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ORIGINAL ARTICLE

Analysis of charisma, comfort and realism in CG characters from a gender perspective

Victor Araujo[1] · Bruna Dalmoro[1] · Soraia Raupp Musse[1]

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Abstract
Realistic characters from movies, games and simulations can make viewers feel strange (discomfort), an effect known as the Uncanny Valley (UV) theory. However, can the genders of CG characters and the genders of viewers change perceived comfort? In addition, can the genders (both characters and viewers) also influence the perceived charisma? Can the realism of a character also influence these aspects? This work aims to evaluate the perception of women and men about female and male characters, created using Computer Graphics (CG), presented in various media (movies, games, computer simulations, among others). Our goal is to answer the following questions: (i) How does the comfort perceived by people of both tested genders (female and male) relate to the genders of the characters? and (ii) Is the charisma influenced by the realism of the characters, considering the subjects and genders of the characters? We conducted perceptual studies on characters created using CG in images and videos through questionnaires. Our results indicated that the gender of the subjects and characters affected comfort, charisma and perceived realism. In addition, we also revisited the aspect of the UV theory (perception of comfort and human likeness) and found coherent curves compared to many works in the literature.

Keywords Uncanny valley · Perceived comfort · Perceived realism · Perceived charisma · Cg characters · Gender

1 Introduction

Games, movies and real-time simulations are increasingly using CG to create their characters, often capturing facial and body expressions of real actors to produce highly realistic faces and characters [10,14]. Lately, the cinematographic and game industries have sought to create products with female protagonists, to increase female representation.[1],[2] For example, from 2016 to 2020, there was a 16%[3] growth in female protagonists in games. Regarding the creation of these characters, in Draude's paper [5], the author states that the simulation of human appearance and behavior, in virtual characters, represents ease of use and reliability, transforming something abstract into comfortable. Therefore, Draude hypothesizes that most artificial beings in cinema and science are attributed to the female gender to guarantee this comfort in those who watch them. However, the percentage of male characters has always been higher than female characters during the past few years.

An open question is how we perceive CG characters when they can be visibly associated with a particular gender and whether that perception changes depending on the observer's gender. Laue [13] states that we, as a species, tend to anthropomorphize and sympathize, even with the simplest and

✉ Soraia Raupp Musse
soraia.musse@pucrs.br

Victor Araujo
victor.flavio@acad.pucrs.br

Bruna Dalmoro
bruna.dalmoro@edu.pucrs.br

[1] PUCRS, Porto Alegre, Brazil

[1] https://www.playstation.com/en-us/games/the-last-of-us-part-ii-ps4/.

[2] https://www.playstation.com/en-us/games/horizon-zero-dawn-ps4/.

[3] https://www.statista.com/statistics/871912/character-gender-share-video-games/.

weirdest technologies. In addition, from the designer to the viewer, we tend to attribute human characteristics, such as gender, to these technologies. Regarding the gender of a person who observes, according to Hall et al. [8] and Cheetham et al. [3], women more easily perceive tasks of face detection, discrimination of facial identity and facial expressions, in human beings. Regarding the faces of the characters created using CG, according to Chethaam et al. [3], women recognize faces similarly to how they recognize real human beings, but more quickly than men. Still, according to Chethaam and colleagues, regarding the categorization of less realistic faces, there is no significant difference between the perception of women and men.

Avoiding discomfort is important for a CG character to be more similar to a human being, which can improve the experience of watching movies, playing games, etc. There are examples of real actors being exchanged for characters created using CG, such as Princess Leia and Genius, respectively, in the Disney films Rogue One (2016) and Aladdin (2019). About Aladdin, people on social media felt uncomfortable with genius animations in the first movie trailer,[4] ever if character has always been considered charismatic since the original animated version. According to the dictionary, charisma is a compelling attraction or charm that can inspire devotion in others and is closely linked to leadership [21]. Following this concept (more concepts about charisma in Sect. 2), many famous animated CG characters are adored by several people, but what is the relationship between realism and this adoration? The charisma? Does gender also influence this case? Does the character's realism influence comfort and perceived charisma?

To answer all these questions, we performed some analyzes: Initially, we chose several females and male characters created using CG from different media (from games, movies, the internet) and created a questionnaire to measure the perception of realism, discomfort and charisma about images and videos of such characters. With that, we compared the perceptions regarding female characters with the perceptions about male characters quantitatively, and we compare the perceptions of women participants with the perceptions of men, regarding all characters. To make this paper more comfortable to read, we present some definitions as follows. Regarding comfort, charisma and realism, consider (PGe, CGe) being a tuple that returns perceptual data, where PGe indicates the participants' gender and CGe the characters' gender. Therefore, $PGe = W$, when we refer to data answered by women participants, and M, representing men. In addition, $PGe = A$, if we considered all participants. CGe is related to the character's gender, $CGe = F$ representing the female characters, $CGe = M$ representing the male characters, and $CGe = A$ all characters. To answer our research questions, we proposed four null hypotheses , using the defined terminology.

- $H0_1$ defining that $(A, F) = (A, M)$, i.e., the perceptual data of all the participants about the female characters indicate comfort/charisma similar to the data related to male characters;
- $H0_2$ defining that $(W, F) = (W, M)$, i.e., the perceptual data of women participants about the female characters indicate comfort/charisma similar to that obtained about male characters;
- $H0_3$ defining that $(M, F) = (M, M)$, i.e., a hypothesis similar to $H0_2$, but in relation to men;
- $H0_4$ defining that $(W, A) = (M, A)$, i.e., the data obtained by women indicate comfort/charisma similar to that obtained by men, in relation to all characters.

The main contribution of this work is to investigate the relationship between comfort/charisma perceived by the participants with respect to their gender and from the CG characters. Similar to presented by Dill et al. [4] and Kätsyri et al. [12], we analyzed human perception in natural situations, that is, without stylizing the characters, without controlling the intensity of emotion, lighting or shading. That is why we use characters from different media, with images and videos obtained from the internet (more details on the choice of characters in Sect. 3). Our hypothesis is that we should test and measure the perceptual comfort/charisma as it is, in real life, even if we do not have control over the tested data. Although it is desirable that experiments are highly controlled, we argue that it is also interesting to study wild characters once they represent what people see, play, and interact with in real life, while controlled characters are only tested in controlled situations. For example, it is not necessary true that if light impacts a controlled CG character, a real game or movie character is going to be impacted in same way. So, we proceed with evaluation of movies and games characters, as presented by Dill et al. [4]. With this, we try to create an approach to evaluate natural stimuli (realism, comfort and charisma), as presented by Katsyri et al. [12].

2 Related work

As discussed in the last section, Uncanny Valley [17] is a theory created by Masahiro Mori. The UV theory analyzes human perception in an emotional context to artificial beings. According to Mori, artificial beings with a high level of realism (high similarity to human beings) and without a characteristic common to human beings, can fall in the "Uncanny Valley", that is, they can cause sensations of strangeness in those who watch them. According to Mori, this sensation is more intensified when artificial beings show signs of life,

[4] https://screenrant.com/aladdin-will-smith-genie-blue-bad-why/2/.

such as movement, changing the shape of the valley. In addition, this feeling of strangeness can also be caused by lack of familiarity or other features that can cause discomfort. Therefore, in this work we use the concept of discomfort described by Mori. Please refer to Mori's [17] research for more details. The perception of CG characters is a very present subject in Computer Animation, according to Zell et al. [25], the creation of a stimulus, measurement, and evaluation of perceptual data, among other things, is essential to understand the human perception. Wisessing et al. [23] designed perceptual studies to assess the effect of lighting on perception. The results were significant between lighting with character emotion, and with appeal.

Zell et al. [24] analyzed two important factors for defining a character's realism: shape and material. In addition, how the perception of different facial expressions was affected by the variation of these characteristics was also studied. The authors concluded that a character's shape is relevant to its realism and expression. The research by Hyde et al. [9] reported the importance of the realism of the characters created using CG. The effect of the Uncanny Valley theory on human perceptions about 3D models has been extensively investigated in CG. For example, Kätsyri et al. [12] investigated whether characters from semi-realistic animated films provoke negative human perceptions. Dill et al. [4] investigated the Uncanny Valley theory to assess its effects on human perception of CG characters in various media . The results indicated qualitative evidence that there was a valley and that the animation of the characters tends to decrease the perception of comfort. MacDorman and Chattopadhyay [15] assessed whether reducing the consistency of realism in virtual human characteristics increases the effect of the Uncanny Valley.

Regarding gender, Zibrek et al. [26] investigated the perception of gender of virtual characters (obtained by real actors, being women and men) . The results indicate that gender classifications are affected by the emotion displayed by the character . Bailey and Blackmore [2] assessed gender differences in the perception of avatars. The results indicated that gender is important in the perception of emotions. Tinwell et al. [20] investigated whether inadequate superior facial animation in virtual human-like characters evoked a sense of strangeness. In one of the results showed that in general male characters were stranger than female ones. Seyama and Nagayama [19] investigated the UV by measuring human perceptions of facial images . The authors evaluated whether the gender classification of artificial and real humans could be an influencing factor for the UV . However, found no significant results. McDonnell et al. [16] investigated the effect of render style on the perception of virtual humans. One of the results showed that people were more correct when they saw female virtual humans than male.

Max Weber [22] said that charisma is a type of authority, or leadership that can be exercised by one person in relation to another. According to Adair-Toteff [1], Max Weber referred to authority as the chances that a specific group of people will behave in order in accordance with specific content. In Groves' work [7], the author

found in his results that women were classified as more charismatic than men. Goethals and Allison [6] made connections between charismatic characters and their visual attributes . Riggio [18] said that charismatic individuals are lively, full of life. However, in CG characters, we found no work related to the charisma. In this work, we evaluate realism, comfort and charisma perceived by women and men about characters (also separated by genders) created using CG. We also assess the influence of perceived realism on perceived comfort and charisma. In addition, we also use UV theory in gender analysis (women, men, female and male characters).

3 Methodology

This section is divided into three parts: Sect.3.1 presents all characters that are used in this work. Section 3.2 presents the proposed questionnaire and its questions, and finally, Sect. 3.3 defines how our Comfort graph was modeled. Indeed, the Y-axis has several interpretations (comfort, eeriness, creepiness, strangeness, familiarity, likability) [11], in our case, we use the term **Comfort**. The X-axis states for **Human Likeness** and it does not have an universally accepted way for its categorization, as far as we know. In comfort graph, artificial beings are categorized by their levels of realism, or human likeness (X-axis), being, from left to right, the least similar to the most similar. The Y-axis, on the other hand, presents the perceptive values of the comfort of people about the evaluated artificial beings.

3.1 Characters

Regarding the characters, we selected the same number of female and male characters in movies, games, series and computer simulations, to be tested. Initially, we chose some characters from the work of Dill et al. [4], since it also used characters from different media. Then, we chose new characters following the steps taken in Dill's work. As can be seen in Fig. 1, ten female characters were chosen, respectively, from character (a) to (j), and ten male characters, respectively, from (k) to (t). Once it was not possible to guarantee that characters come from the same media (movie or game), we tried to capture characters with the same level of realism. Thinking about the distribution of characters from left to right on the X-axis (Human Likeness) of the Comfort graph we chose as follows: (i) cartoon characters: female (h) and (j), and the

Fig. 1 All the characters used in this work. From **a**–**j** are the female characters, and from **k**–**t** the male characters. Characters **a**–**c**, **k**–**p** were chosen in the work of Dill et al. [4]. All the characters' pictures and short sequences have been taken from Youtube videos

male (l) and (s); (ii) semi-realistic: female (a), (b), (c) and (e), and the male (k), (m), (n) and (q); and finally the realistic: female characters (d), (f), (g) and (i), and the male (o), (p), (r) and (t).

Pictures and movies were obtained from the YouTube platform. The videos had no audio, lasted between 10 to 20 seconds and were focused on the faces of the characters. We limited our search to videos with large amounts of views and descriptions that contain copyright, to avoid amateur videos.[5]

3.2 Questions and stimuli

First, as we wanted to study the effects of Uncanny Valley on the human perceptions of CG characters, we used three questions (also based on the work of Dill et al. [4]): one about realism (Q1 - "How realistic is this character?"), one about comfort (Q2 - "Do you feel some discomfort (strangeness) looking to this character?"), and one about charisma (Q3 - "How would you describe this character?"). Q1 is used to measure the participants' perception of realism regarding the characters which answers are used to order the characters in the Comfort graph (X-axis). Q1 was based on Likert Scales, with 3 scores ("Unrealistic", "Moderately realistic" and "Very realistic"). Q2 aims to categorize the perceived comfort and indicates values in graph as well (Y-axis). Q3 aims to obtain the perception of charisma of each character. Q2 and Q3 are categorical questions ("Yes" or "No" for Q2, and "Charismatic" or "Non Charismatic" for Q3).

The entire questionnaire was assembled using Google Forms. Before responding to the survey, participants did not receive an explanation of the original intention of the survey or the concepts of each question. This was done to avoid any influence on the participants' responses. All participants were asked whether they agreed to provide answers and about their gender.

The process was divided into two stages in which all characters are presented randomly. In the first stage, an image of each character was presented, accompanied by the three questions (Q1, Q2 and Q3). In the second stage, performed just after the first stage, a short video was shown of each character, also accompanied by the three questions. These steps assess the level of comfort (Q2), realism (Q1) and charisma (Q3) that people feel when observing the characters. In addition, the analysis of characters in videos (second stage) aims to investigate the hypothesis that perceived discomfort increases with the movement of the artificial being (in our case, CG character animation), as mentioned in Mori's work [17].

3.3 Creating the comfort graph

As mentioned before, the comfort graph is represented by a 2D graph, where the X-axis indicates the level of realism of the characters from less to more realistic (from left to

[5] Copyrighted images reproduced under "fair use policy".

right, with higher values for realism on the right). The Y-axis defines people's perception (in %) of comfort when observing the characters (in this paper, we use the term comfort in our results). It goes from less to more comfortable, where less comfortable is associated with small values on the Y-axis. We use only positive values on both axes.

As the work of Kätsyri et al. [11] shows, human likeness can vary in an almost infinite number in different ways. Question Q1 covers this human likeness criterion, and subjects' answers influenced the order in which the characters are placed on the horizontal axis (Human Likeness), of the Comfort graph. To order the characters on the horizontal axis, we used the medians[6] of the Likert scores in question Q1 (each character has an median realism value), and then we discretized the values for an interval from 1 to 20 for all characters.[7] As a result, the horizontal axis of the Comfort graph is shaped by the increasing order of each character's realism value. While Q1 is used to order characters in the horizontal axis, Q2 is used to measure the perceived comfort in the vertical axis. In this case, we computed the percentage comfort of survey answers, for each character. Next section presents the results obtained in our study.

4 Results

In this section, we used the (PGe, CGe) tuple defined earlier, to represent comfort, charisma and realism obtained from users perception. For example, (A, F) states for perceived data from all participants (A, that is, men and women) about the female characters (F). The questionnaire was applied on social networks, and all participants were volunteers. It was answered by 119 participants. The percentage of data distribution was similar for gender, with 58% male and 42% female participants. Next sections discuss the perceived realism, comfort and charisma of analyzed CG characters, while Sect. 4.3 presents some comparisons between our work and the Uncanny Valley theory.

4.1 Realism analysis

In the work of Katsyri et al. [12], the authors used three levels of realism, which are cartoonish, semi-realistic and real actors. In our work, we only use CG characters, but also used three levels of realism : (i) cartoon or unrealistic characters, (ii) moderately realistic characters and (iii) very realistic characters. In order to have those 3 groups, we used the subjects answers according to a Likert Scale scores of Q1 ("How realistic is this character?"). Thus, for each "Unrealistic" answer, 1 point was computed, 2 points for "Moderately realistic", and 3 points for "Very realistic" answers. We used the following thresholds to separate the characters into three groups: (i) unrealistic characters having realism values ≤ 1.5; (ii) moderately realistic characters having values of realism ≤ 2.5; and (iii) very realistic characters with realism values > 2.5. Table 1 shows the levels of realism (first column), the groups of participants (second column), and the characters present at each level (third column). In addition, Table 1 also presents realism medians of all characters present at each level (fourth column), realism medians of the female and male characters (fifth and sixth columns, respectively).

We performed a statistical analysis (using Python and the Scipy library) with Wilcoxon signed-rank, Kruskal–Wallis and Mann–Whitney rank tests. We used these tests to try to avoid false positives due to the various analyzes with small samples. Once we have a large number of tests to be performed (gender participants (2), gender characters (2), realism levels (3), image (1) = 12 in total), here we present just the tests which results are considered significantly using 5% of significance level. We used Wilcoxon test for paired samples with the same size, for example, women's perception of female characters × women's perception of male characters. For independent samples with different sizes, we first used the Kruskal–Wallis test to compare all three levels of realism, for example, women's perception of characters Unrealistic × Moderately realistic × Very realistic. In case of significant p value in the Kruskal–Wallis test, we used the Mann-Whitney test in comparisons between two of the three levels of realism, for example, Unrealistic x Moderately, Unrealistic $times$ Very, and Moderately × Very. In addition, we also used the Mann–Whitney test in comparisons between groups of equal realism, but with different sample sizes, for example, women's perception of unrealistic characters × men's perception of unrealistic characters, or women's perception of female characters unrealistic × unrealistic male characters.

Regarding all participants perception With regard to all participants, in the perception of realism about female characters (A, F), we found a significant result (p value = .021) when comparing the three levels of realism (Unrealistic x Moderately x Very), showing that the groups of CG characters are different in perception of realism. When comparing one group of realism with another (for example, Unrealistic x Moderately), we only found significant results when we compared the very realistic group with the Unrealistic group (.018), and with moderately (.039), that is, the very realistic characters group (higher percentage of realism, as shown in Table 1) was considered significantly different from the others. Comparing the three groups of male characters (A, M), the result was also significant (.022), also showing that the

[6] We used medians due to the statistical tests used in Sect. 4.

[7] Although it could be possible to have two characters with the same median realism level it did not occur, so it was easy to order the 20 characters.

Table 1 The table presents the characters present in each level of realism, both in the perception of all participants, and in the perception of women and men

Realism level	Obtained data	Characters	All characters (median)	Female characters (median)	Male characters (median)
All levels	All participants	All characters	–	2.30	2.00
Unrealistic	All participants	(c, h, j, l, s)	–	1.38	1.33
Moderately Realistic	All participants	(b, e, k, m, n, p, q)	–	1.87	1.91
Very realistic	All participants	(a, d, f, g, i, o, r, t)	–	2.73	2.60
All levels	Women	All characters	2.03	2.24	1.95
Unrealistic	Women	(c, j, l, q)	1.24	1.23	1.28
Moderately realistic	Women	(a, b, e, h, k, m, n, p, s)	2.84	1.8	1.84
Very realistic	Women	(d, f, g, i, o, r, t)	2.7	2.76	2.6
All levels	Men	All Characters	2.13	2.34	2.07
Unrealistic	Men	(h, j, l, s)	1.34	1.37	1.29
Moderately realistic	Men	(b, c, e, k, m, n, p, q)	1.89	1.69	2.05
Very realistic	Men	(a, d, f, g, i, o, r, t)	2.69	2.69	2.6

In addition, it also presents medians of perceived realism of all characters, female and male characters present in each level. Note: for this work we did not use values for all participants and all characters (being A, A in our notation), since we focused on gender analysis

male characters' levels of realism were considered different. In the separate comparisons between groups, we only found significant results between the unrealistic and moderately groups (.041), and between the moderately and very realistic (.018) groups. In these cases, **the results show that groups of CG characters are different in terms of realism perception in both female and male characters.**

Comparing female and male characters (A, F x A, M), we found no significant result in the general comparison (without separations in levels of realism). Already separating the characters into levels of realism, we only found significant result between very realistic female characters and very realistic male characters (.018), that is, **people considered the very realistic group of female characters more realistic than the group of male characters.**

Regarding women perception (W, A): We found significant results when comparing all groups ($< .001$) and separately (.003 for Unrealistic and Moderately, .005 for Unrealistic and Very, and .001 for Moderately and Very), that is, **for women, the groups of all characters were considered different in terms of realism.** The same happened when comparing all realism groups of female (W, F) characters (.019), and significant only in the comparison between the unrealistic and very realistic groups (.015). In the comparison of all groups of realism of the male characters (W, M), we also found a significant result (.022). However, in the comparisons performed separately, we only found significant results between the unrealistic and moderately realistic groups (.041), and between the moderately and very realistic groups (.018). **In the comparisons between female and male characters (W, F x W, M), we did not find significant results.**

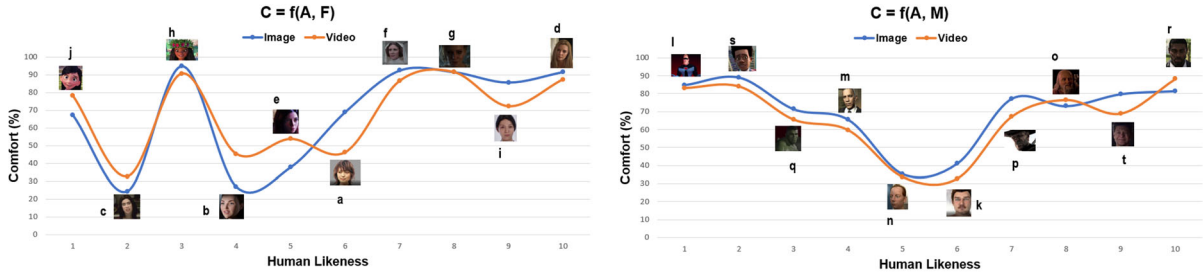
Regarding men perception (W, A) In the analysis of men about all characters (M, A), we also found significant results in the general comparison ($< .001$) and in the separate comparisons (.004 for Unrealistic and Moderately, .004 for Unrealistic and Very, and $< .001$ for Moderately and Very). On female characters (M, F), we also found significant results in the general comparison (.021), and significant in the comparisons between the unrealistic and very realistic groups (.039), and between the moderately and very realistic groups (.018). The same happened in the general comparison (.022) of the male characters (M, M), and significant in the comparisons between the unrealistic and moderately realistic groups (.041), and also between the moderately realistic and very realistic groups (.018). Therefore, **the results show that for men, the groups of realism of all characters, and the groups of female and male characters were considered different.** As mentioned earlier, we also perform analyzes between women's perceptions and men's perceptions (e.g., (W, A x M, A), (W, F x M, F), (W, M x M, M)). However, we did not find any significant results in any of the comparisons.

4.2 Comfort

Regarding perceived comfort, Table 2 shows the percentage of perceptual comfort and standard deviation obtained by the participants (all, women, and men) over the characters (all, female and male, and at all levels of realism) using the percentages of "No" responses. For all participants, the comfort graphs are shown in Fig. 2, for the female characters in Fig. 2a and for the male characters in Fig. 2b. Regarding the perceived data by women, Fig. 3 shows the comfort graphs

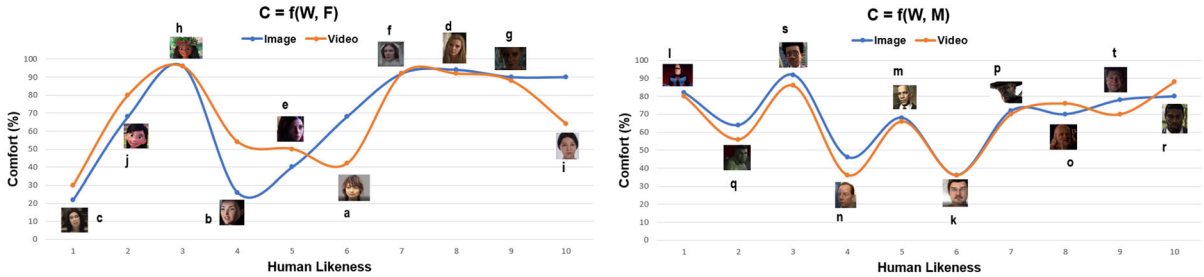
Table 2 Percentages of perceptual comfort and standard deviation obtained by the participants (all, women and men) over the characters (all, female and male) at different realism levels

Participant gender (PGe)	Character gender (CGe)	Image comfort all (%)	SD (%)	Image comfort unrealistic (%)	SD (%)	Image comfort moderately (%)	SD (%)	Image comfort very (%)	SD (%)
A	*F*	68.15	28.39	62.18	35.56	32.35	7.72	86.05	9.95
A	*M*	69.91	18.05	86.97	2.97	58.15	18.76	78.15	4.44
W	*F*	68.6	29.18	45	32.52	57.5	31.04	91.5	1.91
W	*M*	68.8	16.84	73	12.72	62.8	22.16	76	5.29
M	*F*	67.82	27.90	80.43	19.47	29.95	5.48	85.5	9.82
M	*M*	70.72	19.78	86.95	0	58.84	22.46	79.71	3.83
W	*A*	68.7	23.19	59	25.84	60.44	24.79	84.85	8.93
M	*A*	69.27	23.59	83.69	11.85	48	22.81	83.33	8.27
Participant gender (PGe)	Character gender (CGe)	Video comfort all (%)	SD (%)	Video comfort unrealistic (%)	SD (%)	Video comfort moderately (%)	SD (%)	Video comfort very (%)	SD (%)
A	*F*	68.48	21.96	67.22	30.49	49.57	5.94	76.8	18.58
A	*M*	65.96	19.51	83.61	0.59	51.76	17.18	77.87	9.73
W	*F*	68.8	23.87	55	35.35	60.5	24.18	84	13.46
W	*M*	66.4	18.59	68	16.97	58.8	22.11	78	9.16
M	*F*	68.26	21.39	81.88	7.17	43.47	11.5	77.68	16.91
M	*M*	65.65	20.73	84.05	2.04	51.01	19.15	77.77	10.17
W	*A*	67.6	20.86	61.5	23.85	59.55	21.55	81.42	11.35
M	*A*	66.95	20.54	82.97	4.48	48.18	16.2	77.71	13.89



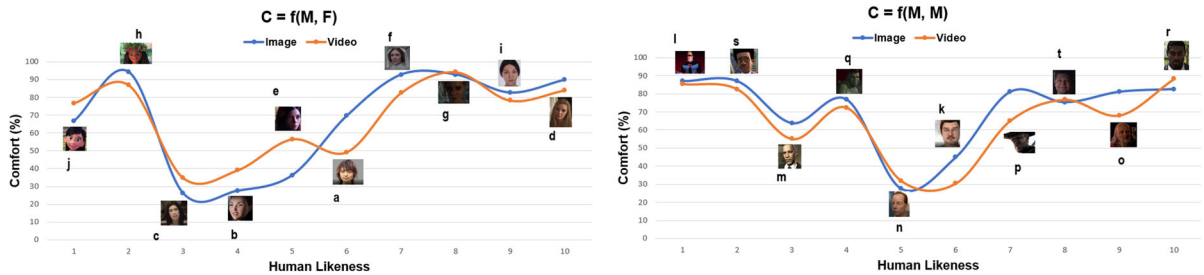
(a) All Participants perceiving Female Characters - (A, F) (b) All Participants perceiving Male Characters - (A, M)

Fig. 2 The figure presents the graphs of the perception of Comfort (X-axis) and Human Likeness (Y-axis), with respect to the female characters (**a**) and the male characters (**b**). The blue and orange lines represent, respectively, the perception of comfort in image and video



(a) Women participants perceiving Female Characters - (W, F) (b) Women participants perceiving Male Characters - (W, M)

Fig. 3 The figure presents the graphs of women's perception of Comfort (X-axis) and Human Likeness (Y-axis), in relation to the female (**a**) and male characters (**b**). The blue and orange lines represent the perception of comfort in the image and video, respectively



(a) Men participants perceiving Female Characters - (M, F) (b) Men participants perceiving Male Characters - (M, M)

Fig. 4 The figure presents the graphs of men's perception of Comfort (X-axis) on Human Likeness (Y-axis), in relation to the female (**a**) and male characters (**b**). The blue and orange lines represent the perception of comfort in the image and video, respectively

for the female and male characters, Fig. 3a, b, respectively. In relation to the data obtained by the responses of men, Fig. 4 shows the comfort graphs. In addition, we can observe the X-axis orders of presented graphs obtained using Likert Scales. The blue and orange lines represent, respectively, the comfort values obtained in the image and video analyzes.

As in the previous section, we also performed a statistical analysis with Wilcoxon signed-rank, Kruskal–Wallis and Mann–Whitney rank tests. For comfort analysis, we also have a large number of tests to be performed (gender participants (2), gender characters (2), realism levels (3), video or image (2) = 24 in total), and we also used a 5% level of significance.

Regarding all participants perception Firstly, with respect to the comfort perception of all participants about female characters (A, F), we did not find a significant result among all groups of realism (both in image analysis and in video), that is, realism did not influence the perceived comfort about female characters. Regarding the perception of comfort about male characters (A, M), we found significant results in the general comparisons of the realism groups in the image (.033) and video (.032) analysis, showing that, **for people, the perceived realism influenced the perception of comfort about male characters.** In separate comparisons between groups, both in image and video, we found signifi-

cant results between the unrealistic and moderately realistic groups (respectively, .041 and .041), and between the moderately and very realistic groups (.037 and .018). As shown in Table 2, both the unrealistic and very realistic male character groups had higher comfort percentages than the moderately realistic group. With that, **the results show that people felt more comfortable with characters present in these two groups (Unrealistic and Very Realistic) than with characters present in the Moderately realistic group.** We did not find significant results when comparing images and videos. Regarding the $H0_1$ hypothesis ($(A, F) = (A, M)$), both in general analyzes (without separating into groups of realism) and in analyzes dividing characters into groups of realism, in image and video, we did not find significant results.

Regarding the perception of women about all characters (W, A) we did not find significant results in the general comparison of groups of realism (both in image and video analysis), that is, realism did not influence the comfort perceived by women over all characters. With this result, we performed no comparisons between groups separately. We also found no significant results in comparisons between image and video. As in the analysis of all characters, the same happened for female characters (W, F) and for male (W, M) characters, that is, we did not find significant results. Therefore, for both female and male characters, realism did not influence perceived comfort by women subjects. In addition, we also found no significant results in comparisons of comfort in image and video. Regarding the comparison between female and male characters ($H0_2$ hypothesis - $(W, F) = (W, M)$), we only found a significant result when comparing very realistic female and very realistic male characters in images (.025). With that, **the results show that, in images, women felt more comfortable with very realistic female characters than very realistic male characters.** This result is in line with Draude's work [5], that is, women can be more comfortable with female characters.

Regarding the perception of men , unlike the perception of women about all characters, we found significant results in images and videos (M, A) in the general comparisons of all groups of realism (respectively, .006 and .004). Therefore, **the results show that realism in this case influenced the perception of comfort.** In the separate comparisons, both in images and videos, we found significant results in the comparisons between groups of unrealistic and moderately realistic (.011 and .004), and between moderately and very realistic groups (.002 and .003). **So for men, unrealistic and very realistic characters were more comfortable than moderately realistic.** This result is in line with the empirical review by Katsyri et al. [11], which the authors presented a series of work that showed results of positive perceptual comforts on less realistic characters and more realistic characters, and negative results on moderately realistic characters. In addition, we found no significant results in comparisons between images and videos. With regard to female (M, F) and male (M, M) characters, we did not find significant results in the general comparisons of the realism groups, that is, having no influence on perceived comfort, and also no significant result in comparisons between images and videos. Regarding our third hypothesis ($H0_3 - (M, F) = (M, M)$), unlike the perception of women, we found no significant results in the comparisons between female and male characters. Therefore, for men, the gender of the characters did not influence the perception of comfort. Regarding $H0_4$, which was defined as $(W, A) = (M, A)$, we also found no significant results.

4.3 Uncanny valley analysis

Relating with the presented comfort graphs, we can notice that the one in Figure 2b(A, M) has the indication of a valley (observe the characters n and k), while in Fig. 2a(A, F), one can say there are two valleys. As can be seen, this may have happened because the characters (c) and (h), in Fig. 2a, may be incorrectly positioned in vertical axis.

Although the orders are similar in X-axis, qualitatively the generated curves can be very different, as can be perceived, for instance, if we compare Figs. 3a and 4a.

Observing the graphs in Fig. 3((W, F)a, (W, M)b), we can see that only the first seems close to the UV theory, regarding the expected valley, since the second has several variations. Unlike such graphs, Fig. 4a, b present perceived comfort by man participants, with respect to perceived comfort of female and male characters, through curves that resemble the structure of the UV graph [17]. So, **assuming that the valley should exist, in these cases, the results show that men seem to categorize according to expected with the UV theory . Anyway, the results also show that men and women perceive the realism of CG characters differently.**

4.4 Charisma

In this section, we used the percentage of "Charismatic" responses to question Q3 for each character to obtain the percentages for image and video analysis, as shown in Table 3. For charisma, we also performed a statistical analysis with Wilcoxon signed-rank, Kruskal–Wallis and Mann–Whitney rank tests. In this case, the tests to be carried out were similar to the tests carried out in the comfort analyzes: gender participants (2), gender characters (2), realism levels (3), video or image (2) = 24 in total. We also used a 5% level of significance.

Regarding the perception of all participants about female (A, F) and male (A, M) characters we did not find signifi-

Table 3 Percentages of perceptual charisma and standard deviation obtained by the participants (all, women and men) over the characters (all, female and male) at different realism levels

Participant gender (PGe)	Character gender (CGe)	Image charisma all (%)	SD (%)	Image charisma unrealistic (%)	SD (%)	Image charisma moderately (%)	SD (%)	Image charisma very (%)	SD (%)
A	*F*	56.47	24.18	64.7	34.96	42.01	5.94	57.31	23.23
A	*M*	45.46	26.64	81.51	3.56	34.95	25.78	38.93	14.8
W	*F*	53.2	23.49	40	31.12	58.5	25.52	54.5	22.94
W	*M*	39	24.13	37	26.87	39.2	32.94	40	9.16
M	*F*	58.84	25.44	88.4	8.19	39.61	8.85	58.55	26.19
M	*M*	36.81	24.24	47.1	46.11	31.88	22.73	38.16	19.46
W	*A*	46.1	24.3	38.5	23.79	47.77	29.84	48.28	18.74
M	*A*	47.82	26.69	67.75	36.05	34.78	18.26	50.9	24.73
Participant gender (PGe)	Character gender (CGe)	Video charisma all (%)	SD (%)	Video charisma unrealistic (%)	SD (%)	Video charisma moderately (%)	SD	Video charisma very (%)	SD (%)
A	*F*	64.34	18	69.56	31.58	57.97	14.34	63.76	12.08
A	*M*	46.81	25.39	81.88	1.02	39.42	25.83	35.78	4.18
W	*F*	66.6	20	53	35.35	71	18.51	69	16.85
W	*M*	48	22.78	68	14.14	46	28.7	38	5.29
M	*F*	64.34	18.1	87.68	5.12	49.75	17.47	63.76	12.08
M	*M*	45.65	25.02	88.1	1.02	37.1	22.73	35.74	4.18
W	*A*	57.3	22.94	60.5	23.62	57.11	26.72	55.71	20.63
M	*A*	55	23.31	84.78	4.5	41.84	21.46	53.26	17.28

cant results. In addition, for both female and male characters, we found no significant results in comparisons between images and videos. However, we performed comparisons between female and male characters ($(A, F) = (A, M)$, i.e., $H0_1$) and we only found a significant result in the comparison between very realistic female and very realistic male characters in videos (.018). So, **for people, the very realistic female characters are more charismatic than the very realistic male ones, in videos.**

Regarding the women's responses to all characters (W, A) we found no significant results in comparisons between groups of realism. In the comparisons between images and videos, we found a significant result in the analysis of characters without separation in levels of realism (.002), and a significant result in the comparison between image and video of characters from the moderately realistic group (.039). Looking at Table 3 in W, A, **the results show that women perceived more charisma in characters in videos than in images, both looking at all characters and looking only at moderately realistic characters.** Regarding female (W, F) and male (W, M) characters, we did not find significant results in the comparisons between levels of realism, that is, not influencing the perceived charisma. In the comparisons between charisma perceived in image and video, we only found a significant result when comparing all female characters (.004). Therefore, as shown in Table 3, **the results show that women found that female characters are more charismatic in videos than in images.** In the comparisons between female and male characters ($(W, F) = (W, M)$, i.e., $H0_2$), we only found a significant result in the comparison between very realistic female and very realistic male characters in videos (.026). Therefore, the results show that, **for women, very realistic female characters are more charismatic than very realistic male characters in videos.** This result is in accordance with Draude's work [5].

Regarding the charisma perceived by men over all characters (M, A) we found only significant results in the analysis of videos (.008), in the general comparison of the three levels of realism. Therefore, **the results show that only in the videos, the realism influence the perceived charisma.** In the separate comparisons between the groups of realism in videos, we found significant results in the comparisons of the unrealistic group with the moderately realistic (.004) and very realistic (.005) groups. With that, **in videos, the results show that for men the unrealistic characters were more charismatic than all other characters.** When comparing images and videos, as well as in the responses of women, we found significant results when we used all characters (.048) and when we used moderately realistic (.008) characters (separation into levels of realism). However, unlike women, men had higher values of perceived charisma in the images than in the videos. Therefore, **the results show that men found characters more charismatic in images than in videos, both in general (all characters) and in the moderately realistic group.** With regard to female (M, F) and male (M, M) characters, we did not find significant results in relation to comparisons of realism and in comparisons between images and videos. In the comparisons between female and male ($(M, F) = (M, M)$, we only find significant results when we compare very realistic female and male characters in videos. With that, **the results show that for men (in videos) very realistic female characters were more charismatic than male characters.**

In the comparisons between women and men about all characters ($(W, A) = (M, A)$, i.e., $H0_4$), we only found a significant result when comparing the group of unrealistic characters in videos (.015). Therefore, **the results show that for men the unrealistic characters were more charismatic than for women.** On comparisons between women and men on female characters and on male characters, we found no significant results.

4.5 Discussion

Following our results, as we could see in last sections, the levels of realism designers/animators put in CG characters can affect perceived comfort and charisma by the audience. Although some analyzes on women and men, and female and male characters have not shown significant differences, some data obtained are interesting and are highlighted in this section (as shown in Table 4).

In general, people felt similarly comfortable with male and female characters, both in images and videos . But going deeply by analyzing women and men perceptions, we observed some relevant aspects. Overall, unrealistic and very realistic characters tend to be more comfortable to people than moderately realistic characters. In this case, professionals, who are concerned with modeling comfortable characters for viewers, need to take into account that moderately realistic (for example, characters who have flaws in their anthropomorphic levels, such as the green skin of the hulk, Alita's big eyes, smiles with disproportionate sizes, among others) characters can cause discomfort. With regard to all the characters observed by women, realism did not influence the perceived comfort. In particular, with a significant difference, women felt more comfortable when watching very realistic female characters than male characters. It can indicate that in realistic games, women can feel more comfortable playing with female characters than with male ones. Furthermore, it is in line with Draude's [5] work. Unlike women, realism influenced the comfort perceived by men, being that they felt more comfortable with unrealistic and very realistic characters than with moderately realistic characters, both in image and video. Although we did not find significantly difference, men perceived very similar comfort

Table 4 The table summarizes all cases (both for perceived Comfort and Charisma, in images and videos) in which we found significantly different results (highlighted with **YES**) from our hypotheses

Hypothesis	Perceived data	Image or video	Unrealistic characters	Very realistic characters
$H0_1$	Charisma	Video	No	**YES**
$(A, F = A, M)$				
$H0_2$	Comfort	Image	No	**YES**
$(W, F = W, M)$	Charisma	Video	No	**YES**
$H0_3$	Charisma	Video	No	**YES**
$(M, F = M, M)$				
$H0_4$	Charisma	Video	**YES**	No
$(W, A = M, A)$				

There were no significant results for both all characters and only moderately realistic characters and for other cases involving unrealistic and very realistic characters

of very realistic male and female characters, in images and videos . Therefore, only the results of women were in agreement with the results of the work of Tinwell et al. [20], which showed that male characters were stranger than female characters. However, contrary to our work, the authors used only few different characters and used morphing between levels of realism. Therefore, thinking about products with high levels of realism (films, games, series, etc.), the industry needs to guarantee representation if it wants to attract female audiences, that is, the ideal is to use female characters. The male audience, on the other hand, does not matter if the characters are male or female for perceived comfort. In this case, the important thing is that the characters cannot be moderately realistic.

Regarding charisma, all participants, in image and videos, perceive more charisma in female characters than in male (see in Table 3), independent of the level of realism. In addition, in videos, all participants felt more charisma with female characters than with male characters. Men perceive higher charisma in images, and women in videos. This result may be an indication that the charisma, in media where characters have movements (movies, games, series, among others), can be more important for female than male viewers. However, with regard to all unrealistic characters (usually cartoon characters, such as Disney characters: Moana, The Incredibles, etc), men perceive higher levels of charisma than women in videos. Which may be an indication that the charisma of the unrealistic character may be more important for male viewers. In addition, in general, female characters got higher charisma percentages than males. These values are consistent with the result of women being considered more charismatic than men in Groves' work [7]. Therefore, if the industry wants to transmit charisma, the ideal is to use female characters. A last word about charisma, we hypothesized that our results seem in accordance with Disney's characters choice regarding cartoon's famous characters. So, for the industry to convey charisma, it is important that they continue to develop unrealistic characters.

5 Final considerations

This paper proposes a set of experiments to assess how people (women and men) perceive CG characters (female and male) in the context of static images and videos (animations). In this work, we try to answer the following questions: (i) How does the comfort perceived by people of both genders (female and male) relate to the genders of the characters? and (ii) Is the charisma influenced by the realism of the characters, considering the subjects and genders of the characters? Regarding the first question, in this text we discussed many aspects and performed several statistical analysis showing that there is a strong relation between perceived comfort and gender of participants and characters. One example is that people felt similarly comfortable with male and female characters, although more comfortable with male characters in the images and with female characters in the videos. Also, men perceived very similar comfort of very realistic male and female characters, in images and videos, while women felt more comfortable with very realistic female characters. Regarding charisma, all participants, in image and videos, perceive more charisma in female characters than in male.

Visually, as discussed in this paper, people's perception of comfort sometimes seems to be closer to Uncanny Valley theory. Our conclusion in this term is that women categorized CG characters differently than men categorized the same characters. In addition to such visual analysis, we divided the characters into three realism levels (Unrealistic, Moderately Realistic and Very Realistic) and measure the influence of these levels on perceived comfort and charisma. Many statistical analysis were performed, and findings were highlighted in a section focused on discussion on characters modeling. In possible future, we would like to study the non-binary or a gender population perception regarding the comfort generated by male and female characters, but also maybe including non-binary like characters. In addition, we intend to use our own 3D models to vary several factors between genders, such as motion control, lights, textures, realism, etc. We also

thought about testing CG characters in specific contexts, for example, groups in a bar, in a classroom, among others.

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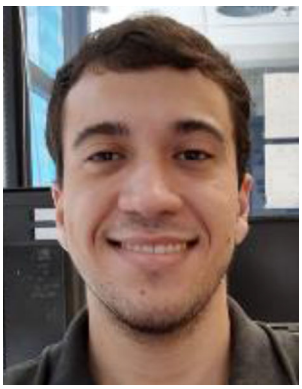

Victor Araujo is a Ph.D. student in Computer Science at the Pontifical Catholic University of Rio Grande do Sul (BR) where he was supervised by Prof. Soraia Musse. His research interests include studies and evaluations of human perception of virtual humans and crowds. Araujo has a master's degree in Computer Science from the Pontifical Catholic University of Rio Grande do Sul, and a graduate in Computer Science from the Tiradentes University (UNIT) in the city of Aracaju in the state of Sergipe (BR).

Bruna Dalmoro is a master's student in Computer Science at the Pontifical Catholic University of Rio Grande do Sul (BR) where she was supervised by Prof. Soraia Musse. Her research interests include human perception in Computer Graphics, and Data Science. Dalmoro has a Bachelor's degree in Statistics from the Federal University of Rio Grande do Sul (BR).

Soraia Raupp Musse is an associate professor at the School of Technology, Pontifical Catholic University of Rio Grande do Sul (Brazil), where she created and still coordinates the Virtual Human Laboratory. Her research interests include Crowd Simulation and Analysis, Facial Animation, and Integration of Computer Graphics, Pattern Recognition and Computer Vision. Dr. Musse has a Ph.D. in Computer Science from the Ecole Polytechnique Fèdèrale de Lausanne (Switzerland) where she was supervised by Prof. Daniel Thalmann. Recently, she spent a year at UPENN (USA) working as a visiting scholar with Prof. Norman Badler. She has supervised more than 40 graduate students and postdocs and published more than 160 papers. She also published three books in Crowd Simulation with Springer-Verlag.