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Mood Induction Using Virtual Reality: a Systematic Review of Recent Findings

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Abstract

Experimental research into emotion has struggled with the lack of ecological validity of the testing paradigms. One potential way to deal with that issue is through the use of virtual reality (VR), which allows immersive experiences in controlled settings. Previous reviews have focused on the clinical use of VR, but there has been no attempt to summarise findings in relation to emotion elicitation through VR. This systematic review compiles studies that have used VR as an emotion induction paradigm. Four databases were used (Web of Science, Science Direct, PsycInfo and PubMed), with a total of 61 articles fitting the inclusion criteria. In most studies, participants were college students, with the most common emotions elicited being anxiety, relaxation, fear and joy. The VR equipment employed included the Head-Mounted Display, the Cave Automatic Virtual Environment, videogames and computers, with almost all studies using subjective measures of emotion and approximately half of them including physiological measures also. The findings suggest that VR is an effective tool to induce emotion in lab settings. Future research should focus, in particular, in the integration of subjective and physiological outcomes and ways of fostering immersion. Furthermore, exploration of the psychological mechanism of emotion elicitation using VR (e.g. embodiment) could lead to new technical advances for the research of emotion.

Keywords Mood · Induction · Emotion · Virtual reality

Introduction

The study of emotion is a traditional field of psychology (James, 1894). James' (1890), p. 449) seminal theory suggests that emotions are perceptions of *bodily responses*. By placing the body at the centre of the emotional experience, James emphasises the importance of physiological arousal in the experience of emotion. Although many authors have explored the predictions of the Jamesian theory of emotion (Furtak, 2018; Haye & Carballo, 2017; Lacasse, 2017), further empirical progress has been prevented, mainly due to methodological issues. Specifically, experimental research about emotion is hindered by issues of ecological validity (Parsons, 2015), that is, emotion induced in laboratory settings is seldom comparable with that experienced in everyday life, lacking, among other things, in intensity and experiential content.

To deal with this difficulty, a number of procedures have been employed to elicit emotional states under controlled conditions. Referred to as mood induction procedures, these techniques include music (Västfjäll, 2001), films (Marcusson-Clavertz, Kjell, Persson, & Cardeña, 2019), self-referential statements (the Velten procedure; Kenealy, 1986), memories (Monnier, Syssau, Blanc, & Brechet, 2018; Schaefer & Philippot, 2005), tasks with manipulated difficulty (e.g. Mograbi, Brown, Salas, & Morris, 2012), and others (for a review, see Westermann, Spies, Stahl, & Hesse, 1996). Evidence has suggested that content such as films (Fernández-Aguilar, Navarro-Bravo, Ricarte, Ros, & Latorre, 2019) or images coupled with music (Zhang, Yu, & Barrett, 2014), are more effective in inducing mood. Arguably, this happens because in these procedures content is presented through multiple sensory modalities.

Regarding this, one important recent methodological advance is the use of virtual reality (VR) in research into emotion. VR is the term used to describe the computer-generated

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simulation of a three-dimensional image or environment that can be interacted with in a seemingly real or physical way by a participant. Interaction involves being able to manipulate objects or perform a series of actions by using special electronic equipment, for example, a helmet with a screen inside or gloves fitted with sensors. The illusion of reality is created by stimulating participants' senses concurrently, including vision, hearing, vestibular sense and, in some cases, touch and proprioception (Chirico, Yaden, Riva, & Gaggioli, 2016). VR provides a number of advantages over previous mood induction techniques. Specifically, it allows immersive experiences in a safe environment, with experimental control over the content and the intensity level of the chosen stimuli. Additionally, as indicated, VR typically stimulates a variety of sensory modalities, leading to the integration of proprioception, interoception and sensorial information (Riva, Wiederhold, & Mantovani, 2019).

For these reasons, VR has had important applications to psychology. Particularly, it has been used as a tool in psychotherapy, in the treatment of patients that suffer from anxiety disorders, such as social anxiety or phobias (Carl et al., 2019; Peperkorn, Diemer, & Mühlberger, 2015), post-traumatic stress disorder (Beidel et al., 2019) and eating disorders (Riva, Gutiérrez-Maldonado, Dakanalis & Ferrer-García, 2019a). Nevertheless, VR has implications beyond treatment of clinical populations. For instance, a better understanding of VR induction of relaxation may help management of stress, one of the leading causes of physical and mental health problems (Adam et al., 2017; Toussaint, Shields, Dorn, & Slavich, 2016). Additionally, advances in emotion elicitation through VR may impact the entertainment industry (immersive films and videogames), as well as having implications for sports (simulations for athletes) and other professions (e.g. negotiators, doctors).

Although the clinical use of VR has been reviewed recently (Riva, Wiederhold & Mantovani, 2019b), a large number of studies have employed this technique with healthy participants, but this research has not been reviewed and integrated theoretically. The use of VR in emotion elicitation with healthy participants allows manipulations not used in vulnerable populations, also providing clearer conclusions for theoretical frameworks of emotions and applicability beyond management of patients. Accordingly, the primary purpose of this systematic literature review is to examine the effect of VR in emotion induction, exploring also the methodologies most frequently used in the studies, both to elicit and measure emotion, as well as the effectiveness of VR to induce specific emotions.

Methods

Four databases were used to search for articles, as follows: Web of Science, Science Direct, PsycInfo and PubMed. Relevant terms, including truncations and variations, were used in order to screen for suitable articles. The following terms were used: 'Emotion* Induction' OR 'Mood Induction' OR 'Emotion* Valence' OR 'Mood' AND 'Virtual Reality' OR 'VR' OR 'Virtual Environment'.

This systematic review focused on studies inducing emotions in healthy participants. Other inclusion criteria were the study had to include empirical data collection, having at least one outcome to measure emotion (self-report, physiological or behavioural measure). Participants that had a diagnosis and studies using VR as a form of therapy were excluded. Only studies written in English were included, and all papers selected were published from 2008 to 2018.

A total of 1752 records were found by using the search terms. The studies were filtered by reading the title or abstract leading to the exclusion of articles due to lack of adherence to the main theme of the review. Duplicates found in each database were also removed. This led to a total of 86 articles that were fully assessed by reading the entire article. As the result of the reading 24 articles was excluded, not having met the inclusion criteria, 61 articles were left eligible for this review (Fig. 1).

Results

Summary information about the studies can be seen in Table 1.

Participants

The studies showed a wide range of sample sizes, from 10 (Brundage, Brinton, & Hancock, 2016) to 324 participants (McCall, Hildebrandt, Hartmann, Baczkowski, & Singer, 2016). The majority of the studies used convenience sampling, with volunteers, typically college students, being included according to availability. Most studies then randomised participants to the experimental and control conditions. Whenever randomisation was not used, participants were typically matched for sociodemographic variables, such as gender. Studies on anxiety and stress commonly used all male samples, considering hormonal issues. However, female participants were the majority among the studies reviewed.

One of the studies (Baños et al., 2012) had a sample composed by older adults, focusing on the use of VR to promote emotional states such as relaxation and joy in this age group. Out of the 61 papers, 12 included a sample containing participants with a mean age above 25 years old. With the exception of the study with older adults, none of the studies had a specific VR paradigm to fit participants' characteristics.

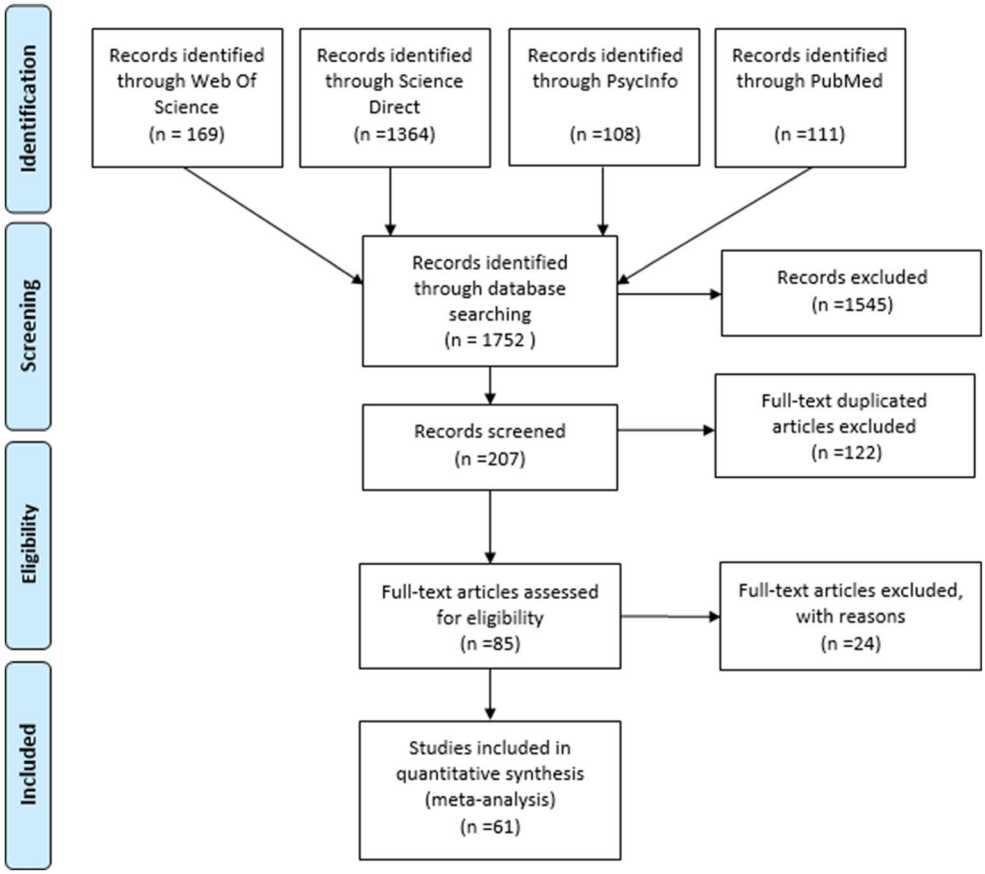

Fig. 1 Flow diagram showing the steps conducted during the literature search and selection process, based on the PRISMA model (Moher, Liberati, Tetzlaff, Altman, & The PRISMA Group, 2009)

Study Design

The mixed-design approach, containing both between- (e.g. experimental condition) and within-subject factors (e.g. pre-post exposure), was the most widely employed (24 studies), with participants being randomly allocated to the different experimental conditions in 16 studies. The single-group repeated measures design, with the same participants being exposed to different experimental conditions, was used in 23 of the reviewed papers. Fourteen studies employed between-subject designs, comparing different participants allocated to the experimental conditions; in eight of those, participants were randomly allocated to the conditions.

Elicited Emotions

Altogether, the studies looked at a total of eight different emotions, including both positive and negative moods. They were joy/happiness, fear, sadness, disgust, anger, relaxation, stress and anxiety. Some of the studies did not focus on discrete emotions, investigating the effects of virtual environments on emotional arousal and valence ($n = 18$). Two studies focused on the induction of complex emotions, as seen in the study of Nazry and Romano (2017), which elicited positive emotions and Chittaro, Sioni, Crescentini, and Fabbro (2017), which elicited death-related emotions. Anxiety, relaxation, fear and joy were the most frequently elicited emotions, appearing on 14, 13, 11 and 7 studies, respectively. Anger, stress and sadness were elicited in few studies, appearing in 6, 6 and 4 studies, respectively. A neutral state was elicited in one study, alongside other emotional states. The least elicited emotion, appearing only in two of the reviewed studies, was disgust. Thirteen studies elicited more than one discrete emotion, typically inducing anxiety/stress together with relaxation or a combination of basic emotions. Disgust and neutral states appeared only in studies eliciting other emotions as well.

Virtual Reality Equipment

Among the equipment used as a mediator between the participants and VEs, the Head-Mounted Display (HMD) with tracking device, which consists of electronic goggles plugged in a computer, was the most used, appearing in 34 of the reviewed papers. The HMD was followed by the Cave Automatic Virtual Environments (CAVE), consisting of a room surrounded by wall-sized screens, which appeared in ten studies. Few studies used a videogame as VE to elicit emotions. The CAVE equipment was found to be used particularly in studies which elicited stress. Videogames were found

Table 1 Summary of studies

Study	Title	Participants	Study design	Type of emotions	Primary findings	Vr equipment	Subjective assessment/ instruments	Physiological assessment
Åhs, Dunsmoor, Zielinski, and LaBar (2015)	Spatial proximity amplifies valence in emotional memory and defensive approach avoidance	Experiment 1, 6 male and 6 female participants (mean age of 22.3). Experiment 2, 11 female and 10 male participants (mean age of 20.30). Experiment 3, 18 female and 12 male participants (mean age of 25.1). Experiment 4, 18 female and 12 male participants (mean age of 25.1)	Single-group repeated measures design	Fear	In experiment 1, participants showed stronger startle responses when closer to the stimuli. Experiment 2 had success in fear learning. Experiment 3 participants showed difficulties in extinguishing fear when closer to the stimuli. Experiment 4 found that rewarded-related stimuli inhibit non-reward related ones	Head-Mounted Display with tracking device	None	Electrodermal activity; electromyography
Åhs, Kragel, Zielinski, Brady, and LaBar (2015)	Medial prefrontal pathways for the contextual regulation of extinguished fear in humans	22 female and 21 male participants (mean age of 28.7)	Single-group repeated measures design	Fear	Contextual control of fear was shown to be successful in the virtual reality paradigm	Head-Mounted Display with tracking device	Visual Analogue Scale (VAS)	Electrodermal activity; fMRI scans
Anderson et al. (2017)	Relaxation with immersive natural scenes presented using virtual reality	9 female and 9 male participants	Single-group repeated measures design	Relaxation	The reduction of the electrodermal activity was greater on the relaxing simulation than the control simulation	Head-Mounted Display with tracking device	15-question Modified Reality Judgement and Presence Questionnaire (MRJPQ); Positive and Negative Affect Schedule (PANAS); Value of VR Questionnaire (VVR)	Electrodermal activity; heart rate
Annerstedt et al. (2013)	Inducing physiological stress recovery with sounds of nature in a virtual reality forest—results from a pilot study	30 male participants (mean age of 27.7)	Randomised between--subject design (3 groups)	Stress; relaxation	Cortisol level increased during the stress condition, then returned to baseline. The audio-visual stress recovery condition was found to be more relaxing, while the visual-only	Cave Automatic Virtual Environmen-ts (CAVE)	State-Trait Anxiety Inventory (STAI-S); Trier Social Stress Test (TSST)	Heart rate; respiration rate; saliva cortisol analysis

Table 1 (continued)

Study	Title	Participants	Study design	Type of emotions	Primary findings	Vr equipment	Subjective assessment/ instruments	Physiological assessment
					condition elicited unpleasantness			
Aymerich-Franch (2010)	Presence and emotions in playing a group game in a virtual environment: the influence of body participation	34 female and 32 male participants (mean age of 22.6)	Randomised between--subject design (2 groups)	Emotional arousal and valence	No significant differences were found on emotion report for the participants that played the game with their body and the participants that played with a joystick	CAVE	Self-Assessment Manikin (SAM); Slater–Usoh–Steed Presence Questionnaire (SUS)	Electrodermal activity; electromyography
Baños et al. (2012)	Positive mood induction procedures for virtual environments designed for elderly people	14 female and 4 male participants (mean age of 66.94)	Mixed-design (2 groups)	Joy; relaxation	Decrease of anxiety and sadness was reported after the mood induction procedure in both procedures	Computer	General Mood State (GMS); Geriatric Depression Scale (GDS-15); Level of Difficulty (LD); Level of Satisfaction with the Virtual Environments (LS); Sense of Presence (Pr); State-Trait Anxiety Inventory (STAI); VAS	None
Brundage et al. (2016)	Utility of virtual reality environments to examine physiological reactivity and subjective distress in adults who stutter	10 male adult participants who stutter (mean age of 26)	Single-group repeated measures design	Anxiety	Significantly higher distress in the virtual audience simulation	Head-Mounted Display with tracking device	Fear of Negative Evaluation (FNE); Modified Erickson Scale (S-24); Overall Assessment of the Speaker's Experience of Stuttering (OASES); State-Trait Anxiety Inventory-Trait (STAI-T); Stuttering Severity Instrument-4 (SSI-4); Subjective Units of Distress Scale (SUDS)	Electrodermal activity; heart rate
Canazei, Pohl, Bliem, Martini, and Weiss (2017)	Artificial skylight effects in a windowless office environment	55 female and 45 male participants	Randomised mixed-design (2 groups)	Emotional arousal and valence	Positive mood states were significantly higher in the skylight condition, but the negative mood raised over time	Computer	Emotional State Adjective Checklist; Claustrophobic Symptoms Scale; Connectedness-To-Nature Scale; Dundee Stress State Questionnaire; Game of	None

Table 1 (continued)

Study	Title	Participants	Study design	Type of emotions	Primary findings	Vr equipment	Subjective assessment/ instruments	Physiological assessment
							Dice Task; Room Atmosphere Questionnaire; Perceived Restorativeness Scale; STAI; The Ultimatum Game	
Cartaud, Ruggiero, Ott, Iachini, and Coello (2018)	Physiological response to facial expressions in peripersonal space determines interpersonal distance in a social interaction context	17 female and 30 male participants (mean age of 21.7)	Single-group repeated measures design	Emotional arousal and valence	Each 1 of the facial expressions (happy, angry and neutral) elicited different electrodermal activity response. The angry facial expression condition had a significantly increase on the physiological response	Wall projection	Interpersonal Comfort Distance Judgement Task; Reachability Judgement Task; SAM; State-Trait Anxiety Inventory (STAI-YB)	Electrodermal activity
Chirico, Ferrise, Cordella, and Gaggioli (2018)	Designing awe in virtual reality: an experimental study	18 female (mean age of 23.33) and 18 male participants (mean age of 23.67)	Single-group repeated measures design	Awe	The snowy mountains simulation showed high awe induction	Head-Mounted Display with tracking device	Awe Intensity Subjective Scale; Global Perceived Awe Subjective Scale; PANAS; Vastness And Need for Accommodation Original Scale	None
Chittaro and Sioni (2014)	Affective computing vs. affective placebo: study of a biofeedback--controlled game for relaxation training	9 female and 26 male participants	Single-group repeated measures design	Relaxation	The electrodermal activity was found to be significantly better than the placebo activity	Videogame	Difficulty of Relaxation Training Original Questionnaire; Perceived Quality of the Feedback Original Questionnaire	Electrodermal activity; heart rate
Chittaro (2014)	Anxiety induction in virtual environments: an experimental comparison of three general techniques	24 female and 84 male participants (mean age of 24.1)	Between-subject design (3 groups)	Anxiety	The experiment results confirmed the study hypothesis of biofeedback inducing higher levels of anxiety compared with other conditions	Head-Mounted Display with tracking device	State-Trait Anxiety Inventory (STAI-Y)	Electrodermal activity
Chittaro et al. (2017)	Mortality salience in virtual reality experiences and its	95 female and 10 male participants	Between-subject design (2 groups)	Sadness	The manipulation check analysis showed significant	Head-Mounted Display with	Delay task questionnaire; Demographic Questionnaire;	Blood volume pulse; heart rate

Table 1 (continued)

Study	Title	Participants	Study design	Type of emotions	Primary findings	Vr equipment	Subjective assessment/ instruments	Physiological assessment
	effects on users' attitudes toward risk				differences in the virtual environment's condition	tracking device	Five-Facet Mindfulness Questionnaire (FFMQ); Locus of Control of Behaviour Scale (LCB); Name-Letter Task (NLT); Risk Assessment Survey (RAS); Temperament and Character Inventory (TCI); Word Fragment Completion Task (WFCT)	
Crescentini, Chittaro, Capurso, Sioni, and Fabbro (2016)	Psychological and physiological responses to stressful situations in immersive virtual reality: differences between users who practice mindfulness meditation and controls	41 participants (mean age of 43.33)	Mixed-design (2 groups)	Anxiety; Stress	The higher stress condition elicited higher stress and anxiety than the low stress condition	Head-Mounted Display with tracking device	FFMQ; Freiburg Mindfulness Inventory (FMI); Mindful Attention Awareness Scale (MAAS); STAI; VAS	Blood pulse amplitude; electrodermal activity; electromyography; heart rate; respiration rate
Cuperus et al. (2016)	Degrading emotional memories induced by a virtual reality paradigm	Experiment 1: 19 male participants (mean age of 28.8) Experiment 2: 24 female and 20 male participants (mean age of 23.5)	Randomised mixed-design (2 groups)	Fear	The VR paradigm was successful in eliciting negative memories	Head-Mounted Display with tracking device	First experiment: Random Interval Repetition Task (RIR); Shape Sorter Task/Second Experiment: Distractor Task; VAS	None
Dibbets and Schulte-Osterm-ann (2015)	Virtual reality, real emotions: a novel analogue for the assessment of risk factors of post-traumatic stress disorder	32 female and 11 male participants	Randomised mixed-design (2 groups)	Anxiety	Virtual reality was capable to induce negative emotions and anxiety, although the participants in the trauma film paradigm condition reported more distress of the intrusions	Head-Mounted Display with tracking device	Beck Depression Inventory II (BDI-II-NL); Independent Television Company-Sense of Presence Inventory (ITC-SOPI); Jellinek-PTSD Screening Questionnaire (JPSQ); Mood Ratings Questionnaire; Questionnaire Upon Mental Imagery (QMI);	None

Table 1 (continued)

Study	Title	Participants	Study design	Type of emotions	Primary findings	Vr equipment	Subjective assessment/ instruments	Physiological assessment
							State-Trait Anxiety Inventory (STAI-DY)	
Felnhofer et al. (2015)	Is virtual reality emotionally arousing? Investigating five emotion inducing virtual park scenarios	61 female and 59 male participants (mean age of 24,89)	Randomised mixed-design (5 groups)	Joy; sadness; anger; anxiety; boredom	4/5 emotions were induced apart from sadness	Head-Mounted Display with tracking device	Differential Emotions Scale (DES); Differential Emotions Theory; Manipulation Check; Modifzierte Differentielle Affekt Skala (mDAS)	Electrodermal activity; heart rate
Fich et al. (2014)	Can architectural design alter the physiological reaction to psychosocial stress? A virtual TSST experiment	49 male participants (mean age of 23.9)	Randomised mixed-design (2 groups)	Stress	Saliva cortisol was found to be increased during the test and peaked minutes after; heart rate also increased; the induction was found to be successful, as indicated by the measures	CAVE	TSST	Heart rate; saliva cortisol analysis
Gordon et al. (2011)	Interactive gaming reduces experimental pain with or without a head mounted display	19 male participants (mean age of 19)	Mixed-design (2 groups)	Relaxation	The gaming condition was the only 1 to significantly reduce pain; the pain in the emotion recall condition reduced the pain, but was not significantly different from baseline	Head-Mounted Display with tracking device	Beck Depression Inventory (BDI)	None
Hildebrandt, McCall, Engen, and Singer (2016)	Cognitive flexibility, heart rate variability and resilience predict fine-grained regulation of arousal during prolonged threat	172 female and 128 male participants (mean age of 40.65)	Single-group repeated measures design	Fear; relaxation; anxiety	Participants who showed better cognitive flexibility had better control over the physiological effect of the elicited emotion; participants who showed better resilience had better control over the subjective effect of the elicited emotion	Head-Mounted Display with tracking device	Ego-Resilience Scale (ER89); Task-Switching Task	Electrodermal activity; heart rate

Table 1 (continued)

Study	Title	Participants	Study design	Type of emotions	Primary findings	Vr equipment	Subjective assessment/ instruments	Physiological assessment
Jackson et al. (2015)	EEVEE: the Empathy-Enhancing Virtual Evolving Environment	Experiment 1 a-b: 10 female and 9 male participants (mean age of 22.6)	Single-group repeated measures design	Experiment 1a-b: disgust; anger; fear	Experiment 1a-b: emotional stimuli ratings ranged from average to high; disgust was detected by the participants in the anger and pain simulations, while fear was the most correctly detected	Head-Mounted Display with tracking device	Facial Action Coding System (FACS); VAS	None
Jönsson et al. (2010)	Cardiovascular and cortisol reactivity and habituation to a virtual reality version of the Trier Social Stress Test: a pilot study	10 male participants (MA = 28.3)	Single-group repeated measures design	Stress	Compared with baseline levels, saliva cortisol almost doubled after stress induction.	CAVE	TSST; Spielberger's STAI	Heart rate; Saliva cortisol analysis
Kwon et al. (2013)	How level of realism influences anxiety in virtual reality environments for a job interview	31 female and 29 male participants (MA = 25.95)	Mixed-design (6 groups)	Anxiety; emotional arousal and valence	BFNE found equal mean measures for all the four interview test conditions (human picture, cartoon 3D, realistic 3D and real interviewer); the realistic 3D interviewer condition was found to elicit more presence, indicating the graphics quality influence; no significant interaction was found between presence and anxiety ratings	Head-Mounted Display with tracking device	Brief Fear of Negative Evaluation Scale (BFNE); Liebowitz social anxiety scale (LSAS); Measure of Anxiety in Selection Interviews (MASI); Temple Presence Inventory (TPI)	Blink startle response; Electrodermal activity; Heart rate
Lin (2017)	Fear in virtual reality (VR): fear elements, coping reactions, immediate and next-day fright responses toward a	92 female and 53 male participants (mean age of 22.57)	Single-group repeated measures design	Fear	Participants related the plausible actions being more feared than the environmental cues	Head-Mounted Display with tracking device	Brief Sensation Seeking Scale (BSSS); Coping Inventory (COPE); Fear Assessment Original scale; Familiarity With First-Person Shooter	None

Table 1 (continued)

Study	Title	Participants	Study design	Type of emotions	Primary findings	Vr equipment	Subjective assessment/ instruments	Physiological assessment
	survival horror zombie virtual reality game						(FPS) Games Original Questionnaire; Subscale of Neuroticism from the Big Five Inventory; Will to Play Horror Games Original Questionnaire; Preference for the Horror Game Genre Original Questionnaire	
Ma, Sellaro, Lippelt, and Hommel (2016)	Mood migration: how enfacing a smile makes you happier	49 female and 11 male participants (mean age of 22.3)	Mixed-design (2 groups)	Happiness	Participants reproduced the virtual emotion expressed	Videogame	Affect Grid (AG); Alternative Uses Task (AUT); Creative Thinking Task; Including Other in the Self (IOS); Perceived Ownership Over the Virtual Face Original Scale	None
Madsen (2016)	The differential effects of agency on fear induction using a horror-themed video game	53 male participants	Randomised between--subject design (2 groups)	Fear	Agency increased fear in the experimental group (videogame players) compared with the control group (videogame watchers)	Videogame	Five-Emotion Likert Scale	Electrodermal activity; heart rate; respiration rate
Maïano, Therme, and Mestre (2011)	Affective, anxiety and behavioural effects of an aversive stimulation during a simulated navigation task within a virtual environment: a pilot study	4 female and 10 male participants (mean age of 23.50)	Single-group repeated measures design	Anxiety	Comparing with the neutral session, significantly higher anxiety was observed in the fire corridor session, containing warning sound and smoke	CAVE	Beck Anxiety Inventory (BAI); PANAS; STAI-Y	None
Marschner, Pannasch, Schulz, and Graupner (2015)	Social communication with virtual agents: the effects of body and gaze direction on attention and emotional responding in human observers	20 female and 20 male participants (mean age of 23.4)	Single-group repeated measures design	Emotional arousal and valence	Emotion was found to be related to body direction and gaze direction; happy facial expressions were rated more pleasant, followed by neutral and angry facial expressions, respectively; angry	Computer	SAM	Electromyography; Eye tracking;

Table 1 (continued)

Study	Title	Participants	Study design	Type of emotions	Primary findings	Vr equipment	Subjective assessment/ instruments	Physiological assessment
					facial expressions were rated as more arousing then the other ones			
Matthias and Beckhaus (2012)	Adaptive generation of emotional impact using enhanced virtual environments	12 female and 18 male participants (mean age of 28.9)	Single-group repeated measures design	Trust; surprise; anticipa-tion; joy; fear; sadness; disgust; anger; emotional arousal and valence	Discrete emotion induction ratings were found to be user dependent; disgust and anger had low ratings	CAVE	International Affective Picture System (IAPS); Interactive Tendencies Questionnaire (ITQ); Presence Questionnaire (PQ); SAM; Simulator Sickness Questionnaire (SSQ)	Blood volume pulse; Electrodermal activity; Respiration rate;
McCall et al. (2016)	Introducing the Wunderkammer as a tool for emotion research: unconstrained gaze and movement patterns in three emotionally evocative virtual worlds	191 female and 133 male participants (mean age of 41)	Randomised mixed-design (2 groups)	Emotional arousal and valence	The results indicate that responses to emotionally valenced stimuli are context-dependent	Head-Mounted Display with tracking device	Cognitive Emotion Regulation Questionnaire (CERQ); COPE; ER89; VR Experience Original Questionnaire	Motion capture
Mira, Campos, Etchemendy, Baños, and Cebolla (2016)	Access to autobiographical memory as an emotion regulation strategy and its relation to dispositional mindfulness	46 female and 14 male participants (mean age of 22.9)	Single-group repeated measures design	Sadness	The virtual scenario using several mood induction procedures led to significant increase in	Head-Mounted Display with tracking device	Autobiographical memory test (AMT); BDI-II; FFMQ; VAS	None
Moghimi, Stone, Rotshtein, and Cooke (2016)	Influencing human affective responses to dynamic virtual environments	48 female and 54 male participants (mean age of 23.23)	Randomised between--subject design (4 groups)	Emotional valence and arousal	Was shown that the VR paradigm can manipulate and predict emotions	Head-Mounted Display with tracking device	Circumplex of Affect; SAM	None
Molet, Billiet, and Bardo (2013)	Conditioned place preference and aversion for music in a virtual reality environment	8 female and 8 male participants (in both experiments)	Single-group repeated measures design	Emotional arousal and valence	Musical stimuli can be associated with VR to produce conditional place preference and aversion	Videogame	None	None

Table 1 (continued)

Study	Title	Participants	Study design	Type of emotions	Primary findings	Vr equipment	Subjective assessment/ instruments	Physiological assessment
Mousas et al. (2018)	The effects of appearance and motion of virtual characters on emotional reactivity	16 female and 56 male participants (mean age of 23.24)	Randomised mixed-design (4 groups)	Emotional arousal and valence	The high-amplitude motion zombie male showed the most negative emotional valence ratings, followed by the low-amplitude zombie male, the high-amplitude male and the low-amplitude male	Head-Mounted Display with tracking device	Emotion Reactivity Scale	None
Mühlberger, Wieser, and Pauli (2008)	Darkness-enhanced startle responses in ecologically valid environments: a virtual tunnel driving experiment	19 female and 7 male participants (mean age of 22.31)	Single-group repeated measures design	Fear	It was shown that state anxiety was associated with darkness enhanced startle responses	Head-Mounted Display with tracking device	Fear of Tunnel Questionnaire (TAF); STAI; Igroup Presence Questionnaire (IPQ); Emotional Valence Original Scale	Startle blink response
Munyan III, Neer, Beidel, and Jentsch (2016)	Olfactory stimuli increase presence in virtual environments	21 female 39 male participants (mean age of 20.48)	Mixed-design (4 groups)	Anxiety	Olfatory stimuli increased perceived presence but did not increased electrodermal activity; participants started to anticipate scripted events	Head-Mounted Display with tracking device	IPQ; ITQ; Presence Rating Scale (PRS); Presence Visual-Analogue Scale (PVAS); Quick Smell Identification Test (QSIT); SSQ; STAI	Electrodermal activity
Murray et al. (2016)	The effects of the presence of others during a rowing exercise in a virtual reality environment	62 female participants (mean age of 20.20)	Randomised mixed-design (3 groups)	Emotional arousal and valence	No significant differences were found between groups; no significant differences were found for the subscales of positive affect, tranquillity, fatigue or negative affect in the physical activity affect scale	Wall projection	Exercise Benefits/Barrier Scale (EBBS); Exercise Thoughts Questionnaire (ETQ); Feeling Scale (FS); Intrinsic Motivation Inventory (IMI); International Physical Activity Questionnaire-Short Form (IPAQ-SF); Physical Activity Affect Scale (PAAS); Physical Activity Enjoyment Scale (PACES)	Heart rate
Nazry and Romano (2017)	Mood and learning in navigation-based serious games	Experiment 1: 18 female and 18 male participants (mean age of 29.9). Experiment 2: 8	Single-group repeated measures design	Joy; relaxation	Participants pleasantness increased significantly after the task and the	Videogame	Reduced Brief Mood Introspection Scale (BMIS); Spatial And Navigation Test	None

Table 1 (continued)

Study	Title	Participants	Study design	Type of emotions	Primary findings	Vr equipment	Subjective assessment/ instruments	Physiological assessment
		female and 8 male participants (mean age of 25.88)			happy score also increased; In the second experiment, participants mood significantly increased			
Nogueira, Rodrigues, Oliveira, and Nacke (2015)	Modelling human emotion in interactive environments: physiological ensemble and grounded approaches for synthetic agents	12 participants (mean age of 24.83)	Single-group repeated measures design	Emotional arousal and valence	The paradigm was able to accurately predict emotional states in both conditions	Computer	IAPS	Electrodermal activity; Electromyography; Heart rate
Pallavicini et al. (2013)	Is virtual reality always an effective stressors for exposure treatments? Some insights from a controlled trial	41 participants (mean age of 21.15)	Single-group repeated measures design	Anxiety	Increases in anxiety and decreases in relaxation scores were found; the virtual reality condition associated with breakdowns was less effective in eliciting anxiety	Head-Mounted Display with tracking device	Post Media Questionnaire (PMQ); SUS	Electromyography; Heart rate; Respiration rate
Peperkorn et al. (2015)	Temporal dynamics in the relation between presence and fear in virtual reality	22 female participants (mean age of 25.18)	Randomised mixed-design (2 groups)	Fear	Fear ratings were higher for the group in the stereoscopic condition rather than the monoscopic condition group; the fear rating decreased by the time	CAVE	Fear of Spiders Questionnaire (FSQ); IPQ; SUDS	Electrodermal activity; Heart Rate
Rodríguez et al. (2015)	Assessing brain activations associated with emotional regulation during virtual reality mood induction procedures	13 female and 14 male participants (mean age of 23.36)	Mixed-design (3 groups)	Sadness	The subjective measures did not find significant differences in evidence for sadness induction, but negative induction was confirmed by the EEG	CAVE	IAPS; PANAS; Velten Self-Statements; VAS	Electroencephalography

Table 1 (continued)

Study	Title	Participants	Study design	Type of emotions	Primary findings	Vr equipment	Subjective assessment/ instruments	Physiological assessment
Ruggiero et al. (2017)	The effect of facial expressions on peripersonal and interpersonal spaces	17 female and 17 male participants (mean age of 23)	Single-group repeated measures design	Emotional arousal and valence	Participants showed increase of distance in angry environment; both spaces were sensitive to emotional valence	Head-Mounted Display with tracking device	Interpersonal reactivity index (IRI); Karolinska Directed Emotional Faces (KDEF)	None
Schweizer et al. (2017)	The impact of pre-existing anxiety on affective and cognitive processing of a virtual reality analogue trauma	66 female and 14 male participants (mean age of 21.86)	Mixed-design (2 groups)	Anxiety	A significant increase in subjective anxiety ratings compared with baseline, indicating success	Head-Mounted Display with tracking device	BDI-II; Difficulties in Emotion Regulation Scale (DERS); Intrusive Memory Questionnaire; STAI-T; Subjective Anxiety Scale; Subjective Presence Scale	Electrodermal activity
Seinfeld et al. (2016)	Influence of music on anxiety induced by fear of heights in virtual reality	27 female and 13 male participants (mean age of 26.27)	Between-subject design (2 groups)	Anxiety	In the no-music scenario, the anxiety state increased significantly and in the music scenario the anxiety state had no increase or even reduced	CAVE	The STAI-Y; SUDS; Autonomic Perception Questionnaire (APQ); Virtual Reality Experience Questionnaire	Electrodermal activity; Heart rate
Serrano, Baños, and Botella (2016))	Virtual reality and stimulation of touch and smell for inducing relaxation: a randomised controlled trial	84 female and 52 male participants (mean age of 27.05)	Randomised between--subject design (4 groups)	Relaxation	Increase in relaxation occurred when there was a decrease in arousal	CAVE	Clinical Assessment Questionnaire; BDI-II; STAI; VAS; SAM; IAPS	None
Sharar et al. (2016)	Circumplex model of affect: a measure of pleasure and arousal during virtual reality distraction analgesia	37 female and 37 male participants (mean age of 29)	Single-group repeated measures design	Joy	Subjective analgesia during VR distraction	Head-Mounted Display with tracking device	Circumplex Model of Affect; Graphic Rating Scales (GRSs)	None
Shiban et al. (2016)	Trier social stress test in vivo and in virtual reality: dissociation of response domains	45 male participants (mean age of 23.76)	Randomised mixed-design (3 groups)	Stress	The stress ratings showed a great effect of phase and condition in the experimental manipulation	Head-Mounted Display with tracking device	AMT; BDI-II; FFMQ; VAS	Electrodermal activity; Heart rate; Saliva cortisol analysis
Shin (2018)	Empathy and embodied experience in virtual environment: to what	100 female and 100 male participants (mean age of 31.17)	Between-subject design (4 groups)	Empathy	The immersion provided a great presence sensation;	Head-Mounted Display with	Empathy and Embodiment Questionnaire; Flow	None

Table 1 (continued)

Study	Title	Participants	Study design	Type of emotions	Primary findings	Vr equipment	Subjective assessment/ instruments	Physiological assessment
	extent can virtual reality stimulates empathy and embodied experience?				immersion was found to be less influential than the participants idiosyncratic traits	tracking device	Questionnaire; Presence Subscale	
Siamionava, Slevitch, and Tomas (2018)	Effects of spatial colours on guests' perceptions of a hotel room	76 female and 63 male participants	Randomised mixed-design (8 groups)	Relaxation; emotional valence and arousal	Blue coloured hotel rooms were found more relaxing than red rooms, but there were no significant differences; the blue colours were associated with low levels of arousal	Head-Mounted Display with tracking device	PAD model; Presence Questionnaire; Semantic Scale	None
van Strien et al. (2013)	Emotional eating and food intake after sadness and joy	60 female participants	Randomised mixed-design (4 groups)	Joy; sadness	Low emotional eaters food intake did not differ after sadness or joy induction, while high emotional eaters food intake increased after sadness induction	Wall projection	BDI; Dutch Eating Behaviour Questionnaire (DEBQ-E: DEBQ Emotional Eating Subscale); Eating Attitudes Test (EAT-26); VAS	None
Thimmesch-Gill, Harder, and Koutstaal (2017)	Perceiving emotions in robot body language: acute stress heightens sensitivity to negativity while attenuating sensitivity to arousal	Experiment 1: 16 female and 1 male participants (mean age of 21.27); Experiment 2: 56 female and 40 male participants (mean age of 21.15)	Randomised between--subject design (4 groups)	Emotional arousal and valence	Participants valence ratings decreased over time with an upturn after the stress induction; participants arousal increased over time with a downturn at the end of the stress induction	Head-Mounted Display with tracking device	Brief Symptom Inventory (BSI); Maastricht Acute Stress Test (MAST); SAM	None
Toet, van Welie, and Houtkamp (2009)	Is a dark virtual environment scary?	52 male participants (mean age of 23.37)	Randomised mixed-design (4 groups)	Stress; relaxation	Subjective and objective measures had shown that participants in the stress condition became distressed; stress was reduced in the relaxation period	Videogame	Game Experience Questionnaire; Recognition test; Semantic Questionnaire; STAI; TSST	Heart rate; Saliva cortisol analysis
Toet and van Schaik (2012)	Effects of signals of disorder on fear of			Fear	Concern for safety in the silent virtual	Videogame	Neighbourhood Safety Original Scale; Personal	None

Table 1 (continued)

Study	Title	Participants	Study design	Type of emotions	Primary findings	Vr equipment	Subjective assessment/ instruments	Physiological assessment
	crime in real and virtual environments	54 female and 66 male participants (mean age of 39)	Between-subject design (3 groups)		environment was significantly more perceived in the disorderly condition than baseline; the real environment and the virtual environment with sound had no difference in concern for safety between disorderly condition and baseline		Safety and Mental State Original Scale	
Tröger, Ewald, Glotzbach, Pauli, and Mühlberger (2012)	Does pre-exposure inhibit fear context conditioning? A virtual reality study	30 female and 10 male participants (mean age of 24.5)	Randomised mixed-design (2 groups)	Emotional arousal and valence; anxiety	Anxiety ratings were slower in conditioning and extinction compared with valence and arousal; success in the context condition was confirmed in the physiological measures	Head-Mounted Display with tracking device	BFNE; State Trait Anxiety Inventory (STAI X2); PANAS	Blink startle response; Electrodermal activity; Heart rate
Vara et al. (2016)	A game for emotional regulation in adolescents: the (body) interface device matters	29 female and 32 male participants (mean age of 13.08)	Randomised between--subject design (3 groups)	Frustration; relaxation	Effectiveness on increasing and decreasing frustration	Videogame	Felt Arousal Scale (FAS); VAS	None
Verplaetse and De Smet (2016)	Mental beliefs about blood, and not its smell, affect presence in a violent computer game	126 male participants (mean age of 21.78)	Between-subject design (6 groups)	Emotional valence and arousal	The game was able to induce excitement, but the experimental conditions did not vary from each other	Head-Mounted Display with tracking device	Buss-Perry Standardised Aggression Questionnaire; Fear Survey Schedule III; Familiarity With First Person Shooter Games Original Survey; Subjective Questionnaire For Presence Assessment; Subjective Assessment of Levels of Excitement, Aggression, Anger, and Power or Dominance;	Electrodermal activity; Heart Rate; Respiration rate

Table 1 (continued)

Study	Title	Participants	Study design	Type of emotions	Primary findings	Vr equipment	Subjective assessment/ instruments	Physiological assessment
							Sniffin' Sticks Screening 12 Test	
Wrzesien et al. (2015)	How the physical similarity of avatars can influence the learning of emotion regulation strategies in teenagers	11 female and 11 male participants (mean age of 13.27)	Randomised between--subject design (2 groups)	Frustration; relaxation	Subjective and objective measures show that the VRS avatar increases and decreases valence and arousal in participants.	Head-Mounted Display with tracking device	Appeal Questionnaire (AQ); Emotion Regulation Questionnaire For Children and Adolescents (ERQ-CA); Identification With The Avatar Questionnaire; SAM; Presence Self-Assessment Manikin (P-SAM); VAS	Electroencephalography
Zhang, Dumas, Kelso, and Tognoli (2016)	Enhanced emotional responses during social coordination with a virtual partner	9 female and 12 male participants (mean age of 25)	Single-group repeated measures design	Emotional valence and arousal	Higher emotional arousal was found when the virtual partner was controlled by humans	Computer	None	Electrodermal activity
Zlomuzica, Preusser, Totzeck, Dere, and Margraf (2016)	The impact of different emotional states on the memory for what, where and when features of specific events	53 female and 22 male participants (mean age of 22)	Randomised mixed-design (3 groups)	Neutral state; anxiety; relaxation	Emotional arousal can modulate memory, with higher arousal hindering event-location memory	Computer	Depression Anxiety Stress Scales (DASS); IPQ; ITQ	None
Zumbach et al. (2015)	Impact of violent video game realism on the self-concept of aggressiveness assessed with explicit and implicit measures	33 female and 36 female participants (mean age of 24.46)	Randomised mixed-design (4 groups)	Anger	In the explicit measures, participants reported decrease of aggressiveness along the time; the association between self and aggressive behaviour was increased after violence exposure	Videogame	Aggression Questionnaire (BPAQ); Association Test On Aggressiveness (Agg-IAT)	None

to be used to elicit emotions such as stress and relaxation, with some studies eliciting anger and positive emotions.

Subjective Measures

Subjective measures were used to measure the efficacy of emotion induction in the VR paradigm, as well as other constructs that were specific to the studies. Several subjective measures were found in the studies analysed in this review, with the scales and questionnaires varying depending on the focused emotion elicited. A group of 26 studies did not use a physiological measure to assess emotion induction, focusing the assessment of the elicited emotion on subjective measures only. The State-Trait Anxiety Inventory (STAI), a 20-item self-reported questionnaire, with each item being scored with a 4-point Likert scale, assesses anxiety both as a transitory state and as a characteristic (trait), was the most commonly used scale, appearing in 16 studies (Spielberger, 1983). The Visual Analogue Scale (VAS) was the second most used instrument, appearing on 12 studies. The scale is used to measure feelings, with participants placing a mark over a line representing their subjective state, with scoring ranging from 0 to 100 (Cline, Herman, Shaw, & Morton, 1992). The Positive and Negative Affect Scale (PANAS), with 20 items divided into 2 factors exploring positive and negative affects (Crawford & Henry, 2004), was present in 8 of the analysed studies. The Self-Assessment Manikin (SAM), used in 8 of the reviewed studies, is a scale that measures valence, arousal and dominance response for each emotion stimuli, with visual aids anchoring the scoring in a 5-point Likert scale (Bradley & Lang, 1994). The Beck Depression Inventory (Beck, Ward, Mendelson, Mock, & Erbaugh, 1961), a 21-item depression questionnaire, comprising 2 main factors (somatic and cognitive symptoms of depression), appeared in 7 studies. Anxiety, fear and stress were commonly assessed subjectively via the State-Trait Anxiety Inventory (STAI), with a smaller number of studies using the Visual Analogue Scale (VAS) and the Self-Assessment Manikin scale (SAM).

Physiological Measures

Physiological measures were used in 35 of the analysed papers. Electrodermal activity was the most commonly employed method (23 studies), followed by heart rate measure (21 studies). Few studies used electromyography and respiration rate measures to complement their findings. Fear and anxiety were usually assessed physiologically by electrodermal activity measures, while joy and relaxation were usually assessed by heart rate measures. Only three of the analysed papers included neuroimaging data collection, namely Functional Magnetic Resonance Imaging (fMRI) and Electroencephalography (EEG).

Effectiveness of VR in Inducing Emotions

Most of the reviewed studies were successful in inducing the selected emotion. In particular, stress and anxiety induction was successful in all studies, with very large effects in a few cases (e.g. Jönsson et al., 2010). Joy, fear and relaxation induction was successful in most studies, although this varied with experimental condition (Gordon, Merchant, Zanbaka, Hodges, & Goolkasian, 2011, relaxation; Toet & van Schaik, 2012, fear).

For a few emotions, such as sadness and anger, effectiveness of induction was lower, with some studies not reporting changes (Felnhofer et al., 2015; Rodríguez, Rey, Clemente, Wrzesien, & Alcañiz, 2015) or only short-lived emotional alterations (Zumbach, Seitz, & Bluemke, 2015, anger). A few studies showed consistently minor changes, regardless of the emotion elicited (Matthias & Beckhaus, 2012). In the study by Jackson, Michon, Geslin, Carignan, and Beaudoin (2015), the elicited emotion was not specific to its experimental condition, with disgust being reported in the anger-inducing condition also.

Studies that explored dimensional aspects of emotion, such as arousal and valence, typically were successful in inducing affective states, with the exceptions being Aymerich-Franch (2010), Murray, Neumann, Moffitt, and Thomas (2016) and Verplaetse and De Smet (2016).

Ethical Issues

According to the reviewed studies, emotion elicitation through VR, similar to other mood induction procedures, appear to induce affective states within the normal range of everyday experience. No study reported adverse effects following VR use, with some excluding participants on the basis of previous negative experiences (e.g. Dibbets & Schulte-Ostermann, 2015). To avoid finishing the testing sessions in a negative mood, studies included positive stimuli after negative emotion elicitation (e.g. Rodríguez et al., 2015; van Strien et al., 2013), other activities (e.g. mindfulness, Cuperus, Laken, van den Hout, & Engelhard, 2016) or a resting period (e.g. Fich et al., 2014). Carry-over effects between experimental conditions were prevented in a few studies by counterbalancing (e.g. Kwon, Powell, & Chalmers, 2013) or randomising conditions (Mousas, Anastasiou, & Spantidi, 2018). Few studies did not provide information on ethics committee approval.

Discussion

In summary, this systematic review compiled 61 studies that used VR as an emotion induction paradigm. In most studies, participants were college students, mixed or within-subject designs were employed, with the most common emotions

elicited being anxiety, relaxation, fear and joy. VR equipment used included the Head Mounted Display, the Cave Automatic VE, videogames and computers, with almost all studies (58/61) using subjective measures of emotion and around half of them (35/61) including physiological measures. The findings suggest that VR is consistently effective as a tool to induce emotion in the lab, for a variety of emotional states, assessed by different outcome measures.

The use of college students in a majority of studies is a trend also in other areas of psychological research, and may reduce generalisability of findings, focusing on what has been termed Western, Educated, Industrialized, Rich and Democratic (WEIRD) samples (Henrich, Heine, & Norenzayan, 2010). Further studies in other age, gender, educational achievement and ethnic groups, as well as research conducted in developing countries, is needed to complement current findings, tailoring procedures for the groups studied (e.g. Baños et al., 2012). Regarding study designs, the most common approach was the mixed-design, including both between- and within-subject factors. In the studies reviewed, between-subject factors were typically the experimental conditions, with within-subject factors indicating time (pre- and post-intervention), but in a few cases, different virtual environments were also repeated for the same participants. The latter approach was used in a large number of studies that employed a full within-subject design; although this provides perfect matching of participants across conditions (i.e. the same participants do all of them), carry-over effects, a concern in emotional elicitation studies, need to be avoided. The majority of studies including between-subject factors randomised participants to the experimental conditions, allowing for a tighter control of intervening variables.

In relation to equipment, HMD was the most commonly used, which is in agreement with previous research on clinical use of VR (e.g. motor rehabilitation: Dascal et al., 2017; mental health management: Valmaggia, Latif, Kempton, & Rus-Calafell, 2016). This is possibly due to its great immersive capacity, which is also seen in the CAVE paradigm (Jönsson et al., 2010), albeit with higher costs. The self-reported measures frequently used in emotion elicitation are also consistent with those indicated in reviews exploring clinical use of VR, alongside instruments used for specific conditions (psychosis: Rus-Calafell, Garety, Sason, Craig, & Valmaggia, 2018; addiction: Segawa et al., 2019), suggesting that comparisons between findings obtained with clinical and non-clinical samples, including of effect sizes, is possible. A large proportion of studies relied solely on self-reported measures, which have been criticised for their subjectivity, proneness to demand characteristics and difficulty to access in certain cases (e.g. subtle emotions) (Baumeister, Vohs, & Funder, 2007), suggesting that, when available, future research should include physiological measures, including when investigating specific emotions (for a review, see Kreibig, 2010).

Effectiveness of VR varied according to the emotion investigation, with stress and anxiety being consistently elicited. It is possible that this reflects more refined experimental paradigms for these emotions, given their use in clinical groups (Segawa et al., 2019). Successful elicitation of stress and anxiety is in agreement with the fact that studies using a dimensional approach, i.e. inducing valence or arousal in general, were normally effective, given that both stress and anxiety are less specific emotional responses. In any case, discrete emotions were also successfully elicited, although for sadness and anger this was either reduced or short-lived.

Having stress, relaxation, fear and joy as the most elicited specific emotions in healthy adults is in agreement with the notion that experimental approaches in healthy participants can be used to model clinical phenomena and responses to them. In addition to management of clinical groups (e.g. Gorini et al., 2009), health applications of VR may include promotion of emotional regulation as a prophylactic measure in healthy groups (Montana et al., 2020; Wrzesien et al., 2015). Improvements in the elicitation of these emotions may have a variety of applications, for instance in the entertainment industry (e.g. horror games, comedy films), as self-development tools (relaxation in paradigms of contemplative practices) and as training resources (e.g. habituating professionals exposed to danger and stress to simulations of real-life situations).

Given that VR use with clinical groups has been summarised elsewhere (e.g. Segawa et al., 2019), this article focused on work with healthy participants. Although this limits clinical applicability of findings, it emphasises the reactivity of non-clinical groups to emotion using VR, facilitating research and everyday life applications. Additionally, although a meta-analytic approach could have been attempted, considerable heterogeneity of methodologies prevented such an analysis; with the expansion of the literature in this field, a critical mass of papers in each subtopic may allow combination of effect sizes.

Finally, although the reviewed studies did not explore the mechanisms behind emotion elicitation through VR, findings allow us to speculate on the reasons behind the effectiveness of VR in causing emotional experiences. In particular, studies that integrated subjective and physiological measures suggest that VR is capable of inducing emotions at a bodily level. Coupled with the preference for equipment that leads to higher immersion, and the known influence of presence in emotional responses in VEs (Price, Mehta, Tone, & Anderson, 2011), it is likely that the mechanisms behind VR emotional induction are linked to the integration of sensory data from multiple sources, including visceral, proprioceptive, visual and auditory information. If correct, that would be in agreement with traditional perspectives in Psychology (James, 1894) and current trends that emphasise the relevance of embodiment in cognitive and affective processes (Kiverstein & Miller, 2015).

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