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Are the effects of *unreal* violent videogames pronounced when playing with a virtual reality system?

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ABSTRACT: The present study was conducted to analyze the short-term effects of violent electronic games, played with or without a virtual reality device, on the instigation of aggressive behavior. Physiological arousal (heart rate), priming of aggressive thoughts, and state hostility, were also measured to test their possible mediation on the relationship between playing the violent game and aggression. The participants - 148 undergraduate students - were randomly assigned to four treatment conditions: two groups played a violent computer game (Unreal Tournament), and the other two a non-violent game (Motocross Madness), half with a virtual reality device and the remaining participants on the computer screen. In order to assess the game effects the following instruments were used: a BIOPAC System MP100 to measure heart rate; an emotional Stroop task to analyze the priming of aggressive and fear thoughts; a self-report state hostility scale to measure hostility; and a Competitive Reaction Time Task to assess aggressive behavior. The main results indicated that the violent computer game had effects on state hostility and aggression. Although no significant mediation effect could be detected, regression analyses showed an indirect effect of state hostility between playing a VG and aggression.

Key Words: violent electronic games; virtual reality system; aggression.

Are the effects of violent video games pronounced when playing with a virtual reality system?

Electronic games are one of today's most popular entertainments among youth. Although there is, in general, some evidence regarding the positive effects of playing video games (*e.g.*, learning, rehearsing, developing and practicing skills such as problem-solving, perseverance, hypothesis testing, constructive thinking, hand-eye motor coordination, creativity) (Rauterberg, 2004), we must not dismiss the possibility that they may also have harmful effects on players.

One of the major concerns is the games' violent content. Most of research done so far has shown that violence is the video games' main ingredient (*e.g.*, Smith, Lachlan, & Tamborini, 2003), even in those rated "Everyone" (Thompson & Haninger, 2001). Given that this new entertainment is very successful among youth, we take it to be highly relevant to understand its psychological and interpersonal effects.

Research on the negative effects of playing violent games (VG) has been based on the same theoretical frameworks used to test the impact of exposure to television and movie violence. However, this new entertainment contains specificities of its own. Interactivity, for instance, allows players a more active participation in the environment, also requiring higher attention and concentration. Factors like previous experience, perception of control, competence, frustration, competitiveness, involvement, and sense of presence, should also be taken into account (*e.g.*, Tamborini, Eastin, Lachlan, Skalski, Fediuk, & Brady, 2001).

Among the several theories on aggression, Anderson and colleagues, Dodge and colleagues, and Huesmann developed the Information Processing Models of Aggression (*e.g.*, Anderson, Anderson & Deuser, 1996; Anderson & Dill, 2000; Dodge & Crick, 1990; Huesmann, 1988; 1998), in which the hypotheses of previous approaches to aggression were integrated. Based on major insights from recent research findings, the Information Processing Models of Aggression (IPMA) set forth some explanations concerning the processes involved in learning, disinhibition, and instigation of human aggressive behavior. According to this model, the way people construe and respond to the social world results from situational and individual factors (the basic input variables). The IPMA emphasizes the relevancy of various situational input variables to the instigation of aggression: offence, provocation, frustration, pain or discomfort, exposure to movie violence, and playing VGs, among others. Regarding the individual factors, IPMA underlines variables such as genetic predispositions, sex, aggressiveness, attitudes, scripts, beliefs, values and long-term goals. These situational and individual factors may influence, directly or indirectly, the aggressive behavior, operating via one, two or all the three processes of the individual's internal state, conceptualized as cognitive, affective and physiological paths. Furthermore, the IPMA also considers the possibility of an existing relationship among the internal state variables (*e.g.*, Anderson *et al*., 1996; Carnagey, & Anderson, 2003; Huesmann, 1998).

Most of the empirical research on the effects of VG on accessibility of aggressive constructs in memory has used tasks such as the emotional Stroop (Kirsh, Olczak, & Mounts, 2005), word reading reaction time (e.g., Anderson & Dill, 2000), word production (e.g., Calvert & Tan, 1994; Tamborini *et al.*, 2000, 2001), or word completion task (Anderson *et al.*, 2004). Relying directly on associative network models of memory (e.g., Anderson, 1983), the IPMA suggests that playing VGs may activate aggressive-related constructs making them more readily accessible in memory. This priming effect may, in turn, be used to make behavioral decisions, increasing the likelihood of engaging in aggressive behaviors (Berkowitz, 1993; 1998). The majority of studies have reported a higher accessibility of aggressive cognitions after playing VGs compared to playing non-violent games (NVGs). However, to our knowledge, only Anderson and Dill´s study (2000, Study 2) showed that this priming effect was a mediator between playing a VG and subsequent aggression.

Fear, conceptualized as a "natural response to perceived physical threat" (Cantor, 2003, p. 188), has also been found to be an outcome of exposure to media violence (*e.g.*, Harrison & Cantor, 1999; Peck, 1999, *in* Valkenburg Cantor, & Peeters, 2000; Signorielli & Morgan, 1990). Cantor (2002) stated that this effect could at least in part be explained through the process of stimulus generalization, and identified some general categories of stimuli that usually evoke those responses, such as dangers, injuries, natural distortions, and the experience of danger and fear by others. If exposure to violence may induce such aversive reactions, it is reasonable to assume that these responses might be enhanced in VGs, because of the interactive nature of this electronic entertainment. During the playing activity in a VG, players may directly experience the threat associated with the violent encounters. Most of the time, players are in danger: to win they are forced to attack the opponents and at the same time they must protect themselves from the dangers of being virtually harmed and killed, which could result in loosing the game. Because players are constantly on guard, it would be possible that playing a VG activates fear-related emotional constructs on players' memory. Furthermore, according to the cognitive-neo-associationist theory (Berkowitz, 1993; 1998), feelings of fear usually predispose individuals to flight responses, thereby reducing aggressive tendencies.

Assuming that fear and aggression-related constructs are both elicited by playing a VG, which may, in turn, increase opposite behavior tendencies that could override their effects on subsequent behavior, it will be important to consider which type of constructs is more activated by VGs, and their relationships with aggressive behavior. Individual differences may also play an important role: because of the players' background and characteristics, it is conceivable that the strength of these priming effects may differ (Berkowitz, 1998). For instance, Peck's meta-analysis (1999, *in* Valkenburg *et al*., 2000) showed that the effect size of fear, induced by the media, was higher for women than for men.

Concerning physiological arousal, studies have mainly analyzed heart rate and blood pressure (systolic and diastolic). Research has shown that playing VGs usually has a more activating effect on the autonomic nervous system than playing a non-action with no violence game (NVG) (Baldaro, Tuozzi, Codispoti, & Montebarocci, 2004; Fleming & Rickwood, 2001), or even than watching a VG or violence on television (Brooks, 2000). However, physiological arousal may increase for multiple reasons. For instance, it may increase because negative emotions were evoked (e.g., anger and fear) or it may be related to pleasurable and rewarding situations (Fowles, Fisher & Tranel, 1982). As stated by Fowles and colleagues (1982, p. 512), "…we might modify the traditional view that cardiac acceleration occurs in anticipation of fight or flight to read "fight, flight, or fun". This could be one of the reasons why action-oriented games, including those without violence, tend to increase physiological arousal, in such way that the values recorded post-game are both larger than baseline levels (Anderson *et al*., 2004, Study 1; Ballard & Wiest, 1996; Calvert & Tan, 1994; Griffiths & Dancaster, 1995).

Research has also shown that playing VGs contributes to an increase in the player's anger or state hostility (Anderson & Ford, 1986; Arriaga, Esteves, Carneiro, & Monteiro, 2006; Ballard & Wiest, 1996; Fleming & Rickwood, 2001). However, other studies suggested no effects of VG playing on the participants' state hostility, or on their perception of a general negative state (Anderson & Dill, 2000, Austin 1987, *in* Bensley & Van Eenwyk, 2001; Calvert & Tan, 1994; Nelson & Carlson, 2001, *in* Bensley & Van Eenwyk, 2001). Also contradicting the finding of an increase in state hostility, Yu (2002) reported opposite results, showing that players displayed a more positive affective state in the VG than in the NVG condition. An interpretation based solely on the number of publications, *i.e.*, limited to inferences drawn from statistical significance, could suggest the absence of a VG effect on the players´ state hostility. However, it would be more accurate to examine the conclusions drawn from meta-analysis studies. This type of research presents a quantitative aggregation of the results obtained in individual studies, using statistical techniques to estimate the magnitude of the effect of the independent variable on the outcomes.

To provide more reliable and valid estimates of the VG effects on the outcomes, at least three meta-analyses were conducted. In the meta-analysis conducted by Anderson and Bushman (2001), a positive association was found between playing VGs and the following variables: aggressive affect (r = .18), physiological arousal (r = .22), aggressive cognitions (r = .27) and display of aggressive behavior (r = .19). This paper also established a negative association with prosocial behaviors (r = - .16). Most of the 54 studies included in their analysis were experimental, suggesting a causal relation between VG playing and those dependent variables. More recently, Anderson (2004) carried out another meta-analysis, setting apart studies with an appropriate methodology from those suffering from numerous limitations, concluding that the effect size was clearly higher in this meta-analysis.

On the other hand, Sherry's meta-analysis (2001) dealt solely with the effects of VG playing on aggressive behavior. The average effect size of VG playing on aggression was significant, albeit lower (r = .15) than the effect sizes usually found on exposure to television and movie violence. Nevertheless, the author points out that the highest effects were established in recent studies, stating that such results could be due to technological advances in this area. Improvements on sound, image quality and game performance may also increase the realism perception and provide players with a finer sense of being "inside" the VGs.

In addition to these improvements, playing with a virtual reality interface may enhance its realism and grant players a finer sense of presence, providing higher involvement and immersion (Persky & Blascovich, 2006; Stanney, Mourant & Kennedy, 1998; Tamborini *et al*., 2001). These features may also favor participants' identification with the game character (Persky & Blascovich, 2006), which in turn has also been associated with increases on aggression (e.g., Huesmann, Moise, Podolski, & Eron, 2003). Wiederhold and colleagues (2003) have also found that immersiveness and realism were highly correlated with two physiological indices (heart rate and skin resistance), and recommended these physiological parameters as objective measures of immersiveness. Considering these results, it is possible that the use of immersive virtual reality technology applied to VGs may enhance its impact on the internal state variables and on the aggressive behavior of players (Persky & Blascovich, 2006; Tamborini *et al.*, 2001), provided that such enhanced experience (i.e., immersion) does in fact occur. However, studies specifically concerned with the effects of new technologies applied to electronic entertainment are still scarce. The results of the research are mixed as to whether or not the use of virtual reality technologies during the playing activity enhances its impact. The studies conducted by Calvert and Tan (1994), Tamborini *et al*. (2000, 2001) and Arriaga *et al*. (2006) emphasized that current technologies still fall short of providing the desired amount of immersion. In contrast, the studies conducted by Persky and Blascovich (2006, 2007) showed different results. For instance, Persky and Blascovich (2005, *in* Persky & Blascovich, 2006) found that aggressive feelings and aggression, both during and post-game, were higher after the use of immersive virtual environments during a VG, compared to the playing activity of the same game on a traditional desktop interface. Presence was also measured by means of self-report and revealed a mediation effect between the platform effects on aggressive feelings, but not on aggressive behavior. However, they did not use NVG conditions; thus, no inferences could be drawn to the effects of game content. More recently, Persky and Blascovich (2007) included a NVG in their experimental design, and found that those who played the VG with Virtual reality device reported more aggressive/hostile feelings compared to the participants who played the same VG on the computer desktop platform. Yet, for those who played the NVG, the results were reversed: those who played on the desktop platform reported higher aggressive feeling compared to the participants in the VR condition. Although this interaction between Game content and VR was expected, it is more difficult to interpret the later result. In this study the aggressive behavior was not measured. Findings such as these led us to analyze whether the VR might really enhance the VG effects, shedding some light on the possible consequences that immersive entertainment may have on feelings, cognitions and behaviors of players.

Whether the sex of the player affects the responses to the VGs is also under debate. This question arises because, when compared to their female counterparts, men spend more time (*e.g.*, Krahé & Möller, 2004; Lucas & Sherry, 2004; Media Analysis Laboratory, 1998), and show a greater interest in this type of entertainment (*e.g.*, Arriaga, 2000; Lucas & Sherry, 2004). Furthermore, studies have shown that boys tend to associate positive emotions to games (*e.g.*, pleasure and excitement), whereas girls tend to associate them to negative emotions (*e.g.*, frustration, boredom and stress) (Media Analysis Laboratory, 1998). When it comes to determine the moderation effect of sex in the relationship between playing VG and aggressive behavior, the current line of research is, at best, inconclusive. Cooper and Mackie (1986) showed the effects of playing a VG to be more pronounced in girls' than in boys' aggressive playing. Bartholow and Anderson (2002) showed the effect of playing VG on aggressive behavior to be higher in men than in women. In contrast, others studies found no significant differences between the two sexes (Anderson & Dill, 2000; Persky & Blascovich, 2007; Silvern & Williamson, 1987). The meta-analysis of Anderson & Bushman (2001) also reported no evidence for sex as a moderating variable. Also, no significant gender differences have been found regarding responses to videogames using immersive virtual devices (Persky & Blascovich, 2007).

Most experimental studies conducted so far usually manipulated the video games' violence by comparing playing VGs with playing NVGs, although not always controlling for some relevant factors that are likely to affect such variables. Studies conducting mediation analysis are also quite scarce. The most complete study to date was developed by Anderson and Dill (2000, Study 2). The authors chose to conduct a pretest of the games, so as to select only those which matched physiological arousal levels. They then tested the effects of playing those matched games on the remaining cognitive-affective variables and on the players' aggressive behavior. In the present study we found it relevant to conduct a pilot study in order to pretest the selected games on several variables, including excitement.

In the light of these potential moderators and mediators, the main purpose of the present research will be to experimentally test the hypotheses that virtual game environment moderates the effects of playing a VG on the internal state variables (*i.e.*, physiological arousal, state hostility, and accessibility of aggression- or to fear-related constructs) and on the aggressive behavior. In an attempt to identify the processes by which playing a VG exerts effects on aggressive behavior, we will examine whether this violent entertainment has a direct effect on the aggressive behavior, or whether such behavior results from indirect effects of the internal state variables postulated by the IPMA framework. Finally, the possible moderator effect of sex on the internal variables and on aggressive behavior will be also analyzed. Assessing sex as a moderating variable may help to clarify its relevance in the relationship among the variables under scrutiny; however, no a priori hypotheses regarding gender effects will be made given the mixed results obtained in previous work.

Specifically, we will address the following hypotheses:

First, we predict that VR will provide higher perceptions of immersion and identification with the avatar: therefore, we expect that participants playing with VR device will report higher immersion (H1a) and higher identification with the game character (H1b) than those using the computer screen interface.

From the assumption that VGs affect the outcome variables, various hypotheses are drawn: we expect that participants playing a VG, compared to those playing a NVG, will: display higher accessibility of aggression constructs (H2a), and/or higher accessibility of fear constructs (H2b); report higher state hostility (H2c); and display more aggressive behavior (H2d). Regarding physiological arousal, as both games were chosen to require action, we do not expect to find any differences between participants playing with different contents (violent and nonviolent).

The moderation hypotheses of virtual environment predicts that the effects of playing a VG on aggression and/or fear-related constructs, on state hostility, and on displays of aggressive behavior will be greater for participants playing with virtual reality device than for those playing on the computer screen; thus, we expect that participants playing a VG with VR device, compared to those playing the same VG without VR device, will show higher accessibility of aggressive constructs (H3a) and/or to fear-related constructs (H3b); will report higher state hostility (H3c); and will display more aggressive behavior (H3d). No differences are expected between virtual reality conditions, for those who play the NVG, on these outcomes. It is also possible that playing with a virtual reality (VR) device may contribute to an increase physiological arousal, compared with playing on the computer screen, regardless of game content (H3e).

Based on the IPMA assumptions, the mediation hypothesis predicts that the effects of playing a VG on aggression might be mediated by the internal variables. Therefore, we predict that the effect of playing a VG on higher aggressive behavior will be explained by higher state hostility (H4a), and/ or by the priming effect of aggression-related constructs (H4b). However, if playing with a VG activates more fear structures in memory than aggression-constructs, it is possible that aggression will be inhibited, and therefore, no differences between conditions on aggression are expected.

Method

Participants.

Participants were 148 Portuguese college students from different Universities in Lisbon. Seventy nine were female (55.4%) and 69 were male (46.6%) students. The average age of participants was 23 years (*SD* = 3.21; range 18–46). They were randomly assigned to one of the following four experimental conditions: NVG with VR (*n* = 38); NVG without VR (*n* = 36); VG with VR (*n* = 37); and VG without VR (*n* = 37). Participants' sex was balanced across experimental conditions. None of the participants suffered from daltonism or epilepsy.

Measures and material

Sociodemographic data and prior experience with electronic games. Sociodemographic information, gathered at the end of each experimental session, covered participants' age, sex, and academic course attended at the time. In order to collect information about participant's prior experience with electronic games, they were asked to estimate, on a scale ranging from 1 (*never*) to 5 (*more than 10 hours per week*), the amount of time they usually spend playing electronic games at arcades, on the computer or using consoles, regardless of game content. Information regarding their experience with the games used in this study and with VR device was also collected, by simple yes/no responses.

Computer Games. The selection of computer games was necessary to guarantee a reliable difference concerning the violent content of the games (VG *vs.* NVG), while at the same time assuring their equivalence regarding other crucial dimensions. Therefore, a preliminary analysis of several action games – with and without violence – was carried out. All those games featured web-available demonstrations and were VR-compatible. We selected the following two for further evaluation: the VG *Unreal Tournament* (Epic Games, 1999) and the NVG *Motocross Madness* (Microsoft, 1998). In the pilot study we used a repeated measures design, in which all participants played both games in a counterbalanced order and evaluated them on several key dimensions (see Footnote 1). Participants competed against six opponents randomly selected by the game program; participants also adopted the viewpoint of the chosen avatars in order to increase their identification with the characters. In both games the characters were human-like representations with some level of realism. The American Entertainment Software Rating Board (ESRB, 1999-2006) rated the VG as “Mature (17+)” and the selected NVG as “Everyone” (game suitable for children aged six or older). Participants in the VG condition played the Unreal Tournament Deathmatch, in the “DM-Gothic” map and “Classic” game style, with average base skill. The participants’ goal consisted in annihilating as many adversaries as possible while minimizing the number of times their character died. To win, the participant should have the highest number of killings, compared to the other six virtual players (one point was granted for each kill, and one was subtracted for each time his character died). “Othello” and “Olga” were the characters assumed by our male and female participants, respectively. The selected NVG configuration was “National Race”, “Flatlands Easy” circuit, in which each participant could choose his/her preferred motorcycle and pilot. The game goal was to complete as many laps as possible within a given time limit.

In order to reduce the initial physiological impact of an exposure to a computer game, all participants were exposed to a non-action, non-violent, puzzle game (*Tetris Classic*; Sphere, 1992), prior to their random assignment to one of the experimental games (VG or NVG).

State hostility. State Hostility was measured using Anderson, Deuser and DeNeve’s (1995) *State Hostility Scale* (SHS). The SHS comprises 35 items and is set to gauge how a person feels at that moment (e.g., *I feel irritated*; *I feel cruel*). Responses were expressed using a 5-point scale, ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). To perform the overall state hostility index, 12 items were reverse-scored and the sum of the 35 items was computed. Total scores on the SHS can range between 35 and 175 points; the higher the scores, the higher the state hostility reported by the participant. This scale is known to have a high reliability (Cronbach α between .90 and .95) (Anderson, Carnagey & Eubanks, 2003).

Video game experience: perceived competence, immersion and identification with the game character. The pilot study showed that the games themselves were likely to affect how participants evaluated their performance. Therefore, participants were asked to rate their perception of competence concerning their performance (*I felt disappointed with my performance*), using a scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). We have included other single items to measure how immersed participants felt (*I felt absorbed/immersed inside the game*) and how identified they were with the avatar (*I felt identified with the character I played with*). Both items were rated using the aforementioned 5-point response scale.

Physiological arousal. To assess autonomic activity, participants' heart rate (HR) was recorded continuously using the BIOPAC MP100 data acquisition system (BIOPAC Systems Inc.) and the Acknowledge 3.5.4 software. For each participant, three disposable electrocardiogram electrodes were used to measure HR. Signals were recorded at a sampling rate 500 samples/sec.

Heart rate was obtained in terms of beats per minute (BPM) by automatic detection of the waveform intervals between positive peaks. In our study, we took values for every .05 milliseconds. Each R-wave was inspected because of the difficulties and the artifacts that usually occur during the recording of HR measurements, which in turn may distort the results (e.g., arrhythmic events; ectopic beats; abrupt interruption during signal recording; body movement; electrical interference). Those waveforms falling outside the recommended amplitudes (below 40 bpm or higher than 170 bpm) were deleted and ten participants had to be excluded from the physiological analysis, yielding a total of 138 participants for all HR analyses.

Accessibility of aggression- and to fear-related semantic constructs. From the most commonly used tasks based on information processing approaches, we have chosen the Emotional Stroop paradigm to assess the priming of negative emotional constructs (fear and aggression). In this task, participants were required to identify the colour of a written word while ignoring its semantic content. When the semantic content is activated, its colour-naming is found to be slower compared with the time spent on the identification of a word with a neutral semantic content. Therefore, slower reaction times (RTs) when identifying the color of the words related to aggression, or to fear, compared with the RTs to the color of the control stimuli will correspond, respectively, to higher accessibility of aggressive and to fear-related constructs (Anderson, Anderson & Deuser, 1996). In our study, this task was programmed using software developed by the Centre of Visual Cognition and Neuropsychology *(Núcleo de Cognição Visual e Neuropsicologia, Lisbon University*). The task comprised exposure to words semantically associated with aggression and fear, and to words of positive and neutral valence.

Two previous studies were conducted in order to select the verbal stimuli in order to obtain a reliable evaluation of the participants' accessibility of aggression and fear thoughts (Footnote 2). Twelve words for each category were selected. Because length and average orthographic neighborhood (Footnote 3) tend to be related to word recognition speed (Larsen, Mercer, & Balota, 2006), we analyzed these important lexical characteristics. The words in these four categories did not differ neither in length, F (3, 9) = .49, p > .50, nor in orthographic neighborhood, F (3, 9) = .23, p > .50. Table 1 presents the word lists and reports the mean and standard deviation for each category.

A total of 144 trials (12 words × 4 categories × 3 colors) were presented, individually, on the computer screen. Green, blue and yellow words were displayed over a black background. The randomized sequence of stimuli presentation had two sequential constraints: (i) the same word could not be displayed consecutively, and (ii) words of the same category and words with the same colour could not be showed in more than two successive trials.

During the collection of the Emotional Stroop data, some technical failures have occurred involving data from five participants. The analysis of the total number of errors also revealed five outliers (n errors ≥ 15). Therefore, 10 participants were excluded from these analyses, yielding a total of 138 participants. In order to normalize the distribution of these responses, a log transformation [Iog (RT+ 1)] was used. The accessibility indexes of fear- and aggression-related constructs were computed based on Anderson and Dill's procedures (2000). First, a control index was computed by averaging the RTs of constructs with positive and neutral valences: RTs to these control stimuli did not differ significantly between game conditions (ps > .10) and were highly correlated, r (138) = .94, p < .001. Second, the *accessibility of aggression-related constructs* index was obtained by subtracting the mean RT for the control categories from the mean RT for aggression-related stimuli. High values indicate a higher cognitive interference to words associated to aggression and, therefore, a higher accessibility of aggression constructs. Finally, to obtain the *accessibility of fear-related constructs* index, we calculated the mean RT to fear-related stimuli minus the mean RT to the control stimuli. Likewise, high values in this index indicate a higher cognitive interference to words associated to fear. These indices simplify data interpretation and minimize possible biases caused by confounding variables that interfere with RTs (*e.g.*, fatigue, loss of motivation, individual differences).

Aggressive Behavior. A competitive reaction-time task was used to evaluate aggressive behavior.

This measure follows Taylor's aggression paradigm (1967) and is based on studies developed by Anderson and Bushman (*e.g.*, Anderson *et al*., 2004; Anderson & Dill, 2000; Bushman, 1995). In an earlier study conducted by Arriaga, Esteves, and Monteiro (2004), this measure revealed good psychometric qualities for the Portuguese college population.

In this procedure, the participant was led to believe that he/she would be competing in a reaction-time task (25 trials) against an opponent. Actually, no opponent existed and the feedback the participant received was predetermined by the computer program. The participant was told that, in each trial, both competitors have to press a computer key, as quickly as possible, after a change in the color of the stimulus occurs. Participants were also told that, before each trial, they could also choose the levels of noise blasts to administer to their opponent. The levels of noise duration and intensity were distributed on a continuum, ranging from 0 to 10. It was explained that noise could vary between 0 and 95 dB (intensity) with a time span from 0 to 4 s (duration). Thus, the possibility of not punishing the opponent was given to the participant (by choosing the level zero of noise intensity or duration) in order to ensure that all would act of their own free will, instead of being forced to administer some level of noise to the opponent (Tedeschi & Quigley, 2000). Participants were further informed that, for such blast to be actually administered, their reaction to the stimuli had to be quicker than their opponent's: in each trial, only the winner would be granted the chance to impose the noise blast on the competitor.

The task was designed so that every participant always ended as victorious, winning 13 and loosing 12 trials. The schedule of win/loose trials, and the intensity of the noise received by the participants was identical for every participant. Finally, to assure that the noise levels accurately reflected the intentions of the participant to harm the opponent (Berkowitz, 1993) this task was followed by an interview, in which we asked participants about the reasons involved in the administration of the noise blasts to their opponents. The level of discomfort felt by the participant and his perceptions regarding how unpleasant the opponent felt with the noise blasts were also collected using a *Visual Analogue Scale* (an horizontal line, with 10 cm in length, ranging from 0 – *no discomfort/unpleasant* to 10 – *high discomfort/unpleasant*).

Procedures

Participants were asked to take part in a 50 minutes experiment for which they would be paid 5 Euros. At the beginning of the experimental session, participants were briefly introduced to the study's goals, and informed that the purpose of the session was to analyze the effects of playing computer games on physiological arousal and reaction time to visual stimuli. Every participant was required to sign an informed consent form. Assurances were stated concerning the preservation of anonymity, and permission was sought to use the data collected for research purposes.

Three disposable electrodes for heart rate (HR) recording were attached to the participant: one placed in the left ankle, the remaining two on participant's inner wrists. HR was continuously monitored throughout the experimental session.

Because there could be some differences on prior arousal state, all participants were initially exposed to the same calm melody ("Distant Thunder" theme; Stanton, 1996; 2'39"), played over headphones, before the experimental manipulations. This procedure was also used to collect a physiological baseline (i.e., to estimate the impact of the experimental conditions compared to a relevant baseline reference) (Footnote 4).

The participants were then asked to play the non-action, non-violent game (*Tetris Classic*) for two minutes, so as to familiarize themselves with a game task.

They were afterwards assigned to one of the following four experimental conditions: playing a non-violent game on the computer screen (NVG without VR); playing the same game with a virtual reality device (NVG with VR); playing a violent game on the desktop platform (VG without VR); or playing this same game with the virtual reality device (VG with VR). Games were played for seven minutes (game phase one). In the *VR* conditions, participants played using i-glasses SVGA 3D PRO (Footnote 5); in the non-VR conditions, the games were visualized on a 17 inches computer screen.

Participants were then asked to complete the State Hostility Scale (SHS; Anderson *et al.,* 1995), and to rate their perceived competence, immersion and identification with the game character.

The Emotional Stroop task ensued in order to measure the priming effect. A total of 164 trials (144 + 20 practice trials) were presented on the computer screen. Participants were instructed to ignore the meaning of the words, and to respond solely to their color by pressing one of three computer keys, each bearing one of the three possible colors of the stimuli (blue, green or yellow), as quickly and as accurately as possible. Each trial began with the presentation of a fixation cross in the centre of the computer screen (500 ms), followed by a centered word stimulus. The stimulus word remained on the screen until a response was given, initiating the next trial. The participants´ responses were recorded by the software program. After completing this task, participants played the game they had been previously assigned to for another seven minutes (game phase two).

The second game session was followed by a competitive reaction-time task. The experimenter informed the participant that he/she would now be performing a task against an opponent who was already sat in the adjacent room. The competitive task was then explained, after which the experimenter left the room, allegedly to explain the task to the other participant. After completing this task, participants were interviewed. Feedback about their motivations for administering the noise blasts and the level of discomfort felt and inflicted to their opponent were collected. None of the participants suspected the real purposes of the experiment. Socio-demographic details were collected at this time.

We concluded the session by thanking the participant for his/her collaboration, disclosing the real purpose of the experiment and paying him/her a symbolic monetary compensation. Participants who explicitly manifested interest in being given further details about the study results provided us with personal contacts for the effect. The experimental session took an average of 60 minutes to be completed.

Results

The means, standard deviation, and Cronbach's alpha for the main study variables are displayed in Table 2. To have more confidence that the noise levels chosen by the participants during the competitive reaction time task reflected their intentions to harm the opponent, we took into account their motivations to administer the noise blasts. According to the participants´ responses their motivations could be classified as ‘‘Instrumental Aggressive Motivation’’ (e.g., “*Because I wanted to win/impair his performance*”); or “Affective/ Revenge Motivation’’ (e.g., “*Because I wanted to pay back for the noise levels I felt*”) (for a more detailed description of these two types of motivations see Anderson *et al.*, 2004). We also analyzed both the levels of discomfort felt by participants and the discomfort they thought was felt by the opponent. The average level of discomfort regarding the noise blasts they received was 5.31 (SD = 2.66), which corresponds to the midpoint of the scale. Using the same rating scale, the average discomfort they thought was felt by the opponent was also moderate ($M = 4.60$; $SD = 2.82$). The level of aggression was then calculated by the simple mean of the two noise indexes (intensity and duration) the participant chose to inflict to the opponent (mean values ranged between .26 and 10; $M = 4.96$; $SD = 2.42$). These values suggest that all the participants chose some level of noise to administer. The decision to average intensity and duration levels was based on (i) the high correlation between both indexes, $r\ (148) = .82$, $p < .001$, and (ii) the high reliability for the 25 trials (Cronbach $\alpha = .99$ for noise intensity and .98 for noise duration).

Playing Experience.

Almost half of the participants were not regular players. Actually, 73 participants (49.3%) reported that they had "never" spend time playing electronic games at arcades, on the computer or using consoles. Of those who reported some experience with electronic games (50.7%; $n = 75$), i.e., from *less than one hour* to *more than 10 hours per week*, the majority reported playing on the computer (89.3%, $n = 67$), although some participants also use console platforms (30.7%, $n = 23$) and spend some time playing at arcades (17.3%, $n = 13$). There were, however, sex differences in prior experience with electronic games, $\chi^2\ (1, N = 148) = 13.22$, $p < .001$, with more male participants reporting prior use with electronic games ($n = 49$) than women ($n = 29$). No significant differences were found between players and nonplayers on perceived competence reported after playing the games of the present study, $t\ (145) = 1.24$, $p > .10$.

Regarding their experience with the games used in this study, we also found that most participants had never played the selected games ($n = 116$; 78.9%): only 15 were familiar with *Motocross Madness* (10.2%) and 17 with *Unreal Tournament* (11.6%). Also, none of the participants had ever played with a VR device.

Intercorrelations among the main study variables.

Zero-order correlations among the main study variables are given in Table 3. Overall means on these variables can be found in Table 2.

We examined the correlations among perceived competence, identification with the game character, immersion and the internal states (accessibility of aggressive and fear constructs, state hostility and HR changes) and aggression measures to rule out a possible interference of those variables on the outcomes. Results reported in Table 3 only show a negative association between perceived competence and state hostility, r (147) = -.36, p < .001. We therefore controlled for this variable in the analyses involving state hostility.

As expected, there was a positive but weak correlation between the identification with the game character and how immersed participants felt during the game task, r (147) = .29, p < .001. Unexpectedly, higher perception of competence was related to less immersion, r (146) = -.23, p < .01.

Pearson's correlations among all the internal variables were also conducted (see Table 3). With the exception of the significant associations between accessibility of aggression- and to fear-related constructs, r (138) = .36, p < .001, and between mean HR changes from baseline for the two phases of game playing, r (138) = .69, p < .001, no other significant correlations were found.

Perceived competence, immersion and identification with the game character as a function of experimental conditions and sex.

The mean ratings on perceived competence, immersion and identification with the game character, as a function of experimental conditions, are shown in Table 2.

A univariate analysis of variance (ANOVA) was conducted using a 2 (Game) X 2 (Virtual Reality) X 2 (Sex) between-subjects design, with perceived competence as the dependent variable. There were no significant main effects or interactions between the variables (all ps > .05), suggesting that female and male participants evaluated their performance in a similar way, regardless the Game or the VR conditions.

A three-way (Game X Virtual Reality X Sex) multivariate analysis of variance (MANOVA) was conducted, with immersion and identification with the game character as the dependent variables. The choice for a MANOVA instead of an ANOVA was related to the theory and to the empirical association between these two variables (Table 3). The results did not support our hypothesis H1a and H1b: the main effect of VR did not approach significance, Wilks′ Lambda = .998, F (2, 138) = .15, p >.10, η_p^2 = .002, suggesting that VR interface did not provide players either with a higher perception of immersion or with a higher identification with the avatar compared to playing on the computer screen.

Results showed only a significant main game effect of Game content, Wilks´ Lambda = .903, *F* (2, 138) = 7.40, p <.01, η_p^2 = .097. According to subsequent ANOVAs, the differences between Game conditions were only significant for the identification with the game character, *F* (1, 139) = 12.64, p <.01, η_p^2 = .083, indicating that participants felt less identified with the character of the VG (*M* = 1.87) than did the participants playing with the character of the NVG (*M* = 2.45).

Accessibility of aggression- or to fear-related constructs as a function of experimental conditions and sex.

An analysis of variance (ANOVA) was conducted on accessibility of affective constructs, using a 2 (Game: VG vs NVG) X 2 (Virtual Reality: With vs Without) X 2 (Sex: male vs female) X 2 (Affective-related constructs: aggression vs. fear) mixed design. Game, Virtual reality and Sex were between-subjects factors and Affect-related constructs was a within-subjects variable. Aggression- and fear-related constructs were treated as a within-subjects factor because, as mentioned earlier, we were interested in testing which type of construct could be more accessible after playing the VG.

Table 2 shows the mean scores of the accessibility of these affective constructs for each experimental condition. Overall, no main effect or interactions between these variables were found (all *p*s > .10). In particularly, the Game by Affect-related constructs interaction effect did not approach significance: Wilks´ Lambda = 1.000, *F* (1, 130) = .001, p > .10, η_p^2 = .00001, indicating that there were no significant differences between the accessibility of aggression- and to fear-related constructs after playing either games. Contrary to our expectations neither the interaction Game X Virtual Reality, *F* (1, 130) = .002, p > .10, η_p^2 = .00001, nor the interaction Game X Virtual Reality X Affective-related constructs, Wilks´ Lambda =.995, *F* (1, 130) = .65, p > .10, η_p^2 = .005, approached significance. In sum, our hypotheses that participants playing the VG, compared to playing a NVG, would have a higher accessibility of aggressive constructs (H2a) and/or to fear-related constructs (H2b) were not confirmed. Also, the hypotheses stating that playing VG with virtual reality devices would increase the accessibility of aggression (H3a) - and/or to fear-related constructs (H3b) were not supported. There was also no interaction between Sex and the other variables, indicating that sex did not contribute to these results.

Physiological arousal as a function of experimental conditions, sex, and game phase.

Because averaging over the entire 7-min of playing did not allow us to see the physiological changes that may occur during this activity, HR was averaged for every minute during each playing-game phase. Delta (Δ) change scores were calculated as the mean HR values for every minute over the 7-min period of each game phase minus the mean HR values over the baseline period. A 2 (Game: VG or NVG) X 2 (Virtual Reality: With or Without VR) X 2 (Sex: male or female) X 2 (Game phase: first, second) X 7 (Time: each minute over the 7 min) multivariate analysis of variance (MANOVA) was performed on the HR delta (Δ) changes from baseline (HR during game activity minus HR baseline). Game, Virtual Reality and Sex are between-subjects factors, and Game phase and Time are within-subjects factors.

The MANOVA showed a significant main effect of VR, F (1, 128) = 13.90, $p < .001$, $\eta_p^2 = .10$, supporting our initial hypothesis (H3e): participants who played with VR device had higher changes in HR (M = 9.75) compared to those who played on the desktop platform (M = 2.10). As expected the effect of Game content was also non-significant, F (1, 128) = .32, $p > .10$, $\eta_p^2 = .002$. The analysis also showed significant interactions between Game phase X Sex, Wilks' Lambda = .956, F (1, 128) = 5.96, $p < .05$, $\eta_p^2 = .04$, and Game phase X Time, Wilks' Lambda = .796, F (6, 123) = 5.24, $p < .001$, $\eta_p^2 = .20$. We have further analyzed the simple main effects using the confidence intervals adjusted by the Bonferroni procedure.

The Game phase X Sex interaction showed that there were differences between the first and the second phase of playing, but only for female participants, Wilks' Lambda = .937, F (1, 128) = 8.67, $p < .01$, $\eta_p^2 = .06$. Female participants had higher HR changes during the first time they played (M = 6.94) than during the second phase of game activity (M = 3.17). No differences between game phases emerged for male participants, Wilks' Lambda = .997, F (1, 128) =.35, $p > .10$, $\eta_p^2 = .003$.

The simple main effects of Time for each Game phase suggest that there were differences during both phases on HR changes over the seven minutes of playing [Wilk´s F (13, 114) = 2.25, $p < .05$, $\eta_p^2 = .20$, for the first phase; Wilk´s F (13, 114) = 2.25, $p < .05$, $\eta_p^2 = .20$, for the second phase]. However, in both phases, the differences occurred mostly in the beginning: during phase one, HR change was higher in the first minute of playing (M = 8.56), which was followed by a decrease that remained relatively stable over the game activity (Ms = 6.61, 6.34, 6.36, 6.74, 6.20, and 6.23, for 2, 3, 4, 5, 6 and 7 min, respectively); by contrast, during the second phase, HR changes were lower in first minute of playing (M

= 3.34), which was followed by an increase that also remained relatively constant throughout the whole game session (*M*s = 4.76, 4.75, 5.41, 5.98, 5.78, and 6.22, for 2, 3, 4, 5, 6 and 7 min, respectively). If we consider the simple main effects of Game phase within each period of time, we can also conclude that the significant differences on HR changes between the game phases occurred only during the first minute of the game activity, Wilks' Lambda = .871, F (1, 128) = 18.97, $p < .001$, $\eta_p^2 = .13$, with higher HR during the first minute of the first game phase. No differences between game phases occurred for the remaining periods of the game session (all *p*s > .10). These results might also suggest a relative stable rise in HR levels compared to a resting state (baseline). However, because there were differences in HR changes between VR conditions, we present Figure 1 to illustrate the pattern of HR changes over the entire seven minutes of playing, as a function of game phase and experimental conditions.

State hostility as a function of experimental conditions and sex.

To assess the effects of experimental conditions and sex on state hostility, a three-way (Game X Virtual Reality X Sex) analysis of covariance (ANCOVA) was conducted, controlling for perceived competence. Besides the significant main effect of the covariate variable, F (1, 138) = 19.09, $p < .001$, $\eta_p^2 = .12$, the analysis has also revealed significant main effects of Game, F (1, 138) = 4.53, $p < .05$, $\eta_p^2 = .03$, and Virtual Reality, F (1, 138) = 11.49, $p < .01$, $\eta_p^2 = .08$. The Game effect supported our hypothesis (H2c) showing that those who played the VG reported higher state hostility ($M = 74.71$) than those in the NVG conditions ($M = 69.40$). Surprisingly, the main effect of Virtual Reality revealed that participants who played with the computer desktop interface reported higher state hostility ($M = 76.29$) than those playing with VR device ($M = 67.81$). Contrary to the moderator hypothesis of VR (H3c), the interaction of Game X Virtual Reality did not approach significance, F (1, 138) =.74, $p > .10$, $\eta_p^2 = .005$. No main effect was found for Sex, and no other significant interactions emerged (all *p*s > .10).

Aggressive behavior as a function of experimental conditions and sex.

An ANOVA was conducted using the same 2 X 2 X 2 between-subjects design, with levels of aggression as the dependent variable. Supporting our hypothesis (H2d), the analysis revealed a significant main effect of Game, F (1, 140) = 4.08, $p < .05$, $\eta_p^2 = .03$, showing that participants in the VG condition behaved more aggressively toward their opponent ($M = 5.40$), compared to the participants who had played the NVG (M = 4.61). However, no Game by Virtual Reality interaction was found as hypothesized (H3d), $F(1, 140) = 3.00$, $p > .05$, $\eta_p^2 = .02$. Also, no main effect of Sex was found and the other interactions were also non significant (all ps > .10).

Mediation analysis

As shown in Table 3, the correlations between the aggressive behavior and the internal state variables (accessibility of constructs, state hostility and HR) revealed only one positive association, albeit weak, between aggression and state hostility, $r(148) = .25$, $p < .01$, suggesting that the higher the state hostility reported by the participant, the more aggressively he/she behaved afterwards. Given that state hostility is affected by game content and is associated with aggression, we examined whether state hostility could be an intervenient variable in the relation between playing a VG and aggressive behavior (cf. Baron & Kenny, 1986).

The first conditions of mediation were met: Game content was a significant predictor of aggressive behavior, $\beta = .18$, $t(147) = 2.20$, $p < .05$, and of state hostility, $\beta = .16$, $t(147) = 1.91$, $p = .05$, and state hostility was a significant predictor of aggressive behavior while controlling for Game content, $\beta = .22$, $t(147) = 2.76$, $p < .01$. Figure 2 illustrates the mediation results. We have found that the standardized regression coefficient between Game content and aggressive behavior was reduced, when controlling for hostility, $\beta = .15$, t (147) = 1.79, $p = .075$, $R^2 ajust = .08$. However, the Sobel test did not confirm that the effect of Game on aggression was significantly reduced after state hostility entered the model, suggesting that there was a small indirect effect of VG on aggression via state hostility, as hypothesized (H4a), and a higher direct effect of VG on aggression.

Discussion

The main questions examined in the present research were the short-term effects of VG playing, moderated by VR device, on the participant's internal states (hostility, accessibility of aggression- and fear-related constructs, and physiological arousal) and aggression, and the hypothetical mediation played by these internal variables on the aggressive behavior. We also examined whether these effects would be moderated by sex.

Overall, the VR device did not moderate the VG impact on the outcome variables under scrutiny. However, these null results (Footnote 6) should be interpreted with caution as we must consider several possible explanations. First, because the VR device was used to create an immersive virtual environment, we expected this technology to increase immersion in the game and to provide a higher identification with the game character. However, the results reported here do not support these hypotheses and suggest that the VR device failed to provide the intended feeling of "being in" the game environment. It is conceivable that, by asking players to use a technology they were unfamiliar with, we have unwillingly put them in a more challenging situation, therefore making it more difficult for them to successfully comply with the task. The unforeseen uneasiness thus caused may have cancelled the expected enhanced immersiveness (Tamborini *et al.*, 2001). However, it must be noted that the mean values for immersion exceeded the midpoint of the scale for all conditions. Thus, some levels of immersiveness were felt by participants playing either the VG or the NVG, with or without the VR device. Secondly, we only measured the degree of immersion felt by participants during the game activity, but not the 'sense of presence', which also includes the degree of involvement in the environment (e.g., Persky & Blascovich, 2006; Tamborini *et al*., 2001). Also, immersion was assessed with a single item, and therefore, is it much more vulnerable to measurement error relative to multiple-item measures.

In line with previous studies (Persky & Blascovich, 2006), we also found that perceived immersion was positively associated with players' identification with the game character. However, it must be noted that participants identified more with the character of the NVG than with the character of the VG. This result was also unexpected, because the characters of both games resembled a human-like representation. Both games were also pretested and no differences between games emerged on this feature in the pilot study. Nevertheless, it is possible that the VG *Unreal Tournament* scenario might have been perceived as less plausible and less believable than the scenario of the NVG *Motocross Madness*.

Also relevant and supposedly supporting our initial hypothesis playing with the VR device increased HR changes, regardless of game content. However, taking in consideration our previous interpretations, we are inclined to believe that this increase on HR changes found in the VR conditions may have been due, not to the perceived immersiveness of game environment, but rather to the extra effort imposed on the participants, *i.e.* to the use of an apparatus they were unprepared for. Also relevant was the relationship obtained between low immersiveness and higher perception of competence. According to Persky and Blascovich (2006), task performance may not increase as a function of higher immersive virtual environment. In fact, these authors found that the performance was better evaluated by those using the desktop computer system than with those playing using the VR interface.

The finding that higher state hostility was reported by those participants who did not play with VR device, compared to those who played with this device, also contradicts our initial expectations. This result may be related to the difficulties in concentrating during the gaming activity with the VR device during the first gaming phase, which, in turn, could have evoked this negative affect; however this explanation require further investigation, as it was not analyzed in our study. Furthermore, our data also indicates that higher state hostility was related to lower evaluation of competence.

In face of the null results found for the VR role as a moderator, we suggest that the adaptation to the VR material must be carefully addressed in future studies: If a participant has no previous experience with the device, he/she may focus on learning how to use it. In fact, Howarth and Hodder (2007) have alerted to some of the side effects that may be caused by immersion in a virtual environment, such as visual discomfort, nausea and eyestrain. With repeated exposures, these symptoms are likely to be reduced and even to disappear for the majority of individuals. For future research, it would be convenient either to restrict the selection of participants to those already familiar with VR device, or to provide a training period prior to the experimental sessions.

Considering the effects of the game content, the hypotheses that playing a VG would evoke a higher state hostility and the display of more aggressive behavior, compared to playing a NVG game, were supported. These results were already predicted by the IPMA and were also found in meta-analytic reviews (Anderson, 2004; Anderson & Bushman, 2001). Regarding the hypothesis of the internal state variables having an intervenient role in the relationship between playing a violent game and aggression, our data only confirmed a small indirect effect via state hostility. We should also note that the percentage of explained variance in aggression, when controlling for state hostility, was weak yet reflecting a magnitude similar to the values reported in other studies on exposure to media violence (*e.g.,* Comstock & Scharrer, 2003). While strongly believing that the values found are relevant, we must emphasize that there is a complex web of factors contributing to aggression, some of which acknowledged as more cogent than the one in question (Sparks & Sparks, 2002). Gentile and Sesma Jr. (2003) consider an effect of media violence of at least 1 to 10 percent as rather large and, therefore, not to be dismissed. They stated "media violence is likely to be one of the pushes that interact with other forces at work. In most situations, it is neither necessary nor sufficient. However, that does not mean that it is not the cause – it just means that it is *one* of the causes" (p. 25). On the other hand, this weak effect may be due to other moderating effects not measured in the present study. Gentile and Stone (2005), for example, mentioned that, in general, the habits of playing VGs may enhance the negative effects of playing VGs - a factor that was not tested and analyzed in our study but should be considered in future studies.

The null result of game content on physiological arousal was also predicted (H2e), given that our pilot study showed both action games to be perceived as exciting. Zillmann's excitation transfer theory (1991) also stated that physiological arousal may explain the effects of viewers' exposure to violence on aggression; therefore, we considered it extremely relevant to directly test physiological arousal levels. Our results showed that physiological arousal increased during the playing activity; however the higher increases on HR occurred in the beginning of the first game session, after which the arousal levels decreased and remained relatively stable. Most relevant for the purposes of our study was the fact that the overall changes on HR levels were not related to aggressive behavior.

The hypothesis of a VG effect on the accessibility of aggression-related constructs in memory was not supported by our data. Our results differ from the findings of Anderson and Dill´s experimental study (2000), and from the conclusions found by meta-analysis research on this issue (Anderson, 2004; Anderson & Bushman, 2001). We observed no statistical (main or interaction) effects for game, virtual reality or sex on accessibility of aggression semantic constructs. Such inconsistency may be due to a carryover effect. The stimulus words presented in the Emotional Stroop task were semantically related to the affective words used to assess state hostility. The temporal contiguity in the application of the affective state measure and the Emotional Stroop task might have masked the game effect. In fact, given that both groups (VG players and NVG players) evaluated the affective state before performing the Emotional Stroop task, two distinct effects may have surfaced: the first is that the concentration of cognitive capacities on the evaluation of the affective state may have reduced the impact of game exposure; the second is that if we accept the affective state congruency hypothesis (Bower & Forgas, 2001), we are bound to assume that facilitation of mnesic activity of congruent emotional constructs has most likely occurred. Considering the latter rationale, the perception of state hostility may have affected the processing of words with similar emotional content. However, our data do show evidence of dissociation between the two measures, suggesting that they are related to distinct processes. In line with this view, other studies have mentioned that reports of emotional states are not accompanied by activation of concurring semantic networks (Rossell & Nobre, 2004). The current indetermination strongly calls for further research on this issue, particularly on the association between state hostility and mnesic activation of aggression constructs. In face of these difficulties, it would not be prudent to conclude that playing a violent game entails no effects on the accessibility of aggression constructs. We would rather suggest that, in further studies in which this specific process is examined, the assessment should be conducted immediately after the VG task, so as to prevent carryover effects by the sequential application of the two measures. We also recommend counterbalancing the order of their application, without extending the duration of the experiment.

Failure to establish the accessibility of fear-related constructs after playing a VG also contradicts our initial hypothesis. We also found that no significant differences between the accessibility of aggression compared to fear-related constructs emerged. It is possible that these results could be explained by the age of the sample population under analysis: Displays of fear reactions after exposure to filmed violence are usually more pronounced in children than in adults (Cantor, 2002, 2003). If applied to a sample of children, an identical experimental design could possibly reveal the expected effects of VG playing on the accessibility of fear-related constructs.

It was also interesting to find independence between HR levels and the remaining internal state variables, namely accessibility of aggression- and to fear-related constructs and to perceived state hostility. The lack of agreement between physiological responses and verbal reports of affective states is not uncommon (e.g., Mordkoff, 1964), and various explanations have been offered for such discrepancy. One possible interpretation would be that there is actually no linear correspondence between the perception of such specific affective states and the way our organism regulates and deals with physiological arousal. Alternatively, we could explain it by admitting the emotional non-specificity of physiological arousal, in which case it could run parallel to the appraisal of the emotions (Tannenbaum &

Zillmann, 1975). A third option would be to consider that this lack of agreement is due to an existing temporal asynchrony between assessing the physiological data and reporting the affective state (Zillmann, 1991). In fact, although the physiological responses were continuously measured, state hostility self-reports were measured only at the end of the games.

Overall the tests for the moderator effects of sex were non-significant for all our main outcomes, suggesting that the effects reported are not related to gender. These results comport well with findings obtained in other studies (Anderson & Dill, 2000; Persky & Blascovich, 2007; Silvern & Williamson, 1987), including the meta-analysis conducted by Anderson and Bushman (2001). There were differences between male and female participants only on HR changes, when taking into account the two gaming phases. Women had higher HR changes during the first time played compared to the second game phase; yet, no differences between game phases emerged for male participants. This result could be related to the gender differences in prior experience with electronic games that are reported in almost every study (*e.g.*, Arriaga, 2000; Krahé & Möller, 2004; Lucas & Sherry, 2004) and also confirmed in the present research. The fact that more women reported to have less prior experience with videogames than men, might have contributed to an initial anxiety during the first gaming activity, explaining their higher HR changes from baseline. Their repeated exposure to the same task might have contributed to lowering their HR during the second gaming phase. These results suggest that with some game practice the preexisting sex differences on game experience may be reduced. It was also interesting to find that no significant differences emerged on perceived competence regarding their own performance.

There were some other limitations that must be addressed. For instance, our design did not include a baseline measure of state hostility, thus it is not possible to examine the degree of change from baseline to posttest, and consequently we can not state that hostility increased as a consequence of playing a VG. However, our decision not to pretest state hostility has to do with the need to control for the "testing confounds", usually a threat to the internal validity of research. That is, it could the possible that this baseline assessment might affect the self-report on the posttest, regardless the effect of the manipulation. Nevertheless, because participants were randomly assigned to the experimental conditions, we can conclude for an effect of playing a VG on state hostility and state that it is higher for those previously playing the VG when comparing with the participants playing a NVG. A further limitation refers to the use of single-items for some of our measurements, such as the sense of presence and the players' identification with the game character. Research in this area might benefit from a more complete evaluation of these variables.

Everything considered, we can conclude that, regardless the use of virtual reality device and the sex of the player, playing a violent game influenced state hostility and interpersonal aggression. Additional research will be necessary to evaluate the moderator role of immersive virtual environment between playing VGs and the cognitive, affective and behavioral outcomes.

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Footnotes

Footnote 1. A pilot study was conducted with 20 college students (7 male and 13 female; *M*age = 27 years; *DP* = 7.32) in order to compare the characteristics of the chosen games (VG and NVG). Participants played both games in reverse orders: 9 played the NVG after the VG; 11 played the VG after the NVG. After each game, that lasted seven minutes, the participants provided their opinion regarding the following 14 dimensions: satisfaction, pleasure, excitement, discomfort, competence, boredom, disorientation, difficulty, frustration, involvement, game action, identification with the game character, game realism, and sense of presence. With the exception of presence, all the other features were measured with single items. The 7-items of the Telepresence scale (TP; Klein, 2002) were adapted and used to measure the sense of "being in" the game environment. Each item was rated on a 1 (strongly disagree) to 5 (strongly agree) Likert-type scale. In this pilot study, these seven items yielded a Cronbach alpha of .71 and average was calculated to estimate the sense of presence. T-tests for paired measurements were used to compare the selected games. Bonferroni correction was performed to control for the Type I error, where the nominal significance level (.05) was divided by the number of paired comparisons (14). The significance for each comparison was .0036. Overall, both games provided similar levels of satisfaction, t (19) = .83, p = .419, pleasure, t (19) = 1.29, p = .214, excitement, t (19) =.89, p = .385, discomfort, t (19) = 1.67, p = .110, boredom, t (19) = .79, p = .437, disorientation, t (19) = 1.14, p = .267, frustration, t (19) = 1.32, p = .201, and involvement, t (19) = .48, p = .634. Both games were perceived as rendering similar levels of action, t (19) = 1.24, p = .229, and realism, t (19) = 1.56, p = .135, and as providing similar identification levels with the character, t (19) = .86, p = .398, and similar senses of presence, t (19) = .53, p = .601. Similar opinions were also expressed as to the overall feeling of competence, t (19) = 2.27, p = .035, and game difficulty, t (19) = 2.63, p = .017. Based on these results we have considered these two games appropriate for our research purposes. However, because the number of participants used in this pilot study was very small we must be caution and reevaluate those features that could be most relevant in the main study.

Footnote 2. For choosing target words for the emotional Stroop task, we initially used a free association task: 271 college students were asked to generate words associated to the categories “aggression”, “fear”, “positive” and “neutral”. This procedure was chosen because free association has been previously used to select other words for tasks that require the words to be semantically strength within the same category (Nelson, McEvoy, & Dennis, 2000). The underlying assumption is that in a free association task the word responses would also tend to co-occur more often in the natural language (Prior & Geffet, 2003). In a second study, the more frequently generated words from the previous study (25 per category) were evaluated by an independent sample of 145 college students. Participants were asked to place each of the given words under one of our four categories. The criterion used for our final selection of words (12 per category) was a percentage agreement higher than 60%.

Footnote 3. Orthographic neighborhood corresponds to the number of words that one single word can be transformed by changing one letter while preserving the identity and positions of the other letters. To compute the orthographic neighbourhood sizes for each single word, we have also taken into account the letters with diacritical marks of the Portuguese language. Average orthographic neighborhood indexes for each category were then calculated.

Footnote 4. By exposing all participants to a calm melody we intended to create an initial relaxation period in which a mild level of autonomic nervous system activity could be elicited. Calm music or neutral-emotion-film instead of resting baselines have been previously suggested by other authors (e.g., Nakasone, Prendinger, & Ishizuka, 2005; Rottenberg, Day, & Gross, 2007).

Footnote 5. The display of the i-glasses, connected to the player's head, attempts to provide immersive quality to the games. It features: visual field (26º diagonal), resolution (1.44 million pixels 800×600), stereoscopic vision (dimension of the virtual image: 70” at 13’), stereo headphones to simulate auditory sensations, and movement detection sensors.

Footnote 6. The term “null results” was used because it suggests that, although no effect was detected, it may exist.

Table 1

Portuguese Stimulus Words for the Emotional Stroop Task, with Average Length and Ortographic Neighbourhood by Category

Aggression	Fear	Positive Valence	Neutral valence
Agressão (*aggression)*	Angústia (*anguish)*	Alegria (*joy*)	Centro (*centre*)
Armas (*guns)*	Fobia (*phobia*)	Amigos (*friends*)	Empresa (*enterprise*)
Bater (*beating*)	Insegurança (*insecurity*)	Convívio (*hanging out*)	Escritório (*office*)
Luta (*fight*)	Medo (*fear*)	Diversão (*fun*)	Fábrica (*factory*)
Murro (*punch*)	Nervos (*nerves*)	Férias (*vacation*)	Gerir (*managing*)
Ódio (*hate*)	Pânico (*panic*)	Liberdade (*freedom*)	Governo (*government*)
Pontapé (*kick*)	Pavor (*dread*)	Música (*music*)	Horário (*schedule*)
Porrada (*trashing*)	Receio (*afraid*)	Namorar (*dating*)	Mandar (*ordering*)
Racismo (*racism*)	Perda (*loss*)	Passear (*promenading*)	Máquina (*machine*)
Raiva (*anger*)	Perigo (*danger*)	Praia (*beach*)	Povo (*People*)
Violação (*rape*)	Susto (*susto*)	Prazer (*pleasure*)	Reunião (*meeting*)
Violência (*violence*)	Terror (*terror*)	Sol (*sun*)	Unidade (*unity*)
Length: M = 6. 17; SD = 1.70	Length: M = 6.08; SD = 1.83	Length: M = 6.50; SD = 1.57	Length: M = 6.67; SD = 1.44
Ortographic N.: M = 4.50; SD = 4.12	Ortographic N.: M = 5.75; SD = 5.66	Ortographic N.: M = 3.92; SD = 3.29	Ortographic N.: M = 3.92; SD = 3.29

Table 2

Means, Standard Deviation and Cronbach's Alpha for the Entire Sample and also Standard Error of Measurement *for each Experimental Condition.*

	Entire Sample			Nonviolent game				Violent game			
				Without VR		With VR		Without VR		With VR	
	M	*SD*	α	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*
Perceived competence (PC)	3.55	1.25	--	3.62	.20	3.65	.21	3.28	.20	3.73	.21
Immersiveness (I)	3,50	1.00	--	3.43	.17	3.52	.17	3.57	.16	3.51	.17
Game character identification (GCI)	2.14	1.04	--	2.44	.16	2.46	.16	1.79	.16	1.95	.16
ΔHRgamephase1 (bpm)	6.39	12.70	--	1.72	2.04	9.78	2.15	4.41	2.10	9.87	2.22
ΔHRgamephase2 (bpm)	4.73	14.45	--	.46	2.27	10.02	2.40	1.30	2.34	7.52	2.48
State Hostility (SHS)	72.05	16.51	.89	74.71	2.49	64.09	2.51	77.87	2.49	71.54	2.50
Aggression Accessibility (ms)	1.78	31.77	--	4.49	5.46	-2.98	5.59	4.34	5.67	1.63	5.56
Fear Accessibility (ms)	2.88	32.62	--	5.10	5.55	-.30	5.67	10.27	5.76	-.70	5.65
Aggressive behaviour	4.96	2.42	.96	4.62	.39	4.59	.40	6.09	.39	4.70	.39

Note. PC, I & GCI (values range 1-5; higher values indicate higher perceived competence, higher immersiveness and higher identification with the game character, respectively); SHS (= Sate Hostility Scale; 35-items scale: values range 35-175; higher values indicate higher state hostility); ΔHR (Heart Rate change from baseline; values in bpm); Aggression accessibility (Reaction time to aggressive words minus Reaction time to control words; values in milliseconds); Fear accessibility (Reaction time to fear words minus Reaction time to control words); Aggressive behaviour (values range 0-10; higher values indicate higher display of aggression).

Table 3

Intercorrelations among the Main Study Variables

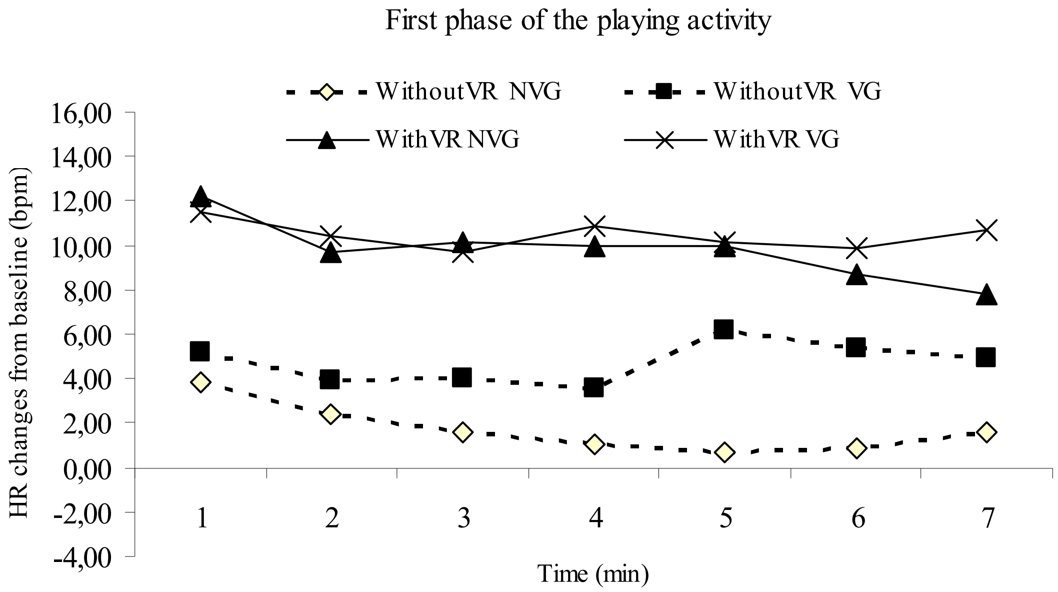
		1	2	3	4	5	6	7	8
1	Perceived competence (PC)	--							
2	Immersiveness (I)	-.23**	--						
3	Game character identification (GCI)	.06	.29***	--					
4	State Hostility (SHS)	-.36***	.17*	.12	--				
5	ΔHRgamephase1 (bpm)	-.01	-.09	-.10	-.15	--			
6	ΔHRgamephase2 (bpm)	-.02	-.08	-.03	-.12	.69***	--		
7	Aggression accessibility (ms)	-.19*	.01	.07	.04	.04	-.06	--	
8	Fear accessibility (ms)	-.08	.07	-.03	.17*	-.001	-.14	.36***	--
9	Aggressive behaviour	-.12	.11	.08	.25**	.01	.10	.01	.05

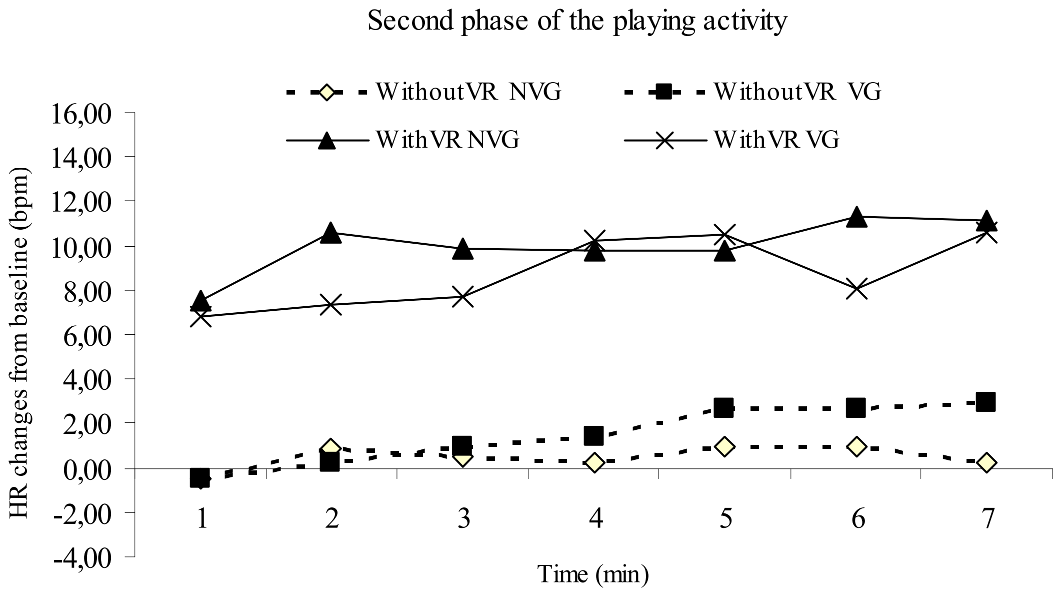
Note. *$p < .05$; ** $p < .01$; *** $p < .001$; PC, I, GCI & SHS (higher values indicate higher perceived competence; higher immersiveness, higher identification with the game character, and higher state hostility, respectively); ΔHR (Heart Rate change from baseline; values in bpm); Aggression accessibility (Reaction time to aggressive words minus Reaction time to control words; values in milliseconds); Fear accessibility (Reaction time to fear words minus Reaction time to control words); Aggressive behaviour (higher values indicate higher display of aggression).

Figure Captions

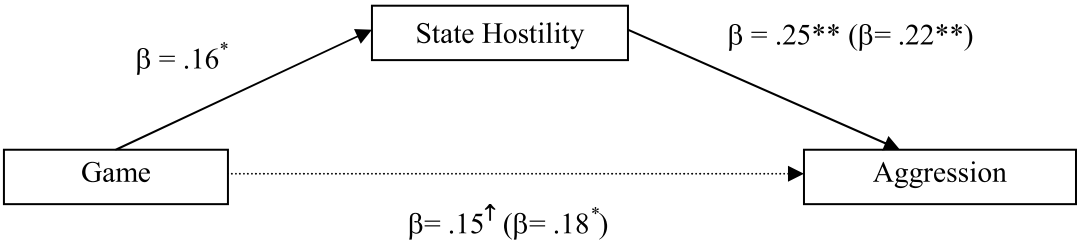
Figure 1. Average HR changes from baseline over the 7-min of playing activity during the first phase (top half) and second phase (bottom half) as a function of experimental conditions.

Figure 2. Relation between Game and Aggression as mediated by state hostility.





Note. VR = Virtual Reality; VG = Violent game; NVG = non-violent game.



Note. ↑p = .075; *p < .05; **p < .01. Games were coded 0 for non-violent and 1 for violent game. The standardized regression coefficient shown outside the parenthesis corresponds to the regression model's estimated parameters and include the two predictors (Games and Hostility).