Perception of Charisma, Comfort, Micro and Macro Expressions in Computer Graphics Characters

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***Abstract*—This paper presents the reproduction of a research focused on the perception of micro and macro expressions of a character generated by Computer Graphics (CG), firstly described in 2014. Our main goal is to investigate whether the perceptual analysis of CG characters in 2014 is similar to people's perception in 2021. We also performed other analyses, such as the impact of familiarity with CG technologies, gender, age and education on the perception of micro and macro expressions, by subjects. In addition to the perceptual analysis of micro and macro expressions, we also evaluate the perceived comfort and charisma in relation to the presented CG characters.**

***Index Terms*—Computer Graphics, Comfort, Charisma, Perception, Emotion.**

I. Introduction

Perception comes from the Latin word with the same spelling that means "to apprehend" or "to understand". According to Zell et al. [1], the brain processes information from the senses and interprets its relevance to the organism. The first process of transforming information driven by the senses is called the ascending process. The second process is based on information acquired about the world through learning and provides a context for meaning information to be interpreted, known as the top-down process. Therefore, when looking at a person or a character, for example, a perception is created about what is being seen and represented by the face of the other.

In 2014, Queiroz et al. [2] presented a pioneer work where the authors investigate if people perceive the facial micro expressions in a similar way with CG characters than with real people. It is interesting because micro and macro facial expressions can be used to provide more realistic characters in many applications as games and simulations. This paper presents a reproduction of such research. Our main goal is to investigate whether the perceptual analysis of CG characters in 2014 is similar to people's perception in 2021. We also performed other analyses, such as the impact of familiarity with CG technologies, gender, age and education, of tested subjects, on the perception of micro and macro expressions. In addition to the perceptual analysis of micro and macro expressions, we also evaluate the perceived comfort and charisma in relation to the presented CG character.

Furthermore, the faces can be considered a human communication center [2]. It is through them that we perceive emotions and feelings. In some situations, expressions generated by faces can indicate whether a person is sad, happy or angry. The roboticist Masahiro Mori [3] conducts an analysis of the emotional reaction of humans when exposed to artificial beings. According to his theory, artificial beings (robots, CG characters, etc) with a high degree of realism next to real humans may fall into the Uncanny Valley (UV), causing a strange impression on the viewer. The UV theory analyses human perception in an emotional context for artificial beings. According to Mori, artificial beings with a high level of realism (high similarity to humans) and without a common characteristic can cause strange sensations to those who watch them. This feeling is intensified when artificial beings give signs of life, as a movement, thereby changing the shape of the valley. Moreover, this feeling can also be caused by lack of familiarity with being artificial or other characteristics that can cause discomfort.

Another aspect that can influence the human perception of a character is its charisma. According to Max Weber [4], charisma is related to a possible authority, or leadership and/or

dominance that one person can exercise over another. That is why certain characters and public figures are rigorously followed and admired, making others buy their products or their speech.

In order to conduct our research, we formulate three hypothesis, as follows:

- $H0_1$ - The perception of micro and macro facial expressions of CG characters in 2014 is similar in 2021;
- $H0_2$ - The perception of micro and macro expressions in positive emotions is similar to the perception of micro and macro expressions in negative emotions;
- $H0_3$ - Subjects consider that our evaluated character is charismatic and comfortable, according to their perception.

In the present work, the original research [2] was partially reproduced with the goal to evaluate, in a more recent CG character, the perceptions of micro and macro expressions. In addition, we investigate the perception of charisma and comfort in relation to the same tested character. This work is structured as follows: Section II presents works related to the subject discussed, Section III explains the applied experiment, Section IV presents the results, and Section VI final considerations.

II. Related Work

There are several authors and related work about micro expressions. However, it is important to cite authors such as Haggard and Isaacs [5] who reported for the first time micro expressions as micro momentary expressions after analyzing psychotherapy cinematographic films for hours in search of non verbal communications between patient and therapist [1]. According to the free translation available at CICEM [2], during these explorations it was noticed that occasionally the expression on the patient's face changed drastically within three to five frames (smile to frown to smile), which is equivalent to a period of 1/8 to 1/5 second. Later, Paul Ekman began to formally call them micro expressions [6]. Currently there is great interest in this branch related research to lie detection [7].

The Computer Graphics field is also involved in studies with animated characters, macro and micro expressions. Several authors have already developed methods that sought to imitate and respond to the emotions presented by humans ([8]).

The research developed in this work is inspired by the work of Queiroz et al. [2] and based on three psychological studies that deal with the perceptions of micro expressions. The first study is proposed by Bornemann et al. [9], in which micro expressions are displayed briefly enough (between 10 and 20 milliseconds) to ensure that people do not consciously perceive them. In the second study, Shen et al. [10] applied two experiments based on two methodologies, BART (*Brief Affect Recognition Test*) and METT (*Microexpression Training Tool*), also based on Ekman's studies. The BART condition consists of showing the six universal expressions after a fixed point. In the METT paradigm, the universal expressions are displayed between two sequences of neutral faces. This study investigated a possible upper limit of time for the perception of micro expressions, concluding that from 160 milliseconds on, the accuracy of the participants' responses began to stabilize. The third and last study used as the basis for our research is the work of Li et al. [11]. In this work, the expression of surprise was preceded by 30 milliseconds of happiness or fear, asking the observers if they considered it to be positive or negative expressions.

Considered the related methods briefly presented in this section, we decide to reproduce the research under the same foundations as the original research [2].

Regarding perception of facial expressions in CG, in another work by Queiroz et al. [12], the authors proposed a model for the automatic generation of expressive gauze through examining eye behavior in different affective states. In addition, the authors also implemented a prototype and collected user perceptions about the impact of eye behavior during some expressions of emotion. In the work of Normoyle et al. [13], the authors proposed using an NPC's animations to reflect how they feel about the player and investigated the potential for a straightforward gaze model to convey trust. The authors found that people can distinguish between high and low confidence animations, can also associate and the gaze differences, and that the effect can be maintained for different facial expressions and scene contexts. In the work by Carrigan et al. [14], the authors measured the importance of blendshapes for animating facial expressions (based on Action Units) in the perception of emotions.

Regarding charisma, in the work of Awamleh and Gardner [15], the authors reported on the importance of animated facial expressions. In Riggio's work [16], the author also reported that charismatic individuals are lively, charged with emotion, and full of life. Furthermore, there are a recent interest in the studies of comfort and charisma in CG characters, as presented by V. Araujo et al. [17] and [18]. In the first work, authors study the influence of gender on the perception of charisma and comfort in CG characters, while in the other study, authors analyse the impact of time in perceived comfort in relation to the CG characters between 2012 and 2020. With regard to perceived comfort only, in the work by Dill et al. [19], the authors revisited the Uncanny Valley theory and assessed the perceptions of comfort and realism about CG characters from various media (games, movies, etc).

III. Methodology

In the research proposed by Queiroz et al. [2], two experiments were performed. In each of them, videos of the character were played along with questions, about the expression presented, to be answered by subjects. Experiment 1 was applied online and divided into two parts: one with six videos of micro expressions and the second with ten videos containing micro and macro expressions. For the second experiment, applied in person (i.e., not online), Part 1 and Part 2 were similar

[1] https://www.humintell.com/microexpressions-2/

[2] http://cicem.com.br/sobre-as-microexpressoes-faciais/

to Experiment 1. With the addition of ten videos for Part 2, totaling 20. A third Part was added to the second experiment to assess the participants' perception of realism, falsehood and valence in the character's expressions.

In this work, only Experiment 1 was used, since face-to-face evaluations could not be performed due to pandemic reasons. The animations and also the form that were made available to the participants were reproduced based on Queiroz research. The form was divided into five parts:

1) Consent form: to make the participant aware of the scientific purposes of the form.
2) Participant profile: to collect demographic information about the subjects, as gender, age group, educational level and familiarity with CG.
3) Control Questions: firstly, six macro expressions are presented in images and videos, followed by questions about each macro expression. The control questions are important to select people who can perceive correctly the macro expressions, otherwise their perceived data output were not used in the final results.
4) Experiment - Part 1: six micro expressions with videos followed by one question for each of them.
5) Experiment - Part 2: it presents twenty videos, with micro and macro expressions, followed by four questions for each of them.

Next section detail the experiments (parts 3 to 5).

A. Performed Experiments

First, Figure 1 was showed to the participants, containing the six universal emotions [6] represented by the character used in our research.

The 3d character chosen in this work is available at *https://www.turbosquid.com/FullPreview/Index.cfm/ID/917863*. As shown in the work by Araujo et al. [17], [18], cartoon and female (the character used in the work of Queiroz et al. [2] was also female) characters tend to be more comfortable and charismatic to people. Therefore, we chose a female cartoon character to evaluate this hypothesis in relation to our character, independently if the micro or macro expressions are correctly identified. Furthermore, we chose a character that we could manipulate the facial structure to reproduce the facial expressions. Therefore, we performed the animations of facial expressions through the blendshapes of this character. The work Carrigan et al. [14] showed the importance of blendshapes for the perception of facial expressions.

Animations and video were generated using the Unity engine. Unity provides the generation of videos with time defined by the user, and for this, the same time definitions of the research of Queiroz et al. [2] could be replicated. Further information about time of animations are later presented. The animation videos were exported to digital files and published at *Youtube* platform. A research form was created with Google Forms platform, integrating the presented videos, images and questions from the tested experiment. Firstly, we present the control questions (part 3 from last section), then the two performed experiments (parts 4 and 5 from last section).

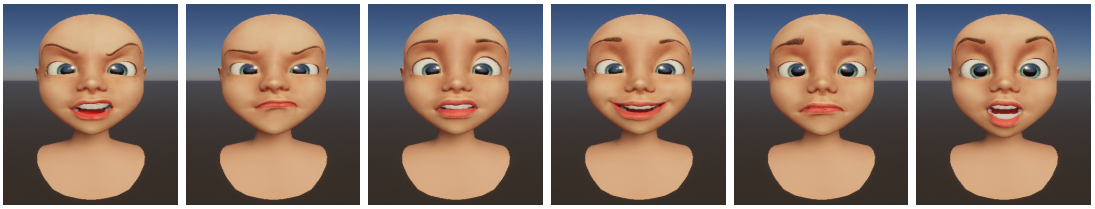
1) Control questions: As mentioned before, firstly, the six macro expressions images and videos, illustrated in Figure 1, are presented to the subjects, followed by a control question ("What emotion was presented in the video?", having all six emotions as possible answers) for each video. The goal was to certify that the participant can perceive the main expressions. Each video has a duration of approximately four seconds where the character performed a neutral reaction for two seconds, followed by a 510 milliseconds of a macro expression and more two seconds with neutral expression. It is followed by the two parts of the form, the first and the second part of the experiment, as presented in Table I and discussed in next sections. It is important to mention that in order to compare with Queiroz et al. [2] we replicate the same videos as produced by the authors, i.e., 6 videos from Part 1 and 10 videos from Part 2. In addition we produced more 10 videos, as presented in Table VI. Next sections detail the performed experiments.

TABLE I
ORDER OF USED VIDEOS AND EMOTIONS FOR THE EXPERIMENTS.

Experiment Part 1	**Experiment Part 2**	
Micro Expression	**Macro Expression**	**Micro Expression**
Sadness	Happiness	Sadness
Happiness	Surprise	Sadness
Surprise	Sadness	Happiness
Fear	Fear	Anger
Anger	Anger	Happiness
Disgust	Fear	Disgust
	Sadness	Anger
	Surprise	Fear
	Surprise	Happiness
	Happiness	Anger

2) Experiment Part 1 - Perception of Micro expressions: In this part of the experiment, a single micro expression for each universal emotion was reproduced in a video, as shown in the first column of Table I. The two first seconds presented a neutral expression, followed by a micro expressions of 100 milliseconds, and another two seconds with a neutral expression. After each video, the question "What emotion was presented in the video?" was asked to the subjects (as possible answers: Anger, Disgust, Fear, Happy, Sad, Surprise, I don't know and No emotion). It is important to mention that Unity let available animation interface that allow such precise and accurate time definitions.

3) Experiment Part 2 - Perception of Micro and Macro expressions: The Part 2 of the experiment presented 20 videos, each of them containing one micro expression followed by a macro expression. The videos were assembled with 300 milliseconds of a neutral expression, 100 milliseconds of a micro expression, 510 milliseconds of a macro expression and 300 milliseconds of a neutral expression. After each video, four questions were presented to the subjects: *Question A* - "What was the main emotion presented by the character?" (as possible answers: Anger, Disgust, Fear, Happy, Sad, Surprise), *Question B* - "Do you think the character has another emotion?" (as possible answers: Anger, Disgust, Fear, Happy, Sad,



(a) Anger (b) Disgust (c) Fear (d) Happy (e) Sad (f) Surprise

Fig. 1. All expressions (emotions) represented by the character, used in our work.

Surprise, I don't know and No emotion), *Question C* - "What is your comfort level with the character shown in the video?" and *Question D* - "What is the character's level of charisma in the video?" Questions C and D were included to give a chance to the participant to report his/her perception of comfort and charisma regarding the character. We used the 5-Likert scales answer options, from the most negative ("Very uncomfortable" and "No charisma") until a most positive ("Very comfortable" and "Very charismatic"). Next section discusses the results obtained with our perceptual experiments.

IV. Results

Our experiments were answered by 81 participants, collected through the Google Forms (distributed through social networks) during ten days. We made it clear, on the form, that if participants wanted or if they felt any discomfort (such as boredom and tiredness), they could stop responding at any time. From the participants, 53.42% were women and 46.57% were men. Regarding the age of the participants, 67.12% were under 30 years old and 32.87% were over 30 years old. Regarding the familiarity with CG, 54.79% were familiar with CG and 45.20% were not. In all of our control questions, participants had more than 80% correct answers.

The percentage and standard deviation of the correct answers for each part of the experiments are presented in the **first four lines of Table** II. The highest percentage of correct answers was in Part 2, question A (question about only macro expressions). Parts 1 and Part 2-question B, which contained questions about perception regarding micro expressions, have lower percentages compared to Part 2-question A. In addition, between Parts 1 and 2-question B, there was a difference in percentages that may be related to the presence of a macro expression in the same video, as Part 1 contained only the video with a micro expression and Part 2 has a video with micro and macro expressions together. Our results indicate that the difficulty increases considerably in identifying the micro expression when it is accompanied by a macro expression in the same video (see results of Part 2-question B and Part 1). The average percentage of correct answers to both questions (A and B) in Part 2 (i.e., subjects who answered correctly on the macro and micro expression) is also shown in the Table II, illustrating the low percentage correct answers.

The **second group of data in Table** II presents the results obtained by Queiroz et al. [2]. One can notice that Queiroz data presents higher percentage of correct answers in Part 1, Part 2-question B and Part 2AB (correct answers in questions A and B) of the experiment. The only value similar to the original work (from Queiroz) was the percentage of correct answers in Part 2A (macro expressions). The averages of correct answers for questions involving micro expressions were lower in the current work than in the previous one. Our hypothesis here is that the observed difference can be an effect of the used technology. In 2014, the authors used a more realistic character, while we use a cartoon one. We hypothesize that the animations applied by the realistic character were less smooth in the realistic character and could be more noticeable.

TABLE II
Percentages and Standard Deviation of the Participants' Correct Answers in our work (first four lines), and in the work of Queiroz et al. [2] (second group of data).

Our (10 videos)	**Part 1**	**Part 2 (10 videos)**		
		Question A	**Question B**	**Questions A and B**
Average	38.05%	75.65%	11.48%	4.75%
SD	24.60%	25.14%	6.36%	3.13%
Queiroz et al.	**Part 1**	**Part 2**		
		Question A	**Question B**	**Questions A and B**
Average	80.00%	73.00%	45.00%	41.19%
SD	15.75%	27.65%	31.03%	30.20%

The first seven lines of Table III present the confusion matrix with the results of the Experiment Part 1 of our work, where the micro expressions were analyzed. It is possible to observe that the subjects provided more correct answers when analysing the Surprise, with 69.10% of the answers, while Sadness was the emotion that subjects most answered wrongly, with only 7.40% of the subjects choosing the correct emotion (67.90% chose the the option "No Emotion"). Similarly, the last seven lines of Table III presents the confusion matrix obtained in the work of Queiroz et al. [2]. The emotion with the highest percentage of correct answers was also Surprise, with 92.86% of the answers. Unlike our work, Fear was the emotion with the lowest percentage of correct answers in the work of Queiroz et al., with 45.24% of the answers.

The first seven lines of Table IV present the confusion matrix obtained from our method with respect to the Experiment Part 2A with questions involving macro expressions. Note the percentage of correct answers was above 70% for the emotions of Anger, Happiness, Surprise and Sadness. The

TABLE III
CONFUSION MATRIX BETWEEN EMOTIONS OF EXPERIMENT 1 (MICRO EXPRESSIONS) - IN THE FIRST SEVEN LINES, THE RESULTS OF THE PERCENTAGES OF CORRECT ANSWERS OBTAINED IN OUR WORK ARE PRESENTED. IN THE LAST SEVEN LINES, THE RESULTS OF THE PERCENTAGES OF CORRECT ANSWERS OBTAINED IN THE WORK BY QUEIROZ ET AL. [2].

Our	Anger	Happiness	Sadness	Fear	Disgust	Surprise	No Emotion	I Don't Know
Anger	**61.70%**	4.90%	0.00%	2.50%	9.90%	2.50%	4.90%	13.60%
Happiness	1.20%	**43.20%**	0.00%	1.20%	6.20%	13.60%	16.00%	18.50%
Sadness	0.00%	0.00%	**7.40%**	7.40%	3.70%	2.50%	67.90%	11.10%
Fear	0.00%	4.90%	1.20%	**16.00%**	11.10%	21.00%	18.50%	27.20%
Disgust	16.00%	0.00%	6.20%	6.20%	**30.90%**	0.00%	23.50%	17.30%
Surprise	0.00%	3.70%	0.00%	1.20%	4.90%	**69.10%**	3.70%	17.30%
Queiroz et al.	**Anger**	**Happiness**	**Sadness**	**Fear**	**Disgust**	**Surprise**	**No Emotion**	**I Don't Know**
Anger	**92.26%**	0.60%	0.00%	2.98%	3.57%	0.00%	0.00%	0.60%
Happiness	0.60%	**87.50%**	0.60%	0.60%	0.60%	2.98%	1.19%	5.95%
Sadness	0.00%	0.60%	**75.60%**	10.12%	6.55%	0.60%	1.79%	4.76%
Fear	3.57%	0,00%	2.38%	**45.24%**	4.76%	30.95%	1.19%	11.90%
Disgust	19.05%	0.00%	1.79%	0.00%	**75.60%**	0.60%	0.60%	2.38%
Surprise	0.00%	1.19%	0.00%	2.38%	1.19%	**92.86%**	1.19%	1.19%

TABLE IV
CONFUSION MATRIX BETWEEN EMOTIONS OF EXPERIMENT PART 2 IN QUESTION A (MACRO EXPRESSIONS) - IN THE FIRST SEVEN LINES, THE RESULTS OF THE PERCENTAGES OF CORRECT ANSWERS OBTAINED IN OUR WORK ARE PRESENTED. IN THE LAST SEVEN LINES, THE RESULTS OF THE PERCENTAGES OF CORRECT ANSWERS OBTAINED IN THE WORK BY QUEIROZ ET AL. [2]. NOTE: WE DID NOT USE DISGUST IN THIS TABLE, AS IT WAS NOT USED IN THE VIDEOS. THE SAME HAPPENED IN THE WORK OF QUEIROZ ET AL.

Our	Anger	Happiness	Surprise	Sadness	Disgust	Fear	No Emotion	I Don't Know
Anger	**85.00%**	3.75%	1.25%	0.00%	8.75%	2.50%	0.00%	0.00%
Happiness	5.00%	**88.13%**	6.25%	0.00%	0.63%	1.25%	0.00%	0.00%
Surprise	1.25%	4.58%	**90.80%**	0.41%	0.83%	2.91%	0.00%	0.00%
Sadness	5.00%	1.25%	6.25%	**72.50%**	10.00%	6.25%	0.00%	0.00%
Disgust	-	-	-	-	-	-	-	-
Fear	3.75%	1.25%	30.00%	4.37%	33.75%	**28.12%**	0.00%	0.00%
Queiroz et al.	**Anger**	**Happiness**	**Surprise**	**Sadness**	**Disgust**	**Fear**	**No Emotion**	**I Don't Know**
Anger	**70.24%**	13.10%	7.74%	1.79%	3.57%	3.57%	0.00%	0.00%
Happiness	8.93%	**86.31%**	1.19%	1.79%	1.79%	0.00%	0.00%	0.00%
Surprise	0.40%	7.94%	**83.33%**	3.57%	1.59%	3.17%	0.00%	0.00%
Sadness	12.50%	6.55%	1.79%	**72.02%**	2.38%	4.76%	0.00%	0.00%
Disgust	-	-	-	-	-	-	-	-
Fear	28.57%	0.00%	22.62%	2.38%	20.24%	**26.19%**	0.00%	0.00%

results obtained in the work of Queiroz et al. for this part of the experiment are presented in the last seven lines of Table IV, and the percentages were also above 70% for the same emotions obtained in our work. In both in our work and in the work of Queiroz et al, the emotion with the lowest percentage of correct answers was Fear, with a value below 30%.

Regarding the Experiment Part 2-question B, the first seven lines of Table V present our results involving the perception of micro expressions. The percentages of correct answers were the lower presented if compared with other tables, and the same happened with results obtained by Queiroz et al. [2], as shown in the last seven lines of Table V. It indicates that subjects had greater difficulty to answer question B from Experiment Part 2, i.e., was difficult to identify the micro expression, when combined with a macro expression.

Comparing all our results, macro expressions were better identified and, in particular, the emotions of surprise, happiness and anger were the most perceived, both in micro and macro expressions. Also, in our case as well as in Queiroz et al. [2], the values of correct identification of micro expressions, when followed by macro expressions, presented lower values, according to the subjects perception.

A. Analysis with participant profile filters

Until now, we provide results and comparisons with the work proposed by Queiroz et al. [2]. So, we used only the videos that replicate the experiments proposed by these authors. In this section we discuss the results obtained when we analysed all the videos we included in our experiment. Indeed, we increase the number of videos because Queiroz did not tested all emotions in combinations micro and macro expressions, in Experiment Part 2. In addition, we are interested in investigating the charisma and comfort perceived by the subjects, as mentioned before, when watching our character. Table VI presents, in bold, the videos we included in our analysis, in Part 2.

With the demographic information about the participants collected in the form (age, gender, familiarity with CG and education), we sought to find some relationship between the profiles and the percentages of correct answers for micro and macro expressions, as well as the perception of charisma and

TABLE V
CONFUSION MATRIX BETWEEN EMOTIONS OF EXPERIMENT PART 2 IN QUESTION B (MICRO EXPRESSIONS) - IN THE FIRST SEVEN LINES, THE RESULTS OF THE PERCENTAGES OF CORRECT ANSWERS OBTAINED IN OUR WORK ARE PRESENTED. IN THE LAST SEVEN LINES, THE RESULTS OF THE PERCENTAGES OF CORRECT ANSWERS OBTAINED IN THE WORK BY QUEIROZ ET AL. [2]. NOTE: WE DID NOT USE SURPRISE IN THIS TABLE, AS IT WAS NOT USED IN THE VIDEOS. WHILE QUEIROZ ET AL. DID NOT USE SURPRISE IN THEIR EXPERIMENTS EITHER, AND DID NOT PRESENT DISGUST'S RESULTS.

Our	**Anger**	**Happiness**	**Surprise**	**Sadness**	**Disgust**	**Fear**	**No Emotion**	**I Don't Know**
Anger	**16.66%**	5.83%	17.08%	7.08%	16.25%	8.33%	22.50%	7.50%
Happiness	5.41%	**13.33%**	8.33%	4.16%	13.33%	5.83%	40.83%	10.00%
Surprise	-	-	-	-	-	-	-	-
Sadness	3.75%	6.87%	26.25%	**2.50%**	3.75%	10.63%	41.25%	6.25%
Disgust	8.75%	2.50%	15.00%	11.25%	**11.25%**	10.00%	31.25%	11.25%
Fear	2.50%	11.25%	13.75%	2.50%	2.50%	**10.00%**	50.00%	8.75%
Queiroz et al.	**Anger**	**Happiness**	**Surprise**	**Sadness**	**Disgust**	**Fear**	**No Emotion**	**I Don't Know**
Anger	**48.41%**	8.33%	5.16%	9.92%	12.90%	6.35%	4.76%	4.37%
Happiness	10.71%	**56.75%**	9.13%	6.75%	3.57%	0.79%	8.73%	3.57%
Surprise	-	-	-	-	-	-	-	-
Sadness	0.00%	8.33%	11.90%	**47.02%**	2.38%	4.76%	19.64%	5.95%
Disgust	-	-	-	-	-	-	-	-
Fear	13.69%	2.98%	25.00%	8.33%	9.52%	**20.24%**	11.31%	8.93%

TABLE VI
ALL VIDEOS WE USED IN EXPERIMENT PART 2. BOLD EMOTIONS ARE VIDEOS WE DID IN ADDITION TO ONES PRESENTED IN QUEIROZ ET AL. [2].

Our Experiment Part 2	
Macro Expression	**Micro Expression**
Happiness	Sadness
Surprise	Sadness
Sadness	Happiness
Fear	Anger
Anger	Happiness
Fear	Disgust
Sadness	Anger
Surprise	Fear
Surprise	Happiness
Happiness	Anger
Disgust	**Sadness**
Anger	**Surprise**
Fear	**Surprise**
Disgust	**Surprise**
Happiness	**Surprise**
Sadness	**Disgust**
Fear	**Disgust**
Disgust	**Fear**
Surprise	**Disgust**
Fear	**Happy**

comfort in relation to character. In addition, The six universal emotions were divided in two groups: positive emotions (happiness and surprise) and negative emotions (anger, sadness, disgust, fear). Such grouping was done to verify if the positive and negative emotions influenced the results, as discussed in one of the main hypothesis of this work ($H0_2$).

Table VII presents the data generated for each group of emotions from the participants' filtered demographic data. The table contains the average percentages of correct answers of each experiment (micro expressions in Part 1, macro expressions in Part 2-question A and micro expressions in Part 2-question B). We developed filters to select specific groups to be compared in our analyses. For each participants filter (familiarity, gender, Age and Education), the average percentage was calculated considering each emotion group, including the 'Total average percentage'. For the lines 'Part 2A' and 'Part 2B', the 'Ma' terminology is used for macro expression, 'Mi' for micro expression, 'Pos' for the positive emotion and 'Neg' for a negative emotion. This way, 'MaPos-MiPos' represents the set of questions whose videos present the positives macro and micro expressions. In addition, for these analyses, we removed participants who could not answer whether they were familiar with CG, so we only let information about subjects who answered YES or NO to such question.

With the data presented in Table VII, in most cases, the participants more familiar with CG had higher levels of correct answers. Between women and men, there was little difference of correct answers, with women having more correct answers in Part 1, and results were very similar in Part 2. . Regarding age, in most cases, participants under 30 years old had higher percentages of correct answers than participants over 30 years old. The same happened when we separated the participants into levels of education, and, in most cases, the group of participants with less education obtained more percentages of correct answers.

Performing the analysis on the groups of emotions for Part 1 of the experiment, positive micro expressions had a higher percentage of correct answers than negative micro expressions. In Part 2A (macro expression), the correct answers in macro expressions were also higher when the video had a positive macro expression. In addition, the correct answers were higher when the video presented macro and micro expressions of opposite groups (positive and negative). For the micro expressions in Part 2B, positive emotions also had a higher percentage of correct answers than negative ones. When the macro expression of the video was positive and followed by positive micro expression, the percentage of correct answers was higher than the videos with positive macro followed by negative micro expression.

We performed statistical analysis (paired and independent

t-tests, using 95% significance level) to compare the average percentages of correct answers between groups of expressions, as discussed in next sections.

1) Part 1: Regarding the comparisons of averages presented in Part 1 of Table VII, we only found significant results when we divided the participants by age (under and over 30 years old). Both in Total (first line of means of Part 1) and in Positive Micro Expression (second line of means of Part 1) we find significant *p*-values (respectively, .01 and .04). Therefore, **in total and in positive expressions, we can say that participants under 30 years old had more correct answers than people over 30 years old.**

2) Part 2A: In the analysis without filters, we found significant results when we compared MaPos-MiPos Vs. MaNeg-MiNeg (.02), MaPos-MiNeg Vs. MaNeg-MiPos (.02), and MaPos-MiNeg Vs. MaNeg-MiNeg ($<$ .001). Therefore, **we can say that participants had more correct answers when the video had at least one positive micro or macro expression than when the video had negative micro and macro expressions.**

Regarding the analysis of familiarity with CG, both when separating participants who had familiarity and participants without familiarity, we also found significant results when comparing MaPos-MiPos Vs. MaNeg-MiNeg (respectively, .04 for subjects with familiarity, and .01 for subject without familiarity), MaPos-MiNeg Vs. MaNeg-MiPos (.03 and .01), and MaPos-MiNeg Vs. MaNeg-MiNeg (.001 and $<$ .001). Therefore, **we can say that both types of participants, with and without familiarity with CG familiarity, had more correct answers when the video started with a positive macro expression than when the video started with a negative macro expression**.

Regarding the analysis of gender, both when separating participants into women and men, we found significant results when comparing MaPos-MiPos Vs. MaNeg-MiNeg (.009 and .04), and MaPos-MiNeg Vs. MaNeg-MiNeg ($<$ .001 and .002). So, **we can say that women and men had more correct answers when they saw videos that started with positive macro expressions than videos that had negative macro expression followed by negative micro expression.**

With respect to participants under 30 and over 30 years old, we found significant results when comparing MaPos-MiPos Vs. MaNeg-MiNeg (.03 and .01), MaPos-MiNeg Vs. MaNeg-MiPos (.02 and .02), and MaPos-MiNeg Vs. MaNeg-MiNeg (.001 and $<$ .001). Therefore, **we can say that both participants, under 30 and participants over 30 years, also had more correct answers when the video started with a positive macro expression than when the video started with a negative macro expression.**

Regarding the analysis of educational level, separating participants in high school and complete higher education, we found significant results when we compared MaPos-MiPos Vs. MaNeg-MiNeg (.02 and .02), and MaPos-MiNeg Vs. MaNeg-MiNeg (.001 and $<$ .001). We also found significant results in MaPos-MiNeg Vs. MaNeg-MiPos (.01) when we analyzed the answers of participants with higher education. Therefore, **we can say that both types of participants had more correct answers when they saw videos that started with positive macro expressions than videos that had negative macro expression followed by negative micro expression.** In the comparison analysis between the answers of participants with complete high school Vs. participants with complete higher education, we found significant results when we performed the analysis without filter (.01) and MaNeg-MiPos (.005). Therefore, **both in general and when watching videos with negative macro expressions followed by positive micro expressions, we can say that participants with complete high school had more correct answers than participants with complete higher education.**

3) Part 2B: Regarding the unfiltered analysis of Part 2B, we found significant results in MaPos-MiPos Vs. MaPos-MiNeg (.02), and in MaPos-MiPos Vs. MaNeg-MiNeg (.01). With that, **we can say that, in Experiment Part 2B, the participants had more correct answers in videos that had macro and micro positive expressions than videos that ended with negative micro expressions.** Comparing answers from participants with and without CG familiarity, we found only significant results in the total data. Therefore, **we can say that participants with CG familiarity had more correct answers than participants without CG familiarity.**

With respect to gender, we did not find significant results in comparisons between the values of the two genders, that is, **there was no gender effect.** Separating participants under 30 and over 30 years of age, we did not find significant results, that is, **there was no age effect.**

With regards to educational level, **we can say that participants with complete high school had more correct answers than participants with complete higher education.**

B. Perception of Charisma and Comfort analysed in our experiments

Table VIII presents the average value of the participants' perception of comfort and charisma in relation to the evaluated character in Part 1 and Parts 2 experiments, the last one containing 20 videos, as presented in Table VI. Even with several videos containing different macro and micro expressions, the perceived charisma and comfort remained similar. However, according to the Table VIII, we can say that the character was considered comfortable and charismatic by the research participants, since most values were greater than 3 (average value of the 5-Likert Scales).

As in the previous section, we also performed statistical analysis (paired and independent *t*-tests, using 95% significance level) to compare the comfort/charisma averages (as shown in Table VIII) between groups of expressions, and between comfort/charisma averages according to the demographic data filters.

1) Perceived Comfort: In the analysis without filters, we found significant results in MaPos-MiPos Vs. MaNeg-MiPos (.04), MaPos-MiPos Vs. MaNeg-MiNeg (.01), MaPos-MiNeg Vs. MaNeg-MiPos (.009), and MaPos-MiNeg Vs. MaNeg-MiNeg (.003). Therefore, **we can say that participants**

TABLE VII
AVERAGES OF THE PERCENTAGES OF CORRECT ANSWERS IN EACH FILTER WITH GROUPED EXPRESSIONS. NOTE: CHS STANDS FOR COMPLETE HIGH SCHOOL, AND CHE STANDS FOR COMPLETE HIGHER EDUCATION.

Part 1	**No Filter (AVG)**	**Familiarity (AVG)**		**Gender (AVG)**		**Age (AVG)**		**Education (AVG)**	
Micro Expression		**Yes**	**No**	**Female**	**Male**	**<30**	**>30**	**CHS**	**CHE**
Total	37.67%	43.33%	30.80%	40.59%	34.31%	43.87%	25%	43.05%	32.43%
Positive Micro Expression	54.79%	65%	42,42%	60.25%	48.52%	65.30%	33.33%	62.5%	47.29%
Negative Micro Expression	29.10%	32.5%	25%	30.76%	27.20%	33.16%	20.83%	33.33%	25%

Part 2A	**No Filter (AVG)**	**Familiarity (AVG)**		**Gender (AVG)**		**Age (AVG)**		**Education (AVG)**	
Macro Expression		**Yes**	**No**	**Female**	**Male**	**<30**	**>30**	**CHS**	**CHE**
Total	63.49%	67%	59.24%	64.61%	62.20%	66.42%	57.5%	67.08%	60%
MaPos-MiPos	86.30%	86.25%	86.36%	85.89%	86.76%	87.75%	83.33%	86.11%	86.48%
MaPos-MiNeg	89.58%	89%	90.30%	91.28%	87.64%	89.79%	89.16%	87.77%	91.35%
MaNeg-MiNeg	43.24%	49.28%	35.93%	41.39%	45.37%	48.10%	33.33%	48.80%	37.83%
MaNeg-MiPos	57.76%	62.91%	51.51%	62.39%	52.45%	61.22%	50.69%	64.81%	50.90%

Part 2B	**No Filter (AVG)**	**Familiarity (AVG)**		**Gender (AVG)**		**Age (AVG)**		**Education (AVG)**	
Micro Expression		**Yes**	**No**	**Female**	**Male**	**<30**	**>30**	**CHS**	**CHE**
Total	14.17%	16.62%	11.21%	14.10%	14.26%	15%	12.5%	16.94%	11.48%
MaPos-MiPos	32.19%	38.75%	24.24%	32.05%	32.35%	32.65%	31.25%	38.88%	25.67%
MaPos-MiNeg	8.49%	8%	9.09%	11.79%	4.70%	7.75%	10%	9.44%	7.56%
MaNeg-MiNeg	11.74%	14.28%	8.65%	11.72%	11.76%	12.53%	10.11%	15.07%	8.49%
MaNega-MiPos	15.75%	19.16%	11.61%	12.82%	19.11%	18.02%	11.11%	18.05%	13.51%

TABLE VIII
AVERAGES OF PERCEIVED COMFORT AND CHARISMA IN EACH FILTER WITH GROUPED EXPRESSIONS. NOTE: CHS STANDS FOR COMPLETE HIGH SCHOOL, AND CHE STANDS FOR COMPLETE HIGHER EDUCATION.

Comfort	**No Filter (AVG)**	**Familiarity (AVG)**		**Gender (AVG)**		**Age (AVG)**		**Education (AVG)**	
Macro Expression		**Yes**	**No**	**Female**	**Male**	**<30**	**>30**	**CHS**	**CHE**
Total	3.30	3.31	3.28	3.24	3.36	3.29	3.30	3.30	3.29
MaPos-MiPos	3.50	3.57	3.42	3.44	3.57	3.51	3.50	3.40	3.60
MaPos-MiNeg	3.44	3.45	3.42	3.43	3.45	3.40	3.53	3.36	3.52
MaNeg-MiNeg	3.22	3.25	3.19	3.17	3.28	3.23	3.22	3.26	3.18
MaNeg-MiPos	3.19	3.18	3.21	3.10	3.29	3.21	3.15	3.26	3.13

Charisma	**No Filter (AVG)**	**Familiarity (AVG)**		**Gender (AVG)**		**Age (AVG)**		**Education (AVG)**	
Micro Expression		**Yes**	**No**	**Female**	**Male**	**<30**	**>30**	**CHS**	**CHE**
Total	3.01	3.12	3.07	3.08	3.12	3.12	3.01	3.15	3.04
MaPos-MiPos	3.30	3.38	3.21	3.32	3.29	3.36	3.18	3.30	3.31
MaPos-MiNeg	3.21	3.24	3.17	3.24	3.17	3.27	3.07	3.25	3.17
MaNeg-MiNeg	3.04	3.07	3.00	3.00	3.09	3.05	3.01	3.08	3.00
MaNega-MiPos	3.00	2.99	3.02	2.98	3.03	3.05	2.90	3.11	2.90

felt more comfortable in videos that started with macro positive expressions than videos that started with macro negative expressions.

Regarding CG familiarity, we found significant results. Therefore, **we can say that both participants with and without CG familiarity felt more comfortable in videos that started with positive macro expressions than videos that started with negative macro expressions**. Comparing participants with CG familiarity versus without CG familiarity, we found no significant results, that is, **no effect of familiarity with CG.**

Regarding gender, **we can say that women and men felt more comfortable with videos that started with macro positive expressions than videos that started with macro negative expressions**. Regarding age, **we can say that both types of participants, under 30 and over 30, felt more comfortable in videos that started with positive macro expressions than videos that started with negative macro expressions**.

Regarding educational level, **we can say that participants with complete higher education felt more comfortable in videos that started with macro positive expressions than videos that started with macro negative expressions.** Comparing participants with complete high school and complete higher education, we found no significant results, that is, **no effect of educational level.**

2) Perceived Charisma: In the analysis without filters, **we can say that participants perceived more charisma in videos that started with positive macro expressions than in videos that started with negative macro expressions**. Regarding CG familiarity, **we can say that participants with and without CG familiarity perceived more charisma in videos that started with positive macro expressions than videos that started with negative micro expressions**. Comparing genders, we did not find significant results, that is, **no gender effect.**

Regarding age, **we can say that participants under 30**

years old perceived more charisma in general, in videos with positive macro expressions followed by negative micro expressions, and in videos with negative macro expressions followed by positive micro expressions, than participants with more than 30 years old.

Regarding educational level, **we can say that participants with complete high school perceived more charisma in general and in videos with macro negative expressions followed by micro positive expressions, than participants with complete higher education.**

V. Discussion

This section presents discussions on the main results presented in Section IV related to our research hypotheses: $H0_1$ - The perception of micro and macro facial expressions of CG characters in 2014 is similar in 2021; $H0_2$ - The perception of micro and macro expressions in positive emotions is similar to the perception of micro and macro expressions in negative emotions; $H0_3$ - Subjects consider that our evaluated character is charismatic and comfortable, according to their perception.

Regarding the comparisons between our work and the work of Queiroz et al. [2] ($H0_1$), we do not find a significant result only when we compared the results on macro expressions. However, in the two cases on micro expressions, both in Experiment Part 1 and Experiment Part 2A, the work of Queiroz had more correct answers than our experiments. Therefore our hypothesis was true for macro expressions and refuted for micro expressions. Perhaps two aspects can be discussed here to possibly explain the observed difference with respect to the micro expressions: *i)* The evolution of technology. The work developed by Queiroz et al. [2] was carried out in 2014, and since then, technology has advanced a lot over time, so, with more realistic animations in relation to face, micro expressions may have become more imperceptible; and *ii)* The type of realism of the character (while we used a cartoon character, Queiroz and her colleagues used a realistic character) may have influenced. Regarding macro expressions, as the results were similar, we can say that the perception was independent of the used technology nd the character's realism type. However, it was not true for micro expressions. One possibility is that the cartoon character (our), less realistic (cartoon) than Queiroz character (realistic), interfere in some way in the subjects perception.

In conclusion, we can say that if designers, developers, animators, and the industry in general want to present macro expressions, it does not matter if the character is cartoon or realistic or if the technology is current or from 7 years ago, so subjects are going to perceive correctly the expressed emotion. The same is not true for micro expressions.

Regarding $H0_2$, in this work, we could see that in all cases positive emotions were perceived more than negative ones. Particularly, in Experiment Part 2A (still in $H0_2$), we found that all participants perceived more macro expressions in videos with positive micro and macro expressions than in videos with negative micro and macro expressions. Therefore, we can say that for macro expressions, the hypothesis has been refuted. Still in Experiment Part 2A, another interesting result was that participants with CG familiarity perceived more correctly the negative macro expressions in videos with macro and micro negative expressions than participants without CG familiarity.

In Experiment Part 2B (still in $H0_2$), we also found that in almost in all cases, people perceived more positive micro expressions than negative ones. Therefore, our hypothesis was also refuted in Experiment Part 2B. In addition, in agreement with the Part 2A experiment, people with CG familiarity noticed more negative micro expressions than people without CG familiarity.

In these cases, even if they are followed by negative micro expressions, designers and animators can design positive macro expressions that people will notice, especially if the macro expressions are followed by positive micro expressions. In the case of negative macro expressions, ideally these macro expressions should not be followed by negative micro expressions. Regarding micro expressions, positive ones also tend to be more perceived than negative ones. In addition, video game industries, which usually have consumers who are familiar with CG (movies, games, etc), may use macro negative expressions in their characters once our results indicate that the audience can perceive these expressions. These consumers also tend to perceive more negative micro expressions. In comparison between macro and micro expressions, following our results, people tend to perceive more macro expressions (both positive and negative) than micro expressions. Therefore, the industry can focus on macro expressions in case they want to avoid sequences of complex expressions that can cause feelings of discomfort (Uncanny Valley).

Regarding $H0_3$, firstly, as predicted in the work by Araujo et al. [17], [18], our character, female and unrealistic, had values above 3 on the 5-Likert Scales (above average), that is, the character was considered charismatic and did not generate discomfort for the evaluated subjects. Regarding perceived comfort and charisma, we found some aspects that can be discussed: *i)* in most significant results about videos that started with positive macro expressions, people felt more comfortable and perceived more charisma in the character; *ii)* in most cases, people felt more comfortable and perceived more charisma in the characters in videos that had positive macro expressions followed by negative micro expressions than videos that had negative macro expressions followed by positive micro expressions; *iii)* looking at the averages in Table VIII, people felt more comfortable and perceived more charisma in the character in videos that started with macro positive expressions, especially in videos that had macro and micro positive expressions. The results of perceived charisma are in line with the work of Riggio [16], in which the author described charismatic individuals as animated and full of emotion. Therefore, the industry that wants to convey charisma through unrealistic characters can focus on macro expressions, especially the positive ones.

VI. Final Considerations

This paper presented a perceptual analysis of macro and micro expression of facial emotions applied by a cartoon character. Firstly, we replicated the exact experiment conducted by Queiroz et al. [2] with the same goal, i.e., evaluate the identification os emotions in micro and macro expressions. It helps us to respond our first hypothesis. Regarding $H0_1$, our conclusions is that the both evaluated characters (from Queiroz and from us) presented similar results for the macro expressions perception, however, very different values for the micro expressions. In particular, subjects evaluated in our work perceived less precisely the micro expressions. We hypothesize that such difference can be caused by the type of character (we used cartoon and Queiroz et al. [2] used a realistic character). But also, the animation algorithms and tools were different. While Queiroz et al. [2] developed an IN-HOUSE software to animate faces, we used Unity. So, one can think that the tools available for the creation of characters have evolved and this may imply a difference in quality of facial expressions, since animations can be smoother. Indeed, more analysis are necessary in order to respond that question, and are going to be developed as future work.

In order to answer $H0_2$ and $H0_3$, we include 10 more videos to test all emotions in micro and macro expressions, in Experiment Part 2. Regarding $H0_2$, the new analysis considering the profile of the participants and the grouping of positive and negative emotions showed that positive expressions obtained more correct answers than negative expressions in both evaluations, considering macro expressions and micro expressions. One possible explanation is that positive expressions may contain more evident movements, i.e., involving more regions of the face, making their identification easier. In addition, regarding $H0_3$, the perceptions of comfort and charisma presented high values, showing that the female character cartoon corresponds to what was presented by Araujo et al. [18].

In future work, we want to mitigate some limitations of the present work, e.g., to evaluate other characters, test various time specification for the animation, various combinations of micro and macro, and evaluate with more subjects. One of our biggest limitations to compare with the work of Queiroz et al. [2] was not having the same technique of animation, as tested and evaluated in 2014. In addition, once we tested a cartoon character instead of a more realistic one, it also seems to interfere in the subjects perception. Even knowing that cartoon characters tend to be more charismatic and convey comfort to people, it seems that the micro expressions perception was influenced by that. In future work we intend to use a more realistic character to compare with the results of Queiroz et al, and also experiment other animation techniques to provide micro expressions.

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