# The Uncanny Valley: does it exist?

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## Abstract

The 'Uncanny Valley' refers to a sense of unease and discomfort when people look at increasingly realistic virtual humans. Despite growing academic interest in the Uncanny Valley our understanding is limited and there has been little rigorous questioning to determine if the phenomenon actually exists. The Uncanny Valley questions widely held assumptions about the correlation between realism and believability within a virtual world. There is considerable anecdotal evidence for the uncanny from film, CGI and sculpture, but this does not in itself support the valley model. Four hypothesises are proposed; considering the role of presence, mismatch of cue realism, the contribution of the eyes and cultural habituation. Future research aims are then described in order to experimentally test the Uncanny Valley.

## 1 Introduction

The term 'Uncanny Valley' refers to a graph of emotional reaction against the similarity of a robot to human appearance and movement (Figure 1). The term was coined by the Japanese roboticist Masahiro Mori (1970), although it is often wrongly associated with his later work "The Buddha in the Robot" (1982). As a machine acquires greater similarity to a human, it becomes more emotionally appealing to the observer. However, when it becomes disconcertingly close to human there is a very strong drop in believability and comfort, before finally achieving full humanity and eliciting positive reactions once more; this is the Uncanny Valley.

Although the Uncanny Valley is widely cited in the computer graphics and virtual reality community our understanding of it is limited and there has been no proper research to determine if the phenomenon actually exists.

The roboticist David Hanson rejects the Uncanny Valley as 'pseudoscientific' (Ferber, 2003), arguing that robot designers should not be conceptually limited by a theory without scientific proof. Understanding the uncanny becomes increasingly important where games are close to delivering real-time photo realistic characters and environments on a standard desktop PC. Substantiated guidelines for building realistic characters that don't fall foul of the uncanny would be useful for anyone engaged in character creation for human-computer interaction.
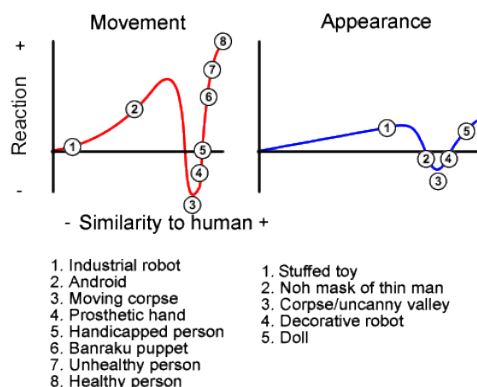


Figure 1. Graphs of emotional response against similarity to human appearance and movement
Adapted from Reichardt (1978) and Bryant (2001)

This paper aims to provide a foundation for research and further debate; first by citing examples of the uncanny from film, CGI and sculpture, then reviewing the evidence for the

valley effect, proposing hypotheses and future research aims.

## 2 Examples of the Uncanny
Computer generated characters in films, humanoids in horror movies and photorealistic sculptures provide useful examples of uncanny responses to artificial humans.

In an essay on the nature of the uncanny, Freud (1955) describes his extreme discomfort at seeing someone wearing a prosthetic limb. He argues that uncanny reactions occur when something alien is presented in a familiar context or setting. Many horror movie directors have deliberately exploited this phenomenon to heighten an audience's sense of fear and dread. A classic example is Frankenstein's monster (Whale, 1931), an abomination who exists in a liminal realm between the living and the dead simultaneously provoking sympathy and disgust.

Realistic depiction of lifelike humans is more advanced in film computer-generated imagery (CGI) than within current real time virtual environments. Animators working with CGI characters have described the uncanny as a design limitation which they have had to find creative ways to work around. The team behind "Shrek" (Adamson, 2001) made Princess Fiona less human because "she was beginning to look too real, and the effect was getting distinctly unpleasant". The animation director on "Final Fantasy: the spirits within" (Sakaguchi, 2001) describes an eerie sensation as he worked with increasingly photorealistic models: "it begins to get grotesque. You start to feel like you're puppeteering a corpse." Both quoted in Weschler (2002).

The sculptor Duane Hanson made highly realistic sculptures of people, placing them in locations where they can easily be mistaken for a real person. Viewers are confused because they are initially uncertain if they are looking at a human or a work of art. Hanson's sculpture The Jogger is particularly disturbing because it depicts a middle aged man sitting on the floor in pain; a typical audience instinctively gathers around him to see if he needs help.

## 3 Is there an Uncanny Valley?
There is good anecdotal evidence from film, CGI and sculpture that an uncanny reaction can occur when viewing disconcertingly lifelike artificial humans. However the existence of an uncanny reaction does not validate the valley model. For example, in the movement graph (Figure 1) an asymptote goes through points 1 & 2 and another through points 3, 4, 5, 6, 7, 8. The middle section is referred to as a valley, but this is only because it has been drawn this way. It could equally be represented as a stepped discontinuity.

To examine the Uncanny Valley the axis of the graph must be defined more rigorously. "Reaction" may be measured by self report or a more objective measure, perhaps physiologically based. "Similarity to Human" may be quantified by techniques such as Multidimensional Scaling (MDS).

Avatars in collaborative virtual environments and autonomous social agents have been extensively studied experimentally. However, the number of studies that are relevant to the Uncanny Valley is limited. Few manipulate realism as an experimental condition, and generally the level of realism in the models is low. A further problem is that character designers appear to instinctively to shy away from models that exhibit signs of uncanniness.

However, Nowak & Biocca (2001) show that, up to a certain level, increasing realism has a positive effect on users' evaluation of a character. They also give anecdotal evidence that high realism can seem uncanny in certain circumstances. Tromp et al. (1998) give a particularly clear example explicitly stating that a subject was disturbed by the fact that an avatar was graphically realistic but that this realism was not matched with behavioural realism, making the avatar seem "like a zombie". This was only reported by one person, indicating that the uncanny response may be subjective. Evidence that behavioural realism should be matched with graphical realism also comes from Garau et al., (2003), who found that while high behavioural realism was preferred for a graphically realistic avatar, the opposite was true with a graphically unrealistic one. Nass, Isbister, & Lee (2000) present a similar result: that personalities portrayed verbally have to match those portrayed non-verbally.

**4 Working Hypotheses**
Having a testable hypothesis is a prerequisite for a scientific study. However we are not proposing a complete and consistent theoretical model because our understanding is currently too limited. Instead we suggest four working hypotheses intended to provoke further research and debate.

**4.1 The Uncanny Valley response related to presence**
Slater (2004) presents a theory of presence that proposes that at any given moment in time the human brain formulates hypotheses about the world based on our perceptions. However, slight changes in mental state can trigger a switch of hypothesis that Slater terms a Break In Presence (BIP). With the uncanny the brain is choosing between two different hypotheses: "this is a human being" versus "this is not a human being". BIPs and the uncanny effect are different domains because one concerns location and the other the nature of an object. However, both theories are linked and underpinned by a consideration of the grey area between two possible hypotheses. Existing methods of studying and measuring presence (Slater and Steed 2000, Slater, Brogni and Steed 2003) might therefore be relevant to understanding the uncanny.

**4.2 Increasing realism heightens sensitivity to cues indicating falsehood**
Animated characters give off a number of perceptual cues that suggest that they are people. For example, a simple character might move its eyes in a way that we recognise as similar to human behaviour, and so we accept it as being a person on some level. At all levels of realism it is possible to create characters that are "not quite right" or that "don't quite work", while others are appealing and easily accepted. Highly realistic characters operate within a different set of aesthetic constraints than those exhibiting lower realism. As a character becomes increasingly realistic it is constrained to the physical attributes of a real person and a viewer's tolerance for abstracted appearance and behaviour is reduced.

Current technology allows increasingly graphically realistic characters but often their behaviour and movements do not match up to this realism. The high graphical realism gives strong cues that suggest the character is a person and thus raises high expectations for motion and behaviour. When the quality of these does not match up, it suggests the character is in fact not real. This creates a perceptual paradox which may generate the sense of the uncanny.

**4.3 Perceptual cues indicating falsehood are especially potent in the eyes of faces**
The Uncanny Valley is probably related to our innate ability to extract social and emotional information from human faces. We are highly attuned to the cues given by faces, and therefore find it easier to spot small variations (Donath, 2001). The artist Michael Najjar has created an eerie series of photographs depicting normal people with manipulated eyeballs, the Nexus project. This disturbing "undead" effect has been used for so many zombies in horror movies that it has become a parodied cliché. The eyes are especially powerful in our recognition of 'life' because they allow us to attribute a perceptual state to another organism (Weschler, 2002) they also play a crucial role in understanding the intentions of others (Baron-Cohen, 1995). Where the eye gaze fails to communicate intent, the ensuing unpredictable behaviour promotes fear.

**4.4 The uncanny response is culturally dynamic and subject to change over time**
We have grown comfortable with representations of humans on film and it no longer seems uncanny to stare at gigantic flat representations of ourselves projected onto a screen. The Uncanny Valley describes an emotional reaction which may be subject to change over time. Currently 'uncanny' avatars may foster a climate of their own acceptance once we are used to looking at them. For example Duane Hanson's sculpture The Jogger is less uncanny the second time it is viewed because you are expecting it and have pre-classified it as a dead object. Thompson (2004) suggests that reactions to people with plastic surgery may indicate future responses to avatars in computer games. However, in cultures where plastic surgery is unknown a facelift probably would get provoke a far stronger response. The community of practice reading this paper are likely to have markedly different responses to realistic avatars because they have become inured to them by constant interaction and this raises an important issue for future research of the Uncanny Valley.

## 5 Research Aims

The principle research aim is to discover whether the uncanny response can be measured experimentally. As it is currently not well understood, this poses certain problems. It might be most useful to start by researching media in which realism is easier to achieve, such as film or animation, rather than interactive characters. Studies would proceed by manipulating characters and recording which are perceived as uncanny by subjects. Although initial evaluation is likely to be qualitative, we aim should to develop a reliable questionnaire which can be used by researchers in their experiments.

As a result of this work a set of heuristics for creators of animated characters may be produced to avoid the uncanny. Our hypotheses suggest that it is important to balance the realism of the various elements (graphics, animation, interaction) and to pay particular attention to certain aspects such as the appearance of the eyes.

The hypotheses suggest a number of experimental tasks: firstly, to investigate the effect of mismatching the realism of cues such as behaviour and appearance, by extending the work of Garau et al (2003). This could be achieved by systematically manipulating the realism of cues and presenting them to users for comment. We aim to discover if it is possible to reliably reproduce the uncanny response in this way. Secondly, to investigate the relationship between presence and the uncanny, by looking at correlations between measures of presence and measures of the uncanny response. Thirdly, to investigate face perception in greater depth, in particular the effect of manipulating different parts of the face, and determining if the eyes play a special role in causing the uncanny response.

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