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Facial expression of emotion and perception of the Uncanny Valley in virtual characters

Angela Tinwell [a,*], Mark Grimshaw [a], Debbie Abdel Nabi [b], Andrew Williams [a]

[a] School of Business and Creative Technologies, The University of Bolton, Deane Road, Bolton BL3 5AB, United Kingdom
[b] School of Health and Social Sciences, The University of Bolton, Deane Road, Bolton BL3 5AB, United Kingdom

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ABSTRACT

With technology allowing for increased realism in video games, realistic, human-like characters risk falling into the Uncanny Valley. The Uncanny Valley phenomenon implies that virtual characters approaching full human-likeness will evoke a negative reaction from the viewer, due to aspects of the character's appearance and behavior differing from the human norm. This study investigates if "uncanniness" is increased for a character with a perceived lack of facial expression in the upper parts of the face. More important, our study also investigates if the magnitude of this increased uncanniness varies depending on which emotion is being communicated. Individual parameters for each facial muscle in a 3D model were controlled for the six emotions: anger, disgust, fear, happiness, sadness and surprise in addition to a neutral expression. The results indicate that even fully and expertly animated characters are rated as more uncanny than humans and that, in virtual characters, a lack of facial expression in the upper parts of the face during speech exaggerates the uncanny by inhibiting effective communication of the perceived emotion, significantly so for fear, sadness, disgust, and surprise but not for anger and happiness. Based on our results, we consider the implications for virtual character design.

1. Introduction

1.1. The Uncanny Valley

Jentsch (1906) first introduced the subject of "The Uncanny" into contemporary thought in an essay entitled "On the Psychology of the Uncanny". The uncanny was described as a mental state where one cannot distinguish between what is real or unreal and which objects are alive or dead. Referring to Jentsch's essay, Freud (1919) characterized the uncanny as a feeling caused when one cannot detect if an object is animate or inanimate upon encountering objects such as "waxwork figures, ingeniously constructed dolls and automata" (p. 226).

In 1970 (as translated by MacDorman and Minato (2005)), the roboticist Masahiro Mori made associations of the uncanny with robot design. Mori observed that as a robot's appearance became more human-like, a robot continued to be perceived as more familiar and likeable to a viewer, until a certain point was reached (between 80% and 85% human-likeness), where the robot was regarded as more strange than familiar. As the robot's appearance reached a stage of being close to human, but not fully, it evoked a negative affective response from the viewer. Fig. 1 depicts a visualization of Mori's theory showing familiarity increasing steadily as perceived human-likeness increases, then decreasing sharply, causing a valley-shaped dip.

The unpleasant feelings evoked by the uncanny have been attributed to it being a reminder of one's own mortality (MacDorman, 2005; Mori, 1970). Kang (2009) however, suggested the negative impact of the uncanny is related to how much of a threat a character is perceived to be and how much control we have over the potentially threatening or dangerous interaction.

1.2. Explorations of cross-modal influence and the Uncanny Valley

Advances in technology have facilitated increased visual realism in video games and designers in some game genres are creating near-realistic, human-like characters. Contrary to Mori's advice, these designers are aiming for the second peak as enhanced realism is believed to improve the player experience and sense of immersion (e.g. Ashcraft, 2008; Plantec, 2008). As characters approach high levels of human-likeness and exhibit human-like motor behavior, aspects of their appearance and behavior are being placed under greater scrutiny by the audience. Factors such as facial expression may appear odd or unnatural and can adversely make a character appear life-less as opposed to life-like. As with robots, highly human-like video game characters may be subject to the Uncanny Valley phenomenon (e.g. Brenton, Gillies, Ballin,

* Corresponding author. Tel.: +44 (0) 1204 903589; fax: +44 (0) 1204 903500.
E-mail address: A.Tinwell@bolton.ac.uk (A. Tinwell).

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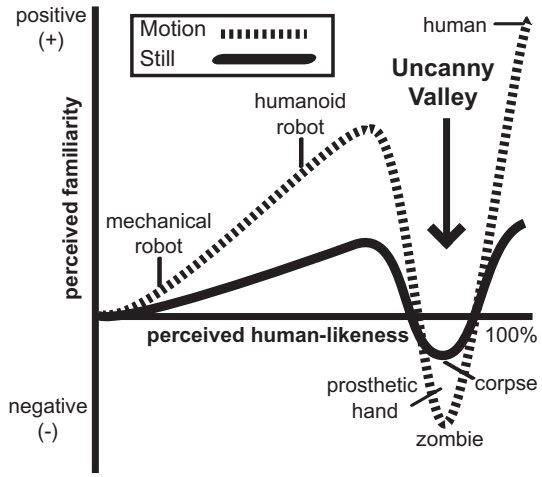

Fig. 1. Mori's plot of perceived familiarity against human-likeness as the Uncanny Valley taken from a translation by MacDorman and Minato of Mori's "the Uncanny Valley".

& Chatting, 2005; Gouskos, 2006; MacDorman, Green, Ho, & Koch, 2009; Pollick, 2009).

Design guidelines have been authored to advise character designers on how to avoid the Uncanny Valley. Such guidelines have included factors such as facial features and proportion and level of detail in skin texture (e.g. Green, MacDorman, Ho, & Vasudevan, 2008; MacDorman et al., 2009; Seyama & Nagayama, 2007). Hanson (2006) found that by changing a character's features to a more cartoon-like style eliminated the uncanny. Schneider, Wang, and Yang (2007) identified that character designs of a non-human appearance with the ability to emote like a human were regarded more positively. These authors acknowledge that the results from their experiments provide only a partial understanding of what a viewer perceives to be uncanny, based on "inert" (unresponsive) still images. The majority of characters featured in animation and video games do not remain still, and cross-modal factors such as motion, sound, timing and facial animation contribute to the Uncanny Valley (Richards, 2008; Weschler, 2002). When a human engages with an android, behavior that seems natural and appropriate from the android (referred to as "contingent interaction" by Ho, MacDorman, and Pramono (2008, p. 170)) is important to obtain a positive response to that android (Bartneck, Kanda, Ishiguro, & Hagita, 2009; Kanda, Hirano, Eaton, & Ishiguro, 2004). Previous authors (such as Green et al., 2008; Hanson, 2006; MacDorman et al., 2009; Schneider et al., 2007) state that, had movement been included as a factor, the results and conclusions drawn from their experiments might have differed.

Previous attempts to recreate an Uncanny Valley shape do not comply with Mori's (1970) diagram and suggest that it may be too simplistic with various factors (including dynamic facial expression) influencing how uncanny an object is perceived to be (see e.g. Bartneck et al., 2009; Ho et al., 2008; MacDorman, 2006; Minato, Shimda, Ishiguro, & Itakura, 2004; Tinwell & Grimshaw, 2009; Tinwell, Grimshaw, & Williams, 2010).

1.3. Facial expression of emotion and the Uncanny Valley

It is well-documented that, in humans and animals, successful recognition of each type of the six universally recognized basic emotions, anger, disgust, fear, happiness, sadness and surprise, (Ekman, 1992a, 1992b) serves a different adaptive (survival or social interaction) function (Darwin, 1872; Ekman, 1979, 1992a, 1992b). For example, detection of fear and sadness in others may foretell potential harm or distress to self and humans react instinctively to such emotions to avoid a possible threat. As Blair (2003) states:

> Fearful faces have been seen as aversive unconditioned stimuli that rapidly convey information to others that a novel stimulus is aversive and should be avoided (Mineka & Cook, 1993). Similarly, it has been suggested that sad facial expressions also act as aversive unconditioned stimuli discouraging actions that caused the display of sadness in another individual and motivating reparatory behaviors (Blair, 1995, p. 561).

It has been suggested that disgust also serves the adaptive function of evoking a negative, aversive reaction from the viewer; it warns others to be concerned about potential infection or approaching a distasteful object (Blair, 2003). In contrast, displays of anger or embarrassment do not serve to act as unconditioned stimuli for instrumental learning. Instead, they are important signals to modulate current behavioral responses, particularly in social situations involving hierarchy interactions (Blair & Cipolotti, 2000; Keltner & Anderson, 2000).

Ekman and Friesen's (1978) Facial Action Coding System (FACS) has been integrated within facial animation software to achieve authentic facial expression of emotion in realistic, human-like video games characters. Dyck et al. (2008) conducted a study to investigate whether the facial emotional expressions of a virtual character could be recognized as easily as those produced on human faces. Still images of virtual characters expressing the emotions happiness, sadness, anger, fear, disgust, and neutral were compared to still images of humans expressing the same emotions at the same medium levels of intensity. Emotion recognition between the two groups indicated that while emotions expressed were, for the most part, recognized equally well in humans and virtual characters, the two emotions fear and sadness achieved better recognition rates when presented in the virtual character than when expressed on human faces; disgust was the only emotion that could not achieve an acceptable recognition rate in virtual characters when compared to humans and was mainly confused with anger. The emotions anger and happiness were recognized equally well for both groups. Again, the authors acknowledged that the results of their study might have been different had animated characters been used to assess how emotions can be interpreted with motion (and speech).

There have been no studies investigating if the type of emotion portrayed by a virtual character influences level of perceived uncanniness and if so which emotions are most significant in exaggerating the uncanny. Considering that anger, fear, sadness and disgust may be considered signals of a threat, harm or distress (Ekman, 1979), it would be reasonable to suggest that these survival-related emotions will be regarded as more uncanny in near human-like (but not quite fully authentic), virtual characters; especially when part of the facial expression of them is aberrant, blurring the clarity of their depiction. Emotions not associated with threat or distress (i.e. happiness and surprise) may be regarded as less important, formidable or essential for survival and therefore less noticeably strange or uncanny; even when the animation of facial features appears odd or wrong to the viewer.

1.4. The importance of upper face animation

During speech nonverbal signals are used to interpret the emotional state of a person. Nonverbal signals are largely conveyed by the upper part of the face; the lower region of the face constrained by the articulatory processes (Busso & Narayanan, 2006; Ekman, 2004, 1979; Ekman & Friesen, 1978, 1969). For example a narrowing of the eyes and a shaking fist show that a person is angry. Raised eyebrows typically demonstrate the emotion surprise