Safety Science 102 (2018) 159–168

Contents lists available at ScienceDirect

Safety Science

journal homepage: www.elsevier.com/locate/safety

Safety knowledge transfer through mobile virtual reality: A study of aviation life preserver donning

Luca Chittaro[a,*], Cynthia L. Corbett[b], G.A. McLean[b], Nicola Zangrando[a]

[a] Human-Computer Interaction Lab (HCI Lab), University of Udine, Italy
[b] Prime Stratagem, LLC, United States

ARTICLE INFO

Keywords:
Aviation safety
Virtual reality
Mobile devices
Safety education
Safety training

ABSTRACT

Aviation safety knowledge is a key factor in determining how passengers will respond in an emergency, but the effectiveness of the tools (preflight safety briefing, safety briefing card) used by airlines to educate passengers about safety has been shown to be lacking. This paper explores how one of these tools could be made interactive in order to increase its effectiveness. In particular, we use Virtual Reality (VR) techniques, adapting them to the constraints imposed by on-board aircraft use, such as usage on non-immersive, small displays. As a practical application, the paper examines aviation life preserver donning, which the literature has shown to be particularly difficult for passengers. To evaluate the proposed mobile VR tool, we contrasted it with the traditional safety briefing card in a between-groups study with 68 participants, age 20–24, focusing on different aspects of effectiveness. The results of the study show that the participants who used the mobile VR tool were able to transfer the presented safety knowledge to the real world, and don an aviation life preserver significantly faster and with fewer errors than participants who used the traditional briefing card. Moreover, these objective results were consistent with subjective ratings by participants; the mobile VR tool was perceived as significantly more engaging, simpler, and more effective than the traditional briefing card. Finally, participants who used the mobile VR tool attained a higher level of self-efficacy. The generalizability of these results would benefit with additional work aimed at an older age cohort that would ostensibly be less familiar with interactive VR technology.

1. Introduction

Aviation safety knowledge is a key factor in determining how passengers will respond in an emergency (Chang and Liao, 2009; Muir and Thomas, 2004; Thomas, 2003; Edwards, 1990), greater knowledge making them better able to handle the situation and better prepared to utilize the emergency equipment in the cabin. The two knowledge-based tools routinely used by airlines to educate passengers about safety are the preflight safety briefing and the safety briefing card. Unfortunately, both of them have been shown to suffer from a serious lack of effectiveness, as shown by empirical studies conducted with passengers (Corbett and McLean, 2007; Corbett et al., 2008; Seneviratne and Molesworth, 2015), interviews of aircraft accident survivors (NTSB, 2000; Chang and Yang, 2011), and accident reports (e.g., NTSB, 2010).

One reason for the lack of effectiveness of current tools is that they are not engaging enough, and as a result only a minority of passengers pays attention to them. Corbett and McLean (2007) found that only 30–40% of people reported that they attended to safety information, and the NTSB (2000, 2010) found similar results in accident investigations. The other major reason is lack of comprehension, even among those passengers who reportedly paid attention to the briefings and engaged the safety briefing card (Corbett and McLean, 2007; Corbett et al., 2008). The ineffectiveness of these current tools has been confirmed by the experiences of aircraft accidents survivors. For example, in the interviews of 110 accident survivors conducted by Chang and Yang (2011), only 14% found the preflight safety briefing to be useful for successfully surviving the accident, and only 16% found the safety briefing card to be effective. The majority of survivors said that they did not believe they were adequately instructed.

In an attempt to face these shortcomings, some airlines have begun to employ preflight safety briefing videos that aim at being more engaging by using humour or employing celebrities as speakers, although the effectiveness of these efforts also remains in doubt. Seneviratne and Molesworth (2015) have provided an initial evaluation of these approaches, contrasting the traditional safety briefing video with these

* Corresponding author at: Human-Computer Interaction Lab (HCI Lab), Department of Mathematics, Computer Science, and Physics, University of Udine, Via delle Scienze, 206, 33100 Udine, Italy.
E-mail address: luca.chittaro@uniud.it (L. Chittaro).

http://dx.doi.org/10.1016/j.ssci.2017.10.012
Received 24 December 2015; Received in revised form 24 December 2016; Accepted 18 October 2017

new types of safety videos, one based on humour and the other presented by a celebrity. Although the humorous video did slightly better, the overall results obtained by the three types of videos were considered "alarming" (participants recalled only about half of the safety information), leading the authors to conclude that "airlines and aviation authorities need to rethink the way in which they convey safety critical information to passengers."

Other researchers (Muir and Thomas, 2004; Chang and Liao, 2009) and reports from aviation safety authorities (Cosper and McLean, 2004; NTSB, 2010) have made similar recommendations, recommending instead more creative approaches, such as interactive technologies (Cosper and McLean, 2004; Chittaro, 2017) or hands-on safety education exhibits at airports (Chang and Yang, 2011).

1.1. Exploring mobile virtual reality for aviation safety briefings

The goal of this paper is to explore and evaluate the possible effectiveness of a novel Virtual Reality (VR) approach to make safety briefings interactive. Among the interactive technologies one could consider, VR appears as a promising choice, based on its increasingly important role in safety training spanning several domains, including fire safety (Cha et al., 2012; Smith and Ericson, 2009), mining industry operations (Grabowski and Jankowski, 2015), construction workers safety (Guo et al., 2012), naval safety (Stone et al., 2009), road safety (Li and Tay, 2014), disaster preparedness (Andreatta et al., 2010), and emergency medical response (Cohen et al., 2013). In addition to showing the effectiveness of VR as a safety training tool, the literature has also emphasized the engagement that VR can create in its users, considering it as a factor that can improve safety training (Grabowski and Jankowski, 2015).

In consideration of aircraft passenger safety briefings, however, two major barriers must be overcome in order to use VR for creating novel types of safety briefings that passengers could use on-board the aircraft. The first concerns the equipment needed to use the interactive tool. Current VR safety training tools are often based on immersive hardware (such as head-mounted displays or multi-screen projections), and even tools that are not based on such special hardware require a personal computer with a good 3D graphics board. This makes it essentially impossible to offer current VR training tools to the passenger on-board an aircraft, restricting their usage to special ground facilities or, in the best case, to home and office environments. An interactive safety briefing tool for aircraft passengers should instead be designed for small screens and less powerful systems that are currently used in the aircraft cabin. The In-Flight Entertainment Systems (IFEs) mounted on the seats of some aircraft support interactive applications and could provide a first opportunity to offer interactive safety briefings. Unfortunately, such IFEs are currently available only on selected long-haul flights. Another opportunity is to exploit the widespread Personal Electronic Devices (PEDs), such as smartphones and tablets, that most passengers bring on-board. Regulatory constraints on PED usage have eased, as the latest FAA and EASA policy is to allow PED use by passengers during all phases of flight. Moreover, it opens up new opportunities for delivering safety knowledge, e.g. the interactive content could be sent together with electronic tickets or boarding passes that passengers already receive on their smartphones, making it possible to use it more discreetly than IFEs and before boarding the aircraft. To overcome the first barrier, this paper focuses on creating a VR tool that can run on the small touchscreens of mobile systems such as those of IFEs and PEDs, including common smartphones. For this reason, we use the term "Mobile VR" in the paper.

The second barrier concerns the design of the content of VR safety training tools, which are typically based on realistic simulations of the emergencies one should prepare for. In aviation safety, such an approach would likely result in 3D reconstructions of serious aircraft accidents and their effects on passengers. All previous work on using VR for safety training of aircraft passengers has followed this simulation approach (Chittaro and Buttussi, 2015; Chittaro, 2016). Unfortunately, although realistic accident simulation is effective when used in on-ground training, such fearful content is emotionally inappropriate for on-board use by passengers (Chittaro, 2016).

To overcome the second barrier, the design we evaluate in this paper aims at creating a reassuring experience that does not expose the user to fearful content as the previously mentioned simulations do. In particular, we focus on creating an interactive version of the non-interactive illustrations that are currently provided by airlines in safety briefing cards and videos.

1.2. Evaluating the approach

As a practical application of the Mobile VR approach, we considered aviation life preserver donning, because it appears particularly difficult for passengers to understand. Indeed, recent studies have shown that illustrations used by airlines to present life preserver donning are difficult to comprehend, even when study participants are given an unlimited amount of time to study them (Corbett and McLean, 2007; Weed et al., 2013). Moreover, the US Airways Flight 1549 accident, in which the aircraft was forced to ditch in the Hudson River after a bird strike, brought significant, fresh attention to the fact that passengers are not knowledgeable about life preservers and not well prepared for using them. In its accident investigation report, the NTSB (2010) noted that many passengers did not even retrieve the life preservers and, of those who did, the majority indicated that they had difficulty donning them. Errors in using life preservers can cause passenger deaths in conditions that would otherwise be survivable, as Chang and Liao (2009) exemplify in their description of two different aviation accidents.

To evaluate thoroughly our Mobile VR tool, this paper contrasts it with the traditional non-interactive illustrations used by airlines on safety briefing cards, and focuses on measuring different aspects of effectiveness. First, we measured knowledge transfer, because any instructional technique (traditional or computer-based) would be of limited value if people could not effectively apply the acquired knowledge to the real world (Carpenter, 2012). The word "transfer" indicates such application of knowledge. As Bertram et al. (2015) recently pointed out in searching the training transfer literature, a lack of studies on the transfer of VR training to reality is apparent. Moreover, the few available studies are based on traditional VR set-ups (immersive or desktop) and, to the best of our knowledge, no study has been conducted on training transfer from Mobile VR. Second, we measured subjective perceptions of users in terms of simplicity and efficacy of the received safety instructions and level of engagement. Third, we included a measure of attitude change. As pointed out by Chang and Liao (2009), in addition to providing passengers with accurate cabin safety knowledge, aviation safety education must also cultivate positive passenger attitudes that could enhance their behavior in an emergency. An important positive attitude is self-efficacy, which can be defined as the confidence in one's ability to perform a behavior. According to Social Cognitive Theory (Bandura, 1997, 2001), this belief significantly determines performance outcomes, and different people with similar skills may perform differently depending on differences in their conviction that they can successfully execute a required behavior. In particular, positive associations between safety training, self-efficacy and attitudes toward safety have been described in the literature (see Grau et al., 2002; Katz-Navon et al., 2007, for summaries). Increasing self-efficacy is particularly important in aviation safety education, because passenger attitudes about aircraft accidents tend to be pessimistic and fatalistic; they believe that there is little hope of survival and/or shift the responsibility and capability of their safety to the cabin crew (Muir and Thomas, 2004). Actually, the majority of aircraft accidents is survivable, as shown by surveys of commercial jet airplane accidents (Cherry, 2013). Moreover, workload and time constraints in aircraft evacuations make it impossible for the crew to provide individual assistance to every passenger.