The Effect of User Control on The Elicitation of Fear in Virtual Reality

Literature Review

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ABSTRACT

The ability of an interactive virtual environment to fully embody a user is unique among affective digital media. This phenomenon, also described as the VR user's sense of immersion, has been shown at length to be positively correlated with the capacity of VEs to evoke strong emotions. This has important implications for the use of VR to create controlled environments for arousing fear in the exposure-based treatment of individuals with debilitating, clinical phobias and anxieties. This review will explore the effects of user control as a means of enhancing the affective emotional content of VEs designed to elicit fear, with reference to psychological theory on agency, emotional processing, and self-efficacy.

KEYWORDS

Virtual reality, Agency, Fear, Psychophysiology, Human Computer Interaction, Affective media, Interactive virtual environments

1 Introduction

Virtual Environments (VEs) use a combination of immersive audio-visuals and Virtual Reality (VR) peripherals in order to "place" a user in a computer-generated world. While VR hardware remains expensive as a consumer electronic device, its cost and the space required to use it has decreased significantly in the past decade [1]. Recent adoption of VR into mainstream forms of entertainment, such as video games [29,33], have seen the technology further integrated into popular culture, continuing this trend of increasing widespread usability.

The immersive experience that VEs offer has great utility in research involving human behaviour [22]. In the context of psychological and social research, VEs allow for the realistic simulation of dangerous, or terror-inducing, scenarios in a way that maintains experimental control [21] and never physically endangers the participant. This is invaluable in the case of Virtual Reality Exposure Therapy (VRET), which has shown positive results for the elicitation and treatment of social anxiety both with professional guidance [13,25], and through the use of a self-guided app [23]. In VRET treatment for specific phobias, patients must be repeatedly faced with fear arousing stimuli in order to overwrite the memory construct in their brain responsible for producing the fearful behaviour [16]. As such, the success of the treatment is predicated on the effectiveness of the VE to elicit fear realistically. This review will approach the topic of the elicitation of fear in VR by, firstly, discussing the pre-requisite conditions for a VE to be considered immersive. Following that, user control in VR will be analyzed with regards to its impact on sense of agency, and the resulting emotion elicited. Finally, the psychological basis for how fear manifests in VR in will be examined, in order to theorize a link between sense of agency, perceived self-efficacy, and fear responses in a VE.

2 Immersive Virtual Environments

2.1 Presence and Immersion

Current research on the elicitation of emotions within VEs is dominated by the relationship between emotional response and the psychological phenomenon of presence [2,3,4,5,7,8,9,10,11]. Presence can be described roughly as the level of involvement that a user feels with the simulated scenario, despite its artificial nature. Defined more formally, Slater's Response-As-If-Real framework [18] proposes two components of presence. Firstly, the concept of Place Illusion (PI), or the belief that one is really in the simulated environment. PI is concerned with how accurately a VE can replicate movement, sounds, and visuals in order to fool our sensory organs into believing that the computer-generated stimuli are real. The second component is Plausibility Illusion (Psi), or the feeling that the simulated events are actually occurring. Psi is concerned with aspects of the VE which remain outside of the user's control, but are still a product their actions, further validating their experience [20]. This includes design elements such as accurate physics simulation for interactable objects, or dynamic shadows in the simulation of a great height to give a realistic sense of scale. Intuitively, the ability of an immersive VE to mimic reality should aid the arousal of an authentic emotional response when targeted by a relevant scenario. This is corroborated by the bulk of the research, which indicates a strong, positive correlation between presence and emotional elicitation [2,4,5,8,9,10,11]. However, presence is not a definitive measure of the capacity of an immersive VE to elicit emotions. Some studies instead suggest a non-linear relationship between the two [3,7], while only a few provide empirical reasoning for the causal primacy of one over the other [3,4,10]. Additionally, common, self-reported methods of measuring presence have also been brought into question. Problems identified with presence questionnaires include: the inadequacy of individuals' ability to measure the experience of being in VR in relation to the rest of their experiences [12], as well as the validity of the content of the questionnaires themselves [13]. This is not to mention the inconsistent definition of the phenomenon of immersion, often characterized as an objective measure of a user's experience of a VE, throughout the literature [14]. In order to effectively combine the concepts of immersion and presence for the purpose of this review, unless stated otherwise, any VEs discussed will assume a sufficiently high level of technological fidelity and quality of narrative to maintain presence. In this way, the scenario presented in the simulation is unambiguous and so is not subject to creative interpretation by the participant, which could lead to unexpected results when measuring emotional elicitation. In doing so, the review can move away from the more theoretical underpinnings of immersive VEs.

2.2 Hardware Components

Immersion in VEs can also be thought of as a way to evaluate how the technical aspects of a modern VR system impact the user experience. Pan & Hamilton [22] suggest 3 defining hardware components that give rise to immersion in a VE:

2.2.1 3D Stereo Vision. In a head-mounted display (HMD) this is created through the use of two screens, each assigned to one of the user's eyes [22]. The visuals displayed on them are combined via the eye's natural image processing to produce the illusion of depth, or an artificial 3D image. The screens are constantly updated at a frame rate matching the capture speed of the human eye, estimated at around 60 frames per second [20]. These factors all work in combination to enhance the user's feeling of PI in the environment.

2.2.2 Surround Vision. This is the component of a VR device that isolates the simulated visuals from the user's real-world surroundings [22]. In an HMD this takes the form of padded plastic casing, which connects the viewing screens to the user's face, while blocking out external light. Mixed reality devices attempt to produce partially virtual environments without the use of surround vision. Instead, as is the case with augmented reality (AR) environments, they utilize the user's real-world surroundings as a backdrop for simulated visuals [32]. As such, mixed reality may lack the immersive qualities required from a VR system to arouse strong emotions. This is possibly reflected in the extensive use of HMDs [2,3,4,5,8,9,10] in studies exploring the link between presence and emotional elicitation in immersive technology, while studies using mixed reality devices, such as AR [32] or mounted 3D TV displays [24] are less common. At present there is too little research comparing the effectiveness of mixed and immersive virtual reality to make any significant conclusions.

2.2.3 Dynamic Control of Viewpoint. In order to simulate dynamic head movement, the display is continuously tracked to the location and orientation of the HMD device in relation to mounted sensors [20]. This helps the user to feel that the viewing camera is integrated with their actual vision, increasing the feeling of embodiment.

3 User Control and Emotions in VR

3.1 Interaction Tasks in VR

In an interactive VE, the user is given selective control over the simulation in order to allow them to complete some interaction task. The most common VR interaction tasks are navigation [6,17,31], object manipulation [10], or a combination of the two in order to achieve some end goal [11,19,29,35] [34]. In a VE designed to elicit emotion, this task may take the form of an action which, itself, produces an emotion-arousing stimulus. For example, in the case of a VR scenario simulating acrophobia, the act of a phobic user looking down from a great height, alone, will result in a significant fear response, as noted by Diemer et al. [6]. Alternatively, the task may prompt a scripted counter action from the environment, intended to stimulate an emotional response. An example of this can be found in a VR horror game, where the user must use a gun to fight AI-scripted zombies, as used in a study by Lin [29]. The task of manipulating the gun to shoot a zombie may not cause a significant emotional response in isolation, but if the zombie's AI is then triggered to wail or writhe around, this stimulus could cause the arousal of fear, disgust or even excitement in the user. To this effect, control, characterized by interaction tasks that cause emotional responses, can be seen as the activating factor in the elicitation of emotion in a VE. Despite this, empirical research exploring the effects of control in interactive affective media is limited.

3.2 Sense of Agency

The concept of agency provides a psychological basis for the link between user control in a VE, and emotional elicitation. Gallagher [37] describes an individual's sense of agency (SoA) as one's belief in the ownership of their actions. In the case of a VE, we can characterize sense of agency as the perceived conformity between the actions that one takes in reality, and their presentation in the simulated environment. Jeunet et al. [30] validated this view of agency in an experiment designed to manipulate the user's perception of their actions within a VE. In the experiment, which used an HMD for visuals, participants were tasked with a series of trials where they were required to copy a sequence of hand movements, as displayed on a diegetic screen within the simulation. These hand movements were restricted to simple actions involving the extension or retraction of the fingers, such as counting or tapping in the air. The participant's hand was tracked by an additional sensor, allowing them to view their own body within the VE. Each trial was split into 6 sub-trials, where the prompted hand movement would not change. Among the sub-trials, half were manipulated such that the representation of the user's hand in the VE was inconsistent with their movement in reality. The study theorized that this discrepancy in movement would cause the participants to experience a tangible loss of control, which they would associate with a loss of agency in their evaluation of each trial. Neural activity measured during the manipulated trials was consistent with electroencephalographic (EEG) activity, which is observed in individuals who feel that they have lost control of their actions, such as clinical schizophrenics [36]. These results were also consistent with the user's self-reported SoA on those trials. This suggests that VR is a sufficient medium to confer a realistic SoA upon a user, and that this is introduced by way of control. From this it follows that, if the emotional impact of the manipulation of a user's SoA can be determined, user control can be assed as another means to enhance the affective quality of VEs.

In an earlier study, Madsen [33] investigated the effect of user control on the capacity of a non-immersive horror video game to evoke fear. The experiment involved two testing groups. The first was tasked with playing an interactive horror game using a standard PlayStation 4 (PS4) and controller, with a television for display. In this case, their interaction task was to navigate the environment, which would play scripted cues when specific locations were reached. The other group would be shown the raw footage from the first group's gameplay with no means to input command. In order to determine the level of fear evoked in both groups, physiological markers were examined at three scripted events, and, after completing the game, participants were made to answer a series of questions about their experience. The results showed that heart rate and respiratory rate of the interaction group increased by a significantly higher amount than the watching group in the 3rd event, where the user was trapped in a small room. In effect, their subject of control, the task of navigating the environment, had become restricted. A possible reason for this physiological response is that the introduction of user control fostered a heightened SoA in the interaction group. Consequently, when control was restricted, due to the user becoming trapped, agency was diminished, resulting in a heightened fear response. In the qualitative evaluations, however, this was not accompanied by a corresponding difference in self-reported fear between the two groups. In fact, the only self-reported measure that the groups significantly differed in was perceived level of entertainment, another valid reason for the physiological differences measured [15]. The results of the study may show evidence of a heightened fear response in participants when control of a simulation is introduced and then suddenly restricted, however, it is also possible that the interaction group was simply more entertained than their watching group counterparts.

More recently, Osking & Doucette [26] investigated the emotional impact of using voice activated control in dialogue driven VR game, designed to provoke sadness. The scenario presented was a video game called *Flowers for Dan dan*. Much of the game takes the form of a conversation between the user character, who is a young boy, and the boy's father, who is distraught over the inevitability of the death of the family's ailing pet dog. To complete the game the user must select from a series of dialogue options that advance the conversation. The participants were split into two groups. The first played through the game using a controller to select the dialogue options, while the second spoke their answers into a microphone, which were then selected for them remotely. Emotional impact of the method of control was then determined by a self-reported questionnaire. The study found that the speaking group rated the game to be more emotionally affective than the controller group. Many from the speaking group said that the voice activated control forced them to engage with the dialogue in visceral and uncomfortable ways, which they might have glossed over if they were using a controller to play. These results raise another question about the nature of SoA in VR: *Do methods of control that more realistically mimic the performed interaction task in a VE heighten user belief in ownership of actions, thus heightening emotional response?*

4 The Psychology of Fear

4.1 Emotional Processing and Avoidance Response

In the context of behavioural psychology, Foa & Kozak [16] give a widely accepted explanation for the intense fear response observed in clinical phobics, known as Emotional Processing Theory. Under their definition, fears are activated when an external stimulus interacts with an informational network in an individual's memory, which they call a fear structure. This network maintains descriptive data about the stimulus, possible behavioural and physiological responses, and interpretations of the stimulus' level of threat in order to inform a plan of response. In other words, the fear structure can be seen as a program designed to escape danger [16]. In order to do so, it must invoke information classifying the feared stimuli as dangerous, and command corresponding physiological activity to prepare for escape. As such, emotional processing provides another lens through which one can analyze the capacity of a VE to elicit fear, in the form of user behaviour.

Kisker et al. [31] investigated realistic behavioural responses in a VE designed to provoke height-related anxiety. Participants were tasked with walking along a series of steel girders in one of two scenarios, where they were either elevated over a city skyline or placed at ground level. The HMD-based VR setup was supplemented with wooden boards in the same configuration as the girders, which the user would walk over during the simulation. This acted as a haptic prop, ensuring that the sensation of touching the edges of the girders in the VE was matched in reality. Participant behaviour was measured through observations of body language, as well as length of time taken to traverse the girders. The results showed that the group who completed the task at a height walked carefully, toe-to-heel, and moved significantly slower than the ground-based group. This behaviour is consistent with how one would act if they were forced to maintain their balance in a dangerous situation in the real world. Furthermore, their behaviour was also found to be correlated with equivalent psychophysiological responses. The study concludes that a VE is suitable for eliciting a realistic behavioural response to a fear inducing scenario. While no participants displayed overt fearful behaviour, such as fleeing the scenario or freezing up [39], this can be explained by the exclusion of clinical acrophobics from the pool of participants. Emotional processing in phobics is characterized by an excessive response to a feared stimuli [16], and is responsible for the manifestation of these extreme behaviours. This is commonly described as an avoidance response.

In another VE targeting acrophobia, Gomer et al. [11] used the avoidance response as a behavioural correlate of fear elicitation, with strongly positive results. The study used a Cave Automatic Virtual Environment (CAVE) where surrounding wall panels situated the user on a tall, metal lookout tower, overlooking a stretch of countryside. Participants were tasked with using a gamepad to teleport themselves to each ascending level of the multi-tiered tower, where they could move around freely. Once they had reached the top, participants were then instructed to approach the side railing of the platform. The choice to complete these tasks was left open to the user, as they could opt out at any point by pressing a button on the gamepad. Participants with a pre-determined high height avoidance (HHA) trait were shown frequently to avoid the upper levels of the tower altogether, choosing to end the simulation early. Those with HHA who did reach the top remained in the middle of the platform, choosing not to approach the side. Not only do these results further suggest that VEs are an effective medium for fear elicitation, but they also validate the avoidance response as a behavioural marker of fear.

4.2 Fear in Psychophysiology

In considering fear as a behavioural response to stimuli, we must also consider the physical markers of fear-induced behaviour. As the body prepares to mitigate danger, HR, RR, blood pressure, and electrodermal activity are raised involuntarily [15,39]. These processes can be measured empirically and are used extensively in research to correlate with and assess trends in self-reported surveys, which are predominantly qualitative. Another psychophysiological indicator of fear is the measured increase in saliva cortisol (SC), a neuroendocrine response to stress [15]. Testing for SC levels is more expensive and time intensive than the previously listed methods [38]. For these reasons, SC measurement is less commonly used in small-scale research of fear elicitation. Moreover, in a study by Diemer et al., measurements of saliva cortisol failed to return significant differences between phobics and non-phobics when exposed to a fear-inducing stimulus in a VE [6]. In more recent studies, the activation of fear responses of the body has been linked to specific patterns of neural activity in the amygdala [18, 40], but this has yet to see widespread application in clinical trials.

Psychophysiological measurements necessitate an important limitation to VE experiment design: interaction tasks observed cannot require greater-than-average physical exertion. Strenuous movements may alter the subject's physical markers beyond their measured baseline. This would lead to data noise when trying to extract information pertaining to emotional elicitation, which could result in erroneous readings. For example, if Kisker et al. [31] had decided to observe height-anxiety influenced behaviour by having the participants climb a ladder, the resulting physical exertion might have influenced readings of HR and RR. Instead, they chose a task that was less physically demanding (i.e., walking along a flat, elevated path), while preserving the fear-inducing scenario.

4.3 Agency, Self-efficacy and Fear

Considering section 3.2 on the effect of SoA on emotional elicitation, the review will now look at a possible interaction between user control and fear, in the form of perceived self-efficacy.

Bandura [27] first described self-efficacy as the internal judgment of how well one can execute a course of action required to deal with a prospective situation. Under this definition, judgements of self-efficacy are task specific. In effect, they determine how persistently people will face aversive experiences while completing these tasks. Theoretically, subjects with a high level of self-efficacy will effectively cope with any obstacles that they face, while subjects with low self-efficacy will quickly feel powerless and look to escape the situation. Phrased differently: individuals exhibiting low self-efficacy in a task are more likely to display avoidant behaviour, which we have previously associated with a fear response. To test this, Bandura et al. [28] explored the relationship between perceived self-efficacy and fear responses observed in clinical phobics. The study characterized participants with clinical arachnophobia not by their reported distress when exposed to spiders, but by their inability to complete increasingly threatening performance tasks involving them. The least fear-inducing tasks involved simple actions, such as looking down at the spider or approaching the spider from a distance, while the most fear-inducing involved direct physical contact with the spider. To measure self-efficacy, participants were asked how certain they were of their ability to complete each performance task, provided as a questionnaire. As theorized, subjects with low reported self-efficacy were able to complete the fewest tasks due to the avoidance behaviour they exhibited. Subsequent testing involved gradually increasing participant self-efficacy through the introduction and application of effective coping strategies for arachnophobia, accompanied by evidence of the predictability of spider behaviour. Further results showed that task performance increased proportionately to perceived self-efficacy in participants, indicating reduced avoidance behaviour. From this, we can characterize low self-efficacy in VR as a perceived lack of effective coping strategies in response to some interaction task. Recall the study by Jeunet et al. [30] that validated user control in VR as a method of influencing SoA. If there is evidence of a direct relationship between SoA and perceived self-efficacy in VR, then it can be reasoned that user control is also a valid way to manipulate self-efficacy. Using the results from Bandura et al. [28], linking self-efficacy and fear elicitation in the form of avoidant behaviour, this could provide a crucial link between user control and the emotional affective quality of a VE.

The most compelling link between self-efficacy, control of a VE, and fear as an avoidance response can be found in Lin's 2018 study [29], investigating coping reactions in a VR horror game. The study was centered around participant experience of *The Brookhaven*

Experiment, a game where the player is tasked with fighting zombies in an eerie location. In the study, Lin discovered that, among the participants, those who reported the highest levels of fear during their gameplay displayed relevant, fearfully avoidant behaviours. These responses included looking away from the feared imagery, as well as complete submission to the threat in order to "die" in-game and end the simulation. Importantly, these behaviours were most prominent when users ran out of ammo for the gun that they controlled and, consequently, could no longer protect themselves. As a sequence of events: a loss of user control, and thus a loss of agency, generated feelings of inability to cope with the already-frightening scenario. This, in turn, produced overt avoidance behaviour, indicative of a heightened experience of fear [16]. In a later study using the same environment, Lin et al. [35] identified this interaction between self-efficacy and user experience of fear, however, the role of user control and agency was not explored further.

5 Discussion

Section 4.3 of this review proposed a chain of psychological processes which links user control to fear elicitation in VR. Specifically, the proposed interaction is that restriction of existing user control will lead to a heightened fear response in a VE, where the interaction tasks performed by the user already have some fear-inducing quality, as described in section 3.1. Ordered as a list: 1) User control in a VE is restricted. 2) Modulation of control causes the user to experience a reduced SoA [30,33]. 3) Reduction in agency causes the user to feel unable to control their actions [29,30,33]. 4) Feelings of loss of control contribute to the user's perception of inability to cope with the interaction tasks presented in the VE [29,33]. 5) Reduction in perceived self-efficacy causes a fear response in subsequent exposure to the feared stimulus [28,29], which manifests as either avoidance behaviour [11,29], or less overt activation of the fear structure in non-phobic cases [31]. This discussion section will suggest possible ways to investigate this proposed interaction, with regards to its integration into current clinical research involving VEs as an affective medium. Following that, it will outline possible issues with the contents of the review, as well as any additional future areas of study.

One way in which the proposed interaction could be tested is through the deliberate manipulation of user control in a VE, already determined to be sufficient for fear elicitation. For example, a VE could be redesigned to have inconsistent control elements. This might be done in one of two ways. Firstly, the modified VE could use the method from Juenet et al. [30], where the virtual representation of the user's actions deviates from how they are input. Secondly, the user's control could be modulated in a diegetic way, by suddenly restricting access to a method of control that the user was confident in, or took for granted before, in a way that is consistent with the VE's narrative [29,33]. If control is altered in this way throughout the simulation, users are less likely to develop sufficiently high self-efficacy to feel confident in their ability to complete interaction tasks in the VE. As a result, the user may feel unable to cope with any fear-inducing stimuli with which they are faced [29], theoretically enhancing the level of fear experienced. The results of the original scenario, including psychophysiological and behavioural indicators of fear, could then be compared to those from the modified VE to assess this process.

In the context of exposure-based treatment of clinical phobics, a testing environment could be used to reduce fear by increasing user self-efficacy. Some studies of fear elicitation use a fear hierarchy to test the psychological effects of progressively more frightening scenarios on VE users [2]. Similarly, a self-efficacy or control hierarchy might be used to introduce progressively more effective ways of coping with a simulated scenario. Sustained virtual exposure to a feared stimulus, as well as other techniques already employed in VRET, could be combined with enhanced user control over the simulation in order to heighten self-efficacy. For example, in the case of arachnophobia, the first session of treatment may only permit the user to stand in place and observe the spider. In subsequent sessions, methods of control for navigation or interaction with the environment may be used to accompany the exposure therapy treatments shown to increase self-efficacy, as used by Bandura et al. [28].

Another potential topic of research is the relationship between method of user control and SoA. Specifically, whether a method of control of a VR system that more closely models the real-world interaction will lead to heightened emotions. For example, using an additional capture method to allow the user to articulate each of their fingers to interact with objects, as in Juenet et al. [30], rather than pressing a button on a controller. This was explored in Osking & Doucette's study [26], but not in the context of fear arousal.

The effects of the narrative of a VE could also be explored as a factor in perceived control, and related emotional response. A study by Gorini et al. [19] identified that the introduction of a horror narrative to a VE caused users to report that they felt capable of influencing the outcome of the events in the simulation. Specifically, when interacting with characters and objects. This was in spite of the fact that their interaction tasks were functionally identical to the control group, who experienced the same VE with no narrative. In addition, they also reported higher levels of fear when encountering certain contextual cues in the environment. Further study could link this phenomenon to user SoA, or other factors of user control.

One under-researched area throughout the literature is the potential for the control elements of fear inducing VEs to elicit excitement in users, which could undermine their capacity to arouse authentic fear responses. The VEs analyzed in this review that tested the effects of control and agency on fear elicitation were both horror games [29, 33]. These are designed specifically for entertainment purposes, which means that, in addition to their capacity to elicit fear, they also intend to elicit emotions such as excitement and relief [35]. Future research should involve testing in less gamified environments in order to provide better experimental control over the emotions elicited by the VE. Additionally, since fear responses are stimulus specific [16] and perceived self-efficacy is task-specific [28], there is a need for a much larger pool of studies investigating a range of phobias and interaction tasks before any strong conclusions can be made about behavioural responses to them. Finally, although this review attempted to offer a comprehensive view of the interaction between user control in VR and fear elicitation, the wide variation in stimuli form, and manifestations of fear in humans [15], make it difficult to give a generalized relationship between the two, given current limitations in the research. As such, the interaction outlined in section 4.3 should be seen more as a theoretical building block for future research, rather than a real set of discrete psychological events.

6 Conclusions

Most studies analyzing fear elicitation in VEs make no attempt to investigate user control as an independent variable of research. Due to the lack of empirical research to discuss, this review aimed to find a theoretical basis for the interaction between user control and fear elicitation by synthesizing information found in studies from these two areas. In this review, the ideas of control and agency, as well as the concept of fear arousal as a result of perceived self-efficacy, have been linked together to develop a theory on how they might enhance the elicitation of a fear in VR. Utilizing research connecting user control and agency, it was established that, given a sufficient level of immersion, VR is capable of conferring a realistic SoA upon a user. This is done by way of selective control of the VE. Additionally, this SoA can be manipulated by deliberately altering elements of user control. In research involving the manifestation of fear in VEs, VR was also shown to produce avoidance behaviour in users in response to feared stimuli, which is indicative of the activation of the fear structure. This avoidance behaviour was shown to arise due to a perception of inability to cope when faced with tasks involving a stimulus, or low self-efficacy. In the case where user control was restricted in a VE already designed to elicit fear, a loss of agency was caused, which engendered feelings of inability to effectively cope with the situation. This was then shown to produce avoidance behaviour, commonly associated with the elicitation of fear. Through this interaction, a potential link between user control in VR and the enhancement of fear elicitation has been established.

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Appendix

Reference and Key Author	Subject	Control Group(s)	No. Participants (Control group)	VR Peripherals and other components	Evaluation Metrics	Interaction Task	Results
[10] Peperkorn	Arachnophobia	Yes - alternated experiment conditions, all participants were phobic	32 (32)	HMD, box	SRQ, EDA	Participants were tasked with touching a container which either: a) contained a spider and was reflected in VR to contain a snake b) vice versa	1) Presence was reported to be high in phobics and non-phobics - significantly higher in phobics 2) Fear was higher when participants knew they were touching a box containing a spider in real life 4) Fear of touch is more aversive than visual context 5) Display of virtual hand next to spider lead to higher SCR reading 6) Increase in reported self-efficacy after exposure
[6] Diemer	Acrophobia	Yes	40 (40)	HMD, wooden board	SRQ, HR, EDA, SC	Looking down or forwards as commanded from a simulated height	1) HR and EDA increased during height exposure in both controls and phobics 2) SC levels were only increased in a small portion of participants 3) Phobics showed significant increase when tasked with looking down 4) Increased HR and EDA in controls cannot be explained by novelty alone as the baseline test, also in VR, did not record results as high
[23] Gorini	Fear of a dangerous individual	Yes (3)	84 (21 per group)	HMD, 2D Laptop screen, joystick	SRQ, HR	Navigate and collect blood containers in a simulated hospital environment which is either: 1) presented immersively (using HMD) with fear-arousing content 2) presented immersively with no narrative 3) presented non-immersively (laptop screen) with fear-arousing content 4) presented non-immersively with no fear arousing content	1) Immersive condition lead to participants reporting that they felt they could influence the events of the simulation when interacting with characters and objects 2) Narrative conditions showed increased HR. especially when encountering the dangerous individual 3) responses to the man also changed the behaviour of the VR user
[21] Muhlberger	Fear of driving in a tunnel	Yes	15 (15)	Large, curved projection screen - 180 degrees of horizontal and 55 degrees of vertical movement, Car frame with seating	SRQ, HR, EDA, Accoustic Startle Response	Drive a virtual car through a series of 3 environments, the 2nd and 3rd of which represent a tunnel and a gallery (tunnel with open side panel)	1) Phobics reported much higher fear than non-phobics 2) HR matched reported fear, accelerated only in the tunnel environment 3) ASR of phobics was enhanced during the runnel drive 4) Little correlation of the fear response variables, which could be a factor of the active baseline environment (moving vehicle) rather than a more relaxed scenario 5) HR could determine fearful participants with 88% accuracy 6) Perhaps fear responses are disorder specific
[38] Lin	Coping responses provoked by an immersive horror game	No	145	HMD	SRQ, BR	The participant must fight through five waves of zombies using a simulated gun, represented by the controller	1) Provoked an avoidance response as an effective coping method for a non-specific, non-clinical fear - some players disengaging with the material, and others looking away from the zombies to avoid the imagery 2) Avoidance behaviour was most prominent when users lost control of their actions
[49] Madsen	Difference between fear evoked by an interactive game vs. passively watching a video	Yes	26 (24)	2D Television screen, PS4 device with handheld controller, computer monitor	SRQ, HR, EDA, RR	Participants either played the interactive horror game *Playable Teaser (P.T.),* or passively watched another participant's gameplay, remotely. Interactions in the game include 360 degree camera control and free navigation, as well as	1) Interaction group measured with increased HR and RR during exposure to fear-inducing material 2) Change scores of HR and RR were higher in players than non-players 3) EDA of the play group was only measured as significantly higher than the watch group during the 3rd scripted event - characterised by longer exposure (60s section instead of 30s) 4) Play group did not score significantly higher for self reported fear - this is likely due to the inadequacy of the TV and base PS4 hardware to facilitate PI - shown as a neccesity for a VE to reach a base level of immersion in order for emotional elicitation to be possible 5) Higher entertainment
[42] Kisker	Measurement of realistic behaviour in a height-based simulation	Yes	29 (27)	HMD, Slippers, Wooden Planks	SRQ, BR, HR	Participants were tasked with walking along virtual steel girders either at a height or at ground level	1) Participants in the elevated scenario showed signs of behaviour found when exposed to heights in reality - walking carefully, heel-to-toe, significantly slower than the ground group 2) HR increased significantly in the height group, corresponding to real life exposure to heights
[11] Gromer	Acrophobia	Yes	55 (44)	CAVE System, Interference-filtering glasses, Gamepad	SRQ, BR	Participants were tasked with climbing to the top of a tall, metal lookout structure in a simulated countryside hill in either windy or calm conditions. If they did not want to complete the task they could opt out by pressing the gamepad button	1)High height-avoidance participants more regularly avoided the top platform of the lookout - a reflection of realistic behaviour

Key for Evaluation Measures:

SRQ	Self-Reported Questionnaire
HR	Heart Rate
EDA	Electrodermal Activity
RR	Respiration Rate
BR	Behavioural Response
SC	Saliva Cortisol