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

Luciano Gamberini [a], Luca Chittaro [b], Anna Spagnolli [a,*], Claudio Carlesso [a]

[a] HTLab, Department of General Psychology, University of Padua, via Venezia 8, 35131 Padova, Italy
[b] Human-Computer Interaction Lab, Department of Mathematics and Computer Science, University of Udine, via delle Scienze 206, 33100 Udine, Italy

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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.

1. Introduction

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, Murphy, & 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 et al., 2012; Dugdale, Pavard, Pallamin, el Jed, & Maugan, 2004; Julien & Shaw, 2003; Li et al., 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 et al., 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,

* Corresponding author. Tel.: +39 049 8276644; fax: +39 049 8276600.
E-mail addresses: luciano.gamberini@unipd.it (L. Gamberini), luca.chittaro@uniud.it (L. Chittaro), anna.spagnolli@unipd.it (A. Spagnolli), claudio.carlesso@gmail.com (C. Carlesso).

[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.

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& 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 et al., 2007; Mol et al., 2008; Tate et al., 1997; Toups et al., 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 "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 et al., 2007). Although several virtual training environments are designed to induce stress by adding time limits or threatening visual and auditory stimuli (Backlund et al., 2007; Chittaro, 2014; Tate et al., 1997; Toups et al., 2009) or include virtual humans that show emotional states, personality, and mood (e.g., Dugdale et al., 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 evaluation 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 et al., 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 et al., 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 Vriesc, & 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, 2009; 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).

2. 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 (Fig. 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 et al., 2012; DeChamplain et al., 2012; Dugdale et al., 2004; Julien & Shaw, 2003; Li et al., 2004; Mol et al., 2008; Ren et al., 2008; Tate et al., 1997; Toups et al., 2009, 2011). Time pressure is a typical emergency used in social psychology studies of discrimination in helping behavior (Darley & Batson, 1973; Guéguen, Martin, & Meineri, 2011; Saucier et al., 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 (Fig. 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 depended on the kind of emergency experienced by the potential helper (Objective 3).

2.1. 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