Fear In Virtual Reality

Eliciting Fear In Participants Without Phobias With A Virtual Environment Stimulus

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ABSTRACT

Inducing and studying fear responses may hold the key to breakthroughs in psychological treatment of anxiety disorders. Virtual reality is seen as a novel medium for eliciting emotions in people. With that in mind, this paper investigates the use of a virtual environment as a mood induction protocol for eliciting fear in participants without phobias. We discuss the design of the virtual environment which was done in collaboration with the UCT Department of Psychology. We also analyse the results of a study conducted to evaluate the virtual environment. The study was a within subjects design with 11 participants. The participants' emotions were assessed before and after the virtual reality experience using physiological and subjective self-report measures. Physiological measures were skin conductance response and heart rate. Subjective measures were the Self Assessment Manikin and the Discrete Emotions Scale. The results showed a statistically significant difference between baseline skin conductance response and virtual environment skin conductance response ($p = 0.0008$, $d = 0.83$). A statistically significant difference was also observed for heart rate ($p = 0.006$, $d = 0.77$). The Self Assessment Manikin was only statistically significant for the emotional arousal component ($p = 0.001$, $d = 1.84$). Emotional valence was not statistically significant ($p = 0.66$, $d = -0.16$). The Discrete Emotions Scale was statistically significant for the fear ($p = 0.0008$, $d = 1.72$) and surprise ($p = 0.0001$, $d = 2.41$) self-reports.

KEYWORDS

Virtual Reality; Fear; Phobia; Psychophysiological Measures; User-Centred Design

1 Introduction

Virtual reality is a powerful tool that is being adopted more and more in psychology research. This is because of its ability to simulate complex situations that are useful for study in a controlled lab environment. Psychologists are particularly interested in studying scenarios wherein people experience strong emotional reactions, because this might hold the key to understanding mood disorders. The traditional way of eliciting emotional reactions in subjects include showing films, pictures or playing music. These methods have been reasonably successful in the past, but are limited because subjects experience the emotion from a third person perspective, which weakens the emotional reaction.

Virtual reality is considered a better alternative for eliciting emotions because of the first person experience that it offers (Riva et al., 2007). So far, a number of emotions have successfully been elicited through virtual reality. Several studies (Banos et al., 2012; Serrano et al., 2013) have succeeded in eliciting positive emotions like joy and relaxation. Fear has also been consistently elicited with the use of virtual reality under controlled lab conditions (Lin, 2017; Toet et al., 2009). Felnhofer et al. (2015) succeeded in generating fear, joy, anger and boredom in participants.

Eliciting fear in virtual reality is of particular importance because it has led to the successful treatment of certain phobias (arachnophobia, fear of public speaking, fear of heights, etc.) through a technique called exposure therapy. During exposure therapy, patients are exposed to their phobia in a safe virtual environment, and over time the intensity of the phobia is increased as the patient gets more and more comfortable, until they are able to face their phobia in real life. In order for exposure therapy to work the fear that the patient experiences must be related to their phobia.

Although a lot of research has been done investigating phobias in virtual environments, limited research has been done to investigate fear in participants without phobias. In light of this, the aim is to contribute to the literature by designing and creating a virtual environment to elicit fear in participants without phobias and conduct a study to evaluate the effectiveness of this virtual environment.

The design of the virtual environment and evaluation study was done in collaboration with the UCT Department of Psychology. Furthermore, the psychology department plans to use the virtual environment in future studies related to research in fear and virtual reality. The virtual environment has already been used by Siphumelele Sigwebela (UCT Master's in Psychology student) in her study comparing the effectiveness of film, pictures and virtual reality as media for eliciting emotions.

Research Question:

(1) Can a virtual environment generate a fear-response in participants without phobias?

Hypotheses:

(1) The virtual environment will induce higher physiological arousal in participants compared to baseline.

(2) Participants will report feeling a higher degree of fear after experiencing the virtual environment.

2 Previous Work

The research done concerning emotional elicitation in virtual reality has been related to two goals: (1) eliciting specific emotions and (2) investigating the link between presence and emotions. Studying how specific emotions are elicited is important because it will lead to a better understanding of emotions, which in turn, will aid the treatment of mood disorders and lead to the creation of media and art that are richer in emotional content.

So far, research into emotional elicitation with the use of virtual reality has only investigated eliciting emotions such as sadness, joy, fear, relaxation, boredom and anger (Felnhofer et al., 2015; Toet et al., 2009). Emotions like disgust, shame, envy, pride, hope, love etc. have yet to be elicited. The types of virtual environments that have been used in studies include parks, towns, houses and villages (Banos et al., 2012; Alsina-Jurne et al., 2011; Serrano et al., 2013). The differences between these environments is due to the fact that a new virtual environment is created from scratch for each study. This makes it difficult to compare the different virtual environments. Studies have also varied in terms of the interfaces used by participants to interact with the virtual environment. These interfaces include head-mounted displays, keyboards and mobile phones (Toet et al., 2009; Lin, 2017).

Presence refers to a user's sense of being in a virtual environment. The work done on investigating the link between presence and emotion seeks to see if there is a relationship between the intensity of emotions and the sense of presence that participants feel in a virtual environment. This is important because it might hold the key to creating virtual environments that people can lose themselves in. Studies have investigated the link between presence and emotions such as fear, sadness and happiness (Riva et al., 2007; Banos et al., 2008, Alsina-Jurne et al., 2011). This link has yet to be confirmed because studies have reached conflicting conclusions. Alsina-Jurne et al. found a positive correlation between fear and presence. In contrast to this, Banos et al. found no correlation between emotions (joy, fear, relaxation) and presence. Riva et al. found a negative correlation between joy and presence. Given these studies, research has to be done to reconcile the conflicting results.

3 Virtual Environment Design

3.1 Clients

Since the Psychology Department guided the design of the virtual environment, they acted as clients for the project. Specifically, these clients were Siphumelele Sigwebela, Gina Gilpin and Gosia Lipinska. The clients specified the requirements for the virtual environment. The clients also provided a script for the virtual environment, see Appendix A. They required that elements of the environment be configurable in real time, to allow them to use it in future studies.

3.2 Methodology

User-Centered Design (UCD) was used, as opposed to agile or waterfall methodologies, to design and develop the virtual environment (Abras et al., 2004) . UCD is an iterative design process where users (clients) are central to the development of the product. At every iterative step in UCD, a prototype that meets the latest user requirements is produced. The prototype is then tested by users and the feedback informs the design for the next iteration of the prototype.

The reason UCD was the chosen design methodology is because the requirements for the virtual environment were initially vague, there was a lot of uncertainty surrounding them and they were potentially subject to change during development. The biggest source of uncertainty was whether or not the right assets (3D models, character animations, sound effects, etc.) to actualise the vision of the clients could be found.

UCD was used in two phases. Phase one involved developing the virtual environment so that it met the requirements of the clients. During this phase the virtual environment went through three iterations. At the end of each iteration a client meeting was held to demo the current state of the virtual environment to the clients. Feedback was taken from the clients about what should be changed and what features should be worked on next. Some features which the clients had initially requested were not included in the final version of the environment (e.g., the environment fog). Other features which were not included in the initial specification were later added during the development cycle (e.g., a falling pipe, the blood on the walls). Making such changes to the software product would not have been possible had a methodology like waterfall been used, but UCD provided the flexibility to make these changes even though late in the development cycle.

During phase two, a pilot study involving seven participants was conducted. The aim of the pilot study was to test the virtual environment on real subjects, because up until that point the clients were the only people who had tested the virtual environment. The pilot study gave feedback about how participants would react to the virtual environment in the final evaluation study. The feedback was then used to make the fourth and final version of the virtual environment. The fourth version included fixes for the bugs that were identified during the pilot testing.

3.3 Design

The initial design for the virtual environment was a straight underground canal down which a boat carrying the participant would travel. There would be two gates, the first of which would be initially open and the second which would be closed. The boat would travel down the canal for about a minute before a rock

would fall from the ceiling and hit the boat. During this collision a torch would be flung out of its hiding place and roll in front of the participant. The participant would then be able to reach out and pick it up.

Around the two minute mark the boat would pass through the first gate and the gate would mysteriously close behind the participant. At the three minute mark the participant would witness a monster run across a side-corridor. The boat would then get to the closed gate at the end (around minute four) and the monster would attack the participant. Then the experience would be over.

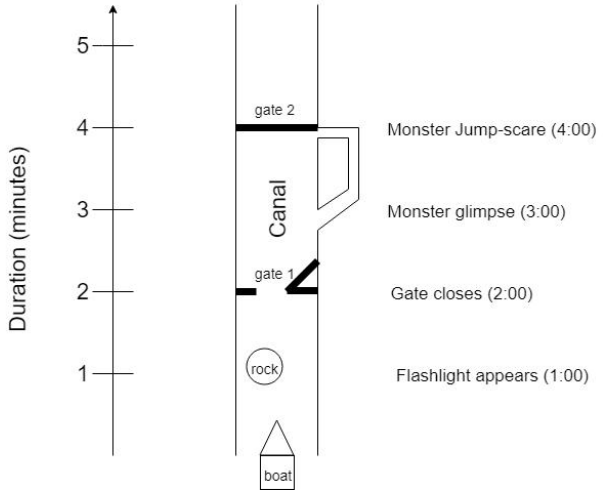

Figure 1: Initial design for virtual environment

Three principles for inducing fear were used in the design of the virtual environment, namely: isolation of the participant, darkness and the presence of a predator (Ohman, 1986). During the entire experience the participant is alone and there is no sign of other people in the canal. This creates feelings of helplessness and dread. The helplessness is made worse by the fact that the participant has no control over the boat. They are just a passenger on this frightening ride.

It has been shown that dark virtual environments are scarier than brighter virtual environments (Toet et al., 2009). The only sources of light in the virtual environment are the torch which the participant picks up and a few lights on the walls of the canal. The rest of the canal is completely dark. The purpose of the torch is to allow the participant to look around in this pitch black environment and witness the events that place (the monster appearing, the gate closing, etc.). The light of the torch has a narrow angle of spread, this allows the participants to only look at specific areas without lighting up the entire canal, ensuring that the environment still retains its dark ambience.

Human beings, just like other animals, have evolved a fear-response to predatory creatures. The function of this fear response is to avoid and escape predators (Russel, 1979). In the virtual environment, a monster lurking in the canal plays the role of a predator. The participant has two brief encounters with monster before it attacks them. These initial encounters are to make the participant aware that there is a predator inside the canal and trigger their fear response. The monster attack at the end simulates the terror that a prey animal experiences when caught by a predator (Cresswell et al., 2003).

A number of changes were made to the initial design during the iterations that the virtual environment went through. Feedback from the clients and pilot study participants drove these changes. The path that the boat follows changed from a straight path to a winding path in order to give the participant the feeling that they did not know where they were going or what to expect.

In the final design, instead of having a rock falling onto the boat around the one minute mark, a pipe falls into the water in front of the boat. This was mainly prompted by a desire for realism. It is unlikely that there would be a loose rock on the ceiling of a man-made structure. A pipe is a more convincing object to have falling from the ceiling. Once the pipe falls, it hits the bottom of the canal but still sticks out of the water. The boat then hits the pipe and the collision causes the torch to appear, just as in the initial design. But instead of having the participant manually pick up the torch, we made it appear in their hand (it was observed that participants were not reaching out to pick up the torch during the pilot study).

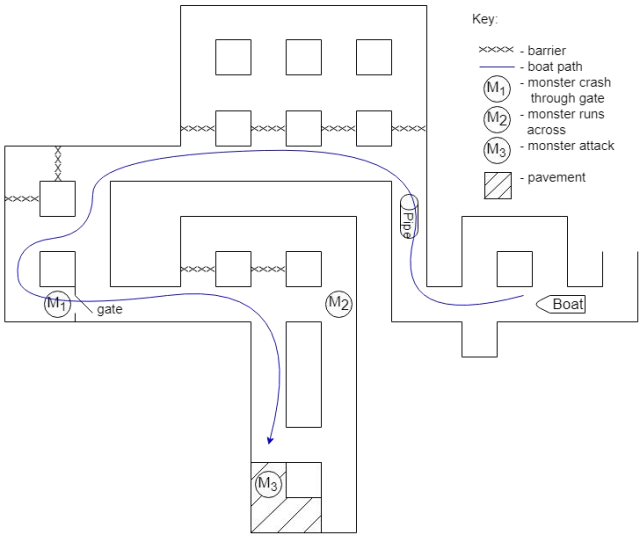

Figure 2: Final design for virtual environment

Around the two minute mark, a new event was added. The monster crashes through a closed gate. This happens directly in front of the participant. The crash also causes a loud bang to draw the participant's attention. This event was added because we wanted the participant to have an encounter with the monster earlier in the experience. In the initial design the participant did not get to see the monster until the final minute of the experience.

At the two and a half minute mark, the participant passes through the gate which the monster has now opened. The gate then mysteriously closes behind the participant, just like in the first design. Around the three minute mark, the monster runs across the participant's line of sight. We placed this event directly

in front of participant because when it happened in their peripheral vision (as specified in the initial design), many participants failed to see it. About four minutes in, the participant reaches pavement, where the boat can not move any further. As soon as the boat stops, the monster leaps out of the darkness in front of the participant and attacks. Then the experience ends.

The initial design for the virtual environment aimed to create a slow build up of fear in the participant with no jump scares to spook the participant. Unfortunately, the participants in the pilot study did not report any fear when exposed to the initial environment. This feedback is what prompted the change from a slow build up of fear, to fear elicited through jump scares and loud sudden noises.

3.4 Environment

Figure 3: Canal wall with text written in blood

The setting that the virtual reality experience takes place in, as outlined by the clients in the script they provided, is a dark underground canal (tunnel). In order to create the canal, an asset package containing modular canal pieces was purchased. The modularity of the pieces made it possible to construct a canal of any length, size or shape by combining the pieces together in different configurations. A standard unity asset was used for the water in the canal. The color and transparency values had to be tweaked in order to make the water look murky and ominous. The boat that the participant rides on was also purchased from the unity asset store. A collider, which is a component that defines the shape of an object for the purposes of physical collisions, was placed on the boat because the triggered events (which are discussed later in this section) used the boat's collider to detect the participant's position and to trigger when the participant was in range.

3.5 Virtual Avatar

A virtual reality avatar asset package (Oculus VR Avatar) was used to give the participant an avatar to control in the environment. The avatar consisted of two floating hands and a camera. The hands were controlled by the participant via two virtual reality hand controllers. The Oculus headset which participants put on controlled the positioning of the camera and determined what they saw.

3.6 Visuals

The only source of lighting in the environment, excluding the torch, is from lights attached to the walls of the canal. Having lights on the wall made it easy to create darkness in certain areas and also have light in other areas. Some lights stay on the whole time, other lights only turn on for a short duration, and the remaining lights flicker on and off rapidly. The lights that stay on the whole time are used to draw the participant's attention to the triggered events (appearance of the torch, the gate closing, the monster attack, etc.). The flickering light effect was achieved by randomly selecting a duration of time between 0 and 0.5 seconds during which the light would be either on or off.

On some of the walls in the canal there are stains of blood and words that have been written in blood. 2D sprites of red ink spots were attached onto the walls in order to achieve the blood stain effect. For the words written in blood, a font that had a watery texture was used with red text to create the effect.

3.7 Triggered Events

There are six triggered events that happen during the experience. In chronological order these are: (1) the falling pipe, (2) the appearance of the torch, (3) the monster crashing through the gate, (4) the gate closing behind the participant, (5) the monster running across the participant's line of sight, (6) the monster attacking the participant. Each of these events has a trigger collider associated with it. When the participant's boat touches the trigger collider of the event, the event is set off.

The falling pipe, as the name suggests, is a pipe attached to the ceiling of the canal that falls unexpectedly into the water below it. When this event is triggered, a script attached to the pipe moves the pipe downward in the y-axis, which makes it look like it is falling under the force of gravity.

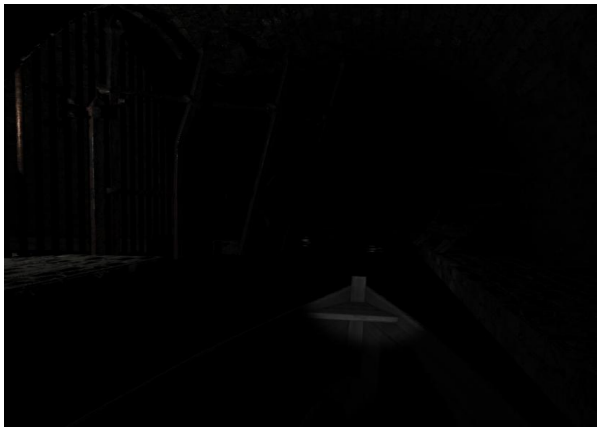

Figure 4: Participant's boat illuminated by torch

The torch appears when the participant's boat hits the pipe that fell into the water. The collision causes the torch to roll out in front of the participant. The torch then teleports into the avatar's hand. The rolling effect is achieved by moving the torch without actually rotating it. Playing the accompanying sound effect of a rolling object makes the participant think that the torch is rolling, even though in actual fact it is not, it is just being translated.

The monster crashing through the gate event is a triggered event where the monster swiftly bursts through a closed gate. This is achieved by initially positioning the monster model behind the closed gate. When the script that handles this event is triggered, it plays the jump animation of the monster model, causing the monster to jump towards the gate. At the same time this is happening the script rotates the gate so that gate begins to open. Having the monster jump and gate rotate at the same time creates the illusion that the monster is bursting through the gate and causing it to open. The accompanying bang and splash sound effects reinforce this in the participants mind.

Figure 5: Monster that lurks in the canal

The gate closing event happens when the participant's boat passes through the gate, which the monster has now opened. It is done with a simple script that rotates the gate. The monster running across the participant's line of sight event happens when the monster dashes in front of the boat, offering the participant a brief glimpse. The script that handled this event played the monster's run animation.

3.8 Sound Effects

All of the sound in the virtual environment is stereoscopic, meaning that each ear hears a slightly different sound wave depending on how it is positioned relative to the virtual sound source. This simulates the way people hear in real life and adds to the immersiveness of the virtual environment (Baños et al., 2008).

Various sound effects were used during the development of the virtual environment. The sound effects ranged from water splashes and the creaking of the wood on the boat, to the growls of the monster and the echoing of the wind blowing through the canal. Some of these sound effects play constantly in the background, e.g., wind blowing. These were implemented by having an audio source object constantly playing the sound effect on loop. Other sound effects play when events are triggered, e.g., the monster growling when the participant is close by. These are implemented through trigger colliders that fire when the boat touches them and a system of timers with delays (in cases where different sound effects have to play one after the other).

All sound effects related to the triggered events were played loudly and in sync with the appropriate visual cues (e.g., the monster roar sound effect starts playing as soon as the monster's mouth opens). This was done in accordance with the literature on fear which strongly suggests that the best sound design for causing fear is high volume sound effects that are synchronized with visual movement or events (Toprac et al., 2011).

3.9 Configuration Interface

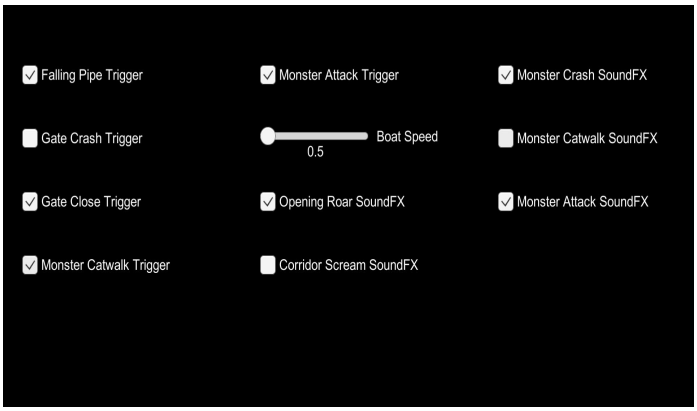

Figure 6: Configuration interface

The configuration interface is intended for the virtual environment operator. It consists of a start menu and a configuration screen. The start menu has a slider and a button. The slider is for indicating whether the participant is right-handed or left-handed (this will determine which hand the torch will appear in). Clicking on the button starts the virtual experience.

The configuration screen allows the operator to change elements of the experience in real time. Such changes include: the speed of the boat, which events get triggered and which sound effects will play. The check-boxes control boolean values in the sound effect and triggered event scripts. If the check-boxes are checked, the boolean values are set to true and the corresponding sound effect or event will play.

4 Experiment Design

The evaluation study for the virtual environment was a within subjects study to determine if the environment would elicit the hypothesised emotion (fear). The data collected from participants in the study was both objective (physiological) and subjective (questionnaires). The data collected during the virtual experience was compared to the participant's baseline measures to determine the effectiveness of the virtual environment. The study took place at the UCT psychology building's ACSENT laboratory, in a soundproof room. The room ensured that there were no

interruptions or distractions during presentation of the virtual environment.

4.1 Participants

Participants were acquired through UCT Student Research Participation Points. This initiative requires psychology students to take part in studies conducted by the psychology department. The advert that was sent out outlined what the study was about and had a URL link to the screening questionnaires participants had to complete before participating in the study.

Participants with phobias were screened out using the Marks and Matthews Fear Questionnaire (Marks et al., 1979) because the study focused on eliciting fear that people without phobias. Participants with depression, post-traumatic stress disorder and alcohol misuse disorder were also screened out because they are at risk of having an extreme fear-response that could have an effect on their well-being. The respective questionnaires for these were The Patient Health Questionnaire for Depression-9 (Kroenke et al., 2002), The 4-item Primary Care Post-Traumatic Stress Disorder Screen (Cameron et al., 2003) and The Alcohol Use Disorders Identification Test Consumption (Bradley et al., 2007).

325 people responded to the advert about the study, 243 went through screening (the rest pulled out) and 41 passed screening. Unfortunately, only eleven participants out of the 41 that passed screening showed up to participate in the study. The participants were between the ages of 18 and 26 (1 male and 10 females).

4.2 Measures

The following physiological measures were taken during the study: heart rate and skin conductance response. The subjective measures taken were the Self Assessment Manikin and Discrete Emotions Scale.

4.2.1 ***Skin Conductance Response.*** Skin conductance is associated with arousal related to emotional activity (Mendolia & Kleck; 1998). Skin conductance gives an indication of the activation of the autonomic nervous system. It increases when a subject experiences fear.

4.2.2 ***Heart Rate.*** Heart rate is a common measure used to analyse the activation of the sympathetic branch of the autonomic nervous system, which governs the fight or flight response seen when someone experiences fear (Kreibig; 2010). Heart rate increases are indicative of negative experiences and are associated with negative emotions like fear.

4.2.3 ***Self Assessment Manikin.*** The Self Assessment Manikin (Morris, 1995) asks participants to rate the emotional valence (negative to positive) and arousal (calm to excited) that they are feeling on a scale from 1 to 9. Having participants rate valence and arousal, gives a sense of the general feeling that they are experiencing without having to force them to verbally categorise the feeling.

4.2.4 ***Discrete Emotions Scale.*** The Discrete Emotions Scale (Harmon-Jones et al., 2016) asks participants to rate how often they felt different emotions (Anger, Sadness, Happiness, Fear, Surprise) during an experience on a scale from 1 to 7 (not at all to extremely often). This measure clearly differentiates each emotion.

4.3 Procedure

Participants who passed screening were invited to take part in the study. Upon arrival, they were briefed on what the study was about and told that their participation was voluntary and that they could stop at any time. They were also given an informed consent form for them to read through and sign. Once consent was acquired, electrodes were attached under the participant's left and right clavicles, under the right rib, on their index finger and palm in order to measure their physiological data (heart rate and skin conductance). Baseline measures for the participant were then taken for 3 minutes, both physiological and subjective. The participant then went through a virtual reality tutorial (oculus touch tutorial) to get them accustomed to virtual reality and show them how to use the virtual reality controllers.

Once the participant completed the tutorial, they were placed in the virtual environment. The experience in the environment lasted about four minutes and during that time their physiological data was recorded. Once the participant was done with the fear environment they were asked to fill in the questionnaires again (subjective measures). After this, the electrodes were removed from the participant, they were debriefed and re-assured on the confidentiality of their participation.

5 Results

Hypothesis 1: The virtual environment will induce higher physiological arousal in participants compared to baseline.

Skin Conductance Response. It was predicted that the skin conductance response in the virtual environment condition would be higher than in the baseline. A paired sample t-test was used to determine whether the mean difference between these two sets of measurements was significant. A paired sample t-test assumes two things about the data: (1) assumption of normality and (2) assumption of homogeneity of variance. The Shapiro-Wilk test was used to prove the assumption of normality. The Brown-Forsythe test was used to prove the assumption of homogeneity of variance. Baseline measures passed the Shapiro-Wilk ($p > 0.05$). Virtual environment measures also passed the Shapiro-Wilk ($p > 0.05$). Both measures passed Brown-Forsythe ($p > 0.05$).

The paired sample t-test revealed a statistically significant difference between baseline mean skin conductance response ($M=8.29$, $SD=4.85$) and virtual environment mean skin conductance response ($M=12.32$, $SD=4.91$); $t(10) = -4.7438$, $p = 0.0007875$, $d = 0.8263392$ (large effect size).

This result indicates that the virtual environment induced higher physiological arousal in participants compared to baseline.

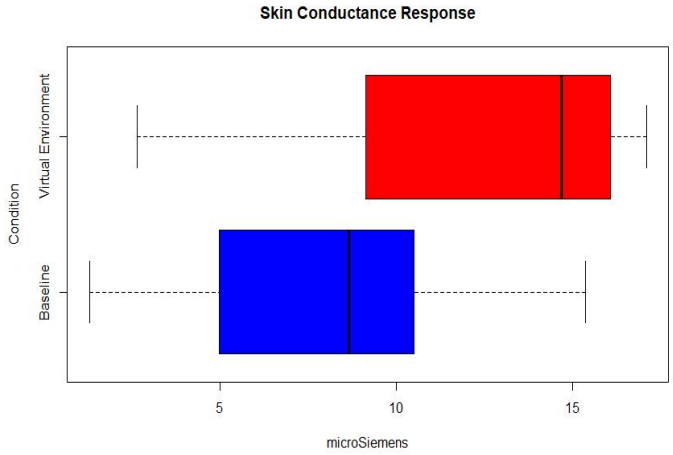

Figure 8: Box-and-Whisker plot of skin conductance response

Heart Rate. It was predicted that the heart rate in the virtual environment condition would be higher than in the baseline. A paired sample t-test was used to determine whether the mean difference between these two sets of measurements was significant. Baseline measures passed the Shapiro-Wilk ($p > 0.05$). Virtual environment measures also passed the Shapiro-Wilk ($p > 0.05$). Both measures passed Brown-Forsythe ($p > 0.05$).

The paired sample t-test revealed a statistically significant difference between baseline mean heart rate (M=80.87 SD=11.23) and virtual environment mean heart rate (M=90.00, SD=12.32); $t(10) = -3.4347$, $p = 0.006388$, $d = 0.7741581$ (medium effect size).

This result indicates that the virtual environment induced higher physiological arousal in participants compared to baseline.

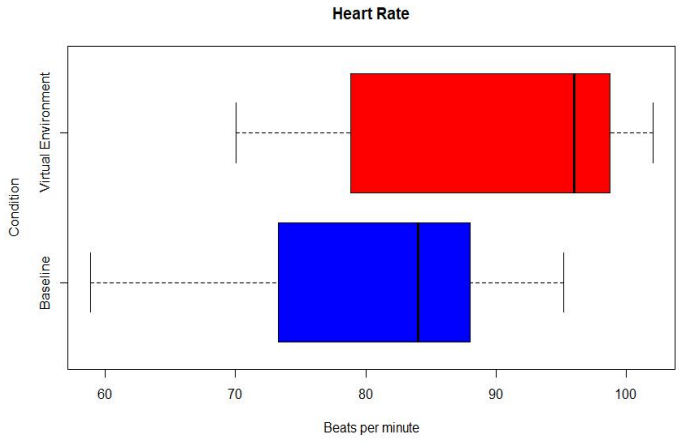

Figure 9: Box-and-Whisker plot of heart rate

Hypothesis 2: Participants will report feeling a higher degree of fear after experiencing the virtual environment.

Emotional Arousal. It was predicted that the self-reported emotional arousal in the virtual environment condition would be higher than in the baseline. A paired sample t-test was used to determine whether the mean difference between these two sets of measurements was significant. Baseline measures passed the Shapiro-Wilk ($p > 0.05$). Virtual environment measures also passed the Shapiro-Wilk ($p > 0.05$). Both measures passed Brown-Forsythe ($p > 0.05$).

The paired sample t-test revealed a statistically significant difference between baseline arousal (M=4.27, SD=2.41) and virtual environment arousal (M=7.73, SD=1.10); $t(10) = -4.3082$, $p = 0.001541$, $d = 1.841755$ (large effect size).

This result indicates that participants reported feeling a higher degree of fear after experiencing the virtual environment.

Emotional Valence. It was predicted that the self-reported emotional valence in the virtual environment condition would be lower than that in the baseline. A paired sample t-test was used to determine whether the mean difference between these two sets of measurements was significant. Baseline measures passed the Shapiro-Wilk ($p > 0.05$). Virtual environment measures failed the Shapiro-Wilk ($p < 0.05$). We can still continue the analysis though because t-tests are robust to violations of normality (Field, 2013). Both measures passed Brown-Forsythe ($p > 0.05$).

The paired sample t-test did not reveal a statistically significant difference between baseline valence (M=5.91, SD=2.39) and virtual environment valence (M=5.55, SD=2.30); $t(10) = 0.44777$, $p = 0.6639$, $d = -0.155312$ (negligible effect size).

This result does not indicate that participants reported feeling a higher degree of fear after experiencing the virtual environment.

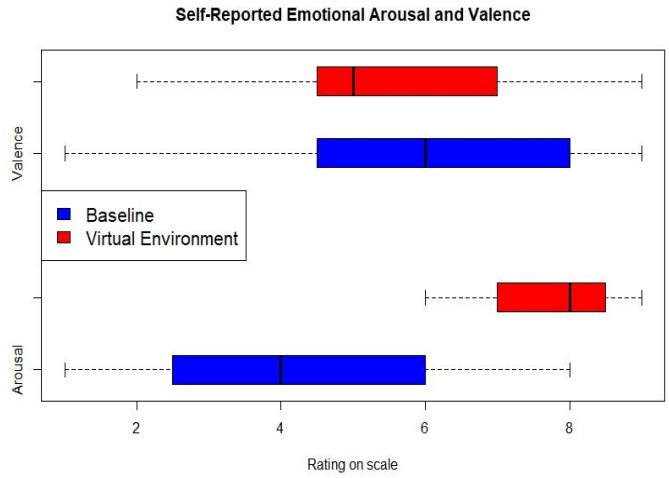

Figure 10: Box-and-Whisker plot of arousal and valence

Emotion	Condition	Mean	Standard Deviation	t - value (df = 10)	p - value	Cohen's d
Anger	Baseline	1.46	1.04	0.43033	0.6761	-0.09260847
	Virtual Environment	1.36	0.92			
Sadness	Baseline	1.55	1.04	0.31944	0.756	-0.09731237
	Virtual Environment	1.46	0.82			
Happiness	Baseline	4.36	1.03	1.748	0.111	-0.6382847
	Virtual Environment	3.36	1.96			
Fear	Baseline	2	1.48	-4.7553	0.000774*	1.721751**
	Virtual Environment	4.73	1.68			
Surprise	Baseline	1.91	1.45	-7.8836	0.0001339*	2.409591**
	Virtual Environment	5	1.10			

Table 1: Statistical analysis of Discrete Emotions Scale

* - significant p - value
** - large effect size

Discrete Emotions Scale. Five emotions were in the Discrete Emotions Scale that participants filled in, namely: Anger, Sadness, Happiness, Fear and Surprise. A paired sample t-test was used for each emotion to determine whether the virtual environment elicited the emotion.

These results indicate that participants did not report feeling a higher degree of anger, sadness or happiness after experiencing the virtual environment. But the results do indicate that participants did report feeling a higher degree of fear and surprise.

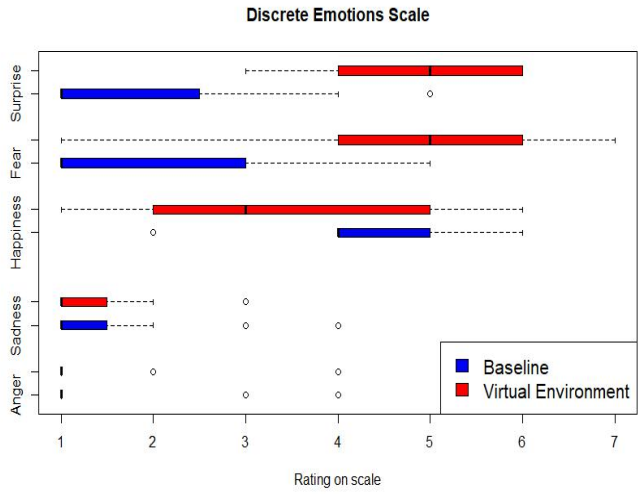

Figure 11: Box-and-Whisker plot of anger, sadness, happiness, fear and surprise

Discussion

Skin conductance response increased significantly as expected during a fear response and so did heart rate. Heart rate has a stronger correlation with fear than skin conductance response because heart rate is specifically linked to the sympathetic autonomic nervous system, whereas skin conductance indicates a general emotional response. These results support the hypothesis that the virtual environment would induce higher physiological arousal in participants compared to baseline.

Self-reported arousal increased significantly but self-reported valence did not decrease significantly. Having high arousal and low valence is a sign of fear, so the reason that self-reported valence was not statistically significant may be due to having a small number of participants (eleven) who took part in the study. Our findings for the Discrete Emotions Scale revealed that participants did not significantly feel anger, sadness or happiness in the virtual environment but participants significantly felt fear and surprise.

It might seem strange that two emotions were significantly elicited in the virtual environment. This effect is actually well-known in emotion research as it is common for negative emotions to be accompanied by other affective states (Mayeretal., 1995). An explanation for why surprise was experienced in the virtual environment may be due to the jump scares that were placed in the environment and also the novelty of the environment itself because participants had not experienced it before. All things considered, these findings support the hypothesis that participants would report feeling a higher degree of fear after experiencing the virtual environment.

6 Conclusion

The virtual environment significantly induced higher physiological arousal in participants compared to baseline with regards to heart rate and skin conductance response. Participants reported a significant increase in emotional arousal but there was no significant decrease in emotional valence. The data does indicate that there is a trend and that if the experiment is performed again with more participants a statistically significant result for emotional valence could be observed.

The data from the Discrete Emotions Scale indicates that the virtual environment successfully induced fear even though the data set was small (11 participants). This clearly shows that the

effect is significant and that more data would likely reinforce the conclusion.

Future work to be done is to have a larger study with more participants to investigate the effects on self-reported valence. It would also be interesting to investigate the individual triggered events in the virtual environment to see what effect they have with regards to inducing fear.

ACKNOWLEDGMENTS

Thank you Prof. James Gain for supervising this project. Thanks also goes to Johan Bontes and Timothy Gwynn who were our assistant supervisors. We thank Siphumelele Sigwebela, Gina Gilpin and Prof. Gosia Lipinska from the UCT Department of Psychology for their guidance with designing the virtual environment, designing the experiment and providing the physiological measuring instruments used in experiments.

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APPENDIX

A. Script for virtual environment

The condition will immerse participants in a dark, damp underground canal. The participant will be sitting in a boat/gondola that is being controlled by an unseen operator. In the foggy darkness of the canal the participant will hear the sounds of water lapping and splashing, the hollow echoes of the tunnel, the sound of sinister breathing and dripping, which will suggest that they are not alone. After 30 seconds of acclimatising to the dim environment the participant will be informed about their only tool, a torch. Using the torch the participant will be able to explore the environment; catching glimpses of the messages written in graffiti on the walls, a closed gate behind them, indistinguishable stains on the boat, murky waters and shadow like glimpses of creatures in the tunnel. They will then hear a more distinct animal-like sound and see the abnormal shape and skin of the creatures arm. Feeling the presence of the creature draw near, the participant will look to escape only to find that through the fog there is another rusted gate before them. The creatures' presence will then escalate and the creature will attack the participant. The participant is then exposed to the creature, an amphibian humanoid with hollowed eyes, no mouth, slimy translucent skin, long arms and frog-like legs