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The apparent reality of movies and emotional arousal: A study using physiological and self-report measures

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Abstract

Historical developments of cinema technology have contributed to the apparent reality of movie-goers' experience. The current study uses both self-report and physiological measures (heart-rate, skin conductance, skin temperature) as indices of 29 participants' negative emotional arousal, so as to investigate the effect of increasing a movie's perceptual realism (i.e., stereoscopic depth) on emotional experience. Data were recorded while half of the participants viewed emotional movie scenes in 3D and half viewed them in 2D. The groups did not differ significantly in terms of their self-reported feelings of negative emotional arousal, tonic skin conductance level or skin temperature. However, the 3D group reported their experience as significantly more perceptually realistic (natural), and they also demonstrated a significantly higher heart-rate change-score than their counterparts in the 2D condition. Importantly, the current study provides evidence that these results are not due to group differences in emotional sensitivity, engagement, or the novelty of the 3D effect. Group differences in heart-rate, but not skin conductance level, suggest that increasing stereoscopic depth reduces the emotional regulation processes. Although caution is expressed about assumptions of causation, consideration is given to the idea that increased physiological arousal contributes to perceived apparent reality and vice versa.

1. Introduction

Since the Lumière brothers hosted the first public screening of a motion picture in 1895 (Karney, 2005), major developments in cinema have made the experience seem more realistic. Over the years, we have been introduced to "the talkies", the 3D movie, surround sound, CGI

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(i.e., computer-generated imagery), and high definition—each development adding to the illusion of non-mediated reality in the cinema. Yet, humans have used even the most primitive forms of fiction and storytelling since the very first *Homo sapiens* wandered the planet more than 30,000 years ago (Mithen, 1998). And in more modern times. we know that even a story with shadow puppets can make our emotions soar. One might wonder if these developments are even necessary. James Cameron's (2009) 3D blockbuster *Avatar* was made famous by its use of all the above mentioned techniques to increase the illusion of non-mediated reality. In 2010, *Avatar* smashed all box office records around the world and is currently the highest grossing movie worldwide (over $2.7 billion) (Boxofficemojo, 2012). Presumably, these developments will continue and the movies we see in the cinema will seem increasingly realistic. With these ideas in mind, the current study seeks to explore the impact of such apparent realism on the psychological experience of movie-watching and its associated emotions.

2. The law of apparent reality and the dual awareness model

Frijda (1988) attempts to formulate a set of laws or stable unifying characteristics that, he argues, define and predict our emotional behaviour. One such characteristic is that the intensity of an emotional experience is related to the extent to which the eliciting event is appraised as ‘‘real’’ (i.e., the situation's ‘‘apparent reality’’). Thus, according to Frijda's ‘‘law of apparent reality’’, emotional arousal comes from events that are *appraised* as real rather than referring to the actual validity of the event. At first, this law makes sense; there is no reason to become emotional towards something that is not real. Yet people frequently become emotional towards fiction, and so this constitutes a special case that needs to be explained.

Grodal (2009) proposes an explanation for engagement with fiction using his PECMA model (**P**erceptions, **E**motions, **C**ognitions and **M**otor **A**ction). This model states that people experience emotion towards narrative fiction due to an innate neural operation that seeks to arrange psychological processes. According to Grodal, stories, by definition, operate in-line with the way our neural mechanisms organise narrative, and they involve the interaction of perceptions, emotions, cognitions and actions. Thus for Grodal, films serve as ‘‘embodied simulations’’ of everyday experience. The PECMA model argues that cognitive appraisal of the film's realism interacts with automatically triggered perceptions and emotions as part of an embodied innate neurological system. Yet, without specific details about the way in which these elements interact, this idea requires elaboration.

Tan's (2008) dual awareness model offers such elaboration and allows for Frijda's law to remain true for fictional film—by conceptualising an independent yet symbiotic appraisal system. Tan proposes that dealing with fiction is facilitated by two mental domains. One of these domains, the ‘‘Entertainment Space’’, engages with the fictional events as though they were real, while the other domain, the ‘‘Executive Space’’, supports the constructed imagery of the entertainment space and interfaces with the real-world. According to Tan, the ontological status of a fictional event (how real, plausible, or fictional it is) is appraised by the executive space, while the entertainment space remains unaffected. Also according to Tan (2008), it is the attention to these different spaces that regulates emotional arousal. When attention is drawn away from the executive space (i.e., away from the fictional nature of the events), the viewer becomes ‘‘drawn in’’ to the film and the events they view are perceived as more realistic. Equally, a realistic film creates emotional believability, which in turn, draws attention away from the executive space. Disbelief sustains realism and realism sustains disbelief.

According to the dual awareness model, the opposing process is also possible. Viewers can regulate their emotional experiences by attending to the fictional nature of the experience. Attending to the executive space serves to remind a viewer that ‘‘it is just a film’’ and reduces emotional arousal. This attentional shift can also be caused by external forces (a ringing phone or a nearby chatterbox), drawing attention towards the executive space and reminding the viewer that they are merely watching fiction. This reduces the apparent reality and, in turn, inhibits emotional arousal (towards the film at least). Thus, the emotional experience of watching film involves allowing oneself to switch off, to become emotional and be drawn in, while carefully keeping emotions in check and regulating their intensity by attending to the fictional nature of events when necessary.

Importantly, this theory does not champion a simple one-way relationship between apparent reality and emotional arousal. Tan (2008) claims that the emotional arousal a film produces, in turn, sustains suspension of disbelief and accordingly aids the illusion of non-mediated reality. Naturally, these processes would also interact with the content of the film and variable viewer characteristics and preferences. But even with this complex interplay, this theory can, in a sense, save Frijda’s (1988) law of apparent reality. Whether it is the realism that causes the emotion, vice versa or a combination of both, this interplay allows for the prediction that there will be a positive relationship between the level of realism a film demonstrates and the associated emotional intensity of the experience.

3. Apparent reality, emotion, and their operational measures

Researchers have primarily conceived of realism as a multi-dimensional construct (Busselle and Greenberg, 2000; Hawkins, 1977; Potter, 1988; Shapiro and Chock, 2004), involving various types of subcomponents—such as, for example, how much a representation simulates real sensory data, or how much it represents what is likely to occur in the real world. Resulting from qualitative focus groups, Hall (2003) identifies six dimensions that she claims constitute perceived realism; *plausibility* (something that could be true), *typicality* (commonly or frequently occurs), *factuality* (accurate representation of specific real-world events), *narrative consistency* (internal coherence of the story), *involvement* (generates emotion), and *perceptual persuasiveness* (the extent to which the film creates a compelling visual illusion of realism). In her discussion of the components of realism, Hall (2003) recognises that the first three (plausibility, typicality and factuality) are in-line with the way that many researchers in the area have conceptualised and operationalised realism in their research (Huston et al., 1995; Pouliot and Cowen, 2007; Wright et al., 1994). Oftentimes, researchers will manipulate realism by telling participants that they are (or are not) watching something that actually happened. Yet the remaining components (narrative consistency, involvement, perceptual persuasiveness) have received very little attention within the literature. And it is these components that are most in-line with an online *experience* of realism (apparent reality) rather than an *assessment* of possible realism (relative realism).

Thus, the research literature that directly deals with apparent reality and emotion towards fiction is scant. This point is also made by Konijn et al. (2009), who have conducted one of the few empirical studies in the area. Specifically, Konijn et al. (2009) test the hypothesis that induced-emotions from movie scenes would increase viewers’ perceptions of realism in a fake documentary. While they report no significant effect of inducing emotion on perceived realism, they report that those who were more emotionally involved *while* watching the target film judged it more realistic. Visch et al. (2010) report significantly higher levels of self-reported emotion from participants who viewed animated movie clips in a more immersive and realistic virtual reality CAVE than a 3D projection. Thus there is empirical evidence to support the prediction that increasing the apparent reality of a film will be associated with increased emotional arousal in the viewer.

The cited studies have each used self-report measures, whereas several researchers have called for more objective measures of "behavioural realism" and have argued that perhaps physiological measures of emotional arousal might produce different results (Baños et al., 2004; Freeman et al., 2000; Meehan et al., 2005). They argue that when observers experience a mediated environment that induces a feeling of greater apparent reality, they will demonstrate responses (psychological and physiological) similar to those evoked by the corresponding real environment. For this reason research can triangulate the data from self-report measures with those from behavioural measures, such as physiological measures of autonomic arousal.

Emotional arousal has been widely operationalised by measuring the activity of the sympathetic nervous system (SNS) and, in particular, electrodermal activity (EDA) (Ravaja, 2004). When someone becomes emotionally aroused, their skin becomes more conductive due to increased eccrine sweat gland secretions. Thus, skin conductance serves as a measure of the SNS activity that has been associated with increased emotional arousal (Dawson et al., 2005). SNS activation also increases cardiovascular activity, and so researchers commonly use heart-rate (HR) as an additional measure of emotional arousal. However, interpretation of HR is perhaps not as straightforward as that of EDA because it is also subject to the influence of the parasympathetic nervous system (PSNS). While SNS activation of the cardiovascular system has been associated with emotional arousal, PSNS activity has been associated with various attentional and emotion regulatory processes that decrease cardiovascular activity (Porges, 1995; Thayer and Lane, 2000). Thus, a measure of HR represents the effect of the relative contributions of an excitatory system (SNS) and an inhibitory system (PSNS) (Papillo and Shapiro, 1990; Ravaja, 2004).

According to Lang et al. (1997), when participants are presented with emotional stimuli, the PSNS is usually dominant and so HR reduces. There is a substantial body of research that demonstrates that this HR deceleration is associated with an increase in attention (Lacey and Lacey, 1970; Lang, 1990; Mulder and Mulder, 1981; Turpin, 1986). This deceleration is brief for pleasant and neutral stimuli (Bradley et al., 1993; Lang et al., 1995), but more extended for aversive stimuli (Lang et al., 1997). However, Lang et al. (1997) point out that, for certain intense aversive emotions (e.g., with phobic participants), the SNS dominates the HR influence and an increase is observed (Hamm et al., 1997; Klorman et al., 1977). Thus, the relationship between PNS and SNS activation is not a simple one. Importantly, it has also been shown that reciprocal and non-reciprocal co-activation or co-inhibition can occur in both the PSNS and the SNS (Berntson et al., 1994). For this reason, physiological measures of autonomic arousal cannot be definitively attributed to any single source, and this might lead to difficulties with interpretation of HR data (Ravaja, 2004).

To help go some way towards addressing this problem, researchers can use HR data in conjunction with EDA. The presence or absence of differences in EDA might help determine if differences in HR are indicative of SNS activity (emotional arousal) or PSNS activity (emotional regulation). For example, Reeves et al. (1999) use measures of HR and EDA, specifically skin conductance (SC), when comparing groups of female students who watched emotional moving pictures on different sized screens. They report a significantly higher level of skin conductance, indicative of emotional arousal, and lower HR towards the messages displayed on the larger screen than on the smaller screens. Given the differences in SC, they interpret the lower HR as an index of increased attention.

Contrary to the above, Meehan et al. (2005) have conducted four experiments that investigate participants' self-reported feelings of apparent reality and their physiological arousal (heart-rate, skin conductance, skin temperature) in a number of 3D virtual environments that were manipulated to be more or less realistic (by including passive haptics, an increased frame-rate, or a delay in visual correspondence to actions). In reviewing the four experiments, they find significantly higher levels of both HR and skin conductance when the environment was more realistic. Thus, they interpret HR effect as an index of emotional arousal.

Considering these interpretations we might ask why one manipulation (screen size) might increase attention in viewers and another (apparent reality) might increase emotional arousal. In user studies of virtual reality researchers exploring the ''realness'' of the experience have distinguished between the contributing aspects of the medium and the psychological processes of the user. Here, immersion has been defined in terms of the sensory information the technology provides to the user (Slater, 1999). Thus one could say that modern cinema experience is becoming more immersive with the introduction of surround sound, high definition, etc. However, this can be distinguished from the illusion of apparent reality. While there is a large overlap between the techniques of increasing immersion and increasing apparent reality, these are not necessarily synonymous. There are ways to increase the apparent reality of a movie experience without increasing how immersive the technology is (e.g., a plausible story). The converse is also true. While, arguably, increasing both screen-size and, say, visual frame-rate makes a viewing environment more immersive, the screen size manipulation does not necessarily improve the illusion of non-mediated reality. The size of an actor's face might be more similar to a realistic size if presented on a smaller screen.

4. The present study

While previous research supports the predicted association between apparent reality and emotional arousal, it has not directly tested the affect of manipulating the illusion of apparent reality on emotional arousal. Furthermore, the stimuli used in previous studies (virtual environments or animated moving shapes with no narrative element) are perhaps insufficient for testing the current question. Previous research has yet to explore empirically the role of apparent reality in the emotional engagement with narrative fictional film. The present study aims to address this gap in the research.

The current study manipulates the film experience only on the dimension of stereoscopic depth. Previous research has demonstrated that the experience of watching films in stereoscopic 3D differs in several ways from 2D film experiences. For example, Pölönen et al. (2009) report that participants rated 3D films as more credible, more realistic, and more immersive. Other research has demonstrated that 3D depth increases the feeling of presence (i.e., naturalness or non-mediation) (Ijsselsteijn et al., 2001, 1998a,b). Thus, by manipulating stereoscopic depth in this way, it becomes possible to present a visual experience that is either more similar (3D) or dissimilar (2D) from a viewer's everyday perception of his or her physical world. This manipulation also allows for empirical control of things like sound volume, screen size or acting quality—as these variables will be held constant. Thus, by manipulating the inclusion of stereoscopy, the current study manipulates the illusion of apparent reality.

In order to attribute any group differences that are observed to the manipulation of apparent reality, it is also necessary to control for the fact that the 3D group might simply be more engaged by a novel experience. Even though 3D movies have experienced a revival in recent years, they were probably not yet widespread enough to assume that everyone has experienced one. It is possible that the 3D group will experience elevated emotion due to their engagement with a new experience, and so this must be controlled.

It has been demonstrated that the type of emotion elicited can have an impact on the extent of the arousal, and so the emotional content of the stimuli can have varying effects (Gollnisch and Averill, 1993; Kreibig et al., 2007; Stark et al., 2005). To control this, the current study limits its focus to aversive stimuli, specifically those that contain an element of disgust. Disgust was chosen for the following reasons: it is more easily and perhaps more intensely evoked visually than some other emotions (e.g., anger); it is (like stereoscopy) more related to physical proximity (Angyal, 1941; Rozin et al., 2008); and it has had a growing appearance in television and film for all ages (Goldstein, 1998). While the use of disgust in the current study may impact on the generalisability of findings, we feel it will allow for a specific yet fruitful exploration of the current questions.

It should be noted that when using film clips, it is almost impossible to control for the arousal of multiple emotions. This may be especially true with disgusting scenes, as the distinctions between states of disgust and fear arousal are contentious (Woody and Teachman, 2000) and as research can seldom dissociate the two (Huijding and de Jong, 2007). Due to the muddy distinction between these emotional states, many film scenes involving disgust also contain elements of fear inducing stimuli. Researchers can, however, gear the stimuli towards the likelihood of eliciting a target emotion more strongly or frequently than other emotions, as is the case for the current study.

4.1. Study aims

The current study investigates the effect of increasing the illusion of apparent reality on emotional arousal towards movie scenes. Given the considerations and complexities involved with documenting the experience, the current study uses self-report measures of emotional arousal in addition to physiological measures of autonomic activity (HR, EDA and skin temperature).

4.2. Hypotheses

The current hypotheses are constructed by integrating Tan's (2008) dual awareness model with the review of operational measures of emotional arousal and the processes by which the autonomic system has been shown to operate. Immersion acts primarily by redirecting our attention from the executive space to the entertainment space, which is predicted to increase our emotional arousal. The same can be said for increasing the apparent reality of an experience, yet this also has an additional quality. If the experience is more real, rather than simply more immersive, then the viewer's ability to regulate their emotional arousal based on the fictional nature of the experience is reduced. For this reason, we hypothesis that, compared to the 2D group, the 3D group will demonstrate significantly greater levels of emotional arousal. Thus, the 3D group will demonstrate higher scores on (H_{a1}) self-reported feelings of disgust and fear and on (H_{a2}) physiological measures of autonomic arousal (HR, EDA and skin temperature).

5. Method

5.1. Design

This study used an independent groups design, with two levels of the independent variable (2D or 3D). Physiological measures of autonomic arousal (heart-rate, skin conductance level and skin temperature) and self-reported emotional arousal served as the dependent variables.

Table 1
List of empirically short-listed stimulus clips in order of presentation with source film.

No.	Source	Duration	Brief description
1	Slee (2003). *Bugs 3D*	32 s	*Narrative story applied to documentary style footage of a praying mantis attacking a fly and eating its head.*
2	Miner (1982). *Friday the 13th 3*	68 s	*After eating fish food, Harold realises it is made from fly eggs. He continues to eat other foods noisily while holding a pet rabbit.*
3	Miner (1982). *Friday the 13th 3*	45 s	*Harold drinks whiskey, while using the toilet (accompanied by sounds). He searches for the source of a noise. Murderer appears and kills him with a hatchet to the chest.*
4	Miner (1982). *Friday the 13th 3*	42 s	*Edna searches the garage to find Harold. She reveals a rat that walks towards the viewer. She becomes startled and the murderer appears and stabs her in the neck.*
5	Miner (1982). *Friday the 13th 3*	13 s	*Blood drips down from above Debbie who is on a hammock. She looks up to see her boyfriend's mutilated body in the rafters. She screams and is stabbed up through her back and chest from under the hammock.*
6	Miner (1982). *Friday the 13th 3*	101 s	*Chris, being chased by the murderer, hides in a room and locks the door. She discovers Debbie's body and screams. The murderer finds her, and they fight. The murderer gets stabbed in the hand and the knee, allowing Chris to get away.*
7	Alves (1983). *Jaws 3-D*	24 s	*Michael tries to convince Kay not to look at the body of her colleague, Shelby, who has been killed by a shark. She uncovers the body anyway, and we see his partly decomposed and mutilated body covered in seaweed and insects.*
8	Morrissey (1974). *Frankenstein*	30 s	*We see Frankenstein's assistant, Otto, chase the Baroness through a dungeon. He catches her and appears to rip open her stomach. She falls to the ground, and we see her organs hang towards us.*

5.2. Participants

Twenty-nine participants, from a university campus (13 males, 16 females, age range 21–62 years, mean age = 27.38 years, Sd = 7.44 years) volunteered for this study. These were randomly assigned (while maintaining gender balance) to either the 2D or 3D group. Due to technical failure, all physiological data were lost for one participant and HR data were lost for another.

5.3. Stimuli

Four commercially available fictional movies were selected using specific criteria: the movie needed to be in 3D, containing scenes of disgust and involving real-life actors in live-action scenes set in familiar surroundings of the present day. Four movies were selected (see Table 1). Various scenes that contained instances of ‘‘disgust’’ and seemed to contain emotional value were selected from each movie by the researchers. The choice of these enactments was guided by six domains of disgust outlined by Rozin et al. (1999). These domains involve issues of food, animals, body products, death, injury/deformity, and moral offence. Scenes of a sexual nature were not included for ethical reasons. In light of the earlier stated contentious distinction between disgust and fear, some of the chosen scenes containing elements of disgust also contained dimensions of fear or general tension. Once the scenes in the current study were selected, along with some additional scenes for contextual purposes, they were combined and prepared in 2D/3D format.

It was necessary to identify the periods of interest for analysis (high emotional arousal) rather than scenes that served merely to set the scene or progress the story. To this end, 19 people (5 females and 4 males watched in 2D; 5 males and 5 females watched in 3D) rated the stimulus clips, identifying the most ‘‘emotionally arousing’’ parts, so as to avoid problems associated with the contentious distinction between disgust and fear (Woody and Teachman, 2000). Using these ratings, 8 periods of high-emotion were identified, ranging from 13 to 101 s (see Table 1 details of these clips). Consequently, these aspects of the movie clips were identified for their emotional value rather than specifically rating the level of disgust they elicit. Yet, as stated earlier, the stimuli were almost entirely geared towards eliciting disgust.

5.4. Measures

5.4.1. Physiological measures of emotional arousal

Physiological data were collected using a Dell computer and a BioSemi Active Two measurement system. The analog physiology signals were digitized and amplified with a Mark II ActiveTwo A/D box. Once the data were collected, BESA, an accompanying biofeedback software application, coordinated the sampling and storage of the physiology data. HR was recorded by using two Ag/AgCl (0.5 cm^2) flat-type active electrodes (placed on the participant’s torso and chest) as an electrocardiogram. Electrodermal activity (EDA) was operationalised as the participants’ Tonic Skin Conductance Level (SCL). This SCL was recorded by attaching an Ag/AgCl (0.5 cm^2) flat-type passive electrode on two fingers (palmar surface) of the participant’s hand (or in some cases, the thenar and hypothenar eminences of the participant’s hand). In all cases, a polymer electrolyte (SignaGel) was used as an electrode medium. Skin conductance in micro-Siemens (μS) using a current 1 μA (16 Hz) was sampled 512 times per second. Skin temperature was measured by placing a high precision (Agilent 21078A) temperature sensor on the participant’s neck. Skin temperature was also sampled at 512 times per second.

5.4.2. Self-reported emotional arousal

Self-reported disgust and fear experienced during the movie were measured using two short scales designed specifically for this study. For the Disgust Arousal Scale (DAS) participants were asked to indicate, on a 5-point scale (1–5), their level of agreement with 4 statements about how much the movie disgusted them (e.g., ‘‘*I was revolted by the movie content*’’, ‘‘*I felt aversion towards the content of the movie clips*’’), 3 (reverse scored) statements of the opposite (e.g., *charmed*) and 2 statements of the magnitude of the arousal (e.g., *intense*). An analysis of internal consistency demonstrated adequate levels of reliability for this measure in the current sample (α = .77).

Similarly, for the Fear Arousal Scale (FAS), participants were asked to indicate, on a 5 point scale (1–5), their level of agreement with 3 statements about how much the movie frightened them (e.g., *fear, aversive*), 1 (reverse scored) statement of the opposite (e.g., *bored*) and the same 2 statements of the magnitude of the arousal (e.g., *intense*). This measure demonstrated an adequate level of internal consistency with the current sample (α = .80).

5.4.3. Perceived apparent reality

In order to confirm that the manipulation of stereoscopy served as a manipulation of apparent reality, participants’ perceptions of apparent reality were operationalised through the ecological validity subscale from *The ITC-Sense of Presence Inventory* (ITC-SOPI) (Lessiter et al., 2001). This self-report measure indicates the level to which a viewer perceives the mediated environment as lifelike and real. The ecological validity subscale of the ITC-SOPI (hereafter referred to as perceived apparent reality) consists of 5 items that focus on feelings of perceived naturalness or apparent reality during the media experience. Participants are asked to indicate their level of agreement with each item on a five-point Likert scale (1–5). This subscale demonstrated acceptable levels of internal reliability in the original samples ($\alpha = .76$) and the current sample ($\alpha = .72$).

5.4.4. Engagement

As a further exploratory measure, the current study uses the subscale of engagement from *The ITC-Sense of Presence Inventory* (ITC-SOPI) (Lessiter et al., 2001). This subscale comprises eight items (five-point Likert scale; 1–5) that focus on feelings of engagement during the media experience and five items that deal with feelings after the media experience. This subscale also demonstrated acceptable levels of internal consistency with the original samples ($\alpha = .89$) and the current sample ($\alpha = .68$).

5.4.5. Enjoyment

While the subscale of engagement offers a measure of participants' psychological activation toward the film experience, it includes numerous items that are neutral, such as "*...my experience was intense*" and items that are positive "*...I enjoyed myself*". By removing the neutral items from this scale, selecting only the positive items, a subscale of enjoyment was constructed. This subscale comprises two items (five-point Likert scale; 1–5) that focus on positive feelings during the media experience and two items that deal with feelings after the media experience. An analysis of internal consistency demonstrated adequate levels of reliability for this new measure in the current sample ($\alpha = .86$).

5.4.6. Disgust sensitivity

To eliminate the possibility that any differences in emotional arousal would be due to differences in disgust sensitivity, participants' disgust sensitivity was measured using *The Disgust Scale-R* (DS-R) (Haidt et al., 1994; Olatunji et al., 2007). The DS-R requires participants to indicate on a 5-point Likert scale (1–5) their level of agreement or their self-reported feelings of disgust towards 25 items from the seven domains of disgust—including food, animals, body products, death, injury/deformity, sex, and moral offence. Higher total scores indicate greater disgust sensitivity. An internal consistency analysis for the modified version yielded an acceptable level of reliability in the original sample ($\alpha = .87$) and the current sample ($\alpha = .83$).

5.5. Controlling novelty

The current study controlled for the potentially confounding novelty of the 3D movie in two ways. Firstly, groups of participants viewed an abridged version of the commercially available 3D movie *Journey to the Centre of the Earth* (Brevig, 2008) at least 24 h before data collection. This session offered an additional opportunity to confirm that the stereoscopic illusion was successful for all participants. It allowed participants to meet the researcher, ask questions, see the room, and it generally served to reduce anxieties about the experience.

Secondly, during the data collection session before participants viewed the emotional test stimuli, they viewed a three minute neutral introductory clip in the appropriate style for each group (either 2D or 3D). This included a narrator's introductory statements, some music, and some colourful images of the jungle. This allowed the participant's physiological arousal for this period to serve as a measure of activation: the physiological arousal that occurs from simply watching any 3D/2D movie. If it is true that the *novelty* of the 3D experience increases arousal, then we would observe greater activation for the 3D group compared to the 2D group.

5.6. Ethics

All participants were informed that, while it was not possible to tell them exactly what they will see (so as to avoid a biased sample of horror-movie fans), they may find the content of the scenes unappealing and that some clips involve violence and injury. This study was approved by the institution's Human Research Ethics Committee.

5.7. Procedure

All of the testing for the current study took place in a mini-3D-cinema on the university campus. The room was equipped with a 5.1 Axiom surround sound system, black-out blinds, and polarised-3D projector equipment. The stimuli were run using stereoscopic player on a Dell computer, which allowed the manipulation of the 2D or 3D format, independent of the sound or other picture settings. The stimuli were projected onto a Stewart front-silver non-depolarizing screen that measured approximately 2.5 m^2 using 2 evo2sx+ projectors. All 3D stimuli were viewed using polarised type 3D glasses to preserve the stimulus colour.

In the data collection session, participants were tested individually, seated in a comfortable chair. All stimuli subtended a visual angle of $\sim 40^\circ$ in width and $\sim 40^\circ$ in height, at a viewing distance of approximately 3 m from the centre of the screen. Participants were fitted with the electrodes of the polygraph machine. Once participants were fitted with the electrodes they were asked to sit still and relax, while the lights were brought down. Next, participants in the 3D group put on their polarised glasses and the movie began. After the activation period, participants watched the disgust scenes for approximately 25 min. Groups of clips that came from the same source film were presented together (to provide some context) in a fixed order and these groups of clips were separated by a black screen and silence (5 s). When the movie had finished, participants immediately completed the questionnaires in an electronic format on a Dell laptop.

6. Results

To calculate participants' physiological activation, the number of heart-beats observed in each participant was recorded for the activation period and for a 3-s comparative period before this (pre-activation). These were then converted to a measure of beats-per-minute (BPM) for the pre-activation and the activation period. For the test phase, the number of heart-beats observed in each participant was recorded for each of the 8 periods of high-emotion, and converted into BPM. In-line with (Hubert and de Jong-Meyer, 1990), for each of the physiological measures (BPM, tonic SCL and skin temperature), an average score was created from responses during the 8 periods of high-emotion. Finally, a baseline score was subtracted from each of these to produce physiological change-scores for heart-rate, skin-conductance level and skin temperature. A three-second period immediately before the first high-emotion clip served as the baseline measure. Means or total scores were calculated for perceived apparent reality, engagement, enjoyment, the DS-R, the DAS and the FAS. Kolmogorov–Smirnov tests of normality were conducted on all the dependent variables and parametric analyses were deemed appropriate for

Table 2
Means (M), standard deviations (SD), *t*-tests, and effect sizes for dependent variables by group.

Dependent variable	*M* (SD)				*t* (df)	Effect size	
	2D		3D			Cohen's *d*	r^2_{pbi}
Physiological change scores							
Heart-rate (BPM)*	−3.17	(9.23)	4.79	(8.87)	−2.28 (25)*	−.88	.16
SCL (μS)	.25	(.70)	.07	(1.4)	.44 (26)	.16	.007
Skin temperature (°C)	.15	(.11)	.11	(.09)	1.01 (26)	.38	.04
Self-report measures							
Disgust (DAS)	3.47	(.69)	3.44	(.53)	.10 (27)	.04	.0004
Fear (FAS)	3.89	(.73)	3.88	(.66)	.03 (27)	.01	.00003
Enjoyment	2.98	(.93)	3.09	(.90)	.76 (27)	−.01	.0036
Manipulation and control							
Perceive apparent reality*	2.56	(.70)	3.01	(.72)	−1.72 (27)*	−.66	.10
Disgust sensitivity (DS-R)	51.53	(12.73)	45.64	(13.1)	1.23 (27)	.47	.05
Engagement	3.48	(.45)	3.43	(.44)	.32 (27)	.12	.004
Age (years)	26.33	(4.12)	28.5	(9.92)	−.78 (27)	−.29	.02
TV viewing (hrs per week)	10.07	(4.38)	9.07	(7.5)	.44 (27)	.16	.007
3D experience	1.33	(.49)	1.29	(.47)	.27 (27)	.08	.002

* Group differences are significant at $p < .05$.
Note: Possible DS-R scores range from 0 to 100. DAS, FAS, Perceive Apparent Reality, Enjoyment and Engagement mean scores range from 1 to 5. 3D experience mean scores range from 0 to 2. In all cases, higher scores are indicative of higher levels of the construct.

all. The alpha level was set to 0.05 for all tests. Descriptive statistics were calculated for all dependent variables (means and standard deviations are presented in Table 2).

Before testing the hypotheses, it was necessary to confirm that the manipulation was successful. To test this, an independent *t*-test was conducted to compare the group scores on the measure of perceived apparent reality (see Table 2 for means and effect sizes). Results showed that the 3D group reported significantly higher levels of perceived apparent reality than the 2D group, $t\ (27) = -1.72$; $p < .05$, $d = -.64$. According to Cohen's (1992) conventional criteria for interpreting effect size, this falls in the medium to large effect size range. Thus participants in the 3D group rated their experience as more perceptually natural or realistic than the 2D group (i.e., closer to a non-mediated experience). Thus, the manipulation was successful.

Next it was necessary to explore the possibility that the groups, while randomly assigned, did not differ in terms of any potential confounding variables. Here, a series of independent *t*-tests confirmed that the groups did not significantly differ in terms of their age, the amount of TV they watch per week or their previous experience with 3D media (see Table 2). In addition, there were no significant group differences in participants' sensitivity to disgust. Therefore disgust sensitivity can be ruled out as a confounding variable and independent *t*-tests were sufficient to test the hypotheses.

6.1. Hypothesis testing

Hypothesis one predicted that, compared to the 2D group, the 3D group would demonstrate significantly greater levels of self-reported feelings disgust and fear. Independent *t*-tests revealed no significant group differences in self-reported level of disgust or fear (see Table 2). Thus, participants in the 3D group did not report experiencing any more feelings of disgust or fear than their 2D counterparts. An independent *t*-test also identified no significant group differences in self-reported enjoyment of the experience (see Table 2).

Next, we tested hypotheses two, which predicted a higher level of emotion in the 3D group than the 2D group when operationalised by the physiological measures of autonomic arousal. Independent *t*-tests revealed no significant group differences in participants' tonic skin conductance level or their skin temperature. However, a significant group difference was observed for the HR data. The 3D group showed significantly higher HR than the 2D while watching the films, $t\,(25) = -2.28$; $p < .05$, $d = -.88$. Once again, this falls within the medium to large effect size range (Cohen, 1992). We note that the 2D group demonstrated a negative mean HR change score. This indicates that the HR of participants in the 2D group was higher at baseline than during the high emotion periods of the film clips, while the participants in the 3D group showed a significant increase in HR from baseline.

Having observed significant differences in the groups' HR, it was necessary to control for the possibility that 3D movies may bring about group differences in HR simply because they are more novel. To test this hypothesis a 2 (group) by 2 (time: pre-activation and activation) mixed-measures ANOVA (repeated on the second factor) was conducted using participants' HR data. No significant interaction was observed between group and time, $F\ (1, 25) = .028$; $p > .05$, $\eta_p^2 = .001$. This means that any changes that might have occurred in participants' HR from baseline to activation occurred independently of the group to which they were assigned. However, the same was observed for any changes that might have occurred from activation to test phase, $F\ (1, 25) = 1.97$; $p > .05$, $\eta_p^2 = .073$. This identifies the possibility that activation scores might play a role in the observed differences in HR. For this reason, group differences were reinvestigated using ANCOVA with HR activation scores as a potential covariate. This test did not identify activation as a significant covariate, and the same significant group differences in HR were evident when activation was controlled, $F\ (1, 24) = 4.96$; $p < .05$, $\eta_p^2 = .171$—demonstrating that the higher HR for the 3D group is present, even when the variance that is associated with simply watching a 3D movie is removed. An independent *t*-test further supported this finding by demonstrating that there were no significant group differences in participant's reported engagement with the experience (see Table 2).

7. Discussion

The current study asks whether increased perceptual reality in film is associated with higher levels of emotional arousal. The effect of stereoscopic depth on both self-report and physiological measures of emotional arousal was explored, while controlling for participants' emotional sensitivity and the novelty of the experience.

We tested first to determine whether the manipulation of the visual realness of the experience was successful. The current study identified group differences with the participants in the 3D group reporting their experience to be more perceptually realistic or natural. This suggests that participants in the 3D group were less aware that they were viewing their experience through a medium, that is, on a screen.

Was this increased perceived apparent reality associated with greater emotion towards the films? While there were no group differences in the participants' skin conductance or temperature, the 3D group presented a significantly higher heart-rate than the 2D group. More specifically, the 3D group presented an increase in heart-rate when compared to the baseline, whereas the 2D group experienced a decrease in their heart-rate.

So how can we explain the increased HR with the 3D group? Bradley et al. (2001) propose a two factor model of emotion, involving arousal and valence. They propose that measures of SC track arousal (activation), while HR is thought to track valence (direction of activation). Using this model, we might interpret the current results as indicative of differences in valence but not arousal. In other words, it is possible that 2D and 3D were experienced as equally arousing (no SC effect), whereas the HR acceleration may indicate a positive valence of 3D compared to 2D presentation. Thus, both groups experienced the same level of activation, but the 3D condition was experienced as more positive. Perhaps the 3D condition outperformed the 2D version for its paradoxically entertaining horror content. However, it is important to note that the current study reported no group differences in self-reported enjoyment of the experience.

A further interpretation is also possible. As mentioned earlier, SCL is solely controlled by the SNS, whereas there is a dual contribution of the SNS and PSNS on HR function (Ravaja, 2004). Lang et al. (1997) point out that a deceleration in heart-rate when presented with emotional stimuli occurs due to a dominant PSNS influence. They also point out that under certain conditions, the SNS can become more dominant. The current study showed no group differences in skin conductance, which acts as an index of SNS activity, thus the observed group differences in heart-rate are likely to stem from differences in PSNS activity rather than SNS activity. As PSNS activation has been associated with emotion regulation and attentional processes (Porges, 1995; Thayer and Friedman, 2000; Thayer and Lane, 2000) we might propose that the increased HR of the 3D group represents a *lower* PSNS activation compared to the 2D group. In other words, the 3D group showed lower HR *regulation* than the 2D group.

PSNS activity has been associated with cognitive activity such as attention and emotional regulation, and Tan (2008) proposes that attention plays a crucial role in emotion regulation. He proposes that a viewer regulates his/her emotion by attending to the fictional aspects of the experience and this is supported by empirical research (Speisman et al., 1964). In addition, Tan proposes that if an experience is more realistic, the viewer becomes less motivated to attend to the executive space. These ideas are also in-line with Visch et al. (2010), who conclude that increasing the immersiveness of a mediated experience might be related to a decreased ability to regulate emotion.

With these ideas in mind, one might interpret the above results as follows. Both groups may have been susceptible to an equal level of SNS activity and emotional arousal, demonstrated by their similar SCL. But participants in the 3D group were less able (or less inclined) to employ such techniques of emotional regulation due to their reduced attention to the mediated nature of the experience (i.e., higher perceived apparent reality). Thus the 3D group experienced more apparent reality and so cognitive regulation was reduced. The reduced emotional regulation would be associated with decreased PSNS activity and accordingly produce a higher HR in the 3D group when compared to the 2D group. However, it must be emphasised, the current study did not control for participants' techniques of emotional regulation.

It might seem intuitive that the 3D experience reduced participants' awareness of the medium (screen)—which, in turn, increased the apparent reality of their experience, and subsequently inhibited the regulation of their feelings of disgust or fear. It would, however, be inappropriate to assume causation from the identified association between perceived apparent reality and emotional regulation. Alternatively, it is possible that the sense of depth affected participants' autonomic arousal, and it was these feelings that disposed the 3D group to rate their experience as more similar to a non-mediated experience.

There is evidence to support this idea. Neurological research has pointed towards a system for unconscious processing of spatial information, before conscious recognition occurs (Goodale and Humphrey, 1998; Goodale and Milner, 1992; Köhler and Moscovitch, 1997). In addition, research supports the idea that neurophysiological responses to emotional stimuli occur prior to cognitive awareness (Whalen et al., 1998). This is complemented by behavioural evidence that supports cognitive appraisal and component process theories of emotion. These state that we feel physiological arousal prior to the emotional labels that we assign to those experiences (Schachter and Singer, 1962; Scherer, 2009). Further evidence suggests that these emotions then influence processing, appraisals or beliefs about an experience (Forgas, 1995, 1999; Prentice and Gerrig, 1999). It is possible that participants in the 3D condition physiologically responded to the feelings of space, depth and movement rather than a more cognitive *evaluation* of how realistic the experience was. This interpretation might also be in-line with Grodal's (2009) PECMA model that proposes that films activate a neurological "embodied simulation".

The idea that our physiological responses play a role in our subsequent appraisal of the experience is in-line with Konijn et al.'s (2009) interpretation of their findings. They report that participants who feel stronger emotional responses while watching a film, in turn evaluate their experience as more realistic or natural. We suggest that this might be due to a combination of increased perceptual "realness" (stereoscopic depth) *and* decreased emotional regulation. This suggestion is also in-line with Tan's (2008) dual awareness model, which proposes that the associated emotions and the feelings of being drawn in to a film are mutually sustaining.

7.1. Limitations and future directions

The current study is exploratory and limited in focus. It investigated the connection between a film's stereoscopic depth and emotional arousal. By using stimuli that were chosen to elicit disgust (and fear) the generalisability of findings may be restricted. Especially, given the previously reported interaction between the type (and intensity) of emotion elicited by a stimulus and the corresponding autonomic arousal (Bradley et al., 1993; Hamm et al., 1997; Klorman et al., 1977; Lang et al., 1997, 1995). Yet, even with such restrictions, this study offers an encouraging step towards further questions and answers.

The current interpretation is that increased realism is not directly associated with emotional arousal, but instead, it is associated with a reduced ability to regulate such emotional arousal. If this is so, then we would still expect the end result, the overall emotional experience, to be greater for those with reduced emotional regulation. Perhaps surprising is the fact that the current study observed no group differences in self-reported negative emotion (disgust or fear). While this may be attributed to the modest sample size of the current study and its reduced power to detect differences, it is also possible that this reflects the problems with self-report measures to which previous research has referred (Baños et al., 2004; Freeman et al., 2000; Meehan et al., 2005). For example, participants were asked to rate how disgusted they were by the film clips, on a scale from 1 to 5. Using the between groups design, there is ambiguity around the participants' frame of reference for those ratings. In addition, participants were asked only to consider the questions after viewing, so they are reporting from their memory of the experience. For these reasons, real-time physiological measures of autonomic arousal might be more reliable.

The current study presents evidence that adding dimensions to a film's apparent reality can increase emotional arousal, but it did not provide evidence that the 3D experience was more enjoyable. This finding is supported by Takatalo et al. (2011) who reported that adding stereoscopy to a digital video game did not improve the user's reported experience. Previous theory and research makes emotional arousal a central function of film entertainment (de Wied et al., 1994; Izod, 2000; Tan, 2008; Zillmann and Vorderer, 2000), suggesting that a good film is one that prompts strong emotional arousal. However, there is evidence that films involving disgust and violence are less enjoyable when they are framed as non-fiction, and so the viewer believes they are watching something disgusting that really happened (McCauley, 1998). Therefore, increasing the film's apparent reality might only be enjoyable for certain types of films.

Future research would benefit by further exploring how the increased apparent reality and its relationship with emotional arousal might interact with viewers' enjoyment of the experience. It is also advised that researchers use mixed measures to operationalise emotions or feelings of apparent reality and that researchers incorporate some level of control over the emotion regulation techniques that participants might employ.

8. Conclusion

The current study set out to explore how the use of stereoscopic depth (increasing the illusion of non-mediated reality) in emotional movie scenes affects participants' emotional arousal, specifically disgust and fear. Watching films in 3D produces significantly higher levels of perceived naturalness and an increased heart-rate in viewers. These differences cannot be attributed to group differences in emotional sensitivity, engagement, or to the novelty of the 3D effect. Thus we propose that suspension of disbelief is further assisted by stereoscopic depth, with associated increases in reported perceived apparent reality and in heart-rate, as an index of emotional regulation.

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