Using virtual reality technology to elicit an emotional response

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ABSTRACT

The two main objectives of this literature review are investigating if virtual reality technology can elicit an emotional response and how it compares to other methods used to elicit an emotional response. We also investigating the measuring techniques used for measuring emotional responses and what elements of a virtual environment make it emotional inducing. After reviewing the limited literature, it seems that virtual reality technology can induce an emotional response and it is as or more effective than other methods reviewed. Also, we discovered that it is useful to use both subjective and objective measuring techniques for research, and that head-tracking, stereoscopy, devices that are used to interact in the virtual environment and sound effects contribute in making a virtual environment emotion inducing.

KEYWORDS

Virtual reality, emotions, measures.

1 Introduction

The need to understand the effects of emotions on behaviour and mental faculties has led to the development of techniques that elicit emotional responses [3]. Techniques like imagery vignettes [8], film sequences [9] and music pieces [10] and many more. Virtual reality technology also can be considered as a technique for eliciting emotions. There is been growing interest in using virtual reality technology for the elicitation of emotions [3]. Virtual reality technology creates an immersive virtual environment that has the potential to elicit an emotional response [3]. It does this by making a user don a head-mounted display unit that allows a user to view a 3-demsional computer generated world [21]. The head-mounted display consists of separate display screens for each eye, along with some type of display optics, stereo earphones and a head-tracking device [21]. The virtual environment created is realistic. Due to the growing interest in using virtual reality technology as medium for eliciting emotions it is important to see if virtual reality technology can elicit an emotional response. We will review literature on this, in order to see if virtual reality technology can be used as a medium for the elicitation of emotions. We also compare the use of virtual reality technology to other methods used to elicit emotions. We will then discuss methods used to measure an emotional response and different virtual environments used in the literature reviewed.

2 Using virtual reality as a medium for eliciting an emotional response.

Many techniques that are used to elicit an emotional response have been developed. The nascent field of virtual reality offers a new method for the elicitation of emotions. In this section we examine the use of Virtual Reality (VR) as a medium for eliciting emotional responses.

Felnhofer et al. investigated if five virtual environments (VE), created, could elicit the intended emotion. Four VE's were successful in eliciting the intended emotion. Anxiety, boredom, joy and anger were correctly elicited. One VE failed in eliciting the intended emotion. It was supposed to elicit sadness, but it elicited boredom in participants [3]. Josman et al. showed that as the level of VR exposure increases the anxiety felt by the participants also increased. The VE used has four levels, level one being there least distressful and level four being the most distressful. The participants used did not suffer from PTSD [13]. Difede et al. showed that VR Exposure Therapy could reduce PTSD symptoms [14].

3 Comparison of the use of virtual reality technology for eliciting emotional responses to other emotion inducing methods

It is important to compare the effectiveness of using virtual reality to elicit an emotional response to other techniques, in order to assess the usefulness of it. In this section we present

studies that compare the use of virtual reality for eliciting emotions to established methods used to elicit emotions.

In a study done by Courtney et al. virtual reality was more effective than IAPS still images in eliciting a fear response in participants, even though the virtual environment used was not immersive [4]. IAPS or International Affective Picture System rather, is a database that provides a standardize set of images for studying emotions in humans [6]. Kothgassner et al. investigated the stress responses of participants performing public speaking in front of a real audience versus participants performing public speaking in front of a virtual audience. The results showed no difference in stress levels for participants performing in a virtual environment and participants performing for a real audience [2]. Kuntze et al. compared the use of immersive virtual reality technology in evoking subjective and physiological cravings for narcotics to the use of Cue Exposure Therapy (CET). The results showed that immersive virtual reality had the same effective as CET [7]. CET "refers to a manualized, repeated exposure to drug-related cues, aimed at the reduction of cue reactivity by extinction [7]". Park et al. investigated the effectiveness of Virtual Reality Cue Exposure Therapy (VR-CET) and Cognitive Behavioural Therapy (CBT) for participants with nicotine addiction. The results showed that VR-CET and CBT have a similar effect [5].

4 Analysis of various types of measures used to measure an emotional response

In the literature reviewed, various measuring techniques are used to see if an emotional response can be elicited using a VE. The various measuring techniques used, can be classified as either being subjective or objective. A subjective technique, in the literature reviewed, involves a participant completing a self-report on emotion felt. An objective technique, in the literature reviewed, involves measuring some physiological response. A full list of measuring techniques used is shown in the table below.

Various self-reports are used in the literature reviewed. To see a list of self-reports used refer to table below. Since self-reports are only useful if they are done for fresh emotional experiences and not emotional experiences that happened long ago [15], the self-reports in the literature reviewed are useful, because the self-reports are done for fresh emotional experience. There are problems with self-reports done for fresh emotional experiences though. Participants involved maybe unable to report the current emotions they are feeling or/and are oblivious to their current emotional state [15]. In the literature reviewed there are no counter-measures to the problems described.

The physiological responses measured, by the objective measuring techniques, are from the autonomic nervous system (ANS) and other areas. The ANS is responsible for involuntary body functions such as heartbeat, blood-flow and digestion [15]. The ANS contains a sympathetic branch, linked to emotional responses (regulating sweat, heartrates etc.), and a parasympathetic branch, linked to digestion, attention and effort [15]. So, activity in the ANS could be linked to emotional responses or other body processes [15]. The most commonly used way to assess if an emotional response has occurred in the ANS is by measuring electrodermal and cardiovascular activity [15]. In the literature reviewed the measuring techniques used to measure activity in the ANS are electrodermal activity [3,4], electrocardiogram [2,4,7], salivary cortisol measure [2], pneumograph [7] and non-invasive finger-hemodynamometry [7]. ANS measures can reliable detect emotional arousal but the measures cannot differentiate between emotions, an emotion does not have a unique ANS activity signature [15]. We see this in a study done by Felnhofer et al. were electrodermal activity (EDA) levels showed emotional arousal in the different VE's but could not differentiate between different emotional states [3]. Also, another measuring technique used in the literature, for detecting an emotional response, is an electromyogram [4]. An electromyogram used to measure the startle responses, it does this by measuring the amplitude of the eye-blink [15]. Measuring startle responses is only reliable when the stimuli being evaluated is negative [15]. That's why in a study done by Courtney et al an electromyogram was used, participants where shown videos and imagery of things they feared [4]. Also, you cannot differentiate between emotions using startle responses [15].
In general objective measuring techniques are very important for research, but participants involved may consider the techniques as unpleasant or uncomfortable [1].

The objective measuring techniques used in the literature reviewed are equivalent in terms of usefulness, there is no best or recommended objective technique. Although it is useful to use electromyogram (assessing startle responses) only when the stimuli are negative. And it is better to use both subjective and objective measuring techniques [16].

Table 1. Measuring techniques used in the literature reviewed.

Name of the measuring technique	Subjective or Objective?	Brief description of the technique
Subjective Units of Distress Scale (SUDS)	Subjective	SUDS rating scale is used to subjectively measure the intensity of distress felt by participants.
Visual Analog Scale (VAS)	Subjective	Is a subjective measuring technique used for subjective characteristics or positions that can't be measured directly. With a VAS, a participant indicates his/her level agreement about a statement.
Yale-Brown Obsessive-Compulsive Scale (Y-BOCS)	Subjective	Used to measure how sever OCD symptoms are in a participant.
The Minnesota Nicotine Withdrawal Scale (MNWS)	Subjective	A subjective questionnaire of 15 question is used to assess drug withdrawal in participants
Questionnaire on Smoking Urges (*QSU)*	Subjective	Used to assess subjective cravings

Fagerstrom Test for Nicotine Dependence (FTND)	Subjective	Used to measure nicotine dependence in participants.
Likert scale	Subjective	Used for assessing arousal levels
The Personal Report of Confidence as a Speaker (PRCS)	Subjective	Used to assess if a person has a fear of public speaking.
The State Trait Inventory	Subjective	Used to assess a participant's anxiety level
German version of the Differential Emotions Scale (DES)	Subjective	Assesses the emotional state of a participant.
Electrocardiographic (ECG)	Objective	Recording of the electrical activity of the heart.
Pneumographic	Objective	Recording of the chest movements velocity and force during respiration
Continuous non-invasive finger-hemodynamometry	Objective	Measures oxygen saturation at the finger
Expiratory CO concentration	Objective	Used to measure CO levels in the alveoli after smoking
Electrodermal Activity (EDA)	Objective	EDA measures the changes in conductivity produced in the skin due to the activity of sweat glands.
Electromyogram (EMG)	Objective	Used to measure the startle responses, it does this by measuring the amplitude of the eye-blink
Salivary cortisol measure	Objective	Measuring cortisol levels in the saliva.

5 Discussion

From the literature reviewed it seems like virtual reality technology is effective in eliciting an emotional response and it is better or as effective as other method used to elicit an emotional response. All of the VE's in the literature reviewed were sufficient in eliciting an emotional response.

Virtual environments used, in the literature reviewed, differ in some ways and are similar in some. It is useful to know which design characteristics of a VE enable it to elicit an emotional response. Presence seems like an important component for an emotive virtual environment, since presence is a precondition for an emotional response to happen in a VE [3]. There are design principles that contribute or increase presence levels of a virtual environment. Head-tracking and stereoscopic displays contribute to presence [18], Sound effects in the virtual environment also contributes to presence [19] and finally the use of a device for interaction in the virtual environment seems to enhance presence [17,20]. These are not the only elements that influence presence, only the elements found in the literature reviewed. Head-tracking in the literature reviewed is used by Felnhofer et al [3], Kothgassner et al [2], Kuntze et al [7], Josman et al [13] and Difede et al [14] .And stereoscopic displays are used by Felnhofer et al[3], Kothgassner et al [2] and Park et al [5]. Sound effects are utilised by all VE's in the literature reviewed, excluding a study done by Kuntze at el [7]. Devices used for interaction in the virtual environment are used by Felnhofer et al [3] and Kuntze et al [7].The virtual environments used in the literature reviewed had one or more element of presence, probably that's the reason why all the VE's used were successful in eliciting an emotional response.

Table 2. Comparison of papers that investigated the use of Virtual Reality for emotion elicitation

Paper	**Year published**	**Number of times the paper was cited**	**Did the VE(s) elicit an emotion?**	**Objective measuring techniques used**	**Subjective measuring techniue used**	**What design principles, concerning an emotive VE, are implemented?**	**What method(s) were compared to VR?**
Kothgassner et al [2]	2016	21	Yes	Salivary cortisol measure ECG	The State Trait Inventory PRCS	Head-tracking Stereoscopic displays Sound effects	Real stimulus
Felnhofer et al [3]	2015	66	Yes	EDA	DES	Head-tracking Stereoscopic displays Sound effects Device used for interaction	N/A
Courtney et al [4]	2010	50	Yes	ECG EDA EMG	Likert scale	Sound effects	IAPS still images

Park et al [5]	2014	22	Yes	Expiratory CO concentration	MNWS *QSU* FTND	Stereoscopic displays Sound effects	Cognitive behavioral Therapy
Kuntze et al [7]	2001	102	Yes	ECG Pneumographic	Y-BOCS VAS	Head-tracking	Cue Exposure Therapy
Difede at al [14]	2002	381	Yes	N/A	SUDS	Head-tracking Sound effects	N/A
Josman et al [13]	2008	28	Yes	N/A	SUDS	Head-tracking Sound effects	N/A

6 Conclusion

From the literature reviewed virtual reality technology could elicit an emotional response in participants and it fairs well with other methods used to elicit an emotional response. Some of the elements that contribute to presence in a virtual environment were discussed and the virtual environments in the literature reviewed contained at least one of these elements. When measuring emotional responses in participants it is recommend using both objective (physiological measures) and subjective measuring techniques.

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