Int. J. Human-Computer Studies 111 (2018) 49–61

Contents lists available at ScienceDirect

International Journal of Human-Computer Studies

journal homepage: www.elsevier.com/locate/ijhcs

Is there an uncanny valley of virtual animals? A quantitative and qualitative investigation

V. Schwind[a,*], K. Leicht[b], S. Jäger[b], K. Wolf[c], N. Henze[a]

[a] VIS, University of Stuttgart, Pfaffenwaldring 5a, Stuttgart 70569 Germany
[b] HdM, Stuttgart Media University, Nobelstr. 10, Stuttgart 70569 Germany
[c] Hamburg University of Applied Science, Berliner Tor 5, Hamburg 20099 Germany

ARTICLE INFO

Keywords:
Uncanny valley
Virtual animals
Virtual character
Games

ABSTRACT

Approaching a high degree of realism, android robots, and virtual humans may evoke uncomfortable feelings. Due to technologies that increase the realism of human replicas, this phenomenon, which is known as the *uncanny valley*, has been frequently highlighted in recent years by researchers from various fields. Although virtual animals play an important role in video games and entertainment, the question whether there is also an uncanny valley for virtual animals has been little investigated. This paper examines whether very realistic virtual pets tend to cause a similar aversion as humanlike characters. We conducted two empirical studies using cat renderings to investigate the effects of realism, stylization, and facial expressions of virtual cats on human perception. Through qualitative feedback, we gained deeper insight into the perception of realistic computer-generated animals. Our results indicate that depicting virtual animal-like characters at realism levels used in current video games causes negative reactions just as the uncanny valley predicts for humanlike characters. We conclude design implication to avoid that sensation and suggest that virtual animals should either be given a completely natural or a stylized appearance. We propose to further examine the uncanny valley by the inclusion of artificial animals.

1. Introduction

In 1970, Mori observed negative emotional reactions of human observers towards very life-like robots and prostheses (Mori et al., 1970/2012). Mori assumed that adding humanlike attributes to robots generally causes people's emotional response to become more positive. However, past a certain point of human likeness, when a human entity appears almost–but not completely–real, it suddenly evokes uncomfortable feelings in human observers. Mori called the sudden dip in that relation between human likeness and acceptance of people the *uncanny valley*, which is illustrated in Fig. 1. Mori also noted that motion or physical contact increases the effect. He mentioned zombies and puppets as examples to explain the concept of the uncanny valley. Today, it is commonly assumed, that the uncanny valley also occurs in video games and computer-animated movies (Kätsyri et al., 2016; MacDorman et al., 2009; Schneider et al., 2007; Tinwell et al., 2010).

Today, the uncanny valley by Mori is an actively discussed topic in research on human-computer interaction (HCI) (Brenton et al., 2005; Burleigh et al., 2013; Cafaro et al., 2014; MacDorman, 2005a), human-robot interaction (HRI), video games (Schneider et al., 2007; Tinwell et al., 2010), animated movies (Kätsyri et al., 2016), neuroscience (Cheetham et al., 2011), psychology (Cheetham and Jancke, 2013), and philosophy (Misselhorn, 2009). Although a "stuffed animal" is mentioned in Mori's graph, non-human artificial characters have been insufficiently taken into account by empirical research. The uncanny valley has mainly been investigated using humanlike characters and on dimensions of human likeness. Thus, it remains unclear whether effects or design implications of the uncanny valley can be transferred from humanlike to animal-like virtual characters or robots.

Due to their symbolic and allegorical character, designers, storytellers, and engineers often prefer animal characters instead of humans. Artificial animals are frequently used in entertainment and advertising as well as for therapeutic and educational purposes (Kidd et al., 2006). Beside the positive effects of using artificial animals, there are also reports of negative experiences with virtual or stuffed animals. Noteworthy examples of negative responses are critiques of the computer-generated cat *Azrael* in the movie *The Smurfs*. One feature of Azrael is that the cat expresses itself using human emotions and behaves humanly. Burr from the Boston Globe calls that cat a "creepy animal CGI" (Burr, 2011). Duralde from The Wrap, in reviewing *The Smurfs 2* movie,

* Corresponding author.
E-mail addresses: valentin.schwind@vis.uni-stuttgart.de (V. Schwind), kl040@hdm-stuttgart.de (K. Leicht), sj038@hdm-stuttgart.de (S. Jäger), katrin.wolf@acm.org (K. Wolf), niels.henze@vis.uni-stuttgart.de (N. Henze).

https://doi.org/10.1016/j.ijhcs.2017.11.003
Received 5 November 2016; Received in revised form 17 November 2017; Accepted 26 November 2017
1071-5819/

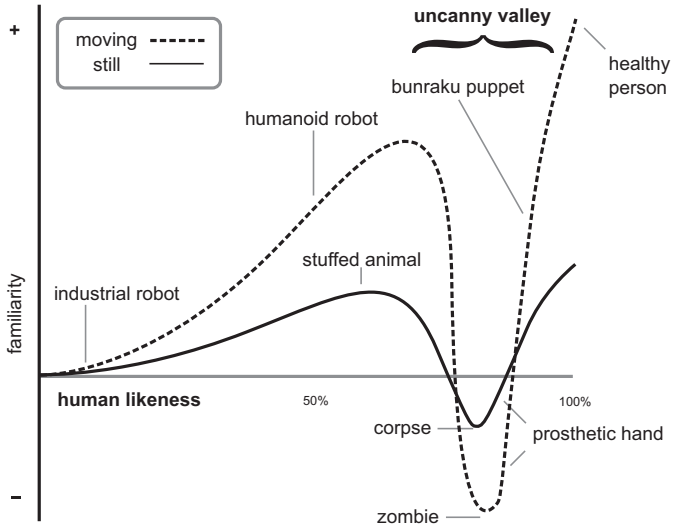

Fig. 1. Simplified version of Mori's original graph. Modified illustration by MacDorman (2005a).

states that *Azrael* "never feels like a real feline; turns out there's an uncanny valley for animals, too" (Duralde, 2013). In art and literature, reactions to stuffed and composed animals, for example through taxidermy, were also associated with uncanny sensations (cf. Gutierrez, 2009; Powell, 2004).

The question whether realistic artificial depictions of animals can fall into an uncanny valley is important because it would have a significant impact on research investigating that phenomenon. A hypothetical "uncanny valley of animals" would either mean that Mori's dimension of human likeness is not only related to humans and has to be enhanced or that the phenomenon appears in a different shape (or not at all). However, there is currently no empirical investigation of Mori's hypothesis, which explicitly considers an uncanny valley of virtual animals or discusses how and whether animals should be incorporated into the uncanny valley hypothesis.

In this paper, we therefore investigate whether the uncanny valley is applicable to *virtual* animals. We aim to answer the following research questions: (1) Can findings of the uncanny valley be transferred from humanlike to animal-like virtual characters? (2) Which factors potentially cause unpleasant effects for virtual animals? (3) Which design implications result from these findings? Research found that using computer-generated characters the uncanny valley appears between intermediate and high levels of virtual realism and using atypical entity feature, which indicates there are potentially two kinds of uncanny valleys (Cheetham and Jancke, 2013; Cheetham et al., 2013; 2011; Gray and Wegner, 2012; Kätsyri et al., 2015; Looser and Wheatley, 2010; MacDorman et al., 2009; Mitchell et al., 2011; Moore, 2012; Seyama and Nagayama, 2007). We hypothesize that both aspects can exist for human observations of non-human computer-generated characters (virtual animals) and operationalize the effect as lower familiarity ratings.

- H1. A virtual animal rendered at high levels of realism is perceived less familiar than using photo-realism or stylization.
- H2. At high levels of photo-realism atypical virtual animal features decrease familiarity more than at lower levels of photo-realism.

Furthermore, it is important to understand which factors trigger potentially unpleasant effects using virtual animals. By contrasting these findings with previous work for humanlike characters we are able to extend our knowledge of existing frameworks that try to explain the uncanny valley or potentially allow the development of a new overarching framework which considers humans *and* animals.

In this paper, we present the results of two studies to gain deeper insights into the human perception of virtual animals. First, we investigate the effect of different levels of realism on the perception of virtual animals and analyze qualitative feedback provided by our participants in an online survey. The second study examines the effects of stylization and anthropomorphic emotions using virtual animals. Our results indicate that the phenomenon of the uncanny valley may apply to virtual animals, particularly of intermediate graphics level as currently used in video games. We contribute design principles for avoiding the effect using realistic animal characters and recommend to consider virtual animals for a better understanding of the uncanny valley.

2. Related work

In the following, we discuss previous work that highlights the importance of animal characters in video games and HCI. Afterward, we discuss previous work on the uncanny valley related to video games and animals.

2.1. Virtual animals in video games & HCI

Based on a survey of game magazines from 1988 to 2005, Miller and Summer report that over the years, animals have been the main character of up to 14.6% (from 1991 to '93) of all video games (Miller and Summers, 2009). Furthermore, animals have been the most prominent enemy in up to 36% (from 1994 to '96) of all surveyed games (Miller and Summers, 2009). Virtual animals are used as companions in educational technology. Chen et al. (2007), for example, purposely selected an animal as the main character whose traits and behaviors are governed by the student's learning profile. Similarly, Hswen et al. (2013) purposely chose a virtual animal for their game that aims to teach children healthy behavior. The authors' choice was motivated by a survey of commercially successful mobile applications and the assumption that virtual animals do not exclude anyone by race or ethnicity.

Dormann et al. state that the value of animal companionship in enhancing social competencies and psychological well-being is widely acknowledged (Dormann et al., 2013). As shown by Chen et al., virtual animal companions can support active self-reflection and learning in the affective and social domains (Chen et al., 2005). The importance of life-like animals is widely acknowledged in therapy of phobias using VR applications as they are used, for example, in the treatment of spider phobia as by Garcia-Palacios et al. (2002). Wrzesien et al. generally discussed the potential impact of using virtual reality (VR) and augmented reality (AR) technologies in therapies of phobia of small animals (Wrzesien et al., 2015).

Previous work in HCI also explores the usage of virtual pets in particular. Ruckenstein, for example, suggests using virtual pets to encourage children to become more mobile in general (Ruckenstein, 2010). Altschuler recommends using virtual pets to increase appreciation in autistic children for their theory of mind and thinking of others (Altschuler, 2008). Chen et al. propose using virtual animals to encourage students to promote effort-making learning behaviors (Chen et al., 2011).

2.2. The uncanny valley in virtual environments

First evidences of the uncanny valley in video games for human characters were found by Schneider et al. based on a paper by Duffy (2003); Schneider et al. (2007). They investigated subjective ratings of participants towards images of game characters and found hints of a non-linear relationship in video games as proposed by Mori et al. (1970/2012). Researchers identified specific influences and derived guidelines for character designers. For example, Tinwell et al. showed that facial expressions and human emotions change the perception of virtual characters (Tinwell et al., 2011). Their design guidelines suggest that designers should pay attention to animations of upper facial expression especially