The Effect of Interaction on Eliciting Sadness in Virtual Reality

Honours Literature Review

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ABSTRACT

Interaction, the degree in which users of a medium can influence the content of the environment, is one of the key features of Virtual Reality, yet there has surprisingly been minimal research on its effect in evoking emotions. Virtual Reality technologies are advancing at a rapid pace and becoming more readily available for wider use so finding ways to improve this experience, either for therapy or entertainment, can be an important advancement. This paper focuses on literature for the emotion of sadness and how interaction can induce it in VR. Presence, the subjective experience of being in a virtual world and how the participant feels engaged with it, is identified as a key feature for eliciting emotion and the association between interaction and presence seems to form, indirectly, a link between emotion and interaction. Understanding the way interaction is perceived and the techniques to do so are valuable steps in understanding how this affects emotion and presence and the impact of it on a person's representation of themselves and the world around them. The different factors of sadness and how interaction can affect them are investigated and discussed and a way to measure the emotion is reviewed.

KEYWORDS

Virtual Reality, Presence, Immersion, Interaction, Mental Model, Parasympathetic Activation.

1 Introduction

Mental disorders, phobias, and other mental health issues are problems that are, and will continue to be, prevalent in the current world. One technique used that has been proven to be effective in rehabilitation is exposure therapy [1], which involves exposing the patient to the source or context in a safe environment with the intention to overcome their distress. While exposure therapy has primarily been used for anxiety disorders, it has also been shown to be effective in the treatment of grief [2]. The importance of eliciting emotions with this therapy is to replace the older anxiety provoking memory structures with newer neutral memory structures [3]. Virtual Reality (VR), the use of technology to create a simulated environment, has been shown to be an effective medium for this psychotherapeutic technique [1, 4, 5, 6] and can evoke the same reactions and emotions as a real experience in a stressor environment [7]. Virtual Reality has also started to become more prevalent in the entertainment industry and the elicitation of emotion can help in storytelling making it applicable in this context as well.

One of the advantages of using VR for rehabilitation compared to only visual mediums is the ability for interaction. While there have been studies revealing the elicitation of various emotions by making use of different techniques [1, 5], this paper will focus on literature relating to the effect of interaction on inducing sadness. This focus has been chosen due to the split of emotions from the topic outset and to better understand emotions and interaction in the virtual world. Focusing on one emotion makes it easier to manipulate in the environment and if we can use already existing techniques of interaction to manipulate emotion, we can understand more about it.

2 PRESENCE IN VR

Presence and immersion have had various definitions over a large variety of papers [7, 8, 9, 10, 11], but this paper will look at them as interchangeable making use of presence. This forgoes immersion, as an objective description of the technology used to create this experience.

Presence is similar to flow - being completely absorbed and immersed in an activity such that one forgets their current physical surroundings and time [10]. The importance of presence in VR in this field is that there has been evidence to suggest that it helps evoke emotion [7, 8, 12]. There has been a small conflict of findings with a few papers finding no correlation – often referring to contamination of the novelty of the technology or the arousing nature of the stimulus, but the majority of papers have found a directly proportional relationship between presence and emotional response with a moderate effect size [7]. Higher presence results in a stronger elicitation of emotion and a lack of presence results in a low elicitation of emotion, meaning that it is a necessary factor.

Presence has been broken into multiple factors, each of which have a direct impact on the overall presence that a person may experience [6, 7, 9]. Four of these factors have been more prevalent and relevant to interaction in VR: Place Illusion, Plausibility Illusion, Involvement and Co-Presence.

Place Illusion or Spatial Presence is the feeling of being physically in the virtual environment even though the participant knows that they are not actually there. This factor has been shown to have an increase in emotional arousal in an interactive virtual environment [9]. To maintain this illusion, an action such as the participant rotating their head to the side should have the environment react in a way to mimic the physical world and rotate the camera in that direction. In a case where the environment has not catered for this, such as tilting the head sideways and the camera not reacting, the illusion in broken. When this illusion is broken, it can be quickly recovered. [9]

Plausibility Illusion is the sense that what is happening in the virtual reality is really happening. An important part of this illusion is that the events of the environment which the participant has no direct control over are referring to them and their sensations [9]. This illusion does not require physical realism, but once it breaks it is unlikely to recover.

Involvement is the extent in which the participant keeps focus on the virtual environment and ignores external information. This factor has been shown to be associated with treatment response and as such should be maximized [6].

Finally, Co-Presence is the sense of being together with another social being in the virtual environment. This means that if the content is engaging and has understandable social interaction, then it would increase the sense of presence that the participant experiences. The results of this factor though, are still inconclusive [7].

Lack of medium awareness is another element that affects the participant's sense of presence, meaning that it is important for the VR technologies to not be too difficult or unintuitive to use [7].
There is a vast amount of literature on the subject of presence of which this paper will not dive into as it will hinder the focus of interaction. These factors have been outlined as they are the best believed to each be individually increased by the use of interaction.

3 INTERACTION

In VR, interaction involves both actions from the participant as well as reactions from the virtual environment. These actions and reactions are the actual interactions that take place between a user and the world and which make up a part of the potential interactions available in the virtual world [7]. For the actions to take place, the user needs to be the main character of the environment. This helps avoid conflict between another character and their own ego in the actions that take place. This conflict of actions occurs when the character makes an action that the user would not want to make, pulling them out of the virtual world. [13]. Reactions of the environment should respond to the presence and actions of the participant [9] and there is an expectation of history of interaction [7] that the environment should acknowledge previous interactions. Reactions can also include actions of avatars in the environment such as mimicking the tilt of the head, maintaining eye contact or mimicking facial expressions [13, 14] of the participant.

3.1 Mental Models

Mental Models are the conceptual representation of ourselves and the world around us such as the way objects work, events happen, or people behave [7]. They are formed through experience, observation, training and instruction due to people's inclination to form explanations [15]. This means that they are created and enforced with interaction. Interaction is also driven and understood by use of these models, meaning that these models are both formed by interaction and form what interactions we can do [7]. Interaction can also confirm existing mental models or Virtual Mental Models (VMM), a mental model of a virtual environment.

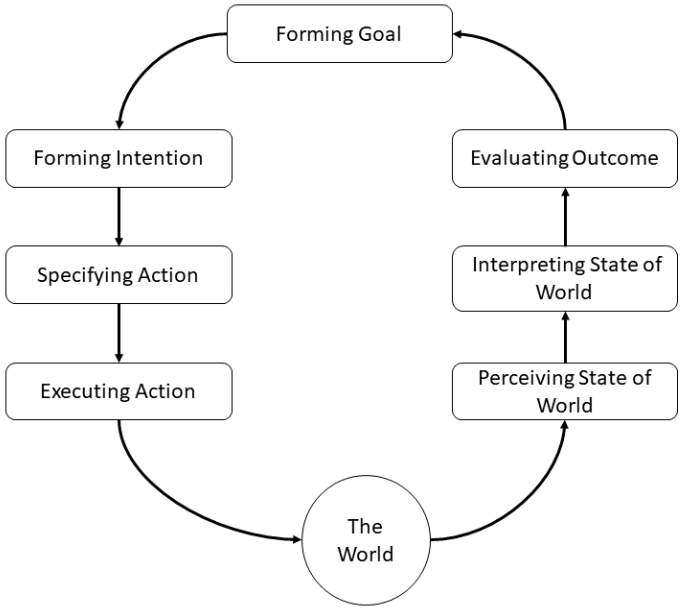

Figure 1: Action Cycle of Actions and Reactions

The action cycle, the continuing cycle of actions and reactions, is suggested to be a seven-stage cycle according to Norman's [15] action model, see Figure 1. It involves forming the goal and intention, specifying and executing the action, perceiving and interpreting the state of the world and evaluation of the outcome. The forming of intention and specifying the action is reliant on a person's mental model whereas interpreting the shape of the world and evaluating the outcome help reshape the person's mental model [7].

While interaction in VR must be engaging, it must also be comprehensible [7] – it must correspond to the participant's mental model, more specifically, their VMM.

3.2 Techniques of Interaction

The environment needs to provide actions that fit the intentions of the participant and in a way that can be perceived and directly interpreted according to their expectations. These issues are referred to as the gulfs of execution and evaluation [15]. We can make use of Norman's seven design principles to make tasks easy for the participant to bridge these gulfs. These principles are as follows:

- Use both knowledge in the world and knowledge in the head – make use of mental models
- Simplify the structure of tasks.
- Make things visible: bridge the gulfs of Execution and Evaluation.
- Get the mappings right.
- Exploit the power of constraints, both natural and artificial.
- Design for error.
- When all else fails, standardize.

There is another model which claims that subjective experience is encoded in terms of three main representation systems - Visual, Auditory and Kinesthetic – and that a person tends to prefer one of these over the others [7]. Interaction in VR can exploit and address each of these systems.

VR has been separated into four components in one of the literature pieces [7]. It uses a PPMC-view naming the components as the purpose, participant, medium - being the mediating technology such as a Head Mounted Display (HMD) - and content – being the Virtual environment. Interaction must take place maximally between the participant and the content and minimally between the participant and the medium as this subtracts from one's experience.

4 ELICITING SADNESS

Throughout the study of emotion in VR, there have been lots of papers measuring emotion felt from the participants. The most prevalent emotions from these have been fear and anxiety [8, 12]. It was also found in some studies that different emotions had different responses [8] – meaning that certain techniques would need to be different to ensure the desired emotion is evoked. This paper is focused on sadness, and more specifically, the parasympathetic withdrawal or "activating" sadness – this is calmer than the sympathetic alternative and occurs when the person has agency where loss is imminent but is not inevitable [17, 18].

Two types of viewer emotions have been distinguished in film viewing which could be applied to Virtual Reality [11]. The first is Fictional World emotions and arise from the illusion of being physically present in a fictional world – or virtual environment. The second is Artifact emotions and arise from the person's awareness that the fictional world or virtual environment is presented through an artifact. The Fictional World emotions is the type which is desired to be evoked while Artifact emotions should be minimized to reduce noise.

Factors of Sadness

Attachment has been shown to be a strong factor in sadness and grief with a strong correlation between the strength of an attachment bond and the extent of grief experienced [18]. Another consequence of a stronger past bond is that a stronger bond is experienced after loss, such as death. This human attachment bond has also been shown to be equal to the attachment bond between a human and a pet. This means that in the context of VR, the use of avatars is not a hinderance [14, 18], but rather that these attachment bonds can be formed to be similar to human bonds. Interaction has an effect on attachment as bonds are formed from the dual elicitation of emotional responses from the participants and the shared activities between them [18].

A factor which influences both attachment as well as the elicitation of sadness is empathy [14, 19], and affective communication, the expression of feelings, plays an important role in forming this. In virtual reality, agency belief - the participant's belief about the virtual agent having agency - is a crucial aspect of affective communication [14]. Visual Imagery is another factor that is largely used to elicit emotion and mood has also been found to impact the emotion induced [19].

Lastly, the elicitation of sadness is caused by events [20]. This event has several conditions which need to be met for the emotion to be evoked. The following conditions are required for eliciting sadness: Firstly, the event is perceived as being in-consistent with the person's motives; Secondly, the participant's motive is to attain reward rather than to avoid punishment; Finally, it is event-directed – meaning that it was either caused by circumstance, no cause was specified, or there was a causal agent but that agency information was disregarded with focus on the event itself. In terms of Virtual Reality, for sadness to be evoked, an event would need to occur in the environment which meets these three criteria.

5 MEASURING OF EMOTIONS

There are various methods of measuring emotions and the main categories of techniques investigated were Autonomic measurements, measurements of the Autonomous Nervous System (ANS) such as cardiovascular, electrodermal and respiratory measurements, and conscious measurement or self-assessment. The self-assessment methods investigated were the Self-Assessment Manikin (SAM) [21] and the Discrete Emotion Questionnaire [22]. The ANS measurements for identifying sadness were also investigated [16].

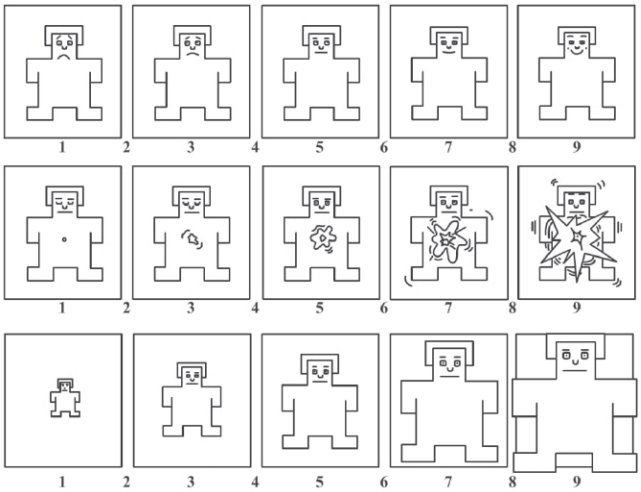

Figure 2: Self Assessment Manikin Graphic Character

The Self-Assessment Manikin [21] depicts each PAD dimension: pleasure, arousal and dominance – with a graphic character ordered along a nine-point scale, see Figure 2. For pleasure the character ranges from a smiling happy face to a frowning unhappy face; For arousal the character ranges from sleepy with closed eyes to excited with open eyes; for dominance the character ranges from a very small figure representing being controlled or submissive to a very large figure representing being in-control or powerful.

The Discrete Emotion Questionnaire allows for a larger amount of words or emotions to be linked to certain discrete emotions and ratings are given to them accordingly. Interestingly, in the study to create the questionnaire [22], keywords were identified to correlate to certain discrete emotions. This could be used to identify the discrete emotion evoked from a larger range of emotion-based adjectives when performing research such as interviews.

Autonomous Nervous System measurements for sadness were investigated in relation to changes in cardiovascular, electrodermal and respiratory measurements [16]. The 'non-crying' measurements were identified in favor of the 'crying' measurements due to the focus on parasympathetic withdrawal. There are a few notable issues with ANS measurements, primarily being noise in the measurements and interpretation of the measurements.

Table 1: Changes in ANS measurements of 'non-crying' sadness

Cardiovascular Measurements	
Heart Rate (HR)	↓
HR Variability	↓
Finger Pulse	↓
Finger Temperature	↓
Electrodermal	
Conductance Levels	↓
Respiratory	
Respiratory Rate	↑
Tidal Volume	↑

↑ - *increase in measurements;* ↓ - *decrease in measurements*

DISCUSSION

In the papers reviewed, an increase in presence in VR was determined to result in an increase in elicitation of emotion [7, 8, 12]. While this may seem promising, it is to be noted that the measurement of presence is a matter of debate in this field [7]. Furthermore, this would drive the focus off topic as there is no need for measurement of presence as emotion can be measured instead and measured more easily. This does not hinder the importance of presence in this paper though, as interaction has been shown to increase presence [7] meaning that there is an indirect link between interaction in VR and the elicitation of emotion. There has been a large amount of research on the topic of presence both in psychology and more focused in VR which provides a vast vat of knowledge. Unfortunately, a weakness with this field is the endless arguments over forming a correct definition of "presence".

Different aspects of interaction are also likely to affect the different factors of presence. An increase in participant actions and potential actions is likely to have an effect on the Place Illusion and Involvement experienced by the participant, whereas the reactions and potential reactions of the virtual environment is likely to have an effect on the Plausibility Illusion and Co-Presence experienced by the participant. Interaction also forms a cyclical process of forming the participant's Mental Model and being formed by it, making it more comprehensible and increasing presence [7]. Interaction has been shown to increase presence overall in papers [7] and there have been notes suggesting people feeling more immersed and using more emotional words to describe experiences where interaction has been used – though there have not been any studies focused on this. Interaction, like presence, has also been shown to strengthen people's attention which has been associated with an increase in emotion [7] and the interaction used in VR should follow design principles to be most effective and avoid distracting the participant [15]. This field of interaction has limited research relating it to presence, but the research done seems to show a strong correlation. In terms of eliciting emotion, there seems to be a gap where no research is done, and links need to be made from research in similar fields to make hypotheses on this topic.

There is this lack of research on interaction impacting emotion, but in terms of sadness, one would assume that it would form and strengthen an attachment bond. If this were to be the case, it would be a direct influence on the sadness elicited from the Virtual Environment. The use of an avatar not being a hindrance in forming this bond is vital for this topic, as it allows strong bonds to still occur between the virtual agents and the participants. There is a large amount of research in psychology on sadness and this knowledge can be applied to this specific field of VR. In terms of measuring of emotions, the SAM model seems useful in gathering self-assessment measurements of sadness while the Discrete

Emotion Questionnaire seems useful in both self-assessment as well as interview-based assessment. ANS measurements are also effective and as such, a combination of these three techniques would seem advisable to measure the self-evaluated experience of the participant as well as the physiological changes.

CONCLUSIONS

The study of interaction in VR and its effect on eliciting emotions can produce results that affect the environments used in therapeutic practices, making them more effective as well as have an impact in the story-telling capability of the VR entertainment industry. This is a field that is barren of existing research, but which exists in a time of ever-growing technologies, becoming both more powerful as well as more widely used.

There is a gap of research in this field, how interaction affects emotional response in VR, and there seems to already be indirect links from relevant research topics which one can draw on for hypotheses, and once researched can produce new insights as well as a better understanding of emotions in VR.

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