Exploring the Uncanny Valley with Japanese Video Game Characters

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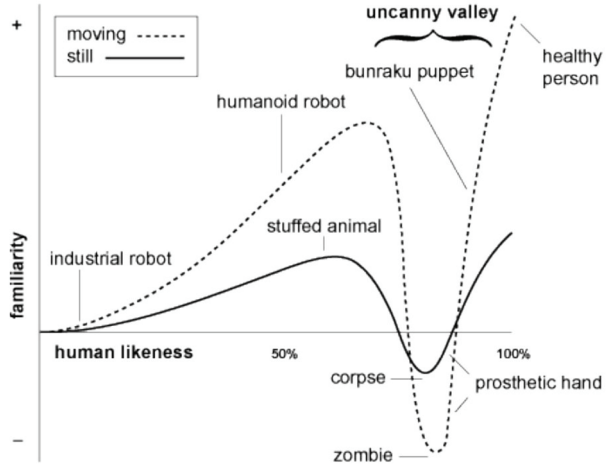
Abstract:
Dr. Masahiro Mori's robotics design theory, the Uncanny Valley, has become a common reference in virtual character design. The theory holds that robots whose appearance is very close to being human, but not fully, will evoke a very negative human reaction. The theory is often referenced in design outside of robots, especially in video games, but there is very little data to support this application. The attempts at photorealistic graphics in the latest round of video game hardware have made reference to the valley common in even mass media discussion.

This study asked 60 subjects their opinions on 75 different virtual characters from both inside and outside video games to investigate the relationship between human-like appearance and attraction. The results found definite parallels between Mori's predictions with robots and subject opinion on virtual characters, and have direct application to video game character design.

Keywords:
Uncanny Valley, virtual characters, video games, character design.

Introduction:
Masahiro Mori's robotics theory, The Uncanny Valley, has become an increasingly common reference in discussion of video game character design [Duffy 2003]. The term 'Uncanny Valley' refers to a temporary dip in the positive relationship between how human a robot looks and how comfortable people are with its appearance. Mori theorized the positive relationship continues until robots get too close to being human in appearance without being fully, at which point human reaction becomes negative [Mori 1970]. Mori uses prosthetic limbs and zombies as examples to explain the concept of being very close to being human but still evoking a negative reaction. The most positive reaction then will come from robots that perfectly mirror humans. The dip in perceived attractiveness is what he called the 'uncanny valley.'

Examples of the concept coming up in media are the repeated mentions by film critic Roger Ebert [2004, 2006] and its use in discussion on American sports channel ESPN of the newest version of an American football game franchise [Hruby 2006]. However, unlike academic discussion of the Valley, popular media discussion will most often use it in discussion of media like video game and film..[Mori 2005] Research on the existence or other aspects of the Uncanny Valley are almost entirely with Robots, thus application to virtual characters is not what the theory was intended to describe.



Mori's original depiction of the Uncanny Valley [1970]

This research is an effort to investigate the application of Mori's theory to virtual characters, especially looking at how popular video game characters fit into the spectrum. The design of this study is simple, it asked 60 people to give their reactions to 75 virtual characters from both games and elsewhere, as an effort to study the relationship between human-like appearance and visual appeal.

Objective:
Obviously in the early 1970's robots were less common than they are today. At the time of its writing it would have been very difficult for Mori to find robots that represented the range from industrial to human in order to test his theory. Lack of available robots is informally indicated by how Mori uses non-robotic examples to explain the Valley. His use of a Japanese bunraku puppet as an example in his initial graphing of the valley, as well as comments he has made since its publication indicate that he feels the theory could apply outside of pure robotics.

Today there are thousands, if not millions, of virtual characters that span video games, television, film, and comics. Considering the frequency of which Mori's theory comes up in virtual character design [Weschler 2002], it is appropriate to investigate and measure the relationship between how human-like virtual characters appear and how people react to them.

This is an especially important issue in video game design, where all the characters are virtual, and the increasing strides towards photorealism in games has put more and more characters into what many feel is the Uncanny Valley [Thompson 2005]. The

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objective of this study is to investigate if the positive relationship between human-like appearance and attractiveness in virtual characters exists, and if it temporarily reverses, as Mori predicted with robots.

The overall goal of the research is to provide a visual framework for game designers to understand how virtual characters fit in Mori's context of human-like appearance and familiarity. The question of the Valley's existence in robotics is still debated, thus whether or not the Valley is a reality with virtual characters is still far from certain.

The original design for this study included only characters exclusive to video games, but this was changed because the lines between video game, cartoon and film characters is not clear. Film characters spawn games, and game characters spawn television shows and movies. Including characters that only appear in games would be difficult, and would rule out most popular characters.

The Valley in Academic and Non-Academic Media:

Since its publication, numerous articles have been written applying the theory to everything from social interaction of robots [Duffy 2003] to inattentional blindness [Gu et al. 2005] but research investigating rather than applying the concept almost exclusively are done in the field of robotics research. The article that was largely responsible for the Internet based popularity of Mori's theory is Dave Bryant's 2004 article "The Uncanny Valley: Why are Monster-Movie Zombies so horrifying and Talking Animals so fascinating?" The article does an excellent job of placing the uncanny valley in a social, cultural and visual context, but has no research data to back up claims. However, as will be explained later, many of the predictions and descriptions in this article were seen clearly in our data.

Ishiguro (2007) pointed to three main concepts seen in research and discussion on the subject. The first is that humans expect a balance between appearance and behavior. The second is that the mental model people have for robots is much less sensitive than the one we have for other humans. The last concept Ishiguro points out is that reaction towards robots changes tremendously dependent on the subject's age. Age based differences have been found [Woods, 2004 & 2007] with differences ranging from desired appearance to functionality.

The most high profile critic of the concept is Robotics designer David Hanson, unfortunately his arguments against the Valley have often been supported by data from robot development over research. In "Upending the Uncanny Valley" for instance [2005], his research consisted in showing an undisclosed number of subjects two videos of robots of his own creation. Not surprisingly his study found 0.0% of subjects said they find human-looking robots disturbing, and 73% found the two disembodied robot heads shown to be appealing.

Other research does imply that the Uncanny Valley may be an oversimplification, but again, these studies are done with robots, not virtual characters. Research has found children feel the more human a robot is the more likely it is to be aggressive. [Woods, 2006] Subjects have been found to insert personalities into computers and agents when there is no personality intentionally created [Dryer, 1999]. Most interestingly subject reaction to robotics was much more standard using a robotic dog (Sony's Aibo) than humanoid robots [Friedman, B. et. al., 2003].

Brian Duffy's 2003 article, Anthropomorphism and the Social Robot, warns designers of the difficulties of making characters with very human looking faces that have to "contend with the minute subtleties of facial expression." His advice is that more mechanistic or iconic heads would be more effective at clearly conveying emotion. Mori's concept of close but not too close can clearly be seen reflected in Duffy's advice.

In Scott McCloud's book, Understanding Comics [1993], he presents a related design concept explaining that cartoon characters can work both in photorealistic settings and cartoon settings, while photorealistic characters in a cartoon setting will appear less natural. The idea is that a cartoon character is conceptual and therefore more flexible, while photographs are a literal representation. McCloud's concept, although not supported directly by research, does bring up the problem of how backgrounds could influence subjects' ranking of virtual characters.

Vinayagamoorthy [2004, 2005] studied the interaction between character detail and background quality, especially the impact on players reported sense of presence. His study found that placing more realistic characters in low-resolution environments created the lowest sense of presence, and the highest level of presence when placed in high-resolution environments. His data supported McCloud's claim by finding cartoon-like characters were more adaptable, scoring similar scores in each virtual setting.

The interaction between virtual character and environment influenced the decision to have all characters shown against a white background to minimize potential bias by a background image.

Methodology:

Once the research goals were established, 75 virtual characters were randomly selected from a larger pool of characters from video games and animation. There was a range from well-known characters to the obscure. Each character's picture was displayed on a white background, and all were resized to be within a few pixels of each other in resolution. Pictures were then assembled into a slideshow. Tests were conducted with trial subjects to determine the amount of time subjects would need to view the characters and answer each question. Four versions of the slideshow were created, each with its own random order.

Sixty subjects were recruited from throughout the community, 28 men and 32 women. Subjects were then randomly assigned one of the four orders. Subjects were given 30 seconds to evaluate each character on a provided survey instrument.

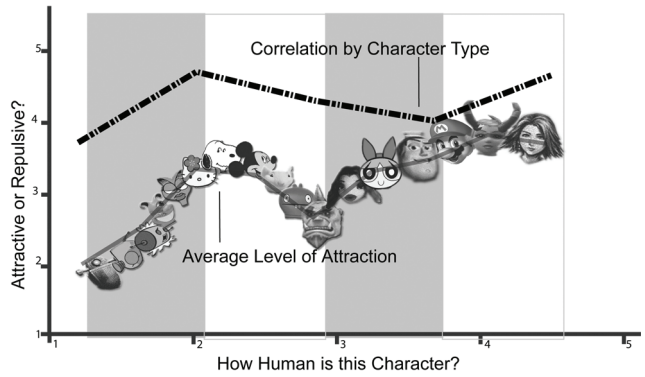
Subjects were asked to give their opinions on each character, including their opinions on how human the character looked and how attractive they perceived the character to be. The characters slides were clearly numbered, and subjects were directed to continue with the character shown if they lost their place in the survey. (Less than 3% of survey items were left unanswered] They gave their opinions on a five point scale. Once data was collected it was then sorted to provide data on each virtual character.

Dependent Variables:

As mentioned, each subject gave each character a score ranking of how human or non-human they felt the character appeared and of how attractive or repulsive they felt the character to be. After the data was collected from subjects using a self report instrument, each character was given a human (h) score based on the average mark on the five-point, human to non-human scale (mean=3.17 μ=.67). Likewise each character was given an attractive (a) score based on the five-point, attractive to repulsive scale (mean=2.84 μ=.94).

Results:

Across all the characters used in the study there was a positive correlation between the average results given for each virtual character's level of attractiveness and human-like appearance. (r=.43) Just as Mori did in the original graphic of the Valley, the characters were placed in order according to their average human score. The scale from non-human to human was divided into quarters and human to attractiveness correlations were performed for characters in each. These correlations are plotted in figure 2.



The correlation between how human a character looked and how attractive subjects ranked it was very high for non-human characters in the lowest quarter of the human scale (h>2.19). These characters were generally robots and the less anthropomorphized, more animalistic figures. The attraction-human correlation for is r =.70.

Example Characters and average scores from this range:

Character & Source	Human	Attraction
One Eyed Robot (Dexter)	1.32	2.42
One Eyed Cat (Kidrobot)	1.84	2.53
Rosie (Jetsons)	1.74	3.17
Totoro (Studio Ghibli)	1.89	3.64

For characters in the center two quarters of the scale (2.19>h>2.46 and 3.23>h>2.46) the correlation between human appearance and attractiveness is slightly negative. (r=-.34. and r=-.23. respectively) These characters tended to be made up of highly anthropomorphic animals and alien-like humanoids, generally characters with human-like bodies and animal-like or otherwise non-human faces.

Example Characters and average scores from this range:

Character & Source	Human	Attraction
Tauren (Warcraft)	2.27	3.19
Donkey Kong	2.29	3.32
Crash Bandicoot	2.41	2.24
Bugs Bunny	2.42	3.86

A strong correlation between human appearance and attraction is again seen in the characters in the highest quarter of the human scale (h>4.56). As expected, with human-like characters the more human a character was ranked the more attractive people felt it appeared. The characters in the highest quarter were generally stylized human characters. The correlation for the two in this range was r=.57.

Example Characters and average scores from this range:

Character & Source	Human	Attraction
Ogre (Warcraft)	3.03	2.10
Megaman (Capcom)	3.46	3.32
Mario (Mario Sunshine)	4.19	3.86
Lara Croft (Tomb Raider)	4.52	4.28

Another way to visualize the data came from to determining and plotting the average attraction score for characters that fell in half-point ranges across the five point scale on the human score. Plotting this data creates a graph that shows the decrease in attraction score for characters that are human but not fully, just as Mori predicted. An overall pattern similar to the correlation analysis appears. Subjects in the study gave the lowest attraction score (2.30 out of 5) to characters with a human score of between 3 and 3.5. Meanwhile characters with the second highest average attraction scores were given to clearly non-human characters with mild human characteristics. The highest level of attraction is as Mori has later predicted [2005], not at the perfect human (4.28<h), but just before with the slightly stylized human (4.14<h<4.28, a=3.58). These scores are plotted in Figure 2.

Just as McCloud's concepts are mirrored in Vinayagamoorthy's data, plotting the characters visually creates some very close reflections between Mori's theory and this study's results. The lowest average attractive scores were given to human like creatures, with the lowest individual attraction score reserved for an ogre from World of Warcraft, a character with a human-like appearance. Around the Ogre were other characters of general human appearance but low attractive scores, such as a character from Shark Tale and Howdy Doody. The characters that received scores positioning them in the dip in correlation are very much the type of characters that Mori describes in his original article. Each possesses a clearly human appearance but each also had features that strongly say not human.

Discussion:

The relationship between human appearance and attraction for different types of characters has design implications for video game characters. The results of this data imply that making a character more human can sometimes, but not always make it better. The high level of correlation in the characters with clearly non-human appearances suggests designing animals and robots with human-like traits while keeping them clearly non-human in appearance is a much safer strategy than using a more anthropomorphized animal or entity. The safest combination for a character designer seems to be a clearly non human appearance with the ability to emote like a human. The Jetson's robot Rosie, Nemo from Finding Nemo and Tweety Bird are examples of characters that received low (>2) human scores but are in the human-score range that scored consistently better on the attraction measure than characters with much more humanoid traits. Research has shown that animal forms can be less annoying to subjects than machine forms [Stefan & Schmandt, 2005]. Nintendo's successful Nintendogs is an excellent example of a

game whose characters would fall into this category. The dogs in the game are clearly canine, but have the ability to emote and communicate more like a human than a normal dog.

The negative correlation between attraction and human-like appearance for the characters in the center of the human scale has its own implications for design. This doesn't completely imply creating characters that are anthropomorphized animals, alien, robot, or otherwise inhuman can't be successful. (Mickey Mouse is in this range) The negative correlation can be interpreted to tell designers not to be afraid to make humanoid characters more reflective of their non-human influence.

The characters designed to be obviously human scored the overall highest levels on the attraction scale. Like the obviously non-human characters, there existed a high level of correlation between human-like appearance and attraction. The rankings of the characters in this range created a visual picture that very much supports Dr. Mori's theory. Although there have been attempts to discredit Mori's theory, the results of this study give backing to the concept, at least if when it is applied to virtual characters. When designing virtual characters for video games or otherwise, designers should understand how adding human appearance will influence viewer opinion.

There is a tremendous potential for future research in this area. Repeating this same study with more focused sets of characters (for instance robots only, humanoid characters only, or animal characters only) would create more detailed looks at the relationship between human appearance and attraction. Mori was also interested in how motion would impact perception, and stated that the valley would be even more exaggerated with moving characters [1970]. Another study using video clips instead of images could help bring more backing to the theory.

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