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Psychological response to an emergency in virtual reality: effects of victim ethnicity and emergency type on helping behavior and navigation

Abstract

Virtual environments are increasingly used for emergency training, but tend to focus mainly on teaching prescribed emergency procedures. However, social psychology literature highlights several factors that can bias individual response to an emergency in the real world, and would be worth considering in virtual training systems. In this paper, we focus on withdrawal of help due to racial discrimination and explore the potential of virtual environments to trigger this bias in emergency situations. We also test if a virtual emergency is actually reacted to as an emergency. We use an immersive virtual environment (IVE) where a victim issues help requests during two different emergency situations (time pressure or fire). While experiencing the emergency, white participants (N = 96) receive a request for help from a black or white virtual human. The results show a psychological response to the virtual experience consistent with an emergency situation (increased state anxiety and increased frequency of collisions with objects in the environment) and biased by racial discrimination in help provision. In addition, racial discrimination increases under time pressure, but not in a fire. The implications for virtual training are discussed.

Keywords: emergency, virtual reality, helping behavior, navigation behavior, racial discrimination, validation

A fire is an emergency situation, "a serious, unexpected, and often dangerous situation requiring immediate action" (McKean, 2005) where a proper individual response is crucial to reduce psychological, physical, and material damage. Since a fire emergency is also stressful (Proulx, 1993) and thus might hamper performance (Spitzer, & Neely, 1993), firefighters or common citizens have to undergo drills and training to learn response procedures and practice them under high psychological and physical stress (Williams-Bell, Kapralos, Hogue, Weckman, in press). An increasing number of virtual environments[1] are designed to offer parts of this training (e.g.; Cha, Han, Lee, & Choi 2012; DeChamplain, Rosendale, McCabe, Stephan, Cole, & Kapralos, 2012; Dugdale, Pavard, Pallamin, el Jed, & Maugan, 2004; Julien & Shaw, 2003; Li, Jin, Li, Guo, Peng, & Chen, 2004; Mantovani, Gamberini, Martinelli, & Varotto, 2001; Mol, Jorge, & Couto, 2008; Ren, Chen, & Luo, 2008; Tate, Sibert & King, 1997; Toups, Kerne, Hamilton, & Blevins, 2009; Toups, Kerne, Hamilton, & Shahzad, 2011). Virtual emergency training is motivated by the fact that, unlike real-world emergency drills, virtual environments allow trainees to rehearse the situation several times, with controlled variations, contained costs, and under safe conditions (Kinateder et al, 2014); in addition, through simulated realistic situations and by including game elements, digital environments can increase learning motivation (Kovačević, Minović, Milovanović, De Pablos, & Starčević, 2013; Wong, Packard, Girod, & Pugh, 2000). The digital environment is usually a full-scale virtual model of a real environment (a building, a forest, a ship) and fire development, smoke dynamics, and virtual agents are modeled to obtain a realistic effect (for a review of the technical solutions adopted, see Williams-Bell, Kapralos, Hogue, & Weckman, in press). Users typically must make decisions, perform actions, and coordinate with others under circumstances that can undermine their ability to issue a proper response (e.g. low visibility due to smoke, complex buildings, threats). In some of these environments, training is presented as a game: proper responses are assigned better scores and the completion of one scenario allows trainees to access new, more challenging levels of the game (Backlund, Engstrom, Hammar, Johannesson, & Lebram, 2007; Chittaro & Ranon, 2009; Smith, & Trenholme, 2009). Studies of the effectiveness of virtual training have obtained satisfactory results in performance within the virtual environment (Backlund, Engstrom, Hammar, Johannesson, & Lebram, 2007; Mol, Jorge, & Couto, 2008; Tate, Sibert & King, 1997; Toups, Kerne, Hamilton, & Shahzad, 2011), in one case affected by prior expertise with similar computer environments (Smith, & Trenholme, 2009).

These environments focus on the procedural response to an emergency situation, such as how firefighters can properly issue a set of commands to other firefighters and extinguish a fire

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[1] Virtual environments are constituted of synthetic sensory information generated by a computer system and can lead the user to perceive an environmental context. Such a computer system comprises "some or all of the following components: a stereoscopic HMD *[head mounted display]*, with a wide field of view; a tracking system to capture hands, head, and body motion; a data glove to capture hand gestures for basic manipulation and exploration tasks; and software for rendering the scenario, which also communicates with several external devices and enables automatic data collection" (Duarte, Rebelo & Wogalter, 2010, p. 530). Immersive virtual environments (IVEs) isolate the user from the sensorial information of his/her real context through an HMD that provides visual and auditory synthetic stimuli and blocks visual and auditory stimuli from the real context.

"with the least amount of danger to the firefighters and the least amount of damage" (Julien & Shaw, 2003, p. 1), or how the environment should be systematically and thoroughly scanned to find people to evacuate (Backlund, Engstrom, Hammar, Johannesson, & Lebram, 2007). Although several virtual training environments are designed to induce stress by adding time limits or threatening visual and auditory stimuli (Backlund, Engstrom, Hammar, Johannesson, & Lebram, 2007; Chittaro, 2014; Tate, Sibert & King, 1997; Toups, Kerne, Hamilton, & Blevins, 2009) or virtual humans that show emotional states, personality, and mood (e.g., Dugdale, Pavard, Pallamin, el Jed, & Maugan, 2004), none focus on psychological response to fire emergency. By psychological response, we mean the psychological processes involved in responding to an emergency, such as interpretation of the situation, affective valuation of the experience, regulation of behavior expectations based on social norms, and influences of personality traits. Such aspects are crucial to virtual training for at least two reasons.

First, investigating psychological response to the virtual emergency is a way to validate the simulation on which the training relies (Williams-Bell, Kapralos, Hogue, & Weckman, in press), demonstrating that it actually succeeds in creating an emergency experience in the users. This kind of validation is typical of other kinds of virtual reality applications, such as treatments to overcome phobias or addictions, where the virtual environment is tested to check if the user actually experiences anxiety when exposed to the virtual stimuli or feels present in the virtual environment (Spagnolli, Bracken, & Orso, 2014). This can be considered a "manipulation check," testing that the manipulations of independent variables actually occur as intended, and is particularly important for simulation studies (Gravetter & Forzano, 2011, p. 217). In virtual fire emergency training, we are aware of only two studies that included this kind of validation. The first (Dugdale, Pavard, Pallamin, el Jed, & Maugan, 2004) designed avatars and emergency situations based on field studies and tested the effectiveness of the system in conveying avatars' gesture and emotional expressions to users. The other study (Kobes, Helsloot, de Vries, & Post, 2010a) checked whether evacuation behavior in a virtual hotel building is similar to that observed in a real hotel building, with positive results. However, it would be ideal to include this kind of validation in any presentation of virtual environments for emergency training.

Second, psychological factors might undermine how the individual reacts during an emergency. Kobes, Helsloot, de Vries and Post (2010b) mention several human factors that can affect the response to fire emergency and should be taken into account during any intervention to increase safety: personality traits (leader vs. followers, stress resistance, self-efficacy), ability to perceive danger (studied in ergonomics of emergency signals, e.g., Duarte, Rebelo, Teles & Wogalter, 2014; Jiamsanguanwong & Umemuro, 2014), relationships with other people involved, task commitment, and role and responsibilities prior to emergency. Helping behavior, "an intentional action that has the outcome of benefiting another person" (Dovidio & Penner, 2001, p. 162) and often part of fire emergency training, can be affected by several factors including the number of other people involved, the characteristics of the person in need (e.g. responsibility for his/her own state of need, attractiveness), and shared group membership (e.g. ethnicity) (Dovidio & Penner, 2001). Studies have found that black targets receive less and slower help than white targets when at risk of suffering severe harm (Saucier, Miller, & Doucet, 2005). Research in virtual environments has studied racial prejudice and discrimination (Burgess, Dill, Stermer, Burgess, & Brown, 2011; Dotsch & Wigboldus, 2008; Eastwick & Gardner, 2008; Groom, Bailenson, & Nass, 2009; McCall, Blascovich, Young & Persky, 2011; Peck, Seinfeld, Aglioti, & Slater, 2013; Vang & Fox, 2014) as well as pro-social behavior (Gillath, McCall, Shaver, & Blascovich, 2008; Kozlov & Johansen, 2010; Rosenberg, Baughman, & Bailenson, 2013; Slater et al., 2013; Zanon, Novembre, Zangrando, Chittaro, & Silani, 2014), but no study has yet considered them in conjunction.

We will focus on racial discrimination in helping behavior during a virtual emergency. We will first validate the virtual emergency with behavioral and self-reported measures, then investigate the possible effect of victim ethnicity on help provision in two different types of emergency: time pressure and fire. We will first describe the rationale of the study and the scientific background of its hypotheses (section 2); then present the study method (section 3) and report the results of the data analysis (section 4). Finally, we will discuss results and reflect on their implications for virtual training (section 5).

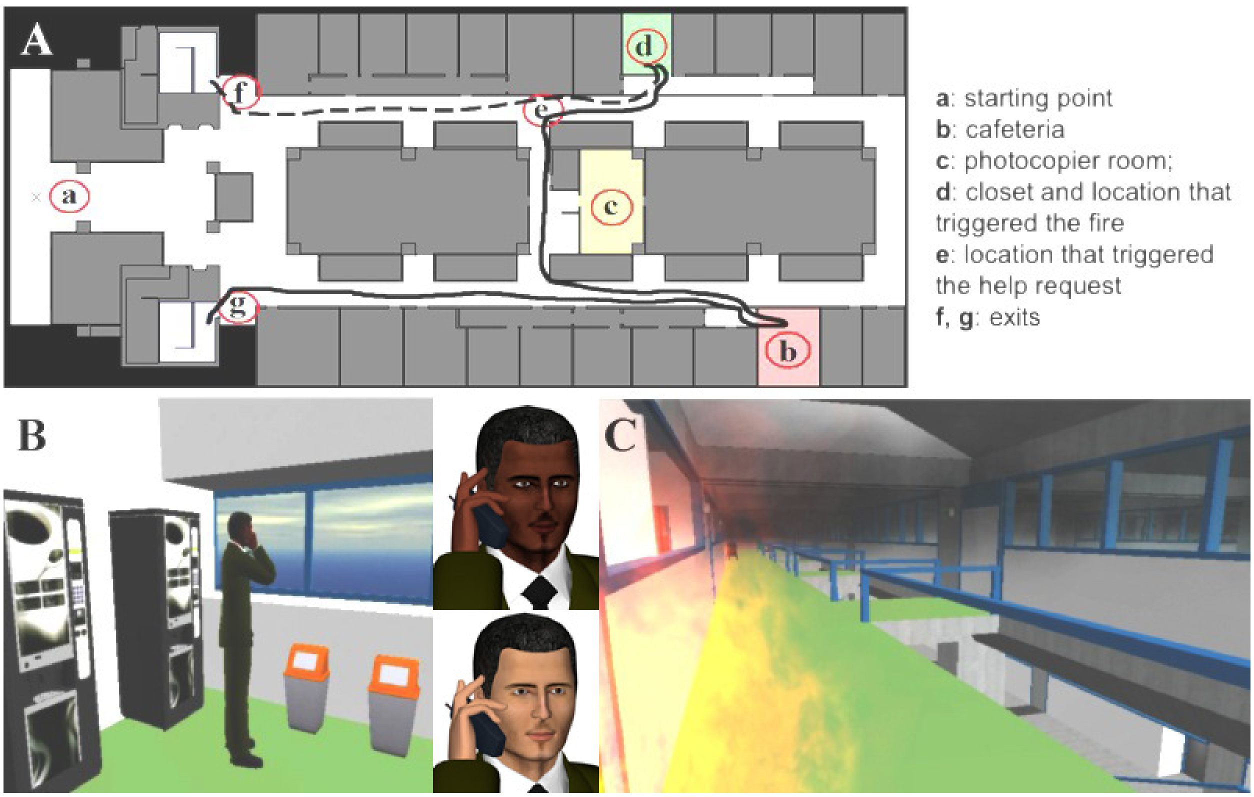


Fig. 1. Views of the IVE used in the study, including the relevant locations in the building and route to the exits, both with (continuous line) or without (dotted line) a detour to the victim located in the cafeteria (a); the virtual human standing in the cafeteria during the exploration phase, in the different ethnicity and same ethnicity conditions (b); fire and smoke spreading in the IVE in the Fire condition (c).

The Present Study

The study uses a virtual environment reproducing an office building. In its central phase, participants are asked to first reach a closet in the building and then go to the exit doors. After reaching the closet, participants hear a cry for help coming from a virtual human they had met in the cafeteria of the virtual building during a prior phase of the experiment. The virtual human (either black or white) is the victim and the participant is the potential helper; nobody else appears in the environment until the participant has decided to help or not, because “the belief that others will take action can relieve a bystander from assuming personal responsibility for intervention" (bystander effect; Dovidio, Penner, 2001, p. 164). When participants hear the cry for help, they are free to head to the exit doors as instructed or go to the cafeteria from which the virtual human has called for help. The two possible paths diverge, to make the participant's decision to provide help immediately or not accessible to analytic observation (Figure 1).

While the virtual victim was in an emergency situation in all conditions, we manipulated the type of emergency between a fire or time pressure. Fire emergency is typical of virtual emergency training (Cha, Han, Lee, & Choi 2012; DeChamplain, Rosendale, McCabe, Stephan, Cole, & Kapralos, 2012; Dugdale, Pavard, Pallamin, el Jed, & Maugan, 2004; Julien & Shaw, 2003; Li, Jin, Li, Guo, Peng, & Chen, 2004; Mol, Jorge, & Couto, 2008; Ren, Chen, & Luo, 2008; Tate, Sibert & King, 1997; Toups, Kerne, Hamilton, & Blevins, 2009; Toups, Kerne, Hamilton, & Shahzad, 2011). Time pressure is a typical emergency used in social psychology studies of discrimination in helping behavior (Darley & Bateson, 1973; Guéguen, Martin & Meineri, 2011; Saucier, Miller, & Doucet, 2005). In a third, control condition, no emergency (neither fire nor time pressure) affected the participant.

Thanks to this design, the study could pursue three objectives (Figure 2): checking whether participants reacted to a virtual emergency as if it were actually an emergency (objective 1); determining whether the response to the help request was subject to racial discrimination (objective 2); assessing whether racial discrimination depends on the kind of emergency experienced by the potential helper (objective 3).

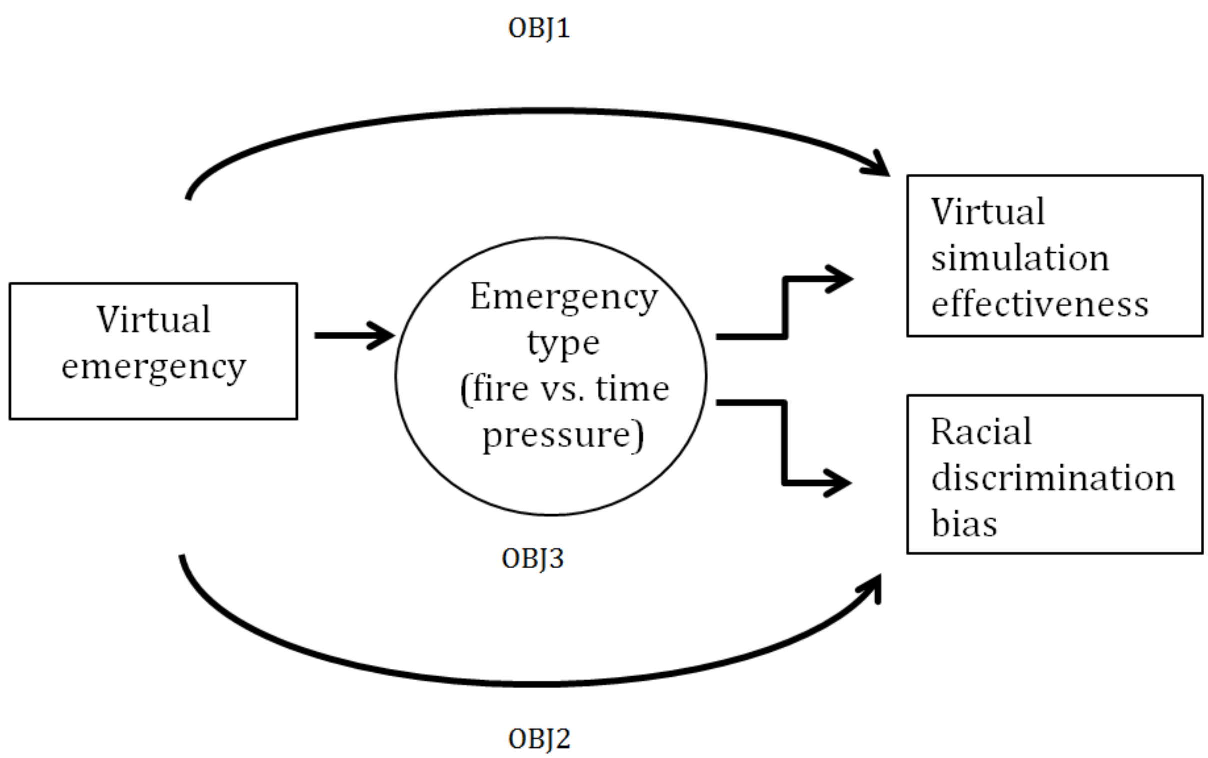


Fig. 2. Representation of the objectives of the study.

Objective 1: Effectively Inducing an Emergency with a Virtual Environment

The first objective of the study was to test if participants actually responded to the simulated emergencies as if they were in an emergency. We used both behavioral and self-reported measures to perform this validation.

Malbos, Rapee and Kavakli (2012) collected several indices of behavioral measures in an inventory related to various simulated disasters: for a fire disaster, the inventory included freezing, rapidly escaping, looking around frenetically, changes in breathing, gasping, exclamations, locomotion movements and avoiding approaching fire when walking. These behaviors are detected through observation by a trained rater. Bode and Codling (2013) also used observation to identify which exit route was followed in an evacuation task with or without stress-inducement; Gamberini, Cottone, Spagnolli, Varotto, and Mantovani (2003), to user's hesitancies after the break of the fire; Kobes, Helsloot, de Vries, and Post (2010), to identify specific fire safety behaviors (inspection of the escape route, use of fire escape maps and use of the green exit signs in the corridor). Behaviors can also be detected automatically and recorded as they occur. Some behaviors can require a special apparatus: Meng and Zhang (2014) collected eye fixation duration to measure the speed of visual exploration of the environment with or without a fire emergency. Other behaviors can be automatically collected by the virtual environment itself: Meng and Zhang (2014) recorded time required to start moving and time to reach the emergency exit since the beginning of a wayfinding task; Gamberini, Cottone, Spagnolli, Varotto, and Mantovani (2003) recorded the frequency and length of forward and backward movements in the virtual space as well as frequency of collisions with objects in the virtual environment. Since participants in our experiment wore an HMD, we used two behavioral indices of effectiveness based on navigation behavior which require no additional detection apparatus: frequency of collisions before and during the emergency, and frequency of backward movements, before and during the emergency. The former detects when the participant's virtual body bumps against a (steady) object in the virtual environment, such as the frame of a door or a wall, because of a mistake in controlling the trajectory of his/her movement. This index was found to increase after a firebreak, as a consequence of movements planned more roughly to move quickly (Gamberini, Cottone, Spagnolli, Varotto, & Mantovani, 2003). Backward movements occur when the participant backs up while moving in the virtual environment as if going into reverse. This index was found by the same authors to increase after fire, both to correct imprecise routes and to retract in front of fire. We expected collisions and backward movements to significantly increase during emergency.

Virtual simulation effectiveness, H1. Collisions and backward movements while navigating in the virtual environment are more frequent after the emergency is induced (during the help request phase of the study, see Method section) than during exploration (the preparatory, baseline phase of the study, see Method section).

Among self-reported measures showing that the user actually experiences the virtual emergency as an emergency, we considered anxiety. Anxiety is "an unpleasant affective experience marked by a significant degree of apprehensiveness about the potential appearance of future aversive or harmful events" (DiTomasso & Gosch, 2002, p. 1). It is a commonly used measure of validity in virtual environments aimed at triggering fear and phobias for psychological treatment (Spagnolli, Bracken & Orso, 2014). It represents an expected response to both the emergency situations we created, since a timely response was relevant due to either instructions or the danger of the virtual situation. Like Smith, Petruzzello, Kramer, and Misner (1997), we used the state anxiety inventory which measures the level of temporary anxiety induced by a specific event considered as dangerous (Spielbergerer, 1983). We compared state anxiety after the exploratory phase, where the participant is only asked to explore the environment without any temporal constraint or risk, with state anxiety measured after the completion of the third phase of the experiment, when emergency was manipulated.

Virtual simulation effectiveness, H2: In the two emergency conditions, state anxiety after the help request phase (in which the emergency was manipulated, see Method section) is higher than after the exploration phase (the preparatory, baseline phase of the study, see Method section).

Objective 2: Racial Discrimination in Responding to the Help Request of a Virtual Human

Ethnicity affects the likelihood of receiving help, because it relates to at least two characteristics of the victim known to affect help provision: similarity with the helper and membership of the same group as the helper (Dovidio & Penner, 2001). Being of the same ethnicity as the helper makes the victim appear more similar, and people act more favorably towards people perceived as similar to them; furthermore, it makes the helper feel a member of the same (ethnic) group as the victim, and members of the same group are treated more favorably than non-members. There is a strong social expectation that people help a victim in need because this behavior complies with a set of social norms and help withdrawal would be socially sanctioned (Dovidio, Penner, 2001). However, if a white helper has some racial prejudice and if racial discrimination is hidden behind a rational justification not related to race, then discrimination against black victims is more likely to occur (Gaertner & Dovidio, 1977; Crandall & Eshleman, 2003; Saucier, Miller, & Doucet, 2005). In our study, participants could justify help withdrawal by mentioning they were explicitly instructed to go to the exit doors of the virtual environment, which were in a different direction than the room the virtual victim was, or the fact that the emergency was not real, so we expected some help withdrawal. However, we expected help withdrawal to occur more frequently with black rather than white virtual humans.

Racial discrimination, *H3: A help request from a black virtual human receives a positive response from white participants less frequently than when the same help request comes from a white virtual human. In other words, the frequency of help offered to the black virtual human is lower than that offered to the white virtual human in the whole sample.*

Objective 3: Effect of Emergency Type on Racial Discrimination

Time pressure. Helping behavior is less likely to be observed when the helper is under time pressure (Darley and Bateson, 1973; Kozlov and Johansen, 2010). When the victim is black, we assume that time pressure might lead to increased discrimination by white participants. In their meta-analysis carried out with 31 journal articles, Saucier, Miller and Doucet (2005) found that when the situation includes temporal constraints, discrimination against black victims is more likely to be found. The authors explained this phenomenon with the aversive racism theory (Gaertner & Dovidio, 1986) and the justification-suppression model (Crandall & Eshleman,

2003) according to which time constraints would provide justification to racially prejudiced people to withhold help to black victims. In our study, where the control condition already offers some justifications for withdrawing help (instructions concerning destination to reach and fictitious nature of the victim), we can assume time pressure adds one more justification, further reducing the cost of not helping (Piliavin, Dovidio, Gaertner, & Clark, 1981), and increasing racial discrimination.

Emergency type, H4: When the potential helper is under time pressure, discrimination in helping behavior against the black virtual human increases relative to the control condition with no time pressure. In other words, in the time pressure condition, the frequency and promptness of help offered to the black virtual human compared to the white virtual human is lower than in the control condition.

Fire. In the fire condition, the participant witnesses the start of a fire in the virtual environment immediately before hearing the cry for help. Although this is a situation in which the participant might feel appropriate to reach the exit doors as soon as possible, as in the time pressure condition, there are deep differences in the way in which we expect the victim to be categorized. First of all, a fire makes it easier to realize that help is required. Such recognition is the first step in the process leading to providing help, according to Latanè and Darley (1968). In the control condition, the reason for the help request is unknown and there is no other cue but the verbal request to indicate that the virtual human needs help; in the fire condition, flames and smoke are visible, indicating the virtual human is in real trouble for external reasons for which the victim is not responsible (an important factor according to Weiner, 1980). In addition to being a very clear emergency situation, both the victim/virtual human and the participant/potential helper share the same kind of emergency, since they are both fire victims. This is different from the control condition (and the time pressure condition), where the helper experiences no emergency (or a different kind of emergency than the virtual human). According to the Common In-group Identity Model (Gaertner & Dovidio, 2005), the discrimination of people who are not members of one’s own group decreases if those people are recategorized as members of another group of which both are members. In other words, what is salient would not be the differentiating factor of ethnicity, but an attribute according to which they are part of the same group, fire victims. The likelihood of this recategorization during emergency situations such as fire and other disasters is argued by the Social Identity Model of Collective Resilience, which explains cooperative behavior among groups of strangers during disasters (Drury, Cocking, & Reicher, 2009a, Drury et al, 2009; Levine, Prosser, Evans, & Reicher, 2005; Reicher, 1984).

Emergency type, H5: A fire does not increase racial discrimination against a black virtual human, compared to the control condition. The frequency and promptness of help offered to the black virtual human compared to that offered to the white virtual human is not lower in the fire emergency with respect to the control condition.

Method

Equipment

The immersive virtual environment (IVE) used in the study was implemented using the NeoAxis game engine (www.neoaxisgroup.com) and the C# programming language. Participants experienced the IVE through a head-mounted display (resolution: 800 x 600; field of view: 60 degrees; head tracker) and in first-person view. The direction and orientation of the field of view in the IVE were controlled by the participant's head position, while forward/backward movement and opening of doors were controlled with a wireless joystick (by moving the stick up and down and by pressing the joystick button, respectively). Movement speed was constant.

Procedure

Participants filled out an informed consent form that outlined the length and general structure of the session and the kinds of data collected, along with some alert notes about the temporary discomfort immersive equipment may cause to some participants (cybersickness). We told participants that the study concerned spatial orientation in virtual environments. Its real goal was disclosed in the debriefing after the end of the session. Participants then filled in the state section of the State-Trait Anxiety Inventory (STAI; Spielbergerer, 1983). Then we handed participants an instruction sheet explaining how to move in the IVE and they wore the helmet.

The immersive session was divided into three phases (familiarization, exploration, and help request), separated by short breaks; instructions related to each phase appeared on the screen of the head-mounted display before the phase started.

Familiarization phase. The participant was immersed in a simple IVE aimed at practicing with the controls. The experimenter made sure that every action useful in the subsequent phase was practiced (moving forward, backward, left, and right; avoiding obstacles; climbing up and down stairs; opening doors).

Exploration phase. The participant was immersed in the experimental IVE, which represented a public building with offices and meeting rooms. The goal of this phase was to make sure that participants knew some locations relevant to the third phase of the study, and that they met the virtual human in the environment. The session started from a designated point in the virtual building, and we asked the participant to reach five locations in any order (elevator, closet, photocopier room, cafeteria, and exits; Figure 1A); all locations were on the same floor of the building, the one used in the third phase of the study. When participants found one of the assigned locations, they had to announce it aloud. This phase ended when all locations were found. In one of these locations, the cafeteria, the participant met the virtual human (Figure 1B). The virtual human spoke on a mobile phone, saying (in Italian), "Hello, this is [name]. How are you?" and then "Yes… good… sure," as if replying to somebody on the phone. He represented either a white Italian man named Mario, whose voice was recorded by an Italian speaker, or a black Center-South African man named Nkhangweleni, voiced by an Ivorian speaker.

Help request phase. The participant was asked to go to the closet of the virtual building and then exit the floor. Under the time pressure condition, the participant was instructed to reach the exit door "as quickly as possible." After reaching the closet (location "e" in Figure 1A), the participant heard the cry for help ("Help me, I'm [Mario/Nkhangweleni]. I'm stuck; I'm in the cafeteria—come here and help me!"). In the fire condition, a fire broke out at the same time (Figure 1C). The task ended when the participant reached the exit doors, with or without helping the virtual human. Participants who reached the virtual human in the cafeteria found a second virtual human near the victim. The second virtual human was dressed in a typical emergency medical service suit and said, "I'm taking care of him; you go to the exit." This second virtual human was introduced to avoid that participants started any attempt to actually "help" the victim, since no interaction was actually possible with the victim; and to direct participants to the exit doors so that they could eventually complete the session.

This three-phase session lasted about 30 minutes. Afterwards, the state anxiety measures were collected again.

Study Design

We followed a 2 x 2 x 3 study design, with one within-subjects variable (Phase) and two between-subjects variables (Ethnicity and Emergency). Each between-subjects condition involved 16 participants (8 female, 8 male). The ethnicity of the virtual human was either the same as the participant (white) or different (black). In all between-subjects conditions, the virtual human was stuck in the cafeteria and asked for help; the emergency varied in three different ways: participants either had to complete the task as quickly as possible (time pressure) or encountered the fire in the virtual environment (fire) or neither (control condition).

Participants

The participants were Italian and white. They were psychology students (N = 96; 48 women, 48 men) who volunteered to participate without any reward. Their mean age was 24 (SD = 2.82). Recruitment was based on convenience sampling, by approaching students in the campus or by posting announcements on social media used by university students. Announcements stated that the study concerned spatial orientation in a virtual environment, and did not mention racism or emergencies.

No participant had a prior knowledge of the building reproduced in the virtual environment. African people are a stigmatized minority in the participants' culture: Center-South African migrants are a recognizable minority in Italy and their presence in the country is a major target of political and public debate, including exclusive stances (Calavita, 2005).

Data

The occurrence of *racial discrimination* during the help request phase was determined by a post-session graphical representation of participants' route in the virtual environment, which was automatically generated by the IVE. The system collected and mapped the sequence of participants' positions (the x and y coordinates on the IVE map) sampled at a 10 Hz frequency. This allowed us to check whether, after hearing the help request, the participant went to the cafeteria where the virtual human was or instead headed directly to the exit doors (Figure 3). If the participant went to the cafeteria, this was taken as help provision, and discrimination in the sample was determined by the relation between the number of black and white virtual humans whose help request produced help provision.

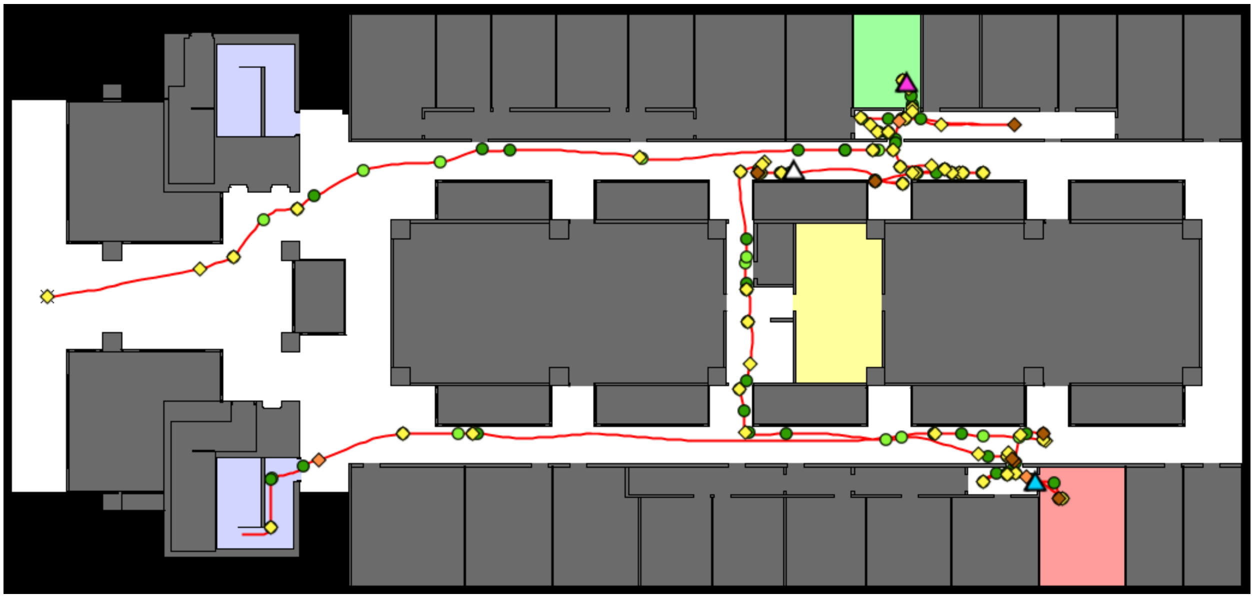


Fig. 3. Graphic representation of the route followed by the participant, automatically generated by the virtual environment at the end of each session. The symbols on the route represent specific events (fire) or commands (backward movement).

Additional data about participants' behavior was automatically recorded in a log file during the interaction with the virtual environment. Two types of data were used to measure the *effectiveness* with which the emergency was induced in the participant:

- frequency of participant's collisions with objects in the virtual environment (number of collisions per second);
- frequency of participant's backward movements (frequency of activation of the backward command per second).

To measure the *promptness* with which help was provided, we considered the subsample of participants who provided help and measured the time elapsed between the help request and the completion of the session by reaching the exit door, as well as the time spent without moving during this interval. These two measures together were meant to capture the hesitancies in users' response to the help request. To rule out the possibility that a longer time taken to complete the task was due instead to a longer route taken, we also measured the spatial distance (in meters) walked in the virtual environment after the help request until the participant reaches the exit doors.

Finally, the scores of the *state anxiety* section of the Italian version of the State-Trait Anxiety Inventory (STAI, Spielberger, 1983, translated by Pedrabissi & Santinello, 1989) were collected; the state section is comprised of 20 items with a response scale ranging from 1 to 4 (1 = not at all, 4 = a lot). The score assigned by the inventory to each respondent is the sum of the single item scores. Unlike the "state" section, the "trait" section of the State-Trait Anxiety Inventory measures anxiety as the tendency of a person to experience anxiety in response to any situation, and was not relevant here. The inventory is protected by copyright; therefore, its items cannot be included in this paper, but psychometric properties of the inventory are described in Spielberger (2010). All statistical analyses were carried out with SPSS v. 18.

Results

Effectiveness of Emergency Virtual Simulation

The navigation behavior during the exploration and help request phases was analyzed using a mixed model for repeated measures, with Phase and Emergency as factors. We compared the frequency of collisions and backward movements per second during the exploration phase with those during the help request phase after the participant reached the required location in the virtual environment (the event that in the fire condition triggered the fire). The results show significant interactions between Phase and Emergency for collisions ($F(1,93) = 6.478$, $p = .002$, $\eta_p^2 = .122$ (Figure 4)), and backward button usage ($F(1,93) = 12.506$, $p = .001$, $\eta_p^2 = .212$ (Figure 5)). A post-hoc analysis indicates the frequency of collisions during the help request phase was higher than during the exploration phase, in both the fire ($F(1,93) = 37.939$, $p = .001$, $\eta_p^2 = .290$) and time pressure conditions ($F(1,93) = 27.485$, $p = .001$, $\eta_p^2 = .228$), but not in the control condition. A post-hoc analysis of the frequency of backward button usage indicates it was higher in the help request phase than in the exploration phase of the fire condition ($F(1,93) = 8.185$, $p = .005$, $\eta_p^2 = .081$). Finally, the navigation behavior of the groups assigned to the different conditions did not differ during the exploration phase.

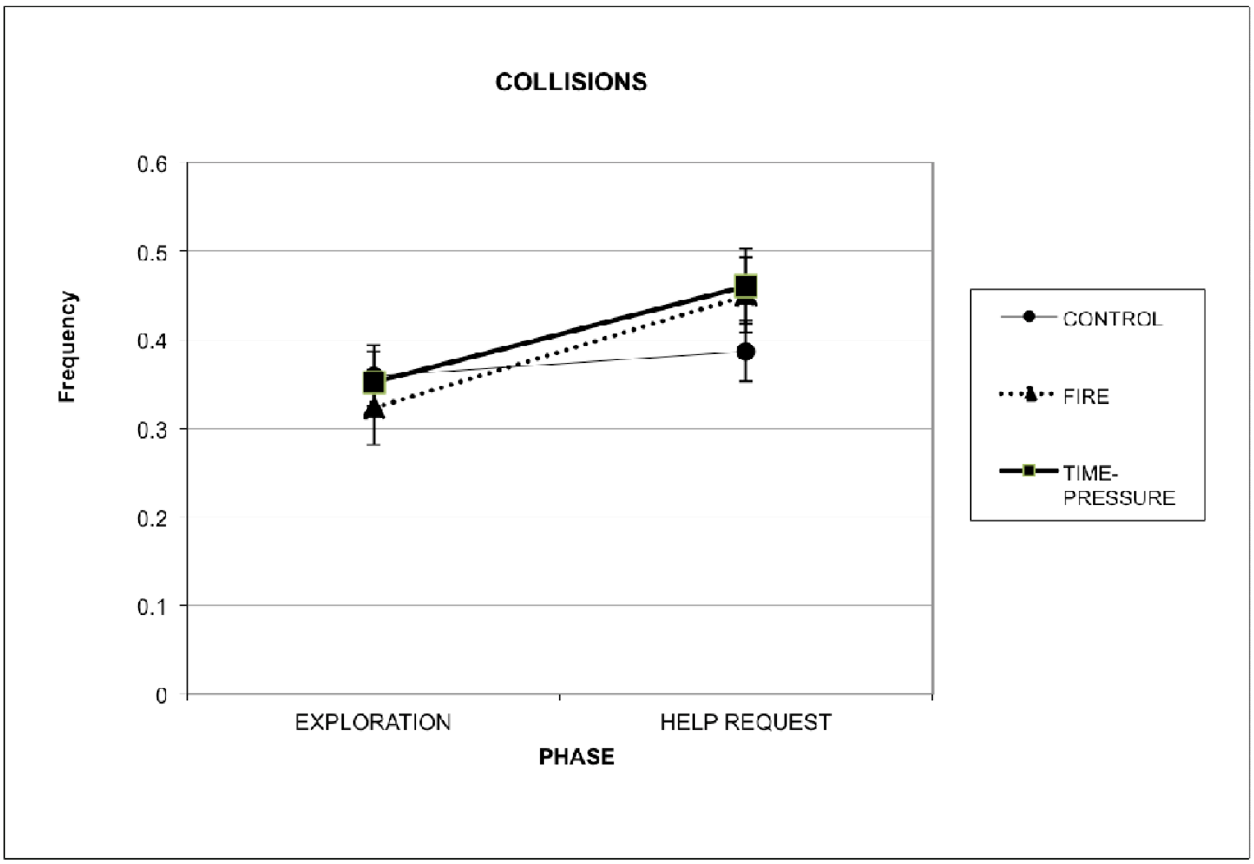


Fig. 4. Frequency of collisions in the different phases of the session and in the three emergency conditions.

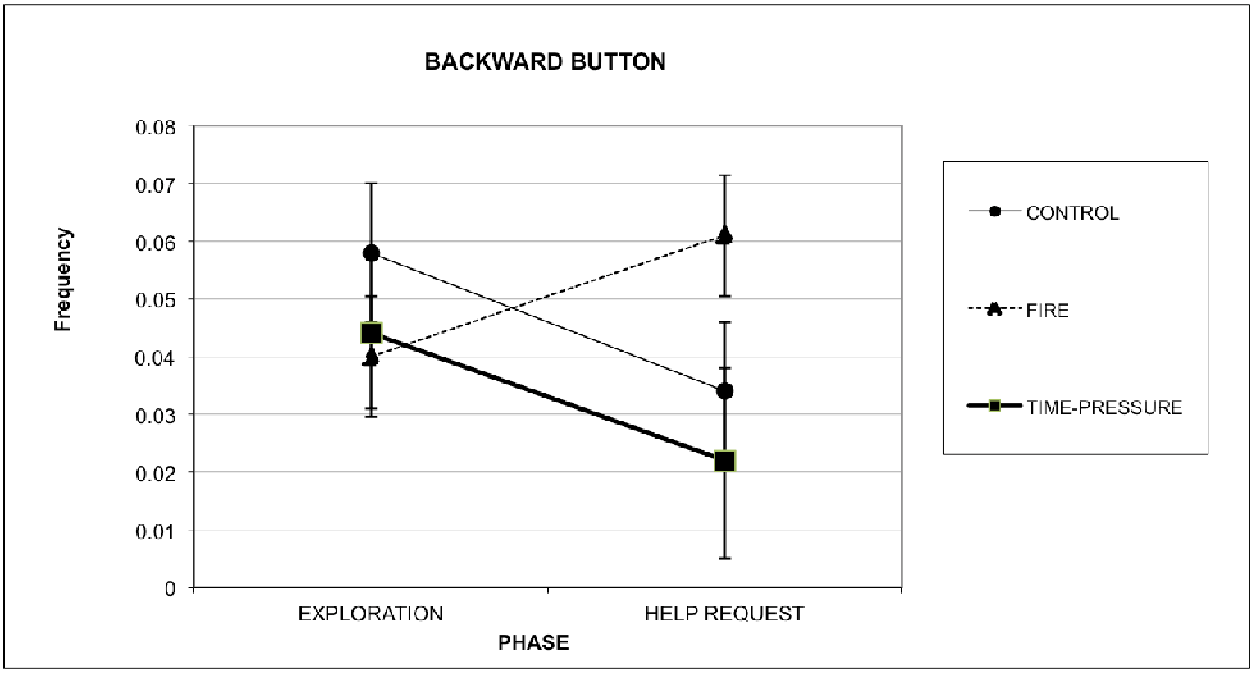


Fig. 5. Frequency of backward button use in the different phases of the session and in the three emergency conditions.

A second indication that the emergency was treated as such by the participant was the state anxiety score; scores measured before and after each session were analyzed with a mixed-model for repeated measures with Time, Emergency, Gender and Ethnicity as factors. Since women tend to report higher intensities of fear and anxiety than men (McLean & Anderson, 2009) for a review, we added Gender to the analysis. As predicted, the test showed a main effect of Time ($F(1,73) = 39.046$, $p = .001$, $\eta_p^2 = .348$) and Emergency ($F(1,73) = 3.225$, $p = .046$, $\eta_p^2 = .081$), as well as a significant interaction between Time and Emergency ($F(1,73) = 3.683$, $p = .030$, $\eta_p^2 = .092$ (Figure 6)). The LSD post-hoc criterion indicates that post-test state anxiety was significantly higher than pre-test anxiety in fire (pre-test M = 34.027, post-test M = 45.961, $F(1,73) = 24.116$, $p = .001$, $\eta_p^2 =.248$) and time pressure conditions (pre-test M = 33.129, post-test M = 44.881, $F(1,73) = 24.321$, $p = .001$, $\eta_p^2 = .250$), but not in the control condition (pre-test M = 31.898, post-test M = 35.020, $F(1,73) = 1.514$, $p = .223$). The other factors (Gender and Ethnicity) did not interact with Time.

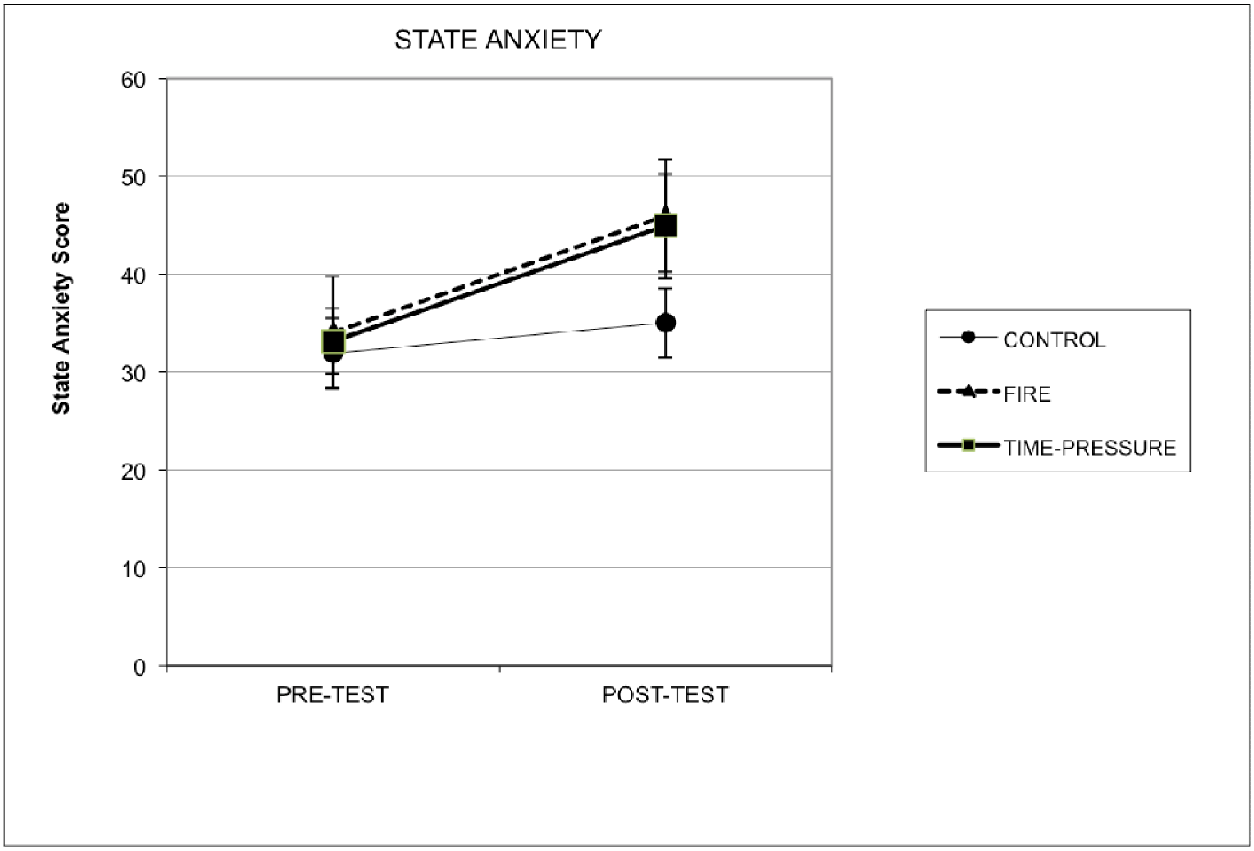


Fig. 6. Pre-test and post-test state anxiety scores in the three emergency conditions.

Overall Discrimination Bias in Helping Behavior

Overall, 65 participants out of 96 (67.7%, 33 men, 32 women) made a detour with respect to their assigned destination (the exit) to reach the cafeteria, where the virtual character had cried for help. As predicted, this behavior was affected by the ethnicity of the virtual human: help was provided less frequently to the black virtual human than to the white one (52.1% versus 83.3%; χ^2 (1, N = 96) = 10.720, p = .001, Cramér's V = .334).

Discrimination in the Different Emergency Types

Considering the specific kind of emergency (Figure 7), we observed significant discrimination against the black virtual human in the time pressure condition, χ^2 (1, N = 32) = 8.000, p = .005, Cramér's V = .500, but not in the control condition, χ^2 (1, N = 32) = 3.282, p = .07, and in the Fire condition, χ^2 (1, N = 32) = 1.391, p = .24. No interaction between Emergency and Ethnicity was found after a multinomial logistic regression (p = .287).

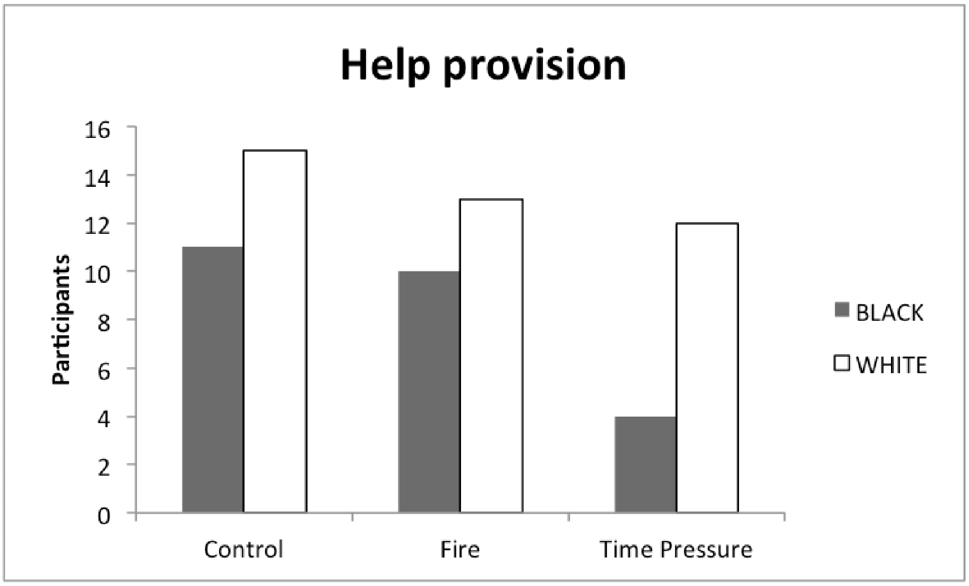
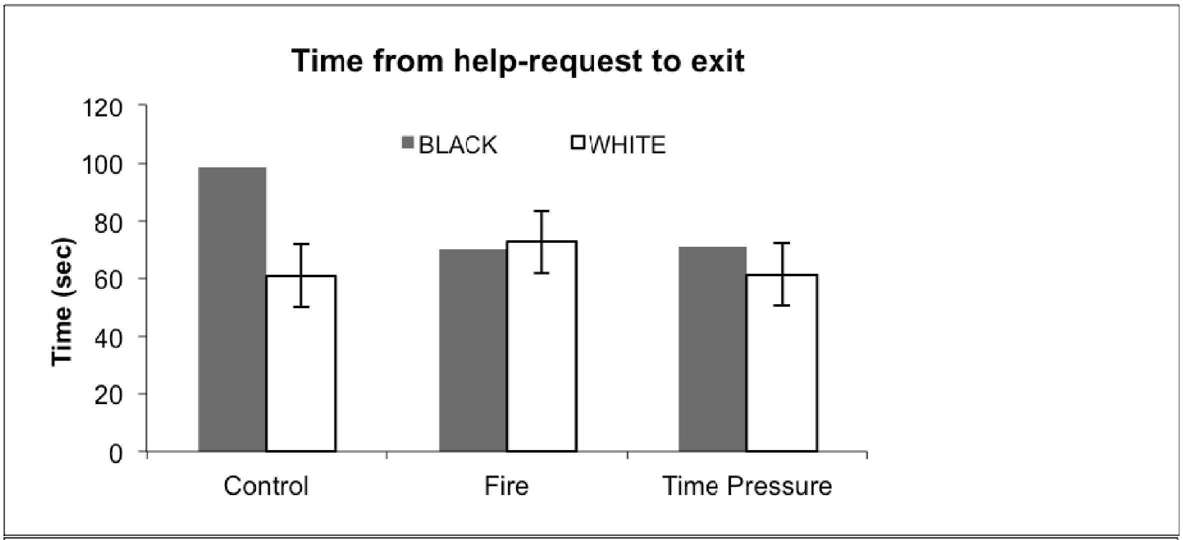
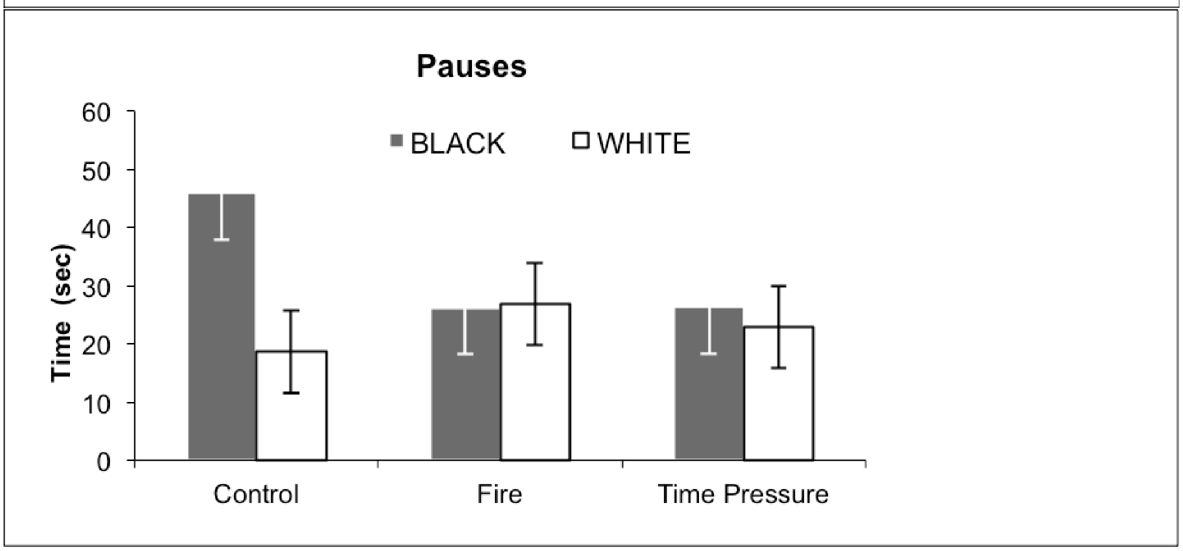


Fig. 7. Amount of participants providing help to the black/white virtual human in the three emergency conditions.

Promptness of help provision for the 65 participants who provided help was also analyzed. A MANOVA was used to test the joint effect of Emergency and Ethnicity on the: (i) distance walked in the IVE after the help request, (ii) time elapsed since the start of the help request until arrival at the exit, and (iii) time elapsed during the intervals in which the participants did not move. No main effect for Emergency was found, but a primary effect of Ethnicity was: the time to reach the virtual human and the pauses were shorter when the virtual human was white ($F(1,53) = 5.304$, $p = .025$, $\eta_p^2 = .091$ and $F(1,53) = 7.090$, $p = .010$, $\eta_p^2 = .118$). Interactions were found between Ethnicity and Emergency for the two time measures ($F(1,52) = 3.905$, $p = .026$, $\eta_p^2 = .128$ and $F(1,52) = 7.360$, $p = .002$, $\eta_p^2 = .217$, respectively). No difference was found for the distance walked in that time period, corroborating that the longer time taken to complete the experiment was not due to a longer route taken but to more hesitancies. A post-hoc analysis using the Bonferroni test indicated that, in the control condition, the time to reach the virtual human and the pauses were shorter when the virtual human was white ($F(1,52) = 17.409$, $p = .001$, $\eta_p^2 = .247$ and $F(1,52) = 27.626$, $p = .001$, $\eta_p^2 = .343$ (Figure 8a, b)).



(a)



(b)

Fig. 8. Time taken to exit (a) and time without moving (b) since the help request (capped bars indicate standard error gap).

Discussion

Participants' navigation behavior changed significantly after both types of emergency began. During that phase, participants were more frequently involved in collisions than during the exploration phase, as if—pressed by the emergency—they could not move along precise trajectories, but adjusted their trajectory after more frequent bumps against obstacles. In addition, in the fire condition, participants performed backward movements more frequently after the fire than in the exploration phase, to retreat from danger or correct trajectory. Therefore, H1 is supported as far as collisions are concerned, and, in the fire condition, for backward movements as well. An increase in backward movements was not observed in the time pressure condition, perhaps due to the fact that this index was taken from Gamberini, Cottone, Varotto, Spagnolli and Mantovani (2003), where only a fire emergency was used. Indeed, backward movements might be more typical of emergencies that involve a danger ahead like flames, which was not present in the time pressure condition.

Anxiety results confirm that the immersive virtual environment could induce state anxiety effectively, since anxiety increased during the help request phase in both emergency conditions, but not in the control condition. This check has rarely been performed in virtual environments for fire training, except by Smith, Petruzzello, Kramer and Misner (1997), who found an increased level of anxiety when their fire simulation was accompanied by high environmental temperature. Overall, participants' observable navigation behavior and self-reported state anxiety show that both virtual emergency situations were actually experienced as an emergency (Objective 1). The virtual environment was thus validated with respect to these indices of emergency.

Concerning helping behavior, H3, H4, and H5 were supported. In the overall sample, the black virtual human was helped by significantly fewer participants than the white one. This indicates that racial discrimination can affect frequency of help provision to virtual humans (H3) (Burgess, Dill, Stermer, Burgess, & Brown, 2011; Dotsch & Wigboldus, 2008; Eastwick & Gardner, 2008; Groom, Bailenson, & Nass, 2009; McCall, Blascovich, Young & Persky, 2009; Vang & Fox, 2014). This encourages the use of virtual humans in studies or training focused on racial discrimination in helping behavior (Objective 2).

Considering the type of emergency (Objective 3), time pressure increased the withdrawal of help based on racial discrimination (H4), whereas fire did not (H5), compared with the control condition without emergency. The hypotheses are then supported with respect to the frequency of help provision. With respect to promptness in help provision, however, H4 was not supported: promptness did not decrease with time pressure. This might be due to the fact that time taken to make a decision is affected not only by willingness, but most prominently by urgency. Ambivalent results in this variable are also reported by other studies (Gaertner, 1982; Fisher, Greitemeier, Pollozek, & Frey, 2006; Kunstman, & Plant, 2008), suggesting that promptness does not seem a good, univocal index of discrimination in emergency.

We explain the effect of time pressure on the frequency of racial discrimination in terms of the aversive racism theory (Gaertner & Dovidio, 1986) and the justification–suppression model (Crandall & Eshleman, 2003), positing that time pressure can provide a justification for racial discrimination. For the fire condition, we hypothesized that discrimination would not increase because the fire provided an interpretative framework that facilitated the recognition of the victim as in trouble (Latanè & Darley, 1968) and recategorized the target as similar to the participant (Gaertner & Dovidio, 2005; Levine, Prosser, Evans, & Reicher, 2005). A possible explanation is that prejudice was set aside in a fire because the risk is more serious than in the case of simple time pressure. However, the literature shows that risk severity per se does not increase likelihood of intervention, and black targets receive less help than white targets when at risk of suffering severe harm (Kunstman & Plant, 2008; Saucier, Miller, & Doucet, 2005).

Although the interaction between ethnicity and emergency did not reach statistical significance in our study, we think the distinctive psychological characteristics of emergencies such as fire are worth additional investigation in further studies with a larger sample. Their difference compared to other kinds of emergencies in terms of effects on racial discrimination and helping behavior is well rooted in theory and backed up by some initial empirical evidence; for instance, helping behavior was observed frequently in natural disasters (Rodriguez, Trainor, & Quarantelli, 2006) and there is evidence of identification with strangers during real and virtual emergencies (Drury, Cocking, & Reicher, 2009; Drury et al., 2009).

In both types of emergency, it seems to be the general framework provided by the overall situation that affects the reaction to the request for help: in the time pressure condition, the situation provides an alternative norm that justifies help withdrawal, while in the fire condition it changes the categorization of the victim. In other words, situational factors in both emergency types have crucial effects on discrimination (Dovidio & Penner, 2001).

Practical Implications for Emergency Training

The main practical implication of this study is that it supports the use of virtual environments to train the psychological response to emergency with specific reference to helping behavior and racial discrimination bias. It does so by showing that emergency situations presented in these environments are recognized as emergencies, that racial discrimination in helping behavior occurs also against virtual humans, and that some situational characteristics of the emergency can affect frequency of discrimination. Although it is clear that provision of help during an emergency also depends on broader political constraints (Avdeyeva, Burgetova, & Welch, 2006), virtual training could help trainees gradually recognize and overcome their biases, an aspect not targeted by current emergency training environments. Virtual training could, for instance, de-emphasize the cues that define a help target as an outgroup member, and emphasize the cues making the help target appear as a victim of the same emergency circumstances as the helper (Gaertner & Dovidio, 2005). The advantage of this strategy would be that trainees would not be forced to relinquish the difference with the victim, but would orient to a superordinate group with respect to which both helper and victim are similar (Gaertner & Dovidio, 2005). For situations in which the helper does not share the same emergency as the victim, virtual training could make the trainee aware of factors that might play a role in withholding help (attribution of responsibility to the victim, ambiguity of the risky situation, bystander effect; Dovidio & Penner, 2001) as well as teaching strategies to sort out rationalizations from facts. The flexibility of virtual environments could help implement this kind of training, where various aspects of the emergency can be manipulated and controlled (Kinateder et al, 2014). More generally, other authors have suggested the use of mediated environments (based on virtual reality or other technologies) to address social identity conflicts: Amichai-Hamburger and Furnham (2007) and Hoter, Shionfeld, and Ganayim (2009) advocate the use of the Internet to facilitate intergroup contact and reduce intergroup conflict; Bachen, Hernandez-Ramos, and Raphael (2012) used simulation games to increase empathy with people living in a different part of the world; Hasler, Hirschberger, Shani-Sherman, and Friedman (2014) used virtual humans to create contact between conflicting groups and increase empathy.

Limitations

Our study could have used other possible validation indices, especially indices of physiological activation, such as heart rate, which change considerably during a fire emergency (Romet & From, 1987).

We also acknowledge that discrimination depends on specific cultural conditions. In our case, black people had recently grown as a minority group in the geographic area in which the experiment was run, and biases against them appeared in the media and the political debate. Generalization to regions with a different ethnic demographic distribution and history must be tested empirically.

Conclusions

The purpose of this paper was to focus on the response to virtual emergencies; advancing current knowledge with a study investigating racial discrimination and helping behavior towards a virtual human are investigated in conjunction. The study presented here suggests that a virtual emergency can be staged in a virtual environment since users would acknowledge it as such. They would respond consistently with an emergency state in terms of navigation behavior and state anxiety. The results also add new evidence that racial discrimination can occur against virtual humans, extending current knowledge about virtual prejudice to the case of help response. We have then suggested possible applications of virtual environments to teach how to overcome the psychological biases that hampers the provision of care during emergency situations. Further psychological aspects of virtual emergencies we are currently exploring concern the specific visual and auditory stimuli able to induce anxiety (Chittaro, 2014) and fear (Chittaro, Buttussi, & Zangrando, 2014) as a real emergency would. We are also studying the improvements in long-term memory retention of emergency procedures that such anxiety-inducing virtual emergencies produce compared to traditional training methods (Chittaro & Buttussi, 2015).

To properly plan and design cues to be included in the training for bias prevention, future studies can examine which conditions are more able to trigger the bias and which factors play a role in differentiating types of emergency in terms of the likelihood of providing unbiased help. Targeting the relevant psychological factors that might prevent a proper emergency response is a largely unexplored research space, which should be embraced to foster an entirely new generation of training environments.

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