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Domestic Violence From a Child Perspective: Impact of an Immersive Virtual Reality Experience on Men With a History of Intimate Partner Violent Behavior

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Abstract

Domestic violence has long-term negative consequences on children. In this study, men with a history of partner aggression and a control group of non-

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offenders were embodied in a child's body from a first-person perspective in virtual reality (VR). From this perspective, participants witnessed a scene of domestic violence where a male avatar assaulted a female avatar. We evaluated the impact of the experience on emotion recognition skills and heart rate deceleration responses. We found that the experience mainly impacted the recognition of angry facial expressions. The results also indicate that males with a history of partner aggression had larger physiological responses during an explicit violent event (when the virtual abuser threw a telephone) compared with controls, while their physiological reactions were less pronounced when the virtual abuser invaded the victim's personal space. We show that embodiment from a child's perspective during a conflict situation in VR impacts emotion recognition, physiological reactions, and attitudes towards violence. We provide initial evidence of the potential of VR in the rehabilitation and neuropsychological assessment of males with a history of domestic violence, especially in relation to children.

Keywords

virtual reality, embodiment, domestic violence, perspective-taking, children, empathy

Introduction

Abused women frequently report that their children were also victims of the violent behaviors of their partner. This is reflected in the high rates of children exposed to domestic violence worldwide (Espinar-Ruiz & López-Monsalve, 2015; Holt et al., 2008; Roberts et al., 2010). Although aggressive behaviors have several long-term negative physical and psychological consequences on the victims, men who have perpetrated domestic violence continue to play an active role in the life of their children in numerous cases (Kim & Gray, 2008; Rhodes et al., 2010; Salisbury et al., 2009). For this reason, rehabilitation programs for domestic violence include approaches that aim to promote the learning of positive parenting skills (Labarre et al., 2016).

There is evidence that males who have perpetrated intimate partner violence (IPV) find it difficult to take their children's perspective, and that they lack awareness of the negative impact that their aggressive behaviors may have on their children (Stover & Spink, 2012). For instance, parents with a history of domestic violence tend to punish and intimidate their children when they display vulnerable emotions such as sadness or fear (Maliken & Katz, 2013). One of the main goals of parenting interventions is to increase awareness of the detrimental consequences that exposure to violence has on a child's wellbeing (Labarre et al., 2016). In these interventions it is critical, as the first step in their rehabilitation process, to help parents to understand their responsibilities and the consequences that their aggressive behaviors have on their family and on the community. In this context, virtual reality (VR) might prove to be an effective medium for helping men who have perpetrated domestic violence to realize the adverse impact of their aggressive behavior on their children and families.

VR supports embodied perspective-taking, based on experiencing a situation not only from the viewpoint of another person but also with the illusion of having their body (Maister et al., 2014; Slater et al., 2009). This is achieved using a head-tracked wide-field-of-view head-mounted display (HMD), where a person's real body is visually substituted for a life-sized virtual one. Moreover, the use of body-tracking technologies makes the virtual body move synchronously and in accordance with the person's real body movements, usually giving rise to perceptual illusions of ownership and agency over the body (Kokkinara & Slater, 2014; Slater et al., 2010).

Several studies have shown that embodiment in VR might lead to perceptual, attitudinal, and behavioral changes. For instance, embodiment of adults in a child avatar body results in participants overestimating the sizes of objects and self-attributing child-like features, an effect not observed when participants embody an adult avatar of the same height as the child (Banakou et al., 2013). Moreover, embodiment of mothers in a child avatar who interacts with a virtual mother who portrays a positive or negative parenting style, results in increased emotion recognition and empathic feelings for children (Hamilton-Giachritsis et al., 2018). Similarly, when patients who are diagnosed with depression deliver a compassionate speech to an avatar and subsequently re-experience their speech from that avatar's perspective, their depressive symptoms and self-criticism decrease (Falconer et al., 2014). Osimo et al. (2015) and Slater et al. (2019) have also shown that when participants embody a therapist avatar in VR to solve a personal problem from a different perspective, they tend to detach from habitual ways of thinking and are able to find novel solutions for personal problems. Finally, there is evidence that when males with a history of IPV are embodied in the perspective of a virtual female victim, there is a significant improvement in their ability to recognize fearful female faces (Seinfeld et al., 2018), an effect that seems to be mediated by changes in the brain default network activity (Seinfeld et al., 2021). For further discussions on how perspective-taking in VR might impact empathy see Van Loon et al. (2018) and Ventura et al. (2020).

In the present study, male participants with and without a history of IPV were embodied in a virtual child perspective, while witnessing a domestic violence scene where a male avatar verbally assaulted a female avatar. We decided to assess the impact of the VR experience on the emotion recognition skills of males with a history of IPV perpetration in comparison to a group of males without a history of violence, based on previous evidence showing that embodiment might improve the emotion recognition skills of specific clinical populations (Hamilton-Giachritsis et al., 2018; Seinfeld et al., 2018) and also on studies suggesting a positive relationship between violent behaviors and deficits identifying negative emotions (Blair et al., 2001; Gillespie et al., 2015; Kret & de Gelder, 2013; Wegrzyn et al., 2017). In the specific context of domestic violence, it has been shown that difficulties recognizing fearful female expression is positively correlated with the occurrence of IPV (Marshall & Holtzworth-Munroe, 2010). Babcock et al. (2008) have also found that generally violent men with a history of IPV tend to misidentify angry facial expressions for disgust and happiness. Therefore, it is important to assess how embodied perspective-taking in VR might improve emotion recognition, especially in populations with a history of violence.

Moreover, to evaluate potential differences in stress-related responses between controls and men with a history of IPV in immersive violent situations when embodied as a child in a conflict situation, we recorded and analyzed heart rate deceleration (HRD) in response to the aggressive behaviors portrayed in the VR scene. HRD is a physiological reaction that forms part of the defensive cascade elicited by aversive stimuli (Pollatos et al., 2007) and has been used as a marker of anxiety and vigilance responses to an acute stressor (Lang et al., 2000). Increased HRD when an embodied virtual body is threatened, positively correlates with body ownership feelings (Slater et al., 2010).

It has also been suggested that physiological responses might predict the occurrence of violence and help differentiate between different types of offenders, although the evidence is contradictory (Pinto et al., 2010). Umhau et al.'s (2002) results indicate that men with a history of IPV have difficulties in autonomic regulation during a conflict situation, when compared with controls. Gottman et al. (1995) found that males with more accentuated antisocial personality traits and who are generally violent (i.e., not only with their partner, but also outside the relationship), tend to have lower heart rates during a laboratory-induced partner conflict situation. In contrast, men whose heart rate increased during a partner conflict are more dependent, jealous, and verbally aggressive. However, these results were not replicated in further studies, potentially due to the moderating role of additional variables (Babcock et al., 2004; Meehan et al., 2001). Recently, Godfrey and Babcock (2020) found that sympathetic and parasympathetic autonomic reactivity in males with a history of IPV during a conflict situation, seems to be related to their baseline affect decoding abilities. Despite the fact that in the present research we only recorded HRD and did not assess personality traits, we considered it relevant to explore potential differences in physiological reactions between males with and without a history of IPV, especially in this novel perspective-taking virtual situation where males are able to experience the perspective of a child that does not play an active role in the conflict situation but instead just witnesses it.

Method

Sample

Men who had perpetrated IPV ($n = 31$) were recruited in collaboration with the Catalan Justice Department. The participants had been convicted by the Spanish legal system for aggression against a woman and sentenced to attend a domestic violence rehabilitation program. The control group ($n = 19$) consisted of men without a history of domestic violence. They were recruited through written or email advertisements in the campus community and also from the maintenance staff of the local university.

This study followed ethical standards as per the Declaration of Helsinki and was approved by the local ethics committee. All participants gave written consent before participation. Specific further ethical considerations and exclusion criteria are described in detail in the Supplementary Materials. Although the control group originally consisted of 23 participants, 4 were excluded because they had a previous history of exposure to violence and one because his emotional recognition scores were outside ±2 standard deviations from the group mean. This resulted in a final sample size of $n = 19$. The control group participants were recruited to match as closely as possible the socio-demographic characteristics of the men who had perpetrated IPV. All participants received an economic compensation for participating in the study.

Our sample included males with a history of IPV perpetration living in Barcelona (Spain) and within the jurisdiction of the Justice Department of Catalonia, with a majority of participants of Spanish nationality, but not limited to it. The sample included men of a wide range of ages and low to moderate educational levels. The common element between these participants was a history of violent behavior against their female partner. Table 1 summarizes the demographic information of the samples that we collected.

Virtual Reality Scene

Participants wore a HMD and full-body tracking suit to experience the VR scene. Through the HMD, participants were immersed in a virtual room with a long hallway where they were embodied as a virtual child with an age appearing to be 4 or 5 years old. All participants saw the virtual child body collocated with their own real body from a first-person perspective (1PP). The virtual body moved in real-time according to the participants' movements, producing visuomotor synchrony between their own and the virtual body's movements.

To begin, participants were asked to become familiar with their own virtual body (avatar) and their surroundings by describing their virtual body

Table 1. Demographic information of the Males who had been partner aggressive and the Control group.

	Males who had been partner aggressive	Control group
Nationality	23 Spanish (74.19%), 8 non-Spanish (25.81%)	16 Spanish (84.21%), 3 non-Spanish (15.79%)
Mean age (SD, range)	41.84 (10.08, 24–63)	40.58 (10.47, 25–57)
Highest education level reached	14 primary school (45.16%) 8 high school (25.81%) 8 vocational training (25.81%) 1 university degree (3.23%)	3 primary school (15.79%) 9 high school (47.37%) 7 vocational training (36.84%)
Work (yes)	21 (67.74%)	15 (78.95%)
Marital status	15 single (48.39%) 11 married or in a relationship (35.48%) 3 divorced (9.68%) 2 widower (6.45%)	9 single (47.37%) 10 married or in a relationship (52.63%)
Children (yes)	22 (70.97%)	8 (42.10%)
Medication (yes)	3 on psychoactive medication (9.68%)	None on medication

and the room. To record a baseline of physiological signals, we asked participants to remain still and relaxed for 2 minutes. Next, participants were asked to turn around and face the open door at the front of the hallway. At this moment, we told them that they were going to hear a series of instructions for several stretching exercises which they should perform in front of the mirror. Before the stretching exercises started, the screen faded out, and a female avatar appeared in the scene. The female avatar approached the participant making gestures with her hands to say hello (Supplementary Figure S1A), and then bending down to caress the child's (the participant's) head (Supplementary Figure S1B). Subsequently, the female avatar started doing the stretching exercises along with the participant in order to promote a positive interaction between the participant and the female avatar (Supplementary Figure S1C). The goal of these exercises was to induce embodiment by emphasizing the visuomotor synchrony between the participant's body and that of the child avatar. The exercises lasted approximately 2½ minutes.

Next, a male avatar entered the room and began to verbally abuse the female avatar following a pre-defined script (Supplementary Figure S1D). The male avatar constantly looked at the eyes of the female avatar. At a given time, the male avatar threw a telephone to the floor in order to include an act of physical violence (Supplementary Figure S1E–F). Additionally, if participants interrupted the monologue of the male avatar the experimenter could trigger the male avatar to say, “Shut up!” to the virtual child (i.e., participant). At three moments during the verbal abuse, the male avatar walked closer towards the female avatar, invading her and the participant’s (i.e., child avatar) personal space by the end of the scene (Supplementary Figure S1G–H). The verbal abuse lasted for approximately 2½ minutes. In this setup, participants (i.e., child avatar) were only indirect victims of the situation since they were observers of the aggression committed by the male avatar towards the female avatar. The dialogue of the male avatar was the same one used in Seinfeld et al. (2018), with the difference that in that study males with a history of partner aggression were embodied in the female avatar and there was no virtual child in the scene. Note that all figures showing the VR scene and details about the technical equipment used are in Supplementary Materials.

Measures

Face-Body Compound Test. In order to assess the impact of the VR embodied experience on emotion recognition skills, we administered a pre- and post-VR emotion recognition test, namely the face-body compound test (FBCT; Gelder et al., 2014; Kret et al., 2013; Meeren et al., 2005). The FBCT is comprised of two independent blocks presented in counterbalanced order. In one of the blocks, faces expressing either fear or happiness are displayed in isolation or on top of a body that expresses the same emotional state (congruent) or not (incongruent) (see Supplementary Figure S2). In the other block, angry and happy emotional expressions are displayed following the same methodology. Participants are told to categorize the facial expression (happiness vs. fear or happiness vs. anger), while instructed to ignore the body. Each block included a total of 60 images (2 facial expressions × 3 body postures × 10 actors) that were presented twice in random order. Each image was presented for 100 ms, with a fixation cross appearing after each response for 750 to 1250 ms.

The decision of including emotional stimuli comprised by faces and bodies was based on its higher ecological validity, since it has been shown that relying only on facial expressions to judge emotions has several shortcomings (see review in Barrett et al., 2019). A body of evidence shows the influence that body language has on the emotional recognition of faces (De Gelder et al., 2010). For instance, while congruent emotional body postures improve the recognition of emotions conveyed by faces, incongruent emotional postures might hamper facial emotion recognition (Meeren et al., 2005). Moreover, due to the high number of trials we aimed to include in each of the blocks of the test and to avoid fatigue effects, we decided to only assess the perception of anger and fear against happiness. These target emotions were selected based on past evidence showing that males with a history of IPV have deficits recognizing fear, anger, and happiness (Babcock et al., 2008; Marshall & Holtzworth-Munroe, 2010; Nyline et al., 2018).

To analyze the emotion recognition test, a signal detection analyses was carried out in order to obtain sensitivity indexes (d') and the response criterion (c) used when recognizing angry and fearful facial expressions following Snodgrass and Corwin (1988), and the procedure outlined in Seinfeld et al., (2018) and Hortensius et al. (2014) (Table 2).

Physiological Reactions. Male abusive perpetrators and controls have different physiological reactivity patterns under conflict situations (Pinto et al., 2010). To evaluate potential differences in stress-related responses we recorded and analyzed Heart Rate Deceleration (HRD). Specifically, HRD was recorded

Table 2. Response variables from the signal detection analysis (face-body compound test) and physiological responses included in the Bayesian analysis.

Variable	Meaning
d'AngerMale	Change in d' score for anger recognition in male faces. Higher scores indicate increased sensitivity in detecting angry male faces after VR.
d'AngerFemale	Change in d' score for anger recognition in female faces. Higher scores indicate increased sensitivity in detecting angry female faces after VR.
d'FearMale	Change in d' score for fear recognition in male faces. Higher scores indicate increase sensitivity in detecting fearful male faces after VR.
d'FearFemale	Change in d' score for fear recognition in female faces. Higher scores indicate increase sensitivity in detecting fearful female faces after VR.
*c*AngerMale	c-criterion for anger recognition in male faces. 0 = no bias, positive value = tendency to answer with happiness, negative value = tendency to answer with anger.
*c*AngerFemale	Same as for *c*AngerMale for female stimuli.
*c*FearMale	c-criterion for fear recognition in male faces. 0 = no bias, positive value = tendency to answer with happiness, negative value = tendency to answer with fear.
*c*FearFemale	Same as for *c*FearMale for female stimuli.
HRD_PersonalSpaceInvasion	HRD when the male avatar approached the female avatar, invading the female and virtual child's personal space.
HRD_TelephoneThrown	HRD when the male avatar threw a telephone to the floor.

during two specific events in the VR scene that represented different types of violent behaviors, namely an act of physical violence and the invasion of personal space. We recorded HRD (1) when the male virtual character approached the female virtual character invading her personal space, and thus also getting close to the participants (i.e., child avatar) and (2) when the male virtual character threw a telephone to the floor. The start of these two specific moments were marked in the ECG by event markers. HRD was computed in a time window of 6 seconds after each of the triggered events.

VR Questionnaire. Following Seinfeld et al. (2018) we designed and administered a VR experience questionnaire to assess the perceptions of men who had perpetrated IPV and controls regarding aspects of the VR experience. The questionnaire and results are described in the Supplementary Materials.

Social Desirability and Interpersonal Reactivity Index. The Social Desirability (SD) scale (Andrews & Meyer, 2003; Crowne & Marlowe, 1960) was used to assess response bias (i.e. subject's tendencies to respond in a socially desirable way), to control whether self-reported questionnaire reliability was not biased by the tendency of the participants to answer in a manner that would be viewed favorably by others, as in Seinfeld et al. (2018). The scale is comprised of 33 true-false items concerning everyday behaviors. Higher scores on the questionnaire indicate a stronger tendency to respond in a socially desirable way. A Spanish validated version was used (Chico et al., 2000).

The Interpersonal Reactivity Index (IRI) was administered before the start of VR procedure. This study used the Spanish version of the questionnaire (Albéniz et al., 2003). Since the IRI and VR questionnaire are prone to bias by socially desirable responding (Seinfeld et al., 2018), they are reported in the Supplementary Materials.

Procedure. On arrival to the laboratory, brief written information about the experiment was given to the participants. They were requested to sign a consent form if they were willing to participate and then filled up the demographic form, the IRI, and the SD questionnaire. Next, participants were requested to complete the pre-VR FBCT. Then participants went on to experience the VR domestic violence scene from the child's perspective, After the VR scene, participants completed again the post-VR FBCT and a questionnaire about the VR experience. Finally, we carried out a semi-structured interview where participants were debriefed about the VR experience. More details on the procedure and equipment used in this study are given in the Supplementary Materials.

Statistical analysis

Response Variables. The data recorded before, during and after the VR experience, resulted in 10 different response variables shown in Table 2. These data were analyzed following a Bayesian approach, with all response variables treated under one model. See Bergström et al. (2016) and Seinfeld et al. (2018) for similar analysis.

The first eight response variables of Table 2 are the d-prime (d') and c-criterion (c) differences between before and after going through the VR experience. If we suppose that y is a d' or c response variable, and y_1 is the emotion recognition score before VR (pre measure) and y_2 after VR (post measure), then $y = y_2 - y_1$ is the final response variable. For each y the model (the likelihood) is of the form

$$y \sim Normal(\beta_0 + \beta_1 Condition, \sigma)$$

where $y \sim Normal(\mu,\sigma)$ means that y has a normal distribution with mean μ and standard deviation σ. The parameters β_0, β_1, and σ are unknown. Condition = 0 for Controls and 1 for males with a history of IPV perpetration.

The method postulates prior distributions for the unknown parameters. Given the data these probability distributions are updated to obtain the posterior distributions. In the present study we were interested in the inferences about β_1. If, on the balance of probability, it seems that $\beta_1 > 0$ then this indicates that the males with a history of IPV perpetration changed positively with respect to the Controls with respect to the variable in question. If $\beta_1 < 0$ then the males with a history of IPV perpetration changed negatively with respect to the Controls. Otherwise, the experimental conditions had no effect.

We initially used a Student-*t* distribution for the likelihoods rather than the normal distribution because the Student-*t* distribution has fatter tails thereby allowing for outliers, when compared with a normal distribution. In the Student-*t* distribution the degrees of freedom are another parameter estimated from the data. However, the posterior distributions of the degrees of freedom indicated very high values for the degrees of freedom, and for high degrees of freedom (approx >30) the Student-*t* distribution is the same as the normal. Similarly, our first strategy was to allow σ to be different for each individual. However, we found that the σ estimates for the d' and c cases were all very similar. Therefore, in the final model we only included two parameters: σ_d for d' and σ_c for the c cases.

The same method is used for the (negative) HRD values, except here we use an exponential distribution (Supplementary Figure S8). The exponential distribution is characterized by its mean, which has to be positive. Hence if z is one of the HRD variables, then the model is

$$z \sim Exponential(\lambda)$$

Here λ is an unknown parameter and the mean of the exponential distributions is $1/\lambda$. Hence the model used was

$$\frac{1}{\lambda} = exp\ (\beta_0 + \beta_1 Condition),\ \text{where}\ \lambda = exp(-(\beta_0 + \beta_1 Condition))$$

The *exp* is used in order to ensure that $\lambda > 0$ no matter what the values of β_0 and β_1 are, following standard methods. Note that β_0 and β_1 are, of course, different parameters for each response variable. In HRD, the missing values where 12 out of 50 for *HRD_TelephoneThrow* (7 values from males who had been partner aggressive and 5 from Controls) and 9 out of 50 for *HRD_PersonalSpaceInvasion* (6 values from males who had been partner aggressive and 3 from Controls) variables. Values were missing because participants did not give informed consent to record physiological data, which was the case for 6 offender participants and 3 controls. Two additional values from the control group and one from the the group of males with a history of IPV perpetration were excluded from the analysis due to technical difficulties (i.e., noise in the signal). The missing values were imputed as part of the Bayesian model using the method described in the "Stan Modeling Language User's Guide and Reference Manual" (2.17.0), p180. (Team, 2015)

Prior Distributions. All $\boldsymbol{\beta_0}$ and $\boldsymbol{\beta_1}$ parameters were given weakly informative prior distributions

$$\beta_0, \beta_1 \sim Normal(0, 10)$$

Hence, their prior 95% credible intervals were between −20 and 20.

$\sigma_c, \sigma_d \sim Cauchy(0, 5)$ distributions, restricted to be non-negative. The Cauchy distributions are used because they are very wide distributions (infinite mean and variance) but nevertheless are proper probability distributions. It means that we have very little prior knowledge about their possible values. The 95% credible intervals for σ_c, σ_d are: 0.1 to 128.

Results

Table 3 summarizes the results (posterior distributions) obtained and below we consider each in turn. It is important to note that this methodology specifies one overall model based on the joint posterior distribution of all the parameters simultaneously, rather than a series of different significance tests for each parameter as in null hypothesis significance testing. The Table also

Table 3. Summary of posterior distributions of the parameters showing the mean, standard deviation, a 95% credible interval. *P* (>0) is the posterior probability of the corresponding parameter being positive.

Parameter	Mean	SD	2.5%	97.5%	*P*(>0)
d´AngerMale					
β_0	0.30	0.13	0.05	0.55	
β_1	0.05	0.16	−0.27	0.37	0.620
d´AngerFemale					
β_0	0.13	0.13	−0.12	0.38	
β_1	0.28	0.16	−0.04	0.60	0.956
d´FearMale					
β_0	0.34	0.13	0.09	0.58	
β_1	−0.27	0.16	−0.58	0.06	0.048
d´FearFemale					
β_0	0.10	0.13	−0.16	0.36	
β_1	0.08	0.17	−0.25	0.40	0.695
cAngerMale					
β_0	−0.01	0.06	−0.12	0.10	
β_1	−0.11	0.07	−0.24	0.03	0.061
cAngerFemale					
β_0	−0.08	0.05	−0.19	0.02	
β_1	0.03	0.07	−0.11	0.16	0.641
cFearMale					
β_0	0.06	0.06	−0.04	0.17	
β_1	−0.05	0.07	−0.19	0.09	0.242
cFearFemale					
β_0	−0.03	0.06	−0.14	0.08	
β_1	−0.03	0.07	−0.17	0.11	0.340
HRDphone					
β_0	0.73	0.27	0.22	1.30	
β_1	0.26	0.34	−0.42	0.92	0.775
HRDapproach					
β_0	0.97	0.25	0.50	1.51	
β_1	−0.44	0.33	−1.11	0.20	0.088
σ					
σ_c,	0.56	0.03	0.50	0.62	
σ_d	0.24	0.01	0.22	0.27	

shows the 95% credible intervals which are notably narrower than the prior credible intervals, as required. The Stan programming language was used for the Bayesian analysis (Carpenter et al., 2017). Four-thousand iterations were used over 4 chains. The simulation converged without problems, and all

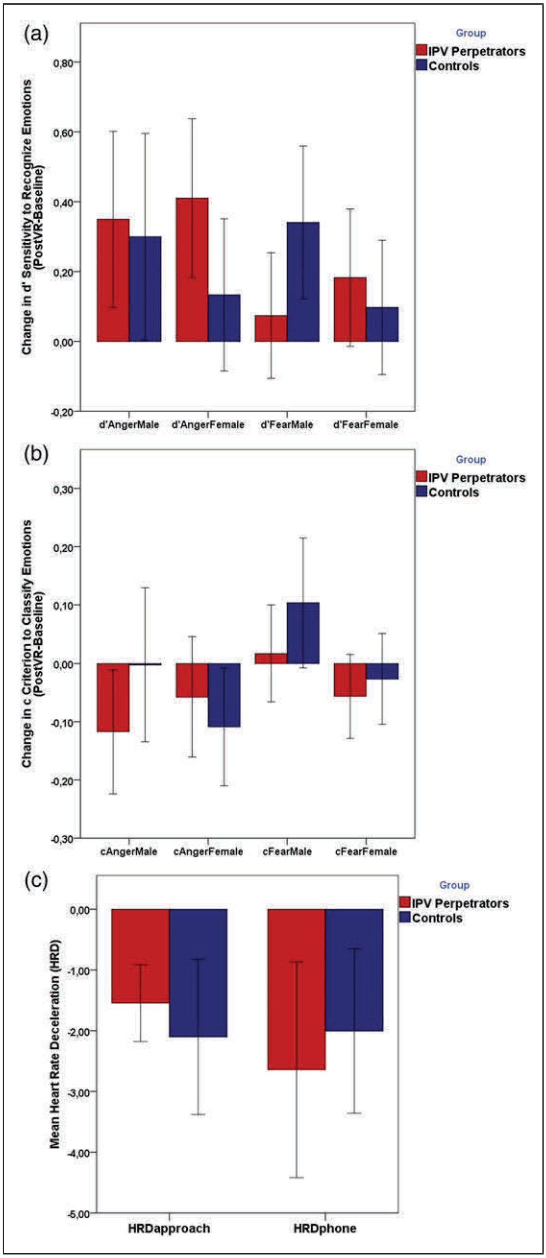

Figure 1. (a). Change in sensitivity d′ in recognizing facial emotions after the VR experience in males with a history of IPV perpetration and non-offender controls. The figure shows means and confidence intervals of the change between the post-VR

minus baseline in sensitivity index d-prime (d′) scores obtained in the Face Body Compound Test. A higher value indicates increased sensitivity for the recognition of that specific emotion. A higher value indicates increased sensitivity for the recognition of that specific emotion. See Table 2 for statistical interpretations using a Bayesian model. (b). Change in bias (c) towards classifying faces as depicting a particular facial emotion after the VR experience in males with a history of IPV perpetration and non-offending controls. The figure shows means and confidence intervals in the Face-Body Compound test, where a c value of 0 indicates no change; a positive value of c indicates an increase in bias towards classifying faces as happy, and a negative c value shows an increase in bias towards classifying faces as angry or fearful after the VR experience. See Table 3 for statistical interpretations using a Bayesian model. (c). Mean and confidence intervals of Heart Rate Deceleration when the male avatar approaches the female and child invading their personal space (left) and when the male avatar throws a telephone to the floor (right).

Rhat values were 1 (meaning that the 4 chains consistently mixed and converged).

Sensitivity in the Recognition of Facial Emotions (d′)

Figure 1(a). shows the means and standard errors of the responses, suggesting no difference in d'AngerMale between the conditions, males with a history of IPV perpetration having greater values than Controls for d'AngerFemale, but smaller values than Controls for d'FearMale, and no difference for d'FearFemale.

With respect to the statistical model, Table 3 shows that after exposure to the VR scene, the males who had been partner aggressive displayed a substantial increase in their sensitivity to recognize angry female facial expressions compared with Controls (d'AngerFemale, posterior probability = 0.956, Table 3). In the case of angry male facial expressions, the results do not provide evidence of a substantial difference between the conditions (d'AngerMale, posterior probability = 0.620). We did, however, find strong evidence that the Controls increased their sensitivity to recognize fear in male faces after the VR experience, compared with the males with a history of IPV perpetration (d'FearMale, posterior probability = 1–0.048 = 0.952). A relatively low probability was found for an increased sensitivity to recognize fearful female faces in the group of males who had been partner aggressive compared with Controls (d'FearFemale, posterior probability = 0.695). Furthermore, effects sizes of differences between males with a history of IPV perpetration and Controls in their baseline (before VR) d' sensitivity emotion recognition scores can be found in Table S1 in the Supplementary Materials.

Bias Towards Classifying Faces as Depicting a Particular Emotion (c)

See Figure 1(b) for more details.

We found strong evidence for an increase in males with a history of IPV perpetration's bias towards classifying male faces as expressing anger after the VR scene compared with Controls (*c*AngerMale, posterior probability = 0.939). For female faces there seemed to be a slight increase in both groups in their bias towards classifying them as expressing anger compared with happiness, without notable differences between the groups (*c*AngerFemale, posterior probability = 0.359). Finally, lesser support was found for differences in bias when classifying fearful facial expressions between the groups. Moderately high probability values indicated that Controls compared with males with a history of IPV perpetration seem to have higher bias to respond with happiness rather than fear when presented with male fearful faces (*c*FearMale, posterior probability = 0.758) after the VR. Despite this, no support was found for differences between the groups when classifying fearful female faces after the VR (*c*FearFemale, posterior probability = 0.340). Males with a history of IPV perpetration after the VR seemed to have a tendency to respond with fear rather than with happiness when presented with female faces, which is coherent with the results found in Seinfeld et al. (2018). Furthermore, effect sizes of the differences between males with a history of IPV perpetration and Controls in their baseline (before VR) d' sensitivity emotion recognition scores can be found in Table S1 in the Supplementary Materials.

Heart Rate Deceleration

See Figure 1(c) for details.

Regarding physiological responses during the VR scene, we found strong evidence indicating that HRD was larger in the Controls than the males with a history of IPV perpetration, when the male avatar approached the female avatar and invaded her and the child's personal space. Thus, Controls seemed to be more stressed in this specific part of the VR scene (HRD approach, posterior probability = 0.912). We found moderate support for the opposite pattern when the male avatar throws a telephone to the floor. In this case HRD was more accentuated in the males with a history of IPV perpetration than in the Controls, although the posterior probability in this case was lower (HRD phone, posterior probability = 0.775).

Social Desirability, Empathy, and Subjective Perception of the VR

In line with the results found by Seinfeld et al. (2018), social desirability scores were higher in the group of males with a history of IPV perpetration (mean = 19.97, standard error = 0.96) compared with the Control group (mean = 17.21, standard error = 1.33). This suggests a tendency of males with a history of IPV perpetration to answer in a manner that would be viewed favorably by others. Therefore, we opted to only descriptively report all of the measures that were prone to be affected by this socially desirable responding. This follows standard strategies used to deal with socially desirable responses (Van de Mortel, 2008). However, it should be noted that in the VR questionnaire males who had been partner aggressive and Controls indicated with high scores that the VR scene helped them to better understand the feelings of a child in this type of violent situation (median 6: see Supplementary Figure S13).

Discussion

We investigated the impact of witnessing a domestic violence scene from the first-person perspective of a virtual child. A novel immersive VR paradigm was used where men, with and without a history of IPV perpetration, experienced being embodied in a child avatar while witnessing the assault of a male abuser towards a female avatar. The main goal was to study the influence of this VR paradigm on participants' emotion recognition skills and physiological responses, with the ultimate goal of assessing whether these types of embodied VR experiences could help increase awareness of the detrimental consequences that domestic violence has on children.

Overall, our study provides strong evidence that virtual embodiment in the perspective of a child exposed to domestic violence, impacts the emotion recognition skills of males with a history of IPV perpetration. Specifically, we found that males with a history of IPV had a substantial increase in their sensitivity to recognize anger in female faces and biases in recognizing males faces as expressing anger, when compared to controls. However, both groups (i.e., males with and without a history of violence) displayed an increase in their sensitivity to recognize anger in male facial expressions, without remarkable difference between them. The control group showed a substantial increase in their sensitivity to recognize fear in male facial expressions, compared to men with a history of IPV. A slight increase in the ability to recognize fear in female faces after the virtual scene was also detected in the group of males with a history of IPV perpetration.

With regard to physiological responses, we observed that the type of virtual content represented in the VR scene evoked different HRD patterns in males who had been partner aggressive compared to controls. While HRD was more pronounced in the control group of non-offenders when the male avatar invaded the female's and child's personal space, males with a history of IPV had a more accentuated HRD when the male avatar carried out an explicit violent act, throwing a telephone to the floor. Thus, the explicit (i.e., throwing a telephone) or implicit (i.e., non-verbal cues and proximity) nature of the virtual violent behavior seemed to play a role on physiological reactivity in response to aggressive behaviors, depending on having or not a previous history of violence perpetration. Finally, based on questionnaire responses, we also observed that both groups reported that the VR experience was useful to better understand how a child feels under this type of violent situation.

Several studies have shown that a history of violent behaviors is associated with decreased recognition of negative emotional states, such as anger and fear (Bowen et al., 2014; Chan et al., 2010; Kret & de Gelder, 2013; Marshall et al., 2011; Robinson et al., 2012). Seinfeld et al., (2018) found that men with a history of IPV perpetration have difficulties in recognizing fearful female faces, which improve after experiencing the perspective of a female victim in VR. In the present study we further demonstrate that virtual embodiment in the perspective of child exposed to violence might also improve the recognition of negative emotions. However, while in Seinfeld et al. (2018) study it was found that having the perspective of a female victim enhanced the recognition of fearful female expressions in males with a history of IPV perpetration, in the present research we have found that being in the perspective of a virtual child clearly impacts the recognition of anger in female and males facial expressions, and to a lesser extent also the recognition of fear. Although we cannot elucidate the reason underlying these differences with the current experimental design, it is possible that they are associated with the type of perspective adopted in VR. While in Seinfeld et al. (2018), males were placed in the perspective of the direct victim of an assault (i.e., a female avatar), in this study participants were indirect victims of the assault (i.e., a child witnessing the violence towards the female avatar). Recent evidence indicates that the viewpoint from which a virtual violent scene is experienced leads to different behavioral and brain responses. For instance, De Borst et al. (2020) and Gonzalez-Liencres et al., (2020) found that the first-person perspective of a virtual victim of domestic violence resulted in increased embodiment, sensation of fear, behavioral and physiological reactivity, amygdala activation, and synchronization of fronto-parietal networks to predict actions towards the body, when compared with a third-person perspective.

It is possible that embodiment in the direct victim of an assault, as is the case with the Seinfeld et al. (2018), De Borst et al. (2020) and Gonzalez-Liencres et al., (2020) studies, results in a higher saliency of fear-related emotions when a threat is directed to the embodied virtual character (i.e., female); however, anger seems to be a more prominent emotion when someone witnesses the violence from the third-person perspective (i.e., virtual child). Although it is difficult to elucidate why anger recognition was enhanced to a larger extent after adopting the virtual child perspective, is possible that increased anger recognition is linked to the adaptive value of quick threat and danger detection. Enhanced anger recognition has been associated with vigilance responses and evolutionary advantageous behavior by allowing an organism to quickly prepare and protect itself from environmental threats (Fox et al., 2000; Pichon et al., 2009). Thus it is possible that witnessing the threatening behaviors of the male avatar facilitated anger detection to enable the observer to quickly react if the male character tried to physically assault the female or harm him as he was embodied in the virtual child avatar.

Alternatively, increased recognition of anger after the VR experience might also possibly be associated with how children and victims actually feel under this type of situation. DeBoard-Lucas and Grych (2011) found that children exposed to IPV frequently experienced anger and sadness. They also found that children often tend to try to stop or withdraw from these types of fights. Is possible that in this case, boosted anger recognition in men with a history of partner aggression is linked to the experience of similar feelings during the VR scene as those experienced by children when exposed to real-life violence. This is relevant in light of past research showing that men who have perpetrated IPV have difficulties in taking the perspective of their children or the victims and frequently lack awareness of the negative impact that their aggressive behaviors may have on their family (Labarre et al., 2016; Maliken & Katz, 2013; Stover & Spink, 2012).

Another possibility is that the VR scene evoked past personal memories of abuse that enhanced anger recognition in participants who have experienced similar situations in their childhood. A high number of males who have perpetrated IPV have suffered or witnessed domestic violence during their childhood, leading in several cases to post-traumatic stress disorders (PTSD) (Voith et al., 2020). This is a factor that has shown to be related to the later perpetration of IPV, due to social learning mechanisms (Hilton et al., 2019). Therefore, traditional IPV interventions include strategies that discuss how traumatic experiences might play a role in the occurrence of aggressive behaviors (e.g., psychoeducation or CBT), showing so far very limited effectiveness in reducing re-offenses (Feder & Wilson, 2005). Recent proposals have suggested that using bottom-up approaches, which tackle higher brain function but also physiological adaptation to trauma, might be more effective. Such approaches include desensitization and reprocessing strategies (Voith et al., 2020). In this regard, the present VR experience might represent a novel means to work on unresolved trauma in these populations, since VR has also proven to be a very powerful and effective tool in the treatment of PTSD (Rizzo et al., 2009). The use of these type of VR tools, in combination with psychological therapy, might help males who have suffered abuse to process their past trauma, realize how they are replicating learned patterns, and attach a more adaptive meaning to the traumatic situation. However, further research is needed to also understand whether VR might lead to some undesirable PTSD symptoms. However, in the present study no PTSD symptoms were reported in a follow-up contact nor in the interviews and questionnaires administered after the VR, based on the feedback from therapists and participants.

An unexpected but relevant finding of this study was the variability of the physiological responses of men who have perpetrated IPV depending on the type of violent content represented. While there was an increased HRD response when the male avatar threw a telephone to the floor in males who have perpetrated IPV (i.e., explicit act of violence) compared with controls, this response was less accentuated when the avatar invaded the female and child avatars' personal space (i.e., implicit act of violence based on non-verbal language). Therefore, it seems that defensive and attentional responses were more accentuated in males without a history of IPV when an explicit act of violence was represented. Although we are not able to disentangle the reasons underlying these differences, it is possible that they are linked to the VR scene evoking past memories of abuse that triggered increased physiological reactivity when a telephone was thrown, due to the higher perception of threat in males with a history of IPV (Hilton et al., 2019; Voith et al., 2020). However, responses to more subtle cues of violence, such as invasion of personal space might be unconsciously considered less dangerous and normalized, resulting in decreased physiological responses due to habituation. These are aspects that deserve further research. The present findings are in accordance with Umhau et al.'s (2002) results, which indicated that men with and without a history of IPV differ in their heart rate reactions and autonomic regulation in a conflict situation. Unfortunately, due to the small sample size and a lack of personality measures, we are unable to compare our results with studies that have proposed a typology of IPV perpetrators depending on their physiological reactions during conflict situations, such as Gottman et al. (1995). However, our results highlight that immersive VR simulations represent a novel and very interesting tool to further study the real-time reactions of violent populations and to facilitate the understanding of different typologies of IPV perpetrators. These typologies could be developed further, taking into account personality variables, but also real-time responses to violent situations with a high ecological validity and experimental control (Parsons, 2015). There have been contradictory findings about this topic in the literature and the use of VR might help clarify any remaining research questions (Babcock et al., 2004).

The present study shows the potential of VR as a tool for better understanding the neuropsychological profile (i.e., emotion recognition) and biological responses of men who have perpetrated IPV when they are exposed to a scene of domestic violence from a different point of view, in this case a child's perspective. Furthermore, our findings also highlight the potential of integrating this type of VR experience into conventional rehabilitation programs for males who have perpetrated IPV, considering the impact the experience might have on emotion recognition skills and insights related to intra-familial violence. Embodied perspective-taking in VR might help violent men empathize with children and realize the detrimental consequences that exposure to violence has on them, since this medium provides the unique possibility of explicitly observing and experiencing the perspective of a child during violent situations that are frequently normalized and considered harmless (i.e., verbal assaults on their partner or children) (Stover, 2013).

In the present VR scene, only violence of a male avatar towards a female avatar was portrayed, despite recent evidence showing a high prevalence of bidirectional violence in several couples. This type of bidirectional violence is frequently witnessed by children. Future studies should study the impact of virtual embodiment from the perspective of a child when bidirectional violence occurs. Due to time and resource constraints, in the present study we were unable to measure personality traits or assess the impact of the VR experience on the recognition of additional emotions. Future studies should research the impact of embodied VR experiences in populations with a history of IPV, also assessing and taking into account personality traits and different emotions. Moreover, the experimental and control group had differences in their relationship status (i.e., singles, divorced, widower, having a partner) and educational levels. As part of the present study we have performed an additional Bayesian analysis including education and relationship status as covariates. This analysis and its results are reported in the Supplementary Materials for interested researchers. However, we consider that education and relationship status are factors that should be more thoroughly controlled and investigated in the future. We think that it is relevant in the future to evaluate how the results of this type of VR experience is modulated by factors such as living with children or not living with children, and also by having or not a parenting role with the children. It would be interesting to design and assess the impact of VR embodied experiences which try to model more positive and assertive behaviors when training different social skills in IPV interventions. For instance, to evaluate the impact of a virtual situation where a male solves a potential conflict situation using assertive behaviors. Future studies should assess the impact of this type of VR experience in participants from different cultural backgrounds.

Conclusion

Our study shows that virtual embodiment in a child that witnesses a scene of domestic violence impacts the emotion recognition skills of men who have been partner-aggressive. We found that the sensitivity in the recognition of angry facial expressions was enhanced after the VR experience in men who have perpetrated IPV. In relation to physiological responses, our findings indicate that stress-related physiological responding (i.e., HRD) of men with a history of partner aggression was differently modulated depending on the type of virtual content represented. While HRD was more pronounced during an act of physical violence carried out by the male avatar (i.e., throwing a telephone), there were decreased physiological responses during a violent act more dependent on non-verbal language (i.e., proximity). The present study provides preliminary evidence for the use of VR as a tool for better understanding the neuropsychological profile of men who have perpetrated IPV and as a potential intervention to improve emotion recognition in these types of populations, or more generally in those with aggressive behavior. It also highlights the potential use of embodied perspective-taking in VR for increasing awareness of the detrimental consequences that domestic violence has on children.

Declaration of Conflicting interests

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Author Contributions

SS, MS, MVSV, BdG, RH, JA-P, and LZ designed the experiments. GH and JA-P generated the virtual environments. SS, J-AP, GH, and LZ ran the experiments. MVSV supervised the research. MS analyzed the data, with help of RR, RH, J-AP. SS wrote the draft with help of all authors. All authors contributed to the final version of the manuscript.

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Supplemental Material

Supplemental material for this article is available online.

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Ruud Hortensius, PhD, is an Assistant Professor in the Department of Psychology at Utrecht University. In his research, he investigates the flexibility of social cognition using perspectives and techniques from psychology, social neuroscience, and social robotics. He is particularly interested in how long-term interactions with social robots and other artificial agents (re)shape human social lives.

Jorge Arroyo Palacios received his PhD and MSc from the University of Sheffield, and his BEng from the Instituto Tecnológico de Ciudad Victoria. He was a postdoctoral researcher at the University of California, San Francisco, and the University of Barcelona. Currently, he works at Sony Interactive Entertainment. He is also a member of the National System of Researchers in Mexico.

Guillermo Iruretagoyena is a developer that specializes in VR experience programming and motion capture using Unity3D and MotionBuilder.

Luis Zapata, psychologist, did his PhD on the use of immersive virtual reality in the field of gender violence and trains master students on this and related fields.

Prof. Beatrice de Gelder is a cognitive neuroscientist, director of the Brain and Emotion Laboratory in Maastricht University. Her main research topics are non-conscious recognition in patients with cortical damage, emotional expression in whole bodies, face recognition and its deficits, and multisensory perception (interaction between auditory and visual processes).

Prof. Mel Slater is a Distinguished Investigator at the University of Barcelona, and Director of the Event Lab (Experimental Virtual Environments for Neuroscience and Technology). He has been involved in research in virtual reality since the early 1990s, and has been first supervisor of 40 PhDs in graphics and virtual reality. He has been one of the leaders of the development and investigation of embodiment in virtual environments. He was awarded the 2005 IEEE Virtual Reality Career Award and the Humboldt Research Prize from Germany in 2021.

Prof. Maria V. Sanchez-Vives, MD, PhD, is ICREA Research Professor at the Institute of Biomedical Investigations August Pi i Sunyer (Barcelona, Spain) where she leads Systems Neuroscience. She is a neuroscientist and expert on the use of virtual reality in different applications, in particular for rehabilitation of violent behavior and medical applications. She is the co-ordinator of the EU-project “VR per Genere”, where she leads the use of VR in prevention and rehabilitation of intimate partner violence.