

JPMTR-2104
DOI 10.14622/JPMTR-2104
UDC 159.925-021.131:004.92

Original scientific paper | 149
Received: 2021-04-09
Accepted: 2021-06-17

Examining the uncanny valley effect in virtual character design for digital games

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Abstract

Today, games, where visuality is at the forefront, have similar features with a cinema project in terms of both the content and the technologies used. When the realistic appearance of robots and digital designs that do not fully resemble humans exceeds a point, the images created leave their place to negative emotions such as disgust, fear, and hate. The feeling of disgust emerges when the level of affinity reaches the highest level. The negative mood status which took its place in the literature as an uncanny valley is an important reference for game designers and researchers. Masahiro Mori's uncanny valley theory about humanoid robots is used by animators and video game designers in the content creation process in video games, every day. In this study, the design evolution of Lara Croft, who has found an important place in the video game world, has been evaluated in terms of exposure to the uncanny valley. This study has used images and videos representing Lara Croft, the strong and smart female icon of the Tomb Raider games. A total of 67 undergraduate students (32 for experiments and 35 as a control group), 34 male (50.7 %), and 33 female (49.3 %), voluntarily participated in this study. In this study, the quasi-experimental design was used with experimental and control groups, since the data collection tool used to compare the experimental and control groups did not allow them to reflect the student's past game experiences. The findings of this study suggest the following design principles: to use a high polygon count to design attractive, ideal faces that are not spooky.

Keywords: computer-generated models, video games, facial expression, human-likeness, emotion design

1. The uncanny valley

The developments in technology have enabled objects in animation movies and video games to look as realistic as possible and characters to act like humans today. The realistic appearance of these computer-generated (CG) imagery visuals created in the computer environment might sometimes have negative effects on users who experience it (Tinwell, 2015). This negative emotion, which is conceptualized and was first introduced by a Japanese roboticist Masahiro Mori in 1970 as the uncanny valley effect (Mori, 1970), is evaluated for realistic characters created in a computer environment as well as robots with humanoid appearance. The origin of the concept of the uncanny valley goes back to the German psychiatrist Ernst Jentsch's explanation of the phenomenon of "uncanniness" in his article. Jentsch (1906) argues that the concept of uncanniness emerges as a result of indecision that occurs when people cannot distinguish whether objects are real and alive. He defined an unknown and unfamiliar phenomenon with

the concept of "unheimlich". In German, "heimlich" expresses the opposite of the word "uncanny" and means familiar, acquaint, native, according to paper of Freud (1919), which is among the pioneering studies on the uncanny concept and explaining the meaning of this concept. Freud identified the uncanny as anything that reminds us of the frightening realm of our unconscious mind, of repressed memories and impulses from childhood that feel unknown but vaguely and threateningly recognizable (Suler, 2016). Today the uncanny valley hypothesis suggested by Mori (1970) has been widely acclaimed in fields involving human–robot interaction throughout the development of increasingly human-like androids (Tung, 2016). In his article, Mori (1970) tried to formulate the emotional effects of beings with artificial appearances such as robots, prosthetic hands, puppets with various features, on humans. These effects were further studied by Bartneck, et al. (2009), and Ho and MacDorman (2010). Mori (1970) assumes that in the relationship of humans with robots, the familiarity with robots will increase as the robots look

more like humans; however, at a certain point, robots will not be able to give what is expected by humans, and this familiarity will be replaced by an extremely uncomfortable feeling (Schwind, et al., 2018). When humanoid robots become too real but do not resemble authentic human beings at the same time, people's perceptions towards the objects turn to negativity (Strait, et al., 2017). Mori (1970) mentioned zombies and puppets as examples to explain the concept of the uncanny valley (Schwind, et al., 2018). Here, the effect of familiarity level on individuals is shown as a deep valley shape on the graph (Figure 1).

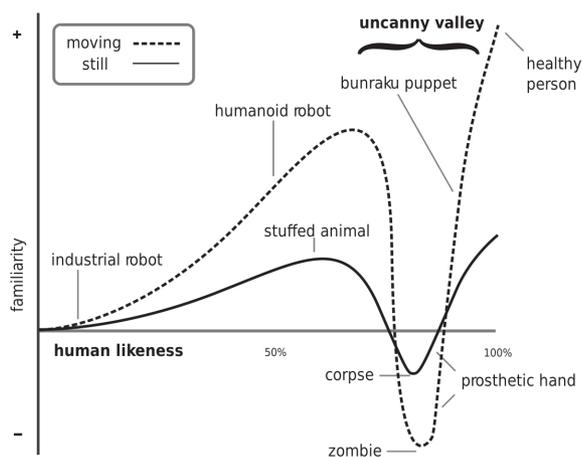


Figure 1: The uncanny valley graph was created by Masahiro Mori (1970)

Mori (1970) has prepared a graph that visualizes the emotional impact of robots resembling humans in terms of physical appearance on individuals. According to Figure 1, the uncanny valley phenomenon divides the characters into two main categories, which are dynamic and static characters (Mohamad Ali and Hamdan, 2017). In this graph, the familiarity level is followed on the vertical plane while the horizontal plane reveals the affinity to humans in terms of percentage. While the dashed line that forms the graph contains human-like products that can move, the continuous line contains products that do not move. When the graph is examined, the starting point of the curve corresponds to industrial robots. Industrial robots, which are completely developed for mass production, do not create a feeling of familiarity because they do not have humanoid features. Robots or prostheses with anthropomorphic features can also be seen on the graph as the first point created by the feeling of familiarity by sliding up the curve. Mori (1970) cites bunraku puppets, toy robots with hands and feet as examples. People continue to be familiar with stimuli such as robots and other artificial devices until they reach a certain point. The sense of familiarity begins to decrease sharply when we perceive that human-

like copies resemble human beings but are not human. The fact that this decrease leaves its place in negative behaviors such as disgust, fear, and hate leads to the formation of the uncanny valley.

1.1 Uncanny valley and game characters

The limited processing capacity of the computer hardware in the early days of video games brought along some issues that video game designers should pay attention to in the preparation process of the games. With the transition from 2D graphics to 3D, the visibility has come to the forefront and the games have become increasingly complex. The characters created in video games, cartoons, caricatures, illustrations, and 3D applications are divided into three groups as stylized, semi-realistic, and realistic in terms of design. Stylized design is a form of design in which the changes in shape, size, and colors come to the fore rather than making the characters look photorealistic. Stylization allows the artist to explore possibilities beyond those found in the real world to enhance the attractiveness or expressiveness of characters, particularly when it comes to cartoons or illustrations (McCloud, 1993; Gooch, Reinhard, and Gooch, 2004). A few common elements found in stylized characters are exaggerated proportions, bold colors, cel-shading, retro effects, and geometric shapes (Lundwall, 2017, p. 8). Such characters are mostly reflected in cartoons, caricatures, and 3D animated movies, with changes in the proportions of the head, hands, feet, and other limbs of the figures.

Semi-realism, in essence, is creating something that we can define as "real" or "close to reality" based on our perceptions, rather than an image of the natural world as it is (Hall, 2016, p. 7). In general, semi-realistic animated movie characters are different from caricatured and exaggerated characters frequently used in traditional animations (Kaba, 2013). Although these concept artists have creative freedom, they have to be close to realism in their designs, especially anatomically. Within the framework of these rules, the elements such as muscles, curves, eyes, etc. are tried to be revealed clearly to show a character more attractively.

In order to create characters with a realistic appearance, it is necessary to reflect the appearance and movements of the character as photorealistically as possible (Wallraven, et al., 2008, p. 23). In this process, artists create a character, starting from basic shape and proportion, adding skin tones, hairstyles, clothes, accessories, basic postures, walk, movement energy, attitude, and facial expressions (Bancroft, 2006). The photorealistic artists who aim to transfer only the photographic image to the work and who are not interested in the original of the object differ from the realistic artists who aim to give life as it is in that sense (Lucie-Smith, 1996, p. 204).

At the same time, this perception of depth provides a perception that the body movements and facial expressions of the characters are close to a real person. The human face is a rich and powerful source full of communicative information about human behavior and emotion (Yong, 2007). Although the face is the primary channel expressing a person's emotions, it forms a meaningful whole in the game only when it combines with the character's posture and body language. Besides the visual features, characters who can think and act like real people can be designed with the possibilities of artificial intelligence technologies in games. While these features bring the character closer to the humanoid appearance, they also increase the tendency to be exposed to the uncanny valley.

For the first time in the digital game market where the main heroes are mostly male, the female character being the main character in a game represents a major transformation in this market. Gender-based game studies have shown that white male characters are generally at the forefront, and female players play a decisive role even in the games that are preferred more than male players, even though white male players are not in the main dominant role (Lynch, et al., 2016). While women generally appear as women in trouble, the male protagonist of the game undertakes the task of rescuing the female character, who is represented as a stereotype as naive and weak.

The first significant change in the way female characters are represented in games over the years was seen in 1996 in the action-adventure digital game *Tomb Raider*, which is about Lara Croft's adventures. Although a series of adventure games offer many female character options, the main protagonist is traditionally male, and female characters appear to be largely in supporting roles. Although Lara represents the success of a heroine, she seems to have done little to change the relationship between female players and the game industry (Cassell and Jenkins, 2000, p. 30). Lara Croft is a powerful figure with incredible gymnastic abilities, able to fight physically like a masculine character. In almost 80 % of the games, there are elements of violence and aggression as a part of the game strategy, and in 28 % of the games where there are female characters, these female characters are featured in their physical appearance or are depicted as sex objects (Dietz, 1998). In contrast to the role of an archaeologist, Lara appears to be represented in an iconic body as men desire, being hyper-sexualized with large breasts, thin waist, curved hips (Mikula, 2003). Therefore, the sociological and psychological dimensions of the game experiences provide important information about the players. Whether or not it has an impact on the attitudes of the people watching or playing this media forum is another topic that researchers investigate.

1.2 Previous research on the uncanny valley in the digital games

The uncanny valley is an assumption that tries to explain the sudden negative reactions we experience when a robot appears and behaves with human-like features, even if not as much as a real human being, such as surprise, fright, disgust, and hate. Many studies examine the different styles of the characters to reveal the uncanny valley effect. Among these studies, participants were asked to classify them as biological or artificial, based on their movements, among a series of examples of point lights, ellipses, robots, aliens, clowns, and running human figures (Chaminade, Hodgins and Kawato, 2007). The participants evaluated that the point lights, which have the simplest appearance among these examples, move more naturally than the other examples. In another study, to examine the relationship between humanoid appearance and visual appeal, they asked participants to react to 75 virtual characters, both from video games and elsewhere (Schneider, Wang, and Yang, 2007). As a result of the study, it was seen that there is a direct relationship between human appearance and attractiveness. It was concluded that characters who have a humanoid appearance but are not completely human-like have a lower rate of attraction. The first experimental research on the uncanny valley was conducted by MacDorman, et al. (2009); they used four empirical studies to reveal the relevance of the effects of motionless images on users with the uncanny valley. They analyzed the examinations of Mori (1970) on the uncanny valley effect by comparing a series of photographs created by combining human and robot faces in two different ways. Hanson (2006) showed that the emergence of the uncanny valley effect on morphed images depends on aesthetic design rather than a realistic appearance of images. Seyama and Nagayama (2007) in the experimental study using the asynchronous morphing technique, where artificial faces gradually turn into real faces, have shown the negative effect of images with abnormal features such as enlarged eyes on people leads to an uncanny valley curve. Another study was carried out to examine whether the character that is visually deficient in facial expressions affects the phenomenon of uncanny (Tinwell, et al., 2011). It was designed to reveal the effects of changes in the facial proportions, skin texture, and detail level of the character designed in a computer environment on perceived strangeness and attractiveness of humanoids, (MacDorman, et al., 2009). In an experimental study using the real robot and human pictures, the effect of anthropomorphism on participants' perceptions has been investigated (Złotowski, et al., 2015). An experimental study has been conducted in order to determine the effects of facial expressions on the real dimension in human perception (Wallraven, et al., 2008).

In four empirical studies (Seyama and Nagayama, 2007; MacDorman, et al., 2009; Złotowski, et al., 2015; Wallraven, et al., 2008), the facial proportions, skin texture, and detail level of the CG human character have been varied. They aimed to reveal whether these changes affect perceived oddness, human resemblance, and attractions. The use of less photo-realistic textures in studies that do not aim to reflect reality is another matter to be considered during the design stage. Chen et al. (2010) conducted an experimental study to determine the changes in perception of human faces of people who have looked at stylized design faces for a certain period. In the same study, cartoon videos with big-eyed characters were shown to the participants, and they were asked to examine human faces in terms of attractiveness during the adaptation process. This study concluded that adapting to cartoon faces with large eyes leads to an orientation in people's preferences towards large-eyed images rather than ordinary human faces (Chen, et al., 2010).

In a study conducted by Flach, et al. (2012), it was evaluated how CG characters in the media are perceived by people and the uncanny valley effect of these characters was examined. In the study, pictures from different media sources were evaluated visually and categorized according to the uncanny valley effect. In another study by McDonnell, Breidt, and Bülthoff (2012), it was tried to determine the uncanny valley effect in video game characters created in the computer environment. In another study on virtual characters that make up the entire visual space of three-dimensional animated movies and designed in a computer environment, the effect of shape and material factors that define how a character looks has been analyzed by Zell, et al. (2015) who observed that the material is a determining factor in reflecting the attractiveness. A study by Mathur and Reichling (2016) was conducted to reveal human responses to 80 android robot faces encountered in real life. The same study constituted another aspect of the study in determining whether a potential uncanny valley effect implicitly influences the social decision-making process of people. In the study conducted by Kätsyri, Mäkäräinen, and Takala (2017), 54 participants were asked to evaluate five movies that included semi-realistic animation, caricatured animation, and human players. It was made in order to reveal whether the semi-realistic animated movie characters affect negative evaluations. As a result of the study, it was seen that movies with semi-realistic characters have higher eeriness scores than those in the other category. While *Beowulf* and *The Polar Express* out of these movies were selected by the participants, it was concluded that *Beowulf* had a higher eeriness rate than all other movies. In another study, 40 participants were asked to evaluate a series of visual images reflecting various happy, neutral, sad, angry, and fearful states of human

and robot faces (Reuten, van Dam, and Naber, 2018). In the same study, the changes in the pupil size of the participants during the appearance of these images were also recorded. It was observed that the uncanny valley effect of humanoid robots was higher than similar visuals, it was scored lower in terms of imaginary interaction, and the pupil showed less change than for other stimuli (Reuten, van Dam, and Naber, 2018).

Emotional expressions were found to be more difficult to notice. Kätsyri, Gelder, and Takala (2019) used both painted and CG faces to test whether CG faces are susceptible to the uncanny valley effect and demonstrate a correlation between large-scale humanity. When the data were evaluated, a linear relationship was found between humanity and affinity. In the same study, it was observed that less realistic faces trigger an eerie sense.

2. Methodology

The purpose of this study is to investigate whether and how playing a realistic game character whose a near-identical resemblance to a human being affects feelings of eeriness and uncanniness compared to a less realistic game character. Perceived both facial attractiveness and distinctiveness was the variable of focus for the character (realistic versus stylized). The case study design was selected because it offered the opportunity to be very descriptive and holistic (Glesne, 2011) and its examination of one or more specific situations and focus on activities as they occur in the real world (Yin, 2009). For this purpose, this study used images and short videos (approx. 30 seconds) representing Lara Croft that is the most iconic character of the Tomb Raider games released by Japanese video game producer Square Enix. Until today, 24 years after the release of the first Tomb Raider game in 1996, Lara Croft still is regarded as one of the most famous video game heroines of all time. And until today, 25 Tomb Raider games, 3 movies, 5 books, and many comic books have been released in total (on all platforms). This study asked participants to compare and rate the proportions of the body and the face of four different Lara Croft characters. Perceived body proportion was the variable of focus for the characters.

To address the primary purpose of this research study, the following research questions (RQ) were investigated:

RQ1 – What is the effect of the realism level and movements of the game characters on falling into the uncanny valley?

RQ2 – Which parts of the faces of the game characters increase the effect of the uncanny valley?

RQ3 – What negative emotions do people who are exposed to the effect of uncanny valley produce?

RQ4 – Which aspect (physical or emotional) of the game characters would increase the uncanny valley effect more?

RQ5 – Is there a significant relationship between the uncanny valley effect and the duration of exposure?

In this study, the quasi-experimental design was used with experimental and control groups, since the data collection tool used to compare the experimental and control groups did not allow them to reflect the participant's past game experiences. Since the uncanny valley effect measured within the scope of the research was not instantaneous and teachable, the pretest and posttest could not be applied. Instead, the experimental group ($n = 32$) played one time TR 13: Rise of the Tomb Raider (2015) before starting the research in connection with the research hypothesis, while the control group ($n = 35$) did not. The reason for choosing this version of the Tomb Raider game is that the haunted valley meat appears more prominently in the characters that are closest to the realistic appearance. In the next step, the differences were measured by applying data collection tools to both groups. The purpose of this activity is to prove that the uncanny valley effect is not permanent, it is experienced instantly, and that the effect is reduced only to a certain level as a result of external intervention.

2.1 Materials and stimuli

This survey included the main character appearing in four editions of the Tomb Raider game series: TR 6: The Angel of Darkness (2003), TR 9: Underworld (2008), TR 13: Rise of the Tomb Raider (2015), and TR 14: Shadow of the Tomb Raider (2018). The first part of the questionnaire was designed with four items that collected participants' demographics information and user preference, and digital game backgrounds. The second part consisted of questions designed to understand the participant's opinions on how the character looked and how attractive was in terms of realism, empathy, and strangeness (Dill, et al., 2012). In the third part, the Subjective Measurement Scale (5 items) was used to determine the type of emotion expressed facially and orally by the human or virtual character such as human-likeness, eeriness, disgust, fear, and attractiveness. The rating scale was developed by Burleigh, Schoenherr, and Lacroix (2013) using 7-point Likert scale. The last part was a 5-item questionnaire that measured the perception of how unrealistic/realistic the characters' body proportions appeared to be (Murphy, 2016). Each character was displayed on a uniform white background with a resolution

of 500×500 pixels. The images for each experiment were presented in random order. After presenting each image and video, the participants were requested to fill a questionnaire.

2.2 Design and procedure

This research centers on the perception of the emotion of CG characters in digital games. Therefore, the problem of the study is to examine the relationship between the impact on attitudes and behavior of undergraduate students that play different editions of the same video game series and their perception of computed graphics characters. According to previous studies' classification criteria the variables perceived strangeness, friendliness, and human-likeness were used as items to measure the uncanny (Bartneck, et al., 2009; Burleigh, Schoenherr and Lacroix, 2013; Schneider, Wang and Yang, 2007; Ho and MacDorman, 2010). The study was carried out as a quasi-experimental with a web-based survey that uses images and videos of game characters and rating questions for each participant. Experimental studies are defined as studies based on testing the differences that occur within the framework of the problem determined by the researcher on the dependent variable. In the quasi-experimental design, just as in the experimental design, it is aimed to compare groups with similar characteristics (Chiang, Jhangiani, and Price, 2015). Quasi-experimental research involves the manipulation of an independent variable without the random assignment of participants to conditions or orders of conditions. The quasi-experimental study is the process of formulating and realizing a series of actions and activities to achieve the desired positive change, evaluating the applications performed through the scientific method, and generating information about the intervention to help practitioners in the field (Proctor and Rosen, 2008).

In the research, the participants were asked to evaluate the visuals of Lara Croft, the main character of the TR 6, TR 9, TR 13, and TR 14 versions of the Tomb Raider game series. In the first phase of the study, the participants were asked to evaluate the character according to only physical appearance features. In the second stage, the emotional states formed in their minds when they look at the character were examined in the "emotional appearance" category.

2.3 Participants

The population for this study was a convenience sample of 67 undergraduate students (32 in experimental and 35 in the control group) selected from different departments at a midsize university in Turkey by appropriate sampling method and determined by random assignment as participants for 30 minutes experiment.

During the 2020–2021 school year, the researchers measured the attitudes of students in a state university in Turkey for two weeks. This limitation was caused by accessibility and convenience of time, location, and availability when conducting this research. To address the aforementioned research questions a between-groups (experiment, and control group) quasi-experimental design with a follow-up study was conducted in the study. All 67 undergraduate students, 34 males (50.7 %) and 33 females (49.3 %), voluntarily participated in this study. Their ages ranged from 17 to 23 years old at the onset of the study. A detailed overview of the scope and goals of the study as well as the link to the survey were posted to the students.

3. Analysis and results

The coded data were entered into a Microsoft Excel spreadsheet. Data were analyzed on the computer by using IBM SPSS Statistics version 24, the margin of error was assumed to be $p < 0.05$. Today, many studies are examining the relationship between game types and addiction level, especially massively multiplayer online role-playing games – MMORPGs. Research results show a significant increase in more time playing computer games when the high image quality and difficulty level of games increase (Wan and Chiou, 2006). All participants were asked: On average, how many hours do you play video games? The response rate was: 50.7 % played for 0–1 hours, 16.4 % for 1–2 hours, 17.9 % for 2–4 hours, and 15 % for 4–6 hours. No significant difference was found according to the *t*-test result in which the difference was investigated according to the game playing times of the participants and the gender variable ($t = -2.615$; $p = 0.111$).

Today, video games can be played through mobile phones, tablets, or portable consoles anywhere with internet access. As the speed and prevalence of the internet increased, the types and playing times of video games were directly affected by this development. When asked about the platforms they frequently play games with, 65.7 % of them stated that they use mobile phones/tablets, 31.3 % of them use comput-

ers (PC, Mac), and 3 % of them use gaming consoles (Xbox, PlayStation, Nintendo). In this study, when the variance by game types is examined, it was observed that the three most preferred game types are 40.3 % traditional games (Tetris, solitaire, checkers, chess), 16.4 % first-person shooting games (FEAR, Half-Life, Counter-Strike) and 13.4 % simulation and strategy games (Warcraft, Rise of Nations, Age of Empires).

In the section where a different dimension of the physical attributes of the characters was evaluated, the participants were asked to rate the video game characters according to the video images and how realistic the body proportions looked. Also, the sexiness, strength, and attractiveness of the character were scored according to the 5-point Likert scale. In this analysis, the direction of the changes in the development process of the character over the years was determined. According to Table 1, while the participants found the Lara Croft character in TR 9 to have realistic human proportions ($M = 3.84$) they found that TR 6 having the least realistic rates ($M = 3.13$). Based on the analysis made according to the weak/strong appearance of the characters, it was determined that the characters in the TR 13 and TR 9 versions seems stronger than the others. Similar results were observed in the distribution of the average scores according to the characters' aggressive/submissive appearance level with weak/strong and unattractive/attractive levels. On this scale, the TR 9 and TR 14 characters are in the first place at the sexy appearance level of the characters, while the TR 13 version, which is positive in the other items, has the lowest average score in this item.

The RQ1 asks if there was an effect of the realism level and movements of the game characters on falling into the uncanny valley. Questions (items 1 and 2 in Table 2) were asked with the intention to capture the level of human-likeness (how realistic is the character) in the user's perception. Results for the first item (Do you think that the character is real person or CG?) demonstrated: 98.5 % of the mean for all of the participants stated that the Lara Croft character in TR 6 seemed to be created in a remote computer environment (created with CG); in the case of TR 9 it was 64.2 % (see Table 2).

Table 1: Descriptive statistics for character body versions (where M denotes mean value, and SD denotes standard deviation)

Variable	TR 6 M (SD)	TR 9 M (SD)	TR 13 M (SD)	TR 14 M (SD)
Weak/strong	3.49 (1.19)	3.67 (1.05)	4.18 (0.97)	3.19 (1.23)
Submissive/aggressive	3.63 (1.36)	3.91 (1.14)	4.30 (1.07)	3.91 (1.18)
Unrealistical/realistical	3.13 (1.23)	3.84 (1.18)	3.33 (1.31)	3.55 (1.28)
Unattractive/attractive	3.81 (1.25)	4.12 (1.07)	4.24 (1.20)	3.79 (1.31)
Not sexualized/sexualized	3.13 (1.38)	3.93 (1.19)	2.87 (1.46)	3.18 (1.36)

Table 2: Descriptive statistics for a physical appearance in percentage by the experimental (Exp.) and control (Cont.) groups, and mean of the groups (M)

Items	TR 6			TR 9			TR 13			TR 14		
	Exp.	Cont.	M	Exp.	Cont.	M	Exp.	Cont.	M	Exp.	Cont.	M
1. View												
A real person	–	2.9	1.5	40.6	31.4	35.8	81.2	34.3	56.7	78.1	60.0	68.7
Created with CG	100.0	97.1	98.5	59.4	68.6	64.2	18.8	65.7	43.3	21.9	40.0	31.3
2. Degree of realism												
Very realistic	–	–	–	28.1	5.7	16.4	93.8	68.6	80.6	78.1	45.7	61.2
Moderately realistic	43.8	45.7	44.8	56.3	65.7	61.2	–	–	–	6.3	37.1	22.4
Unrealistic	56.2	54.3	55.2	15.6	26.6	22.4	6.2	31.4	19.4	15.6	17.1	16.4
3. Characterization												
Sympathetic	46.9	28.6	37.3	65.6	45.7	55.2	50.0	31.4	40.3	56.2	57.1	56.7
Antipathetic	53.1	71.4	62.7	34.4	54.3	44.8	50.0	68.6	59.7	43.8	42.9	43.3
4. Strangeness												
Yes	59.4	74.3	67.2	37.5	62.9	50.7	43.8	57.1	50.7	37.5	20.0	28.4
No	40.6	25.7	32.8	62.5	37.1	49.3	56.2	42.9	49.3	62.5	80.0	71.6

As the answer to the same question, 68.7 % of the participants said that the character in TR 14 was designed as closest to human. Lara's character in TR 14: Shadow of the Tomb Raider, which was released in 2018, has a 4K resolution at 60 fps but can be clearly distinguished from a real person by the participants. With the implementation of technological developments required to produce realistic graphics, game designers feel freer to create all the features of the character they dream of. In the second question, the reality level of the character created in the computer environment was examined at three levels: 61.2 % of the participants find the TR 14 version and 80.6 % the TR 13 version quite realistic. The last two items, which measure the positive and negative perception felt at first glance to Lara Croft's characters, determine the familiarity in exposure to the uncanny valley. Question 3 was asked to evaluate the perception of the character's personality (characterization). In this context, 56.7 % of the participants find TR 14 sympathetic and 55.2 % of them find TR 9 sympathetic, while 62.7 % of them find TR 6 antipathetic and 59.7 % TR 13 antipathetic. In the last question related to antipathetic thinking, 67.2 % of the participants were uncomfortable with TR 6, while a group of 71.6 % reported that there was no disturbing element in TR 14. As seen in Table 2, when the scores of the experimental group with students who played games for one hour were examined, no significant difference compared to the control group was found in the TR 6 and TR 9 versions, which did not have a realistic appearance in the first question answers. In the TR 13 version where the uncanny valley effect is expected, 81.2 % of the experimental group students ($n = 26$) found the character realistic, while 34.3 % ($n = 12$) of the control group students found the character realistic. For the second question, in which the realistic views of the characters were classified, close results were obtained in the TR 6

and TR 9 versions; 93.8 % ($n = 30$) of the experimental group students and 68.6 % ($n = 24$) of the control group students saw the character in TR 13 version as "very realistic". In the same question, 2 % ($n = 2$) of the experimental group and 31.4 % ($n = 11$) of the control group defined it as "unrealistic". According to these results, it was determined that there was a significant decrease in the level of falling into the uncanny valley of the students in the experimental group where the game was practiced for one hour.

The following section addresses the study's second research question RQ2. The human face is an important indicator of other forms of communication and any facial expression that is the source of this indicator is the visible sign of a person's sensation, attitude, character, and psychological state. When the parts of the disturbing face were examined, the participants were asked to evaluate the eyes, mouth, nose, hair, and other elements in the last question. According to results in 46.3 % of the participants in TR 6 and 29.9 % of the participants in TR 9 find the eyes of the characters disturbing, while 49.3 % of the participants in TR 13 and 71.6 % of the participants in TR 14 stated that they found the other factors disturbing in the first place. Research has shown that the large eyes and skin texture of the highly realistic characters are one of the important factors that increase the uncanny valley effect. This is consistent with what has been found in previous studies (Seyama and Nagayama, 2007) wherein the eyes in the character face plays role in the uncanny valley effect.

The RQ3 tried to determine the emotions that occur when exposed to the uncanny valley effect. To define these emotions, the relationship between positive emotions (human-likeness and attractiveness) and

Table 3: Correlation coefficients *r* for observed variables

Emotions	TR 6				TR 9			
	1	2	3	4	1	2	3	4
1 Human-likeness	1				1			
2 Eeriness	-0.356**	1			-0.246*	1		
3 Fear	-0.297*	0.876**	1		-0.177	0.836**	1	
4 Disgust	-0.489**	0.544**	0.481**	1	-0.427**	0.606**	0.560**	1
5 Attractiveness	0.532**	-0.416**	-0.381**	-0.550**	0.534**	-0.502**	-0.491**	-0.628**

Emotions	TR 13				TR 14			
	1	2	3	4	1	2	3	4
1 Human-likeness	1				1			
2 Eeriness	0.015	1			0.150	1		
3 Fear	-0.060	0.930**	1		-0.157	0.789**	1	
4 Disgust	-0.434**	0.498**	0.589**	1	-0.031	0.375**	0.504**	1
5 Attractiveness	0.476**	-0.310*	-0.329**	-0.537**	0.319**	-0.201	-0.114	-0.411**

p* < 0.05; *p* < 0.01

negative emotions (eeriness, fear, disgust) was examined. Correlational analyses were conducted between familiarity and negative emotions and relationships were computed using bivariate Pearson analysis (see Table 3). When facial expressions were examined according to the familiarity dimension that evoked negative emotions, it was found that emotional appearance was more effective in TR 13 and TR 14 compared to TR 6 and TR 9 versions.

The characters were analyzed through emotions, which is the second determinant in the case of exposure to the uncanny valley. Considering the emotional states of the participants towards the characters, it was seen that there was a significant difference in human-likeness status between the character in TR 6 and the character in TR 9. Similarly, differences were observed in human-likeness status between TR 6, TR 13, and TR 14, while no difference was found in familiarity status. A significant difference was determined between TR 9 and TR 13 as well as between TR 13 and TR 14 in both dimensions.

This correlation analysis aims to define the emotions efficient in the emergence of the uncanny valley effect. For this aim, inverse relationships among the emotions in the correlation have been taken into consideration. According to Table 3 as a result of the correlation analysis, it has been determined that there is an inverse correlation *r* between the variables of human-likeness that represents positive emotions and fear (*r* = -0.297; *p* < 0.05) in version TR 6 that contains the least uncanny valley effect, and between human-likeness and the emotion eeriness (*r* = -0.246; *p* < 0.05) in the version TR 9. It has also been determined that

there is an inverse correlation between attractiveness that represents positive emotions of the characters in the version TR 13 in which the uncanny valley effect was measured at a high level and eeriness (*r* = -0.310; *p* < 0.05). It has been stated that there is no meaningful statistical correlation among the other variables because negative emotions such as eeriness, fear, and disgust may be confused with each other as these kinds of emotions have transitivity at a high rate.

Facial expressions that are the elements of non-verbal communication are the most basic elements of interpersonal communication. Many emotions that cannot be explained through words are transferred by facial expressions. People’s expressing their feelings and thoughts with gestures creates a more realistic effect than words. Especially with the technological developments in the designs of the character, with the higher resolution modeling, the emotions of the characters appear more clearly. According to RQ4, when the physical appearances of the character and emotional appearances are compared (Table 4), no significant difference was observed between the physical appearance average scores according to human-likeness. From the results of the study, it has been concluded that the point averages of physical appearance are higher than the point averages of sensory appearance. It has been found that the value of familiarity of the physical appearance in TR 14 in which the uncanny valley effect has been observed is low as compared to the other versions (*M* = 1.886).

Human-likeness and familiarity, the two variables used to measure the uncanny valley, were calculated separately for the experimental and control groups. In

Table 4: Descriptive statistics for the study variables in experiments 1 and 2 (where M denotes mean value and SD standard deviation)

Variable	Physical appearance				Emotional appearance			
	Human-likeness		Familiarity		Human-likeness		Familiarity	
	M	SD	M	SD	M	SD	M	SD
TR 6	2.597	0.974	2.134	1.065	0.231	0.266	0.351	0.418
TR 9	2.384	0.773	1.955	1.003	0.649	0.477	0.522	0.456
TR 13	2.313	0.859	2.592	1.233	1.090	0.577	0.448	0.453
TR 14	2.511	0.593	1.886	0.953	1.067	0.583	0.642	0.425

Table 5: Comparison between experimental and control groups by One-Way ANOVA (where n denotes number of participants, M is for mean value, SD is for standard deviation, and t and p are statistical values)

Game	Uncanny valley effect	Group	n	M	SD	t	p
TR 6	Human-likeness	Exp.	32	1.703	0.560	17.218	0.554
		Cont.	35	1.419	0.557	15.081	
	Familiarity	Exp.	32	2.042	1.113	10.376	
		Cont.	35	2.219	1.028	12.764	
TR 9	Human-likeness	Exp.	32	2.172	0.624	19.689	0.715
		Cont.	35	1.943	0.688	16.703	
	Familiarity	Exp.	32	1.823	0.927	11.122	
		Cont.	35	2.076	1.066	11.518	
TR 13	Human-likeness	Exp.	32	2.125	0.696	17.273	0.326
		Cont.	35	1.743	0.747	13.813	
	Familiarity	Exp.	32	2.428	1.171	11.723	
		Cont.	35	2.743	1.286	12.617	
TR 14	Human-likeness	Exp.	32	2.375	0.635	21.174	0.756
		Cont.	35	2.157	0.616	20.711	
	Familiarity	Exp.	32	1.823	0.817	12.628	
		Cont.	35	1.943	1.071	10.731	

the calculation of the human-likeness value, the mean scores of the reality level, body proportions, and attractiveness level were taken, while when measuring the familiarity values, the disturbing elements on the character’s face, and emotional appearances (eeriness, fear, disgust) score averages were taken. The following section addresses the study’s fifth research question. The findings obtained on the RQ5 showed that the effect of the uncanny valley is different between those who look at a game character for the first time and those who look at the character again after playing the same game for a certain period. The difference between the opinions of the participants in the experimental group that played games for a length of time and the opinions of the participants in the control group that didn’t play any games has been evaluated according to the analysis of One-Way ANOVA (Table 5).

This analysis was used for dependent groups to reveal the uncanny valley effect of the control group and experimental group students and whether there was any difference before and after the experimental proce-

dure. According to the results of the analysis in Table 5, it was found that the uncanny valley effect scores of the students in the experimental group where the game was applied for one hour and the control group students who did not apply the same procedure differ at a certain level, but not at a statistically significant level ($p < 0.05$).

As seen in Figure 2, it was revealed that the students in the experimental group had a less uncanny valley effect compared to the control group in TR 13 and TR 14 games with more realistic graphics.

As a result, when Figure 2 is examined, it is seen that the data obtained from both groups are consistent with each other and the effect occurs at a certain level in both. Because the uncanny valley is an instant effect, after a certain period of exposure, the effect decreases. The uncanny valley effect is at its highest for participants who see the character for the first time. Eyewear occurs after a player plays the game for a certain period and there is a slight change in the perspective of the character.

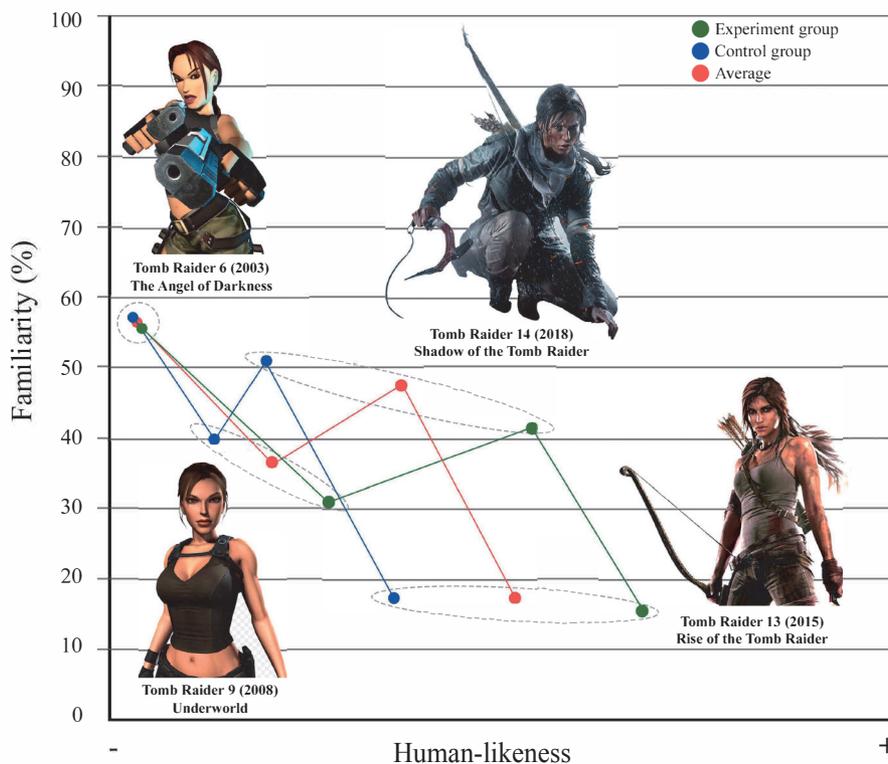


Figure 2: Ratings for the uncanny valley effect by the experimental and control group of students

4. Discussion

As in other media products, digital games need creativity and rationality in the game as well as the fantasy of the game and the characteristics of the characters in order to attract the masses to the game (Walkerdine, 2007, p. 9). The developments in computer technology and the applications developed at the same pace have enabled the creation of virtual images that are hard to distinguish from reality. The ability to reflect the appearance and movements of the characters as real as possible has been made possible by the developments in technology in the last decade. While the characters look humanoid, designers need to take into account the effects of virtual images that can make motor movements similar to facial expressions and human movements. The aim of the figures with a realistic appearance to reflect the reality of all details enriches the visual language and limits the designers to determine their personal preferences in the content creation process. It offers some suggestions regarding the issues that video game designers should pay attention to in the process of making the characters appear realistic to the desired extent.

Lara Croft is recognized as a source of self-empowerment for women, a feminist icon, and a huge step towards gender equality in games. With the transfor-

mation of popular culture into mass culture, digital games have become an important tool in reflecting the identity and cultural values of individuals. In general, players reach satisfaction by reflecting their social and psychological needs in their daily lives to the game content. Today, many types of research are carried out on the effects of digital games on people’s behavior, as in traditional media environments that appeal to millions of people. These researches are used to contribute to the development of the content quality of games, as well as to determine the positive and negative effects on people. It has shown that male characters are at the forefront in gender-based approaches, which have an important place among these studies, and have a determining effect on the outcome of the game even if they are not in the main dominant role. As in all fields of art, it is a pleasure to look at naked women in games, because the female body is one of the most important tools in the formation of admiration and aesthetics. As a symbol of passion and lust in women’s games, it has remained within the framework of this dominant view in patriarchal systems for ages. It is observed that especially the self-expression problem of women is also effective in games. Woman plays an active role in shaping gender-related attitudes under the pressure of men. Nowadays, it is seen that the female body is under the control of men, and roles and duties are given by men in games where mythological subjects are usually

taught. Thus, the powerful and sexy body woman was given a new identity, and this identity was interpreted together with her natural beauty.

In another part of the research, various physical characteristics of the character were evaluated by considering the short videos of the character. It has been determined that the character who appears to be the strongest in this episode is the character with the highest effect of the uncanny valley. Strength is measured by clearly drawing a character's muscular structure. Another factor is the physical reactions of the character in situations that require physical power. With the development of animation technologies such as motion capture, motion elements that are very close to humans have become transferable to the character. While analyzing the aesthetics of many important characters such as Lara Croft, the continuity of the traditional design in previous games and the success of the character in the role in the game are taken into account. Therefore, design analysis should not be considered independent of the character's background. Nowadays, in order to attract the attention of the players, the value perception of the scenario and characters may change according to the user trend. Gender perception sees men as suitable for higher status roles because society considers them to have the qualities necessary for leadership. The character of Lara, who has a free spirit due to her profession, was drawn with a sexy body, especially in the first versions, under the pressure of social morality in the male-dominated order. Generally, the one-piece outfit that covers the whole body emphasizes the operational abilities and sexuality of the characters. With the shirt, covered with armor in the shoulder and neck area, military canvas style trousers, boots, and a blue beret she has a look of a soldier who is ready for duty. This situation is like the projection of an idea in which interest was built on sexuality in the early stages of the game world. The same attitude caused the denial and lockdown of all sexual practices that are the obstructive force of the dominant discourse. The rulership created a detailed template of the sexual act and determined the distribution of all sexual identity roles through the video game character.

5. Conclusion

In this study, the design evolution of Lara Croft, who has found an important place in the video game world, has been evaluated in terms of exposure to the uncanny valley. The game designer, who takes advantage of the opportunities provided by modern technology, tries to adapt the quality and intense data provided by photography and video images to his/her works. The theory is built on the fact that humans empathize with the humanoid features of robots or prostheses with anthro-

pomorphic features. Each of these elements provides important clues for the companies that develop the games and the people researching the games to measure the short- and long-term effects. In this research, participants were asked to evaluate the game character both visually and sensually. In the first evaluation, the realism levels were tried to be determined by examining the character designs only through photographs. The results of this analysis revealed the human-likeness and familiarity position of the characters specified in the uncanny valley methodology. Looking at the designs according to this point, the negative emotions that occur and cannot be defined, that is, the exposure to the uncanny valley can be determined. The concept includes negative emotions such as fear, disgust, hate, and startle, as well as unfamiliarity (alienation), which gives a feeling of discomfort. According to these results, TR 6, which has a more stylized design, appears to be the character with the lowest uncanny valley effect. The TR 13 character, where this effect is at the highest level, has a very realistic design. It is a state of behavior and thought that occurs instantly in a state of antipathy, which includes negativities and negative attitudes in response to a situation. While a person displays this attitude, he/she seeks to produce valid reasons for his/her actions and thoughts. The results showed that semi-realistic characters had a greater impact on players being exposed to the uncanny valley than cartoony or realistic characters (Kätsyri, Mäkäräinen and Takala, 2017). It was also revealed in this work that especially stylized characters have less frightening features for humans. Besides the visual features, characters who can think and act like real people can be designed with the possibilities of artificial intelligence technologies in games. It was found that as the uncertainty of the disturbing elements increased, the tendency to be exposed to the uncanny valley increased as well. In body language, eyes are the most obvious indicator for expressing emotions. It enables the classification and detection of emotional state (emotion) analysis, mental state, and different emotions from eye movements. When asked about the disturbing elements on the faces of the four characters selected from the participants in this study (Figure 1), it was determined that TR 6 and TR 9 characters have certain disturbing elements such as eyes, mouth, and hair. In the characters in TR 13 and TR 14, which have more realistic designs, it was observed that the disturbing elements were more ambiguous. According to these results, it was found that the exposure to the uncanny valley increases in realistic designs where the gruesome elements are uncertain. Many studies in the literature have shown that pupil size changes in size can be noticed during different kinds of emotional stimulation (Kinner, et al., 2017; Chen, et al., 2010; Reuten, van Dam and Naber, 2018). According to the analysis results, the eye features of the TR 13 and TR 14 characters, which have a high tendency to be exposed

to the uncanny valley, were found to be less disturbing by the participants compared to the TR 6 and TR 9 versions. Especially in the recently developed Lara Croft characters such as TR 13 and TR 14, this effect is highly visible. As a result of this research, it was determined that there is a direct relationship between human-like appearance and attractiveness, as in a similar study in the literature (Schneider, Wang and Yang, 2007). Unlike similar research, no link could be established between the level of authenticity and reality. Although especially stylized characters are seen as more sympathetic to people than realistic or semi-realistic characters, sufficient data could not be found to generalize. In the last part of the study, emotional states were examined by revealing the effect of the uncanny valley. A lot of fictional element in the game has a key role in integration between the fictional world and the real world. This section aims to classify the immediate negative emotions that occur in the players' behavior. The sense of attractiveness is evaluated in the human-likeness category and the familiarity category in various emotions such as eeriness, fear, and disgust. In familiarity, where negative emotions are generally determinant, a mix of many emotions is experienced.

In addition to being close concepts in terms of their contents, fear, and disgust, the two most influential emotions in the uncanny valley effect, the situation that reveals the feeling of disgust is not very clear to the person. Naturally, people want to stay away from situations they consider dangerous as much as possible, even if they are in this situation, they want to escape and protect themselves. However, the individual who is afraid or feels the feeling of fear for any reason seeks an authority that will surrender him/herself to. Therefore, emotions such as fear and disgust are universal as well as their severity varies according to individual differences. According to the results of the research, it is seen that the negative effects of the uncanny valley such as fear and disgust increase as the physical power features of the character increase.

Likewise, a negative relationship was found between the character's sexy appearance and fear. When a person encounters or imagines what he is afraid of, the intensity of the fear increases and the feeling of disgust is added. It is almost impossible to determine the dominance level of the fear and disgust situations that cause the uncanny valley effect.

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