Emotional Arousal Through Virtual Reality

Hamandishe Mathivha (MTHHAM005) Department of Computer Science University of Cape Town South Africa <u>mrmathivhahy@gmail.com</u>

1. ABSTRACT

This review looks at the literature on Virtual Reality research concerning emotions and presence. We examine what emotions have been successfully elicited and what emotions have yet to be induced by virtual environments. This review examines different studies that have been done on emotional arousal, and compares factors such as virtual environments, interfaces used, and techniques of measurement. The studies done on presence are critiqued based on the seemingly never-ending search for the "perfect" definition of presence (partly due there being no objective measure for presence), and the conflicting conclusions that studies on link between immersion and emotion reach are highlighted. After reviewing the literature, we conclude by giving thoughts on where virtual reality research efforts should be focused, namely: standardization of virtual reality environments, more emotions being generated by virtual environments, and also the big gap in the literature on presence concerning the investigation into individual traits and how they relate to level of presence in virtual environments.

2. 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 they might hold the key to understanding mood disorders like PTSD and chronic depression. The traditional way of eliciting emotional reactions in subjects include showing them 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 makes the emotional reaction weaker.

Virtual Reality is being considered as a better alternative for eliciting emotions because of the first person experience that it offers. With this in mind, there are two areas of Virtual Reality research that interest us: research concerning the use of Virtual Reality as a Medium For Eliciting Emotions, and also an area that is closely linked to this, research about the link between Emotion, Immersion and Presence. In the remainder of this paper we will proceed to discuss and evaluate the literature from these areas of VR Research.

3. VIRTUAL REALITY AS A MEDIUM FOR ELICITING EMOTIONS

Virtual Reality has been used to generate a number of emotions successfully. Several studies (Banos et al., 2012; Serrano et al., 2013) have succeeded in eliciting positive emotions like joy and relaxation. Fear is also an emotion that has consistently been generated with the use of Virtual Reality under controlled lab conditions (Lin, 2017; Toet et al., 2009). Felnhofer et al. (2015) succeeded in generating anxiety, joy, anger and boredom in participants but failed to generate sadness. Although research into eliciting more emotions and better studies need to be performed, these early results show that Virtual Reality environments show promise as mood induction protocols(MIPS).

At the moment, there are no standard Virtual Reality environments for emotion elicitation. Different studies and researchers have used different environments that are unrelated to each other. It would of benefit if standardized environments were developed. Some studies have used Virtual Environments wherein participants explore a virtual park (Baños et al., 2004, 2012; Riva et al., 2007; Felnhofer et al., 2015). Scene elements of the park like lighting, sound effects, background scenery, number of nonplayer characters, etc. are manipulated in order to create different moods. For example, a park that elicits joy will have a bright sunny environment, with birds chirping in the background and beautiful scenery (Felnhofer et al., 2015; Riva et al., 2007). In contrast, a scary park will have a dark night-time environment with the sound of owls hooting (Felnhofer et al., 2015; Toet et al., 2009). Other settings that have been used for Virtual Environments include a virtual home (Serrano et al., 2013) and a virtual village (Toet et al., 2009).

Studies have also differed in the manner in which users were permitted to navigate in these virtual environments. There are 3 types of navigation: passive navigation, active navigation and stationary navigation. Passive navigation refers to having the participant's avatar move without the participant having any control over the movement. Examples of passive navigation scenarios include roller coasters, boat rides, being in a wheelchair while being pushed by someone else. Active navigation is navigation wherein the user controls the movement of their avatar. Different input devices have been used for this type of navigation: joystick, smartphone (Kothgassner et al. 2013), treadmill. For stationary navigation, the player's avatar never moves (although they may be able to move their head and look around). The type of navigation has been shown to have no effect on emotion (Freeman et al., 2005), but is linked to feelings presence.

Studies also vary in terms of the equipment used. Video walls, PC monitors and Head-Mounted Displays have been used to test virtual environments. It would be expected that equipment that is more immersive will generate stronger emotional reactions in participants, but papers testing this hypothesis have reached conflicting conclusions (Baños et al., 2008 vs Riva et al., 2007). Media content (emotionally arousing content vs. non-emotional content) seems to be more important than the medium (whether PC Monitor or Head Mounted Display) when it comes to emotion elicitation.

Researchers use a variety of measures when detecting whether a specific emotion has been generated. These measures fall into 2 groups: physiological measures and self-report measures. Examples of physiological measures are heart rate and saliva sampling (Toet et al., 2009). Saliva sampling is used to measure levels of fear because the stress hormone cortisol can detected in a person's saliva. Heart rate is used for measuring emotions that are related to the sympathetic nervous system e.g. fear, excitement. Another physiological measure which is extremely popular is skin conductance. Skin conductance does not measure any specific emotion, but it measures emotional arousal in general. Self-report measures are questionnaires that ask participants about their subjective emotional experience. These are questionnaires designed to ask open-ended questions about how a participant is currently feeling and what their mood is like. Some questionnaires target specific emotions like the Translated State Anxiety Inventory (TSAI), others apply to broad groups of emotions like the General Mood State (GMS).

Taking what has been discussed in this section into account, studies wherein Virtual Reality is used as a mood induction protocol can be divided into 2 groups: the first is studies that investigate whether Virtual Reality technology can be used to elicit specific emotions and the second is studies that are focused on the effects of certain emotions (e.g. depression and anxiety studies). The former seeks to refine current methods of eliciting emotions with Virtual Reality (Felnhofer et al., 2015) or tries to elicit new emotions that have not yet been generated using Virtual Reality. The latter is more treatment based, and examples of these studies are any papers exploring the use of Virtual Reality to treat phobias.

4. PRESENCE, IMMERSION AND EMOTION

When discussing emotional arousal in the context of virtual environments, it is important to consider a related phenomenon called presence. Presence refers to a user's sense of being in a virtual environment. There is a lot of speculation about how presence is generated. One theory is that presence requires a suspension of belief, as a continuously updated interior model of the environment mismatches with the actual reality (Sheridan, 1999). Presence is important in our discussion because Price et al. (2011) state that presence is a prerequisite for real emotions to be experienced in a virtual environment. This creates an important link between emotions generated in virtual environments and presence. This link has yet to be completely verified because studies investigating the link, reaching conflicting conclusions.

The method of measuring presence is also an issue of debate. The common way of measuring it is with the use of self-report questionnaires, but the subjective nature of such questionnaires introduces biases and priming effects that would not arise if an objective measure was used. One proposed objective way of measuring presence has been through skin conductance, (Felnhofer, 2015) but this measure did not correlate well with self-report measures of presence.

A concept that is closely related to the subject of presence, is immersion. Whereas presence is concerned more with the subjective experience of the user, immersion refers to the objective description of the technology that generates the user experience (Banos et al., 2004). For example, a virtual reality Head-Mounted Display is a more immersive medium than a PC Monitor. Studies have shown that Virtual Reality systems with higher immersion generate higher levels of presence in users. This is why immersion is important for Virtual Reality experiences, but immersion is not the full picture when it comes to presence. The actual content of the experience plays a large role. Users can experience more presence while using a PC Monitor than when using Head-Mounted Display. If the media content on Monitor is more consistent with the users internal model of the environment (Banos et al., 2004).

Although the relationship between presence and immersion has been clearly identified. The relationship between immersion and emotion is less clear. Some studies have shown that higher immersion leads to increased emotional responses, other studies found that immersion has no effect on emotion. Diemer et al. (2015) speculate that the effects of immersion may depend on the underlying emotion being generated. This is supported by studies that have found that strongly arousing emotions (fear, excitement) show more immersion effects, whereas less arousing emotions (joy, relaxation) show weaker immersion effects. More research still has to be done in order to find the link (if there is any) between immersion and emotion.

Similar to the section discussing research on emotion elicitation, studies on presence differ in terms of the virtual reality environments, the interfaces or equipment, techniques used to measure presence and factors under investigation. Studies have used a variety of Virtual Reality environments: parks, houses, subways and university campuses. But for some reason, that is not clear in the literature, virtual parks are used in a lot of studies. Maybe researchers are not being creative enough and everyone is just copying what has been done in the past. In these virtual environments, users are asked to wander around and explore the surroundings for a set amount of time. Once time is up, their level of presence during the experience is measured.

Head-Mounted Displays are the common interface used in these studies, but other studies have used different equipment like a PC monitor and a rear-projected video wall (Banos et al., 2004). Using different equipment is necessary when investigating the effect of immersion on an emotion or the effect of immersion on

presence, because varying the different interfaces allow for varying levels of immersion.

Levels of immersion are measured objectively by comparing the different interfaces. Presence has not be measured objectively and so far studies have used self-report questionnaires to get readings on presence. Questionnaires that have been used are: UCL Presence Questionnaire, Independent television Company Sense of Presence Inventory, ICT Sense of Presence Inventory, Igroup Presence Questionnaire and the Reality Judgement and Presence questionnaire. There's quite a large number of different questionnaire used, so it would be beneficial to just have one standard questionnaire used in all presence studies. This would make it easier to compare results between studies and see which techniques are better at inducing more presence.

Research around presence is quite broad and studies have investigated a host of factors that might be linked to presence. These studies can be placed into 3 groups: studies investigating the link between presence and specific emotions, studies investigating the link between immersion and presence, and studies investigating new techniques for measuring presence. Studies examining the link between presence and emotion have reached conflicting conclusions, so more work needs to be done here. The link between immersion and presence has been confirmed in papers showing the positive correlation between the two. So far no objective measures for presence have been found.

5. DISCUSSION

Virtual Reality As A Medium For Eliciting Emotions

So far, research into emotional arousal with the use of virtual reality has only investigated eliciting a handful of emotions: sadness, joy, anxiety, relaxation, boredom and anger. More emotions like disgust, shame, envy, pride, hope, love etc. need to be studied and virtual environments that arouse them created. Such research will be very beneficial to psychological studies of emotion.

The virtual environments used in studies are highly variable. This makes it difficult to compare studies and techniques. Standardized environments for eliciting specific emotions need to be designed. This will speed up research because each research team will not have to develop a virtual environment from scratch each time they want to investigate an emotion. Emotion theory from psychology must guide the design of these standardized environments. This area of Virtual Reality research is relatively young, so it is understandable that standards have not been established, but as the field matures standards will have to be put into place. Meanwhile, papers need to report on exactly what conditions (lighting, textures, sound effects, music, scenery, etc.) were used in an environment when creating a specific mode.

The same concerns about standardization also apply to the interfaces used (Head-mounted displays, monitors, etc.) and emotional measures. But this is a less important concern because interfaces indicate the level of immersion.

Presence, Immersion and Emotion

Research into presence is overly focused defining what exactly presence is. There is nothing wrong with making definitions, but there comes a point when it becomes pedantic. It would be more beneficial to refocus the energy and resources that are being spent on finding the "perfect" definition, and focus them on researching better methods for making users feel more present in virtual environments, as this would certainly benefit therapeutic virtual reality methods and also the virtual reality gaming industry.

So far, factors that have been investigated in relation to presence have been those that are external to users (immersiveness of technology, the content of the media and the mood of environment). To the best of our knowledge there are no studies conducted that have investigated factors that are specifically inherent to users. Perhaps people with higher spatial intelligence experience more presence in virtual environments, or perhaps meditation and other mindfulness practices increase the level of presence felt by users. Questions like these have not been explored and there is definitely a gap in the literature here.

6. CONCLUSIONS

Emotion elicitation and Presence are two important areas of Virtual Reality research that will have a large impact on psychology research and gaming. The field is still young, as the processing power and hardware required for Head-mounted displays only recently became widely effective. Only a few emotions have been elicited with the use of virtual reality environments, but research will be done for more emotions as standards around virtual environments are developed.

The link between presence and emotion will be better understood as better studies are designed and currently proposed theories are tested out. The link between presence and individual traits needs to be researched as it could reveal new insights into presence not yet considered. The possibilities are exciting, one can only imagine what virtual reality will look like in a decade.

Paper	Virtual Environment	Interface	Navigation	Measures	Successful Emotions	Failed Emotions
Felnhofer et al. (2015)	Virtual park	Head- mounted display	Active	Self report questionnaires	Joy Boredom Anger Anxiety	Sadness
Toet et al. (2009)	Virtual village	PC Monitor	Active	Self report questionnaires Heart rate Saliva sampling	Anxiety	N/A
Lin (2017)	Abandoned town	Head- mounted display	Stationary	Self report questionnaires	Anxiety	N/A
Banos et al. (2012)	Virtual park	PC Monitor	Passive	Self report questionnaires	Joy Relaxation	N/A
Serrano et al. (2013)	House	Head- mounted display	Stationary	Self report questionnaires	Joy Relaxation	N/A

Table 1: Comparing different emotion elicitation papers

Virtual Environment - the type of environment used

Interface - the interface used by participants to interact with/experience the environment

Navigation - the type of navigation used

Measures - how emotional responses were measured

Successful Emotions - emotions that were successfully elicited

Failed Emotions - emotions that were not successfully elicited

Papers	Virtual Environment	Measures	Emotion(s)	Factor(s)	Correlation
Riva et al. (2007)	Virtual park	Self report questionnaires	Anxiety Relaxation	Emotional Arousal	Negative correlation for positive emotions Positive correlation for negative emotions
Banos et al. (2008)	Virtual park	Self report questionnaires	Relaxation Joy	Stereoscopy	No correlation
Banos et al. (2004)	Virtual park	Self report questionnaires	Neutral Sad	Immersion Media content	Positive correlation
Alsina-Jurne et al. (2011)	House	Self report questionnaires	Anxiety	Anxiety	Positive correlation

Table 2: Comparing different presence papers

Virtual Environment - the type of environment used

Measures - how presence was measured

Emotion(s) - what emotions were elicited

Factor(s) - the factors being investigated relation to presence

Correlation - the correlation found between presence and the factors

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