. The mood states of the participants were not different at the end of the experiment. The hypothesis of the impact of a mismatch between the emotions and the valence of the virtual environment was not supported. This data replicate findings from Experiment 1, this time with an environment that has a negative valence. These converging findings raise important questions about emotions.

4. General discussion

Previous findings have shown a correlation between emotions and presence (Riva et al., 2007; Robillard et al., 2003) and a bidirectional relationship between these constructs (Bouchard et al., 2008; Michaud et al., 2004; Riva et al., 2007). Riva et al. (2007) showed that positive and negative mood could be efficiently induced by immersions in carefully designed virtual environments. The hopes behind the two experiments reported in this chapter were to document if the impact of emotions on presence was related to emotional arousal in general or to the realism of the experience. A mismatch between the emotions felt by the participant and what should be expected given the emotional valence of the virtual environment was expected to have a detrimental impact on presence. Both experiments used a classical method for inducing emotions (Velten, 1968). However, despite the use of two different virtual environments (one with a positive valence and another with a negative valence), it was impossible to confirm our hypothesis.

Although these are non significant findings, they deserve to be examined carefully as they can be interpreted differently whether they are considered from the angle of presence or emotions. From a presence standpoint, few conclusions could be reached since the manipulations could not create a mismatch. In Experiment 1, participants where sadness was induced were not in a negative mood throughout the immersion in the positive valence environment and in Experiment 2 participants where joy was induced were not in a positive mood throughout the immersion in the negative valence environment. Even if there was a slight mismatch in Experiment 1, the difference in mood was certainly too small to have an impact on presence. The only relevant observation is that immersion in the positive emotional valence environment lead to an increase in presence when compared to the training environment and this effect was not observed when comparing the training and the negative valence environments.

When the results are appraised from an emotion standpoint, one striking finding is that immersion in a virtual environment can counteract the effect of a mood induction performed with the classical and popular Velten's (1968) approach. This method has been extensively used and validated (Gilet, 2008). Immersions in moderately positive and negative valence virtual environments, as opposed to other environments designed following carefully planned strategies to impact on emotions (Banos et al., 2004; Bouchard et al., 2006; Riva et al., 2007), can improve moderately negative mood or reduce positive mood. This in itself is a significant, and replicated, finding. Experimental mood induction procedures do not always cause intense emotions (Gilet, 2008) and scores on the Brief Mood Introspection Scale are supporting this notion especially with the negative mood. The saddening induction did not lead to scores as high as the joyful induction. But the immersion in the positive emotional valence environment was able to counter very efficiently the negative induction. The negative emotional valence environment did not increase the negative mood of the participant but induced a negative mood in joyful people and reduced positive mood in all users.

Two conclusions can be reached from this chapter: (a) much stronger and long lasting mood induction techniques have to be found and used to induce *in vivo* emotions that would not match with the emotional valence of a virtual environment; (b) even simple virtual environments can counteract effectively the mood induced by traditional strategies. We cannot conclude, however, whether to increase presence an adequate fit is needed between relevance of emotions felt in virtual reality and emotions afforded by the content of the virtual environment. The question about the role of emotional arousal versus the relevance of the emotions remains.

Unpublished results on the relevance of olfactory cues on presence suggest that mismatch may not be that detrimental (Bouchard & Baus, in preparation). For example, in a study where participants were exposed to odors that match (i.e., smell of apple pie in a kitchen and of urine in a bathroom) or don't match (i.e., smell of apple pie in a bathroom and of urine in a kitchen) with the context of the virtual environment, the presentation or not of an odor had more impact on presence than the effect of a match or a mismatch. In case of mismatches, participants would fill-in for the irrelevance of odors by commenting, for example, that the pies must be really well cooked if they smell that strong in the bathroom, or that the garbage bag is due to be changed because of the awful smell in the kitchen.

Presence should be approached like an advanced perceptual illusion based on the integration of multisensory information. Emotions felt during an immersion can stem from the automatic appraisal of the stimuli and their meaning. But once emotional arousal is felt by the user, it could reinforce the illusion of being *there* in the virtual environment. Depending on the strength and meaning given to these emotions, we think they could foster presence or break the illusion.

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Technological advancement in graphics and other human motion tracking hardware has promoted pushing "virtual reality" closer to "reality" and thus usage of virtual reality has been extended to various fields. The most typical fields for the application of virtual reality are medicine and engineering. The reviews in this book describe the latest virtual reality-related knowledge in these two fields such as: advanced human-computer interaction and virtual reality technologies, evaluation tools for cognition and behavior, medical and surgical treatment, neuroscience and neuro-rehabilitation, assistant tools for overcoming mental illnesses, educational and industrial uses In addition, the considerations for virtual worlds in human society are discussed. This book will serve as a state-of-the-art resource for researchers who are interested in developing a beneficial technology for human society.