Effectiveness of Virtual Reality Survival Horror Games for the Emotional Elicitation: Preliminary Insights Using Resident Evil 7: Biohazard

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Abstract. Survival horror games played in virtual reality can trigger intense fright and anxiety in the players. Such unique characteristics can thus be exploited not only as a source of entertainment, but also as a tool for both emotion elicitation and emotional training. However, studies investigating the players' experience and the emotional activation while playing virtual reality video games are still very limited and horror games represent an even more limited number of these. Within this context, this study was aimed to compare a horror game Resident Evil 7: Biohazard, experienced through virtual reality as opposed to a non-immersive display modality (i.e. console system), and exploring differences in the usability and the emotional activation. In order to answer to such objectives, the game was played by a sample of 26 young adults, half of which played using Playstation VR, while the other half through a more traditional non-immersive console setup (PS4 Pro). The usability and the emotional impact of the game was assessed through self-report questionnaires and the recording of physiological indexes (heart rate, skin conductance response). Results showed that: (a) playing a horror video game in virtual reality was not more difficult than playing in a non-immersive display modality; (b) players showed an increased perceived anxiety both after playing the horror video game in virtual reality and playing in a non-immersive display modality; interestingly, the perceived sense of happiness significantly increased only after playing in virtual reality; finally the sense of presence resulted to be greater in virtual reality as opposed to the non-immersive condition.

Keywords: Virtual reality · Video games · Survival horror games
Emotion

1 Introduction

1.1 Virtual Reality and Survival Horror Video Games

In the last years, virtual reality has become a booming trend in the video game and entertainment industry [1, 2]. Starting from 2016, in particular, there has been an actual

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breakthrough in the gaming business, thanks to the entry in the mass market of several commercial head mounted displays, including Oculus Rift (Oculus), HTC Vive (HTC and Valve corp.), and PlayStation VR (Sony corp.). Only in 2017 over 7249 games developed for virtual reality have been released on the Steam platform [3], while Sony Corp, by June 2017, had already sold more than one million units of its virtual reality headset globally [2].

Among the most successful video games developed for virtual reality, horror games constitute one of the most played genres in 2017 [4]. One of the best-selling games of this genre is Resident Evil 7: Biohazard (Capcom, 2017), the last chapter of the renowned saga that first introduced the term "survival horror" with Resident Evil (Capcom, 1996), and that, by November 2017, achieved an impressive number of 307,884 VR users, comprising 11.55% of the total Resident Evil 7: Biohazard player base [5].

Survival horror games played in virtual reality, thanks to a high level of immersion, defined as a "quantifiable description of a technology, which includes the extent to which the computer displays are extensive, surrounding, inclusive, vivid and matching" [6], can trigger real fright in the players, who are required to actively decide how and when to respond to such threats and manage to survive [7]. Compared to non-immersive display modalities that use a monitor as a graphical interface for users, through virtual reality the player can perform as an actor [6], and actually feel an intense sense of presence, namely "the extent to which a user feels present in a virtual environment [8]", allowing real emotions to be activated by such environment [9, 10].

In virtual reality horror video games, such unique characteristics of "mediated fright" can thus be exploited not only as a source of entertainment, but also as a therapy tool: as a feeling of fear comparable to what is experienced in the real world can be obtained in a realistic yet safe environment, this kind of games can have important applications for both emotion elicitation and emotional training, including the assessment and training of emotional skills (such as stress management and emotional regulation skills), as well as for the therapy of anxiety disorders and phobias [7, 11].

Previous studies suggested in fact that virtual reality is more emotion-inducing than content presented with less immersive technologies (e.g., video, audio) [12], and that it can induce emotional and behavioral responses similar to those that occur in the real world [13, 14]. In addition, studies have reported that commercial video games combining the horror genre and biofeedback techniques could be useful stressors to practice stress management skills [15]. Furthermore, players' fright reactions and coping strategies in an immersive virtual reality horror game have recently been investigated [7], showing that this kind of games provides an excellent means to simulate close-rangephysical threats, and consequently are proven to be useful tools through which toobserve how people react to, and cope with, such fearful stimuli

Despite such interesting results, studies investigating the players' experience and the emotional activation while playing virtual reality video games are still very limited [e.g., 16–18], and studies concerning survival horror games represent an even more limited number of these [i.e., 7]. A deep scientific understanding of the characteristics of virtual reality video games compared to games delivered through non-immersive modalities and of what and how elements elicit effective mediated frights in virtual reality horror games could be fundamental for theoretical contributions and practical implications for entertainment, as well as for the assessment and training of emotional skills [19].

1.2 Aim of the Study

Within the context described above, this study was aimed to compare the usability of acommercial survival horror video game, Resident Evil 7: Biohazard (Capcom 2017), experienced through virtual reality as opposed to a non-immersive display modality (i.e., console system), and to explore differences in the emotional activation while playing the horror video game in the two experimental conditions, and to explore differences in the emotional activation while playing the horror video game in virtual reality or through console. In order to answer to such objectives, Resident Evil 7: Biohazard was played by a sample of 26 young adults, half of which played with a virtual reality device (Playstation VR, Sony Corp.), while the other half through a more traditional non-immersive console setup (PS4 Pro, Sony Corp.). The players' experience has been evaluated in terms of performance, usability, and emotional impact through both self-report questionnaires and the recording of physiological indexes (heart rate and skin conductance response).

More in detail, the main hypotheses explored by the research were:

- (H1) No differences in performance and usability between the two versions of the game: while in the past most video games research has focused on understanding outcomes of playing games [e.g., 20, 21], recently there has been a shift towards understanding how specific game features, especially display devices (virtual reality vs. non-immersive ones, such as desktop modality) can affect the player experience [22–24]. Despite scientific literature exploring the differences between virtual reality video games and non-immersive ones is still limited [17, 18, 24, 25], on the basis of a previous exploratory study we can hypothesize that no differences in performance and usability will be found between the two conditions of the game (virtual reality opposed to non-immersive console setup) [18].
- (H2) The horror game is able to elicit in the players a sense of anxiety, both innon-immersive modality [e.g., 15, 26, 27] and in virtual reality [7]: in particular we hypothesize that such anxious response will be accompanied by a positive emotional response [28–31], and an increased sense of presence [12, 32, 33] when compared to a game experienced in a non-immersive modality (i.e., console).

2 Methods

2.1 Participants

26 participants - 7 females (26.9%) and 19 males (73.1%); age m = 22.65 (SD = 2.54); years of education m = 15.2 (SD = 3.2) - were recruited among students and personnel of the University of Milano-Bicocca and of other universities in Milan. No credits (ECTS) nor economic rewards were provided during the research. In order to be included in the study, individuals had to meet the following criteria: (1) age between 18 and 35 years old; (2) no major medical disorders (heart disease or high blood pressure, neurological disorders, epilepsy); (3) no left-handed; (4) no presence of pharmacotherapy (psychoactive drugs, anti-hypertensive, anti-depressants); (5) no significant visual impairment (all with normal or corrected-to-normal visual acuity).

Before participating, all participants were provided with written information about the study and were required to give written consent in order to be included. The study received ethical approval by the Ethical Committee of the University of Milano-Bicocca. The research was conducted in accordance to American Psychological Association [34] ethical principles and code of conduct.

2.2 Measures

A multi-trait (i.e. focused on both psychological constructs and physiological measures of users' experience) and multi-method (i.e. based on the integrated use of different technical and methodological solutions) approach has been used, previously tested during pilot studies conducted by the researchers involved in this empirical experimentation [18, 35].

In particular, the following self-report questionnaire was given to the participants at the start of the experimental session:

- *Demographics, gaming habits and virtual reality knowledge:* individuals were asked to indicate their gender (female/male), age (years old), their gaming habits (mean hours spent gaming per week), their previous experience with Resident Evil 7: Biohazard (yes/no). In addition, they were asked to assess their knowledge of virtual reality on a 7-point Likert scale.

Furthermore, the following self-administered questionnaires were used to measure the subjective indexes concerning individuals' emotional state:

- *State-Trait Anxiety Inventory, Form-Y2 (STAI-Y2)* [36]: A validated and widely used measure of trait anxiety (STAI-Y2). Individuals are asked to specify to which extent, on a 4–point Likert scale (from "not at all" to "very much"), they usually perceive each of the 20 indicated feelings;
- *Visual Analogue Scale for Subjective Feelings of Anxiety (VAS-A*): an horizontal line, 100 mm in length, anchored by word descriptors at each end. Participants mark on the line the point that they feel to visually represent their perception of their current level of anxiety;
- *Visual Analogue Scale for Subjective Feelings of Happiness (VAS-HP), and Surprise (VAS-SP):* Participants mark on the line the point that they feel to visually represent their perception of their current level of happiness (VAS-HP), and Surprise (VAS-SP).

Finally, after the game, the following self-administered questionnaires were used to measure the subjective indexes concerning the gaming experience:

- *Slater-Usoh-Steed Presence Questionnaire (SUS-II)* [37]: a custom questionnaire concerning the perceived sense of presence, divided into 6 items on a 7-point Likert scale. A single total score is obtained;
- *System Usability Score (SUS)* [38]: a reliable tool for measuring the usability. It consists of a 10-items questionnaire with five response options for respondents (from "strongly agree" to "strongly disagree"), concerning the ease of use or the difficulties encountered by the participant while using the system.

Psychophysiological Assessment. Physiological data can be valuable in helping to read the emotional state of game players [e.g., 39, 40]. For this reason, in this study at the beginning of the experimental session and during the gaming experience, the following psychophysiological data were recorded: Heartbeat (HR), measured with Electrocardiogram (ECG), and Skin Conductance Response (SCR). In particular, HR mean value, measured in Beats per Minute (BMP), was calculated through R-to-R peak detection. The physiological signals have been acquired using a ProComp Infiniti device from Thought Technology, including Biograph Infiniti 5.0.2 software to record and export all raw signals. Every signal was exported at a 256 Hz sampling rate.

Video Game (Resident Evil 7: Biohazard). A first-person survival horror game, the seventh chapter of the Resident Evil saga, one of the best-selling and most famous series of this genre. In Resident Evil 7: Biohazard (Capcom, 2017), the player assumes the role of Ethan, a man who receives an unexpected email from a woman claiming to be his wife Mia, who however has been presumed dead for several years. The gameplay experience proposed during the experiment has been selected among the initial phases of the game. The players will find themselves in an abandoned mansion, in particular in a corridor with three doors, one of which leads back to the basement from which the main character came. After exploring the corridor and the bathroom, the players have to retrace their steps to the basement, where a short cut-scene (a non-interactive scene that breaks up the gameplay) begins. The players will be attacked by a monstrous version of Mia and will have to press the R2 button repeatedly in order to free themselves from the attacking woman, who will regain awareness for a short moment, then collapse on the floor. It takes approximately 4 min to complete this gameplay. The game's difficulty has been set on standard, which is the difficulty Resident Evil 7: Biohazard is automatically set at the beginning of a new game.

Experimental Design. A between-subjects design has been used to compare emotional responses and usability of the two experimental conditions. Specifically, the study compared the following conditions:

- *Virtual Reality (Immersive) Condition.* Participants were seated at a desk and were asked to wear the PlayStation VR (Sony Corp.), connected to a PS4 Pro (Sony Corp.) on which they played the selected game. After a brief training about the PlayStation VR's controls, participants started to play the game using the standard wireless controller of the PS4 (Sony Corp.);
- *Console (Non-immersive) Condition.* Individuals were seated at a desk on which a PS4 Pro (Sony Corp.), and a 32" TV monitor (Samsung HD Flat Series 4 K4100) were positionedat a distance of about 1.5 m from the monitor. Participants were asked to play thegame using the standard wireless controller of the PS4 (Sony Corp.).

Procedure. Participants were randomly assigned to the condition, counterbalanced for the total individuals through an established randomization scheme obtained from http://www.randomizer.org/. At the start of the experimental session, individuals were asked to complete the self-report questionnaire about their demographics, gaming habits and virtual reality knowledge, the STAY-Y2, VAS-A, VAS-HP, VAS-SP. Participants

were then connected with biosensors to record their HR and SCR. A baseline measure of these signals was registered for 3 min in rest condition, with eyes opened. Once the physiological baseline was recorded, the experimental session started, and psychophysiological signals were recorded while the participants completed the game. After completion, participants answered the following self-reported questionnaires: VAS-A, VAS-HP, VAS-SP, SUS-II, and SUS.

Strategy of Data Analysis. Data were analyzed by mean of a set of multivariate statistical tests. First, common assumptions (normality, homogeneity of variance, and homoscedasticity) for multivariate analysis were assessed and procedures of data cleaning (missing values analysis, detection of uni- and multi-variate outliers) were conducted. In general, major violation to assumptions were not found and a multi-variate outlier was skipped. Then, first-order correlation analysis, controlled for the effect of condition, among scores were conducted in order to check the viability of other analysis.

With the aim of verifying the comparability of the sample divided into the two experimental groups, Chi-square tests of independence and independent sample t-tests were calculated on the demographic statistics and on the state characteristics (using both self-report questionnaires and physiological indicators) previous to the gameplay experience.

In line with the epistemological framework of hypothesis 1, plain t-test analyses was conducted in order to test potential differences about the two condition with regards of performance and usability scores. In order to support research hypothesis 2, a series of Generalized Linear Model (GLM) for repeated measures were computed. Such kind of analysis is useful in measuring the effect of a "treatment" at different time points and in different groups. Furthermore, GLM allowed to evaluate the main effect within and between the subjects as well as interaction effects between factors. Finally, GLM estimated the magnitude of effect sizes for all variables. In the present study, the GLM model were in such a way that pre/post measures were the within-subject factor (i.e. two levels) whereas the condition (Virtual Reality vs Console) was the between-subject factor. The interactive effect within*between was included into the model.

3 Results

3.1 Demographics

A Chi-square test of independence was calculated in the two experimental conditions comparing gender and participants' previous experience with Resident Evil 7: Biohazard. No statistically significant differences were found (see Table 1).

Independent sample t-tests revealed no statistically significant differences in participants' age, years of education, hours spent gaming per week, knowledge of videogames, and knowledge of virtual reality (see Table 2).

Similarly, independent sample t-tests revealed no differences between the two experimental conditions in the participants' characteristics, as assessed by STAY-Y2 (Virtual Reality: m = 44.1; SD = 10.1, Console: m = 40.5; SD = 8.56; t(24) = −.967;

Table 1. Chi-square test of independence on gender, and previous experience with Resident Evil 7: Biohazard in the two experimental conditions (Virtual Reality, N = 13; Console, N = 13)

Variable		Virtual Reality	Console	Chi-square	gl	p
Genre	Female	3	4			
	Male	10	9	.195	1	.658
Previous experience with Resident Evil 7: Biohazard	Yes	3	2			
	No	10	11	.248	1	.619

Table 2. Independent sample t-tests on age, years of education, hours spent gaming per week, knowledge of videogames, and knowledge of virtual reality in the two experimental conditions (Virtual Reality, N = 13; Console, N = 13)

Variable	Condition	m	SD	t	gl	p
Age	Virtual reality	23.4	2.87	1.67	24	.107
	Console	21.8	1.95			
Years of education	Virtual reality	14.6	2.06	−.916	24	.561
	Console	15.7	4.04			
Hours spent gaming per week	Virtual reality	13.7	9.4	−.345	24	.733
	Console	15	10.9			
Knowledge of virtual reality	Virtual reality	3.69	1.97	−.102	24	.920
	Console	3.77	1.87			

p = .343), VAS-A (Virtual Reality: m = 24.6; SD = 25.9, Console: m = 26; SD = 32.2; t(24) = −.122 p = .904), VAS-HP (Virtual Reality: m = 67.5; SD = 20.6, Console: m = 68.3; SD = 16.3; t(24) = −.101; p = .921), VAS-SP (Virtual Reality: m = 43; SD = 35.7, Console: m = 26.7; SD = 23.8; t(24) = 1.36; p = .185), HR (Virtual Reality: m = 80.4; SD = 13.4, Console: m = 83.3; SD = 12.1; t(24) = −.579; p = .568), and SCR (Virtual Reality: m = 11.1; SD = 5.71, Console: m = 8.21; SD = 7.88; t(24) = 1.1; p = .282).

3.2 Hypothesis 1

An independent sample t-test was conducted to compare participants' performance in Virtual Reality and Console conditions. Results revealed that there was not a statistically significant difference in the total time required to complete the game for Virtual Reality (m = 226, SD = 49.7) and Console (m = 230, SD = 68.7) conditions; t(24) = .160, p = 87. In a similar way, the condition (m = 80.4, SD = 7.96; m = 83.67, SD = 11.7) seemed to not affect scores on SUS (t(24) = .830, p = .87). The analysis provide support to the first hypothesis of the study and no effect sizes were found.

3.3 Hypothesis 2

Generalized Linear Model for repeated measures was used to test whether and to what extent the pre-post differences on psychometric (VAS-A, VAS-HP, VAS-SP) and psychophysiological (HR and SCR) scores on emotional activation were related to Virtual Reality or Console conditions.

First of all, regarding the self-report questionnaires, the model testing scores on VAS-A resulted statistically significant ($F(1, 24) = 4.51$, $p < .05*$, $\eta^2 = .170$) meaning that, regardless the condition ($F(1, 24) = 0.13$, $p = .99$, $\eta^2 = .004$), participant feelings of anxiety were high at the end of the experience. In contrast, VAS-HP revealed a different dynamics (see Fig. 2). In fact, the GLM suggested that at the end of the experience, scores on happiness in Virtual Reality condition had grown, whereas in Console condition had decreased ($F(1, 24) = 4.28$, $p < .05*$, $\eta^2 = .152$). Finally, the model testing scores on VAS-SP did not revealed a statistical significance $F(1, 24) = 2.89$, $p = .10$, $\eta^2 = .023$.

With regards to physiological measures, the results of GLM revealed a large main effect of the pre/post factor ($F(1, 24) = 23.26$, $p < .05*$, $\eta^2 = .50$) in relation to mean of heart beats. Such effect was not detected in relation to the condition ($F(1, 24) = .61$, $p = .44$, $\eta^2 = .025$). A similar large and statistically significant main effect was also found in relation to skin conductance ($F(1, 24) = 50.77$, $p < .05*$, $\eta^2 = .68$) regardless the condition $F(1, 24) = .26$, $p = .61$, $\eta^2 = .011$). Means and standard deviations for all variables in each condition were summarized in Table 3.

Finally, an independent sample t-test was used to compare participants' scores at SUS-II after the two experimental conditions. Results revealed a statistically significant difference in the feeling of presence for Virtual Reality ($m = 26.9$, $SD = 6.91$) and Console ($m = 20.6$, $SD = 7.8$) conditions; $t(24) = 2.18$, $p < .05*$, $\eta^2 = .50$ (Fig. 2).

4 Discussion

The purpose of this study was to compare the effectiveness of emotional induction caused by virtual reality horror video games if compared to non-immersive ones, such as console games. As such, we want to extend the currently existing academic knowledge about the possible effectiveness of commercial virtual reality video games, in particular of the horror genre, and their possible use as tools for both emotion elicitation and emotional training. Seen video games' intrinsic characteristics of being motivating, engaging, and easily accessible [41], combined with the characteristics of virtual reality as an interactive and deeply immersive instrument [42, 43], virtual reality video games represent potentially useful, low cost, and easily accessible tools to be used in the treatment of anxiety disorders and phobias, as well as to assess and train the healthy individuals' emotional skills.

Starting form the first main hypothesis of this study, we confirmed that playing the horror video game Resident Evil 7: Biohazard (Capcom 2017) in virtual reality did not result to be more complex than playing the classic version of the game (i.e., on the console). Data showed in fact no statistically significant differences between the virtual

Table 3. Summary of VAS-A, VAS-HP, VAS-SP, heart beats (HR) and skin conductance response (SCR) scores in different experimental conditions (Virtual Reality, N = 13; Console, N = 13)

Variable	Condition	Time	m	SD
VAS-A	Virtual reality	Pre	21.7	21.6
		Post	31.1	21.5
	Console	Pre	18.3	23.8
		Post	27.8	14.2
VAS-HP	Virtual reality	Pre	67.5	20.6
		Post	75.9	18.1
	Console	Pre	68.3	16.3
		Post	59.6	20.8
VAS-SP	Virtual reality	Pre	43.1	35.7
		Post	57.1	35.3
	Console	Pre	26.7	23.9
		Post	32.2	21.5
HR	Virtual reality	Pre	80.4	13.4
		Post	92.4	10.7
	Console	Pre	83.3	12.1
		Post	91.9	18.2
SCR	Virtual reality	Pre	11.1	5.71
		Post	15.7	6.01
	Console	Pre	8.21	7.88
		Post	13.4	9.3

reality and console version of the horror video game in terms of total time required to complete the gameplay, and of usability, assessed through the SUS questionnaire [38].

These results seem to be in line with what has been observed in a previous exploratory study [18], in which playing a first-person shooter game Smash Hit (Mediocre 2014) in virtual reality did not result to be more difficult than playing the same video game on a non-immersive mobile device (i.e., the iPad). It is interesting to note that in both studies the majority of the sample population presented a low previous knowledge of virtual reality, possibly suggesting that naive users as well perceive this technology as pleasant and easy to use. VVirtual reality video games, however representing a new or not well-known game experience for the majority of the players, characterized by deeply different characteristics if compared with non-immersive set ups (e.g., PC, console or mobile gaming) [18, 44], do not result to be perceived as more complex compared to more traditional non-immersive gaming modalities.

Results obtained from past experiments comparing non-immersive to virtual reality display modalities reported a different global tendency, stating that individuals tend to perform better when using traditional systems [17, 45, 46]. Nonetheless, it is important to underline that such experiments, when compared to the present one, did not use commercial virtual reality video games as stimuli, but game-like situations (i.e., navigation and wayfinding tasks), and virtual reality hardware systems that are very

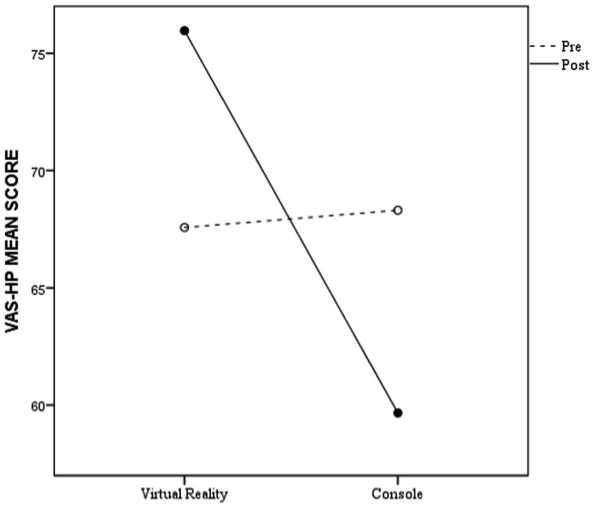

Fig. 1. Generalized Linear Model for repeated measures on the VAS-HP scores before and after the two experimental conditions. Scores in Virtual Reality condition had grown, whereas in Console condition had decreased ($F(1, 24) = 4.28$, $p < .05$*, $\eta^2 = .152$).

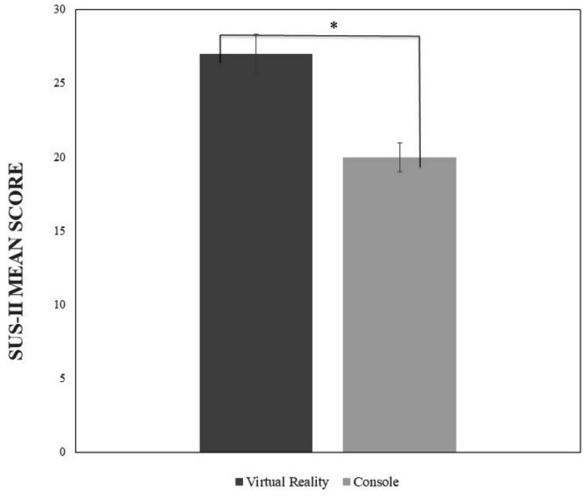

Fig. 2. Independent sample t-test on participants' scores at SUS-II after the two experimental conditions Results revealed statistically significant values, in particular an increased feeling of presence for Virtual Reality if compared to Console conditions; $t(24) = 2.18$, $p < .05$*.

different from what is commercially available nowadays. These elements could explain the differences between what emerged from the present study and previous results. However, future studies are needed to investigate the differences in players' experience between video games presented through virtual reality compared to non-immersive

devices, in order to better understand the relationship between interactivity, the intensity of emotional response, and players' performance.

Secondly, the survival horror video game was confirmed to be effective in eliciting anxious emotional responses in individuals, similarly to what has been observed in previous studies, both in non-immersive [15, 26, 27], and immersive set ups [7]. In particular, results showed a significant increase of perceived anxiety as assessed with self-report questionnaires (VAS-A) and with physiological indexes (heart rate and skin conductance response) after playing the survival horror game, without significant differences in the intensity of the anxious response between the two conditions.

Interestingly, statistically significant differences were instead observed in relation with the users' self-reported feeling of happiness, assessed through the VAS-HP. In particular, results revealed that, while the perceived feeling of happiness increased after the virtual reality game experience, the opposite result was obtained after the console gameplay, namely a decrease in the sense of happiness in comparison to the baseline.

Such results seem to be consistent with previous literature: virtual reality has already been demonstrated to successfully induce positive moods [28–31]. In particular, studies showed that it is possible to evoke positive emotions with virtual reality in healthy individuals [e.g., 30], to the point that participants tend to prefer virtual contents rather than traditional non-immersive techniques [29]. This has been confirmed by many other previous studies: for instance, joy and relaxation were induced by virtually walking into a park designed ad hoc in virtual reality by researchers [28], and a virtual environment specifically designed for chronic pain patients increased their mood state, positive emotions, motivation, and self-efficacy [31]. What emerges from our study shows, interestingly and differently from previous studies, that not only virtual reality contents specifically created for emotional induction, but also a commercial virtual reality game, specifically an horror game among the most popular and best-selling ones as Resident Evil 7: Biohazard, can effectively induce a feeling of anxiety in people, combined to a positive emotional state.

Moreover, in relation to these outcomes, it appears even more interesting to underline the final result obtained by this study: namely, as hypothesized, players reported a statistically larger sense of presence after the virtual reality horror video game experience if compared to the level of presence perceived after the non-immersive (desktop console setup) experience. Such results corroborate what has been observed in previous studies about the possibility for people to "be in the game" thanks to the virtual reality technology [47], and, thanks to the plausibility illusion mechanism [6], to personally face immediate threats, actively deciding how they will react to such threats and manage to survive [7].

Virtual reality has been found to be able to elicit frights similar to those perceived in real events [9] and to be effective in anxiety and phobia treatments, as well as for the stress management training [12, 18, 48]. Triggering real fright in a simulated virtual environment could have important consequences not only on the design of video games that are more and more effective in eliciting emotions in players, but also for emotional assessment and treatment programs. On the one hand, in fact, this kind of video games played in virtual reality, and consequently eliciting an intense emotional response, could become assessment tools for people's emotional skills when confronting dangers or stressful situations. For instance, recording the performance, as well as the subjective

physiological and emotional response during such type of video game, could offer relevant data about the individual's reaction modalities in similar situations. On the other hand, acquiring the psychological skills to cope with frights or stress in a "safe" virtual environment, during a game experience that qualifies as entertaining and highly motivating [49], could represent an effective, low-cost and easily accessible tool for the training of emotional skills (i.e. emotional regulation, stress management), as well as for the rehabilitation of anxiety disorders or phobias.

Although the results of the present study could be interesting for their possible applications, this research has some important limitations that could affect the generalizability of the results or that may have influenced the findings. The main issues are related to the small sample size and the specific sample included in the study, who were young adults, played often (several hours per week) and had a low knowledge of virtual reality systems. In particular, on the basis of the results obtained by previous studies [7, 30, 49], it could be interesting to examine differences in the virtual reality video game experience, in relation with particular users' characteristics such as gender and age.

Another limitation lies in the fact that interesting variables such as the cybersickness experienced by players were not assessed. As it has been observed in previous studies [e.g., 24], in fact, differently from what usually happens while playing non-immersive console games, a particular type of motion sickness occurs when the person is immersed in a virtual environment through an head mounted display, including symptoms such as discomfort, nausea, headache, and dizziness [50]. Cybersickness can therefore negatively affect the users' experience of virtual reality contents, and for this reason it is important to better investigate such aspect, with the objective to limit the negative effects.

Finally, it would be interesting to use other physiological indexes related to the emotional activation, such as the facial electromyography (fEMG), that is considered a good measure of negative emotional state [51, 52], and the electroencephalography (EEG), which has already been used in a previous study about horror games [52].

Despite these limitations, the present exploratory study found that: (a) playing a commercial horror video game in virtual reality was not more difficult than playing in a non-immersive modality, such as console; (b) players showed an increased perceived anxiety both after playing the horror video game in virtual reality and after playing through the console; interestingly, however, the perceived sense of happiness significantly increased only after playing in virtual reality; finally, the sense of presence resulted to be greater in virtual reality as opposed to the console modality.

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