Showa Hanako 2 dentistry robot

Investigating the ‘uncanny valley’ effect in robotic, human and CGI movement

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Abstract

The “uncanny valley” is often viewed as a negative aspect that film-makers must try to avoid. However, it can be implemented purposefully, to create a desired emotional impact on the audience. This small-scale exploratory study aims to examine what makes a character uncanny. Several short video clips including CGI, masked figures and robotics were first analysed by the author to create an inventory of potential triggers. The clips were shown to eight participants, whose initial reactions were observed, documented and explored in interviews. Jordan Bannister is currently studying on BA Animation, and his interests include 3D modelling, animation and motion graphics.

The 'uncanny valley' effect

> *"One is curious to know what this peculiar quality is which allows us to distinguish as "uncanny" certain things within the boundaries of what is "fearful" (Freud, 1919)*

The word 'uncanny' means "strange or mysterious, especially in an unsettling way" (ODE 2010). Ernst Anton Jentsch (1906) discussed the psychology of the uncanny and argued that it arises from the uncertainty whether the object is alive or dead. Sigmund Freud (1919) described this as "Das Unheimliche" which literally translates to "the opposite of what is familiar". Applying this to the field of robotics, Masahiro Mori (1970) theorised that once a robot becomes too close in appearance to being human, the consumer perception changes from 'familiar' to 'unnerving' or 'creepy', and that movement plays a central role in this process. Echoing Freud's assertion that the uncanny effect made us aware of the fear of death, Mori's diagram uses "corpse" as the lowest depths of the valley (see figure 1 below)

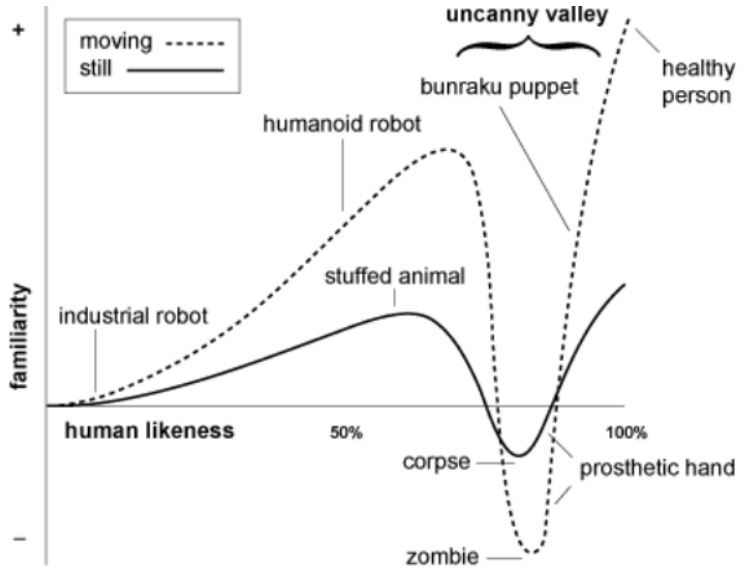


Figure 1 Mori's UVT diagram

Mori's work was followed by a large number of empirical studies into consumer perception of human-like artificial agents, and the term acquired an even broader currency since the development of computer-generated 3D animation. A frequently cited example of the uncanny valley effect in film is *The Polar Express* (Zemeckis, 2004), which attempted to

create realism by motion capturing facial movements from real actors and then applying that to CGI models. But rather than creating a more realistic experience, the film exudes the feeling of "incidental horror" (Geller 2008).

As the vast developments in 3D software, motion capture, games engines and robotics brought about the possibility of a much more realistic representation of human appearance and movement, the existence of the uncanny valley came under question. Do the recent technological developments make the familiarity so high that we can avoid the valley completely? As robots become more human like and human life becomes more robotic will the merging similarities help to flatten out the peaks of the uncanny valley?

Burleigh et al (2013) examined the relationship between human likeness and eeriness using digital human faces and made a number of recommendations for designers trying to avoid the uncanny valley. Whilst arguing that "a fear of the uncanny valley is unwarranted, and even potentially detrimental to the pursuit of design goals where human likeness is involved", they noted that negative responses may be due to "human–nonhuman category mergers", for example "in the design of human-like robots, it would be unwise to present a near-perfect human-like visual appearance with distinctly robotic voice" (Burleigh et al 2013:771). Geller (2008) makes a similar point, when he advises to slightly alter a character's proportions in order to avoid the uncanny valley effect: "The audience subconsciously says, 'He's not human; I don't have to judge him by the same rules as if he were" (Geller, 2008:13).

Whilst the technological development has overcome some of the uncanny valley problems, others remain. Geller (2008) cites the animation supervisor for Industrial Light & Magic Han Hickel who argued that the motion capture technology "has overcome virtually all uncanny effects in replicating gross body movement" but the eyes and facial performance remain difficult; the viewers are acutely sensitive if something is 'off' in facial animation (ibid). This has been supported by empirical research, such as Looser and Wheatley (2010), whose study of sixty student volunteers found that the "appearance of the eyes disproportionately informative in conveying whether something is alive" (Looser and Wheatley, 2010:1).

Other researchers focused on the meaning of the term itself, for example McAndrew and Koenhnke (2013) attempted to identify the main elements of 'creepiness'. They hypothesise that being 'creeped out' is an emotional response to "anxiety aroused by the ambiguity of whether there is something to fear or not, and/or by the ambiguity of the precise nature of the threat", for example in dark environments that "offer a lot of hiding places for potential predators" (McAndrew and Koenhnke 2013:4-5). Although this is more relevant to cinematography or environmental design, which are not the focus of my study, there is an important emphasis on uncertainty, which relates back to Jentsch's definition of the uncanny. Szczurek, Monin, and Gross (2012) argued that we tend to keep away from people/ creatures/ characters that display an inappropriate or use of expression and emotion. Leander (2012) made a similar point stating that inappropriate, movements and behaviours could create creepiness.

If robotics are viewed as uncanny, why is it then that their makers still strive to push them towards realism? In an online video, Koutaro Maki says that "if you don't try to make a robots face look realistic, it doesn't have the same effect on users psychologically", yet the Showa Hanako 2 dentistry robot (see the title page) possesses a distinctly creepy look. Several writers, however, point out that the viewer experience may not be entirely determined by the artefact itself, but by cultural or generational differences between the viewers. Geller (2008:17) cites Bar-Cohen who "noted the influence that Eastern versus Western religion might have on our perceptions of humanlike robots", whilst Burleigh et al (2013:770) warned that their findings may not apply to other population samples. For example, it is possible to expect that the younger generation as a whole will have been more digitally active from a young age, and therefore more used to the computer-generated 3D images: "In 2013, 36 million adults in Great Britain used the Internet every day, or almost every day. This represented 73% of those aged 16 and over and was more than double the number of adults (16 million) that used the Internet daily in 2006 (when directly comparable records began" (Office for National Statistics, 2013).

The reviewed literature helped me develop initial questions and categories for my own study, as well as pointing to the potential limitations. For example, would the participants respond more intensely to subtle movements, such as facial expression, or to larger body

movements? Will people be unnerved more by skin and eye textures than by movement? I suspected that some of the responses would depend on the individual person and their own perceptions, for example, 'digital natives' such as gamers, game designers or 3D artists may respond differently from a 'lay person', and see through the uncanny effects due to the daily exposure to similar imagery. I hypothesised, firstly, that one section of the clips (Robotics, Masks or CGI) will affect my participants more than the others; and secondly, that the extent of the uncanny feeling will differ between individuals, depending on their prior experience and expertise. Because of the small size and specific nature of my sample, the study does not aim to arrive to firm conclusions or wide generalisations, but to explore some of the issues and generate further questions.

Research methods

Collecting the responses. When choosing a suitable research method, I considered the strengths and limitations of focus groups, interviews and questionnaires. My initial intention was to conduct a focus group, in a hope that the ability to bounce ideas around the group would create interesting and abundant data for analysis. However, I realised that this could also become overwhelming and prevent me from extracting all of the useful data I want. I was particularly interested in the participants' initial reaction, and concerned that these may be lost if part of a group. Secondly, there was a possibility that more reserved people would be prevented from expressing their opinions, leading to a biased result in favour of the more outgoing in the group. Hayes (2000) points out that social constraints may be a factor that needs to be countered by an experienced interviewer. Laws (2003:300) suggests that this can be addressed procedurally, by going through all participants in a focus group, asking specific individuals for their opinions, and whether they agree with the group or not. Questions such as: "Does everyone agree?" or "Is that what everyone thinks?" (Bell, 1987, 163) can help to minimize group bias. However, due to lack of experience as an interviewer, I decided that focus group would not be a suitable method.

I briefly considered using a questionnaire, which would have allowed me to access more participants and get a broader and more representative range of results. However, a

questionnaire tends to hide participants' reactions: "The way in which a response is made (the tone of voice, facial expression, hesitation, etc) can provide information that a written response would conceal" (Bell, 1987:157). This made questionnaire inappropriate for my purposes, since the focus of my study is on emotional responses, which may involve non-verbal information.

Using one-to-one interviews would allow me to ask each participant the same question, whilst also observing and documenting the non-verbal information. Bell (1987) suggested that a first-time interviewer may find it beneficial to use a structured interview. This involves creating a brief questionnaire or checklist that the interviewer fills out on the basis of the participants' responses. Following Bell's (1987) advice, I created a structured interview schedule with two sheets that I would fill out while asking my participants questions. One sheet was for the notes of each participant's responses in relation to the media clips, and the other contained a visual diagram representing a scale and allowing the participant to show how strongly they feel the eerie effect of each clip.

The sample. The participants represent an opportunity sample, which allows to recruit participants quickly and conveniently from the researcher's own vicinity. Powell (1997) describes the similar accidental sampling technique, where "the researcher simply selects the cases that are at a hand until the sample reaches a desired, designated size" (Powell, 1997:117). My target number of participants was 8-10 as this would give me enough samples to seek out some correlations within my results and give me a sufficient range and richness of data to examine, without becoming unmanageable. Although the sample is small and unrepresentative of general population, my study is merely exploratory. It does not intend to arrive at firm conclusions or make wide generalisations, but to explore some of the issues and generate interesting questions for further research.

The choice of media clips was based on their length and availability, as well as the equal coverage of the three relevant categories (masks, robotics and CGI). I deliberately tried to include clips without any overpowering lighting or music, because of my focus on character movement and appearance, as opposed to cinematic effects or sound. As this study is very much perception based, and conducted by a single researcher, it was difficult to ensure that

all the clips have a similar level of creepiness/ uncanny content. All video clips were sourced online through Google/ YouTube searches, online forums and on demand TV. Nine clips were selected, as follows

Clip 1: DigInfo TV – SAYA Life-like Reception Robot - *a robot created by Tokyo University of Science Kobayashi lab.*
Clip 2: Diego-San by Hanson Robotics - *created for the Machine Perception Lab at the UCSD Institute for Neural Computation.*
Clip 3: BigDog Overview by Boston Dynamics - *a robot climbing in the woods that keeps balance when kicked and slipping on ice.*
Clip 4: Secrets of the Living Dolls by Channel 4, UK - *Documentary that delves into the secretive world of female masking.*
Clip 5: Hyperflesh Baby Masks by Landon Meiers - *a promotional video for realistic baby masks shot in Denver, Colorado.*
Clip 6: "Creepy Guy Changes Masks and Wigs" by Zzeliionipse - *a YouTube video of an unknown man changing wigs and masks*.
Clip 7: The Emily Project by Image Metrics - *a project that aimed to cross the "uncanny valley". Animation of a digital face using 3d facial capture.*
Clip 8: Tin Toy by Pixar / John Lasseter - *a computer animated short film produces by Pixar from 1988. Shows two characters, a Tin Toy and a baby.*
Clip 9: Real-time Character Demo by Activision - *a hyper realistic facial animation showcasing Activision's new technology.*

Preliminary analysis. Prior to the interviews, I created the scene breakdown for each clip, and examined them in detail *(see Appendix 1)*. By scrutinising the clips along with my own reactions for a rough pilot, I could identify the elements that might make the viewer feel uncomfortable. I rated the clips by colour to give a more visual representation of how strongly 'creeped out' the clips made me feel. This colour chart is very subjective, firstly because I work in CGI field, and secondly due to knowing the footage back to front. I was also aware of each clip's context, which could have reduced the uncanny effect upon me. However, this was not intended to be included as research data, but to create an extremely quick and useful instrument to code and analyse a range of possible results.

Stone (2006) points out the importance of organisation and contrast between data to improved readability: "An effective design presents information in an organised manner, making it easy for the viewer to understand the roles and relationships between the elements" (Stone 2006:1). Following this advice, the results of my preliminary analysis of the clips were colour-coded, using a clear hue division of RGB values *(Fig 2 below).*

The 9 squares along the top row represent the 9 video clips and the colours inside the row represent my own reactions to them. The columns are divided in three groups of three, representing Robotics, Masks and CGI respectively, for example the group D represents the three Robotics clips. The next row down represents the average (mean) RGB values of the corresponding group. The bottom row represents the average level of 'creepiness' for each participant. Although crude, the resulting diagram allows to see at a glance how affected I was by different kinds of material. From the image I can see that I found robotics by far creepier than the CGI, as left-hand side of the diagram has a far more reddish hue than the right-hand side, despite the individual differences between the clips within the sets.

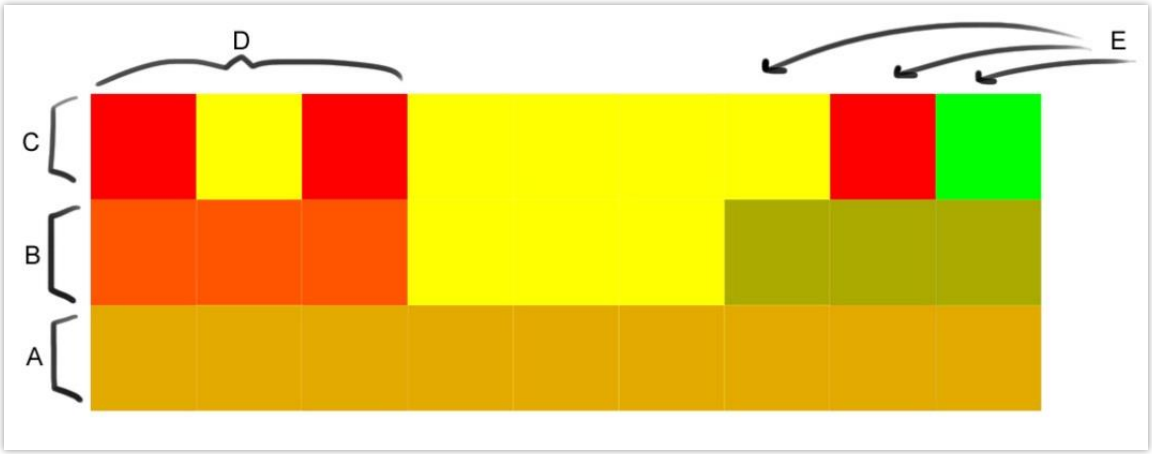


Figure 2 Colour-coded results of the initial analysis of the clips

Interview schedule. Each interview began from a play-through of the full set of clips while monitoring and noting down the participants' reactions. This was followed by asking a set of questions (see Appendix 2) about each clip, and filling out the interview form, for example:

1. What parts of this video stand out to you?
2. Which parts did you feel were the creepiest – if any / at all?
3. How would you describe this clip / the feeling it creates?

Although I am particularly interested in the impact of movement, I was careful to avoid mentioning movement within the interview questions. If movement did play an important part in creating 'creepiness', the open-ended questions provided an opportunity for the participants to point that out without unnecessary guidance.

During the interviews, I asked each participant to plot along a line (Likert-style) how creepy they found each video (see Appendix 3 for the full results). On the basis of these results, I have plotted a line graph representing mean scores given by each participant for each category (see Figure 3 below). The graph shows that most participants found the robotic clips the most uncanny/ creepy, and the CGI clips the least uncanny,

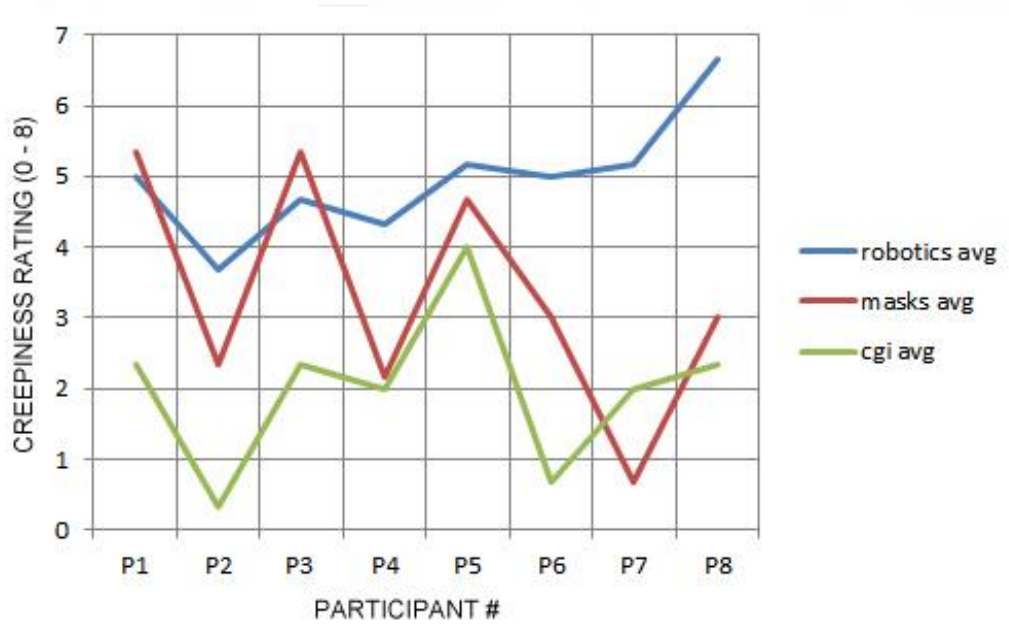


Figure 3 Average creepiness rating (0-8) given by participants for each category (masks, robotics and CGI)

Results.

All the interviews notes were compiled into one document (see Appendix 4) allowing for similar results to be quickly recognised. Figure 4 shows a colour-coded comparison with columns representing the clips and rows representing the participants. Each participant's individual RGB charts can be found in Appendix 5, but at a glance it is obvious that Robotics contain more red values across the board than the other two categories.

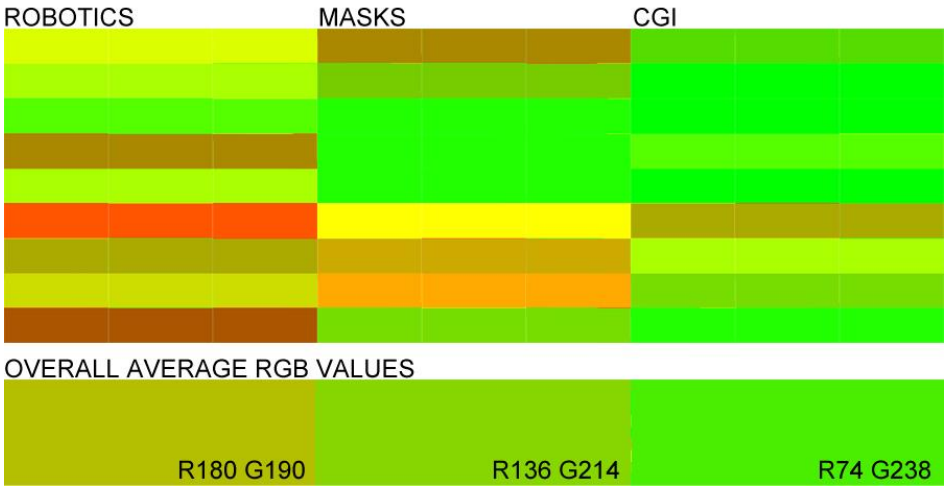


Figure 4. Summary of responses to the clips in different categories

Starting from the robots, most participants placed the SAKO robot (Figure 5) over the half way mark in my 0-8 creepiness rating. The participants consistently mentioned the robot's mouth, make up and eyes as the factors in their dislike ("cracked lips / cracks around the mouth", "weird gel/ liquid on lips", "make up/ blusher on the cheeks doesn't look right", "something about the cheeks is odd", "eyes don't move", "expression is wrong").

Figure 5. Screenshots from clip 1 (DigInfo TV – SAYA Life-like Reception Robot)

The participants linked the robot's appearance to death ("twitchy like she's dying", "nose looks dead", "corpse-like"), which is consistent with Mori's (1970) theory. In the section "The significance of the uncanny" Mori says: "when we die, we fall into the trough of the uncanny valley" (Mori, 1970:np). On his UVT graph "corpse" and "zombie" are at the lowest points, and this is echoed in my participants' reactions to this robot as almost "the living dead", making this the main reason for its uncanniness.

The importance of movement was frequently commented upon, using the words 'twitchy', 'jerky', 'uncontrolled', 'unnatural', 'mechanical', 'weird'. However, it appears that lack of expected movement can also cause creepiness. Some of the participants noticed that the eyes of this robot don't move, supporting the previous writers' findings that "the appearance of the eyes is disproportionately informative in conveying whether something is alive." (Looser and Wheatley, 2010, 1). The lack of life that the SAKO robot shows could be directly related to its eyes.

The Diego robot (Figure 6 below) is relatively similar to the SAKO robot, so why did this clip not affect my participants as much? The participants appeared to respond better to the more "fluid movements" of the robot's face. The facial expressions of this robot are still quite unnatural, and some of the participants found the robot's skin texture unnerving. However, the transitions from one expression into another are delivered more smoothly than in clip 1.

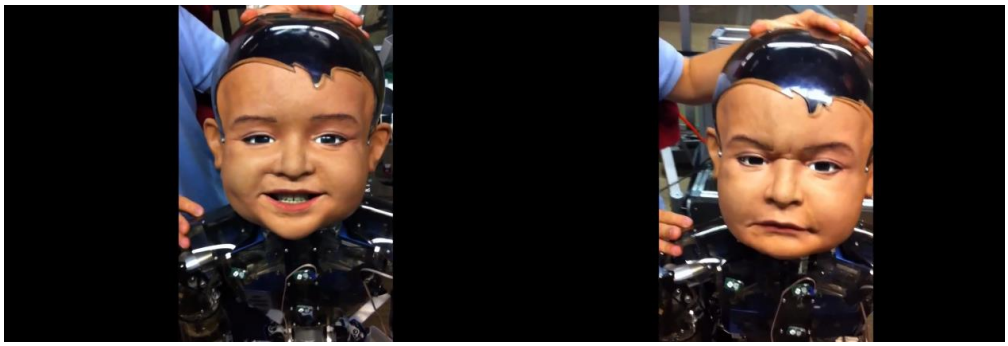


Figure 6. Screenshots from clip 2 (Diego-San by Hanson Robotics)

Another important reason for lack of adverse reaction may have been the context. One of my participants did directly point this out, saying that "in this context, it's not creepy". A few others mentioned the hand holding the robot's head ("you can see it's a test" or "it looks like something being shown off").

The third of the Robotics clips, BigDog (Figure 7 below) caused divided reactions. Several people found it funny, whilst others found it revolting. The negative reaction was explained in the following terms: "tortured", "painful", "legs looked as though they were snapping", "an animal that has been shot", "broken joints", animal in pain", "moves like a giant flea".

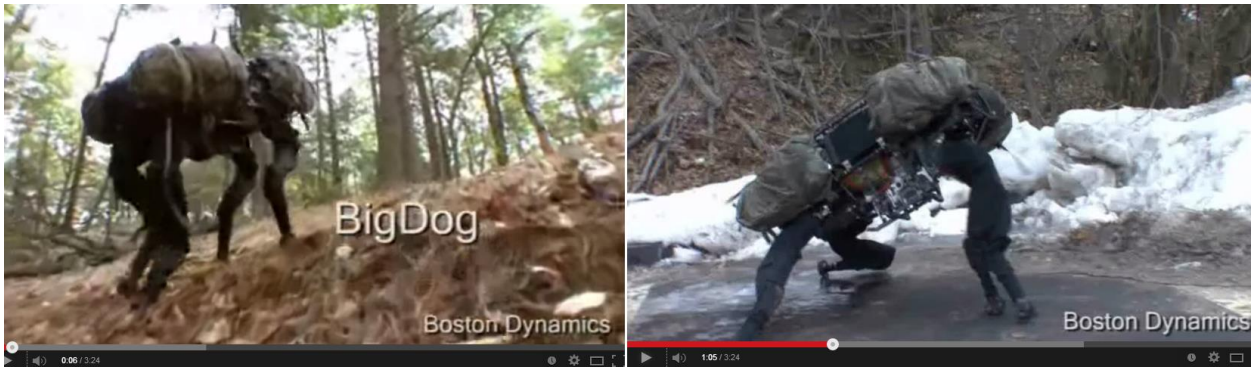


Figure 7. Screenshots from clip 3 (BigDog Overview by Boston Dynamics)

One participant stated that seeing it in a 'real' environment made it worse in comparison with the Diego robot that looked as though it was in a 'test environment'. Others described it as "legs without a torso", "looks like people", "thought it was real human legs". Perhaps our minds see these human-like legs performing so realistically that it triggers a sense of ambiguity. We therefore don't know whether it's a threat, or how to respond to it.

The masks section (Figure 8) did not provoke the reaction as strongly as the robotics yet more than the CGI clips. Only one participant (P7) found the masks less creepy than the CGI, but it transpired that he knew somebody who wears similar masks, so an element of immunity may have been gained from past experience. After the initial shock it seemed that humour was the emotion that prevailed, with the comments such as "not scary when you know they are masks", "too exaggerated to be real". The Living Dolls clip, for example, was described as "ridiculous", "funny", "like a poorly done drag", although some commented on dead eyes and lack of cues about "what they might be thinking".

The Hyperflesh Baby Masks caused the least reaction, due to the obviousness of the mask, frequently noted by the participants ("can tell it's a mask", "obviously a mask", "funny", "no way it could be real", "unpleasant but too obvious", "could not be confused with real people"). The disproportionately large heads were mentioned more than once, linking back to Geller's (2008) point that altering the proportions would remove the uncanny valley effect. However, some of the participants felt the unnatural head size suggested sickness, and lack of expression and facial movement made it "unnatural but still a little creepy".

Figure 8. Screenshots from clips 4-5 (The Living Dolls and the Hyperflesh Baby Masks)

The third clip in the masks category (Figure 9), was seen as the creepiest by all but one participant. The comments focused on skin and facial impressions ("blank eyes", "doesn't look like they had any eyes", "like someone else's skin on his face", "bit creepy because the skin looks real", "don't know who is under there"). Movement also figured prominently in the responses ("eyes moved, but didn't move properly", "didn't move like they should", "angle of the head is creepy", "association with horror – tilt of head, slow move").

Figure 9. Screenshots from clip 6 ("Creepy Guy Changes Masks and Wigs" by Zzeliionipse)

Moving on to the CGI category, immunity and 'obviousness' prominently featured in the participants' responses ("just looks like special features, because I'm used to it", "CG effects don't bother me", "know it's VFX", "trying to find out what's going on as opposed to it being creepy"). In the Project Emily CGI clip (Figure 10), we see a wireframe representation of the face, foregrounding the artificial nature and removing ambiguity. Most participants found this "interesting" and "realistic", some made expert comments "spec map is shocking, but mesh defeats illusion of it being scary", others drew comparisons with popular films. Similarly, the Activision clip was seen as impressive technological achievement, apart from minor issues with the character's mouth.

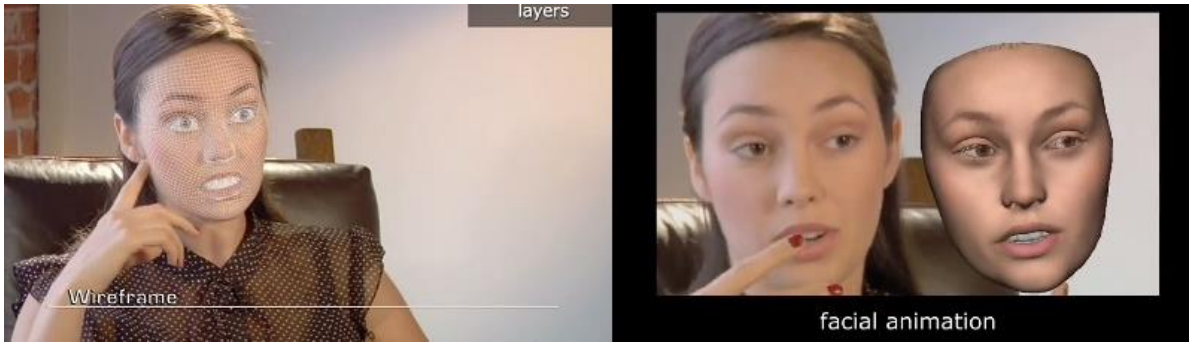


Figure 10. Screenshots from clip 7 (The Emily Project by Image Metrics)

It is possible to suggest that Project Emily and the Activision clip surpass the uncanny valley and make it to the other side. However, the responses in this category may have been entirely different with a different group of people. Further research with a larger and more diverse body of respondents, and more robust methods is required before this can be established with any degree of certainty.

Conclusion

At the start of this study I hypothesised that each participant would have their own perception of each video clip and that it would affect each person differently. I also believed that digital natives would experience less of the uncanny effect with the CGI. Whilst I have remained unsure whether the uncanny effect is created mainly by aesthetics or movement, some interesting issues have surfaced in the course of this research.

I found there to be a much more intense reaction towards the robotics clips than masks and CGI. Some of the issues identified in the literature were confirmed by the participants responses, for example the comparisons with death, or the sense of ambiguity and unpredictability. The importance of movement was demonstrated by the participants' reactions to the BigDog clip, in the absence of other factors such as facial expressions, and bearing in mind that the makers made no effort to hide that this is a robot. The 'realistic' nature of the leg movements must have been a contributing factor to its uncanniness. Unpredictable (twitchy) movements combined with blank eyes and unreadable facial expressions seemed to increase the uncomfortable effect. Vagueness and ambiguity created the sense of creepiness, but as soon as the participants figured out what was going on, the creepiness of the clip was hugely reduced.

The study contains some important limitations, including a simplistic research instrument, and a small sample representing a very specific demographic and professional group. Much more research is required with more diverse groups of participants and video material, to explore these issues. Also, character appearance and movement is only one element. Lighting, character design, environment design are all potentially contributing factors to how a scene is viewed. Custom animated clips could be used in this test with particular features that have been found to generate unease. Such research could be used to identify the specific elements that can be utilised purposefully when creating an animated film.

Bibliography

BELL, Judith (1993). *Doing Your Research Project*. Open University Press .

BOXILL, Ian, CHAMBERS, Claudia, WINT, Eleanor (1997). *Introduction to Social Research*. US. University of the West Indies Press.

BURLEIGH, T. J., SCHOENHERR, J. R., & LACROIX, G. L. (2013). Does the uncanny valley exist? An empirical test of the relationship between eeriness and the human likeness of digitally created faces, *Computers in Human Behaviour*, 29(3)

COHEN, Louis, MANION, Lawrence, Morrison, Keith. (2011). Research Methods in Education, Routledge.

DigInfo TB. (2011). *Ultra-realistic Dental Training Android Robot - Showa Hanako 2 #DigInfo.* [online]. Last Accessed 29 March 2014 at: https://www.youtube.com/watch?v=WhzbFaNueKU.

FREUD, Sigmund, (1919). *The "Uncanny"*. The Standard Edition of the Complete Psychological Works of Sigmund Freud, 17(1), 217-256

GELLER, T. 2008. Overcoming the uncanny valley. *IEEE Computer Graphics and Applications*, vol. 28

HAYES, Nicky. (2000) *Doing Psychological Research: Gathering and Analysing Data*. Buckingham, Open University Press.

JENTSCH, Ernst. (1906). Zur Psychologie des Unheimlichen. *Psychiatrisch-Neurologische Wochenschrif*. **8**(22), 195-198, 203-205.

MCANDREW, Francis., KOEHNKE, Sara. (2013). On the Nature of) CREEPINESS. [online]. *Society for Personality and Social Psychology*. Last Accessed 20 April 2014 at http://www.academia.edu/2465121/Creepiness

MCCLOUD, Scott. (1993). The Vocabulary of Comics. In: *Understanding Comics: The Invisitble Art*. London: William Morrow Paperbacks.

MORI, Masahiro. (1970). The Uncanny Valley, Energy, 7(4), 33-35

OFFICE OF NATHONAL STATISTICS. (2013). *Statistical Bulletin*. *Internet Access - Households and Individuals*. [online]. Last accessed 20 April 2014 at: http://www.ons.gov.uk/ons/dcp171778_322713.pdf

Oxford Dictionary of English (2010). 3rd ed. Oxford: Oxford University Press

STONE, Maureen. (2006). Choosing Colors for Data Visualization. [online]. *Business Intelligence Network.* Last accessed 20 April 2014 at: http://www.perceptualedge.com/articles/b-eye/choosing_colors.pdf

STRAUSS, Claude. (1988). *The Way of the Mask* Last accessed 14th Apr 2012 at: http://www.selectedworks.co.uk/levistrausmasks.html.

SZCZUREK, Lauren., MONIN, Benoît., & GROSS, James. (2012). The Stranger effect: The rejection of affective deviants. *Psychological Science*, **23**(10), 1105-1111.

POWELL, Ronald (1997). *Basic Research Methods for Librarians*. 3rd ed. Westport, CT, Ablex Publishing

VIDEO CLIPS

DigInfo TV (2009) *SAYA Life-like Reception Robot* [video online] available at: https://www.youtube.com/watch?v=aF_8gM4urmA [last accessed 01/03/2014]

david hanson (2013) *Diego Installed* [video online] available at: https://www.youtube.com/watch?v=knRyDcnUc4U [last accessed 01/03/2014]

Boston Dynamics (2010) *BigDog Overview* [video online] available at: https://www.youtube.com/watch?v=cNZPRsrwumQ [last accessed 01/03/2014]

Channel 4 (2014) *Secrets of the Living Dolls* [video online] available at: https://www.youtube.com/watch?v=dI-udPkU7xA [last accessed 01/03/2014]

Landon Meier (2009) *Hyperflesh presents sexy superstar babes* [video online] available at: https://www.youtube.com/watch?v=1rkUDTLMzR4 [last accessed 01/03/2014]

Zzeliionipse (2011) *Creepy Guy Changes Masks and Wigs* [video online] available at: https://www.youtube.com/watch?v=oMx2uA59gJo [last accessed 01/03/2014]

USCICT (2010) *High Resolution Face Scanning for "Digital Emily"* [video online] available at: https://www.youtube.com/watch?v=ErODDCNQWdA#t=18 [last accessed 01/03/2014]

2009dinia (2012) *Pixar Tin Toy* [video online] available at: https://www.youtube.com/watch?v=wtFYP4t9TG0 [last accessed 01/03/2014]

GameSpot (2013) Activision Character Tech Demo in Real Time [video online] available at: https://www.youtube.com/watch?v=y2GhOLHzI1c [last accessed 01/03/2014]

Appendices

Appendix 1: Scene descriptions and analysis

Clip name	Scene Details	Analysis	
Robotics			
1: SAYA – Diginfo	00:01-00:05 Slow downward pan from top of face to lower face. Small twitch in neck and whole head movement. 00:05-00:16 Camera cut to mid shot of face. Zoom onto face until end of clip. Small mouth movements, larger head movement – 'looks' at camera for short moment (a little cross eyed). Eye twitch just as clip ends.	The robot at the beginning is actually rocking, which is instantly off putting and unnatural to see. We are usually well balanced with good weighting on the ground – and even so, if we were off balance, we wouldn't rock like this robot is. The robots head movement is also very jerky which makes us doubt organic movement. The eyes lack shininess as well as realistic. Our eyes dart from one position to another in real life – the robots stay centred and move with the head. During this entire clip, the robot does not blink once apart from one small, slow twitch in the left eye. This would be very unnatural for a human/ uncomfortable. On the topic of eyes, they also appear shrunken back into the head as well as being disconnected from the outer skin. The mouth movements and aesthetics are also very peculiar. The tears in the sides of her mouth make it look at though she is unwell or 'damaged' and the lips don't feel as though they match the gums and teeth. The whole face in general feels off and as though the skin doesn't match the robotic rig/ bones/ muscles behind.	
2: Diego Installed	00:25–00:27 'Baby starts off smiling with	The first thing I notice with this robot is that the eyes don't look	

	eyes closed 00:27-00:33 Expression changes to a neutral/ shocked position before returning to the original 'smiling' facial position. Blinks and then repeats this entire movement again. 00:33-00:35 Goes into a final frowning/ sad pose before the clip ends.	human at all despite the rest of the face being realistic. The skin on the face looks visually/ texturally realistic but despite this, it is very uneven and doesn't suit the young child like look it is going for. The eyes are a white with solid black circle in the middle. There is no definition of an iris, but one large pupil – like a cartoon. This may have been a deliberate design in order to avoid the uncanny valley due to a lot of the uncanny effect being from the eyes (or so it is theorised anyway) (INSERT SOURCE – STUDIES SAY ITS IN THE EYES). The facial movements are slow, unresponsive and sluggish – unlike natural movement – especially for a child; the blinks being the most noticeable. Blinks are extremely quick. This robot feels as though is blinks 2-3 times slower than a human would. The mouth looks very odd when in the sad/ frowning pose and doesn't look very natural – more like a baby suckling rather than an upset pose!	
3: Boston Dynamics	00:41-00:42 4-legged robot travels over a rocky landscape onto a smoother area. 00:43-00:44 Robots front legs slip on the ice but it carries on as before. 00:44-00:46 Back legs continue on after the front legs. Back legs reach the ice and slips. Back right of the robot almost hits the ground at it regains 'balance'.	Immediately, the first thing this looks like is two humans in black tights with their upper bodies in bags which instantly gives me/ the viewer a link to a human creature – therefore making this instantly uncanny. The movements are very fast, and seemingly unpredictable. It doesn't feel slow and harmless like a sloth or a slow loris but fast like a flea and/or potentially dangerous like a spider. The way this robot reacts to the ice is very animal like. This is the first	

	The robot moves extremely quickly in order to stay upright keeping the back half of the machine down low and the legs out wide. 00:46-00:49 Front legs bow down and the back half of the machine rises up as it clears the ice and turns towards the camera. Robot slips slightly to the right hand side before throwing itself quite violently the opposite way. It regains full control and balance and continues two more steps towards the camera.	major part where you notice that the legs aren't human like at all. They have the ability to bend in unnatural ways. When the robot bows down and rises back up, it does so towards the camera which appears very threatening. It reminds me of an animal stomping on the ground to defend its territory. Except its lack of expression stops limits any readability into how it is 'feeling'. It leaves the robot very ambiguous and unpredictable and therefore we fear it/ feel uncomfortable being around it.	
Masks			
4: SOT Living Dolls	00:56-1:00 Side on shot of 'female' character. Lips are instantly noticeable but sunlight makes the face harder to see. The eyes are slightly revealed before the camera cut. 01:00-01:07 Two masked female characters walk towards the camera communicating – although this isn't apparently obvious due to the lips not moving and there being no audio. Camera zooms out to a medium shot.	At first glance at this clip – it looks like a slightly odd, yet normal woman. The sun helps mask the true image here. When the camera angle changes, you see two apparent females – but this time, very odd looking females. There proportions are wrong and their heads are large and therefore feel a little masculine. The neck of the right hand figure is very wide and the skin tone on the face doesn't match the arms. This is an indicator that we don't know the true identity of this person. The eyes of both characters don't blink or move naturally. They don't interact seemingly by moving their lips. Their whole look leaves them looking ambiguous and questionable. The body movements are natural,	

		yet the faces don't move whatsoever despite them being fairly realistic.	
5: Hyperflesh	01:15-01:20 Medium shot of distressed/ confused looking baby mask on a childs body (perhaps between 7-10 years old). The child is holding hands with a male and female. Possibly parents. Boy looks around with relatively large head movements. 01:20-01:25 Camera changes angle to reveal the 3 characters, all in baby masks. They are all walking down the street without interacting with anything or anybody. The grown up male is masculine and wearing a similar mask to the child. The female is wearing another baby mask but looks distressed/ crying. When the camera cuts closer, the female is looking away. She turns her head to reveal the mask and its expression.	We see the boy with his two parent figures looking around. The mask makes him look uneasy or distressed and the fact that his facial movements don't change makes this disturbing. The masks are also so much bigger than a normal head – especially on the child. This makes it look very alien-like or similar to a human with a genetic disorder/ illness or deformity – which can still give off the uncanny effect. The boy in this shot is holding hands with two seemingly normal parents. When the shot and camera angle changes we see that they are all wearing similar masks. The female had her head turned at the start of this clip which makes her notice the neck join of the mask – I'm not sure whether this makes the look more uncanny or less. Either way, the head looks disconnected and unusual. When the females head turns, it looks as though she is distressed, a complete contrast to how she is walking. Her posture doesn't read as though she is upset. As they walk closer to the camera, the viewer is unsure as to if they are looking directly at them or not. Ambiguity and uncertainty is left by these masks. Some people will be creeped out whereas others will find them very unusual and unnerving.	
6: Creepy guy masks	01:31-01:37 First of all see female figure looking down in front of her.	This mask doesn't actually look too bad until you see the eyes. Even taking off the wig is fine in terms of the uncanny effect. The eyes look	

	She tilts 'her' head towards the camera and takes off the black wig. It looks as though her eyes are white or her eyelids are closed – it is hard to tell. 01:37-01:47 Person opens eyes and blinks. Adjusts and stretches the bottom of the mask where it joins her lower neck area. This distorts the mask on 'her' face.	lifeless and demon like. They lack any type of definition and look very odd. This instantly puts me on edge while watching this clip – what else are they hiding? It's not immediately apparent that they are wearing a mask, so our eyes focus on theirs intently. Only once the wig is completely off, the person opens their eyes and we notice that these 'demon eyes' are actually eye lids. They still only open up by about a third though and look extremely odd. When the mask is being adjusted, it's like the skin is stretched over the face deforming it even more and moving the mouth. This clip doesn't necessarily display any threat to the audience; it just makes you a little uneasy – perhaps suggesting a link to the theory that the uncanny effect reminds us of our morality.	
CGI			
7: Emily Project	01:53-01:58 Lady is talking in an interview style throughout this entire clip. Very quickly see natural, human looking face before the diffuse map is shown upon the face which is much more vibrant and doesn't react with the surrounding lights. 01:58-02:02 Specular map is now shown upon her face. Light reacts realistically with it. Eyes are black, shiny and a smooth black colour.	I don't necessarily find this clip uncanny until it gets to the Specular map part. The specular map reacts with the surrounding lights so realistically and the animation/ movement is so spot on that it really gives me the uncanny feeling. I feel as though the completed CGI image out at the opposite side of the uncanny valley, but as soon as the specular map is shown, the entire image and clip is thrown down into the depths of the valley with the corpse/ zombie like images. The wireframe part of the image is	

	Faces she pulls while acting are very expressive. 02:02-02:06 The wireframe map is then revealed over the top of the actors face. Makes it harder to view details of face and expression. Clip shows the real actor for a split second before it finishes.	then not as unsettling as the original – it appears to me as something that has just been projected onto some video footage. This does however mask some of the facial expressions and make them harder to read – this could give the uncanny mask effect displayed in clips 3-6. I think because of how her movements are exaggerated in her acting intensifies the uncanny effect. I don't think that a still image of this would be as unnerving. The eyes, yet again are the most noticeable to me in this clip – especially when they are completely black. It looks like stereotypical alien eyes – something films (in general) have tried to make us fear. Not like E.T's readable and relatable, human-like eyes but like the dark, glossy eyes of the aliens in Close Encounters: of the Third Kind.	
8: Tin Toy – Pixar	02:13-02:19 Shot starts with CGI baby on left third of the image with its hand covering its mouth. Baby opens mouth and is excited with 'skittish' movements. Very sharp and fast. Reaches for its ring toy to pick it up. 02:19-02:24 Clip changes as it is cut together to show the relevant character. Baby has blue ring in hand. Shaking arms and head in excitement. Places the ring in its mouth.	The first thing I notice with the Tin Toy clip is the proportions of the babies head to its body. It looks far too large and therefore instantly off. I understand that Pixar here are going to exaggeration in their character design, but the baby doesn't look stylised enough and therefore remains uncanny. The mouth movements also look very strange. It seems very angular and doesn't look as though it has depth to it (as in it doesn't depress back in like a normal mouth). The movements in general also feel a little erratic and fast. I know the movements are supposed to replicate a babies excited movement, but it feels even less controlled than that.	

		When the baby bends down to reach the toy, the form of the body feels very off. The back of its neck actually had a crevice in it. I think this is probably down to the limitations of rigging in early 3d software, but still, it creates the uncanny effect. The baby also looks very angry and demon-like when looking down and some of the movements are very aggressive.	
9: Activision	02:33-02:50 Hyper realistic head on a neutral blue background. Blinks and smiles revealing teeth. Frowns and adjusts mouth before animating into a shocked expression. Eyes flick side to side before looking upset. More subtle mouth and eye movements before going into another shocked/ scared expression opening the mouth once more.	Generally, as I work in 3D a lot, this clip amazes me more than displaying the uncanny effect. Its purpose in this study is to view whether my participants feel the same way or not. The main thing I notice when viewing this clip is the mouth. That, in my opinion is the main part that feels off with this animation. The darkness inside the mouth is a little strong. The teeth just don't look correct to me. There's a clear dark line division between the upper lip and the teeth. The neck is also disconnected from a body which could break the realism for some of the participants.	

Appendix 2: Interview response form.

	Colour R/O/G
Creepy ⟷ No effect	
1	
2	
3	
4	
5	
6	
7	
8	
9	

Appendix 3: Data used for figure 1. The first table displays the full range of results, the second shows the averages.

	P1	P2	P3	P4	P5	P6	P7	P8
SAKO	6	5	6	5	6.5	7	8	7
Diego	7	5	5	2	1	0	1.5	5
BigDog	2	1	3	6	8	8	6	8
SOTLD	8	5	5.5	0.5	4	0	0	4
Hyperflesh	0	1	4.5	1.5	7	3.5	0	3
Wig take off	8	6	6	3	3	3.5	2	5
Emily	0	0	1.5	2	4.5	2	0	1
Tin Toy	7	1	5	2	5	0	2	6
Activision	0	0	0.5	2	2.5	0	4	0

	P1	P2	P3	P4	P5	P6	P7	P8
robotics avg	5	3.666667	4.666667	4.333333	5.166667	5	5.166667	6.666667
masks avg	5.333333	2.333333	5.333333	2.166667	4.666667	3	0.666667	3
cgi avg	2.333333	0.333333	2.333333	2	4	0.666667	2	2.333333

Appendix 4: Compiled notes from all participants

Clip	Compiled participant results
1	too big for her skull twitchy like shes dying teeth and mouth 2 looked like its from a victim beaten up. Movements are unnatural and jerky 2 lips cracked horrible, hideous. Saw gel, liquid on lips, mechanicanical movement, turning of the head – something about cheeks too. Eyes are sunken and don't move make up eyes don't move loose around the face looks like it has been pulled off and then stitched back on movements don't look controlled / functional weird muscles if it was in a different environment it would be worse expression is wrong lip movement and texture cracks around the mouth scarier than if it were completely broken up jars / contrasts with make up / blusher clearly not a person nose looks dead / corpse like looks like an alive doll
2	'alright' until sad frowning face / bottom lip Somebody holding his head is weird. bolts at side of head, moves slowly. Not like a human (hair cut?) metal hair thing is weird. Half human, half machine realistic the hand on the head makes it more obvious more fluid movements face looks good / expressions are good, lifeless eyes doesn't look real – not creepy - movement is very robotic texture of skin isn't normal can see that its a test. depends on its context - not creepy in this context. creepy is change of expressions but broken illusion by the hand being there the metal top head bit and body creates associations with dvd bonus content looks like something being shown off
3	steps are quick lifting off the floor the falls are a little strange – mind of its own

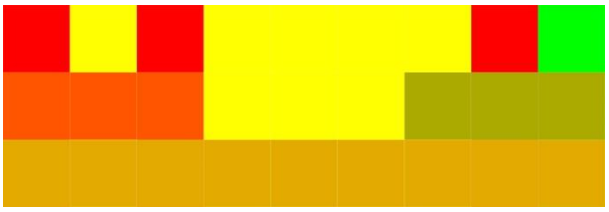
	creepy when legs are 'snapping' looks like legs are breaking or an animal that has been shot and is dying funny 2 thought was real human legs where it slips – definitely the movement – tortured / painful looks like legs should be walking towards each other broken joints – animal in pain. legs without a torso legs the wrong way around 2 looks stupid, looks like people looks like an animal – like it's actually alive looks like a flea (oversized), even WITH context, still creepy. i think because it is in natural environment it is worse doesnt look like a test. the way the legs bend make it look like a flea - when it falls is horrible - like in silent hill.
4	Lack of expression 3 dead persons face lack of being able to see what they are thinking. robots, in a relationship thought real at first not scary when you know they are masks too exaggerated to be real thought one was real / one was mask funny – looks ridiculous 2 looks like poorly done drag
5	heads are too big, weird seeing a big babys head Lack of expression and facial movement. can tell it's a mask 2 looks like it belongs to the person at a glance found funny 2 obviously a mask no way it could be real not believable, but still a bit creepy unpleasant but too obvious could not be confused with real people looks like illness / sickness – depends on context
6	whenever his eyes close under the mask is weird when stretching mask opening mouth Like someone elses skin on his face blank eyes Taking the hair off – stretching looks like pulling its face off can tell it's a mask 3 know someone that has worn a mask don't know who's under there what is being hidden? eyes look creepy but when mask is moved – effect is lost

	doesn't look like they had any eyes, eyes moved, but didn't move properly didn't move like they should. didn't like it when they took the wig off looks really fake, bit creepy because the skin looks real angle of the head is creepy when you see It's a mask – illusion is broken – initially scary association with horror – tilt of head, slow move,
7	everything fine apart from spec map like bit in batman – (first one) on weird drug where he has black face. It moves realistically which makes it okay without the maps layers would just think it was real just looks like special features (because im used to it) trying to find out what was going on as opposed to it being creepy. specular map looks like an alien – like in films interesting realistic don't like the teeth CG effects don't bother me doesn't look like a real person – can tell the difference know it's VFX – doesn't bother me spec map is shocking, but mesh defeats illusion of it being scary - context
8	he looks rubbery like a doll that has come to life. Movement is very 'rubbery' doesn't feel like hes made of skin – twitchy unpredictable way its arms move, jerky really quick, mouth looking like a beak, sharp / pointy 2 not as scary because you can see its animation eyes and the way it moves it looks like realistic animation - but doesn't actually look real maybe with sound it would be creepy mouth was off, obvious it's animation 2 funny flappy arms stretchy belly looks like plastic skin reminds me of the baby in trainspotting = the way is moves looks possessed but not real
9	inside his mouth is clearly nothing there / too dark inside mouth 2 His movements are realistic. impressed 3 interesting 2 looks real 3 bit creepy – movements make it look like someone is in control of his brain. when mouth opens 2 eyes look good / teeth look too perfect know it's VFX – doesn't bother me

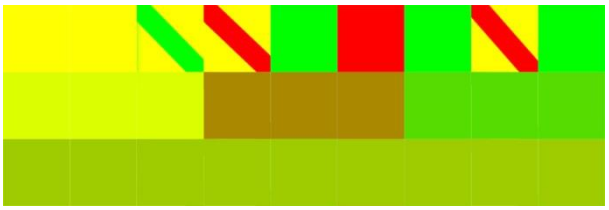
Appendix 5: Participant RGB Charts (The first chart shows the layout)

Clip 1 SAKO	Clip 2 Diego	Clip 3 BigDog	Clip 4 SOTLD	Clip 5 Hyperfle-	Clip 6 Wig	Clip 7 Emily	Clip 8 Tin Toy	Clip 9 Activision
Average RGB of above (robotics)			Average RGB of above (masks)			Average RGB of above (CGI)		
Overall average RGB values								

P0 (Preliminary analysis /my own reactions)



P1



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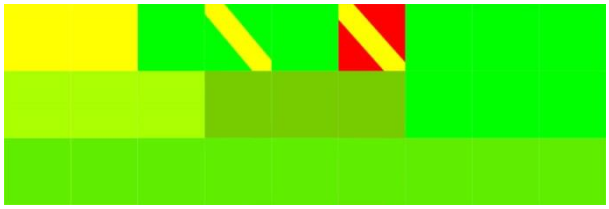

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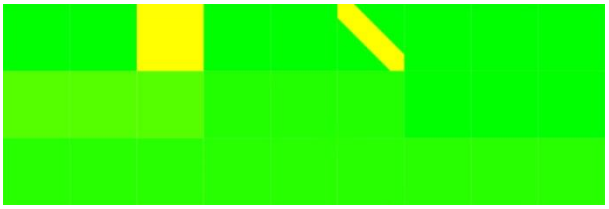
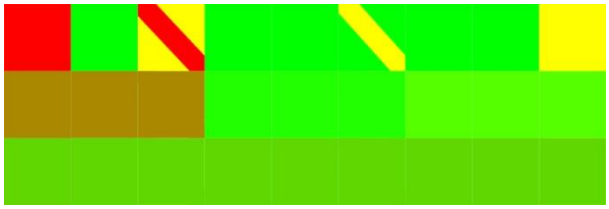


P4



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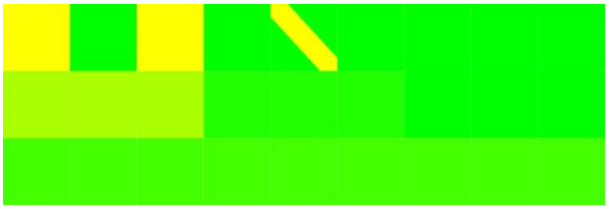

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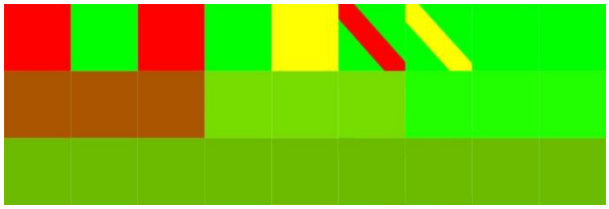
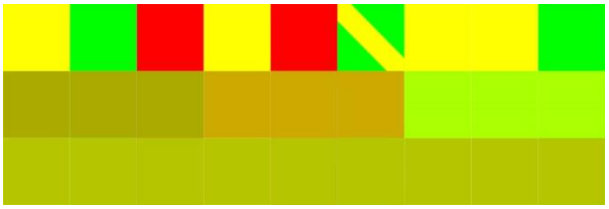


P7



P8