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Published in:
Journal of Gaming & Virtual Worlds

Publication date:
2010

Document Version
Early version, also known as pre-print

2010

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Abstract

This study investigates the relationship between the perceived strangeness of a virtual character and the perception of human likeness for some attributes of motion and sound. Participants (N=100) were asked to rate thirteen video clips of twelve different virtual characters and one human. The results indicate that attributes of motion and sound do exaggerate the uncanny phenomenon and how frightening that character is perceived to be. Strong correlations were identified for the perceived strangeness of a character with how human-like a character's voice sounded, how human-like the facial expression appeared and how synchronized the character's sound was with lip movement; characters rated as the least synchronized were perceived to be the most frightening. Based on the results of this study, this article seeks to define an initial set of hypotheses for the fear-evoking aspects of character facial rendering and vocalization in survival horror games that can be used by game designers seeking to increase the fear factor in the genre, and that will form the basis of further experiments, which, it is hoped, will lead to a conceptual framework for the uncanny.

Keywords

horror games
Uncanny Valley
characters
realism
facial expression
audio-visual speech

Introduction

With an alluring ensemble of freakish, monstrous characters seeking to challenge and destroy players, the survival horror game genre deliberately gratifies the pleasure humans seek in frightening themselves. Players rely on weaponry with survival tactics to defend themselves from the onslaught of horrific monsters that commonly display an abnormal, nonhuman-like appearance and behaviour. Mindless, antipathetic zombie characters such as the grey, scrawny Witch and the formidable, brawny Tank endlessly pursue empathetic characters such as Louis

and Francis in *Left 4 Dead* (Valve 2008). In the game, *Silent Hill Homecoming* (Konami 2008), the protagonist, Alex Shepherd, is hunted by ghastly humanoid mutants such as the 'Schism', whose elongated head serves as a brutal blade, and Siam, a mutilated creature, who combines a male body in the front and female body at the back, both of which bear no eyes. *Resident Evil 5* (Capcom 2009) sees the protagonist, Chris Redfield, encountering a breed of zombies that have been infected by a parasite known as the *Majini* (translated as 'evil spirit'). New releases for 2010 include *BioShock 2* (2K Games 2010) and *Calling* (Hudson Soft 2010), which promise the ambush of ghost-like creatures and the swarming of zombie hordes to haunt and terrify players.

All video games are digitally created and all rely on player input to trigger the majority of the events, images and sounds with this interactivity contributing to player engagement and immersion (e.g. McMahan 2003; Calleja 2007; Grimshaw et al. 2008; Schneider et al. 2007). Whilst video games differ from cinema in their digital origin and their interactive and typically immersive environments, the premise of creating fear for a player within the survival horror game genre can be attributed to the contemplation and confrontation with grotesque, nonhuman-like beings, and in this, is no different from horror cinema.

Some cinematic theorists argue that the success of certain films created within the classic horror cycle of Hollywood films was due to an uncanny modality that evolved as viewers experienced the transition from silent to sound cinema. Spadoni states that the success of the films *Dracula* (Browning 1931) and *Frankenstein* (Whale 1931) was partly due to the timing of the films' releases in relation to the sound transition timeline (Spadoni 2000: 2). At a time when Hollywood was moving from silent to sound cinema, horror film directors were able to exploit the technical limitations of the new medium to increase how creepy their films were perceived to be. Sounds that may have been perceived as unnatural or odd due to the technical restrictions at the time, were used to the advantage of *Dracula* and *Frankenstein*, to create a greater sense of fear for the viewer, thus setting them apart from other horror films. Image and sound were used to elicit sensations of fear and dread for the character Dracula. Critics were impressed with the haunting textures and qualities of Dracula's speech, whilst inaccuracies in the synchronization of sound with image also evoked a sense of the uncanny for the viewer. The nonhuman-like grunts and snarls exaggerated the uncanny for the monster Frankenstein (Spadoni 2000: 94).

As yet, no one has investigated how the cross-modal factors of motion and sound may influence the uncanny for video game characters. Our study investigates the relationships between how strange a virtual character is perceived to be and perceived human-likeness of motion and sound. Initial results indicate that certain attributes, such as facial expression, synchronization of lip movement with the voice and the particular qualities of a character's speech, do exaggerate the uncanny phenomenon and, potentially, how frightening a character is perceived to be. Our study builds upon previous work by using an experimental methodology that concentrates on not only the image (a moving image in this case), but also the sound. As part of a larger ongoing body of work, the results from this study, we hope, will lead to precise cross-modal definitions of the uncanny.

Context

The image modality

In working towards an understanding of what causes certain things to lie within a field of what is frightening or uncanny, Freud (1919) made reference to an essay, 'On the Psychology of the Uncanny', by Jentsch (1906), which first initiated the subject of the uncanny in contemporary thought. Freud (1919: 226) acknowledged Jentsch's argument that the uncanny is a mental state instilled when one cannot distinguish between the living and the dead or between what appears to be animate or inanimate: the feeling caused by 'waxwork figures, ingeniously constructed dolls and automata'. Freud describes an affinity between the uncanny and a doppelganger. The replica of a human at first represents an assurance against death. Trepidation then emerges as one realizes that the doppelganger actually represents the inevitability of one's death, 'a ghastly harbinger of death' (1919: 235).

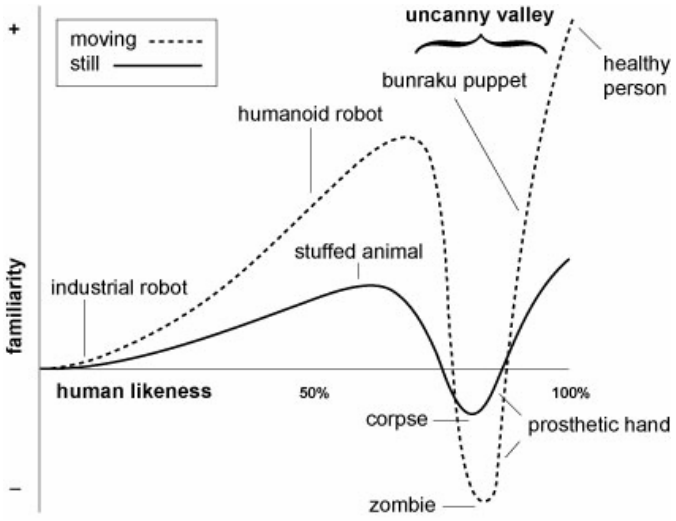

Figure 1: Mori's plot of perceived familiarity against human-likeness as the Uncanny Valley taken from a translation by MacDorman and Minato of Mori's 'The Uncanny Valley'.

Building on the theory of the uncanny, the roboticist Mori (1970) (trans. MacDorman and Minato 2005), observed that as a robot's appearance becomes more human-like it is perceived as familiar to a viewer, until finer nuances from human norms cause them to appear eerie, evoking a negative effect for the viewer (see Figure 1). The positive relationship Mori identified between the perceived familiarity of a robot with human likeness is inverted at a certain point where the robot is perceived as more strange than familiar. This sudden negative relationship occurs at the point where the robot appears close to being human, and is referred to as the 'Uncanny Valley'. Mori included corpses, zombies and lifelike prosthetic limbs as examples of things that lie in the Uncanny Valley and predicted that this phenomenon would be even more exaggerated with moving objects. For robot designers Mori recommended developing mechanical-looking, humanoid robots instead of complete androids. To avoid the risk of falling into the Uncanny Valley, Mori suggested that designers aim for the first valley peak and not the second.

Attempts to increase realism in video games can result in characters not intended to evoke an uncanny sensation of being plunged into the Uncanny Valley as they convey corpse-like attributes that mimic the appearance of zombies. For example, the facial appearance and expression of a player's comrades in the video game, *Quake 4* (Raven Software 2005), have

been criticized as appearing false and uncanny. Members of the Rhino Squad marines such as Corporal Matthew Kane and Lieutenant Scott Voss were taunted as having an appearance similar to that of a human who had undergone unsuccessful cosmetic facial surgery, being left with an artificial and unnatural result (Thompson 2005). Similarly, the Uncanny Valley phenomenon has resulted in the most unlikely of video game characters being compared to Frankenstein's monster. The character, Ann Darrow, in the video game *King Kong* (Ubisoft Entertainment 2005), may have been expected to be perceived as a beautiful heroine, evoking empathy from players as they strive to protect her from enemies within the game, such as Cave Serpents and Swarm Spiders. Yet, Ann Darrow was described as monstrous, with characteristics such as her skin, mouth movement and eyes regarded as comparable to those characteristics of monsters intended to be offensive (Thompson 2005).

> 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)

The title Mori originally used for the Uncanny Valley was *bukimi no tani*. In Japanese, the word *no tani* stands for valley and the word *bukimi* stands for 'weird, ominous, or eerie' (Bartnek et al. 2009: 270). In English, connotations of the word uncanny include 'unfamiliar, eerie, strange, bizarre, abnormal, alien, creepy, spine tingling, inducing goose bumps, freakish, ghastly and horrible' (MacDorman and Ishiguro 2006: 312). The term *eerie* has been attributed to robots that elicit an uncanny sensation for the viewer (Ho et al. 2008; MacDorman 2006). The emotion term 'fear' has also been identified as a strong indicator of both the uncanny and the strange qualities attributed to an uncanny robot (Ho et al. 2008). MacDorman (2006) stated that the principles of Mori's theory of the uncanny can work to the advantage of engineers when designing robots with the purpose of being unnerving within an appropriate setting and context. Based on the success of the horror game genre, MacDorman notes that the perception of the

uncanny does not always serve as a negative impact for the viewer. With words such as 'eerie', 'creepy', 'ghastly' and 'fear' used to interpret the uncanny, we suggest that, for our study, if a character is regarded as more strange than familiar, they may elicit qualities for the viewer appropriate for the horror game genre. Indeed, the uncanny may enhance the overall experience for a viewer if they seek to experience the 'spine tingling' sensations associated with the uncanny.

For virtual characters it seems that, as Mori predicted, anthropomorphic or humanoid characters with a nonhuman-like appearance but that may exhibit human-like traits that are placed before the first peak of the valley (Schneider et al. 2007; Tinwell 2009). However, such results raised the question as to why only some nonhuman-like characters are placed in the uncanny valley and not 'all'. For example, why might the animated character Shrek (Adamson 2001), with a clearly nonhuman-like appearance of green skin with contorted facial features, but with smooth motion and a human-like voice, escape the uncanny, whilst a gremlin character with a similar appearance and behaviour is less likely to? Kang (2009) proposed that an uncanny sensation may occur when a particular character is perceived as a threat, over which the viewer has little or no control. If there is no or little threat, characters such as Shrek may be regarded as cute and amusing, reminding us of childhood play: 'the object's taking us back to the pleasure of childhood play, in a world of infinite imaginative possibilities' (Kang 2009: 53). Yet, if we are presented with an object that threatens our understanding of the world and the human species, a disruption of our 'worldview' (Kang 2009: 50), the encounter could be more traumatic. In defence of our very own existence, we will condemn objects such as high-fidelity, human-like characters and androids if we perceive that we have little or no control over a given situation. Those objects that threaten to replace or challenge the human race may elicit terror, hence placing the object within the Uncanny Valley. Kang (2009: 57) states that 'any object, event or situation that disrupts our normal worldview commands attention, but with differing levels of emotional reaction that is determined by how much of a threat it poses to the schema as a whole'. In the context of video games, further investigation is still required to ascertain which characters we are willing to tolerate and those that may cause alarm regarded as beyond the parameters of our control. We hope this article will form the basis for future research into viewer reaction and the uncanny in video games to allow games developers to make informed

decisions as to whether to design characters either *for* or *against* the uncanny, based on the intended reaction they wish the viewer to experience.

Working towards identifying factors that contribute to the uncanny for robots, Ho et al. (2008: 175–6) observed that aspects of a robot's appearance and motion quality strongly influence how people feel about robots and that the uncanny can be exaggerated if there is a mismatch in the degree of human-likeness of a robot's appearance and motion, for example, 'humanlike eyes and teeth […] combined with its absence of skin or hair'. Other authors suggest that, for androids, if human-like appearance causes us to evaluate an android's behaviour according to a human paradigm, we are more likely to be aware of deviations from human norms; a robot is eeriest when a human-like appearance creates an expectation of a human form (Matsui et al. 2005).

Brenton et al. (2005) proposed that a high level of graphical realism in a character's appearance raises high expectations for a character's motion and behaviour. If the quality of motion and behaviour does not match up with the character's realistic, human-like appearance, it can increase the perception that the character is not real, thus evoking a sense of the uncanny. (Laurel [1993: 164–5] makes a similar point in suggesting that there is an expectation that different modalities have the same resolution – in this case, she is talking about the sensory modalities of vision and sound but we suggest that the same principle holds for visual appearance and motion and behaviour.) Brenton et al. (2005) propose that experiments should be conducted to test this theory using realistic, virtual characters from film and animation as opposed to interactive characters (where high graphical realism may be less achievable). Kevin Walker, of the facial animation company, Image Metrics, states that the realistic facial animation that they have so far achieved for film and television can also be achieved for animation in video games; it is just not *yet* possible for a real-time gaming environment: 'We can produce Emily-quality animation for games as well, but it just can't work in a real-time gaming environment' (quoted in Ashcraft 2008). Walker also suggests that video games would benefit from these more realistically rendered faces; game developers look to realism in characters to increase player engagement and immersion. For contemporary games, the company, Areo Cinematic Games, combines skills in film production with video game design to

produce realistic, cinematic 3D environments for video games. (Authors such as McMahan [2003] and Grimshaw [2008b] suggest that what is required to enhance immersion and engagement is less a mechanical and physical realism and more a perceptual realism.) To analyse user responses to the uncanny, our study uses virtual characters from film and animation, autonomous social agents and characters from video games (in addition to a filmed human). The findings from this study suggest that whilst the current restrictions for interactive characters can exaggerate the uncanny, this works to the advantage of zombie-type characters in the survival horror game genre, which are intended to be regarded as strange. However, for realistic, human-like characters, for which the game designer has not intended such a reaction, the current limitations in technology raise a viewer's awareness that the character does not behave in a way that they would expect based on their realistic appearance.

The sound modality

There is a relatively large body of work that investigates the semantics of sound in a variety of contexts, and some of this includes the potential of sound to arouse the more negative emotions associated with the uncanny. A very brief survey would list the work of Edworthy et al. (1991) on sonic parameters affecting perceived urgency; work on defining a functional semantic framework for sound by Ballas (1994), in which, among other points, he discusses the exclamatory (that is, alarm-like) function of sound and relates this to various sonic parameters; and the soundscape studies of Schafer (1994).

Thus far, there has been little work on the uncanny nature of sound in the context of virtual characters' sounds other than references to lip synchronization with speech. Quantic Dream's tech demo 'The Casting' for the video game, *Heavy Rain* (2006), was first revealed at the third Electronic Entertainment Expo in 2006 and the main character, Mary Smith, received criticism for being uncanny. MacDorman (quoted in Gouskos 2006) states that a lack of synchronization with speech and lip movements was one of the factors that people found disturbing about this character:

> In addition, there is sometimes a lack of synchronization with her speech and lip movements, which is very disturbing to people. People hear with their eyes as well

> as their ears. By this, I mean that if you play an identical sound while looking at a person's lips, the lip movements can cause you to hear the sound differently.
>
> (Gouskos 2006)

The video game *Heavy Rain* is classified within the Action genre of video games. The character, Mary Smith, may have been intended to evoke an empathetic reaction from the viewer, yet in this case, it seems the uncanny has worked against this character, evoking an antipathetic, negative reaction from the viewer.

Work on the uncanny has been almost exclusively visually based. There has, however, been some work, in the field of computer games, on the fear potential of sounds. Grimshaw (2008a) proposes a conceptual framework of sound in First-Person Shooters and includes a discussion of the semantics of alarms in such a context, and discusses some general heuristics for uncanny sound in computer games (Grimshaw 2009). Ekman and Kajastila (2009) conducted a small-scale study, the results of which suggest that making the localization of sound (that is, the ability to perceive the location of the sound source) difficult increases the fear factor. Kromand (2008: 18) identifies a horror game soundscape that 'operates within a framework of uncertainty that constantly holds the player between knowledge and ignorance'. Diegetic sound in survival horror games borrows many of the conventions and clichés of diegetic sound in horror films. Sound for which there is no identifiable on-screen visual source 'intensifies causal listening in taking away the sense of sight' (Chion 1994: 32), and this, for Chion, enhances the mysteriousness of such acousmatic sounds. In the horror genre (film or game), this is the sound that goes bump in the night. In our study, we chose to concentrate on the class of sounds that is diegetic game speech (and its relationship to the visual game character) because the study of the effect of sound on the uncanny is, as mentioned above, an under-researched area in a field of enquiry that is predominantly visually biased.

Cross- modality

Our article only makes a start in investigating the implications of uncanniness in the relationship between the image and sound modalities. There exists a relatively large body of work on this cross-modal relationship and, indeed, some authorities argue that in some contexts the senses

operate together in the perception of a single event (Warren et al. 1982, for instance). Anderson (1996: 82) states that '[p]erception is an information-gathering activity. And when it occurs in two or more sensory modes simultaneously, it is a process of information comparison, an active search for cross-modal confirmation', and Gröhn et al. (2001) discuss the concept of cross-modal confirmation in the context of virtual environments. Gaver (1993), working from an ecological conception of perception as Anderson does, notes there is often a connection between an object or the organism's physical properties and its typical, defining sound, for example material and size (parameters easily represented in virtual worlds): metal objects tend to have brighter timbres than wooden objects and larger objects tend to produce louder and deeper sounds than smaller objects (think of an elephant and a mouse). Perhaps, subverting such relationships in survival horror games could increase the level of uncanniness and fear by aiding in the creation of a 'framework of uncertainty'.

Spadoni (2000: 58–60), discussing the horror genre in early sound cinema, equates much of the uncanny with a lack of perceived synchronization between image and sound. Human laughter is perceived as ghostly, incorporeal laughter because it appears not to emanate from the mouth of the character on screen. This is, in fact, precisely the case and remains so to this day. Cinema speakers, and home entertainment system and computer speakers (and headphones) are physically separate from the screen displaying the image. It took some time for Chion's (1994) 'audio-visual contract' to be established for sound cinema and several different methods of film sound recording and reproduction to be tried and tested before audiences were willing to accept the source of a sound to be the character on screen. This convention of acceptance of synchronization between on-screen image and (physically) off-screen sound goes under several labels such as 'synchresis' (Chion 1994) or 'synchrony' (Anderson 1996) and, in the field of psychoacoustics, the 'ventriloquism effect' (e.g. Warren et al. 1982). (Presumably, there will be no need for such perceptual deceit once flat-panel loudspeakers with accurate point-source technology provide a simultaneous visual display.) Part of our methodology for the experiment detailed here deals with issues such as the perception of voice–character mismatch and asynchrony between speech and lip movement.

Along with previously mentioned differences between cinema and computer games (and the possibilities of the navigational mode of listening [Grimshaw 2008a: 32] and kinaesthetic interaction [Stockburger 2003: 9] inherent in games), there are other ways in which the two mediums differ. These have an effect on the conjunction between image and sound and, as a result, have an effect on the sense of the uncanny. While the quality of individual audio samples (a footstep or a scream, for example) may be viewed as realistic (and are often recorded directly from their real-life correlates should such exist), the quality of the resultant soundscape (the combination of simultaneously sounding audio samples), while often impressive, is much less realistic, particularly in its representation of acoustic space. This is directly due to the lack of computer processing power and this same technical deficiency accounts for the low levels of image realism in the game (especially for animated characters). Real-time graphics cannot compete with the potential realism of film graphics. Another important difference between the survival horror game genre and the horror film genre is that there are rarely any close-ups of characters' faces during gameplay. Should such a thing occur for a significant span of time, and should the character be speaking, then it may well be that the technical limitations of real-time processing would contribute to a sense of the uncanny by destroying the perception of synchresis. This uncanny effect would accord with the results noted in our experiment where there was a strong correlation between a sense of uncanniness and a lack of lip/sound synchronization. Two things should be borne in mind though: the experiment was not run in a game-like context, and statistical association (as indicated by the high correlate) is not necessarily statistical causality. Future experiments can be designed to test the degree of causality between lack of synchronization and uncanniness, for example, adjusting a character's speech over a range of onset asynchronies within a game-like context.

Method

The participants (N = 100), of which 92 were males and eight females, were mainly university students from the School of Games Computing and Creative Technologies at Bolton University, in addition to professionals working within the academic sector and video games industry. Students were selected from the Computer Games Design, Computer Games Software Development and Computer Games Art courses. The majority of participants had advanced experience of playing video games (83 per cent), with 14 per cent of participants having a basic

level and only 3 per cent of participants with no previous experience of playing video games. In all 63 per cent of the participants had a basic level of experience of using 3D modelling software, 23 per cent an advanced level and 13 per cent no experience of using this type of software. In all 84 per cent of the participants were within the age range between 18 and 24 years, 10 per cent between 25 and 30 years and 6 per cent above the age of 31 years.[1]

Participants were presented with twelve video clips of a selection of virtual characters and one video clip of a real human placed in different settings and engaged in different activities (see Figure 2). The video clips included six realistic, human-like characters: (1) the *Emily Project* (2008a) (2) and the Warrior (2008b) by Image Metrics; (3) Mary Smith from Quantic Dream's tech demo, 'The Casting' (2006); (4) Alex Shepherd from *Silent Hill Homecoming* (Konami 2008); two avatars, (5) Louis and (6) Francis, from *Left 4 Dead* (Valve 2008); four zombie characters, (7) a Smoker, (8) The Infected, (9) The Tank and (10) The Witch, from *Left 4 Dead*; (11) a stylized human-like Chatbot character, 'Lillien' (Daden Ltd. 2006); (12) a realistic, human-like zombie ('Zombie 1') from the video game, *Alone in the Dark* (Atari Inc. 2009); and (13) a real human.

Figure 2: The thirteen characters used in the experiment.

The participants were asked through a web-based questionnaire to rate on a 9-point scale how human-like they perceived the character to be from 1 (*nonhuman-like*) to 9 (*very human-like*).[2] To measure the perceived uncanniness of a character, the participants were asked to rate

how strange or familiar they perceived the character to be from 1 (*very strange*) to 9 (*very familiar*). The participants rated how human-like the character's voice sounded and how human-like the facial expression appeared using a scale from 1 (*nonhuman-like*) to 9 (*very human-like*). The participants were asked to select from five statements that best described qualities of the character's speech: (1) the voice is slow, (2) the voice is monotone, (3) the voice is of the wrong pitch/intonation, (4) the voice sounds as if it belongs to the character or (5) none of the above. For facial expression, the participants selected parts of the character's face that either appeared exaggerated or showed a lack of facial expression, including (1) cheeks, (2) forehead, (3) eyes and (4) mouth. Participants could select option (5), no observed exaggeration or no observed lack, if, in their opinion, this was not applicable for a character. The participants were also asked to rate how synchronized the character's voice appeared to be with lip movement from 1 (*not synchronized*) to 9 (*perfectly synchronized*). The video clips were played in random order to each participant.

Results

An assessment of internal consistency reliability revealed satisfactory values for this experiment; Cronbach's α was 0.94 or higher for scales used to measure perceived human-likeness and familiarity (see Figure 3), synchronization of speech with lip movement (see Figure 4) and perceived human-likeness for voice and facial expression (see Figure 5) for virtual characters. All Pearson correlation coefficients presented in this article are significant at the ($p <$ .01) level.

Table 1: Mean scores for perceived familiarity, human-likeness, lip synchronization and human-likeness for voice and facial expression. Note: Judgments were made on 9-point scales; familiarity (1 = very strange, 9 = very familiar); lip-sync (1 = not synchronized, 9 = perfectly synchronized) and from (1 = nonhuman-like, 9 = very human-like), for human-likeness, voice and facial expression

Character and Number	Mean score				
	Familiarity[a]	Human-like[b]	Lip-sync[c]	Voice[d]	Expression[e]
The Tank (9)	2.33	2.39	3.08	2.25	2.72
The Witch (10)	2.4	3.28	3.34	2.76	3.04
Chatbot (11)	2.99	3.23	2.51	2.68	2.39
Zombie 1 (12)	3	5.24	4.89	4.23	4.88
The Infected (8)	3.1	4.43	3.55	2.88	3.42
The Smoker (7)	3.21	4.19	3.34	2.29	3.32
Mary Smith (3)	4.53	6.63	3.52	7.54	5.37
The Warrior (2)	5.23	7.68	7.35	6.37	7.22
Alex Shepherd (4)	6.38	6.84	5.27	7.78	6.18
Francis (5)	6.8	7.34	6.89	7.75	6.85
Louis (6)	7.02	7.27	7.16	8.04	6.92
Emily (1)	7.25	8.67	8.61	8.8	8.4
Human (13)	8.26	8.8	8.46	8.79	8.6

[a] $M = 4.81$, $SD = 2.11$, $SEM = .59$

[b] $M = 5.85$, $SD = 2.17$, $SEM = .60$

[c] $M = 5.23$, $SD = 2.20$, $SEM = .61$

[d] $M = 5.55$, $SD = 2.71$, $SEM = .75$

[e] $M = 5.33$, $SD = 2.20$, $SEM = .61$

Table2: Pearson correlation (*r*) values between perceived familiarity with perceived human-likeness, lip-synchronization, human-likeness of voice and facial expression, for the thirteen stimuli within the experiment

	Familiarity	Human-like	Lip-sync	Voice	Expression
Familiarity	1	.93*	.89*	.94*	.94*
Human-like	.93*	1	.91*	.95*	.98*
Lip-sync	.89*	.91	1	.84*	.96*
Voice	.94*	.95*	.84*	1	.94*
Expression	.94*	.98*	.96*	.94*	1

*. Probability < .01 (2-tailed)

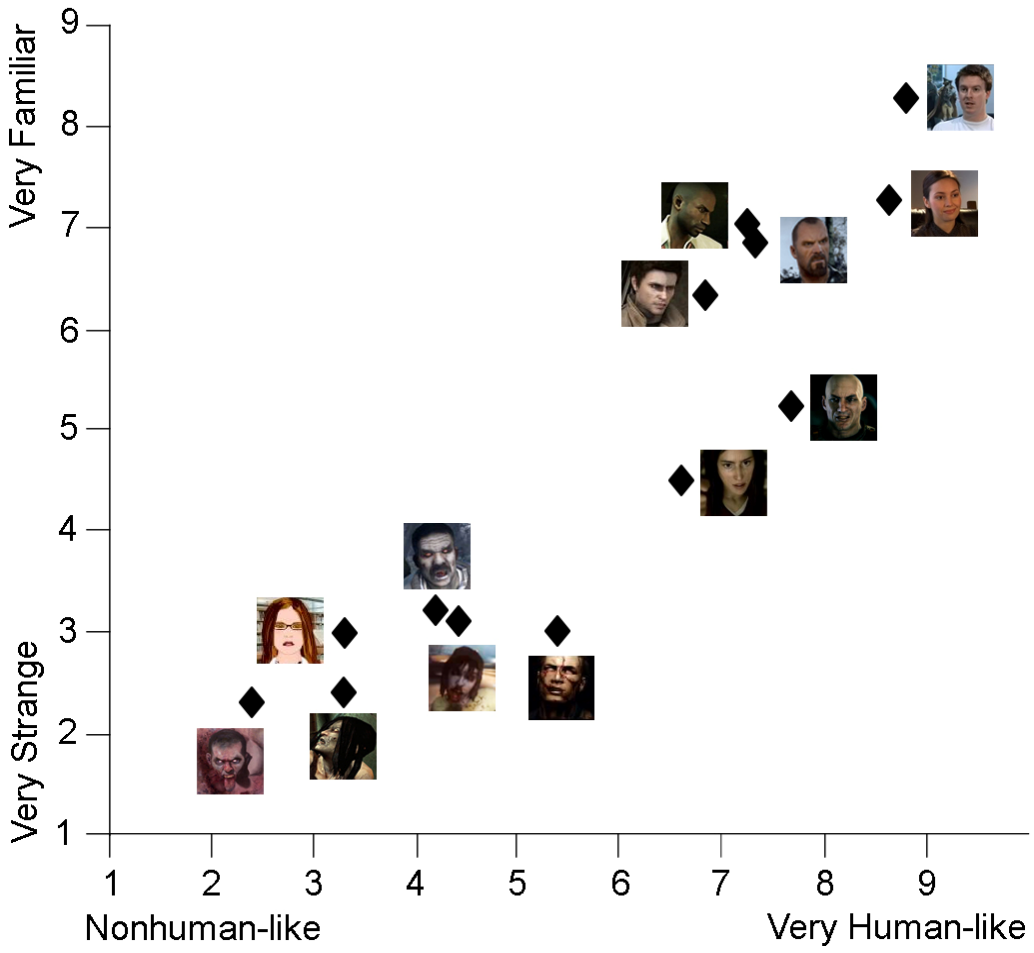

Figure 3: Mean ratings for how human-like a character was perceived to be against mean ratings for perceived familiarity.

The mean rating for familiarity was 4.81 (*SD* = 2.11, *SEM* = .59) (see Table 1). The correlation between perceived human-likeness and perceived familiarity was *r* = .93.

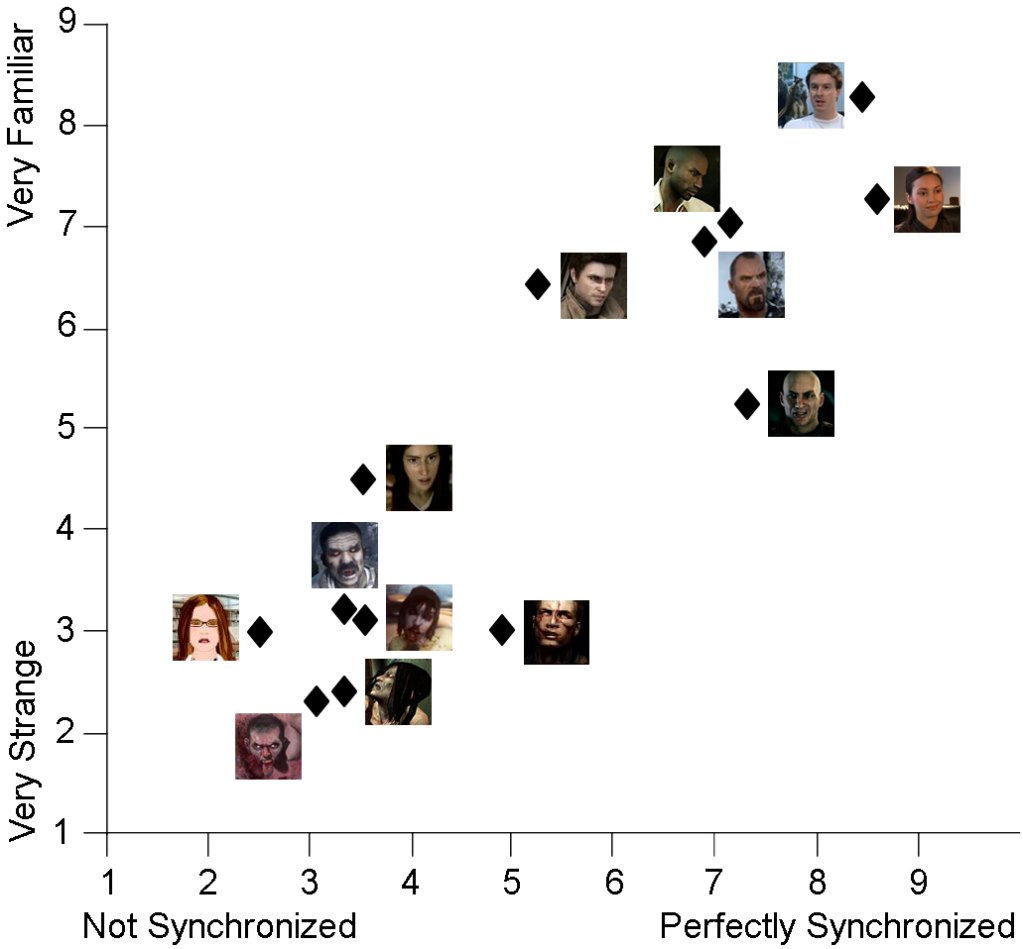

Figure 4: Mean ratings for the perceived strangeness of a character and the mean ratings for synchronization of sound with lip movement.

The results revealed a high correlation of r = .89 between how strange a character is perceived to be and the lack of synchronization of sound and lip movement.

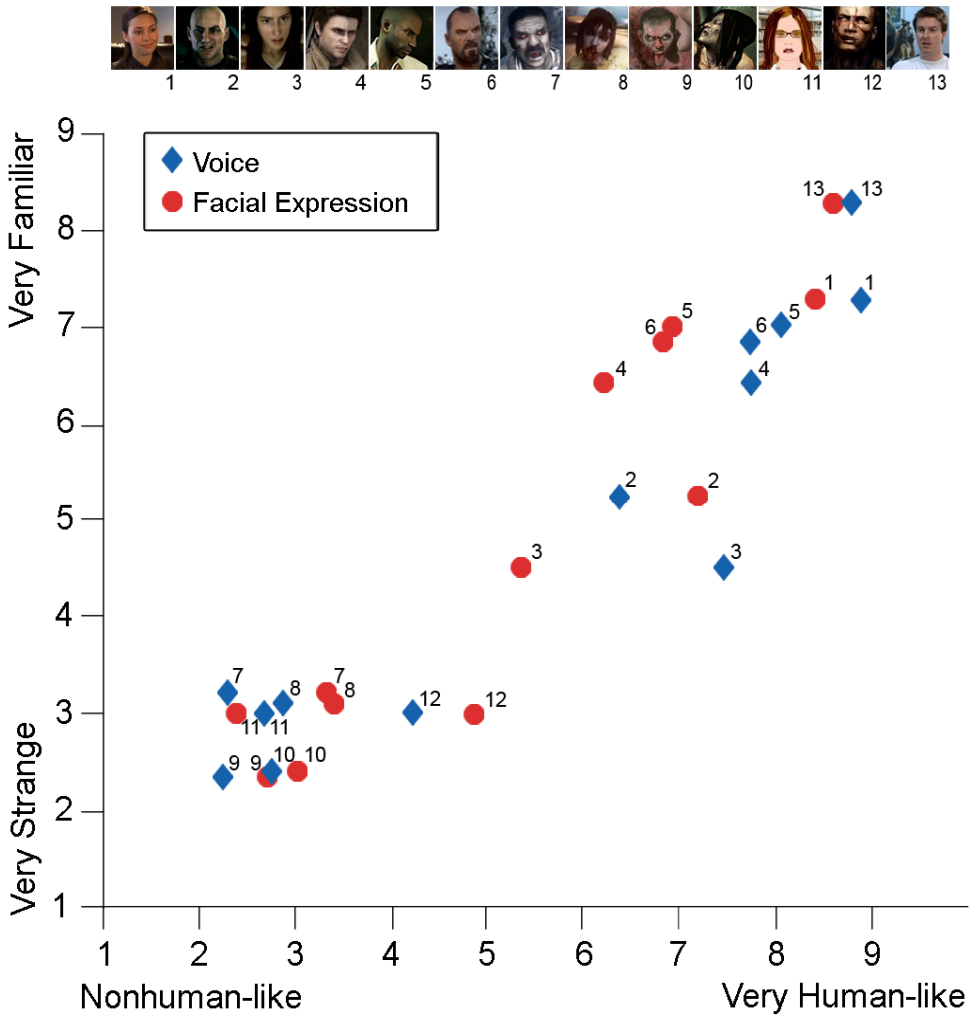

Figure 5: Mean ratings for how strange or familiar a character is perceived to be against perceived human-likeness for a character's voice and facial expression.

The results revealed a correlation of $r = .94$ between how familiar a character was perceived to be and how human-like the character's voice was perceived to be. A correlation of $r = .94$ was also measured between how familiar a character was perceived to be and how human-like facial expression was perceived to be.

Qualities of speech

To assess which speech qualities contribute to the voice of a virtual character being regarded as less human-like, median values were calculated as an indicator of a central tendency for a

character's strangeness rating along with median ratings for speech quality: whether the speech seemed (1) slow, (2) monotone, (3) of the wrong intonation, (4) did not appear to belong to a character or (e) none of the above.

Table 2 shows the median strangeness values for the thirteen characters. With thirteen characters it was difficult to establish a clear overall picture of the vital relationships over multiples of speech, so characters with the same median value for strangeness were grouped together in order that vital relationships were made evident for the grouped data. The median values for the different attributes of speech quality were then calculated for these grouped characters. For example, the characters The Infected, The Smoker, Zombie 1 and the Chatbot all had a median strangeness value of three and were therefore grouped together. The median values for qualities of speech for this character group were then calculated out of 400 responses (100 participant responses for each of the four characters in the group), with the median values of *Slow* (24), *Monotone* (21.5), *Wrong intonation* (40), *Belongs* (*to the character*) (42) and *None* (8.5), also shown in Table 2. If there was just one character with a particular median value for strangeness, then the median values were calculated as a possible rating out of 100 responses. For example, the character Emily was the only character with a median strangeness value of eight, so the results show the median speech ratings for this one character of *Slow* (2), *Monotone* (0), *Wrong intonation* (2), *Belongs* (*to the character*) (87) and *None* (6). Although grouping the characters has hidden much of the original detail for the results, this method provides a clear overall picture as to the fundamental relationships that are associated with the perceived strangeness for a virtual character.

Table 2: Median ratings for speech qualities for those characters or groups with the same median strangeness value. Note: Judgments for strangeness were made on 9-point scales (1 = very strange, 9 = very familiar). For speech qualities, median values were calculated out of a total of 100 participants for each character or as a total of 100 × *N* for each data group.

Median strangeness for character or group	Slow	Monotone	Wrong intonation	Belongs	None
The Tank, The Witch, (*Mdn* = 2)	10	9.5	23.5	56.5	16.5
The Infected, The Smoker, Zombie 1, Chatbot, *(Mdn* = 3)	24	21.5	40	42	8.5
Mary Smith, (*Mdn* = 4)	8	3	20	20	8
The Warrior, Alex Shepherd, (*Mdn* = 6)	14	17	17	62.5	7.5
Louis, Francis, *(Mdn* = 7)	2.5	3.5	6.5	79.5	4.5
Emily*, (Mdn* = 8)	2	0	2	87	6
Human, *(Mdn* = 9)	1	15	4	72	6

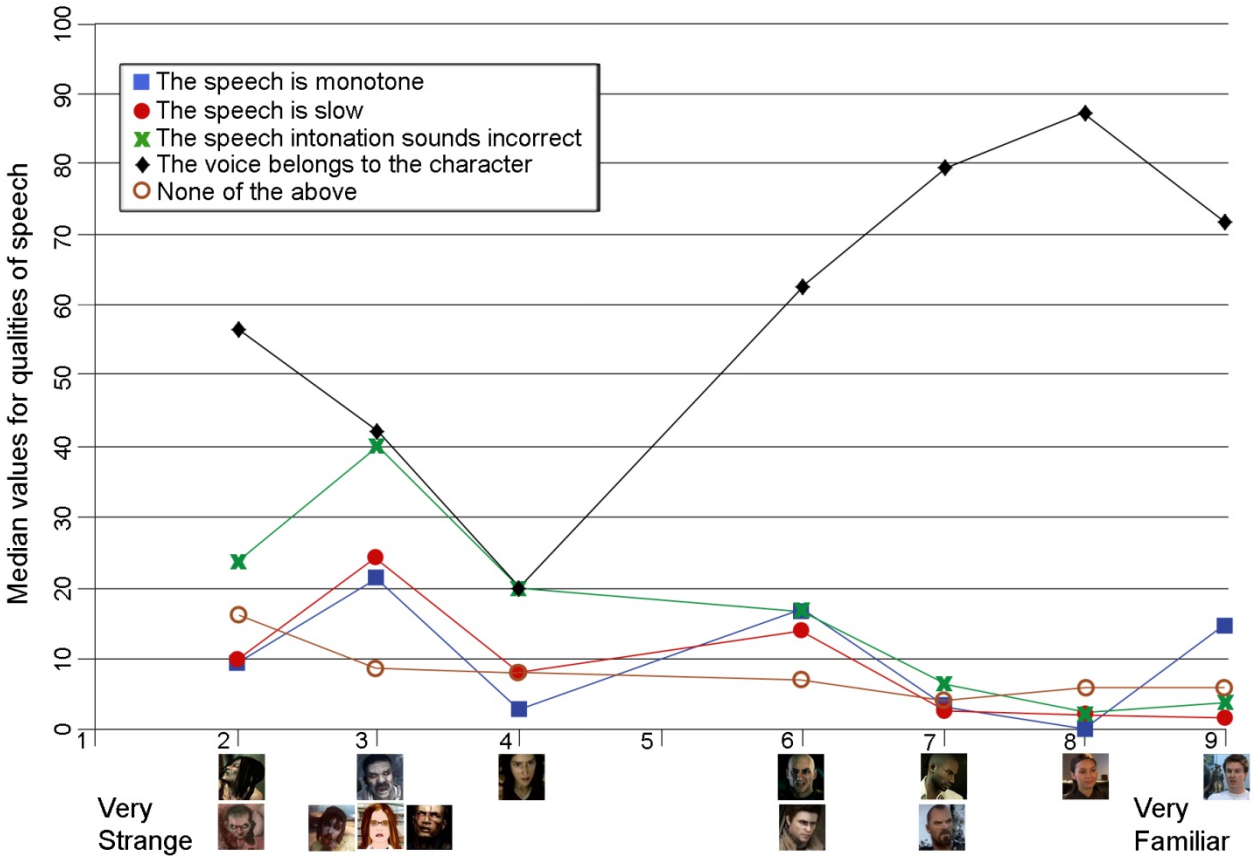

Figure 6: Median strangeness ratings for characters (or groups with the same median strangeness) against median ratings for qualities of speech.

Figure 6 shows the median strangeness ratings for the thirteen characters in Table 2. Median values for speech qualities were then calculated for those characters or groups with the same median value for strangeness. The plot for 'the speech intonation sounds incorrect' and 'the voice belongs to the character' are almost mirror images, indicating that achieving the correct intonation for a voice, in keeping with what the viewer may have expected for that character, might be a contributing factor towards the believability of a character. Characters with the same median value for strangeness can show quite different median values for different speech qualities.

Facial expression

The results from this experiment show a strong correlation of $r = .94$ for the perceived familiarity of a character with how human-like the character's facial expression is perceived to

be (see Figure 5). To investigate which factors of facial exaggeration contributed to the uncanny for virtual characters, median values were calculated for a character's strangeness rating and those characters with the same median value for strangeness were grouped together. The same method of median grouping used for speech qualities was applied to these results in order to determine a clear overall picture as to the relationships between facial expression and perceived uncanniness. The median ratings for a perceived lack of facial expression and a perceived over-exaggeration of facial expression were then calculated for characters or groups with the same median strangeness value including the forehead, eyes, cheeks and mouth (see Table 3).

Table 3: Median ratings for a perceived lack of and over-exaggeration of facial expression for characters or groups with the same median strangeness value. Note: Judgments for strangeness were made on 9-point scales (1 = very strange, 9 = very familiar). For lack of facial expression and an exaggeration of facial expression, median values were calculated out of a total of 100 participants for each character or as a total of 100 × *N* for each data group

Mdn Strangeness for character or group	Forehead		Eyes		Cheeks		Mouth		None	
	Lack	Over	Lack	Over	Lack	Over	Lack	Over	Lack	Over
The Tank, The Witch (*Mdn* = 2)	57.5	4	52.5	26	54.5	4.5	38.5	37.5	26.5	51
The Infected, The Smoker, Zombie 1, Chatbot (*Mdn* = 3)	59	3	51.5	16.5	55	2.5	30	35	21.5	56.5
Mary Smith (*Mdn* = 4)	46	4	19	24	47	8	18	62	31	27
The Warrior, Alex Shepherd (*Mdn* = 6)	32	11	13	21	26.5	15	9	35.5	52	48
Louis, Francis (*Mdn* = 7)	31.5	10	15.5	23	20	6	10	18.5	53	59
Emily (*Mdn* = 8)	14	2	3	6	12	10	1	17	79	78
Human (*Mdn* = 9)	6	9	8	7	5	0	3	7	86	83

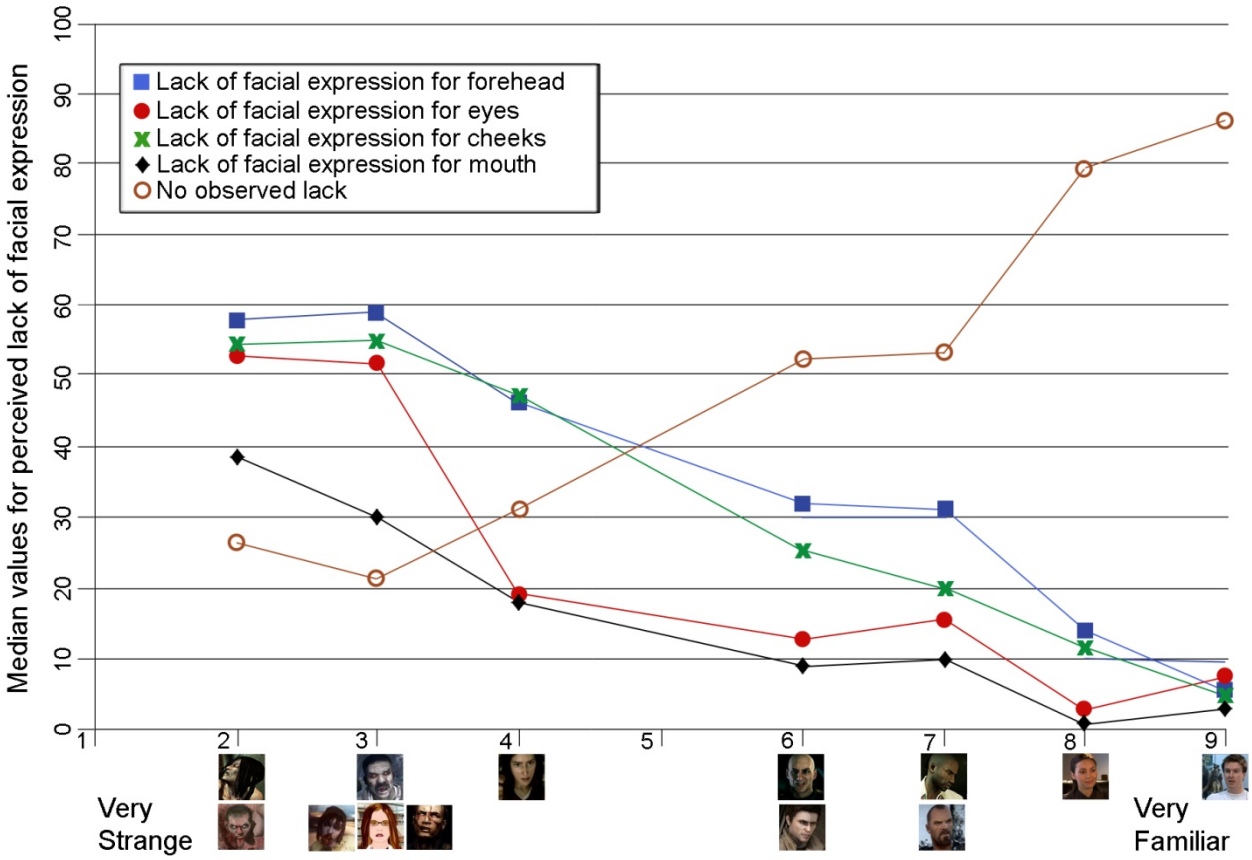

Figure 7: Median ratings for strangeness against median values for a perceived lack of facial expression for those characters or groups with the same median strangeness value.

Figure 7 shows an overall pattern where participants had a heightened awareness of a lack of facial expression for characters rated as more strange than familiar. The character groups perceived as more strange than familiar with median strangeness values 2 and 3 had significant increases in a participant's perception of a lack of emotional expressivity for the forehead, cheeks and eyes (see Figure 7). Overall, a strong indirect correlation of $r = -.98$ was calculated for individual responses, between no observed lack of facial expression and a lack of facial expression in the forehead.

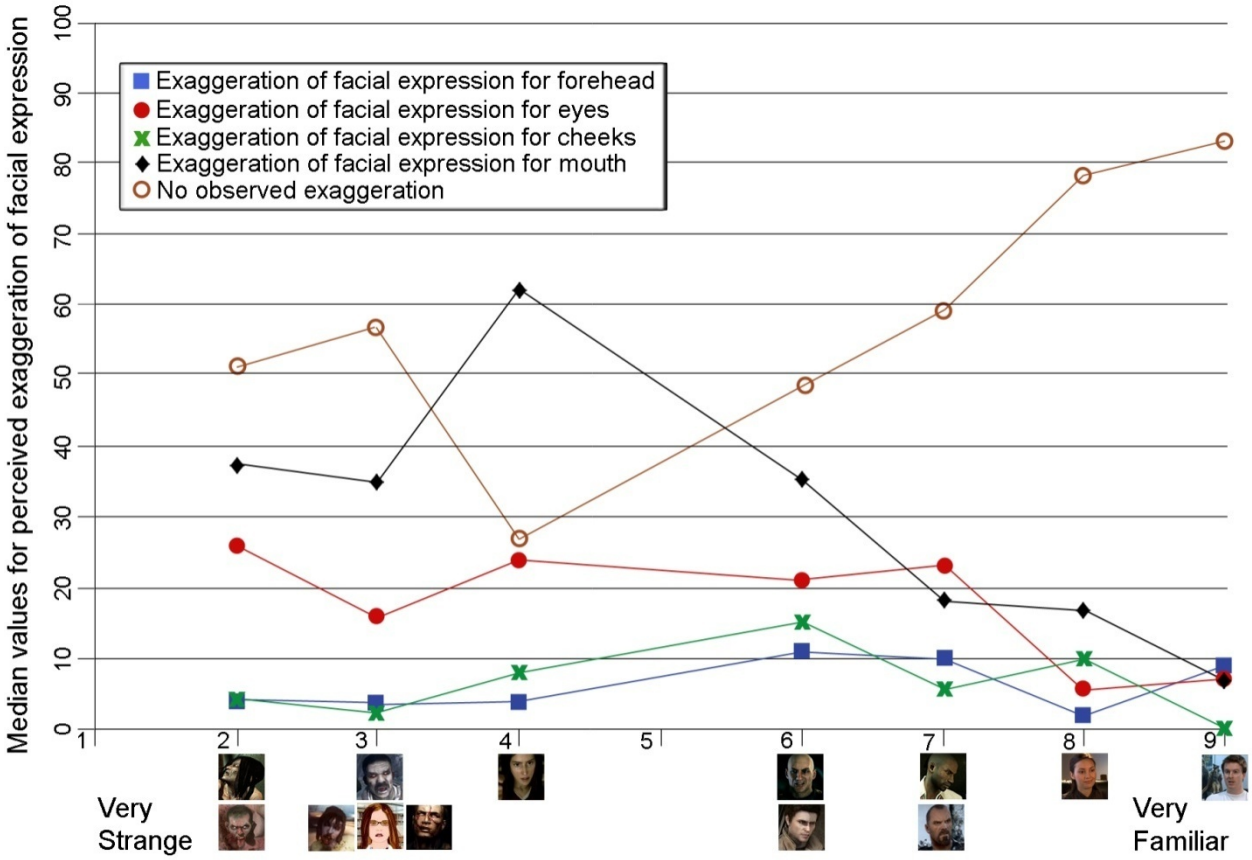

Figure 8: *Median strangeness values against median values for a perceived over-exaggeration of facial expression for those characters with the same median strangeness value.*

Figure 8 demonstrates that for characters rated as more strange than familiar, a perceived over-exaggeration of the mouth is of greater significance than that of other parts of the face, such as the forehead, eyes and cheeks in the middle and upper regions of the face. An indirect correlation of $r = -.90$ was calculated for individual responses for each character and the human, between 'no observed exaggeration' and 'an over-exaggeration of facial expression for the mouth'. This strong indirect correlation implies that a character is regarded as more strange if there is a perceived exaggeration of facial expression for the mouth, whilst a character is perceived as more familiar if there is no observed exaggeration of facial expression, including the mouth.

Discussion

When Mori's (1970) theory of the Uncanny Valley was applied to the thirteen characters the

results reveal that five zombie characters intended to convey a sense of the real fall below the mean rating for familiarity, being perceived as more strange than familiar, evoking an unsettling sensation for the viewer as Mori predicted (see Figure 3). Mori's theory (trans. MacDorman and Minato 2005: 33–5) predicts that zombie characters would fall within the Valley, being perceived as more strange than familiar. The results of this study imply that virtual zombie characters, with the purpose of being unsettling for the viewer, conform to the theory of the Uncanny Valley.

The strong relationship identified between perceived familiarity and human-likeness (see Table 4) indicates that viewers tend to find nonhuman-like characters more uncanny. Despite this broad assessment, the realistic, human-like character Mary Smith fell below the mean rating for perceived familiarity (see Figure 3). The results from our study imply that the less human-like the facial expression of a character, the greater the uncanniness of that character (see Figure 5). Indeed, facial expression was found to be one of the most unsettling characteristics for Mary Smith, with an observed lack of facial expression for the forehead (see Figure 7) and an over-exaggeration of her mouth movements (see Figure 8). This type of behaviour increased the perceived strangeness of this character, resulting in a lack of believability.

This study indicates that particular attributes for motion and sound, identified as factors that exaggerate the uncanny for human figures within the classic horror cycle of Hollywood film, also apply to virtual characters intended for animation and video games. Synchronization problems with the recorded voice during the early sound period heightened the viewer's awareness of films as manufactured artifacts (Spadoni 2000: 34). Instead of a whole entity, figures on-screen were regarded as objects created within a production studio that could easily come apart within a movie theatre, 'a reassembly of a figure' (Spadoni 2000: 19). The results from our study suggest that uncanny perceptions of mismatches in lip movement and sound for on-screen figures within the early sound period of cinema mirror a similar reaction for virtual characters within video games and animation. Characters rated as close to perfect for lip-vocalization synchronization were perceived as less strange than those with disparities in synchronization. Characters rated as the least synchronized were perceived to be the most strange (see Figure 4). The Witch zombie received a below-average rating for perceived

synchronization of voice with lip movement (see Table 1). The high-pitched cries and shrieks from the Witch, combined with the jerky, haphazard movement of the character's lips and face, augmented the perceived strangeness of this character. Participants seemed somewhat confused by the chaotic movement and irregular sounds, and this made them feel uncomfortable. For characters intended to evoke fear within the context of a survival horror game, the results of this study suggest that deliberately causing a mismatch in lip and voice synchronization for zombie characters may help achieve an anticipated effect of fear and eeriness for the viewer; however, further experiments using models for which parameters of lip-vocalization synchronization can be varied would provide more backing for this theory.

For speech qualities associated with the uncanny, the results of our study indicate that the perceived slowness, how monotone speech is and whether speech is of the wrong intonation are qualities that exaggerate the uncanniness of a virtual character (see Figure 6). This type of speech delivery is evident for the Chatbot character, whose voice was rated individually as being slow, monotone and of an incorrect intonation (see Figure 6). The unnatural and unreal qualities of this character's speech serve to increase the perceived strangeness, exaggerating the uncanny for this character.

Similar observations have been made by Spadoni (2000: 63–70) in relation to early horror talkies. In particular, he discusses the 'weird textures' of Bela Lugosi's voice in the title role of *Dracula* (Browning 1931), claiming that the actor's performance set the standard for what the 'voice of horror' should be. In early sound film, words were pronounced slowly, emphasizing every 'syl-la-ble'. Whilst this recording process allowed for the most intelligible dialogue for a film, this impeded delivery style and made the speech sound unnatural and unreal. Critics acknowledged that one of the most shocking characteristics of the eponymous character in *Dracula* (Browning 1931) was the distinctive quality of vocal tone and pronunciation: 'slow painstaking voices pronouncing each syllable at a time like those of radio announcers filled the theatre' (Spadoni 2000: 64). The unique textures of Dracula's speech increased the creepiness of this character and the unsettling feeling for the viewer. Dracula's voice, the ethereal voice of the undead, is compared to the voice of reason and materiality that is Van Helsing's. In the former, the uncanny is marked by uneven and slow pronunciation, staggered rhythm and a foreign (that

is, not British) accent, and all this produces a disconnect between body and speech. Van Helsing's speech, by contrast, is the embodiment of corporeality: authoritative, clearly enunciated and rational in its delivery and meaning.

Our results imply that characters serving the role of protagonist within a video game, such as Mary Smith or Alex Shepherd (see Figure 2), or those characters that may not intentionally contest a sense of the real, such as the Chatbot character, are perceived to be more strange than familiar due to the particular attributes of their speech that make the character appear less human-like to the viewer. Attributes such as 'slowness of speech' and 'how monotone the voice sounds' appear to exaggerate the uncanny, thus detracting from the believability of characters intended to serve as protagonists within a video game (see Figure 6).

Different attributes of facial expression served to increase the uncanniness of figures within the classic horror film genre. For the monster Frankenstein, a boney flat ridge was placed across his forehead to induce a lack of facial expression in this part of the face. This provided a signal of the monster's 'otherness' for the viewer while the rest of his features were left to express the character's emotions naturally (Spadoni 2000: 102–3). Our results imply that the perceived strangeness of a character increased when there was a perceived lack of expressivity for parts of the face in the middle and upper regions, including the eyes, cheeks and particularly the forehead (see Figure 7). Busso and Narayanan (2006: 555) find that, with regard to how humans communicate and interact, the upper-face region has more degrees of freedom to convey non-verbal information (such as emotional content) than the lower-face region, which is highly constrained by the articulatory processes. They recommend that 'for human-like facial animations, this facial area should be properly modelled and rendered to convey more realistic emotional representations'. The results from our study provide backing for this observation by implying that, for those characters perceived as more strange than familiar, there is a heightened awareness of a lack of facial expression for the cheeks, eyes and forehead in the middle and upper parts of the face. As viewers find it harder to interpret human emotion for the virtual character, they may be less trusting, thereby increasing the perceived strangeness of that character. Whilst this attribute may add to the fear factor for zombie characters (with viewers being more suspicious of them), if a game designer has not accurately depicted the facial

expression of a photo-realistic, human-like character correctly, viewers may find it strange and uncanny.

This study also suggests that an over-exaggeration of the mouth can exaggerate the uncanniness of a virtual character. For characters rated as more strange than familiar, a perceived over-exaggeration of the mouth is of greater significance than other parts of the face, such as the forehead, eyes and cheeks (see Figure 8). As actors adjusted to the transition from silent to sound film, viewers were acutely aware of the exaggerated lip movements of human figures on-screen; the over-acting and expressivity of the characters needed to be toned down (Spadoni 2000: 23). Viewers regarded actors with these unnatural gesticulations as more comical and subsequently less believable. Whilst this characteristic has served to increase the perceived strangeness of zombie-type characters within this study, it appears to have also had a negative effect on realistic, human-like characters otherwise not intended to evoke the uncanny. For example, the character Mary Smith received a possible 62 responses out of a possible 100 for a perceived over-exaggeration of facial expression of the mouth; the hero, Alex Shepherd, received an individual score of 24 responses out of a possible 100 for a perceived over-expressivity of the mouth. Mary Smith and Alex Shepherd might have been perceived as more human-like and familiar had the intensity of articulation been toned down for these characters. Based on these findings it can be suggested that game designers should ensure that the lower part of the face and mouth is modelled with less exaggeration of articulation and that a greater level of attention be paid to details of facial expression for the middle and upper regions of the face; if the desire is to avoid the uncanny, the modelling paradigm should be more Marlon Brando than Bela Lugosi.

Vinayagamoorthy et al. (2005) suggest that a virtual character will be regarded more positively when the fidelity of human-likeness of a character's behaviour matches the character's appearance (see also Brenton et al. 2005). The results of our study support these theories for the realistic, human-like characters used here. If the attributes of a character's facial expression and voice did not match with the perceived human-like realism of that character, they were regarded as more uncanny. The virtual character Emily received the highest scores for familiarity and human-likeness (see Table 1). It seems that the expected motion and behaviour

for Emily were more in keeping with Emily's realistic, human-like appearance than other realistic, human-like characters within this study (see Figures 5, 6, 7 and 8). The character Mary Smith may have received higher scores for familiarity and human-likeness if the behavioural fidelity for this character had been more in keeping with her realistic, human-like appearance (see Table 1).

Conclusion

With regard to increase in the realism of the visual appearance of virtual characters, our study leads to the following hypotheses:

1. Uncanniness increases with increasing perceptions of lack of human-likeness of the facial expression.
2. Uncanniness increases with increasing perceptions of lack of human-likeness of the character's voice.
3. Uncanniness increases strongly with increasing exaggeration of articulation of the mouth during speech, and this relationship is of more significance than that between uncanniness and middle and upper facial expression.
4. Uncanniness increases with increasing perceptions of lack of synchronization between the character's lips and the character's voice.

In order to work further towards the construction of a conceptual framework of the uncanny for video game characters, we plan further experiments to test the validity of the hypotheses above. Then, building on the outcomes of these studies, we propose the development of a facial animation tool incorporating interactive controls to measure and control the uncanny for virtual characters intended for 3D immersive environments. The uncanny controls would be used to adjust the level of uncanniness for a character's facial expression and speech. For example, a slider bar would be available to adjust the level of human-likeness for a character's voice to sound more or less uncanny. Similarly, controls would be available to manipulate how exaggerated aspects of facial expression appeared, such as mouth or brow movement. Instead of simply ignoring the uncanny as a symptom that may or may not occur in their work, a designer could introduce or remove the uncanny as desired, based on empirical evidence. Interactive 3D environments will also be created so that characters can be tested interacting with other

characters within a given scenario, such as a fight scene. With such player interaction, characters can be tested for the uncanny within a game-like context and not in isolation.

It might be thought that deliberately adding uncanny characters to a game would militate against player immersion, breaking Huizinga's (1949) *magic circle* or (a more recent reformulation of that theory) the *magic cycle* (Arsenault and Perron 2009). However, in the context of horror games and, as we have discussed, the requirement for an atmosphere of fear (or at the least unease) in such games, we argue that because immersion is, in part, based on user expectations, this would be increased as a result of this design. Other experiments can be designed to test this hypothesis: how far, for example, can asynchrony between visual and auditory modalities or the 'belongingness' of a voice to a character be exploited in the search for the uncanny before the magic circle is broken? Perhaps the circle is quite elastic and therefore quite tolerant of *prima facie* anti-immersion parameters such as the uncanny. This is a matter for future investigation.

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Acknowledgements

This work is an expansion of an earlier work, 'Survival Horror Games: An Uncanny Modality', presented at the Thinking After Dark Conference, Montreal, Canada (April, 2009).

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Endnotes

[1] For future studies participants will be selected to represent a wider demographic of the population to investigate the significance of gender, age and experience in interacting with virtual characters and the uncanny.

[2] The same 9-point scales used by MacDorman (2006) were used to rate perceived familiarity and human-likeness in this experiment so that results could be compared.