Perception of psychopathy and the Uncanny Valley in virtual characters

Angela Tinwell a,⇑, Deborah Abdel Nabi b, John P. Charlton b

⇑ Faculty of Media, Arts and Technology, The University of Bolton, Deane Road, Bolton, BL3 5AB, United Kingdom
⇑ Faculty of Well-Being and Social Sciences, The University of Bolton, Deane Road, Bolton, BL3 5AB, United Kingdom

A R T I C L E   I N F O

Article history:
Available online 5 March 2013

Keywords:
Uncanny Valley
Facial expression
Psychopathy
Emotion
Characters
Realism
Video games

A B S T R A C T

Virtual characters with a realistic, human-like appearance are increasingly being used in video games and animation. However, increased realism does not necessarily imply increased acceptance and factors such as aberrant facial expression may evoke the Uncanny Valley phenomenon. In humans, personality traits such as anger, callousness, coldness, dominance, being unconcerned, and untrustworthiness are associated with psychopathy; a visual facial marker of this condition being a lack of visible response in the eye region to emotive situations. As such, the present study investigated if inadequate upper facial animation in human-like virtual characters evoked the uncanny due to a perception of psychopathic traits within a character. The results revealed that virtual characters that showed a lack of a startle response to a scream sound were regarded as most uncanny and perceptions of personality traits associated with psychopathy were a strong predictor of reported uncanniness but, that other negative personality traits not associated with psychopathy were not. The study presents possible psychological drivers of uncanniness to inform designers why a lack of detail in a character’s upper face when portraying a startle response may evoke perception of specific negative personality traits in a character, to help control the uncanny in character design.

© 2013 Elsevier Ltd. All rights reserved.

1. Introduction

Recent empirical investigation into the Uncanny Valley in synthetic agents has helped elucidate factors which may exaggerate the uncanny. Tinwell, Grimshaw, and Williams (2011a) revealed that some facial expressions of emotion are more prone to perception of uncanniness than others. Specifically, viewers are especially sensitive to uncanniness in realistic, human-like, male characters presenting the emotions fear and surprise when the uncanny is exaggerated by eliminating movement (and therefore emotional expressivity) in the character’s upper face including the eyelids, eyebrows and forehead (Tinwell, Grimshaw, Williams, & Abdel Nabi, 2011b).

While the study by Tinwell et al. (2011a, 2011b) successfully investigated how aspects of a character’s appearance may be manipulated to reduce the uncanny for empathetic characters (or to enhance the uncanny for antipathetic characters intended to be frightening), the possible psychological processes driving the uncanny response were not empirically examined. The present study sought to replicate Tinwell et al.’s findings for male characters and tested whether it generalized to female characters too. It then moved onto investigate some of the psychological processes that may drive the uncanny response by exploring if inadequate upper facial animation (i.e., lack of upper facial emotional expressivity) leads to the perception of a particular type of negative personality traits in virtual characters, psychopathy, and whether it is this which elicits an uncanny response in viewers. The findings from this study may be used to inform character designers in video games and animation and elucidate how, and importantly why, a lack of detail in the upper face region in particular contexts may evoke perception of specific negative personality traits in a character. Furthermore, it may help towards building a conceptual framework of the uncanny in virtual characters to help us better understand which factors contribute to the uncanny, and how it may be controlled in character design.

1.1. The Uncanny Valley

The concept of the uncanny was first proposed in psychological writings of the early twentieth century as a way to explain why some objects may appear strange or eerie to a viewer. For example, the psychologist Jentsch (1906) suggested that life-like wax-work dolls and automata are often regarded as frightening because the viewer cannot distinguish if the object is real or unreal and that this indecision constitutes “uncanniness”. In 1919, Freud offered an alternative perspective by theorizing that the uncanny occurred when objects or situations evoke a sinister revelation of that which
is normally concealed from human experience and should, for psychological health and ego stability purposes, remain out of conscious awareness.

Given that Jentsch’s examples of uncanny objects included automatons, it is understandable that in more recent times human experience of uncanniness in response to robots has been investigated. In a seminal study, the roboticist Marashiro Mori (2012) explored human reaction to human-like robots and drafted a graph to demonstrate the relationship between experience of the uncanny and increasing human-likeness in a robot’s appearance (see Fig. 1). Mori originally used the Japanese neologism Shinwa-kan as a measure of perceived uncanniness that has since been translated in English as one’s “affinity” towards a given object (see MacDorman & Kageki, 2012; also, Bartneck, Kanda, Ishiguro, & Hagita, 2009; Ho & MacDorman, 2010).

As Fig. 1 shows, unlike robots with a traditionally mechanical appearance, the level of affinity towards human-like robots drops sharply at a point where the robot appears close to, but not quite, authentically human-like. The incongruence between a robot’s behavior and their human-like, physical appearance caused a negative affective response in the viewer, thus creating a valley shaped dip in the otherwise linear relationship between perceived affinity and human-likeness (see Fig. 1). Furthermore, the effect of object movement would amplify the uncanny effect for the viewer. Rather than just one particular factor such as facial expression (Tinwell et al., 2011a, 2011b), it has been suggested that multiple factors may contribute to uncanniness, especially so with animated characters (Hanson, 2006; Pollick, 2010). For example, a perception of jerky or unnatural movement (MacDorman, Coram, Ho, & Patel, 2010) may exaggerate the uncanny as might perception of a lack of synchronization of lip movement with speech (Tinwell, Grimshaw, & Williams, 2010). This line of investigation follows the work of previous authors who have put forward a range of explanations as to why we experience the uncanny including whether it may be an instinctive reaction to a perception of potential danger.

1.2. Explanations of the Uncanny Valley

In an attempt to understand and explain the Uncanny Valley, in his original paper Mori (2012) reflected on issues related to its function:

Why were we equipped with this eerie sensation? Is it essential for human beings? I have not yet considered these questions deeply, but I have no doubt it is an integral part of our instinct for self-preservation. (Note: The sense of eeriness is probably a form of instinct that protects us from proximal, rather than distal, sources of danger. Proximal sources of danger include corpses, members of different species, and other entities we can closely approach. Distal sources of danger include windstorms and floods.) (Mori, 2012, p. 3).

Mori (2012) postulated that experience of the uncanny in almost, fully human-like characters may serve as a reminder of one’s own death and the resulting feelings of dread, a supposition prompted by the fact that corpses and human-like robots possess a physical human appearance but show no behavioral fidelity. Building on Mori’s (2012) explanation that the Uncanny Valley may be in response to a proximate threat of danger, Kang (2009) later theorized that the uncanny was caused when a man-made object, such as a robot, is regarded as a threat to the viewer; something that intends to, or has the potential to cause harm. If the human is unquestionably of higher stature and in control, then there is little or no threat. In this way, characters such as “Pinocchio” or “Shrek” may be regarded as cute and comical. However, we may judge ourselves as having less (or no) control over other man-made objects such as powerful androids or highly human-like virtual characters which may be more dominant and, thus, a greater threat.

Lewkowicz and Ghazanfar (2012) suggested that perception of the uncanny is not innate but a developmental phenomenon that relies on early perceptual experience of typical human facial expression; hence, the psychological substrates of uncanniness may be related to the adequate development of the skills required for adaptive interpersonal and social functioning.

1.3. Uncanny facial expression of emotion in virtual characters

More recently, due to advances in digital technology for simulating realism, viewers have reported similar uncanny experiences in response to realistic, human-like virtual characters featured in animations and video games (see e.g. Brenton, Gilies, Ballin, & Chatting, 2005; Doerr, 2007; Geller, 2008; Green, MacDorman, Ho, & Vasudevan, 2008; Ho & MacDorman, 2010; Hoggins, 2010; MacDorman, Green, Ho, & Koch, 2009; Rose, 2011; Tinwell et al., 2011a, 2011b). Video game designers (working in genres such as action games and role-playing games) perceive an increased aesthetic realism as highly desirable as this may allow viewers to better appreciate the emotional state of characters, leading to a heightened state of engagement with that character and immersion in the game (Doerr, 2007; Hoggins, 2010; Ravaja, Turpeinen, Saari, Puttonen, & Keltikangas-Järvinen, 2008). However, criticism has been leveled at this approach based on the inability of such characters to reliably, clearly communicate their emotional state to the viewer (Crigger, 2010; Doerr, 2007; Rose, 2011), possibly due to the technological challenges of achieving this.

For scenes involving full motion video (FMV) in video games, such as pre-recorded trailers and cut scenes, motion capture techniques are combined with post-production editing in 3D software to create a character’s facial expression. This process allows for the recording of high fidelity facial expression of emotion from a human that is then modeled to a 3D character. Designers may then use a key-framing technique to edit individual frames of existing motion capture data to attempt to make the character’s facial expression as realistic and accurate as possible and appropriate to the given context of the game. However, this process cannot be used for footage generated in real-time and, instead, automated and/or procedural generation techniques are used to generate a character’s facial expression. These automated techniques may

Fig. 1. Mori’s plot of perceived familiarity against human-likeness depicting the Uncanny Valley (taken from a translation by MacDorman and Kageki of Mori’s “The Uncanny Valley”).

A. Tinwell et al. / Computers in Human Behavior 29 (2013) 1617–1625
not be as accurate as those used in pre-recorded FMV, nor do they always convey an appropriate facial expression for the character given the context and character's state in-game.

Even though advances in technology are increasingly allowing for greater detail in motion capture data and automated animation techniques when generating facial expression of emotion (both in pre-recorded and real-time footage), there is general agreement that, largely, such performances fall short of being perceived as authentically real and fail to cause suspension of disbelief in the viewer (Brenton et al., 2005; Doerr, 2007; Geller, 2008; Ho & MacDorman, 2010; Hoggins, 2010; MacDorman et al., 2010; Pollick, 2010; Rose, 2011; Tinwell et al., 2010; Wang, Han, & Soong, 2012). One such example can be found in the cinematic, drama-type game *Heavy Rain* (Quantic Dream, 2010). The designers anticipated that increased realism in the appearance and performance of characters would evoke heightened emotional contagion in the player, increasing their participation with the story (Doerr, 2007). However, the inadequately detailed, (essentially aberrant) facial expression of the main character, Ethan Mars, who was intended to be regarded as empathetic, was reported as awkward and bizarre with a glazed-over look. This left some players uninspired and disengaged with the game as they failed to make a “meaningful connection” (Chick, 2011, p. 1) with this character due to his strange facial expression and inanimate eyes (see also, Hoggins, 2010; Lui, 2011). Similarly, female empathetic video game characters, such as Naomi from the game *King Kong* (Ubisoft Entertainment, 2005); Sydney Bristow from the game *Alias* (Acclaim Entertainment, 2004) have failed to achieve the desired positive viewer response, instead being described as “monsters” with “dead eyes” comparable to the zombie characters that they are fighting (Thompson, 2004, 2005).

Of particular importance to the present study, previous research has revealed that those with psychopathic traits generally demonstrate a lack of a startle reflex that includes a widening of the eyes and raising of the eyebrows and forehead in response to frightening or shocking/surprising stimuli (Benning, Patrick, & Iacono, 2005; Herpertz et al., 2001; Justus & Finn, 2007; Patrick, Bradley, & Lang, 1993). Those not diagnosed with psychopathy would typically show a startle reflex in such circumstances (Benning et al., 2005; Herpertz et al., 2001; Justus & Finn, 2007). Given that Tinwell et al. (2011a, 2011b) identified that perception of uncanniness was particularly strong in a character when communicating the emotions fear and surprise with a lack of movement in the eyelids, eyebrows and forehead, we suggest that the lack of upper facial movement during facial expression of these emotions may be perceived by the viewer as a physiognomic marker of a lack of startle response and possible psychopathic behavior. Furthermore, we suggest that it is this appraisal and judgment that contributes to the associated uncanny experience. We put forward the notion that it is perception of psychopathic traits in such characters that is a possible psychological contributor to experience of the uncanny.

To test the above idea, participants rated videos of: (1) humans (labeled human); (2) fully animated characters, (labeled virtual full) and; (3) characters with a lack of upper facial movement (labeled virtual lack); for perceived uncanniness, and personality traits associated with psychopathy. We manipulated a lack of movement in the upper face region including the eye lids, eye brows and forehead, for characters in the experimental virtual lack condition based on the following criteria: firstly, the previous study by Tinwell et al. (2011a, 2011b) had identified that perception of the uncanny was strongest in male virtual characters presenting the emotions fear and surprise when movement had been disabled in the upper face region (including the eye lids, eye brows and forehead). Moreover, previous empirical evidence (see e.g. Benning et al., 2005; Herpertz et al., 2001; Justus & Finn, 2007; Patrick et al., 1993) has revealed that in humans, a lack of movement in the upper face in response to a frightening or surprising stimulus can be a visual marker of an individual with psychopathic traits (a formal diagnosis of which is Anti-Social Personality Disorder (ASPD) Hare, Hart, & Harpur, 1991). While the author’s acknowledge that other aspects of a character’s behavior and appearance may contribute to perception of the uncanny (for example, if the character is perceived to have jerky, automated movement (MacDorman et al., 2010), or if they may have a lack of synchronization between their lip movement with speech (Tinwell et al., 2010)) this particular facial manipulation for virtual lack characters facilitated a fundamental investigative aim of the present study; that is, it might trigger perception of possible anti-social, perhaps psychopathic traits, in virtual characters with a human-like appearance.

In order to determine if it is perception of, specifically, psychopathic personality traits that contribute to the uncanny experience, the present study also examined whether other negative affective personality traits, such as depression or anxiety, conditions associated with psychopathy, are also predictive of perceived uncanniness. Startled facial expressions were presented by both male and female characters to test generalizability across character gender for all character types (human, virtual full, and virtual lack). In order to promote viewer expectation of a startled response in characters, the sound of a female human scream preceded each character presentation1. Based on the previously presented reasoning and findings, the following hypotheses were formulated:

H1. Character type: The human group will be rated as least uncanny; the fully animated virtual characters rated second highest for uncanniness; and those characters with a lack of upper facial animation rated as most uncanny. This pattern will be the same across both character genders.

H2. Personality Type: Detection of personality traits associated with psychopathy (evidenced by a character’s psychopathy rating), will be a stronger predictor of its uncanniness rating than ratings of negative non-psychopathic personality traits across all groups.

2. Method

2.1. Design

To consider the hypothesis concerning the effects of character type on uncanniness (H1), a $3 \times 2$ repeated measures design was implemented. The two factors were character type (human vs. virtual full vs. virtual lack) and character gender (male vs. female). Each character stimulus possessed a unique combination of the aforementioned characteristics, with all possible combinations of characteristics occurring across six stimuli. All stimuli were presented in random order. Participants rated each of the stimuli for uncanniness.

To test the hypothesis concerning perceived personality characteristics as drivers of uncanniness (H2), participants provided ratings of perceived psychopathic personality traits and negative non-psychopathic personality traits in response to each of the six stimuli. These personality ratings were used as predictors of uncanniness ratings in six standard (i.e. single stage) multiple regression analyses (one for each stimulus).

2.2. Participants

There were 205 participants (96 females and 109 males) with a mean age of 22.5 years ($SD = 7.51$ years). Participants were mostly

---

1 Sound prime and subsequent facial expressions were designed to be consistently congruent.
undergraduate students with 43.85% recruited from the Faculty of Well Being & Social Sciences and 40.64% recruited from the Faculty of Arts and Media Technologies at the University of Bolton. The remaining 15.51% were postgraduate research students and academic staff from the areas of psychology and computing at the university.

2.3. Human and virtual character stimuli

A Panasonic (AG-HMC/50P), portable, high definition video camera was used in a production studio at The University of Bolton to take video recordings of a male and female actor for the human character group. The actors were instructed to present a startled facial expression in response to a pre-recorded human female scream sound. The sound file was exported from the video game Half-Life 2 (Valve, 2008) as a Wave Sound file (.wav) using the Source SDK video game engine (Valve, 2008).

For the virtual full character group, Flex Animation tools within the facial animation software FacePoser (Valve, 2008) were used to replicate the facial expression of the male actor onto a male virtual character (named “Barney”) and the facial expression of the female actor onto a female virtual character (named “Alyx”). Barney and Alyx were protagonist characters with a realistic human-like appearance selected from the video game Half-Life 2 (Valve, 2008) as a Wave Sound file (.wav) using the Source SDK video game engine (Valve, 2008).

Movement in the virtual characters’ eyelids, eyebrows and forehead was then disabled, to create the two videos with partial facial animation for the virtual lack characters. Adobe Premiere CS3 was then used to embed the sound file (“scream.wav”) into each of the six videos and then edit and export the audio and video footage. The videos were: Standard PAL video (4:3 interlaced), 48 kHz (16 bit) audio, 25 frames/s, and all of a 4 s duration.

2.4. Procedure and measures

The experiment was conducted as a web-based survey with all videos of actors and characters and rating questions played in a random order for each participant. Participants were shown a video clip and, for each, asked if they agreed with given statements from 1 (Strongly Disagree) to 5 (Strongly Agree) for each of the following 18 items:

(i) Six items from scales used to measure the uncanny in synthetic agents. The items used included: eerie (Ho & MacDorman, 2010), nonhuman-like (Mori, 2012; Bartneck et al., 2009; Ho & MacDorman, 2010), repulsive, unattractive, (Ho & MacDorman, 2010), unlikeable, and unresponsive (Bartneck et al., 2009).

(ii) Six personality traits from the Elemental Psychopathy Assessment (EPA) (a self-report inventory for assessment of psychopathy based on the five-factor model of personality traits by Lynam et al., 2011). Traits used for rating comprised: angry, cold personality, dominant, uncer- tain, and untrustworthy.

(iii) Six personality traits from the NEO Neuroticism Facet Scale (Costa & McCrae, 1992) that are not associated with psychopathy: anxiety, shame, depression, hopelessness, nervousness, and self-consciousness.

In selecting the six variables for each of the above three measures, we first looked at indices in new scales used to describe Shinya-kan (Bartneck et al., 2009; Ho & MacDorman, 2010) and then selected items that are commonly used to describe experience of the uncanny in human-like virtual characters (see e.g. Doerr, 2007; Geller, 2008; Rose, 2011). Items were then selected from the EPA (Lynam et al., 2011) that are acknowledged as central, common features of psychopathy in an individual (Hare, 1991) and, might be salient and observable via facial expression and with only a passing, transient encounter. Items were then selected from the NEO Neuroticism Facet Scale (Costa & McCrae, 1992) that represented negative affective states but did not constitute any of the diagnostic criteria for psychopathy.

Given that the auditory prime (a scream sound) used in our study was contextualized as an “alarming sound that may startle a listener”, participants may have expected the startled facial expression of the character to represent either fear or surprise.

Although emotion recognition was not the main focus of this study, emotion recognition rates were calculated for the six stimuli to assess which emotion was detected by participants in the videos (see Table 1). To achieve this, for each video, participants were also asked to select which facial expression best described the character’s reaction to the sound from: (a) anger, (b) disgust, (c) fear, (d) happiness, (e) sad- ness, (f) surprise, and (g) neutral.

The majority of participants recognized either fear or surprise in the characters with a combined recognition rate for these two emotions of 97.07% for the male human, 90.73% for the female human, 91.71% for the male virtual full, and 93.17% for the female virtual full characters. For the male and female characters with a lack of upper facial animation, the combined recognition rates for fear and surprise were lower (62.75% and 70.24%, respectively). These latter findings may be expected given the noted importance of nonverbal communication in the upper facial region when communicating fear or surprise (Ekman, 1979, 2004; Ekman & Friesen, 1969, 1978; Tinwell et al., 2011a, 2011b). Despite a lower recognition rate of fear or surprise for characters in the virtual lack condition, this does not detract from our aim to demonstrate that perceived psychopathy is associated with uncanniness; on the contrary, as has been discussed psychopaths are likely to show a lack of fearful or surprised emotional responsiveness (a startle reflex) to shocking stimuli. Given this, failure of participants to easily distinguish such lends support to the decision to disable movement in

<table>
<thead>
<tr>
<th>Percentage accuracy ratings for emotion recognition of fear, in the three conditions across both character genders (N = 205).</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Emotion</strong></td>
</tr>
<tr>
<td>---------------</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Anger</strong></td>
</tr>
<tr>
<td><strong>Disgust</strong></td>
</tr>
<tr>
<td><strong>Fear</strong></td>
</tr>
<tr>
<td><strong>Happiness</strong></td>
</tr>
<tr>
<td><strong>Sadness</strong></td>
</tr>
<tr>
<td><strong>Surprise</strong></td>
</tr>
<tr>
<td><strong>Neutral</strong></td>
</tr>
</tbody>
</table>

Table 1
the upper face for this (intentionally uncanny) experimental condition.

Cronbach’s alpha coefficients for the three rating measures for each of the six stimulus characters are provided in Table 2. From this table it can be seen that, apart from the coefficients for perceptions of negative non-psychopathic traits of the male and female human characters, all coefficients were above the .70 acceptable minimum. Subsequently, composite measures for psychopathic personality traits, non-psychopathic personality traits and uncanniness were obtained by computing mean ratings across the six items measuring each construct, leading to minimum and maximum possible mean scores of 1 and 5 respectively for each measure.

### 3. Results

#### 3.1. The effect of character type and character gender on uncanniness

To test the hypothesis that virtual lack characters would be rated as most uncanny, followed by virtual full characters and then human characters (H1), a two factor 3 × 2 repeated measures ANOVA was conducted with character type (levels = human vs. virtual full vs. virtual lack) and character gender (male vs. female) as independent variables, and uncanniness rating as the dependent variable. Mauchly’s test of sphericity was significant for character type and the character type by character gender interaction (p < .001 and p = .012 respectively). Because Greenhouse–Geisser estimates were greater than .75 in both of the aforementioned instances, the Huynh–Feldt correction to degrees of freedom was applied in the relevant ANOVA F-tests (Girden, 1992). In reporting these corrections, degrees of freedom are rounded to whole numbers.

The ANOVA (N = 205) showed significant main effects for character type F (2, 381) = 185.53, p < .001, partial η² = .476, and character gender F (1, 204) = 33.49, p < .001, partial η² = .141. Also, the interaction between the two factors was significant, F (2, 395) = 3.51, p = .032, partial η² = .017. With respect to the main effect for character type, using Bonferroni adjustments for multiple comparisons of estimated marginal means, there were significant differences with respect to all pairwise comparisons (p < .001 in all cases), with perceived uncanniness being the greatest for virtual lack (M = 2.99, SE = .05), followed by virtual full (M = 2.62, SE = .04), and human being the least uncanny (M = 2.11, SE = .03). These results supported H1 which predicted these differences. Comparison of estimated marginal means for character gender showed that male characters (M = 2.66, SE = .04) were perceived as significantly more uncanny than female characters (M = 2.48, SE = .03).

#### 3.2. The effect of character type and character gender on personality traits

To interpret the significant interaction, (because comparisons across levels of character type had the greatest relevance as to whether any caveats should be added to the acceptance of H1, initially), one-way ANOVAs were performed to analyze simple effects for each character gender. However, subsequent to obtaining significant main effects for character type in both the analysis for male characters and the analysis for female characters, with Bonferroni corrections, all pairwise comparisons of means were significant for both character genders. While, these results are not reported in full in the interests of brevity, it can be concluded that the significant character type by character gender interaction in the initial two-way ANOVA was of little importance with respect to the acceptance of H1. Nevertheless, in a further attempt to explain the interaction, three paired-samples t-tests with Bonferroni corrections (α = .05/3 = .017) were performed to compare means for character gender across the three levels of character type. These two-tailed tests showed significant differences across character gender for human characters, t (204) = 5.11, p < .001, and virtual full characters, t (204) = 5.10, p < .001, but not virtual lack characters, t (204) = 2.02, p = .045. From the means in Table 3 it is evident that these results show that uncanniness was greater for male characters than female characters for all three character types, but that this difference was significant for human and virtual full characters but not virtual lack characters, thus explaining the interaction in the initial two-way ANOVA.

---

**Table 2**

<table>
<thead>
<tr>
<th>Character gender</th>
<th>Scale</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Psychopathic personality</td>
<td>Non-psychopathic personality</td>
<td>Uncanniness</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>M</td>
<td>F</td>
<td>M</td>
<td>F</td>
<td>M</td>
</tr>
<tr>
<td>Character type</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Human</td>
<td>.78</td>
<td>.77</td>
<td>.63</td>
<td>.61</td>
<td>.74</td>
</tr>
<tr>
<td>Virtual full</td>
<td>.75</td>
<td>.77</td>
<td>.71</td>
<td>.72</td>
<td>.80</td>
</tr>
<tr>
<td>Virtual lack</td>
<td>.78</td>
<td>.76</td>
<td>.71</td>
<td>.80</td>
<td>.80</td>
</tr>
</tbody>
</table>

---

**Table 3**

<table>
<thead>
<tr>
<th>Character gender</th>
<th>Male</th>
<th>Female</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N²</td>
<td>M</td>
<td>SD</td>
<td>N²</td>
</tr>
<tr>
<td>Human</td>
<td>200</td>
<td>2.16</td>
<td>.54</td>
<td>201</td>
</tr>
<tr>
<td>Psychopathic traits</td>
<td>200</td>
<td>2.70</td>
<td>.54</td>
<td>201</td>
</tr>
<tr>
<td>Uncanniness</td>
<td>200</td>
<td>2.20</td>
<td>.52</td>
<td>201</td>
</tr>
<tr>
<td>Virtual full</td>
<td>203</td>
<td>2.29</td>
<td>.51</td>
<td>202</td>
</tr>
<tr>
<td>Psychopathic traits</td>
<td>203</td>
<td>2.85</td>
<td>.59</td>
<td>202</td>
</tr>
<tr>
<td>Uncanniness</td>
<td>203</td>
<td>2.74</td>
<td>.66</td>
<td>202</td>
</tr>
<tr>
<td>Virtual lack</td>
<td>204</td>
<td>2.63</td>
<td>.62</td>
<td>203</td>
</tr>
<tr>
<td>Psychopathic traits</td>
<td>204</td>
<td>2.62</td>
<td>.58</td>
<td>203</td>
</tr>
<tr>
<td>Uncanniness</td>
<td>204</td>
<td>3.03</td>
<td>.72</td>
<td>203</td>
</tr>
</tbody>
</table>

---

2 An initial analysis in which participant gender was included as a third factor revealed a non-significant main effect and no significant interactions involving participant gender. Therefore this factor was excluded from the analyses reported.

3 Huynh–Feldt correction to degrees of freedom.

4 Because of the breaches of the sphericity assumption in the two-way ANOVA, pooled error terms were not used when testing these simple effects (Howell, 2007).
resulted in the same conclusions as the presently reported analyses.

predictor variables and correlated errors for the uncanniness variables, these analyses of 10:1 (Ullman, 2001). For example, ratios in two path analyses for male and female parameters ratios in path analyses were lower than the normally recommended ratio and non-psychopathic traits’ relationships with uncanniness.

3.2. The effect of perceived personality traits (psychopathic vs. non-psychopathic negative traits) on uncanniness

To test whether perception of psychopathic personality traits in a character is a stronger predictor of uncanniness than perception of other negative non-psychopathic personality traits (H2), and whether this differs across character type and character gender, six standard (single stage) multiple regression analyses were conducted with psychopathic personality traits and non-psychopathic personality trait variables as possible predictors of uncanniness ratings5. Descriptive statistics for all character type and character gender combinations involved in the analyses are shown in Table 3.

Table 4 gives Pearson’s r correlation coefficients and tests of the differences in the size of these coefficients for the psychopathic traits – uncanniness and non-psychopathic traits – uncanniness relationships. From the table it can be seen that in all instances psychopathic traits were significantly positively correlated with uncanniness, but, for the non-psychopathic traits, in two instances this was not the case. Also, and supporting H2, for all character type/character gender combinations, coefficients for relationships between psychopathic traits and uncanniness were significantly greater than those for relationships between non-psychopathic traits and uncanniness. Finally, it is interesting to note that the two types of personality trait were significantly positively correlated for all characters.

The regression statistics in Table 5 show that perception of psychopathic personality traits was a significant predictor of uncanniness for all six characters, but for non-psychopathic negative personality traits this was only true for the male and female human characters, and the female virtual lack character. However, it is important to note that for the female virtual lack character the direction of the relationship was opposite to that expected, the negative regression coefficients indicating that uncanniness decreased as perceptions of negative non-psychopathic character-istics increased. Comparison of the standardized regression coefficients for the psychopathic and non-psychopathic traits in Table 5 shows that in all instances the coefficients for the former traits are far greater than those for the latter, and tests of the differences in the beta coefficients for the two personality variables (Cohen & Cohen, 1983)6 for each of the six characters showed that in all instances the coefficient for the psychopathic traits was significantly greater than that for the non-psychopathic traits; male human, t = 6.12, p < .001; female human, t = 5.58, p < .001; male virtual full, t = 5.24, p < .001; female virtual full, t = 7.43, p < .001; male virtual lack, t = 5.02, p < .001; female virtual lack, t = 7.69, p < .001.

In combination, the two types of personality variables were always significantly predictive of uncanniness, the analyses predicting the following proportions of variance; male human, R² = .66, R² adj. = .44, F(2,197) = 75.78, p < .001; female human, R² = .69, R² adj. = .48, F(2,198) = 91.61, p < .001; male virtual full, R² = .53, R² adj. = .28, F(2,200) = 38.83, p < .001; female virtual full, R² = .64, R² adj. = .41, F(2,199) = 70.03, p < .001; male virtual lack, R² = .49, R² adj. = .24, F(2,201) = 32.08, p < .001; female virtual lack, R² = .55, R² adj. = .30, F(2,200) = 42.52, p < .001.

Note. sr = semipartial correlation.

3.2. The effect of perceived personality traits (psychopathic vs. non-psychopathic negative traits) on uncanniness ratings

To test whether perception of psychopathic personality traits in a character is a stronger predictor of uncanniness than perception of other negative non-psychopathic personality traits (H2), and whether this differs across character type and character gender, six standard (single stage) multiple regression analyses were conducted with psychopathic personality traits and non-psychopathic personality trait variables as possible predictors of uncanniness ratings5. Descriptive statistics for all character type and character gender combinations involved in the analyses are shown in Table 3.

Table 4 gives Pearson’s r correlation coefficients and tests of the differences in the size of these coefficients for the psychopathic traits – uncanniness and non-psychopathic traits – uncanniness relationships. From the table it can be seen that in all instances psychopathic traits were significantly positively correlated with uncanniness, but, for the non-psychopathic traits, in two instances this was not the case. Also, and supporting H2, for all character type/character gender combinations, coefficients for relationships between psychopathic traits and uncanniness were significantly greater than those for relationships between non-psychopathic traits and uncanniness. Finally, it is interesting to note that the two types of personality trait were significantly positively correlated for all characters.

The regression statistics in Table 5 show that perception of psychopathic personality traits was a significant predictor of uncanniness for all six characters, but for non-psychopathic negative personality traits this was only true for the male and female human characters, and the female virtual lack character. However, it is important to note that for the female virtual lack character the direction of the relationship was opposite to that expected, the negative regression coefficients indicating that uncanniness decreased as perceptions of negative non-psychopathic characteristics increased. Comparison of the standardized regression coefficients for the psychopathic and non-psychopathic traits in Table 5 shows that in all instances the coefficients for the former traits are far greater than those for the latter, and tests of the differences in the beta coefficients for the two personality variables (Cohen & Cohen, 1983)6 for each of the six characters showed that in all instances the coefficient for the psychopathic traits was significantly greater than that for the non-psychopathic traits; male human, t = 6.12, p < .001; female human, t = 5.58, p < .001; male virtual full, t = 5.24, p < .001; female virtual full, t = 7.43, p < .001; male virtual lack, t = 5.02, p < .001; female virtual lack, t = 7.69, p < .001.

In combination, the two types of personality variables were always significantly predictive of uncanniness, the analyses predicting the following proportions of variance; male human, R² = .66, R² adj. = .44, F(2,197) = 75.78, p < .001; female human, R² = .69, R² adj. = .48, F(2,198) = 91.61, p < .001; male virtual full, R² = .53, R² adj. = .28, F(2,200) = 38.83, p < .001; female virtual full, R² = .64, R² adj. = .41, F(2,199) = 70.03, p < .001; male virtual lack, R² = .49, R² adj. = .24, F(2,201) = 32.08, p < .001; female virtual lack, R² = .55, R² adj. = .30, F(2,200) = 42.52, p < .001.

Note. sr = semipartial correlation.

5 The present regression analyses were preferred to path analysis because cases to parameters ratios in path analyses were lower than the normally recommended ratio of 10:1 (Ullman, 2001). For example, ratios in two path analyses for male and female characters separately were 6:1. However, it should be noted that, with correlated predictor variables and correlated errors for the uncanniness variables, these analyses resulted in the same conclusions as the presently reported analyses.

6 These tests were performed using Enzmann’s (2001) part_tst SPSS Macro, available at http://psyphz.psych.wisc.edu/~shackman/Enzmann_Software.html
From the above analyses it can be concluded that, as hypothesized in H2, perceived psychopathy is a better independent predictor of uncanniness than is perception of other negative non-psychopathic personality traits, and that this is the same for all characters expressing a startled response (fear or surprise) irrespective of their gender or whether these are real humans, virtual representations of humans or virtual representations with a lack of upper facial movement.

4. Discussion

4.1. The effect of character type and character gender on perception of the uncanny

As hypothesized in H1, virtual characters with a lack of upper facial expression were regarded as more uncanny than virtual characters with full facial movement and humans when all were portraying a startled expression. The results followed the predicted trend in that even the male and female virtual characters with carefully crafted, full, facial expression of emotion were rated as more uncanny than human stimuli. While these findings replicate a finding for male characters in the previous study by Tinwell et al. (2011a, 2011b), both male and female characters were used in the present study and our findings show that the above trend generalizes to female characters too. However, overall, male human and male virtual characters were regarded as significantly more uncanny than female human and female virtual characters.

4.2. Perception of psychopathic personality traits in uncanny characters

Rather than just providing practical guidelines as to how facial expression of emotion may be manipulated to control the uncanny in character design (as Tinwell et al. (2011a, 2011b)) did in their previous paper), the present results provide a possible new psychological explanation of the uncanny; aberrant facial expression in a character may trigger a perception that it has psychopathic traits. Here, as hypothesized in H2, it was perception of the traits associated with psychopathy (such as anger, coldness, dominance, callousness, an unconcerned attitude towards others, or untrustworthiness) that was always the best predictor of uncanniness in virtual characters with a lack of movement in the upper face, virtual characters with full facial animation, and in humans.

The results also showed that non-psychopathic, negative traits were related to psychopathic traits. Together with the above findings, this suggests that while we may still detect negative personality traits in characters, these traits do not predict uncanniness, while traits associated with psychopathy are associated with viewer perception of the uncanny in characters; thus providing fairly persuasive evidence that viewer perception of potential psychopathic behavior in a virtual character evokes uncanniness.

In the present study, male virtual characters with a lack of upper facial expression were rated as the most uncanny and psychopathy ratings were a strong predictor of this perceived uncanniness. Given that psychopathy is more common in males (Babiak & Hare, 2006; Buss, 2010; Cleckley, 1964; Glenn, Kurzban, & Raine, 2011; Hamburger, Lilienfeld, & Hogben, 1996; Hart & Hare, 1996; Jonason, Li, Webster, & Schmitt, 2009; Salekin, Rogers, & Sewell, 1997; Lynam et al., 2011) and that a lack of the startle response to aversive stimuli is a visual precursor of psychopathic traits within an individual (Benning et al., 2005; Herpertz et al., 2001; Justus & Finn, 2007; Patrick et al., 1993), this may suggest that the viewer is repulsed or shocked by uncanny characters due to an appraisal and rapid response judgment that they are interacting with someone or something that does not display the typical reaction to shocking stimuli; someone with, possibly psychopathic-like traits who may present a potential threat to one’s self-preservation. In his seminal work, Mori (2012) suggested that experience of the uncanny may serve as an instinctive reaction to protect oneself from danger. Based on data from the current study, we suggest that the lack of an expected startle response in virtual characters when responding to a normally alarming/starting stimulus (the female scream) may, at least momentarily, raise an adaptive alarm in the viewer, increasing awareness of the potential danger, hostility and unpredictability associated with a psychopathic personality. As such (and in support of Mori’s theory) a sense of uncanniness in response to these virtual characters may be the legacy of a very useful real-world survival function.

With the possibility of aggressive or threatening (or at least unpredictable) behavior, the cognitive and negative affective response that accompanies an uncanny reaction follows. Of course, we have to allow for the possibility that the direction of events here might be the reverse; that we perceive something as ‘not quite right’ in the affective expression of an agent with whom we are interacting (the uncanny response is evoked) and this promotes an appraisal of its cause. For survival purposes, the human default interpretation in such circumstances has possibly evolved to be one of ‘err on the side of caution’ and preparedness for the possibility that we are in the presence of a being with psychopathic-like traits and thus potential danger. To summarize, uncanniness might be conceived of as serving as an avoidance response triggered.

In addition to Mori’s explanation of the uncanny, this perspective supports other researchers’ earlier theories of the uncanny. In keeping with Freud’s (1919) analogy, the results might also reflect the idea that when we encounter an uncanny virtual character that we suspect is leaking authentic, but normally repressed, hostile personality traits, that have now been exposed (due to an incongruence between the character’s facial expression and other, more controllable, behavioral responses such as utterances or body posture), this evokes sinister undertones of a dangerously egocentric and Machiavellian nature. Kang (2009) suggested that the uncanny effect emanates from how much control or dominance we believe ourselves to have over an object. With a suspicion of psychopathic traits and unpredictable behavior in a character, the viewer may experience a sense of intimidation and therefore perceive that they are no longer in control, hence experience an uncanny response.

Evidence suggests that in male psychopaths there is an increased likelihood of aggressive and extreme risk taking behavior (see e.g. Benning et al., 2005; Hare, 1970; Herpertz et al., 2001; Justus & Finn, 2007; Patrick et al., 1993), which goes someway to explaining why viewers are generally more uncomfortable with male uncanny virtual characters; they are more wary of not just a cold but also a potentially aggressive response from these character types. However, the results of the present study showed that there was no significant difference in perceived uncanniness between male and female virtual characters with a lack of the startle reflex in response to a scream sound. This may be related to previous evidence suggesting that female psychopaths often demonstrate a lack of empathetic concern and insincerity similar to (or more so than) that of their male counter-parts (Ekman, 1985; Hamburger et al., 1996; Salekin et al., 1997) and implies that prototypical gender-roles were disregarded in appraisal processes; viewers were suspicious of being manipulated by, or taken advantage of, by anyone displaying the physiognomic markers of psychopathy, regardless of gender.
The above finding has significant implications for the creation of female virtual characters that are intended to take on the prototypical role of a woman in a video game, film, or e-learning application, and demonstrate an empathetic and nurturing personality. If the character’s upper facial animation is inadequate and the viewer perceives a psychopathic disposition, yet this character is intended to have a caring nature, then in the viewer’s mind there is a continuous antinomic conflict as the facial actions of that character always contradict their defined (and expected) role in the plot, instead, being more appropriate for that of an antipathetic, uncaring character.

5. Conclusion

This study has shown that viewer perception of psychopathic personality traits is associated with perception of the uncanny in human-like virtual characters and this effect is maximal in the presence of aberrant facial expression and emotion by a character. The present study presents a possible explanation based on empirical evidence as to why viewers fail to connect or establish a rapport with characters of an increased human-like appearance that the designers of video games have otherwise intended to be perceived as empathetic. We propose that in such circumstances, instead of greater affinity with the human-like character, lack of upper facial expression is perceived as incongruous with their actions and this not only fails to communicate their emotional state, but paradoxically, may be interpreted as evidence of an attempt to hide (or even mask) more negative, unpleasant personality traits in that character. The character appears to possess personality traits commonly associated with psychopathy, with all the negative personal and social implications that this carries, and this, possibly along with other factors such as jerky movement (MacDorman et al., 2010) or lip-sync error (Tinwell et al., 2010), may contribute to experience of the uncanny.

Of course, this tactic may be used strategically in games design. Viewer perception that a character may demonstrate a blatant disregard towards others, with a lack of empathy or remorse and an inability to forge a meaningful attachment with others (Glenn et al., 2011) may be beneficial for criminals featured in crime-thriller video games. Such personality traits may make it more believable that a character is defined as having an antagonist role in the story and heighten the dislike for the character so that the player becomes more engrossed in the game. However, such characteristics might inadvertently elicit or exaggerate the Uncanny Valley effect in empathetic characters, to the disadvantage of both the player and designer.

Human-like characters in video games (and animation) are frequently reported in trade press as having a “dead-eyed” look (see e.g. Thompson, 2004, 2005) and this factor contributes as to why the characters are criticized for being uncanny. While the current study does not, of course, assess other aspects that may contribute to a dead-eyed appearance in characters such as light reflectivity in the eyes, pixel dilation, or gaze behavior, the findings presented in this paper may provide a possible psychological explanation as to why we find this “dead-eyed” look so disturbing. An evident lack of a startle-response in characters to what would normally be considered shocking scenes or sounds in-game may exaggerate a perception of this dead-eyed look in a character. Therefore, it may be suggested that video game designers (and 3D animators) ensure that they are aware of the facial muscles involved (especially in the eye region and upper face) of a startle-response in humans. For example, to clearly portray a raising of the brows and a widening of the eye aperture to increase visual input so that such movements can be adequately translated to characters both in real-time and pre-recorded footage in an appropriate context. This may at least, in part, help to prevent or reduce perception of the uncanny in human-like virtual characters.

Evidence indicates that perception of the uncanny is developmentally determined, and not evolutionary in origin, and relies heavily on perception of human faces from infancy (Lewkowicz & Glucksberg, 2012). The findings from the current study indicate a relationship between perception of uncanniness and attribution of psychopathic characteristics. Collectively, this leads us to reflect on whether perception of psychopathy in others, like detection of uncanniness, is also, solely, the product of psychosocial experience; whether developing a ‘nose’ for the uncanny is a necessary precursor for such, or, whether we come armed with instinctive aversion/avoidance responses to characters who violate expectations and whom we may perceive as a potential threat.

Mori (2012) stated that exploration as to the cause of the uncanny in robots is necessary so that we may better understand the essence of being human. The present study has attempted to contribute to this by highlighting possible psychological substrates of the uncanny in ‘non-human’ virtual characters. The study has identified particular personality traits that we may not tolerate in characters designed to replicate human beings. In this way, we are closer to achieving not only a better understanding of human interaction with synthetic agents, but a better understanding of what makes us human.

References
