Emotion Elicitation in the Laboratory:
Virtual reality environments can make you feel fear

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Abstract

In psychological research, the two most widely used emotion elicitation protocols are the International Affective Picture System (IAPS) and film-clip paradigms. A major problem for each of these protocols is that there is data suggesting they do not elicit discrete emotions explicitly without interference from other closely-related emotions (e.g., their stimuli may be designed to elicit fear, but participants report experiencing anger or disgust instead). In this study, we used virtual reality (VR) technology to create an alternative emotion elicitation protocol, and tested whether it could address the observed weakness of current protocols. We predicted that our VR protocol can take advantage of both reporting methods of the IAPS and film-clips by reporting both the cognitive dimensions of emotions (valence and arousal) and discrete emotions (fear, anger, disgust, sadness and happiness). Participants were healthy university students (N = 29, aged 18–25 years). Inside a dedicated research laboratory, they were shown two VR presentations. The first, *Introduction to VR*, featured emotionally neutral content that served to introduce them to the equipment and workings of the virtual environment. The second, *11:57*, featured content (e.g., flickering lights, screaming, zombie-like creatures) intended to provoke fear. Before and after each VR presentation, participants completed the Self-Assessment Manikin, the Differential Emotions Scale, and the Presence Questionnaire. We also monitored their heart rate and skin conductance levels throughout the experimental protocol. Analyses of the self-report and physiological data suggest that the second VR presentation successfully elicited heightened levels of fear over baseline, when compared to anger and disgust. We observed that surprise and fear, however, indicated parallel levels of elicitation. These results suggest that VR environments can be manipulated to focus on specific emotional triggers, and provide evidence for the usefulness of VR as an emotion elicitation tool.

Emotion Elicitation in the Laboratory:
Virtual reality environments can make you feel emotions

Emotions are a difficult aspect of human experience to study because of their subjective nature. Experiments designed to study emotion involve emotion elicitation and measurement. Both aspects of such studies present significant challenges for researchers; however, emotion research has expanded over the years and continues to grow further. Commonly, emotions are elicited using pictures and video clips, however, more ecologically valid, effective and technologically advanced methods are emerging, such as virtual reality (VR). First, we review the main theoretical frameworks of emotion and how these have influenced the already existing emotion elicitation tools such as standardised libraries of picture stimuli and film-clips. Furthermore, we examine how these frameworks and tools have evolved towards emerging technologies such as VR in becoming key methods of emotion elicitation.

Existing Emotion Elicitation Tools: The IAPS and film-clip paradigms

A popular tool for emotion elicitation is the International Affective Picture System (IAPS); this system comprises of over a thousand images of human experience. The IAPS image library is constantly being added to and is subsequently continuously developing. Researchers from across the world use it and add to it (Mikels et al., 2005). Each image has a standardized valence and arousal rating. These ratings were standardized on a large group of males and females college students in the US (Bradley & Lang, 1994). Typically, experiments assessing emotional response require participants to rate their response to each picture stimulus on the Self-Assessment Manikin (SAM) which measures valence and arousal. Additionally, many studies record objective measures of emotional response such as heart rate, facial muscle movement, electroencephalography and functional magnetic imaging (Bradley & Lang, 1994).

Unlike other emotion-eliciting stimuli such as film-clips and VR, the IAPS uses images as static cues, which makes emotion-related measurement easy to control. Researchers can select the images that will exclusively elicit a particular emotion without interference of other images that may unintentionally arouse another emotion. Unfortunately, because the stimuli are only rated along the valence and arousal dimensions, discrete emotions cannot be identified.

However, the IAPS has been criticized on several other grounds. It has been criticized with respect to the strength of the emotions it can elicit - some authors argue that that images are too limited in emotion elicitation because they are static and do not engage the participant enough, especially with regards to discrete emotion elicitation (Verschuere, Crombez, & Koster, 2001). Moreover, when participants rate IAPS pictures they may respond in a manner that is socially appropriate. For example, while seeing a sad image, they may indicate that they feel sad because it is socially appropriate. This may not, however, be the way they feel. (Bradley & Lang, 1994).

Emotion has also been elicited using film or video; this medium forms an integral part of emotion elicitation. Using this method participants observe a variety of films that are designed to elicit discrete emotions. The film-clips are designed to elicit amusement, anger, contentment, disgust, a neutral state, sadness, surprise and fear (Gross & Levenson, 1995). More recently they have been rated by a culturally diverse gender groups aged 17-43 (Schaefer, Nils, Sanchez, & Philippot, 2010). To rate the video-clips participants completed the Differential Emotion Scale (DES) which asked participants to indicate on a scale how many times they experienced a specific emotion.

Film-clips have better potential to elicit stronger emotions (Picard, Vyzas, & Healey, 2001). However, researchers have also criticized this method of emotion elicitation, especially with respect to its ability to evoke certain discrete emotions reliably. This is because each study used a different set of self-selected film-clips. Subsequently this resulted in varied responses as some films were not standardized (Schaefer et al., 2010). Schaefer et al. (2010) attempted to address these shortcomings by getting experts to select the sixteen clips and the results were improved. This was because the films were selected and agreed upon by film critics who were able to provide more specific and reliable film-clips that were likely to elicit the appropriate responses. Furthermore this study evaluated a blend of dimensional and categorical emotional responses that included arousal, valence and emotional discreteness (Schaefer et al., 2010).

Despite these improvements, film-clips remain limited in their ability to evoke discreet emotions. For example, both studies by Gross & Levenson (1995) and Schaefer et al. (2010) failed to effectively elicit fear because fear scores were not significant or would be concernedly correlated with another emotional state such as anger, disgust or tension. Another difficulty with film-clips is that they are not standardized - various studies have used

different clips in each study (Gross & Levenson, 1995; Ray, 2007; Sato, Noguchi, & Yoshikawa, 2007; Schaefer et al., 2010).

Eliciting Discrete Emotions

Some emotions present themselves as particularly difficult to elicit based on the described methods of emotion elicitation, such as, fear. Research on fear emotions suggest that fear is elicited in threat-like situations due to the appearance of a known or unknown threat; which could manifest itself as a ghost, a threatening human, a large known animal or even a mythical creature. This is because throughout evolution things that bear a different likeness from ourselves, have been perceived as a threat to survival (Öhman, 1986). As is clear from the studies of the IAPS and film-clips, fear either correlates too highly with other emotions, or is not significantly elicited. In the studies using film-clips, participants' fear was correlated with anger, disgust and surprise (Gross & Levenson, 1995; Schaefer et al., 2010). Thus, the reason there is difficulty differentiating fear from other emotions may be due to context; that participants were identifying their emotions from subjective, third-party observation of images, faces, stories or videos. Participants may for example have perceived threat, but not to their own survival. In other words, they may not have been immersed in the presented environment. Furthermore, they may have experienced other emotions related to the characters they were observing. Hence the correlation with surprise, disgust or anger for the subjects in the presentation, but not for themselves (Hugdahl, 1981; Öhman, 1986). However, there are some newer systems of emotion elicitation that may be better at stimulating emotions that researchers have previously found difficult to provoke.

Virtual Environments and Virtual Reality

In recent times, the fast development of Computer Generated Imagery has led to the creation of VR. VR blends both categorical and dimensional frameworks to create a reliable emotion eliciting tool that records valence and arousal responses and categorizes emotional states. VR can be used to measure both physiological and subjective elements of participants' responses to stimuli (Nasoz, Alvarez, Lisetti, & Finkelstein, 2004). VR can effectively elicit difficult emotions like anxiety in a controlled and manageable way (Tichon & Banks, 2006). This is attributed to the phenomenon of presence, which is the experience of sensing that you are in one place despite being in another (Robillard, Bouchard, Fournier, & Renaud, 2003). This presence is what the other tools such as the IAPS and film-clips are lacking. The creators of VR systems suggest that to elicit a strong emotion response, the tool must be close to a real environment situation (Diemer, Alpers, Peperkorn, Shiban, & Mühlberger, 2015).

The reality simulation of VR sets it apart from the other tools. Controversially, though, there is no understood theory that confirms that emotion and presence have a causal relationship. Similarly, the self-reporting unreliability issue has been critiqued in VR. This is in instances where participants will report emotions that are not associated with the stimulus or report what is socially expected of them (Lisetti & Nasoz, 2004).

Rationale, Aims, and Hypotheses

Emotion elicitation has developed steadily over the last two decades, from elicitation using pictures from the IAPS to more dynamic elicitation using films-clips. However, each tool had significant shortcomings – the IAPS was largely criticised for its ability to elicit strong responses while film-clips were not standardised and researchers could not control for inappropriate emotion elicitation from images in the clips. Furthermore, these models could not strongly and accurately elicit fear. Thus, VR presents itself as a better tool because it simulates reality; strong emotion responses are more probable and it can be programmed so that only specific emotions are elicited. It can be programmed so that the participants are not being overwhelmed by stimuli. It can create more natural neutral stimuli. With all these possible outcomes for emotion elicitation using VR, our study aims to use this system to develop an emotion elicitation tool. We hypothesize that (1) A fear-eliciting VR protocol will elicit more negative and more physiologically aroused responses in comparison with baseline and a neutral virtual environment. We expect the participants to report arousal in the trend: baseline < neutral < fear. Moreover, we expect the same trend to occur in recorded heart rate at 45% and 95%. We expect reported valence to follow the trend: fear < baseline < neutral. (2), we hypothesize that VR will exclusively elicit the emotion of fear without significant reports of anger, disgust and surprise. We expect that participants fear scores will indicate the trend: baseline ≤ neutral < fear. We expect the other emotions to follow the trend baseline < neutral = fear. To confirm that our independent variables (neutral and fear VR) have been successfully set up as emotion elicitation stimuli, we conduct a manipulation check using the WSPQ. We expect the norms of our two conditions to meet the standardised norms.

Methods

Design and Setting

Our study is of a quantitative cross-sectional design. Participants were exposed to two VR experiences: The study took place in the Whisper Room in the ACSENT Sleep

Laboratories in the Psychology Department at the University of Cape Town. The independent variables in this study are the virtual environments, the neutral condition and the fear conditions respectively. The trigger points occur at 45% and 95% of the fear condition. The dependent variables are the self-report measures which are explained later. Heart rate is the objective dependent variable which is recorded at 45% and 95% of the duration of all three conditions.

Participants

Recruitment. Participants were recruited through the University of Cape Town's Student Research Participation Points (SRPP). This program requires undergraduate psychology students to take part in research done by the Psychology Department. The study required a minimum of 23 participants for statistical power of >.80 (when alpha is set at .05 and a medium effect size is used). 53 participants responded to the screening measures, of which only 33 were eligible for the study. 4 surveys were incomplete and 16 participants were not eligible. 10 participants scored to high on the PC-PTSD, 14 participants scored to high on the PHQ-9 and 2 participants scored to high on the MMFQ. 30 participants were invited to take part in the study and 29 completed the entire study.

Eligibility criteria. Participants needed to be between the ages of 18- 26. Participants diagnosed with mood or anxiety disorders were excluded as this may have biased self-reports (American Psychiatric Association, 2013). Participants who had experienced trauma 2 weeks prior to screening were excluded (De Bellis, Hooper, & Sapia, 2005) . Participants with phobias and phobia related disorders were excluded because such participants would likely report fear anyway. Participants with sensitive heart conditions and epilepsy were excluded, the virtual reality environments can trigger epilepsy attacks and therefore people with a history of epilepsy were excluded.

Measures and Materials

VR presentations.

Presentation 1. Introduction to Virtual Reality which was the neutral condition comprises of several different environments including a river boat ride, a Mongolian home experience, watching circus performers, interacting with a herd of elephants, an interaction with a dinosaur, floating in outer space and a basketball practice with the Cavaliers.

Presentation 2. 11:57, the fear condition is a VR horror film in which the participants of the study are a kidnapped victim who is left in a dark building with strange and scary people. We have identified 2 main fear trigger events in the film. The first is the jump scare

attack of the zombie. The second scare is the appearance and attack of the main villain which is very like the first trigger. The virtual environment is dark and features flickering lights, long echoes, footsteps and creepy violin scores (Collective, 2016).

Screening measures.

The Patient Health Questionnaire for Depression-9 (PHQ-9). Features 9 questions which are used to detect depression and its severity of participants within a two-week period, see Appendix A. Minimal scores are between 5 and 9, these suggest that there are minimal depression symptoms. Any score above 10 indicates that the individual has a higher depression potential. Thus individual scoring less than 10 were eligible for this study (Smarr & Keefer, 2011). Individuals scoring more than 10 were excluded to ensure that the stimuli used in the presentation does not have negative effects on vulnerable participants.

The 4-item Primary Care Post-Traumatic Stress Disorder Screen (PC-PTSD). This measure features four yes/no questions to identify symptoms of trauma in an individual, see Appendix B. Those individuals who answered 'yes' to three or more questions were not eligible for the study (Cameron & Gusman, 2003). It is important that in this study participants were not triggered by the features or nature of the VR presentation. See Appendix B.

The Marks and Matthews Fear Questionnaire (MMFQ). This is a 17 item, 7 sub-scale fear questionnaire to identify participant phobia see Appendix C. The first item requires the participant to score their phobia on a scale of 0-8. Participants with a score of more than 5 were not eligible. Participants with a total score of more than 46 were not eligible (Marks & Mathews, 1979).

Physiological measures. We recorded participants' heart rate. Heart rate was measured using the BIOPAC MP160 system. Normal heart rate ranges from 60-100 beats per minute (BPM). In the context of emotional stimuli, a heart rate of 110 BPM or higher indicates elevated heart rate and is suggestive of a negative emotional response such as fear (Kreibig, 2010).

Heart rate was measured at baseline rate before the presentation of the VR worlds. Heart rate was also measured during both neutral and fear conditions respectively.

Subjective measures

The Witmer and Singer Presence Questionnaire (WSPQ). Is a 19-item questionnaire that is divided into 4 requirements or sections that predict reliable presence; Involved/Control, Natural, Interface Quality and Resolutions. Each question was answered by

the participant on a scale of intensity. The wording of each question differed according the question. The participants reported according to the scale ‘not compelling’ and ‘very compelling’ (Witmer, Jerome, & Singer, 2005; 1998). This measure was used to ensure that participants are engaging adequately with the VR system. See Appendix D.

The Self-Assessment Manikin (SAM). Is a non-verbal 9-point scale measure. SAM looks both at the valence spectrum, if the condition was positive or negative, as well as arousal, how aroused participants felt during the respective conditions. The participant placed an ‘x’ on one of the 9 images that bests represent how they feel; the image changes from a smiling, happy manikin, which indicated pleasure to a frowning, unhappy, which indicated displeasure. (Bradley & Lang, 1994; Morris, 1995). Baseline scores were taken before as well as after each condition was presented. A second administration of the SAM informed us about the valence of the emotion elicited during VR presentation. See Appendix E.

The Differential Emotions Scale (DES) is an emotion scale in which participants select how often they experienced a certain emotion; joy, fear, anger, disgust, surprise, sadness, guilt, contempt and shame. They then indicate the frequency on a 5 point scale ranging from never to very often (Izard, 1982; Kotsch, Gerbing, & Schwartz, 1982). The scale consists of 30 adjectives, 3 adjectives per emotion. The three adjective scores are added, the closer the score to 15 the more the participant felt the specific emotion. This measure was used to verify whether we were eliciting fear from the participants. Only the scores for anger, disgust, fear and surprise were used for the purposes of this study even though the whole DES was administered. Baseline scores were also taken. See Appendix F.

Procedure

Screening. Participants who were eligible after the screening measures were sent an email invite to participate in the study. We saw one participant per booked time slot (1 hour). We invited each participant to the Whisper Room and told them about the experimental process, as well as to read and sign an informed consent form. We proceeded to connect the participants to electrodes; under their left clavicle, under the right rib cage and at the back of the neck. Participants were asked to fill out a survey containing the SAM, DES and WSPQ, in that order. Whilst they filled out the survey we ran the BIOPAC MP160 to record their heart rate. These would serve as baseline measures.

Following the completion of the baseline collections, each participant was shown the first presentation, the neutral condition. While the participants watched we recorded their heart rate. After the presentation participants filled out the SAM, DES and WSPQ. The

second presentation, the fear condition, was then presented to participants and heart rate was recorded during the presentation. After the presentation, the participants filled out the self-reports. Each participant watched the presentation in the order neutral condition followed by fear condition. Soothing music was played throughout the experiment, with exception of when presentations were being viewed, this was to create a relaxing environment for the participants.

Ethical Considerations

We followed the University of Cape Town's ethical guidelines for conducting research comprising human participants. Ethical approval was granted by the Department of Psychology Research Ethics Committee. If at any point the participants felt uncomfortable, or that the presentations were overwhelming, they were encouraged to communicate that they no longer wanted to continue with the presentation. A researcher was constantly observing participants in the Whisper Room. We then concluded each session by thanking and de-briefing the participant., This included informing the participants of the purpose of the study, re-assuring the confidentiality of their participation and providing them with appropriate contact details should they feel distressed. They were also sent an email (Appendix G) containing the de-briefing form as well as having their SRPP points uploaded. One researcher did have First Aid training in case of emergency as there was a possibility of epilepsy or other distressful situations as a fear eliciting condition was used. One participant did terminate participation during the fear condition, the presentation was stopped and the participant was debriefed. In a separate incident during the fear condition one participant was distressed however after enquiring the participant did want to voluntarily continue. After the presentation, the participant was calmed down by the researcher and debriefed.

Statistical Analyses

For the statistical analysis, we used IBM SPSS Statistics 24 software, with alpha set at .05. We began all analyses by examining the assumptions underlying parametric tests. Where we found violations to these assumptions we have noted them in each relevant section. Where there are no violations we have proceeded by describing the results.

Manipulation check. We conducted a manipulation check to identify if participants feel present in the two VR conditions. We can gather the mean scores for each factor in the WSPQ

and compare the factor means of the two presentation conditions to the standardized factor means of the questionnaire.

Hypothesis 1. We hypothesize that participants will be the most arousing in the fear condition. To test the hypothesis, we first ran a 3 x 1 within-effects repeated measures ANOVA. The independent variables are the three conditions: baseline, fear and neutral; the dependent variable is the arousal scores from the SAM, as these report perceived activation. To determine which environment has the most significant activating effect we ran *Bonferroni* post-hoc analyses. We ran a 3 x 1 repeated measures ANOVA with the same independent variables as the first hypothesis, however the independent variable is the valence scores from the SAM. The results as to which condition elicited the highest reported valence is determined by the *Bonferroni* post-hoc analyses. We expect reported valence to follow the trend: fear < baseline < neutral. To examine arousal objectively we ran two 3 (condition: baseline, fear and neutral) x 1 (time point: 45% and 95% of VR presentation) repeated measures ANOVA with the same independent variables and heart rate as dependent variables respectively. The ANOVA analysis was also supported by *Bonferroni* post-hoc analyses.

Hypothesis 2. The second hypothesis predicts that participants will find the fear condition to be the most unpleasant and scary. To determine which emotion may have caused unpleasant experiences we ran four 3 x 1 repeated measures ANOVA's with condition (baseline, fear and neutral) as the independent variable and discrete emotions (fear, surprise, anger and disgust) as the dependent variables. As with all the other ANOVA analyses, post-hoc *Bonferroni* t-tests indicate the contrast results for each environment.

Results

Screening

Thirty UCT psychology students were recruited to the study. Participants were aged 18 – 26 and 22 were female and 8 male. Table 1 (below) describes the results of the screening measures. The average scores for the PHQ-6 indicate that the participants had low anxiety and depression. The average scores of the MMFQ were indicated to be in the middle range well

below the exclusion score of < 40, which indicates that participants did not have any pre-condition phobias. The PC-PTSD-4 in table 2 revealed more no responses than yes responses, this means that participants did not have trauma related sensitivity and anxiety.

Table 1.
Screening results: Descriptive Statistics of the PHQ-6 and MMFQ

	N	Minimum	Maximum	*M*	*SD*
PHQ-9	30	0.00	9.00	3.83	2.34
MMFQ	30	6.00	40.00	26.00	8.99

Note. SD = standard deviation

Table 2.
Frequency of responses to PC-PTSD-4

	Response		
	N	Yes	No
Question			
1	30	7	23
2	30	2	28
3	30	3	27
4	30	4	26
Total		16	104

Manipulation check: Comparing the factor means

The questionnaire aims to measure how present the participant felt. For our study, we predict that the participant will feel present in both the environments. Thus, we will compare the descriptive means of each subset for each virtual environment. We will compare them to the norms set out by Witmer and Singer (1998). Results are indicated in Table 3 below.

Table 3.

Descriptive statistics for the Presence Questionnaire

	Conditions		
	Norm	Neutral	Fear
		N = 29	*N* = 29
Factor			
Realism	29.45(12.04)	39.4 (10.8)	32.31 (11.9)
Possibility to act	20.76 (6.01)	16.49 (6.79)	15.2(7.23)
*Quality of interface	15.37 (5.15)	7.29 (4.97)	7.11(5.11)
Possibility to examine	15.38 (4.9)	15.38 (4.90)	15.62(4.98)
Self-evaluation of performance	11.00 (2.87)	11.26 (2.87)	11.10(3.65)
Total	104.39(18.99)		

Note. Means are presented with standard deviations in parentheses. These norms are per the French standard obtained from the UQO Cyberpsychology Lab (2004). *Quality of interface is negatively scored, values lower than the norm indicate good quality interface.

Realism. The mean total score for realism in neutral condition is greater than the norm. This means that the presentation felt realistic to participants and that the graphics are true to real life. The fear condition realism scores are in line with the norm, however, the standard deviation indicates that some participants did not feel as though the presentation was real enough. This is expected because the graphics in fear condition are not as high quality as those in neutral condition.

Possibility to act. Neutral condition results did not meet the norms especially in terms of mean scores. This result is because participants were mostly sitting in the chair and not walking or running. However, Neutral condition did have scenes where the participant could interact with the dinosaur and elephants. The fear condition means are much lower than the norm, this is because the presentation did not require the participants to do anything, all the action was being done to them.

Quality of interface. Neutral condition means are less than the norm, in this case this is a good indication. This means that there is little interference or delay in the presentation.

The fear condition means are also lower than the norm, although these are below the norm they indicate good results for quality of interface in presence.

Possibility to examine. Neutral condition means are above the norm, which suggests that the participants could see things clearly and from multiple perspectives in the virtual environment. The lower standard deviation indicated that there is less variance in scores. The fear condition means are almost identical to the norm, this means that the presentation provides adequate possibility to examine.

Self-evaluation of performance. Neutral condition mean results are quite like the norm, with the exception that our participants' scores varied more. Just as per the neutral condition, the fear condition results are very close to the norm, this shows that both the presentations indicated that participants were comfortable and could adapt quickly to the environment.

Overall, with exception of possibility to act, the participants felt very present in the virtual environment, this suggests that the environment were quite close to simulating real life. This indicates that the manipulation of each environment for the purpose of emotion elicitation was successful.

Testing hypothesis 1: Between-effects differences of arousal and heart rate scores

Self-Assessment Manikin.

Arousal. We predicted that participants will be more aroused in fear condition than the other environments. That this would manifest in the trend: baseline < neutral < fear. The 3 x 1 ANOVA revealed statistically significant differences between conditions (see Table 3) suggesting that there is a difference in how provoking each virtual environment is. The *Bonferroni* post-hoc test indicated that fear condition has significantly higher scores than baseline. The effect size for the contrast between the baseline and fear condition is greater than 2; suggesting that the strength in mean reports of perceived arousal between the two conditions is greater than 2 standard deviations and has a non-overlap of 81.1% (Becker, 2000). The contrast between the fear and neutral conditions also has a large effect size with an over-lap of 47.4% (Becker, 2000). This signifies that fear condition is the most arousing presentation in the study.

Valence. We predicted that participants will be more pleased for the neutral condition than the other environments following the trend: fear < baseline < neutral. We ran the 3 x 1 ANOVA to identify which condition was the most pleasurable for participants. The ANOVA

revealed a significant difference between conditions (see Table 2). This indicates a statistically significant difference between the levels of valence participants felt in each presentation. The *Bonferroni* post-hoc test indicated that neutral condition has higher arousal reports than both baseline and fear conditions. In particular the effect size of the contrasts for the baseline condition against the neutral condition are greater than 1 which means the strength in reported valence in the neutral condition is greater than 1 standard deviation with a non-overlap of 62.2% (Becker, 2000). The contrast between the fear condition and baseline also has a similar effect size which indicates that the participants probably felt negatively about the fear presentation compared to baseline. Thus, we can deduce that neutral condition is the most positively received presentation and the fear condition was the most negative.

Heart Rate. Our prediction stated that the fear condition would yield the highest heart rate (both at 45% and 95% of the presentation) following the trend: baseline < neutral < fear. We ran two 3 x 1 ANOVAs to determine which condition results in higher heart rates at 45% and 95% of the presented environment. Figures 1 and 2 clearly illustrate that heart rate is the highest during fear condition suggesting that participants are most activated during the fear condition.

45%. The repeated measures ANOVA was run to determine any significant effect in average heart rate across the three environments at 45%. Although some of the data is skewed indicating some variance and some variables have outliers; sphericity is not significant and thus the assumption is upheld. The ANOVA test is robust to violations of normality (Field, 2013). The ANOVA is significant. *Bonferroni* results indicate that heart rate significantly differs between all three conditions. More specifically the fear condition has a significantly higher heart rates at 45% of the presented environment when compared to baseline and the neutral condition. The associated effect sizes for comparisons between fear and (a) baseline and (b) neutral conditions were greater than 1 indicating that there is a substantial difference between the conditions. This suggests that the fear condition strongly elevates heart rate in comparison with the other condition.

95%. A repeated measures ANOVA was run to determine any significant effect in average heart rate across the three environments at 95%. The data is positively skewed with a small number of outliers, however ANOVA test is robust (Field, 2013). The ANOVA is significant. *Bonferroni* results indicate that heart rate significantly differs between all three conditions. More notably the fear condition has a significantly higher heart rates at 45% of

the presented environment when compared to baseline and the neutral condition. Moreover, the associated effect sizes for comparisons between fear and (a) (b) conditions are greater than 1 with a non-overlap range of 65-75% (Becker, 2000). This proposes that the fear condition strongly elevates heart rate in comparison with the other condition. Furthermore, a repeated measures ANOVA was run to determine if there were any significant differences between heart rate at the 45% mark and heart rate at the 95% mark. The ANOVA was non-significant. Thus, no further analysis is needed.

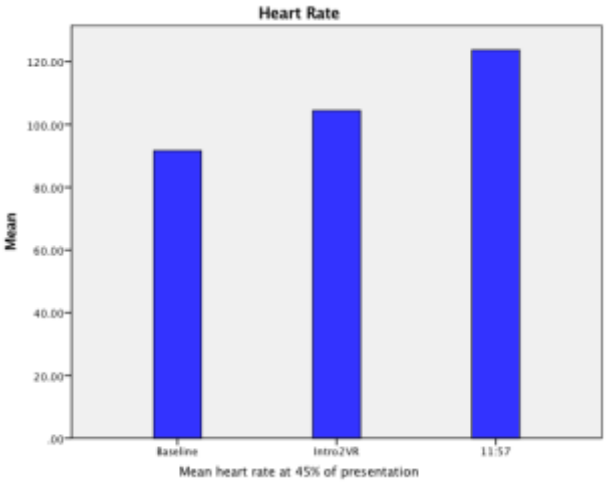


Figure 1. Mean heart rate at 45% of presentation

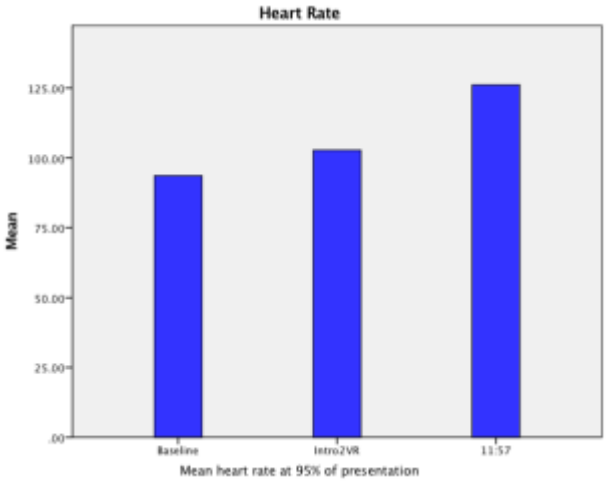


Figure 2. Average heart rate at 95% of presentation

Testing hypothesis 2: Between-effects differences of fear, surprise, anger and disgust

We predicted that during the fear condition, fear will be the highest reported emotion, over anger, disgust and surprise. We predicted fear will be in the trend: baseline ≤ neutral < fear. The other emotions we expect to be in the trend: baseline < neutral = fear. The results are indicated in table 3.

Fear. A repeated measures ANOVA was run to determine significant effect for self-reported fear between baseline, the neutral and fear conditions. Mauchly's test is borderline significant (p = 0.56) thus we decided to use Greenhouse-Geisser (W = .84) which is acceptable (Field, 2013). The data is somewhat normally distributed however, ANOVA is robust and this should not affect results (Field, 2013). The ANOVA for self-reported fear is

significant as seen in Table 2. The *Bonferroni* post-hoc analysis pointed out that self-reported fear in the fear condition is significantly different from baseline as well as the neutral condition, showing that fear is a highly reported emotion in the fear condition. The contrast effect sizes of the fear condition compared to the others were large, close to 1 and over 1 which indicates a non-overlap of 56.1-62.2% (Becker, 2000). Together these results show that fear emotions are experienced the most and strongly during the fear condition in comparison with the other conditions.

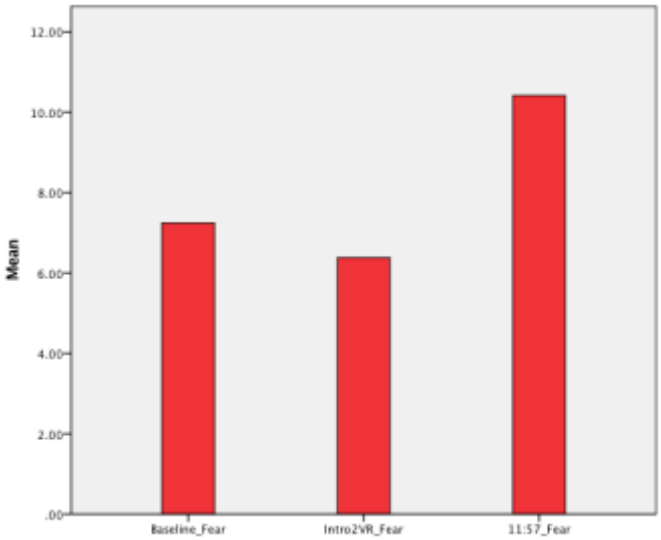
Surprise. A repeated measures ANOVA was run to determine any significant effect for self-reported surprise between baseline, neutral and fear conditions. Sphericity significance is borderline ($p = 0.55$) and Greenhouse-Geisser ($W = .96$) values were used. The data for baseline has 2 outliers, however as stated above ANOVA is robust (Field, 2013). The ANOVA is significant. *Bonferroni* post-hoc analysis showed that there is no significant difference of reported surprise between the neutral and fear conditions. Surprise emotions have the largest effect size in the neutral environment. These results show that surprise emotions are often strongly experienced in the neutral environment.

Anger. A repeated measures ANOVA was run to determine any significant effect for self-reported anger between baseline, neutral and fear conditions. The ANOVA for anger is significant, however it has a medium effect size (Bakeman, 2005). Bonferroni post-hoc analysis indicated a significant difference between the neutral and fear conditions. The contrast effect size was relatively medium, with a non-overlap of 43% (Becker, 2000). These results propose that anger emotions were often experienced more in the fear condition than the neutral condition.

Disgust. The ANOVA for disgust is significant with quite a small effect size (Bakeman, 2005). *Bonferroni* post-hoc analysis indicated no significance in the fear condition between baseline and neutral condition. There is a significant difference of reported disgust between baseline and the neutral condition. The effect size is medium. These results signify that disgust emotions were often experienced strongly in the neutral condition.

Considering the significant ANOVA results and the nature of the self-report in which the effect of the emotion is determined by how close the score is to the total score of 15; we think that an analysis of the means is appropriate. The neutral condition elicited the least amount of fear. Figure 3 indicates the average scores for fear during baseline and the two presentations. Self-reported surprise, however, is moderately high during all three presentations. As seen in figure 4 below it is highest during the neutral condition. The

surprise reported in fear condition is slightly higher than reported fear. Figures 5 and 6 indicate the average scores for Anger and Disgust emotions respectively. For both anger and disgust the average scores indicate mild-moderate sensation.



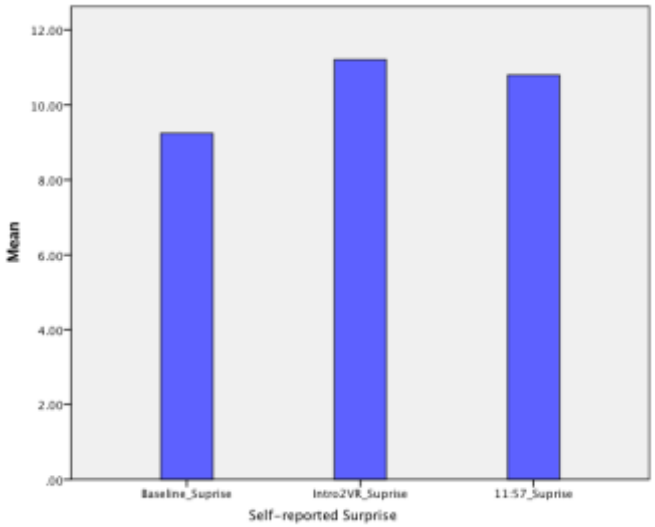
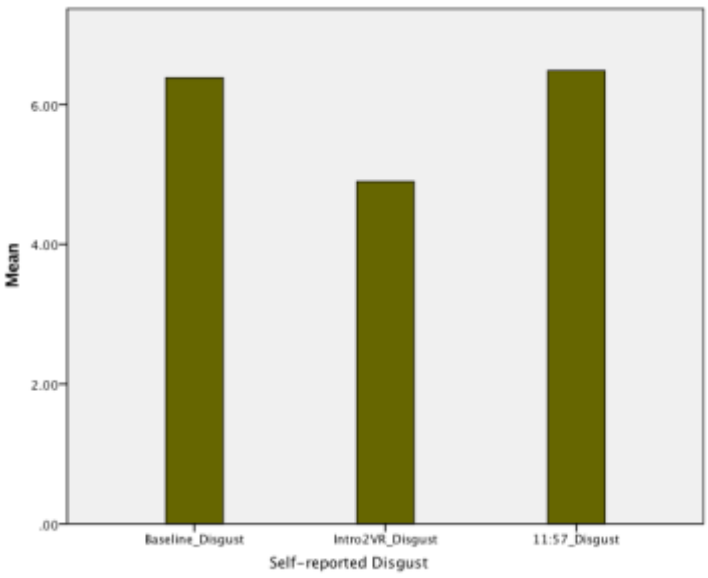


Table 3.

Dimensional and Discrete Emotion Responses: Descriptive Statistics and Results from Between-Group Comparisons

Figure 3. Mean self-reported fear.

Figure 4. Mean self-reported surprise



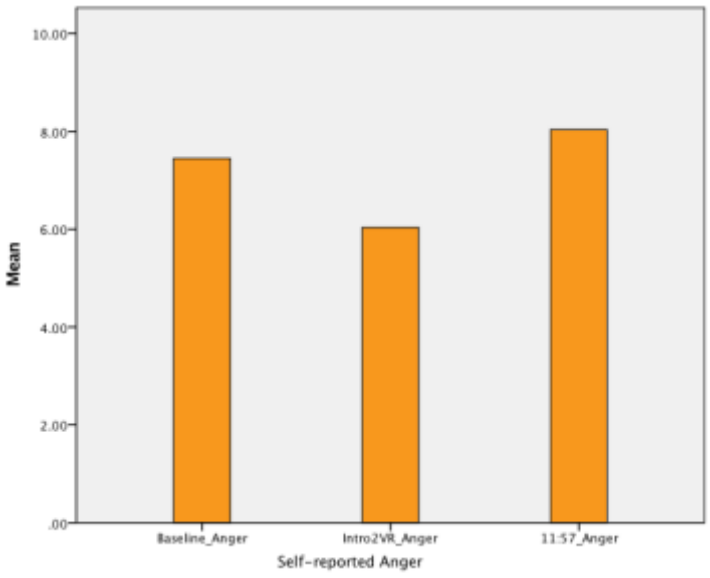


Figure 5. Mean self-reported disgust

Figure 6. Mean self-reported anger

	Conditions		
N	Baseline	Neutral	Fear

Variable					*F/t*	*p*	ESE
Arousal	25	3.44(1.98)	5.80(3.50)	7.72(2.25)	29.41	>.01**	.70
Contrast[a]					4.01	>.01**	.65
Contrast[b]					3.79	>.01**	.83
Contrast[c]					1.17	.76	.42
Valence	29	7.52(1.66)	5.38 (1.76)	4.59(2.90)	12.36	>.01**	.31
Contrast[a]					4.87	>.01**	.33
Contrast[b]					3.94	>.01**	1.25
Contrast[c]					7.55	>.01**	1.24
Heart rate @ 45%	27	91.69(15.75)	104.46(13.84)	123.76(20.08)	27.80	>.01**	.52
Contrast[a]					4.54	>.01**	1.12
Contrast[b]					3.68	>.01**	.86
Contrast[c]					6.28	>.01**	1.78
Heart rate @ 95%	26	93.60(15)	102.74(12.96)	126.11(21.91)	23.82	>.01**	.49
Contrast[a]					4.39	>.01**	1.30
Contrast[b]					1.72	.05	.65
Contrast[c]					6.00	>.01**	1.73
Anger	29	7.45(2.49)	6.03(2.44)	8.03(2.99)	4.60	.01*	.14
Contrast[a]					3.07	.01*	.73
Contrast[b]					2.45	.06	.58
Contrast[c]					.74	1.00	.21
Disgust	29	6.38(2.46)	4.90(2.21)	6.48(3.04)	3.54	.05	.11
Contrast[a]					2.38	.07	.59
Contrast[b]					2.87	.02*	.63
Contrast[c]					.13	1.00	.04
Surprise†	29	9.24(2.42)	11.21(2.01)	10.79(2.61)	5.83	.01*	.17
Contrast[a]					0.77	1.00	.18
Contrast[b]					3.10	.01*	.89
Contrast[c]					2.42	.06	.62
Fear†	29	7.24(2.56)	6.38(2.61)	10.41(3.9)	13.41	>.01**	.32
Contrast[a]					4.88	>.01**	1.21
Contrast[b]					1.34	.57	.33
Contrast[c]					3.30	.01*	.96

Note. Means are presented with standard deviations in parentheses. ESE = effect size estimate (in this case, η^2 for *F* statistic and Cohen's *d* for *t* statistic). *$p < .05$. **$p < .001$. Contrast[a] is the Bonferroni t-test between the fear and neutral condition. Contrast[b] is the t-test between baseline and the neutral condition. Contrast[c] is the t-test between baseline and the fear condition. Surprise† Mauchly's test is significant ($p = 0.55$) and Greenhouse-Geisser ($W = .96$) Fear† Mauchly's test is borderline significant ($p = 0.56$) and Greenhouse-Geisser ($W = .84$) Degrees of freedom were (2, 56) for Anger, Disgust, Surprise and Fear. (2, 52) for Heart rate at 45%, (2, 50) for heart rate at 95%. (2, 48) for Arousal and (2, 56) for Valence. *N* values for heart rate differ because the data was illegible, due to technical interference. *N* values for valence and arousal differ as some of the participants missed questions and arousal baseline outliers violated normality, thus we excluded cases list wise.

Discussion

Emotions are a difficult aspect of human experience to study because of their subjective nature. Nonetheless, a major area of neuroscientific enquiry revolves around eliciting emotions in the laboratory to examine, for instance, the neural substrates underlying, or the physiological markers associated with, different affective states. Two emotion-elicitation tools used commonly in psychological research are the International Affective Picture System (IAPS;Verschuere et al. (2001)) and film-clip paradigms (see, e.g. Emotion Elicitation using Films; Gross and Levenson (1995)). However, these tools are limited in their ability to elicit discrete emotions, and there are question marks surrounding the validity and specificity of the emotional states they elicit (Ray, 2007; Rottenberg, Ray, & Gross, 2007; Sato et al., 2007). Hence, the present study aimed to develop a virtual reality-based tool for elicitation of a specific emotion (fear), without eliciting frequently accompanying emotions such as anger, disgust, and surprise. We found that although strong fear responses were elicited in the fear condition, we were not able to elicit fear exclusively without significant anger.

To achieve the study's aim, we recruited 30 young adult participants (8 men, 22 women, age range 18-26). Each viewed two VR presentations, one aimed at maintaining neutral (baseline) affect and the other aimed at eliciting fear. We tested the following hypotheses: (1) A fear-eliciting VR protocol will have the most activated responses; indicated by the SAM and heart rate recordings at 45% and 95% of the VR condition. (2) the VR fear protocol will elicit negative emotion (specifically, the emotion of fear without significant reports of anger, disgust and surprise) with reports from the DES.

We conducted a manipulation check to determine how successfully we manipulated the VR environments as potential emotion elicitation stimuli. We compared the means of the WSPQ in each environment according to the 5 presence factors. The French sample standardized norms were met, except for possibility to act. Thus, participants action was limited in the VR conditions, but overall, participants reported feeling that the environment was real, even though it was not. We rationalised the use of the WSPQ as our manipulation check because stronger emotions tend to be experienced if the participant is able to see what they are meant to feel (Frijda, 1988). Moreover, research into presence and emotion elicitation has indicated that the stronger the presence, the stronger the reported emotion (Freeman, Lessiter, Pugh, & Keogh, 2005; Villani, Riva, & Riva, 2007). These findings

support the competency of the structure and content of VR conditions as emotion elicitation tools.

Summary and Interpretation of the Current Findings

Hypothesis (1) aimed to test how activated emotions were in the neutral and fear conditions. Results from the SAM reported that in the neutral condition positive valence reports were the strongest in comparison to baseline and the fear condition. Moreover, the strongest negative valence reports between the variables were most present in the fear condition. Participants indicated feeling aroused in both the conditions, however, the fear condition resulted in the strongest arousal reports. Captured heart rate at 45% and 95% respectively supported the arousal reports, as participant recorded heart rates were the highest in in the fear condition. The fear condition also had the strongest effect on increased heart rates between baseline and the neutral condition.

These results prove hypothesis (1) as a priori predictions regarding activation trends (measured via both self-reported arousal and objectively measured heart rate) were confirmed: Both conditions activated emotions, but the fear condition elicited stronger activation.

However, the SAM and heart rate measures, are limited in that they are not able to indicate which (or whether) discrete emotions were elicited. Hence, at this level of analysis, it is not possible to determine *which* negative emotion participants were most likely to experience after exposure to the fear condition.

However, using discrete emotion measures, one is better able to determine whether a discrete emotion was experienced, and which emotion it was. For hypothesis (2) we aimed to elicit explicit fear emotion reports from participants. The DES results are all significant in terms of the emotions: anger, fear and surprise elicited in the two conditions.

Further investigation into whether all the negative emotions were elicited following exposure to the fear conditions indicated that participants reported significant experience of only fear, surprise, and anger. Regarding the relative magnitude of the effect sizes associated with the report of each of those three emotions, angers' was the smallest (it was reported the least frequently, with its scores mostly in the middle range), fear's was the second-largest, and surprise's was the largest.

Analysis of fear condition effects suggest that we did not prove hypothesis (2) as the fear condition had the strongest effect on fear, yet anger and surprise are still significantly elicited. Notably, though the anger effect in the fear condition is not the strongest.

Of further note here is that surprise was also the most strongly-reported emotion overall, following exposure to the both conditions. The DES reported means reveal that during the fear condition surprise emotion is reported higher than the fear emotion by .38. Furthermore, surprise was the highest and strongest emotion elicited in the neutral condition. This result is confounding to hypothesis (1) because the neutral condition is indicated as a positive emotion condition and the fear condition is reported as negative. If we consider surprise to be a positive emotion, then the high surprise scores for the neutral condition confirm hypothesis (1). However, if we also consider surprise to be a negative emotion, which is what is suggested by the results, then the high surprise scores for the fear condition also confirm our hypothesis (2).

We are not sure as to which end on the valence scale surprise emotions belong. Most published literature in the field regard surprise as a positive emotional state because of its associations with happiness/joy. Yet, researchers have found that surprise and fear are most difficult to elicit exclusively (Roy-Charland, Perron, Beaudry, & Eady, 2014) Relying on facial impressions as well as physiological measures, Kreibig (2010) reported that surprise emotions are never elicited exclusively. Often, surprise emotions correspond with fear and other negative emotions. Surprise also tends to correspond with positive emotions. This may demonstrate a relationship between arousal and surprise. As surprise may be an indicator of arousal. For instance, in our study reported surprise in the fear condition, revealed the trend baseline < neutral < fear our predicted trend for arousal is the same. Additionally, much like surprise arousal is not easily determined by positive and negative emotions (Kreibig, 2010).

Current Study Limitations and Recommendation for Future Research

As in most previously published studies within this field, the fact that data relies on self-reported emotional experience is a limitation. This remains a challenge to our study, although, tools like the IAPS have managed to universally standardize their image presentations by developing the protocol across cultures (Verschuere et al., 2001). Larger more diverse samples are needed so that virtual environments can be generalized and used across different contexts and cultures.

The complications we experienced with eliciting discrete emotions, signify a need for self-reports in which participants can report their own overall emotional experiences of the presentations. For future studies it will be beneficial to study surprise as an emotion as it is not currently possible to report it without fear and other emotions Roy-Charland et al. (2014).

Although the sample was well powered it was homogeneous (i.e., all participants were university psychology undergraduates). Future studies should aim to standardize and reflect demographics. We do admit that the time placement of the project did affect our ability to collect more participants, as students were set to write exams furthermore we were not able to handle the turnaround for the screening responses to get participants who would equalize the demographics.

A third possible limitation is that we did not randomise or counterbalance the order of presentation of the two VR environments. Our decision to administer the environments in the same order for each participant was necessary to acclimatize the participants to the environment. We recommend that future emotion elicitation studies use four different conditions (2 x fear and 2 x neutral); so that those can be randomised and the participants are still able to acclimatise to VR. Two participants were distressed during the fear condition; it is necessary to have an intensity scale for how fearful and environment is as this may prevent causing participants' actual harm or distress.

Participants did report closing their eyes in the fear condition, and subsequently missed the stimulus. This can be prevented in the future, as new software exists that makes sure the eyes are open and in the direction of the stimulus so it is not missed.

Significance of the Study

Virtual reality technology has the potential to be of immense benefit to the study of emotion elicitation. A criticism of the IAPS and film-clips paradigms is that the reported emotions are not always strongly felt. Even though our study did not elicit fear emotions explicitly, we managed to elicit strong emotions in the fear condition. The advantage of VR may be a contextual issue concerning the participants ability to relate to the film and picture environments (Gross & Levenson, 1995; Verschuere et al., 2001). The manipulation check confirmed that presence was at expected levels compared to the norms (Witmer & Singer, 1998). These results indicate that participants felt as if they were in a different environment whilst sitting in a safe and sound room exploring space and getting up close with dinosaurs. Not only are VR environments dynamic but they also allow experimenters to put participants in environments that can be programmed to any imaginable context (Baños et al., 2008; Freeman et al., 2005; Villani et al., 2007). These advantages provide additional parameters that could improve how participants report the strength of their emotional experience in the laboratory.

Summary and Conclusion

The present study described the development and evaluation of a novel virtual reality-based emotion elicitation protocol, focused on fear. Analyses of our self-report and physiological data suggested that the protocol stimulated emotional experience and, more importantly, that the fear condition elicited fear significantly more strongly than anger and disgust. Hence, this study illustrates the progression of laboratory-based emotion elicitation protocols from pictures, to films, to VR. VR environments are not static and are more immersive than other standard emotion-elicitation tools. Unlike the film-clips paradigm, and IAPS, our fear protocol was clearly able to elicit fear. The fear protocol, though preliminary, can elicit strong fear emotion however, not exclusively without significant anger and surprise. An important note here, however, is that the effectiveness of VR protocols is mediated by the participant's experience of 'presence' (i.e., feeling as though you are in one place, while being aware you are in another) in the virtual environment. Although this mediating phenomenon, requires more extensive investigation, we conclude by stating that this study suggests that VR emotion elicitation protocols might be a valid, useful tool in the growing discipline of affective neuroscience.

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Appendix A

Patient Health Questionnaire for Depression -9

Please mark or highlight which of the following four options most applies to you.

	Not at all	Several Days	More Than Half the Days	Nearly Every Day
Over the past two weeks: How often have you felt little interest or pleasure in doing things?				
Over the past two weeks: How often have you felt down, depressed, or hopeless?				
Over the past two weeks: How often have you had trouble falling or staying asleep, or sleeping too much?				
Over the past two weeks: How often have you felt tired or had very little energy?				
Over the past two weeks: How often have you had a poor appetite or were overeating?				
Over the past two weeks: How often have you felt bad about yourself – or that you are a failure or have let yourself or your family down?				
Over the past two weeks: How often have you had trouble concentrating on things, such as reading the newspaper or watching television?				
Over the past two weeks: How often have you been moving or speaking so slowly that other people could have noticed. Or the opposite being so fidgety or restless that you have been moving around a lot more than usual?				
Over the past two weeks: How often have you had thoughts that you would be better off dead, or of hurting yourself?				

Appendix B

The 4-Item Primary Care Post-Traumatic Stress Disorder Screen

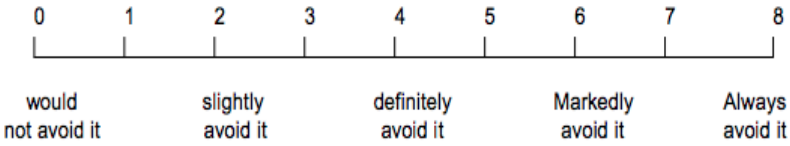
Please just say yes or no to the following questions:

In your life, have you ever had any experience that was so frightening, horrible, or upsetting, that in the past month you:

Question	Yes	No
Have had nightmares or thought about it when you didn't want to?		
Tried hard not to think out it or went out of your way to avoid situations that reminded you of it?		
Were constantly on guard, watchful, or easily startled?		
Felt numb or detached from others, activities, or your surroundings?		

Appendix C

Marks and Matthews Fear Questionnaire



Choose a number from the scale below to show how much you would avoid each of the situations listed below because of fear or other unpleasant feelings. Then write the number you choose in the space opposite each situation.

1.	Main phobia you want treated (describe in your own words)	
2.	Injections or minor surgery	
3.	Eating or drinking with other people	
4.	Hospitals	
5.	Travelling alone or by bus	
6.	Walking alone in busy streets	
7.	Being watched or stared at	
8.	Going into crowded shops	
9.	Talking to people in authority	
10	Sight of blood	
11.	being criticised	
12.	Going alone far from home	
13.	Thought of injury or illness	
14.	Speaking or acting to an audience	
15.	Large open spaces	
16.	Going to the dentist	
17.	Other situations (describe)	

Appendix D

Witmer and Singer Presence Questionnaire

WITH REGARD TO THE EXPERIENCED ENVIRONMENT

1. How much were you able to control events?

|_____|_____|_____|_____|_____|_____|_____|

NOT AT ALL SOMEWHAT COMPLETELY

2. How responsive was the environment to actions that you initiated (or performed)?

|_____|_____|_____|_____|_____|_____|_____|

NOT RESPONSIVE MODERATELY RESPONSIVE COMPLETELY RESPONSIVE

3. How natural did your interactions with the environment seem?

|_____|_____|_____|_____|_____|_____|_____|

EXTREMELY ARTIFICIAL BORDERLINE COMPLETELY NATURAL

4. How much did the visual aspects of the environment involve you?

|_____|_____|_____|_____|_____|_____|_____|

NOT AT ALL SOMEWHAT COMPLETELY

5. How natural was the mechanism which controlled movement through the environment?

|_____|_____|_____|_____|_____|_____|_____|

EXTREMELY ARTIFICIAL BORDERLINE COMPLETELY NATURAL

6. How compelling was your sense of objects moving through space?

|_____|_____|_____|_____|_____|_____|_____|

NOT AT ALL MODERATELY COMPELLING VERY COMPELLING

7. How much did your experiences in the virtual environment seem consistent with your real world experiences?

|_____|_____|_____|_____|_____|_____|_____|

NOT CONSISTENT MODERATELY CONSISTENT VERY CONSISTENT

8. Were you able to anticipate what would happen next in response to the actions that you performed?

|_____|_____|_____|_____|_____|_____|_____|

NOT AT ALL SOMEWHAT COMPLETELY

9. How completely were you able to actively survey or search the environment using vision?

|_____|_____|_____|_____|_____|_____|_____|

NOT AT ALL SOMEWHAT COMPLETELY

10. How compelling was your sense of moving around inside the virtual environment?

|_____|_____|_____|_____|_____|_____|_____|

NOT COMPELLING MODERATELY COMPELLING VERY COMPELLING

11. How closely were you able to examine objects?

|_____|_____|_____|_____|_____|_____|_____|

NOT AT ALL PRETTY CLOSELY VERY CLOSELY

12. How well could you examine objects from multiple viewpoints?

|_____|_____|_____|_____|_____|_____|_____|

NOT AT ALL SOMEWHAT EXTENSIVELY

13. How involved were you in the virtual environment experience?

|_____|_____|_____|_____|_____|_____|_____|

NOT INVOLVED MILDLY INVOLVED COMPLETELY ENGROSSED

14. How much delay did you experience between your actions and expected outcomes?

|_____|_____|_____|_____|_____|_____|_____|

NO DELAYS MODERATE DELAYS LONG DELAYS

15. How quickly did you adjust to the virtual environment experience?

|_____|_____|_____|_____|_____|_____|_____|

NOT AT ALL SLOWLY LESS THAN ONE MINUTE

16. How proficient in moving and interacting with the virtual environment did you feel at the end of the experience?

|_____|_____|_____|_____|_____|_____|_____|

NOT PROFICIENT REASONABLY PROFICIENT VERY PROFICIENT

17. How much did the visual display quality interfere or distract you from performing assigned tasks or required activities?

|_____|_____|_____|_____|_____|_____|_____|

NOT AT ALL INTERFERED SOMEWHAT PREVENTED TASK PERFORMANCE

18. How much did the control devices interfere with the performance of assigned tasks or with other activities?

|_____|_____|_____|_____|_____|_____|_____|

NOT AT ALL INTERFERED SOMEWHAT GREATLY INTERFERED

19. How well could you concentrate on the assigned tasks or required activities rather than on the mechanisms used to perform those tasks or activities?

|_____|_____|_____|_____|_____|_____|_____|

NOT AT ALL SOMEWHAT COMPLETELY

IF THE VIRTUAL ENVIRONMENT INCLUDED SOUNDS:

20. How much did the auditory aspects of the environment involve you?

|_____|_____|_____|_____|_____|_____|_____|

NOT AT ALL SOMEWHAT COMPLETELY

21. How well could you identify sounds?

|_____|_____|_____|_____|_____|_____|_____|

NOT AT ALL SOMEWHAT COMPLETELY

22. How well could you localize sounds?

|_____|_____|_____|_____|_____|_____|_____|

NOT AT ALL SOMEWHAT COMPLETELY

IF THE VIRTUAL ENVIRONMENT INCLUDED HAPTIC (SENSE OF TOUCH):

23. How well could you actively survey or search the virtual environment using touch?

|_____|_____|_____|_____|_____|_____|_____|

NOT AT ALL SOMEWHAT COMPLETELY

24. How well could you move or manipulate objects in the virtual environment?

|_____|_____|_____|_____|_____|_____|_____|

NOT AT ALL SOMEWHAT EXTENSIVELY

Appendix E

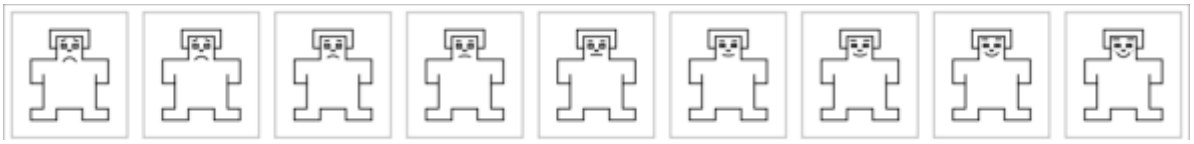
Self-Assessment Manikin

SELF-ASSESSMENT MANIKIN

Indicate how you feel about the presentation by marking the bracket with an [x].

If you are unsure about what to do try and answer according to the following questions:

- Row 1: how pleasurable the presentation was for you ?
- Row 2: how provoking the presentation was for you?



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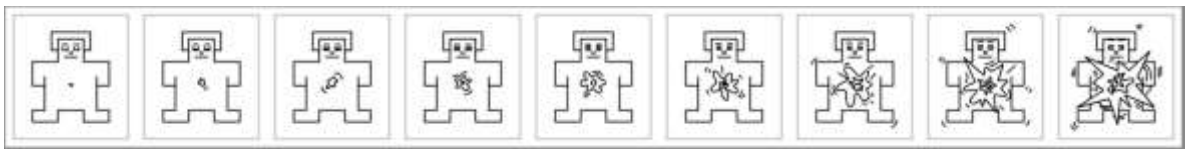

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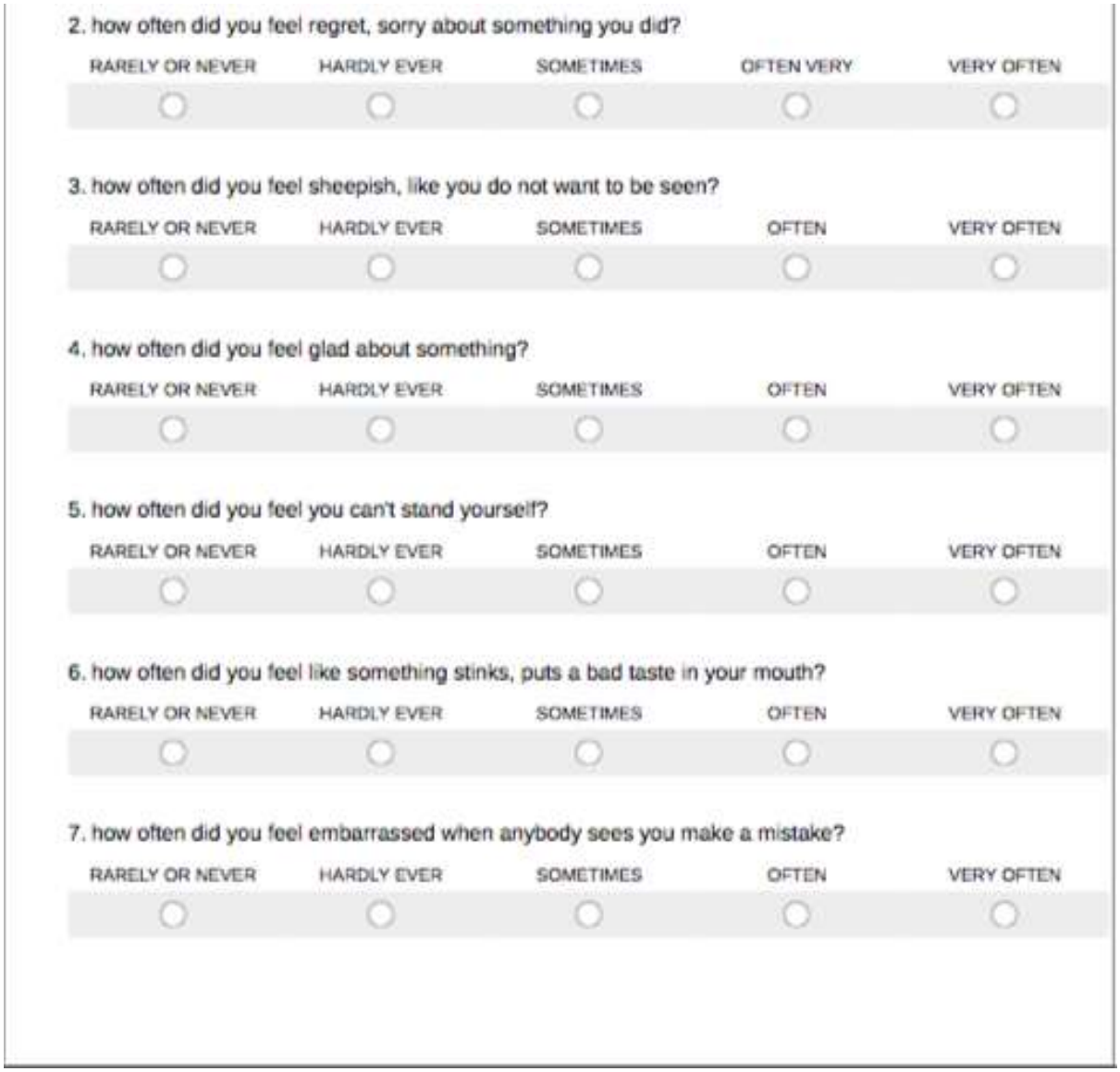
Appendix F

The Differential Emotions Scale



8. how often did you feel unhappy, blue, downhearted?

RARELY OR NEVER	HARDLY EVER	SOMETIMES	OFTEN	VERY OFTEN
○	○	○	○	○

9. how often did you feel surprised, like when something suddenly happens you had no idea would happen?

RARELY OR NEVER	HARDLY EVER	SOMETIMES	OFTEN	VERY OFTEN
○	○	○	○	○

10. how often did you feel like somebody is a low-life, not worth the time of day?

RARELY OR NEVER	HARDLY EVER	SOMETIMES	OFTEN	VERY OFTEN
○	○	○	○	○

11. how often did you feel shy, like you want to hide?

RARELY OR NEVER	HARDLY EVER	SOMETIMES	OFTEN	VERY OFTEN
○	○	○	○	○

12. how often did you feel like what you're doing or watching is interesting?

RARELY OR NEVER	HARDLY EVER	SOMETIMES	OFTEN	VERY OFTEN
○	○	○	○	○

13. how often did you feel scared, uneasy, like something might harm you?

RARELY OR NEVER	HARDLY EVER	SOMETIMES	OFTEN	VERY OFTEN
○	○	○	○	○

14. how often did you feel mad at somebody?

RARELY OR NEVER	HARDLY EVER	SOMETIMES	OFTEN	VERY OFTEN
○	○	○	○	○

15. how often did you feel mad at yourself?

RARELY OR NEVER	HARDLY EVER	SOMETIMES	OFTEN	VERY OFTEN
○	○	○	○	○

16. how often did you feel happy?

RARELY OR NEVER	HARDLY EVER	SOMETIMES	OFTEN	VERY OFTEN
○	○	○	○	○

17. how often did you feel like somebody is "good for nothing"?

RARELY OR NEVER	HARDLY EVER	SOMETIMES	OFTEN	VERY OFTEN
○	○	○	○	○

18. how often did you feel so interested in what you're doing that you're caught up in it?

RARELY OR NEVER	HARDLY EVER	SOMETIMES	OFTEN	VERY OFTEN
○	○	○	○	○

19. how often did you feel amazed,like you can't believe what's happened, it was so unusual?

RARELY OR NEVER	HARDLY EVER	SOMETIMES	OFTEN	VERY OFTEN
○	○	○	○	○

20. how often did you feel fearful, like you're in danger, very tense?

RARELY OR NEVER	HARDLY EVER	SOMETIMES	OFTEN	VERY OFTEN
○	○	○	○	○

21. how often did you feel like screaming at somebody or banging on something?

RARELY OR NEVER	HARDLY EVER	SOMETIMES	OFTEN	VERY OFTEN
○	○	○	○	○

22. how often did you feel sad and gloomy, almost like crying?

RARELY OR NEVER	HARDLY EVER	SOMETIMES	OFTEN	VERY OFTEN
○	○	○	○	○

23. how often did you feel like you did something wrong?

RARELY OR NEVER	HARDLY EVER	SOMETIMES	OFTEN	VERY OFTEN
○	○	○	○	○

24. how often did you feel bashful, embarrassed?

RARELY OR NEVER	HARDLY EVER	SOMETIMES	OFTEN	VERY OFTEN
○	○	○	○	○

25. how often did you feel disgusted, like something is sickening?

RARELY OR NEVER	HARDLY EVER	SOMETIMES	OFTEN	VERY OFTEN
○	○	○	○	○

26. how often did you feel joyful, like everything is going your way, everything is rosy?

RARELY OR NEVER	HARDLY EVER	SOMETIMES	OFTEN	VERY OFTEN
○	○	○	○	○

27. how often did you feel like people laugh at you?

RARELY OR NEVER	HARDLY EVER	SOMETIMES	OFTEN	VERY OFTEN
○	○	○	○	○

28. how often did you feel like things are so rotten you could make you sick?

RARELY OR NEVER	HARDLY EVER	SOMETIMES	OFTEN	VERY OFTEN
○	○	○	○	○

29. how often did you feel sick about yourself?

RARELY OR NEVER	NEVER HARDLY	SOMETIMES	OFTEN	VERY OFTEN
○	○	○	○	○

30. how often did you feel like you are better than somebody?

RARELY OR NEVER	HARDLY EVER	SOMETIMES	OFTEN	VERY OFTEN
○	○	○	○	○

31. how often did you feel like you ought to be blamed for something?

RARELY OR NEVER	HARDLY EVER	SOMETIMES	OFTEN	VERY OFTEN
○	○	○	○	○

32. how often did you feel the way you do when something unexpected happens?

RARELY OR NEVER	HARDLY EVER	SOMETIMES	OFTEN VERY	VERY OFTEN
○	○	○	○	○

33. how often did you feel alert, curious, kind of excited about something unusual?

RARELY OR NEVER	HARDLY EVER	SOMETIMES	OFTEN	VERY OFTEN
○	○	○	○	○

34. how often did you feel angry, irritated, annoyed with somebody?

RARELY OR NEVER	HARDLY EVER	SOMETIMES	OFTEN	VERY OFTEN
○	○	○	○	○

35. how often did you feel discouraged, like you can't make it, nothing's going right?

RARELY OR NEVER	HARDLY EVER	SOMETIMES	OFTEN	VERY OFTEN
○	○	○	○	○

36. how often did you feel afraid?

RARELY OR NEVER	HARDLY EVER	SOMETIMES	OFTEN	VERY OFTEN
○	○	○	○	○

37. how often did you feel like people always look at you when anything goes wrong?

RARELY OR NEVER	HARDLY EVER	SOMETIMES	OFTEN	VERY OFTEN
○	○	○	○	○

Appendix G

Informed Consent Form

UNIVERSITY OF CAPE TOWN

Department of Psychology

INFORMED CONSENT

Developing a fear elicitation protocol using Virtual Reality

We would like to invite you to take part in our honours Psychology research study on fear. This form provides you with information about this study and seeks your informed consent to participate. Before you agree to take part in this study, please read the information below and ask the researchers (Siphumelele and Mohamed) questions about anything that you do not understand. The data collected in this study is to be used towards the completion of an Honours degree in the Department of Psychology at the University of Cape Town.

Study Purpose

To develop more reliable methods for studying emotion, we want to find out if we can make people feel fear by showing them a Virtual Reality movie.

Participation Tasks and Benefits of Participation

If you agree to participate in this study, you will complete screening questionnaires after which eligibility will be determined. If you are not eligible, testing will come to an end and you will receive 1 SRPP point for your participation. Participation up to this point will take 30 minutes. If you are eligible, the researchers will admit you into the VR presentation and after all three sessions you will receive 6 SRPP points for your participation in this study. Participation in the full study will take approximately 120 minutes.

Participation, Withdrawal, Confidentiality and Risks

Participation in this study is completely voluntary and you may withdraw from the study at any time without any consequences. All information will be treated with confidentiality; at no point will your name or personal details be disclosed to anyone other than the researchers. All data will be safely stored on a hard drive and consent forms will be stored in a locked file cabinet. Only the data from the measurements of your heart beat and finger tips will be used, as well as the scores from the tests you fill out. We will use this information to write a report on the study and possibly also publish the results in a research journal. Names and screening test scores will not be included in the write up or available for other researchers to access. The study does aim to explore whether feelings of fear can be created in the research laboratory situation, so you

may feel some fear or distress in response to the virtual reality movie. There are no costs involved on your behalf.

Appendix H

Debrief, Email version

To:

CC

From

Hello XXX

Thank you for participating in our study today. This is just to follow up on what we talked about today concerning the methods, protocols and aims of the study.

Title of the research study

Developing a fear eliciting protocol using Virtual Reality (VR)

Purpose of the research study

The study aims to see if we can make people feel fear using VR. This will help us to develop more reliable methods of assessing emotions in the research laboratory setting, because we cannot always assess emotions in the real-life context as events happen.

Procedure of Research Study

Today you were presented with one of the VR Fear presentations in which your heart rate and finger tips were measured twice, once before and once after, to see how the presentation affected you. You were also required to fill out three self-reports; in the form of questionnaires and a scale before and after the presentation. These are also needed to identify how you felt during the presentation. From your responses, we will be able to determine if the presentation affected you, by making you feel fear. This session was approximately 30 minutes long.

Deception during the study

There was no deception during the study

Further requirements

The content of the presentation may have distressed you quite significantly and may still be affecting you now. If this is the case please contact the UCT Student Wellness Centre or the UCT Student Careline on the following numbers:

- UCT Student Wellness centre: 021 650 1017 or 021 650 1020
- UCT Student Careline (a free 24-hour counselling hotline): 0800 24 25 26 free from a Telkom line or send an SMS to 31393 for a call-me-back

SRPP points will be uploaded once you have completed all your sessions.
Please take care not to mention any of the procedures of the study to anyone, as informing others may affect the effect of the presentation on them.

Please respond to this email by stating your name and that you have been informed about the study, its aims and procedures.

Thanks once again ☺

Warmest
Mohamed and Siphumelele

If you have any further questions or concerns about the study, you can contact the researchers (Siphumelele and Mohamed) on vrprotocol@gmail.com, supervisor Ms Gosia Lipinska gosia.lipinska@uct.ac.za or Dr Kevin Thomas on kevin.thomas@uct.ac.za

For ethical concerns contact Mrs Rosalind Adams on 021 650 3417 or rosalind.adams@uct.ac.za

Appendix I

SRPP Advertisement

Announcement

Subject Get next semester's SRPP points in early!

Groups site

Message

Hello everyone,

We are running a research study through the Department of Psychology. The project aims to accurately evoke the emotion of fear using virtual reality, so that we can develop more reliable ways of researching emotions. We will be using VR headgear and 360-degree video environments.

To participate in this study, you need:

1. To be a fluent English-speaker
2. To be between the ages of 18-25
3. NOT have a history of psychological, psychiatric or neurological disorders
4. NOT to have any phobia or recent trauma
5. NOT currently be taking any psychiatric/chronic medication
6. NOT to have epilepsy or any seizure related disorders

If you meet the above criteria, you can click on the 'Sign-up' tab on this Vula site. Please do not sign-up if you are not eligible. Also, please remember to take note of the time and date of your session if your sign-up.

Once you have signed up, you will complete two administrative forms. You will then be asked to fill in a few questionnaires which will take you 10-30 minutes.

If you ARE NOT eligible to continue with the study you will be awarded with 1 SRPP for completing the questionnaires.

If you ARE eligible after filling in the questionnaires, you will be invited to attend four 30 minute sessions on different days, in which you will be shown the VR presentations. For this you will receive 4 SRPP points for your 120 minutes of participation in the full study. Participation in the total study will result in 6 SRPP points being rewarded to you.

If you have any further questions about this study, please email us:

vrprotocol@gmail.com

Kind regards,

Mohamed Ali Anwary & Siphumelele Sigwebela

Appendix J

SRPP Slip

Developing a Fear-Eliciting Protocol Using VR

SRPP ATTENDANCE SLIP

(Please keep this until the end of the semester as proof of participation in this study)

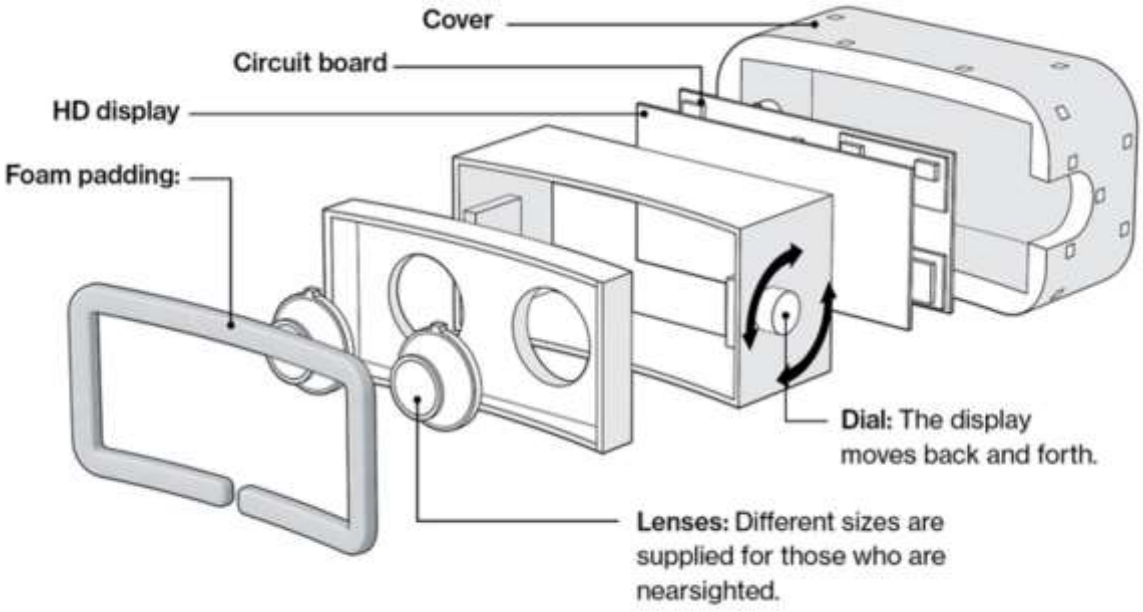
NAME: _____RESEARCHER SIGNATURE: _____

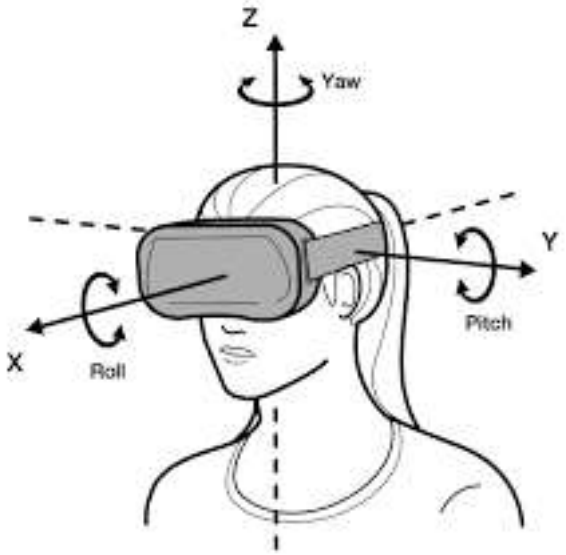
COURSE CODE: _____SRPP POINTS EARNED: _____

Thank you for participating in this study. If you have any further questions, you can contact the researchers on vrprotocol@gmail.com

Appendix K

Oculus Rift Schematic





Appendix L

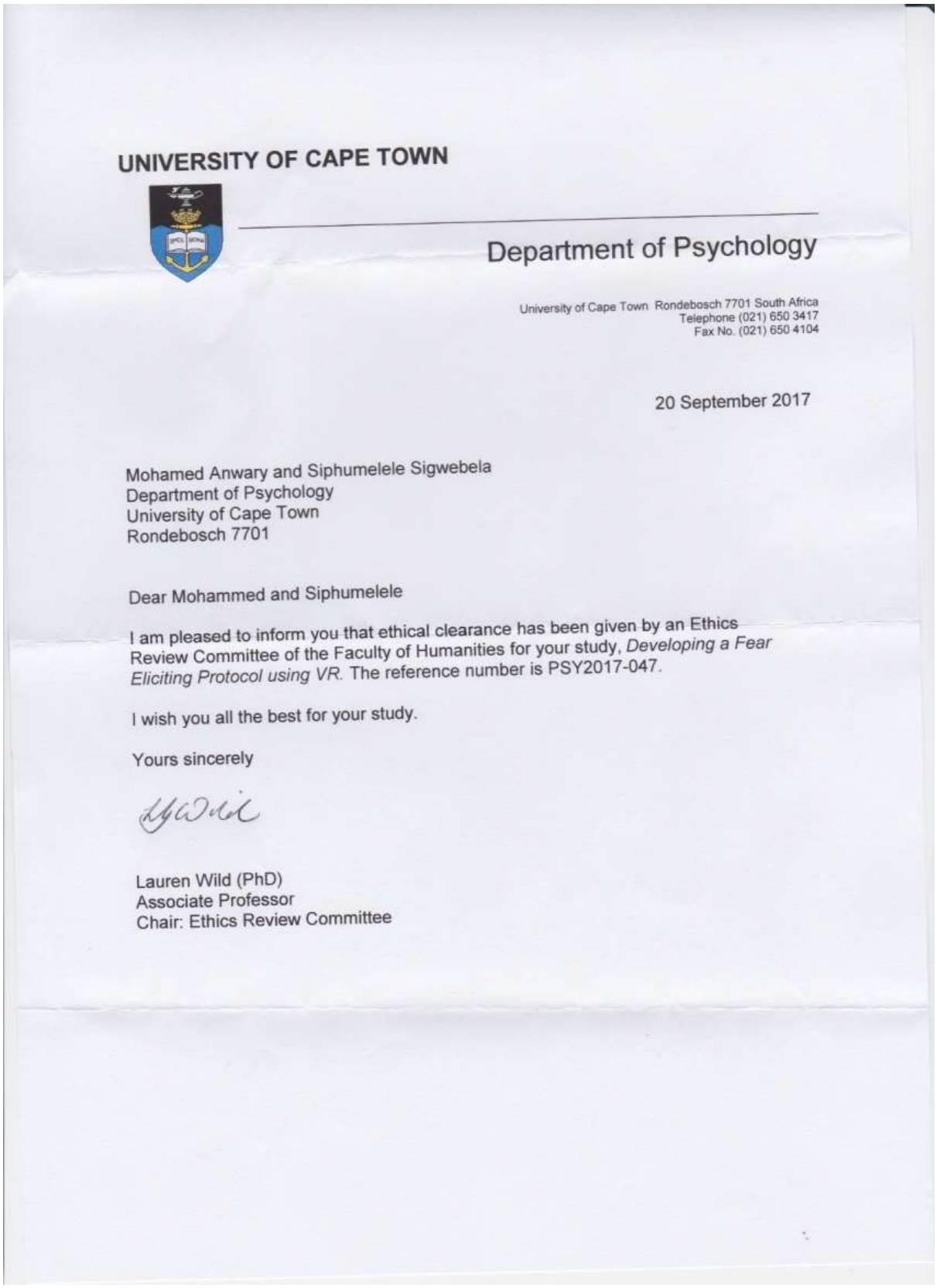
VR Models

Presentation 1: Introduction to Virtual Reality

Presentation 2:11:57

Appendix M

Department of Psychology Ethical Approval Form.



UNIVERSITY OF CAPE TOWN

Department of Psychology

University of Cape Town Rondebosch 7701 South Africa
Telephone (021) 650 3417
Fax No. (021) 650 4104

20 September 2017

Mohamed Anwary and Siphumelele Sigwebela
Department of Psychology
University of Cape Town
Rondebosch 7701

Dear Mohammed and Siphumelele

I am pleased to inform you that ethical clearance has been given by an Ethics Review Committee of the Faculty of Humanities for your study, *Developing a Fear Eliciting Protocol using VR.* The reference number is PSY2017-047.

I wish you all the best for your study.

Yours sincerely

Lauren Wild (PhD)
Associate Professor
Chair: Ethics Review Committee