Perception of Computer Graphics Characters in Groups with Skin Color Diversity

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***Abstract*—This paper aims to assess the human perception of groups about charisma, comfort and realism in relation to black and white skin colors of characters created with Computer Graphics (CG) in different media, such as movies, games, animations, simulations, among others. We created a form that contained images of groups of CG characters with black and white skin colors, and asked participants to rate perceived comfort, charisma and realism. After that, we compared these results with data collected from related work. The results indicated that people can feel comfortable, and observe charisma similarly to CG characters with black and white skin colors.**

***Index Terms*—perception of groups, CG characters, black and white skin colors, comfort, charisma, realism**

I. Introduction

CG has evolved a lot in recent years [1]. Several media have taken advantage of this evolution, such as games, movies, animations, simulations. In movies and games, real actors are constantly replaced by characters created with CG. However, as shown in Kim's Siggraph 2021 presentation[1], and in the work of Kim et al. [2], most of time, the scientific community chooses to show CG advances based on 3D models with white skin colors. In addition, the work of Kim and his colleagues also shows that in games where the user can choose character attributes, both black skin tones and afro-descendant hair appear in the last choice options. Regarding characters created with CG, the user experience (movie viewers, video game players, etc) often requires that the character be charismatic and not fall into the Uncanny Valley [3] (UV). This work aims to assess people's perception of comfort, charisma and realism in relation to characters with black and white skin colors in groups. For this, we used the dataset from the work of Araujo et al. [4], that contains CG characters with black and white skin colors, and that also contains perceptual data (obtained from people's answers) about realism, comfort and charisma.

In this case, the concepts of realism and comfort are based on UV [3], which is a theory created by roboticist Mori, and based on comfort chart used in the work of Araujo et al. [4]. The UV theory says that an artificial being very similar to a human being tends to fall into a perceptual valley that causes feelings of discomfort in those who observe it. The UV is represented by a chart: *i)* the *x*-axis represents the Human Likeness, the farther to the right, the more similar to a human being. In our case, artificial beings are CG characters, and the most realistic ones are to the right of the *x*-axis; and *ii)* the *y*-axis represents perceived comfort. According to Max Weber [5], charisma is related to leadership, or domination, or a type of authority that one person can exercise over another. Charismatic characters can make people adore them. In the works by Araujo et al. [4], [6], the authors found relationships between perceived charisma and perceived comfort about CG characters.

Group perception causes observers to obtain direct information about social groups and therefore is a basis for learning social categories [7]. In this work, we apply this concept with Ensemble Coding which is a process used for observers to quickly extract representative summaries of visual information [7]. In the work of Lamer et al. [7], the authors utilized

[1] www.youtube.com/watch?v=ROuE8xYLpX8

Ensemble Coding with real people to show that emotional segregation and group perception strengthens racial boundaries and race essentialism. Therefore, by measuring the perception of groups of CG characters, segregated by realism, containing characters with the same skin color (black or white), and images containing both black and white skin colors. With this, we can compare the data from Araujo et al. [4] dataset with the results obtained in our work.

II. Related Work

Human perception has been extensively studied in CG research [4], [6], [8]. Virtual humans can be observed through various stimuli: images, videos, games, among others. For virtual humans not to cause feelings of discomfort (UV theory [3]), they need to have anthropomorphic traits and other human characteristics. Many works discuss this theme, such as the work of Araujo et al. [6]. Regarding the perception of characters with different skin colors, some works focus on the perception based on the use of white and black skin colors in the experiment (Hasler et al. [9]), perception of blendshapes in characters with black and white skin colors (McDonnell et al. [8]), perception of faces of various ethnic groups (Krumhuber et al. [10]), among others.

Group perception is very important for learning about group patterns. In the work of Lamer et al. [7], the authors used Ensemble Coding to assess whether racial categories were influenced by emotional segregation (faces with different emotions), and vice versa. The area of group perception has grown in recent years in several scientific research in Psychology and in Computer Science, for example, the work of McDonnel et al. [11] evaluated the perception of different models of agents in crowd simulations, the work of Goldenberg et al. [12] evaluated perceptions of emotions using Ensemble Coding, among other research.

We chose the work of Araujo et al. [4] for the use of the dataset, due to the fact that the authors evaluated comfort, charisma and realism perceived about CG characters from various media (movies, series, animations, simulations, etc). Thus, we can use the perceptual values of comfort, realism and charisma to compare with data obtained in our research through Ensemble Coding of images created with the characters obtained in the dataset. The next sections detail this process.

III. Methodology

A. Data Obtained

First, to follow the Ensemble Coding concept, we used the dataset from the Work of Araujo et al. [4], which has perceptual data on realism, comfort and charisma about characters from different media (movies, games, animations and simulations). In addition, the dataset has characters in three realism groups (unrealistic, moderately realistic, and very realistic), having both black and white skin colors in all three groups. To obtain the perceptual data, we used the questions used in the work of Araujo et al. [4]: *i)* Realism, having answers in three Likert-Scales to know what level of realism perceived by the participant about the presented character. Therefore, each character had an average of realism between 1 and 3; *ii)* Discomfort, having answers "Yes" or "No" to know if the participant felt uncomfortable with the presented character. In this case, the authors counted the percentages of "No" answers (i.e., comfort percentage) for each character; *iii)* Charisma, having "Charismatic" and "Non Charismatic" answers to obtain the perceived charisma in relation to the presented character. Therefore, the authors counted the percentages of "Charismatic" answers. Thus, we used the average values of perceived realism, and the percentage values of comfort and charisma perceived for each character used in our work (for more information about the dataset, please read the work by Araujo et al. [4]). In our work, these values are used for generating the realism, comfort and charisma averaged scores of each group of characters in the images used as stimuli presented to the participants, which is explained in Section III-C.

B. Characters

To include different skin colors in our work, we chose three characters for both black and white skin colors from the dataset of the work of Araujo et al. [4] (only image data). Each of these groups had an unrealistic character, a moderately realistic character, and a very realistic character, guaranteeing the three levels of realism presented in Araujo's work. We chose the only three characters with black skin color in the dataset. While the characters with white skin color were chosen based on the similarities between their values of realism, comfort and charisma (for example, moderately realistic characters who had similar realism values). The characters are shown in Table I, where the first column shows the id of each character presented in the work by Araujo et al. [4], the second column presents the figures of the characters, the third column the average values of perceived realism, the fourth and fifth columns present the percentages of perceived comfort and charisma. The first two characters ("m", and "s") in Table I represent the unrealistic group of characters, the "e" and "a" characters represent the moderately realistic group, and the last two represent the very realistic ("v", and "r") characters.

C. Creation of Stimuli

Group perception is important as it allows people to assess patterns of groups directly and quickly, without requiring complex inspections and comparisons [7]. In an Ensemble Coding, the summarized representations of a set of objects can be obtained through simple statistics, such as average and standard deviation, in a short period of time [7].

Based on Ensemble Coding, the work of Goldenberg et al. [12] and the work of Lamer et al. [7], we created images with groups of 12 faces of the characters presented in Section III-B, varying the realism and skin color. Each of these images had two characters (six faces of each character), one or two levels of realism, and one or two skin color type. In addition, based on the values in Table I, each image also had an average realism value, a charisma percentage and a comfort

TABLE I
THE TABLE PRESENTS THE ID AND FIGURE OF EACH CHARACTER PRESENTED IN THE WORK BY ARAUJO ET AL. [4], AND USED IN OUR WORK. IN ADDITION, THE TABLE ALSO PRESENTS THE AVERAGE VALUES OF PERCEIVED REALISM, AND THE VALUES OF PERCENTAGES OF COMFORT AND CHARISMA PERCEIVED IN RELATION TO THE CHARACTERS.

Id	Figure	Realism	Comfort	Charisma
m		1.39	88.23%	84.87%
s		1.43	89.07%	78.99%
e		1.75	65.54%	63.86%
a		2.08	41.17%	39.49%
v		2.6	79.83%	47.89%
r		2.72	81.51%	21.84%

percentage. Therefore, the image could have six faces of an unrealistic character with white skin color and six faces of a very realistic character with black skin color, as shown in Fig.1. With respect to the values in Fig.1, the average realism was 2.05 (obtained by the average of the two realism values of the two characters), and the comfort and charisma percentages were 84.87% (obtained by the average percentage of the two comfort values of the two characters) and 53.35% (obtained by the average percentage of the two charisma values of the two characters). With that, we created 15 images with all possibilities.

Following the Ensemble Coding concept that people can summarize features in short periods of time, we showed each image to the participants for 500 milliseconds. After that, the image disappeared, and then three questions were presented to the participants about realism, comfort, and charisma. In these three questions, we presented three sliders (one for each question) with values between 0 and 100, and we asked participants to mark values that represented the realism of the image, the comfort perceived by the participant, and the charisma transmitted by the characters in the image.

First, participants viewed images with a single realism, from less realistic to more realistic, and images of different skin colors. For example, the first image presented contained the characters ”m” and ”s”, the second image contained the characters ”e” and ”a”, the third contained the characters ”v” and ”r”, etc. After that, we presented images without repeating characters from the previous image, and without repeating a level of realism more than twice (for example, it could not have three images in a row containing an unrealistic character). All these processes were carried out to try to avoid realism and skin color biases.

The images and questions were presented through a form created on the JotForm [2] platform, and transmitted through social networks. Before the questions we presented a consent form approved by an ethics committee, we asked the participants to answer demographic questions (gender, race, educational level, age, and familiarity with CG), and we explained that the images would appear only for 500 milliseconds and would be followed by three questions about them. In the consent form, it was informed that the participants could withdraw from the research at any time, and if they felt uncomfortable. In addition, no financial compensation was provided, meaning we only collected data from volunteer participants.

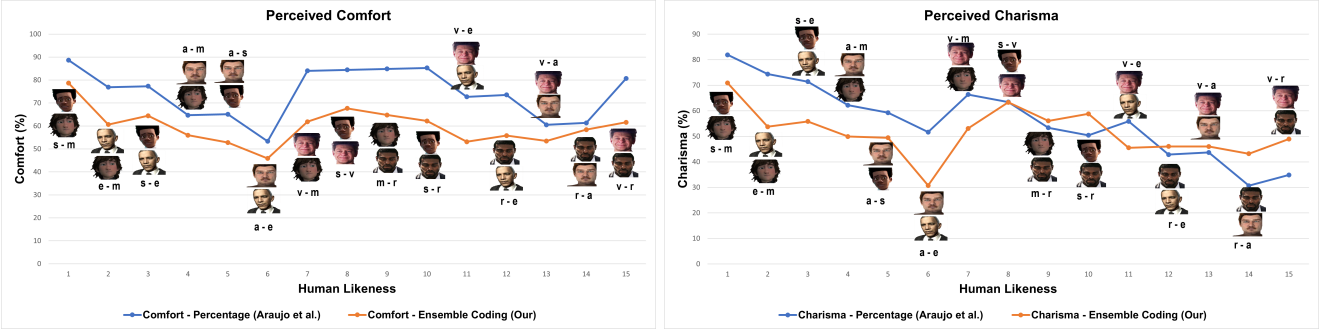
Fig. 1. One of 15 images created with 12 character faces. In this case, six faces of character ”m” and six of character ”r”. These images were created as a stimulus for using Ensemble Coding.

IV. RESULTS

Regarding the results, 32 volunteer participants answered our form (all agreed with the consent form), 81% were men and 19% women, 88% were white people, 53% had completed high school at most and 47% had at most complete higher education, only one person was over 35 years old, and only two people were unfamiliar with CG. Initially, with the objective of ordering in levels of realism the images created with the CG characters (presented in Section III-C, and in Fig.1), we used as a basis the comfort chart presented in the work by Araujo et al. [4], and the UV chart presented in the work by Mori [3]. In these two charts, the x-axis represents Human Likeness, that is, the farther to the right is the image with characters, the more it is considered realistic. The x-axis in Fig.2 shows the ordering of the images according to the values of the average realism of the characters shown in Table I. In addition, the blue y-axis line in Fig.2(a) represents the comfort percentage values (obtained in Table I), and the orange line represents the values of comfort obtained by Ensemble Coding. The blue y-axis line in (b) represents the charisma percentage values, and the orange line represents the values of charisma obtained by Ensemble Coding.

Regarding realism, we performed a Spearman’s rank test to compare the ordering of images between the average realism

[2]www.jotform.com



(a) Analysis of Comfort

(b) Analysis of Charisma

Fig. 2. Charts representing comfort and realism in (a), and charisma and realism in (b).

values obtained by Table I and the realism values obtained by Ensemble Coding. First, we separated the images into two groups, the first contained characters with black and white skin colors in each of the images, while the second each image contained characters with the same skin color. This was done to assess whether realism could be influenced by skin color separation. Overall (all 15 images), we found a strong correlation (0.91) between the order of realism averages and the realism value obtained by Ensemble Coding, that is, the perception of a group of characters when compared to the individual perception did not impact the perceived realism. The same happened when we separated the images into two groups, being 0.917 for the group of images that contained black and white skin colors, and 1.0 for the group of images containing characters with the same skin color. It means the skin color of characters does not affect the perceived realism.

Regarding perceived comfort, comparing the comfort percentages presented in the blue line (percentages of the values obtained in the work by Araujo et al. [4], and shown in Table I) with the comfort perceived through the Ensemble Coding presented in the orange line in Fig.2(a), we can notice that the comfort perceived individually behaves in a similar way to the comfort perceived globally (in a group of characters), even if the images have characters with different skin colors. If we look individually, the two characters with comfort below 70% (one with black skin color and one with white skin color, as shown in Table I) had increased comfort values when paired with other characters. The same happened with the perceived charisma (blue line with the charisma perceived through the Ensemble Coding presented in the orange line in Fig.2(b)).

V. Final Considerations

In terms of realism, charisma, and comfort, the results on global perceptual data (i.e., using Ensemble Coding) were similar to the results obtained using the Araujo et al. [4] dataset, both for images that contained the same skin colors and for images that contained black and white skin colors. With this, we can conclude that, all tested characters can convey similarly charisma, can make people feel comfortable, and do not interfere with the perception of realism. In our limitations, we cannot control the race of the participants, and some characteristics of the characters' images, such as lighting, shape, etc. The results could have been different if we had managed to control for these limitations, but this is a preliminary study and we will be able to include these points in future work. As future work, we intend to isolate and better test these features.

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