Facial Feature Study of Cartoon and Real People with the Aid of Artificial Intelligence

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Abstract: There is an impression that there are many facial differences between different American animated characters. Japanese animated characters, on the other hand, tend to be typecast, with large eyes, sharp chins, and angular faces. In essence, the subject matter of animation is primarily based on the culture of the people who make it, and the designers of the characters also have their own sense of national belonging; therefore, is it possible that the characters in animation are designed with more reference to their own people? In this study, the facial features of characters are extracted from the data of animation with high awards, box office, and ratings in America and Japan. R-language analysis of four sets of facial features data, comparing American and Japanese animated characters, was conducted using: U.S. and Japanese live action; American animated characters with American live action; and Japanese animated characters with Japanese live action. Results revealed that 23 of the 42 observations for the American animated character sample and the American live action sample were ≤ 0.05. Among them, 15 reference values were ≤ 0.001. In the group of Japanese animated characters, compared to Japanese live action, only 12 of the 42 observations were ≤ 0.05. Among them, seven reference values ≤ 0.001. These data prove that the design of faces of American and Japanese animated characters are exaggerated and, based on proportions of their own faces, American animators prefer to design a diverse cast of characters, which is perhaps related to the diverse ethnic structure of the United States. It is true that Japanese animated characters mostly have a single face design, and although this face has Western characteristics, it retains more of its own Japanese characteristics. However, the ‘formulaic’ style of Japanese animated characters can easily lead to aesthetic fatigue, and without continued innovation in storytelling, the character-based Japanese animation industry may be in decline.

Keywords: American animation; Japanese animation; characters design; exaggerate; face

1. Introduction

1.1. Relationship between the Design of Faces of Animated Characters and the Native People

The characters in animation play a significant role. Like film actors, animated characters act as virtual interpreters, bringing the audience into the story and allowing them to immerse themselves in it [1]. As such, animated characters are often a central element in determining the success of an animated film. The visual design of an animated character includes the character’s gender, age, skin color, shape, hair style, etc. [2]. Comic books precede animation, but characterization in the two formats is the same. Perkins referred to two core concepts of comics: exaggeration and personalization of the character [3]. Facial features are the starting point for most drawings of comic characters [4]. From a superficial point of view, animated characters from different countries and regions have distinct regional characteristics; for example, Japanese and U.S. animators animate characters to leave...
different impressions. This study aims to analyze how those characters are designed, and whether they are linked to the appearance of the people in their native nation. Specifically, this study investigated how human appearance, as a part of culture, is reflected in national animation works, taking the United States and Japan as examples, and using the method of a decision tree classification to analyze data to explain the relationship between animated characters and their native appearance.

1.2. Research and Related Work on Character Design and Human Appearance

Peck suggests that during the primitive period, human aesthetic preferences for the face favoured twisted and distorted imagery, with some figures having faces similar to those of today’s animated characters [5]. Hamilton suggests that facial appearance can reflect a person’s health status, immunity, and even certain diseases, that can then be visualized on the face. This has led to positive and negative comments regarding a face, and even leads to sarcasm and ridicule [6]. Early paintings of human figures featured similar satirical figures and, during the Renaissance, Davinci used the features of the human face as a foundation for his contorted, exaggerated drawings of the faces of some of his enemies. Those exaggeratedly drawn faces are considered to be his explorations of the satirical caricature form [4]. It is clear that satirical caricatures are the origin of today’s comic books and animations, and there is a definite link between the portrayal of characters in animation and the real-world appearance of people. Töpffer compiled a large number of sketches of facial features and expressions by altering the contours and proportions of the face [7]. Comic book researcher Parkins denotes that the image of a comic book character is based on the exaggeration and distortion of the features of the human face. However, the same caricatures, which are created by exaggerating facial features and changing proportions, take on various forms in different countries and regions [8]. Amys suggests that most ‘princesses’ and ‘princes’ in Hollywood animation are based on the images of white people, but does not mention specific facial features of those characters, or the ethnicity of their people [9]. Soikun and Ibrahim proposed the concept of a local character, and argued that characters with local elements are more “attractive” [10]. Khalis argues that elements in animation, as cultural symbols, essentially reflect the local culture of religion, clothing, etc. [11]. However, how are the appearances of a native people represented in animation?

To clarify whether or not an animated character is based on the appearance of people in the native country or region, it is important to first clarify the appearance of humans in a particular region, and then compare them with the visual output and appearance in animated characters.

In terms of facial appearance, there are significant differences between Asian, Cauca- sian, and African groups, and the aesthetics of the face follow different systems and aesthetic standards. For example, Deguchi argues that Asian groups have wider and rounder faces, higher eyebrows, fuller upper eyelids, lower noses, flatter midfaces, more prominent lips, and more receding chins than Caucasian groups. These features are similar to the broad face of a toddler, and give a more youthful appearance [12]. Giunta suggests that the face of Asian groups significantly differs from Caucasian appearances in many ways, because of the different nature of the bones and soft tissues of the face [13]. Lam suggests that the distance from the eyebrow to the edge of the upper eyelid is much wider in Asian groups than in Caucasian groups, and that the eyelid fissure is narrower [14]. Modabber et al. measured white faces, and suggested that the distance between different facial features becomes longer as people age; for example, the distance between the base of the nose and the lip line becomes significantly longer in women [15]. A systematic review by Fang et al. used pooled data from studies of different ethnic groups, and concluded that forehead, eye, nose, and mouth height showed the greatest inter-ethnic differences [16]. Wamalwa et al. demonstrated, through a Kenyan-Chinese facial photogrammetry study, that there are many differences in the mean angular measurements of the standard facial profile of Black, Chinese, and White Kenyans [17]. Farkas et al. measured the faces of Americans, and suggested that the nose and orbital region are the parts of the face that
show the greatest differences in characteristics between white and black Americans [18]. Hugenberg et al. suggested that the Chinese and Caucasian groups share a similar understanding of facial aesthetics [19]. The Western description of the longitudinal trichotomy of the face is close to the Chinese theory of the “three-part proportions of face” [20]. Penton-Voak concluded that respondents in the U.K. and Japan preferred feminine faces [21].

Analysis of the literature by the abovementioned researchers shows that there are some differences in facial features between Eastern and Western human groups of different genders and ages, but they all follow the same proportional relationship. Rhodes et al. suggest that caricatures of people are more recognizable than photographs, and leave a stronger impression on the subject [22]. Goldman and Hagen confirm Parkins’ suggestion, that Western cartoonists focused more on the exaggeration of two features, the chin and the nose [23]. As can be seen in the existing animation and comic books, most American animated characters have distinctive, individual Western-looking features, and there are clear differences between characters. Van Rooij denotes that characters in the animations of major animation companies in the United States are designed to be more exaggerated, simplified, and differentiated, which causes the audience to empathize with animated characters as much as with real actors [24]. Tomos outlines that some of the characters portrayed in early Japanese cartoons first originated as figures in woodblock prints from the Heian period, featuring Japanese appearance features, such as thin, thread-like eyes and hooked noses [25]. Cavalier and Chomet discovered that a series of comic book characters by Riyoko Ikeda and Tomoeko Hosokawa, among others, responded to Western stories and all had features such as large eyes and pointed chins. This type of character laid the foundation for later Japanese animation characterization [26]. These characters do not appear to have Asian appearances, but rather have faces and features that look more like those of Westerners [9]. Japanese animated characters look more like Westerners due to factors such as marketing and cultural identity. Most the Asian animated characters originally designed are eventually considered to be Caucasian [27].

Characters in animation are often designed to be anthropomorphized, based on human physical features and emotions. An attempt can be made to explore the stylistic design of animated characters based on human facial features and the proportions of the form. The animation industries in the U.S. and Japan are relatively well developed, and the animation produced in these two countries enjoys high international ratings in terms of both quantity and quality. This study therefore attempts to examine the characterization of the best animations produced by these two countries, using American and Japanese animations as examples.

Animated characters are designed based on the appearance of people, and there are significant differences in the appearance of people from different countries and regions, especially between West and East. Farkas et. al conducted a study of the human face through portrait photography as an efficient and practical measurement method [28]. The same method of data collection can be used for the facial features of animated characters [29]. Hyde et al. took a sample of 40 characters from Disney’s animated history and measured the face, eyes, and facial features of the positive and negative characters, and used the data to quantify the differences between them in regard to seven characteristic points that defined the ‘hero’ and ‘villain’ images [30].

The above theoretical and practical approaches have provided insights into elements of animated character design, and the methods they have used to measure the faces of both live action and animated characters, provided a starting point for this study. What facial features of the characters in the animations of the United States and Japan are related to people in their native countries? In order to explore this question, the study began by finding characters from the last 20 years in Oscar-nominated and award-winning animation, including 100 characters from American animated characters, and 100 characters from the top 50 grossing animated films of the last 20 years in Japanese animation. In addition, 100 facial profiles were randomly selected from the official website of the U.S. Congress, and 100 facial profiles were selected from the official website of the Japanese Senate. The
data were extracted by selecting animated characters and real human facial features, and measuring the length and area of the features. The differences between the different categories were initially categorized through statistics, and then analyzed by correlation coefficients to determine inevitability. Finally, a discussion and summary of the relationship between animated characters and real faces was determined, based on the results of the correlation analysis.

This paper is divided into five sections. The first section introduces the study, which puts forward the research questions and outlines the research purpose and methods of the study with references. The second section is the design of research materials and research methods. The third section is the presentation of the research results. The fourth section is a discussion of research issues. The fifth section summarizes the study, and puts forward research contributions and directions for future research. In addition, some preliminary data and materials are attached to Appendices A and B at the end of the article.

2. Materials and Methods

2.1. Animated and Live-Action Face Profiles

This section concerns the design of research methods and the collection of research data. In order to verify the correlation between the facial appearance of people in a certain country or region, and the facial design of animated characters, it is necessary to collect sufficient representative human face profiles and animated human faces as samples. The animation industries in the United States and Japan are in a leading global position, and each has its own unique style characteristics. Facial appearances in these two countries belong to two completely different ethnic groups. Therefore, this study selected the faces of popular American and Japanese individuals and the faces of animated characters as samples.

Four groups of face data were collected for this study: American live action, Japanese live action, American animation, and Japanese animation. For each group, 75 faces were collected separately. The U.S. and Japanese animation data were used from the references [31]. The human facial profiles used were 75 members of the US Senate and 75 members of the Japanese Senate, since 2000. The Senate was chosen because it contains candidates from each of the regions that have a similar ethnic composition to that of the country’s population. Each state in the United States is represented by two members in the Senate through election, and the most popular candidates overall are elected to represent the country. Using this method, it is possible to obtain an secondary indication of the more popular facial appearances of a particular area in the United States, and they are more representative of the facial profiles of the American people. Japan’s Senate is also based on a system of electoral districts, in which each prefecture elects one to six members. The members of the Senate are therefore used as a representative sample of the faces of the residents of Japan.

The face image used for American live action comes from Wikipedia and the Japanese live action face image comes from the official website of the Japanese Senate. The original files of the selected pictures of human face profiles and animated character faces are listed in Appendix A. Figure 1 shows two representative pictures selected from each of the four groups.
2.2. Face Feature Extraction

One approach to classify the samples is to mark the locating point of a facial feature and a corresponding letter code, which represents this feature on the facial features of real people and animated characters, to collect distance data between two points, angle data composed of three points, and area data between four points. These data represent the large or small, round, or sharp shape of multiple facial features. Through statistics, we can preliminarily understand the differences in the appearance of people in different countries, the differences in the appearance of people and animated characters in different countries, and the differences in the facial design of animated characters. The method used a decision tree classifier to analyze various facial features. A total of 100 significance tests were conducted on the facial feature parameters of Japanese and American facial profiles and animated characters, as well as the differences between the two. Determinations of facial features, as taken from a previous study [31], defined 26 positioning points on the face, with localization point locations, as seen in Figure 2. From these positioning points, 19 length features, 17 angle features, and 6 area features of the face were defined. The detailed feature definitions are listed in Table 1. Once the positions were defined, the feature parameters were calculated.
Figure 2. Schematic diagram of the parameter positioning points.

Table 1. Definition of facial feature parameters.

| Definition of Length Parameters | Definition of Area Parameters | Definition of Angle Parameters |
|---------------------------------|-------------------------------|-------------------------------|
| LA2 nose ac                      | R1 nose abcd                  | A1 nose ∠abd                  |
| LA8 faceL ae                     | R2 faceR aigj                 | A2 faceA ∠aig                 |
| LA9 faceL ag                     | R3 chin ifgj                  | A3 ear ∠alc                   |
| LB3 nose bd                      | R4 faceR okeq                 | A4 nose ∠bcd                   |
| LA3 mouth ce                     | R5 faceR pkgl                 | A5 chin ∠fgh                   |
| LA10 faceL cg                    | R6 eye rstu                   | A6 chin ∠hgz                   |
| LB5 chin fh                      |                               | A7 chin ∠igz                   |
| LB4 jaw ij                       |                               | A8 chin ∠igz                   |
| LB2 faceL kl                     |                               | A9 faceA ∠kig                  |
| LB6 ear mk                       |                               | A10 faceA ∠leq                 |
| LB1 faceL oq                     |                               | A11 faceA ∠leq                 |
| LA1 faceL pa                     |                               | A12 faceA ∠lez                 |
| LA5 faceL pc                     |                               | A13 faceA ∠qez                 |
| LA6 faceL pe                     |                               | A14 eyebrow ∠pwy               |
| LA7 faceL pg                     |                               | A15 eyebrow ∠wyn                |
| LA11 eye us                      |                               | A16 eyebrow ∠psy               |
| LA4 mouth eg                     |                               | A17 eyebrow ∠vxy               |
| LB7 eyebrow wx                   |                               |                                |
2.3. Decision Tree Algorithm Implementation

The classifier used for the subsequent classification is the decision tree algorithm [4], using recursive partitioning and regression trees, executed with rpart [7,31] instruction in the R language. An amount of 80% of the total node parameter data was set as training data, and the remaining 20% was set as testing data, and averaged over 100 runs. There are six combinations of input feature parameters: All; Single; Length all; Area all; Angle all; and Five senses.

The parameters of the five senses were derived from previous studies [31]. There are four combinations of classification: American live action vs. Japanese live action; American animation vs. Japanese live action; Japanese live action vs. Japanese animation; American live action vs. American animation. The results of the classification were measured by three parameters: accuracy, sensitivity, and specificity, using the following formula:

\[
\text{Accuracy} = \frac{TP + TN}{(TP + TN + FP + FN)} \\
\text{Sensitivity} = \frac{TP}{(TP + FN)} \\
\text{Specificity} = \frac{TN}{(TN + FP)}
\]

where TP is true positive, TN is true negative, FP is false positive, and FN is false negative. The code used in the calculation is shown in Appendix B.

2.4. Statistics

We divided the above face samples of real people and anime characters into four groups and estimated the descriptive statistics. \( t \)-test was used to reflect statistical differences between groups.

2.4.1. Descriptive Statistics

Mean and standard deviation of four groups of facial data were estimated. Additionally, the mean and standard deviation of decision tree classification performance, accuracy, sensitivity, and specificity, and both in training and testing group, after 100 runs evaluation, were derived.

2.4.2. Statistical Test

We first divided the sample data into four groups: American real face, American animation character face, Japanese real face, and Japanese animation character face. The characteristic differences of the facial data between each group was examined by \( t \)-test test, with examination threshold alpha value = 0.05 to meet the statistical difference criterion.

The procedure of all experiments is shown in Figure 3. Figure 3 is the flow chart of this study, and the research idea of this paper can be understood through this. In the first step, we can see the collection of live face samples and animated character samples from the two animation countries. In the second step, we can see that we have defined the length, angle, and area of 43 facial features. The third step is the classification and statistics of facial feature data. The fourth step is to input the angle, length, and area data of all facial features into the decision tree classifier, and classify different types of faces at three levels: accuracy, sensitivity, and specificity.
3. Results

In this study, decision tree classifier is used to comprehensively analyze various facial features. The detailed significance test of 100 runs was conducted on the facial feature parameters of Japanese and American facial profiles and animated characters, as well as the differences between Japanese and American facial profiles and animated characters.

3.1. Facial Feature Parameters

The results of the examination of the parameters of the facial features of live action and animated characters in Japan and America, and the differences between the parameters of live action and animated characters in Japan and America, are displayed in Table 2.

According to Table 2, there are some differences between the real faces of the two countries. However, there are more differences between the faces of cartoon characters from the two countries, especially in the length and size of features. This proves that there are more subjective and exaggerated factors in the design of animated characters. Compared with the faces of Japanese animated characters, there are not as many exaggerated features. Compared with American animated faces, American human faces are very different in length, area, and angle of features. This also shows that Japanese anime characters are more conservative and more similar to their real appearance. American anime character design is more freestyle. However, as shown by the exaggerated features and their own appearance, it also conforms to their appearance.

It can be found that, in terms of the animated character’s face, the facial parameters of American animated characters are longer than those of Japanese cartoon characters, including: LA2, LA8, LA9, LB3, LA10, LB5, LB4, LB2, LA6, LA12, and LB7. Larger angle and area parameters include: R1, R2, R3, R5, A3, A5, A10, A11, A15, and A17. Conversely, the parameters of Japanese animated characters’ face length are longer than those of American animated characters, including: LA3, LB6, LB1, LA1, LA5, LA11, and LA4. Larger angle and area parameters include: R4, R6, A1, A2, A4, A6, A7, A8, A9, A12, A13, A14, and A16.

In terms of the face of live action characters, the facial length parameter of American animated faces is longer than that of Japanese live action, including: LA3, LB6, LA6, and LA4. Larger angle and area parameters include: R3, R4, A5, A7, and A14; while the parameters of Japanese live action face length are longer than those of American live action, including: LA2, LA8, LA9, LB3, LA10, LB5, LB4, LB2, LB1, LA1, LA5, LA11, LA12, and LB7. Larger

Figure 3. Experiment flowchart.
angle and area parameters include: R1, R2, R5, R6, A1, A2, A3, A4, A6, A8, A9, A10, A11, A12, A13, A15, A16, and A17.

**Table 2.** Facial features difference between four groups. Data is represented as facial feature name and corresponding p-value.

| Facial Feature Type | Jc vs. Uc | Jt vs. Ut | Jc vs. Jt | Uc vs. Ut |
|---------------------|-----------|-----------|-----------|-----------|
| Length              |           |           |           |           |
| R1                  | <0.001 ***|           |           |           |
| R2                  | >0.001 ** |           |           |           |
| R3                  | 0.003 **  |           |           |           |
| LA9                 | 0.006 **  |           |           |           |
| LB3                 | <0.001 ***|           |           |           |
| LA10                | 0.041 *   |           |           |           |
| LB5                 | 0.010 *   |           |           |           |
| LB4                 | 0.006 **  |           | LA11: <0.001 ***| |
| LB1                 | 0.003 **  |           |           |           |
| LA5                 | 0.018 *   |           |           |           |
|                    |           |           |           |           |
| Area                |           |           |           |           |
| R1                  | <0.001 ***|           |           |           |
| R2                  | >0.001 ** |           |           |           |
| R3                  | 0.003 **  |           |           |           |
| A1                  | <0.001 ***| A1: <0.001 ***|           |           |
| A5                  | 0.035 *   | A1: <0.001 ***|           |           |
| A8                  | 0.031 *   | A3: <0.001 ***|           |           |
| A10                 | >0.001 ** | A5: >0.001 **| A10: 0.012 * |           |
| A11                 | >0.001 ** | A6: >0.001 **| A11: 0.01 * | A12: <0.001 ***|
| A13                 | 0.002 **  | A13: 0 *** | A12: <0.001 ***|           |
| A14                 | 0.002 **  | A14: <0.001 ***| A14: 0.003 **|           |
| A15                 | 0.005 **  | A16: <0.001 ***| A15: <0.001 ***|           |
|                    |           | A17: <0.001 ***|           |           |

* p-value < 0.05; ** p-value < 0.01; *** p-value < 0.001.

By comparing the faces of animated characters and live action, the length parameters of American facial profiles are longer than those of American animated characters, including: LA2, LA9, LB3, LA10, LB5, LB4, LB2, and LA4. Larger angle and area parameters include: R6, A2, A4, A6, A8, A9, A12, A14, A15, and A17. The length parameters of American facial profiles are shorter than those of American animated characters, including: LA8, LA3, LB6, LB1, LA1, LA5, LA6, LA11, LA12, and LB7. Smaller angle and area parameters include: R1, R2, R3, R4, R5, A1, A3, A5, A7, A10, A11, A13, and A17. Japanese facial profiles are longer than those of Japanese animated characters, including: LA9, LB5, LB4, LB2, LA1, LA5, and LA12. Larger angle and area parameters include: R2, R3, R4, R5, A2, A3, A4, A8, A9, A10, A11, A12, A15, and A17. The length parameters of Japanese facial profiles are shorter than those of Japanese animated characters, including LA8, LB3, LA3, LB6, LB1, LA6, LA11, LA4, and LB7. Smaller angle and area parameters include: R1, R6, A1, A5, A6, A7, A13, A14, and A16.

3.2. Facial Feature Parameters

There are several findings from Table 2:

1. From J_t vs. U_t, the facial profiles of people from America and Japan show no statistical differences in length and area, and only seven angular parameters differ in angle.
(2) From \( J_c \) vs. \( U_c \), the faces of the animated characters in America and Japan differ in 8 length, 3 area, and 10 angle parameters. Since the difference between \( J_t \) vs. \( U_t \) is not significant, this indicates that the faces of American and Japanese animated characters are not exaggerated in the same way.

(3) The differences between facial profiles and cartoons, \( U_c \) vs. \( U_t \) and \( J_c \) vs. \( J_t \), are significant in both America and Japan, showing that the cartoons do have an exaggerated effect. In addition, the parameters that differ between \( U_c \) vs. \( U_t \) and \( J_c \) vs. \( J_t \) are significantly different, both in terms of length position and angle. Again, this shows that the faces of American and Japanese animated characters are not exaggerated in the same way.

The above reveals that there is little difference in the facial profiles of people from America and Japan, but there is a large difference in the faces between American and Japanese animations. It can be concluded that the animations have a greater level of exaggeration, and that the cartoon faces in the two countries exaggerate different parts of the face.

### 3.3. Binary Classification Result from Decision Tree

These parameters, divided into all parameters, single feature, all length parameters, all angle parameters, all area parameters, five senses parameters, etc., were entered into the decision tree, and classified into four combinations of categories: American live action vs. Japanese live action; American animation vs. Japanese animation; American live action vs. American animation; and Japanese live action vs. Japanese animation. The categorisation results are compiled in Table 3.

| Features        | Jc vs. Uc | Jt vs. Ut | Jc vs. Jt | Uc vs. Ut |
|-----------------|-----------|-----------|-----------|-----------|
| train_acc       | test_acc  | train_acc | test_acc  | train_acc | test_acc |
| ALL             | 96.867 (1.293) | 73.167 (8.032) | 96.158 (1.401) | 74.833 (7.222) | 98.742 (0.763) | 90.767 (4.390) | 98.95 (0.726) | 89.633 (6.175) |
| single          | 90.058 (1.625) | 69.833 (7.616) | 90.283 (1.471) | 60.967 (8.114) | 95.517 (0.869) | 93.167 (4.140) | 93.742 (1.082) | 86.000 (6.356) |
| [LB3 nose]      | 90.058 (1.625) | 69.833 (7.616) | 90.283 (1.471) | 60.967 (8.114) | 95.517 (0.869) | 93.167 (4.140) | 93.742 (1.082) | 86.000 (6.356) |
| [A13 faceA]     | 90.058 (1.625) | 69.833 (7.616) | 90.283 (1.471) | 60.967 (8.114) | 95.517 (0.869) | 93.167 (4.140) | 93.742 (1.082) | 86.000 (6.356) |
| [LA11 eye]      | 90.058 (1.625) | 69.833 (7.616) | 90.283 (1.471) | 60.967 (8.114) | 95.517 (0.869) | 93.167 (4.140) | 93.742 (1.082) | 86.000 (6.356) |
| L_ALL           | 96.033 (1.451) | 72.600 (7.194) | 95.425 (2.778) | 71.500 (6.595) | 98.292 (0.771) | 90.967 (4.084) | 98.683 (0.769) | 90.433 (4.893) |
| R_ALL           | 94.583 (1.414) | 71.500 (6.537) | 93.233 (1.590) | 60.300 (8.647) | 97.600 (0.733) | 95.133 (4.327) | 97.150 (1.197) | 87.300 (5.175) |
| A_ALL           | 96.083 (1.353) | 66.033 (7.086) | 95.875 (1.126) | 76.500 (6.806) | 98.492 (0.818) | 92.833 (4.113) | 97.692 (0.769) | 87.400 (5.647) |
| five sense organs | 95.108 (1.420) | 73.733 (7.673) | 94.125 (1.491) | 66.667 (8.409) | 97.75 (0.890) | 90.567 (5.060) | 98.108 (1.078) | 90.567 (5.478) |
| first high      | 95.108 (1.420) | 73.733 (7.673) | 94.125 (1.491) | 66.667 (8.409) | 97.75 (0.890) | 90.567 (5.060) | 98.108 (1.078) | 90.567 (5.478) |

All the feature parameters were entered into the classification and the results showed that, between Japan and the United States, the classification rate for the test group was around 74% for both real and cartoon faces, and up to 90% for the classification between real and cartoon faces in individual countries. Again, this indicates that the difference between real and cartoon faces is significant, and this is true for both countries.

The best classification of the difference between American and Japanese cartoon faces was LB3, with 69.8% of the group correct, which was the length of the nose. The best classification between American and Japanese real faces was the A13 parameter, with 60.9% correct for the angle of the face. The difference between real and cartoon faces was classified
by the parameter LA11, which is the part of the eye, in both Japan and America, with 93.1% and 86.0% of the group correct, respectively. This shows that the eyes are the most exaggerated part in both the U.S. and Japan. In addition, the correct rate of classification between facial profiles and cartoons in the same country was higher than the difference between facial profiles and cartoons in different countries, regardless of whether it was the U.S. or Japan. Using all length, area, and angle parameters, each of the four classification groups had the highest correct classification rates. Therefore, it is not possible to determine which of the length, area, and angle parameters has the best classification difference. In terms of the five senses, the highest correct rates for the test groups were nose (73.7%) for American and Japanese cartoon faces, eyebrow (66.6%) for American and Japanese actual faces, nose (90.5%) for Japanese actual faces and cartoons, and facial (90.5%) for American actual faces and cartoons.

4. Discussion

American characters are always funny and comical. Japanese animated characters have big eyes and pointy chins. So how are animated characters anthropomorphic and exaggerated? How do American and Japanese animated characters relate to actual faces? Are they designed to look like their native people? Do the characters in those animations follow the same pattern? There should be some sort of design pattern, and if this can be found, it could provide some new insights into the design of animated characters in different countries.

4.1. Comparison of Animated Character Faces between America and Japan

The data show that there are eight differences between the American and Japanese samples of outstanding animated characters in terms of length, three differences in terms of area, and ten differences in terms of angle. These parameters are: LA10, LB5, LA5, LA9, LB4, LB1, LA1, LB3; R2, R3, R1; A5, A8, A16, A17, A10, A11, A13, A14, A15, A16, and A17. It can be stated that the U.S. and Japan each have their own features, which is in line with the authors’ conclusion. The only significant differences between the Japanese and American actual faces are in the 8 parameters, as A1, A3, A5, A6, A13, A14, A15, and A16. In the American real-life data, A1 shows a long nose tip, A3 a short midriff, an upward-facing mouth, A13 a narrow forehead, A14 a wide eyebrow tail, A5 a thin eyebrow, and A6 a pointed chin. In the Japanese real-life data, A1 shows a curved nose, A3 a long midriff, a downward-facing mouth, A13 a wide forehead, A14 a thin eyebrow tail, A5 a thick eyebrow, and A6 a wide chin. This shows that there is little difference between the facial features of American and Japanese people. The differences are only in some overall areas, such as the width of the forehead, the size of the midriff, and the spatial distance from the nose to the ears. In terms of specific features of the five senses, their size and length are not obvious.

4.2. Comparison between American Animated Character Faces and American Real Human Faces

A comparison of facial feature data from the American animated character samples with the American real-life samples showed that there were significant differences in 23 of all 42 observed options, including 11 parameters of length, 5 of area, and 7 of angle. American animated characters with larger than life features with significant differences include LB6 with wider ears, LB1 with a wider forehead, LA11 with larger open eyes, and LB7 with longer eyebrows. Those with smaller angles and areas include R1 with a larger nose, R2 with a larger mouth surround, R3 with a larger chin, R5 with a larger face, R6 with larger eyes, and A1, A3, A7, and A16 with exaggerated features. Compared with actual length parameters, comic characters with lower parameters and significant differences include LA1 forehead length, LA2 nose length, LA5 forehead to nose base length, LA9 brow to chin length, LA10 nose base to chin length, LB4 jaw width, and LB2 face width. Larger angles and areas include A4, A12, and A14 with exaggerated features. The 23 options cover almost all features of the face, meaning that almost every feature
has been designed, and more than half of the features have a clear sense of design. This demonstrates that the faces of American animated characters considerably differ from those of real people, and that the looks of different American animated characters vary in form, with most features chosen to be enlarged and only a few chosen to be narrowed compared to the facial designs of Japanese animated characters. In the results of the comparison between the American animated characters and the real-life samples, seven out of eleven significantly different lengths were ≤0.001; 3 out of 5 significantly different areas were ≤0.001; there was significant exaggeration in the area of the eyes, but the standard deviation between the American animated character samples was larger, indicating greater morphological variation, while the standard deviation of the American real-life samples was also larger, reflecting that the area of the human eyes also varies. Overall although some of the animated characters have smaller eyes, more of them have been exaggerated. Of the seven angles with significant differences, five were ≤0.001. These figures prove that their facial features are also exaggerated to a greater extent. We can therefore say with certainty that exaggeration, diversification, innovation, and differentiation are the design ideas of American animated characters. The variety, rather than the preference to focus on a few exaggerated features, has led to a style of facial styling in American animated characters. This is why American animated characters are closer to traditional Western comic characters, just as the characters in the first Western animation, *The Expressions of Funny Faces*, retained the characteristics of the comic characters of the time. Therefore, today’s American animated characters are in the same vein as typical Western comic characters, and their stylistic characteristics continue to this day. What is the relationship between this characteristic and the look of their native people?

In the 18 observation points of LA8, LB3, LA3, LB5, LA6, LA4, LA12, R4, A2, A5, A6, A8, A9, A10, A11, A13, A15, and A17, there was no significant difference between the facial features of the American animated characters and those of Americans, indicating that the animated characters, although strongly and exaggeratedly distorted, have a quarter of their features close to the appearance of actual Americans. As for the observation points A5 and A6 (degree of chin sharpness), the American real-life sample has a wider and somewhat more squared-off chin. From the data, the American animated character is more exaggerated than the actual person in almost every position, and the exaggerated facial features are even more recognizable.

### 4.3. Comparison between Japanese Animated Character Faces and Japanese Human Faces

The Japanese animated characters, compared to the Japanese live-action characters, are significantly different in only 12 out of 42 observations, including 3 lengths and 8 angles. Of these, LB3, the width of the nose, is narrower than that of the actual person. LB6, the ear width, is wider than that of the actual person. LA11, the longitudinal distance between the eyes, is wider than that of the actual person. A1 represents the angle between the nose and the base of the nose, which is larger for the animated character than for the real person, proving that the animated character has a distinct ( or ) shape, appearing more three-dimensional, and that the actual person’s nose is close to this shape. A7 represents the jaw part, the lower part of the face, which is both wider and exaggerated in comparison to the facial profile. A8 has a small angle, proving the shape of the jaw in reverse. A10 has a slightly longer nose, with the ears positioned downwards. A11 illustrates the mouth, with the ears positioned downwards. A12 has a small forehead. A15 shows the eyebrows slender at the end. A17 has a thin, narrow brow. However, area, the most obvious basis for judging exaggeration, is not reflected in the Japanese animated characters as a clear difference from the facial profile. In the R6 data, the area of the eyes of the animated characters is exaggerated a little overall, but close to the area of the facial profile’s eyes (the overall difference in the eyes of the Japanese facial profile sample is not significant). In addition, there were no significant differences between Japanese and Japanese animated characters in the 29 facial observation points of LA2, LA8, LA9, LA3, LA10, LB5, LB4, LB2, LB1, LA1, LA5, LA6, LA4, LA12, LB7; R1, R2, R3, R4, R5, R6; A2, A3, A4, A5, A6, A9, A13,
and A16. In contrast, the results of the comparison of the degree of exaggeration between Japanese animated characters and Japanese facial profiles showed that only one of the three significantly different lengths was ≤0.001; areas without features reached significant differences; and six of the nine angles that reached a significant difference were ≤0.001.

The data suggests that Japanese animated characters are more concentrated in exaggerated features or locations, with some exaggerated and some reduced. Significantly, different features make up about a quarter of the characters, and encompass some of the main features of the human face. This compares with the ‘multiplicity’ of American animated characters, who all seem to have a narrow, slightly longer curved nose. The ears and eyes are also larger, the lower part of the face is wider, the mouth and ears are positioned downwards, and the forehead is small. Therefore, in contrast to the American animated characters, most of whose features are much larger than those of the American facial profile samples, the Japanese animated characters are exaggerated to a lesser extent in comparison, and are a far cry from the image we have of the Japanese animated character with two eyes taking up half the face.

After finding that three-quarters of the features were not significantly exaggerated, it is assumed that the facial features of Japanese animated characters are more akin to human-looking features. Thus, the exaggeration and deformation of Japanese animated characters follow a characteristic proportion that is close to the Japanese appearance. One of the interesting features to observe is A1. This feature corresponds to the shape of the nose. This feature is more prominent in the Japanese live-action samples and even more so in the Japanese animated characters. This feature of the A8 is what determines the length and area of the atrium area, and the relationship between the position of each of the surrounding features, and the design of the animated characters is similar to the appearance of the Japanese live action in this feature point. In a few features, the Japanese animated characters are closer to the appearance of the American live action samples. For example, in LA5, the length from the hairline to the base of the nose, and in LA10, the length from the base of the nose to the chin, the Japanese animated characters are on the long side, close to the length of the American real-life characters. R3, the size of the chin, is very close to the American real-life characters in this position overall. It is not as wide, short, or large as with the real-life Japanese characters.

4.4. The Thinking Mode of Animated Character Design in America and Japan

The comparison of the selected American and Japanese real-life samples, the comparison of American and Japanese animated character samples, and the comparison of animated characters with their respective nationalities shows that the faces of the characters in Japanese animation focus on exaggerating the nose, the ears, and eyes. They are exaggerated to varying degrees, and the other features are close to the facial features of Japanese facial profiles, indicating that the sense of design in Japanese animated characters is relatively more conservative and tends to follow a uniform standard, a standard close to the proportions followed by real human faces, and that the style of these character images does not belong to the large-eyed, pointed chin model, but a kind of uniform standard combining large eyes and pointed chin with the appearance of Japanese facial profiles.

The design of the American animated characters, on the other hand, has been thought through in a holistic manner. American animated characters widely vary, and are richly varied in the feature R6, the eye area, which is large or small, and, overall, on the large side. As do the data on the eye area for the live-action American sample, which is large and varied. The combination of one-fourth of the features being close to the native look-alike sample, and the data on feature points such as A13, suggests that American-Japanese animated characters are unconsciously designed with native look-alike features in some places. Rhodes et al. has pointed out that cartoon portraits exaggerate human features, instead making the person’s appearance more recognizable than a photograph of the subject [23]. Therefore, although American animated characters are so much more exaggerated than real people, some of them have become so exaggerated that the basic shape of a person
cannot be seen. However, it cannot be argued that these American animated characters are designed to be less American, but rather that they are closer to the American look-alike. This extreme exaggeration of features is inherited from the Western satirical caricatures, which were designed to be funny and humorous, and they are not constrained, preferring to exaggerate boldly and freely based on their own looks, which can also be interpreted as a preference for using certain features as references.

The observation option A13 represents the shape of the forehead, and there is a significant difference in this feature between the American and Japanese real-life samples and the American and Japanese animated character samples, while the animated characters in each country look similar to the real-life samples from their own country. From this, we can infer that animated characters are often designed based on the looks of the people in their own country.

A common feature between America and Japan is LB6, where real-life samples are close in ear size, and animated characters from both countries all exaggerate this feature. This shows that people prefer large ears to small ears.

The data for this study mainly comes from the facial distribution of existing cartoons and facial profiles. Although the results of the current research have clearly revealed the differences between the United States and Japan, either in regard to facial profiles and cartoon faces, what is the actual experience of the audience? The facial profiles are taken from elected congressmen, and the cartoons are taken from high-grossing films, so they are all results of popularity. Therefore, we can expect that, with such data, the actual audience’s feelings should be positive. This will be the focus of the follow-up research. We will study actual audience experience in watching these pictures of facial profiles and cartoons with questionnaires and physiological signal instruments to understand their feelings.

5. Conclusions

American and Japanese animated characters are, in most cases, designed with reference to the appearance of their own people. Japanese animated characters deliberately mimic Western look-alikes in a few features. In comparison, it can only be assumed that Japanese animated characters contain Western features, and do not resemble Americans any more than American animated characters.

Comics and animation belong to the category of art, in which the most characteristic features of the facial forms of the characters are exaggeration and distortion. Obviously, the characters in comics are supposed to be imaginative, even abstract. As the art of caricature and animation matures and becomes increasingly popular, the characters in caricature are no longer confined to the traditional status of being satirized, but can also be given a richer meaning and used as objects of praise.

How do you see the relationship between animated characters and people in different countries and regions? Appearance and cultural differences contribute to the regionalization of characters. Apart from the costumes that provide a reference for the design of animated characters, the skin color, facial features, and hairstyle of people provide valuable material for the design of characters.

Why are American and Japanese animated characters designed the way they are? When analyzed, one reason is the difference in ethnic appearance, which is a key reason. It can be seen from our comparison of data, whether intentionally or not, the appearance of the native population are the primary source of material for animated character design. Caucasian groups have more three-dimensional features, and the characters in the early ‘Yellow Kid’ cartoons were more like their white American counterparts. Although the American animated characters have a wide variety of appearances, to the extent that we feel that their designs are irregular, we can understand that it is their right to exaggerate diversity based on their ethnicity. The Malay genes give some Japanese a dark complexion, angular face, large eyes, thick eyebrows, and full hair; whereas the yellow genes of North-East Asia give others a lighter complexion, a longer nose, and a rounded facial profile. From some comics and animation, it can be seen that some people conform to the former
image and some to the latter. However, neither seem to be mainstream in animation. The impression is that the dominant animation image is one with large eyes, a pointed chin and a small, pointed nose, which seems to be more in line with European and American look-alikes. Therefore, mainstream Japanese characterization is indeed a deliberate act, as they portray animated characters with large eyes and pointy chins in a European and American image, in order to appeal to a European and American audience. The characters in the animations still retain more of their national look.

The contribution of this study is that we used data to show the thinking mode of animation character design in the United States and Japan. The animation character design in the United States follows the exaggerated route of diversification, innovation, and differentiation. There is a preference toward variety rather than exaggeration, focusing on certain characteristics. The design of Japanese anime characters is relatively conservative, preferring to exaggerate only a few features. Although there are some designs that imitate the appearance of Westerners, more of them retain the characteristics of their own people. In a word, the excellent animation characters of the United States and Japan are designed according to the appearance of their own people. Although the degree and location of “exaggeration” have different preferences, they can both reflect the appearance characteristics of their own people. This result also inspired designers in different regions to pay more attention to the beauty of the faces of their own people. In addition, we provide a method to extract data by measurement, and classify and analyze data by decision tree to understand abstract art images. The results obtained by this research method have certain reliability.

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Appendix A. The Original Face Files Are Listed in the Following Links

1. USA_true Figure. https://doi.org/10.6084/m9.figshare.13207235, accessed on 1 January 2022.
2. Japan_true Figure. https://doi.org/10.6084/m9.figshare.13207232.v1, accessed on 1 January 2022
3. USA_cartoon_face Figure. https://figshare.com/articles/figure/USA_cartoon_face/13207229, accessed on 1 January 2022
4. Japan_cartoon_face Figure. https://doi.org/10.6084/m9.figshare.13277792.v1, accessed on 1 January 2022

Appendix B. The R Code and Extracted Face Features Are Listed in the Following Links
https://doi.org/10.6084/m9.figshare.13219076.v1, accessed on 1 January 2022

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