The Uncanny Valley and Nonverbal Communication in Virtual Characters.

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ABSTRACT

This chapter provides a case study of a research project investigating aspects of facial expression and viewer response to the 'Uncanny Valley' (Mori, 1970) in realistic, human-like, virtual characters. In humans, there exists a rich variety of information that can be obtained through nonverbal communication (NVC) (Ekman, 1965). However, empirical evidence collected as part of this research project, suggests that this information is lacking in animated realistic, human-like, virtual characters (Tinwell, Grimshaw, & Williams, 2010; Tinwell, Grimshaw, Abdel-Nabi, & Williams, 2011). Specifically, a perceived lack of emotional expressivity generated in the upper face region during speech was found to strongly influence perception of the Uncanny Valley in realistic, human-like, virtual characters (Tinwell, Grimshaw, Abdel-Nabi, et al., 2011). Building on empirical evidence provided so far in this research project, the consequences of a lack of NVC in the upper face region with regards to perception of the uncanny in characters is considered. New theories as to the cause of the uncanny phenomenon are put forward that go beyond Mori's original theory based on a perception of spontaneous versus deliberate facial expression, the detection of transient microexpressions with suggestion of possible deceit, and a recognition of psychopathic behavior. This chapter also considers the limitations of the stimuli and methodology used in previous experiments, with suggestions made for future experiments. The implications of a lack of NVC in virtual worlds are discussed with possible caveats against the use of characters in virtual simulations used for assessment purposes in the real world.

INTRODUCTION

Viewer perception of a character's emotive state is of ever-growing significance in virtual worlds. Developers of cinematic, interactive-drama, video games such as *Heavy Rain* (Quantic Dream) and *LA Noire* (Team Bondi, 2011) claim to have taken the next frontier in computer generated animation within gaming. Advanced motion capture technologies and performance

captured animation allows for increasing sophistication of characters' emotional expressions, gesture and movement. The video game LA Noire requires the player interrogate both civilians and suspects to solve crimes in the story. So that the player can reveal new clues, it is important that they can understand the facial expression made by character's that they interview. In the crime thriller Heavy Rain, the player's aim in is to identify a serial killer. To do so the player must continuously seek feedback from the characters facial expression and emotive state to inform decisions as to their next actions in the game. Failure to do so may risk not solving the mystery or protagonist characters becoming victims of the killer.

Virtual worlds are also being implemented outside the remit of gaming, for use in training and testing simulations, where a clear understanding of a character's emotive state is crucial to achieve a successful outcome for the viewer. Such technology is being introduced as an innovative method of assessing and improving people's skills with the intention that participant will then apply those skills to similar scenarios in the real world (ACTIVE Lab, 2011; Bergen, 2010; Bowers et al., 2010; MacDorman et al., 2010). As such, virtual characters are being used in roles once exclusively assigned to humans both in the public and private sectors. For example, a virtual character may be used to present moral or ethical dilemmas to trainees in the medical, military and legal professions (ACTIVE Lab, 2011; Bergen, 2010; Bowers et al., 2010; MacDorman et al., 2010). A virtual character may deliver a personal problem to a trainee doctor so that the trainee doctor's response to that problem may be assessed (MacDorman et al., 2010); or be featured as an injured civilian in a warfare scenario who requires help from a trainee soldier (Bowers et al., 2010).

Similarly, commercial companies are implementing virtual worlds for psychological assessment as part of the recruitment process to find the best possible employees (Bergen, 2010). Potential employees interact with virtual worlds that simulate 'real world' scenarios featuring annoyed customers or argumentative colleagues. Companies seem keen to explore this new method of assessing possible new recruits as it improves the value of their employee branding and raises awareness of the company as a forward thinking and advanced place to work. Handler, who is involved in the simulation development of virtual worlds at the human resources software company, Kanexa states, "It's the wow factor," as companies seek to be established as an exciting and desirable place to be (Bergen, 2010). In this way, virtual characters are used to test how effective potential new recruits may be in coping with the potential challenges of a role. However, recent evidence suggests that the Uncanny Valley phenomenon may act as a limitation to this type of endeavor and companies should be aware of what effect the uncanny may have on recruiting the right candidate for the job. This chapter investigates how a lack of Nonverbal Communication (NVC) in realistic, human-like, characters may affect perception of the uncanny and the potential consequences of interacting with such characters in virtual worlds, used not only for entertainment, but for training and assessment purposes.

The first section provides a synopsis of how experience of the uncanny was first considered in psychological writings of the twentieth century, leading to Mori's hypothetical notion of the Uncanny Valley (1970). An account of previous research investigating the uncanny in synthetic agents is also given including: exploration of factors which may exaggerate the uncanny; and design guidelines published on how to control the uncanny in virtual characters. The origins and adaptive functions of facial expression in primates are discussed in section two. This serves as a

rationale of why perception of the uncanny was stronger for some emotions than others when presented in characters with limited upper facial movement (Tinwell, Grimshaw, Abdel-Nabi, et al., 2011).

Section three provides a retrospective of the role of NVC in humans and the purpose and associated meaning of movement in the eyebrows, lids and forehead. The psychologist, Paul Ekman, has established a conceptual framework of facial action in humans used to create facial expressions. Based on Ekman's work, descriptions are provided for facial actions used in NVC including the differences between voluntary and involuntary facial movements and the facial muscles used in fabricated expressions. As well as the purpose of NVC, this section examines how a perceived lack of NVC in facial expression may exaggerate the uncanny for characters in virtual worlds. Importantly, consideration is also given to the potential confounding impact on the viewer if such facial actions are missing in virtual characters. A summary of the importance of the role of NVC in creating believable, realistic, human-like, characters and the antithetical consequences of aberrant upper facial movement is provided in the conclusion.

Finally, it should be noted that while the focus of this current research project explores the centrality of the role of a perceived lack of NVC in the upper face with perception of the uncanny in virtual characters, the authors acknowledge that these actions should not simply be studied in isolation from other facial and body movements. The stimuli used in experiments have included vocalizations and speech, yet head and body movements can also complement NVC in various social contexts. This chapter does disclose how NVC in the upper face may contribute to a more multi-dimensional model to measure the uncanny.

1 THE UNCANNY VALLEY

The subject of the uncanny was first introduced in 1906 by the psychologist, Jentsch, who likened the uncanny to a state of uncertainty as to whether an object was real or unreal or alive or dead. Jentsch gave examples of objects such as automaton or wax-work, human-like dolls that may elicit the uncanny effect. As a way towards understanding why some objects were not regarded as aesthetically pleasing to the extent of frightening or repulsing the viewer, Freud (1919) described the uncanny as a state of confusion that occurred as a seemingly familiar object behaved in a strange or unfamiliar way. Freud implied that the uncanny may exist as a revelation of what is normally withheld or hidden from others, for example, a revelation of a repressed emotion or thought, resulting in odd or disturbing behavior.

Building on this literature, a potential bench mark has now been set for designers in creating a virtual character that is believably (and authentically) human in their appearance and behavior. This benchmark is referred to as "The Uncanny Valley" and derived from observations made by the roboticist, Marashiro Mori (1970), when designing androids. Mori hypothesized that humans would be less accepting of synthetic agents as their human-likeness increased and created a graph to demonstrate this theory (see Figure 1).

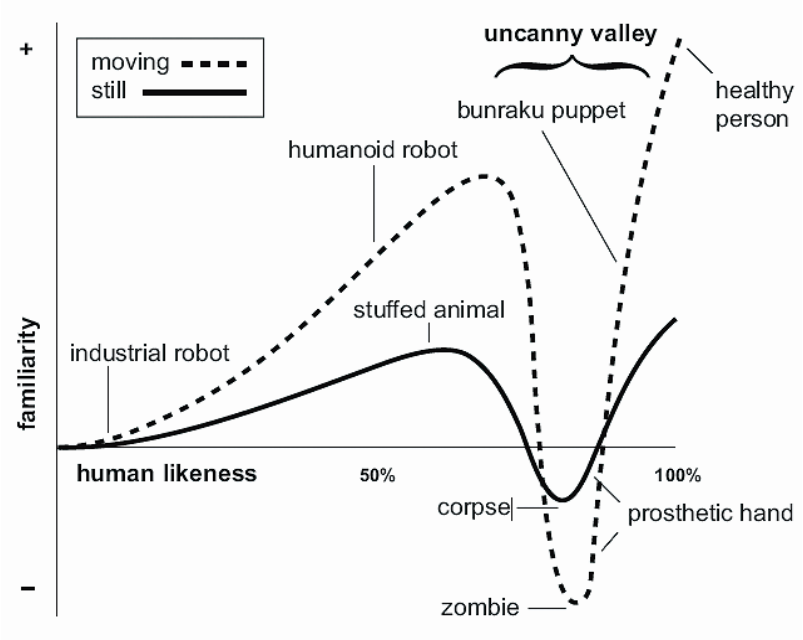

Figure 1. Mori's plot of perceived familiarity against human-likeness as the Uncanny Valley taken from a translation by MacDorman and Minato of Mori's 'The Uncanny Valley'.

A valley shaped dip shows the negative affective response Mori observed in viewers towards android designs approaching fully, authentic human-likeness. Androids with a human-like appearance built an expectation from the viewer that their behavioral fidelity would match their human-like appearance. Androids that deviated from the human norm in their appearance and behavior repulsed the viewer, falling into the valley alongside zombies, corpses and prosthetic limbs. Mori (1970) recommended that for robot designers, it was best to aim for the first valley peak and not the second, developing humanoid robots with human-like traits, but avoiding android designs.

The Uncanny in Virtual Worlds

With increasing realism achieved in virtual worlds, the Uncanny Valley phenomenon is frequently being associated with realistic, human-like, characters (see e.g. Geller, 2008; Pavlus, 2011; Plantec, 2007, 2008; Pollick, 2009; Stuart, 2007; Tinwell, Grimshaw, & Williams, 2011a). Viewers seem particularly discerning of characters' facial expression (Doerr, 2007; Gouskos, 2006; Thompson 2005). Critical of movements that appear odd or unnatural, parallels have been made between unsuccessful facial surgery in humans and virtual characters recognized as being uncanny. Thompson (2005) observed that realistic, human-like, comrade Marine characters featured in the video game *Quake 4*, "looked like the victims of thoroughly botched face lifts". Similarly, the admirably beautiful appearance of the heroine, Naomi (as modeled on the actress Anne Darrow), in the video game *King Kong* (Ubisoft Entertainment, 2005) was not enough to appease audiences and she was described as a monster. Facial expression that was regarded as stiff and distorted exaggerated the uncanny for this character, despite her aesthetically pleasing appearance.

> In some ways, her avatar is an admirably good replica, with the requisite long blond hair and juicy voice-acting from Watts herself. But the problem begins when you look at her face – and the Corpse Bride stares back. The skin on virtual Naomi is oddly slack, as if it weren't quite connected to the musculature beneath; when she speaks, her lips move with a Frankensteinian stiffness. And those eyes! My god, they're like two portholes into a soulless howling electric universe. (Thompson, 2005)

With such criticism of characters designed to endear and not repel the viewer, designers required guidance as to how to control the uncanny in character design. Various factors have been found to influence perception of the uncanny. Importantly, humans can experience a less positive affective response towards androids and realistic, human-like, virtual characters when there is a perceived mis-match between a character's behavioral fidelity with their human-like appearance (Bartneck, Kanda, Ishiguro, & Hagita, 2009; Ho, MacDorman, & Pramono, 2008; Kanda, Hirano, Eaton, & Ishiguro, 2004; Vinayagamoorthy, Steed, & Slater, 2005). Viewers expect that, characteristics of speech (Tinwell et al., 2010; Tinwell, Grimshaw, & Williams, 2011b; Tinwell, Grimshaw, & Abdel Nabi, 2011; Mitchell et al., 2011), gestures and timing of movements (MacDorman, Coram, Ho & Patel, 2010; Ho et al., 2008; Minato, Shimda, Ishiguro, & Itakura, 2004), and a character's response to others and external events (MacDorman & Ishiguro, 2006) will match a character's human-like appearance. Failing this, the uncanny may be exaggerated for the character.

Despite the Uncanny Valley phenomenon often being regarded as a negative consequence, it can work to the advantage of characters within an appropriate setting and context. For example, robots designed with the intention to be unnerving and antipathetic characters such as zombies within the horror game genre (MacDorman, 2006). Based on this analogy, a study was undertaken to investigate how cross-modal factors such as motion and sound may be manipulated to enhance the fear-factor in horror games (Tinwell, Grimshaw and Williams, 2010). One hundred participants rated 6, empathetic, realistic, human-like characters; 5 antipathetic, zombie characters; a Chatbot character with a stylized, human-like appearance; and a human.[1] The results indicated that a lack of human-likeness in a character's facial expression and speech exaggerated the uncanny. Specifically, perception of the uncanny was increased under the following conditions: an awareness of a lack of expressivity in the upper face region, the forehead area being of particular significance; a perceived over-exaggeration of mouth movement (articulatory motion) during speech; doubt in judgment as to whether the voice actually belonged to the character or not; and a perceived lack of synchronization between lip movement and speech (Tinwell et al., 2010).

Particular concern has been raised as to how the uncanny may have a potentially confounding impact on a participant's performance if presented with an uncanny character for assessment or training purposes (Bergen, 2010; MacDorman, et al., 2010). Doubt may be raised as to the validity and suitability of using virtual characters in such circumstances, given the negative effect associated with the uncanny. So that the uncanny does not have an unintentional

[1] Please see the original paper (Tinwell et al., 2010) for a full description of the stimuli used in this experiment.

negative effect on those interacting with characters in virtual worlds (or to exaggerate the uncanny for those characters intended to be unnerving or frightening), designers should be aware of factors that may exaggerate or reduce the uncanny. Based on the body of research undertaken so far on the uncanny, this chapter investigates the relationship between NVC in virtual characters and the Uncanny Valley phenomenon. The next section examines more closely how a perceived lack of NVC in a character's facial expression, specifically in the upper face region, may be used to control the uncanny when designing emotive characters in virtual worlds.

2 FACIAL EXPRESSION OF EMOTION AND THE UNCANNY

It is well-established that we rely on our innate ability to recognize and respond to others emotions as a primordial survival technique. The successful recognition of each type of the six universally recognized basic emotions, anger, disgust, fear, happiness, sadness and surprise, (Ekman & Friesen, 1978; Ekman, 1992a, 1992b) serves a different adaptive (survival or social interaction) function in humans and animals (Darwin, 1872; Ekman, 1979, 1992a, 1992b). Facial expressions evolved antecedently to help cope with fundamental life-tasks in our progenitors (Andrew, 1963; Darwin, 1872; Eibl-Eibesfeldt, 1970). The receiver can gain information about the sender's possible future behavior, or the event that may have elicited such an expression, and react aptly to that information (Ekman, 1979).

Importantly, the spoken language and movements of the body take second place to facial expression in human communication, "Words are not emotions, but representations of emotions" (Ekman, 2004, pg. 45). Evidence of this proposition has been found in rhesus monkeys (Izard, 1971). As more phylogenetically advanced mammals, the communication mechanisms of rhesus monkeys may be related to the evolutionary development of human communication (Darwin, 1872; Izard, 1971). An experiment was conducted with two groups of rhesus monkeys: In one group, the facial nerves of the monkeys had been cut so that they were unable to move facial muscles and create expressions; the other group had normal facial movement (Izard, 1971). When the groups merged, the monkeys with limited facial movement used full body gestures to communicate with other monkeys. Such gestures escalated to increased aggression and the attack of those monkeys with normal facial movement. Wary of their facial handicap, if the monkeys with limited facial movement felt fearful of others in the group, they had to resort to physical attack as a way to communicate that they felt threatened (Izard, 1971).

Similar patterns of behavior have been identified in members of the human population diagnosed with anti-social personality disorders (ASPD), otherwise known as psychopathy (Hart and Hare 1996; Herpertz et al. 2001; Lynam et al. 2011; Miller et al. 2011). Such people are more prone to violent outbursts as they lack emotions that would normally 'check' or regulate one's behaviour to prevent acting on impulse (Hart and Hare, 1996; Herpertz et al., 2001; Lynam et al. 2011). Hence, the patterns of behavior observed in our progenitors can still be observed in humans in those diagnosed with ASPD. It is imperative that humans can identify emotion promptly, to ensure minimal time is required to respond and act accordingly (Ekman, 1992a).

Otherwise, the consequences of a delayed reaction, particularly to a perceived threat, may be life threatening.

Each emotion is perceived differently by humans, both cognitively and in terms of physical response (Darwin, 1872; Ekman, 1979, 1992a, 1992b; Johnson, Ekman, & Friesen, 1990). Humans react instinctively aversively to the emotions anger, disgust, fear, and sadness to avoid potential harm, threat or disease and the detection of such emotions in others may raise anxiety levels as a threat to one's own well-being. Evidence implies that there is distinct physiology (i.e. distinctive sympathetic autonomic nervous system (ANS) patterns) for separate emotions depending on the reaction required (Ekman 1992a, 1992b; Johnson, Ekman, & Friesen, 1990). Evidence of emotion-specific ANS activity has been found for anger, fear, disgust and sadness, but not so for happiness and surprise (Ekman 1992a, 1992b; Johnson, Ekman, & Friesen, 1990). An adaptive function for fear can be to run or flee from danger. When experiencing fear, evidence shows that blood rushes to the large skeletal muscles, to support such a reaction. Fighting may have been the adaptive action for anger, consistent with the movement of blood to the hands (Ekman 1992a).

Given that NVC in the face is the primary method of communicating the affective state of an individual, and the importance of recognizing and responding promptly to another's emotive state, Tinwell, Grimshaw, Abdel Nabi, et al., (2011) conducted an experiment to investigate whether inadequate movement in the upper face may have differential effects on perceived uncanniness depending on which emotion was being portrayed by a character. It was put forward that those survival-related emotions considered signals of a threat, harm or distress (including anger, fear, sadness and disgust (Ekman, 1979)) would be regarded as more uncanny in near human-like, virtual characters; especially when part of the facial expression was aberrant, impeding one's ability to recognize the emotional state of a character (Tinwell, Grimshaw, Abdel Nabi, et al., 2011). Emotions regarded as less important for survival such as happiness and surprise would be less noticeably strange or uncanny, even when the animation of facial features appeared odd or wrong to the viewer.

One hundred and sixteen participants rated perceived familiarity and human-likeness for head shots of a male human and a male virtual character ('Barney' from the video game *Half-Life 2*, (Valve, 2008)) who produced prosodically congruent utterances for the six basic emotions (in addition to a neutral expression). Two experimental conditions were created for the virtual character: a fully animated character (named *full*) and a partially animated character where movement above the lower eyelids was disabled (named *lack*) (see Figure 2). The results showed that obscuring the salience of an emotion by limiting NVC in the upper face did exaggerate the uncanny.

Figure 2. The three Conditions, Human, Full and Lack, expressing the emotion Anger.

Participants rated the virtual character as less familiar and human-like (more uncanny) than the human, but significantly more so when facial signals were removed from the upper face. As the authors predicted, the extent of this increased uncanniness varied depending upon which emotion was being portrayed. Yet, the results indicated that emotions with distinctly *different* adaptive functions (social vs. survival), were regarded as more tolerable than others with an ambiguity of facial expression. In the lack condition, perception of uncanniness was strongest for the emotions fear, sadness, disgust, and surprise. Tinwell, Grimshaw, Abdel Nabi, et al. (2011) postulated that as both fear and sadness can require only small facial movements, the character may have resembled a corpse-like state with no movement in the upper face, hence exaggerating the uncanny. It was suggested that as surprise is commonly mistaken with fear in humans (Ekman, 2003b), the same characteristics attributed to fear in the lack condition may be applicable to the emotion surprise. Despite disgust possibly serving as a warning signal to others to avoid a repugnant object or situation (Blair, 2003), a lack of detail in creating the folding and wrinkling of the skin in the upper nose (referred to as the "nose wrinkler" action (Ekman, 1992a, 1992b)) was regarded as a more viable explanation as to why disgust was rated significantly more uncanny with restricted upper facial movement.

As predicted, participants were less sensitive to the uncanny when the emotion happiness was presented in characters with a lack of upper facial movement. Yet, unpredictably, the uncanny was also less noticeable for anger in characters with restricted upper facial movement. This finding was accounted for in that participants were able to recognize anger and happiness due to action unit movement in the lower half of the face, articulation and prosody (Tinwell, Grimshaw, Abdel Nabi, et al., 2011). Surprisingly, the results also revealed that happiness was rated the least familiar and human-like (most uncanny) when presented in the fully animated character. This finding was unexpected due to happiness being a more positive emotion. Tinwell, Grimshaw, Abdel Nabi, et al. (2011) suggested that participants may have been suspicious of being presented with a "false smile" (Ekman & Friesen, 1982, pp. 244-248) thus, exaggerating the uncanny.

Based on these findings, it was recommended that designers make informed decisions as to how to control the perceived level of uncanniness in virtual characters. Strategic design modifications can be made when modeling the upper face region, bespoke to each different emotion. To reduce the uncanny, substantial amounts of time need not be invested to convey upper facial expressivity for anger and happiness. However, particular attention should be paid to

facial expressivity in the upper face for the emotions, fear, sadness, disgust, and surprise. These guidelines may be reversed if the designer wished to exaggerate the uncanny. For example, characters may be perceived as stranger and less human-like with reduced upper facial animation when expressing the emotions fear and sadness (Tinwell, Grimshaw, Abdel Nabi, et al., 2011).

3 NONVERBAL COMMUNICATION (NVC)

Behavior (either conscious or subconscious) in the presence of others is instilled with meaning. The perceiver may obtain critical information as to the emotional state of a person by observing behavior of their face or body (Ekman, 1965, 1979, 2004; Ekman & Friesen, 1969, 1978). Nonverbal communication can be detected by: the intonation, speed, and volume of a person's speech; body posture; gestures; and facial expression, that may otherwise render verbal-communication ambiguous (Ekman, 1965). For example a narrowing of the eyes and a shaking fist show that a person is angry (Ekman, 2004). Empirical evidence shows that the perceiver can make accurate judgments about a person's attitude, personality and emotive state (in keeping with independent assessment as to the personality traits and circumstance of an individual) from observing movements of their face and/or body.

> In studies designed to determine what kinds of information could be derived from observing facial or body behavior we found that inferences about emotions, attitudes, interpersonal roles, and severity of pathology can be made by observers with no specialized training in emotion recognition. (Ekman and Friesen 1969, p.50)

So that the great number of human facial actions could be described, Ekman and Friesen (1978) devised a categorical scheme based on facial anatomy, called the Facial Action Coding System (FACS). FACS provided a method so that individual muscles or combinations of muscles used in creating facial expression could be recorded systematically (Ekman and Friesen, 1978; Ekman, 1979). The muscular activities used to generate changes in facial appearance for a particular emotive state have been assigned specific Action Units (AU). In the upper face, AU1, *Inner Brow Raiser*; AU2, *Outer Brow Raiser*, and AU4, *Brow Lowerer*, can work independently or together to achieve one of the seven observably distinct brow actions in humans across the six basic emotions (Ekman, 1979; Ekman and Friesen, 1978). When contracted, the facial muscle *Depressor Glabellae* (described as AU4) lowers the eyebrows resulting in a corrugated furrow between the brows, creating a frown expression. AU1 defines the changes in appearance when the inner section of the frontalis muscle is contracted (Ekman, 1979). Wrinkles appear (or deepen) in the centre of the forehead as a result of the inner corner of the eyebrow being raised. AU2 defines the visual changes that occur when the outer frontalis muscle is contracted. This action creates wrinkles in the lateral (outside) portion of the forehead. As a signal of surprise and interest the AUs 1 and 2 work in cohesion to open the eye area and increase the visual field (Ekman, 1979; Ekman and Friesen, 1978).

Various quantitative studies have been undertaken to unravel the complex interrelationships between spontaneous and contrived facial movements (Duchenne, 1862; Ekman, 2003b; Ekman & Friesen, 1982). Ekman distinguished two different types of facial social signals to convey NVC in humans: *Emotional Expressions* and *Conversational Actions* (Ekman, 1979). Both

emotional and conversational signals can occur during speech, but are related to different components of conversation. Conversational signals tend to be made voluntarily and may replicate, precede, occur simultaneously or in some cases, replace a spoken word. Emotional signals occur involuntarily and are used to support the semantic meaning of a word. The listener may also use emotional signals to convey that they understand, agree, or disagree, what the sender has said (Ekman, 1979).

In a way towards classifying the nonverbal signals presented during speech Ekman and Friesen (1969) included the two categories *Emblems* and *Illustrators*, both of which use movement in the upper part of the face. Brow lowering and raising can be used as Illustrators to provide additional emphasis for words or phrases during speech. A lowered brow (AU4), associated with more negative emotions such as fear, sadness, distress and anger may help accentuate a negative word, whereas a raised brow (AU1+2), associated with more positive emotions such as Happiness and Surprise may "baton-accent" a more positive word such as "easy, light, good, etc" (Ekman, 2004, p.42). Ekman suggested that the brows are more frequently used as conversational signals than other facial actions, because they are contrastive (positive vs. negative) and easiest to perform (1979). Emblems can include movement of the hands, shoulders, head and face. For example, raised eyebrows typically demonstrate the emotion Surprise. Mostly intentional, Emblems are performed in the "presentation position" (Ekman, 2004, p.40) when facing people and a person is aware of presenting Emblems to others. Interestingly, some can occur unintentionally, as the person unwittingly divulges repressed or deliberately suppressed information. A person is unaware they have made such a gesture, akin to "a verbal slip of the tongue", (Ekman, 2004, p.40).

In 1872, Darwin suggested that facial expression can give away a person's true feelings, despite efforts to try to conceal or hide an emotion. People are also aware of being presented with a false expression, fabricated to try to convince them an emotion is actually felt (Darwin, 1872). Furthermore, people may be unable to mask those facial movements that are most difficult to make voluntarily (Darwin 1872, Ekman, 2003b; Ekman & Friesen, 1969b). For example, one may be able to control body movements, such as a clenched fist, in an attempt to hide that one is angry, but may not be able inhibit the momentarily passing of a frown expression. To investigate how facial expression may be used to detect possible deception, Ekman conducted experiments to establish which facial movements could not be made deliberately (Ekman, 2001, 2003b). Those movements that could not be made without the involuntary processes of spontaneous emotional response could then be recognized as reliable signals of a person's emotional state (Ekman, 2001, 2003b; Ekman & Friesen, 1969b). For anger it was identified that AU24, *Lip Pressor*, that creates a tightening of the lips, could not be activated voluntarily. This finding may explain why the uncanny was less noticeable in virtual characters expressing the emotion anger when movement was disabled in the upper face as pressed lips clarified the authenticity of this emotion (Tinwell, Grimshaw, Abdel Nabi, et al., 2011). As well as a droopy mouth (activated by AU 15, *Lip Corner Depressor*), Sadness requires that AU1, the Inner Brow Raiser, be active for people to perceive this emotion as felt (Ekman, 2001, 2003b). As the uncanny was increased for those characters communicating sadness without upper facial movement (Tinwell, Grimshaw, Abdel Nabi, et al., 2011), this emotion may have been perceived as superficial without evidence of this facial action. The combination of AUs 1+2+4 cannot be voluntarily activated for the emotion fear (Ekman, 2001, 2003b). Ekman (1979) speculated that, as fear is considered an anticipatory response of distress,

the origin of this facial movement may be explained in the following ways: AUs 1+2 provide greater visual input, thus increased attention; AU4 communicates that a distress experience is expected.

Without evidence of the reliable expressions (Ekman, 2001, 2003b; Ekman & Friesen, 1969b), one may question the authenticity of the portrayed emotion. If one attempts to communicate joy, when one is otherwise experiencing more negative emotions, the smile action that uses the *Zygomatic Major* muscle (referred to as AU12) will be used in conjunction with other facial expressions characteristic of fear, sadness or disgust (Darwin, 1872; Duchenne, 1862; Ekman, 2003b; Ekman & Friesen, 1982; Frank, Ekman, & Friesen, 1993). It is presumed a smile is false if the upper facial features show expressions associated with more negative emotions. If the upper face region for a realistic, human-like, virtual character is not modeled correctly, then expression in the lower face may not be sufficient to convince the viewer a positive emotion is felt. A reliable expression may be evident for fear in the upper face when a smile is shown in the lower face. Hence, the perceiver is presented with a potential leakage of emotion to portray concealed, negative emotion. This may have been the contributing factor as to why the uncanny was actually reduced for those realistic, human-like characters expressing happiness with no upper facial movement, when compared to fully animated characters (Tinwell, Grimshaw, Abdel Nabi, et al., 2011).

A perception of emotional hyporesponsiveness in virtual characters may evoke more sinister undertones as to what a character may be trying to conceal. As shown in our progenitors, monkeys with limited facial expression may become frustrated and physically attack other monkeys to make themselves understood (Izard, 1979). Similarly, humans with particular personality disorders may also be more likely to resort to more violent tactics in order to communicate their feelings (Hart & Hare, 1996; Herpertz et al., 2001). Empirical evidence has revealed that a salient trait in those members of the population who are notably affectively hyporesponsive, e.g. psychopaths, is a lack of fear response to aversive events (Herpertz et al., 2001). Specifically, this is communicated with an absence of movement in the upper facial region in response to fear-related stimuli. In those diagnosed with psychopathy, the startle reflex (evident with raised brows and a blink response) that includes the combined facial movement of AU 1+2+4 to demonstrate genuine fear, may not be evident when presented with aversive stimuli (Herpertz et al., 2001). Tinwell, Grimshaw, Abdel Nabi, et al., (2011) also found that perception of the uncanny was particularly strong in characters communicating the emotion fear with a lack of movement in the eyelids, brows and forehead. Hence, the uncanny may be evoked through viewer perception of a personality disorder bordering on that of psychopathy. What is repressed and now unconcealed (Freud, 1919) may have dangerous consequences for the viewer. Psychopaths may be more predisposed to violence as they fail to experience emotions that would otherwise inhibit acting on violent impulses (Hart & Hare, 1996; Herpertz et al., 2001). The viewer cannot be aware of that characters anticipated (potentially violent and threatening) behavior. Thus, perception of hypoemotionality in virtual characters may raise alarm and fear, as the viewer is wary of a heightened threat of attack, exaggerating the uncanny.

5 A LACK OF NVC IN VIRTUAL WORLDS

In 2006, Quantic Dream released a tech demo called “The Casting” for the much awaited video game *Heavy Rain* at the E3 in 2006. Modeled after film noir and pre-empted as a revolutionary, cinematic, interactive drama, the game was expected to set new heights in levels of player engagement and rapport with the characters and plot (Hoggins, 2010). Utilizing the ‘Vicon’ motion capture system to achieve the highest quality of precision in capturing not only full body movement, but small facial movement and expression (such as Emblems and Illustrators prevalent in facial NVC (Ekman and Friesen, 1969)), the developers intended that the viewer would be able to completely suspend disbelief with the virtual characters (Martin, 2007; Hoggins, 2010). Guillaume de Fondaumière, the co-founder of the game developer Quantic Dream, stated that "I can officially announce that there is no uncanny valley any more, not in real-time” (as quoted in Doerr, 2007). The Casting featured the empathetic character Mary Smith, providing a personal account as to the recent devastating news of her husband’s betrayal. It was intended that viewers felt sympathy and would empathize with Mary as she delivered her dramatic narrative; however instead of eliciting empathy from her audience, this character was simply mocked. Viewers claimed that Mary’s emotion seemed awkward and wooden and that her facial expression did not match the emotive quality of her voice, thus reducing the overall believability for this character (Doerr, 2007; Gouskos, 2006).On closer inspection of Mary’s facial expression, when expressing fear, whilst the lower facial features were fully animated as she spoke, there was little movement in the upper face. Viewers may otherwise have expected to see raised outer eyelids (AUs 1+2), with a furrowed brow (AU4) (Ekman, 1979; Ekman and Friesen, 1978) however there was insufficient movement to demonstrate these facial actions. This resulted in a lack of plausibility for this emotion. While the viewer could hear what she said, the character lacked believability as her facial expression did not suggest that this character experienced fear.

In 2009, the video game Heavy Rain was released. Whilst the graphical fidelity of the characters featured in the game had improved (such as the quality of their skin texture), their behavioral fidelity still did not match their realistic, human-like appearance. Again, aspects of the main characters’ facial expression were regarded as odd or strange. A poignant scene takes place where the protagonist Ethan Mars loses his son in a busy shopping mall and hunts desperately to find him. As an interactive, drama game, eliciting emotion was one of the game’s key targets, essential for viewers to participate fully with each evolving chapter (Hoggins, 2010). However, Ethan’s facial expression was criticized as one of the reasons as to why this scene fell below expectations of fully engaging the viewer as the search progressed. With a demonstrable lack of NVC in this character’s facial expression, the viewer could not empathize with Ethan’s affective state and his apparent panic and fear at the trepidation of a loss of his son. As Ethan calls out his son’s name the evident despair in his voice was not evident in his facial expression: there was a distinct lack of his brows being raised and wrinkles created as a result of this movement in the forehead, a typical facial action in humans when in despair (Ekman, 2001, 2003b); nor his brows being lowered to baton-accent and accentuate more negative words (Ekman, 2004)). Quantic Dream intended that the viewer would experience a heightened emotive experience in playing the game based on the character’s heightened emotive states. However, a perceived lack of NVC in the characters’ facial expression reduced the overall believability and impact of this game for the player.

Perception of a lack of NVC in virtual characters leads to a state of confusion for the viewer. The viewer may risk receiving contradictory information from indiscriminate,

contradictory facial signals raising confusion as to how to interpret the character. If one cannot identify the emotion for a character based on an incongruence between their upper and lower facial features (during or without speech), the viewer may be unsure as to the consequent actions of that character. As demonstrated with the empathetic character, Mary Smith, if there is possible doubt as to a character's emotive state, based on expectations of the given context within which the character is presented, the character may be perceived as less believable, less human-like and uncanny. The viewer is unsure of how to react to the given character or what their next intended actions will be. Moreover, the aesthetic consequences of an ambiguity of facial expression may have a more alarming response than one being confused as to a character's emotive state. This may make the viewer feel uncomfortable given that, under certain circumstances, a human may resort to more physical and aggressive means of behavior to communicate how they feel, if they perceive that they are not being understood (as evidenced in those with ASPD). Whilst this behavior works to the detriment of empathetic characters by increasing the uncanny, such characteristics may be beneficial for protagonist characters intended to be unnerving.

In the video game *LA Noire*, the player must identify a criminal by conducting face to face interviews with characters. As well as keeping pace with the story line and events, the player may use NVC as a way to detect potential suspects from the innocent. Those guilty culprits may exhibit a lack of the startle reflex in response to fear or generate a smile that may otherwise be regarded as false in a human, as a clue to the player that their behavior is strange or suspicious. When being interrogated, it may improve player engagement in a crime-thriller if those guilty characters may convey traits similar to those diagnosed with aspects of ASPD or psychopathy. Social interaction that is perceived as abnormal to the viewer raises alarm that the character may be capable of atypical, anti-social behavior raising suspicion that they may have conducted the crime. Solving a mystery in this way, by observing subtle nuances in NVC provocative of lies of omission, would no doubt be a more rewarding feat for the player, rather than having to rely solely on more blatant clues such as more obvious lies of commission. A lack of facial expression may instill panic in the player that the character is not only untrustworthy, but capable of aggressive or threatening behavior. A hint of psychopathic tendencies in a character (due to a lack of upper facial movement) may raise suspicion that this character is capable of violent behavior to the extent of killing others with little or no remorse for their actions. Experiencing the uncanny may be used as a warning signal for the player to detect a killer within a crime game. However, such tactics would of course not be effective in helping the player eliminate criminals if all the characters were behaving in this way, guilty or not, as it seems is currently the case in such video games. So that the uncanny may be used to the advantage of the player (and the designer) the facial expression in those empathetic characters not intended to deceive, must be accurate to avoid confusion for the player. Acquiring a greater awareness in designers of how to manipulate NVC in facial expression may be necessary to achieve this sophisticated element of player-character interaction the game, alongside improved graphical realism achievable in virtual worlds.

The consequences of a lack of accurate modeling to communicate NVC in the upper facial region may have detrimental effects for those interacting with virtual characters for testing or training purposes. The participant may be less able to empathize with the character and relate to that character's emotional state in order to respond accordingly to the needs of the given dilemma, given the ambiguity of that character's perceived emotional state. As well as the spoken narrative, the participant may seek nonverbal facial cues such as Emblems and

Illustrators (Ekman and Friesen, 1969) to understand a character's emotion. If a trainee doctor is presented with a virtual character who explains that they are feeling depressed, yet whose facial expression does not match the expected feelings associated with their given ethical dilemma (for example, despair, grief, fear) then the trainee doctor may be less sympathetic towards that character. The trainee doctor's response may be perceived by an assessor as unsympathetic towards the character. The candidate may fail the given task in the virtual world despite otherwise being measured as having a high level of empathy.

A trainee soldier may be less willing or delayed in their actions towards helping an injured citizen in a virtual world if there is doubt as to the actual emotion that character is attempting to convey. As a survival tactic, it is imperative that we can recognize and respond to other's emotions quickly and accordingly, to avoid potential harm. In a virtual warfare scenario, trainee soldiers must assess and respond promptly to the perceived emotional state of others, in this case to help establish them as friend or enemy (ACTIVE Lab, 2011). A delay in reaction times due to confusion as to the emotional state of a character (i.e. in deciding as to whether that character is a threat or not) may have a negative consequence for the trainee soldier. The trainee soldier may even be alarmed or put-off by the abhorrent, uncanny, facial expression of those characters he is supposed to help, resulting in a delay in his reaction times as he struggles in making an instant decision to help an injured citizen (or not). With such hesitation, the trainee soldier may become an easy target for other enemies featured in the virtual world or fail to react as quickly as they should, thus failing the given test. In this case, the uncanny may serve as a negative consequence for the participant as they fail to demonstrate their full capabilities and aptitude for performing well when under pressure.

5 LIMITATIONS AND FUTURE WORK

In experiments featured as part of this research project, characters have so far been tested in isolation. However, conversational and emotional signals are most likely to occur in verbal exchange between a sender and receiver (Ekman, 1965, 1979). For example, the brows can be employed as signals of "turn-taking" (Ekman, 1979, p. 186) when two people are engaged in conversation. The listener may use brow movements to signal that have understood what the speaker has said (Ekman, 1979; Dittman, 1972). Without facial signals such as Emblems or Illustrators that help ease the flow of conversation, the conversation may appear staged or unnatural (Ekman, 1965). Future experiments should include role-playing between at least two realistic, human-like characters, with strategic design manipulations made to control facial movement in either, or both, the sender and receiver. The results may lead to a confounding detrimental effect on perception of the uncanny in other characters if they appear to react inappropriately to facial signals (or a lack of) made by the sender or vice-versa. Similarly, the uncanny may be exaggerated if inappropriate or lacking facial signals are made by the receiver in response to what another character has said. Such incongruence between the sender and receiver may increase the magnitude of perceived uncanniness in realistic, human-like characters with aberrant facial movement.

As stated previously in this chapter, NVC is not only limited to upper facial movement. During conversation people may make mouth movements as a signal that they are about to

speak. The receiver may raise the corner of their mouth or part their lips signaling to the sender that they would like a turn in conversation (Ekman, 1979). Movements of the head and body, hand gestures, and direction of gaze can also provide conversational and emotional signals (see e.g. Ekman 1979, 2004; Ekman and Friesen, 1969, 1972; Johnson et al., 1975). Hence, future investigation into NVC and perception of the uncanny in virtual characters may be extended to other parts of the body including: mouth movements and animation in the lower face; head tilting; gaze direction; hand gestures; and the positioning and posture of the body.

6 CONCLUSION

The issues raised in this chapter suggest that the subtleties required to communicate accurate NVC in a character's facial expression may be difficult, if impossible, to replicate due to the current technical and practical limitations in the design and development process of virtual worlds. An inaccurate simulation of NVC in a realistic, human-like virtual character's facial expression may exaggerate perception of the uncanny by: preventing effective communication of the emotional state of the character; and implying ramifications of a personality disorder (bordering on psychopathic tendencies) in that character. Realistic, human-like, virtual characters are commonly being used in virtual simulations with objectives beyond that of purely entertainment purposes (ACTIVE Lab, 2011; Bergen, 2010; Bowers et al., 2010; MacDorman et al., 2010). The effect of experiencing the uncanny may have adverse consequences for those interacting with virtual characters used for training and assessment purposes. In the case of virtual worlds being used to represent real world scenarios for job applicants or trainee professionals, the implications of a lack of NVC in a characters facial expression may have a devastating effect on the outcome of how a participant performs on interacting with that character. If such confusion arises for the candidate, their ability to perform to their best possible ability may be impaired, despite their aptitude to fulfill the requirements of a given job. Interacting with characters judged as strange or uncanny may impair a user from learning new information from a character, or detract from their performance in a given test. A trainee soldier may hesitate in going to help an injured civilian in a virtual world if he cannot comprehend a clear signal of fear and distress from that character. A trainee medical student may fail to realize the mounting panic or fear in her virtual patient due to a lack of nonverbal facial cues in the virtual character and, as a result, fail to respond accordingly to the patient's needs. This may result in a user not accomplishing a task or unable to demonstrate particular skills if their performance is being monitored. It is hoped that continued experimental investigation into the importance of displaying NVC in facial expression and the cause of the uncanny in realistic, human-like characters will help establish a framework for when it is appropriate to use such characters in virtual simulations, and, importantly, when it is not.

Based on the above, it may be recommended that designers do not rely solely on the facial animation achieved by motion capture techniques to demonstrate emotion in their character designs. If the facial actions captured in the upper facial region are insufficient to demonstrate a given emotion (either during or without speech) models should be further manipulated in 3D animation software to ensure that sufficient detail is provided to communicate a given emotion effectively. Whilst this tactic may be beneficial for pre-recorded full motion video, for example, in cut-scenes or trailers featured in video games, footage rendered in real-time such as in-game

play, presents a greater challenge for the designer. Thus, it may be proposed to actually reduce the graphical fidelity of realistic, human-like characters used in real-time gaming and other virtual simulations, so that the more basic and naïve facial expression, currently achievable for animation generated on the fly, matches the character's more basic, human-like appearance. Mori (1970) warned of the dangers of pursuing highly-realistic, synthetic agents, and empirical evidence has shown that the uncanny can be increased if there is a perceived mismatch (or imbalance) between a character's graphical fidelity and their expected behavior, based on their realistic appearance. In moving to heightened graphical realism in virtual worlds, a paradox occurs. Game developers and those creating virtual worlds to simulate real world scenarios for training and testing purposes are doing so in the pursuit of suspending disbelief for the viewer. However, this increased realism simply magnifies the apparent imperfections in the characters' facial expression and behavior. This puts the viewer off and reminds them that they are confronted with a man-made, synthetic agent, rather than being fully immersed within the game or scenario. Ironically, it seems by increasing the realism of human-like, virtual characters the character appears *less*, not more, believable for the viewer.

A lack of NVC in character's facial expression is just one example of how increased realism may impact on a viewer's engagement with a virtual world. There still remains unanswered questions as to the complexity of the cognitive and affective processes by which one interprets and responds to other's facial expression in humans. Until the complexities of emotion recognition are fully understood and developers are made fully aware of such processes (in addition to their advanced technical expertise), it may be that developers are simply setting themselves up for failure in trying to suspend disbelief for the viewer and simulate perception of emotion with increasing realism in virtual worlds. To improve upon this current circumstance, a greater synergy between the disciplines of psychology and animation may be required, rather than leaving all character development work to the hands of the developers. Combining knowledge gained from psychology, such as a typical profile of nonverbal responses in psychopathy, or how NVC may be relied upon in real-life scenarios to detect untruths, with a synthesis of research findings of perception of the uncanny in virtual characters may provide a new direction as to the cause of the uncanny. This is a matter for future discussion and debate.

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