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# Cultural Influences on Saccadic Patterns in Facial Perception: A Comparative Study of American and Japanese Real and Animated Faces

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**Abstract:** This study investigated the influence of saccadic eye movements and emotions on real and animated faces to enhance a detailed perception of facial information. Considering the cross-cultural differences in facial features, animated faces also influence visual preferences due to their unique visual appeal. Since there are differences in facial features across cultures, animated faces can also impact visual preferences due to their unique visual appeal. This study involved 60 participants and utilized four stimulus conditions, including real and animated faces from America and Japan. A five-point Likert scale was employed to measure participants' subjective emotional pleasure and arousal levels, while eye-tracking equipment was used to analyze participants' saccadic eye movements. The results revealed that, in comparison to Japanese real faces (JT), American real faces (AT) exhibited significantly greater average saccadic distances (AT: 113.03 ± 46.26, JT: 110.78 ± 45.55, $p < 0.05$). However, there was no statistically significant difference in the average saccadic distance between Japanese and American animated faces (109.88 ± 45.73 and 110.85 ± 45.31, respectively). Additionally, evaluating the mediating role of pleasure and arousal levels among these facial stimuli did not impact saccadic behavior. Our observations suggest that cultural factors wield a pronounced impact on saccadic behavior within real-life scenarios. However, these cultural nuances appear to attenuate in virtual and abstract animated environments. This study's findings shed new light on the dynamic relationship between saccadic eye movements, emotions, and cultural dimensions, unraveling complexities in facial perception across diverse cultural landscapes. The implications of our research extend to animation, serving as a catalyst for further exploration in this burgeoning field.

**Keywords:** animated faces; eye tracker; saccade distance; self-assessment manikin



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## 1. Introduction

Saccadic eye movements play a pivotal role in visual perception, particularly in the intricate process of visual information processing. Saccadic eye movements rely on straightforward visual stimulus–response mappings, facilitating the swift and precise redirection of the gaze towards peripheral areas of visual stimuli [1]. This phenomenon of visual stimulus–response mapping provides insight into our cognitive functioning during the acquisition of visual information [2]. Due to the continuous evolution of eye-tracking research methodologies [3], and the introduction of various experimental paradigms across multiple scientific applications, such as enhancing visual comfort in virtual reality and 3D displays [4,5], improving human–computer interactions [6], and the analysis of the learning process [7], saccadic eye movements have emerged as a critical domain of applied research. This research aims to deepen our comprehension of decision-making processes within the realms of psychology and cognitive science.

Building upon visual observations, rapid eye movements become crucial in their interaction with specific stimuli, especially those related to social interactions [8,9]. It can be said that among numerous visual stimuli, the brief visual input from facial stimuli enables us to understand social interactions and make basic judgments about others based on their facial expressions and features, ranging from an individual's membership in social categories (e.g., age, gender, race) to their mental and emotional states [10–12]. Therefore, faces constitute a distinct and intricate category of stimuli, distinct from other complex stimulus categories. In terms of the gaze perception of faces, different mechanisms support it. Larger reactive saccades are typically observed during gaze, representing coarse visual processing, while smaller spontaneous saccades occur when we attempt to focus on specific points of interest, representing finer visual processing [13,14].

In the following review of the relevant literature, we divide it into three parts: eye movement differences in facial races, the unique visual attractiveness of animated faces, and the impact of pleasant arousal on eye movements.

### 1.1. Eye Movement Differences in Facial Races

Race serves as a rapid and effective visual signal used for perceiving in-group and out-group members through facial communication [15]. A study conducted by Fu et al. found that Chinese people have different eye movement patterns when viewing faces of different races. They focused more on the eyes of Caucasian faces, and more on the nose and mouth of Chinese faces [16]. Arizpe et al. studied how Caucasian participants viewed faces of different races (Caucasian, African, and Chinese); Caucasian faces received more eye gaze attention, while the noses and mouths of Caucasian faces received less attention compared to faces of other racial groups [17]. Furthermore, a recent study involving an investigation of initial eye movements reported that Asian faces had higher initial gaze positions compared to Caucasian faces among White and Asian observers [18]. Additionally, another study analyzing eye saccade amplitude data examined Chinese individuals of different age groups when viewing Chinese and Caucasian faces. The results showed that saccade amplitudes were smaller when viewing Chinese faces compared to Caucasian faces [19]. These research findings reveal that eye movements on faces are significantly influenced by different races, and performance in facial gaze tasks is affected due to differences in facial features among different racial groups.

### 1.2. Visual Attractiveness of Animated Faces

Processing information from faces of different races often involves the use of unconventional or unique cartoon representations, which can be highly captivating [20,21]. These animated faces are characterized by the exaggeration and distortion of facial features, with regional variations that give them distinct attributes. For instance, American animation frequently features exaggerated chins and noses, whereas Japanese animation tends to emphasize pointed chins and small noses [22]. However, it is important to note that human face perception does not necessarily extend seamlessly to cartoon faces. Recent research has started to explore the physiological responses of humans when exposed to animated face stimuli [23]. For example, Zhao et al. conducted a study to investigate the impact of animated faces versus real faces on human brain activity [24]. Nevertheless, the influence of animated faces on saccadic eye movements has received limited attention in previous studies. In general, when examining animated faces, the presence of unusual features or distinctive artistic styles often captures viewers' attention, leading to unique recognition effects that set them apart from real faces [25,26]. This underscores the significance of exaggerated features in cartoon faces and their role in shaping the distinctiveness of face recognition. Given that the proportional features of animated faces tend to attract our attention, it is plausible that they may influence specific saccadic eye movements in viewers. Therefore, further comprehensive research is warranted to deepen our understanding of how animation employs prominent facial features to convey facial perceptions and to compare these findings with those related to real human faces.

### 1.3. The Impact of Pleasure and Arousal on Eye Movements

Despite the universal impact of facial stimuli on visual attention and eye movements, faces also carry emotional significance. However, understanding the relationship between emotional stimuli and eye movements is not a simple matter [27]. This paper will discuss the impact of emotions on eye movements and attempt to clarify this relationship. Emotions serve as a coordinating mechanism that affects cognition, physiology, and behavior [28,29]. Among emotions, arousal and pleasure are some of the most extensively studied emotional stimuli [30], and their impact on human eye movements in natural environmental conditions has been widely researched. Specifically, Di Stasi et al. found a clear association between increased arousal levels and saccade velocity, while reduced arousal is associated with a slower saccade velocity [31]. Additionally, studies have shown that heightened emotional arousal leads to longer gaze duration on attractive faces [32], and for angry expressions, eye movement patterns are faster [33]. However, recent studies have indicated that the relationship between eye movements and the emotional content of facial expressions is not always straightforward. Instead, perceptual salience factors of faces are more likely to influence eye movement speed. The viewpoint is supported by research carried out by a few previous studies [34,35]. Therefore, the relationship between emotional pleasure or arousal and eye movement indicators may be more complex, and further research is needed to elucidate the precise connection between the subjective emotional perception of different facial stimuli and eye movement behavior.

The focus of our study is currently on saccadic eye movements, as it can shed light on the mechanisms of visual selection during visual search processes. This understanding can lead to a better comprehension of the process as a whole. Our study aims to examine the saccadic distance indicators involved in the free viewing of faces, while also exploring how individuals' subjective perceptions of high and low pleasure and arousal induced by facial stimuli affect saccadic indicators. To achieve this, we utilized facial images of American and Japanese political candidates and popular animated characters from both countries' databases. Drawing from the existing literature, we have formulated the following hypotheses:

Our hypothesis is that viewers will display varying average saccadic distances when comparing pairs of American and Japanese real faces and animated faces. These comparisons will include American real vs. Japanese real, American animated vs. Japanese animated, American real vs. American animated, and Japanese real vs. Japanese animated. Additionally, we expect that viewers' average saccadic distances will significantly change when exposed to facial stimuli with varying levels of pleasure and arousal, whether real or animated.

## 2. Materials and Methods

### 2.1. Subjects

For this study, a total of 60 young individuals between the ages of 20 and 30 participated, comprising 32 males (53.3%) and 28 females (46.7%). The participants were recruited from students in Taiwan. Prior to their involvement, each participant received a detailed explanation of the experimental procedure and provided their informed consent by signing the appropriate form. On 7 February 2022, the Research Ethics Committee of China Medical University Hospital reviewed the study (IRB number CRREC-110-128) to ensure adherence to ethical guidelines.

### 2.2. Stimuli

This study involved collecting four sets of facial features from different types of stimuli: American animated faces (AC), Japanese animated faces (JC), American real faces (AT), and Japanese real faces (JT). Each group consisted of 15 faces, resulting in a total of 60 experimental stimuli. All the pictures shared the same features related to the five senses. The selection process was based on the pre-existing ranking of the images, which considered the size of a specific facial feature. The face images used in this study were obtained from the reference literature by Liu et al. [22]. The animated face samples were chosen from the top 10 Academy Awards and nominees, as well as box office winners, spanning from 2000 to 2019, for both American and Japanese animated films. As for the real-life faces, the representatives were selected from the members of the American and Japanese Senate, serving as portrayals of the residents of the two respective countries.

### *2.3. Apparatus*

The participants viewed the stimuli on a 14-inch personal computer display with a resolution of 1920 × 1080 pixels (Intel Core i7-750). They were seated in front of the screen, maintaining a stable posture and minimizing head movements, with a viewing distance of 55–65 cm from the corneal surface to the screen. Eye movements were recorded using the Eye Tech VT2 mini eye tracker (Mangold). The sampling rate of the eye tracker system was 80 Hz.

### *2.4. SAM Ranking*

In this research study, we utilized the Self-Assessment Manikin (SAM) scale to measure levels of pleasure and arousal. The scale employed was a 5-point Likert scale, where a rating of 1 indicated low pleasure or low arousal, while a rating of 5 represented high pleasure or high arousal. The pleasure and arousal items referred to the extent of pleasure and arousal elicited by each image in the participants. These two questions were presented separately, allowing participants to provide their responses after viewing all the images. Please refer to Figure 1 for the SAM scale.

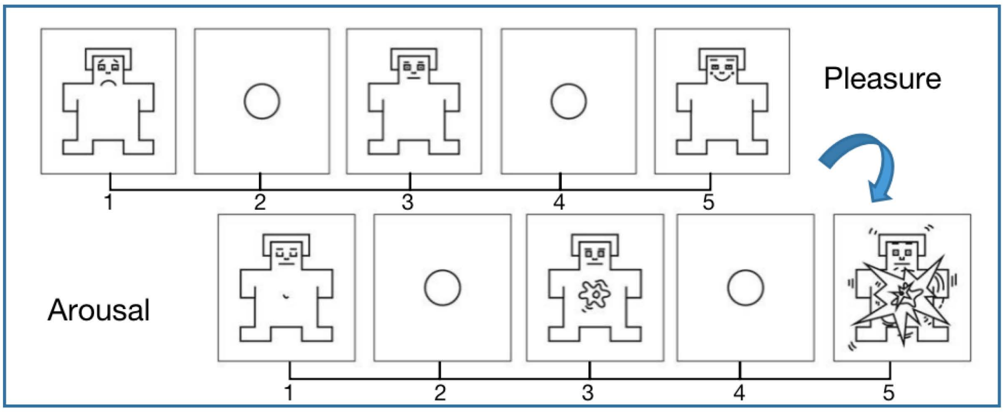


**Figure 1.** SAM Ranking.

### *2.5. Procedure*

We manipulated the presentation order of facial stimuli among the participants so that they would see images of American real faces ($N$ = 15), Japanese real faces ($N$ = 15), American animated faces ($N$ = 15), and Japanese animated faces ($N$ = 15) in random order. Each participant viewed the images in a different sequence.

The target stimuli were faces of American and Japanese individuals, as well as additional animated faces from the America and Japan. Prior to the participants' experiment, eye tracker calibration was conducted to ensure accurate gaze tracking. Calibration tests consisted of sequentially presenting calibration points at the four corners and center of the screen, with participants fixating on each red dot for 1 s. After completing the calibration process and confirming satisfactory calibration quality, the subsequent experiment was carried out.

In each trial, each facial image was presented for 1000 milliseconds, with a 200-millisecond black screen interval between each image presentation. To allow participants sufficient rest, a 120-s break was given after presenting 20 stimulus images. Eye tracker recalibration was performed between each experimental block. Following eye tracking measurements, facial stimuli were presented to the participants again. They were then asked to rate the faces based on pleasure (1 = low pleasure to 5 = high pleasure) and arousal (1 = low arousal to 5 = high arousal). The experimental flow chart is shown in Figure 2.

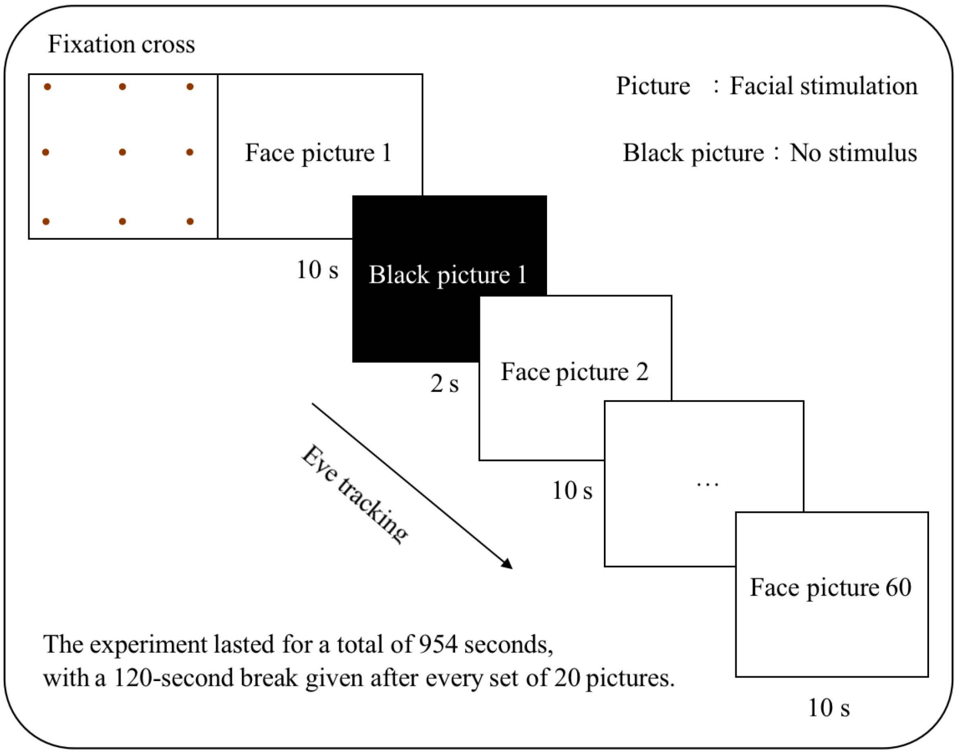


**Figure 2.** Flowchart of eye tracking experiment.

### *2.6. Eye Tracker Feature Definition*

In order to quantify the differences in saccadic eye movements between viewing facial images of American and Japanese individuals in both real and animated forms, we calculated the saccade distance. Saccade distance is defined as the distance between consecutive fixation points. For data collection, we used the Tobii eye tracker and conducted statistical analyses using open-source software R and R Studio (version 3.3.0).

### *2.7. Saccade Distance Calculation Procedure*

To calculate the saccade distance, we conducted the following steps:

Coordinate Extraction: We extracted the coordinates of gaze positions in image space from the raw eye tracking data. These coordinates were measured in pixels, allowing us to precisely capture the movements of the participants' gaze.

Pupil Trajectory Positions: For each participant and condition, we obtained the coordinates ($X_i$, $Y_i$) of the $i$-th pupil trajectory position and the coordinates ($X_{i+1}$, $Y_{i+1}$) of the ($i$ + 1)-th pupil trajectory position.

Saccade Distance Calculation: The saccade distance was computed as the Euclidean distance between the ($i$ + 1)-th and $i$-th pupil trajectory positions. This distance represents the magnitude of the saccadic eye movement between consecutive fixations, as illustrated in Figure 3.

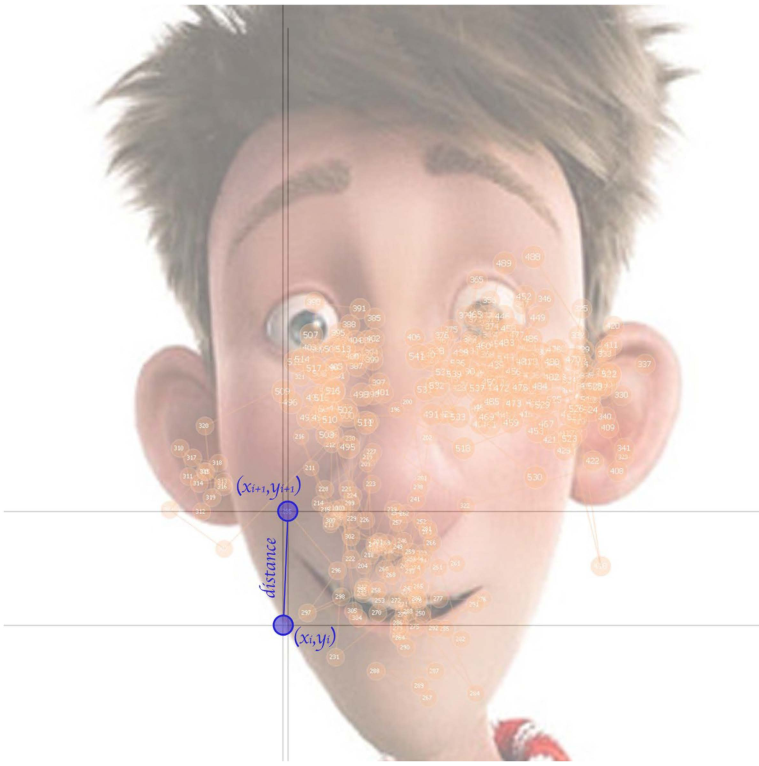


**Figure 3.** Saccade Distance Calculation.

The formula used to calculate the saccade distance between two consecutive pupil trajectory positions is as follows:

$$\text{Saccadic distance} = \sqrt{(X_{i+1} - X_i)^2 + (Y_{i+1} - Y_i)^2}$$

We have calculated 11 features related to saccade distance, including Minimum, First Quartile, Mean, Median, Skewness, Kurtosis, Standard Deviation, Coefficient of Variation, Maximum, Third Quartile, and Mode. These saccade distance-related features provide a comprehensive view of saccadic behavior. The specific code used for these calculations can be found in Appendix A.

*2.8. Statistical Analysis*

Descriptive statistics were utilized to estimate the mean and standard deviation of the 11 parameters related to saccade distances within the four facial groups. Additionally, the mean and standard deviation of pleasure and arousal rankings were calculated for the 60 facial stimuli, including both animations and real faces.

To assess the differences between the facial groups, paired *t*-tests were conducted on the 11 eye tracker features. Four pairwise comparisons were performed: American real faces vs. Japanese real faces, American animations vs. Japanese animations, Japanese real faces vs. Japanese animations, and American real faces vs. American animations. The significance level was set at 0.05. Furthermore, based on the mean rankings of pleasure and arousal, the facial stimuli were categorized into high and low groups. Within each group, paired *t*-tests were employed to examine the differences in average saccade distances between animations and real faces. The significance level for these tests was also set at 0.05. All statistical analyses were carried out using Excel.

## 3. Results

### *3.1. Task Effects on Saccade Distance*

The central focus of our analysis involves the average saccadic distance. According to the statistical results shown in the Table 1 and Figure 4, the average saccadic distance is most prominent under the AT condition, with a value of 113.03 (46.26), surpassing the values observed under the AC condition at 110.85 (45.31), the JT condition at 110.78 (45.55), and the JC condition at 109.88 (45.73). Paired *t*-tests indicate statistical significance ($p < 0.05$) in the differences between AT and JT, as well as AC and AT, highlighting significant distinctions in the average saccadic distances between these conditions. Surprisingly, no significant difference ($p = 0.227 > 0.05$) was observed in the average saccadic distances between the AC and JC animated faces. These findings suggest that saccadic distances are significantly longer for American real faces than Japanese real faces, which have shorter average saccadic distances. There were no significant differences in the average saccadic distances between Japanese animated and American animated faces.

**Table 1.** Saccade distance results for four groups. Data are represented as mean (std).

| Saccade Distance | JC | AC | JT | AT | AC vs. JC | AC vs. AT | JC vs. JT | JT vs. AT |
|---|---|---|---|---|---|---|---|---|
| | Mean (std) | Mean (std) | Mean (std) | Mean (std) | | | | |
| Mean | 109.88 (45.73) | 110.85 (45.31) | 110.78 (45.55) | 113.03 (46.26) | 0.227 | 0.015 * | 0.407 | 0.012 * |
| Skewness | 2.67 (0.96) | 2.64 (0.98) | 2.76 (0.95) | 2.65 (0.90) | 0.206 | 0.426 | 0.017 * | 0.001 ** |
| Kurtosis | 14.22 (8.81) | 14.09 (9.25) | 15.08 (8.89) | 13.87 (7.58) | 0.387 | 0.319 | 0.05 | 0.003 ** |
| Standard Deviation | 117.77 (35.63) | 119.10 (36.89) | 121.62 (35.78) | 121.99 (35.92) | 0.156 | 0.007 ** | 0.002 ** | 0.386 |

Abbreviations: Japanese animated faces (JC), American animated faces (AC), Japanese real faces (JT), and American real faces (AT), * $p < 0.05$, ** $p < 0.01$.

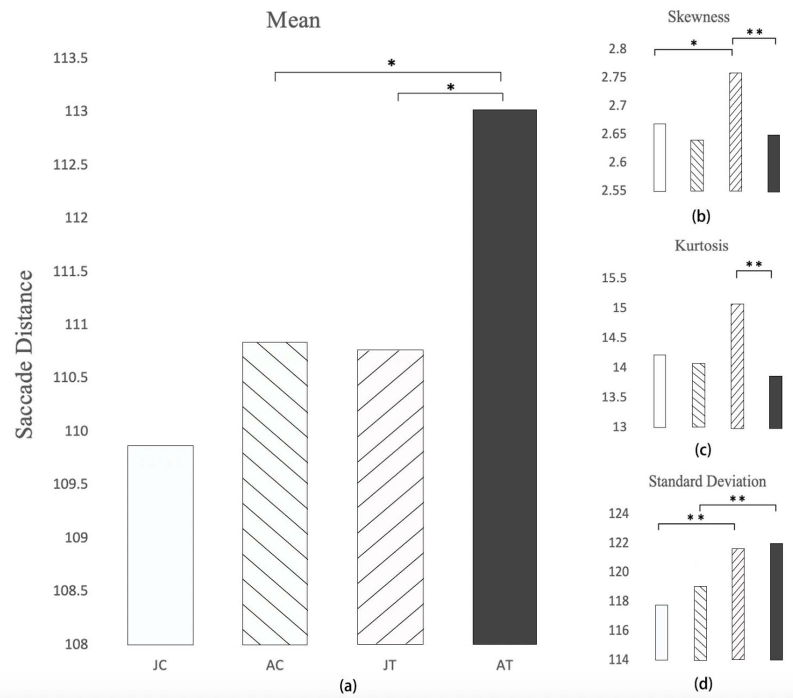


**Figure 4.** Saccade distance (pixel) for four sets of facial stimuli: Japanese animated faces (JC), American animated faces (AC), Japanese real faces (JT), and American real faces (AT). Individual plots show responses to (**a**) mean, (**b**) Skewness, (**c**) Kurtosis, and (**d**) Standard Deviation for saccade distance. (* $p < 0.05$, ** $p < 0.01$).

While the average saccadic distance is our primary focus of investigation, statistical indicators such as the skewness, kurtosis, and standard deviation of saccadic distances suggest potential differences in the shape of data distribution. According to the statistical results from Table 1 and Figure 4, skewness, which measures the asymmetry of data distribution, indicates statistical significance ($p < 0.05$) between JC and JT, as well as JT and AT. Furthermore, kurtosis, which measures the tails or peaks of data distribution, shows statistical significance ($p < 0.05$) in kurtosis between JT and AT. Standard deviation, which measures the dispersion or spread of data, shows statistical significance ($p < 0.05$) in the differences between AC and AT, as well as JC and JT. Therefore, it is evident that American real faces and Japanese real faces exhibit potential differences in the shape of saccadic distance parameter distributions in terms of skewness and kurtosis values.

### 3.2. Task Effects on Arousal and Pleasure Ranking

To investigate the potential impacts of real and animated facial stimuli on the average saccadic distance, we analyzed the subjective pleasure and arousal levels of the stimuli. Based on the results of the saccadic task and the pleasure and arousal rankings (see Table 2), we categorized the stimuli into high (above average) and low (below average) groups. We then conducted paired *t*-tests on the average saccadic distance.

**Table 2.** Arousal pleasure results for high or low ranking. Data are represented as mean (SD).

| Average Saccade Distance | Animated Faces | | Real Faces | |
|---|---|---|---|---|
| | Pleasure | Arousal | Pleasure | Arousal |
| | Mean SD | Mean SD | Mean SD | Mean SD |
| High ranking (above average) | 110.02 (44.86) | 110.52 (46.96) | 111.83 (45.36) | 112.32 (46.06) |
| Low ranking (below average) | 110.72 (46.27) | 110.21 (44.25) | 110.66 (45.36) | 110.13 (46.06) |
| Paired test | 0.312 | 0.420 | 0.197 | 0.084 |

Our findings revealed that there were no significant differences between the high and low pleasure and arousal groups for either real or animated facial stimuli. In the comparison of the saccade distance for animated faces, the pleasure ranking was as follows: [High, M = 110.02, SD = 44.86; Low, M = 110.72, SD = 46.27, $p = 0.312$]. The arousal ranking was as follows: [High, M = 110.52, SD = 46.96; Low, M = 110.21, SD = 44.25, $p = 0.420$]. For real faces, the comparison of the saccade distance resulted in the following rankings: pleasure [High, M = 111.83, SD = 45.36; Low, M = 110.66, SD = 45.36, $p = 0.197$] and arousal [High, M = 112.32, SD = 46.06; Low, M = 110.13, SD = 46.06, $p = 0.084$]. These results suggest that subjective levels of pleasure and arousal are unlikely to have an effect on the average saccadic distance.

## 4. Discussion

Our research is motivated by the significance of the saccadic distance as a spatial region of gaze, where task-relevant information is acquired during scanning, and how it triggers size-related responses in the saccadic distance when visual stimuli are presented. Nevertheless, there has been relatively limited exploration regarding the effects of the saccadic distance on American and Japanese real faces, as well as animated faces. Additionally, since faces often convey emotions, the impact of pleasure, arousal levels, and saccadic indices on these responses remains unclear. To address these questions, our study aims to examine variations in the saccadic distance among four different facial stimuli. Our results are categorized into three primary areas: (1) Interethnic Variation in Mean Saccadic Distances Between American and Japanese Faces; (2) The similarity in a saccade distance comparison between American and Japanese animated faces; (3) The Influence of Emotions on Saccadic Distances in Facial Stimuli.

### *4.1. Interethnic Variation in Mean Saccadic Distances between American and Japanese Faces*

Our results confirm our hypothesis of different saccadic distances among our Taiwanese participants when viewing American and Japanese faces; specifically, the average saccadic distance was smaller when viewing Japanese real faces compared to American real faces. This finding is similar to the results of Hu et al., where Asian participants had smaller saccadic amplitudes when viewing Asian faces compared to Caucasian faces, indicating finer perceptual processing [19]. Therefore, due to the similarity in facial features, the shorter saccadic distance observed in Asian participants when viewing visually more familiar Asian faces, and the longer saccadic distance when viewing less familiar Caucasian faces, it can be inferred that the observed saccadic distance differences may be attributed to the diversity of the Taiwanese urban population, with potentially more visual exposure to Japanese faces and relatively less exposure to American faces.

### *4.2. The Similarity in Saccade Distance Comparison between American and Japanese Animated Faces*

As we are currently focusing on the racial aspects of American and Japanese faces, and each race has its own characteristics, we considered the saccadic distance performance of American and Japanese animated faces. An interesting finding from the visual saccade research on cartoon faces is that there was no difference in saccadic distance between American and Japanese animated facial stimuli. This suggests that people have similar saccadic distances when viewing American and Japanese animated faces, raising a curious question: why is there a difference in saccadic distance when viewing American and Japanese real faces, as observed in our initial findings, but not when comparing saccadic distances between American and Japanese animated faces? We speculate that although American and Japanese animated faces exhibit significant differences in their visual appearance, American and Japanese animations, as an international visual genre popular among global audiences, may have led to visual adaptations among observers to the facial styles of American and Japanese animations, no longer considering them as important visual discriminative features. According to the findings of Frens et al., saccadic adaptation has saccadic distance specificity [36], and this adaptation may result in consistent saccadic responses to animated faces, potentially masking any saccadic distance differences that may exist.

Additionally, animated facial representations may mitigate biases between various racial faces. This phenomenon manifests indirectly through our saccadic distance indicators, underscoring the distinctions in the saccadic distance exhibited when individuals view real faces of American and Japanese people, in contrast to the similarity observed when viewing animated faces from the same cultural backgrounds. Consequently, the effectiveness of animated faces in ameliorating disparities in cross-cultural perceptions of real faces is suggested. This observation aligns with prior scholarly work [37,38], although our findings underscore the distinctiveness of the saccadic distance in the context of eye movements, thereby enhancing the contribution to the extant literature on this subject.

### *4.3. Influence of Emotions on Saccadic Distances in Facial Stimuli*

To examine whether the ranking of facial affective pleasure and arousal levels affects saccadic distances, our results confirmed that there were no differences in saccadic distances when viewers experienced high or low pleasantness or arousal levels in response to both real and animated facial stimuli. This suggests that subjective pleasantness and arousal levels do not influence average saccadic distances. While this finding contrasts with studies demonstrating saccadic amplitudes in response to emotional faces [19,39,40], it contributes to the consistency in the literature that suggests facial affective pleasure does not impact saccadic eye movements [34,35].

The discrepancies in the research findings regarding the role of facial affect perception in eliciting emotional responses can be attributed to variations in experimental approaches and factors, as suggested by C. S. Hu et al., highlighting the necessity of experimental intervention factors, such as manipulating participants' scanning paths by specifying scanning facial eye regions [40]. However, Webb et al. showed that facial affect perception did not influence saccadic eye movements, indicating the absence of the behavioral manipulation of participants' scanning paths and only requiring them to look at facial images [34]. This suggests that the degree of facial affect perception may not play a role in manipulating participants' scanning paths, and our experimental intervention, in summary, did not impose any requirements on manipulating participants' scanning paths, indicating that viewers' saccadic distances were not influenced by differences in pleasure and arousal levels.

### *4.4. Limitations*

Although our findings shed light on saccadic and subjective pleasure arousal in American–Japanese and animated faces, readers should interpret them cautiously. Firstly, our study examined how viewers perform saccadic movements when observing Japanese and American faces. We focused on overall facial stimuli rather than specific features. Future research should explore the differences between the holistic and configural processing of facial features. Secondly, our study used a carefully selected animated character face that was recognized as high-quality. Familiarity and past impressions can influence viewers' emotional preferences toward animated characters. We only focused on visual and emotional aspects, not tactile memories or familiarity. Thirdly, we chose natural facial expressions to avoid exaggerated emotions, but it is difficult to show emotions in still pictures, especially for animated characters in close-up shots. We did not look at other factors affecting facial emotions, but we recognize they may impact our study's results. Future research should examine eye gaze patterns with facial stimuli that show emotions.

Furthermore, our experimental facial stimuli were subject to limitations imposed by a fixed resolution, preventing results from reflecting higher-resolution displays. However, in the context of animated facial perception, this study offers a promising avenue for maintaining smaller saccadic distances in future high-resolution displays featuring cartoon faces. Lastly, our study focused on a specific subgroup, so the findings may not apply to other racial or ethnic groups. Further research should include saccadic distribution studies in other racial groups to gain a more comprehensive understanding of how visual search processes are influenced by racial diversity.

## 5. Conclusions

We have initiated a new research direction: exploring saccadic distances and subjective affective emotions when describing real and animated faces from various regions. According to the eye-tracking results, the saccade distance for Japanese real faces was shorter than that for American real faces, indicating more focused observation. However, different results emerged when considering animated faces, as saccade distances were similar for American and Japanese animated faces. This study highlights the importance of considering cultural differences in visual perception. Demonstrating how animated faces can mitigate the impact of cross-cultural facial differences on visual attention supports the notion that animated faces can reduce the influence of cross-cultural facial differences on saccadic eye movement. This indicates that animated facial features can play a role in promoting inclusivity and reducing the impact of cultural and racial differences on visual attention mechanisms. Additionally, SAM surveys showed no effect of affective arousal on scan distances, implying that pleasure and arousal levels may not impact saccadic distances.

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**Institutional Review Board Statement:** The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Ethics Committee of China Medical University, Taichung, Taiwan (reference No. CRREC-110-128; approved on 07 February 2022).

**Informed Consent Statement:** Written informed consent has been obtained from the patient(s) to publish this paper.

**Data Availability Statement:** The data presented in this study are available on request from the corresponding author.

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**Conflicts of Interest:** The authors declare no conflict of interest.

## Appendix A

The links to the 11 related feature parameters of the saccadic distance we proposed are https://figshare.com/s/ac8a55952764ea116f94 (accessed on 15 July 2023).

## References

1. Pierce, J.E.; Clementz, B.A.; McDowell, J.E. Saccades: Fundamentals and neural mechanisms. In *Eye Movement Research: An Introduction to Its Scientific Foundations and Applications*; Springer: Berlin/Heidelberg, Germany, 2019; pp. 11–71.
2. Hutton, S.B. Cognitive control of saccadic eye movements. *Brain Cogn.* **2008**, *68*, 327–340. [CrossRef]
3. Tatara, S.; Toda, H.; Maeda, F.; Handa, T. Development of a New Eye Movement Measurement Device Using Eye-Tracking Analysis Technology. *Appl. Sci.* **2023**, *13*, 5968. [CrossRef]
4. Lin, C.J.; Widyaningrum, R.; Prasetyo, Y.T. The Effect of 3D TVs on Eye Movement and Motor Performance. *Appl. Sci.* **2023**, *13*, 2656. [CrossRef]
5. Yang, Z.; Qian, Y.; Zou, J.; Lee, C.-L.; Lin, C.-L.; Wu, S.-T. Reducing the power consumption of VR displays with a field sequential color LCD. *Appl. Sci.* **2023**, *13*, 2635. [CrossRef]
6. Rubies, E.; Palacín, J.; Clotet, E. Enhancing the Sense of Attention from an Assistance Mobile Robot by Improving Eye-Gaze Contact from Its Iconic Face Displayed on a Flat Screen. *Sensors* **2022**, *22*, 4282. [CrossRef]
7. Sáiz-Manzanares, M.C.; Pérez, I.R.; Rodríguez, A.A.; Arribas, S.R.; Almeida, L.; Martin, C.F. Analysis of the learning process through eye tracking technology and feature selection techniques. *Appl. Sci.* **2021**, *11*, 6157. [CrossRef]
8. Dalmaso, M. Exploring the Social Environment with the Eyes: A Review of the Impact of Facial Stimuli on Saccadic Trajectories. *Int. J. Environ. Res. Public Health* **2022**, *19*, 16615. [CrossRef]
9. Foulsham, T. Eye movements and their functions in everyday tasks. *Eye* **2015**, *29*, 196–199. [CrossRef]
10. Leopold, D.A.; Rhodes, G. A comparative view of face perception. *J. Comp. Psychol.* **2010**, *124*, 233. [CrossRef]
11. Calder, A. *Oxford Handbook of Face Perception*; Oxford University Press: Oxford, MS, USA, 2011.
12. Sutherland, C.A.; Young, A.W. Understanding trait impressions from faces. *Br. J. Psychol.* **2022**, *113*, 1056–1078. [CrossRef]
13. Maw, N.N.; Pomplun, M. Studying human face recognition with the gaze-contingent window technique. *Proc. Annu. Meet. Cogn. Sci. Soc.* **2004**, *26*.
14. Walker, R.; McSorley, E. The parallel programming of voluntary and reflexive saccades. *Vis. Res.* **2006**, *46*, 2082–2093. [CrossRef] [PubMed]
15. Kawakami, K.; Friesen, J.P.; Fang, X. Perceiving ingroup and outgroup faces within and across nations. *Br. J. Psychol.* **2022**, *113*, 551–574. [CrossRef]
16. Fu, G.; Hu, C.S.; Wang, Q.; Quinn, P.C.; Lee, K. Adults scan own-and other-race faces differently. *PLoS ONE* **2012**, *7*, e37688. [CrossRef] [PubMed]
17. Arizpe, J.; Kravitz, D.J.; Walsh, V.; Yovel, G.; Baker, C.I. Differences in looking at own-and other-race faces are subtle and analysis-dependent: An account of discrepant reports. *PLoS ONE* **2016**, *11*, e0148253. [CrossRef]
18. Or, C.C.-F.; Peterson, M.F.; Eckstein, M.P. Initial eye movements during face identification are optimal and similar across cultures. *J. Vis.* **2015**, *15*, 12. [CrossRef] [PubMed]
19. Hu, C.; Wang, Q.; Fu, G.; Quinn, P.C.; Lee, K. Both children and adults scan faces of own and other races differently. *Vis. Res.* **2014**, *102*, 1–10. [CrossRef]
20. Benson, P.J.; Perrett, D.I. Perception and recognition of photographic quality facial caricatures: Implications for the recognition of natural images. *Eur. J. Cogn. Psychol.* **1991**, *3*, 105–135. [CrossRef]
21. Byatt, G.; Rhodes, G. Recognition of own-race and other-race caricatures: Implications for models of face recognition. *Vis. Res.* **1998**, *38*, 2455–2468. [CrossRef]
22. Liu, K.; Chen, J.-H.; Chang, K.-M. A study of facial features of American and Japanese cartoon characters. *Symmetry* **2019**, *11*, 664. [CrossRef]
23. Kendall, L.N.; Raffaelli, Q.; Kingstone, A.; Todd, R.M. Iconic faces are not real faces: Enhanced emotion detection and altered neural processing as faces become more iconic. *Cogn. Res. Princ. Implic.* **2016**, *1*, 19. [CrossRef]

24. Zhao, J.; Meng, Q.; An, L.; Wang, Y. An event-related potential comparison of facial expression processing between cartoon and real faces. *PLoS ONE* **2019**, *14*, e0198868. [CrossRef]
25. Lee, K.; Byatt, G.; Rhodes, G. Caricature effects, distinctiveness, and identification: Testing the face-space framework. *Psychol. Sci.* **2000**, *11*, 379–385. [CrossRef] [PubMed]
26. Rhodes, G.; Tremewan, T. Understanding face recognition: Caricauture effects, inversion, and the homogeneity problem. *Vis. Cogn.* **1994**, *1*, 275–311. [CrossRef]
27. Mulckhuyse, M. The influence of emotional stimuli on the oculomotor system: A review of the literature. *Cogn. Affect. Behav. Neurosci.* **2018**, *18*, 411–425. [CrossRef]
28. Feldman, J.L.; Freitas, A.L. The generality of effects of emotional experience on emotion-regulation choice. *Emotion* **2021**, *21*, 211. [CrossRef] [PubMed]
29. Knobloch-Westerwick, S. Mood management: Theory, evidence, and advancements. In *Psychology of Entertainment*; Routledge: London, UK, 2013; pp. 257–272.
30. Boukricha, H.; Wachsmuth, I.; Hofstätter, A.; Grammer, K. Pleasure-arousal-dominance driven facial expression simulation. In Proceedings of the 2009 3rd International Conference on Affective Computing and Intelligent Interaction and Workshops, Amsterdam, The Netherlands, 10–12 September 2009; pp. 1–7.
31. Di Stasi, L.L.; Catena, A.; Cañas, J.J.; Macknik, S.L.; Martinez-Conde, S. Saccadic velocity as an arousal index in naturalistic tasks. *Neurosci. Biobehav. Rev.* **2013**, *37*, 968–975. [CrossRef]
32. Zhou, S.; Li, L.; Wang, F.; Tian, Y. How facial attractiveness affects time perception: Increased arousal results in temporal dilation of attractive faces. *Front. Psychol.* **2021**, *12*, 784099. [CrossRef]
33. Schmidt, L.J.; Belopolsky, A.V.; Theeuwes, J. The presence of threat affects saccade trajectories. *Vis. Cogn.* **2012**, *20*, 284–299. [CrossRef]
34. Webb, A.L.; Asher, J.M.; Hibbard, P.B. Saccadic eye movements are deployed faster for salient facial stimuli, but are relatively indifferent to their emotional content. *Vis. Res.* **2022**, *198*, 108054. [CrossRef]
35. Webb, A.L.; Hibbard, P.B.; O'Gorman, R. Contrast normalisation masks natural expression-related differences and artificially enhances the perceived salience of fear expressions. *PLoS ONE* **2020**, *15*, e0234513. [CrossRef] [PubMed]
36. Frens, M.; Van Opstal, A. Transfer of short-term adaptation in human saccadic eye movements. *Exp. Brain Res.* **1994**, *100*, 293–306. [CrossRef]
37. Rodríguez, J.; Bortfeld, H.; Gutiérrez-Osuna, R. Reducing the other-race effect through caricatures. In Proceedings of the 2008 8th IEEE International Conference on Automatic Face & Gesture Recognition, Amsterdam, The Netherlands, 17–19 September 2008; pp. 1–5.
38. Hills, P.J.; Lewis, M.B. Reducing the own-race bias in face recognition by shifting attention. *Q. J. Exp. Psychol.* **2006**, *59*, 996–1002. [CrossRef] [PubMed]
39. Green, M.J.; Williams, L.M.; Davidson, D. Visual scanpaths to threat-related faces in deluded schizophrenia. *Psychiatry Res.* **2003**, *119*, 271–285. [CrossRef] [PubMed]
40. Hu, C.S.; Wang, Q.; Han, T.; Weare, E.; Fu, G. Differential emotion attribution to neutral faces of own and other races. *Cogn. Emot.* **2017**, *31*, 360–368. [CrossRef] [PubMed]