Estimation of Subjective Age Based on Facial Images of Others:

Comparative Studies of the Americans and the Japanese

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Abstract— **We designed a method for estimating the subjective age of a person; using this method, one evaluates one's own age by estimating whether a person shown in a facial image looks older or younger than oneself. Thus far, experiments have shown that Japanese people tend to underestimate their subjective age. In this study, we conducted an international comparative study to focus on the socio-psychological effects that may influence the underestimation of subjective age. Experiments were performed in which American and Japanese participants viewed American facial images; in addition, the American participants viewed Japanese facial images. Through these experiments, it was confirmed that the underestimation of age occurs despite differences in Japanese and American societies and cultures; however, the tendency of underestimation of age is not related to facial images but to social and cultural factors that influence the participants. Moreover, we carried out experiments of conventional look age estimates and compared the results to those of the subjective age estimates.**

Keywords-component; facial images, subjective age, non-linear regression analysis

I. INTRODUCTION

In face-to-face communication, people estimate the attributes of other people, such as age and gender, simply by looking at them and listening to their voices. Age is one of the most important factors in social interactions, and it assumes even greater significance with regard to first impressions. However, we often overestimate the age of another person and then say "I thought he was much older than I am!" It has been observed that people generally tend to overestimate the age of other people or underestimate their own age. In the study, we assumed that people did not really estimate the ages of the other people incorrectly; instead, they simply found themselves to appear younger than they really were [1].

In this study, we carried out an international comparative study to investigate the tendency toward constructing a younger identity. We conducted subjective age estimation experiments in which Japanese and Americans participated, and investigated the socio-psychological factors by comparing the results. In addition, an experiment with conventional look age estimates was performed separately. We compared these with the results of the subjective age estimates, and considered factors influencing one's age image.

II. PREVIOUS WORKS

Several studies on the perception and estimation of age have been carried out. Pittenger and Shaw [2], George and Hole [3] and Burt and Perrett [4] found in their experiments that, overall, participants' estimates of age in unfamiliar faces was highly accurate. Moreover, George and Hole [3] and Anastasi and Rhode found evidence of an "own age bias," where individuals are able to better recognize the ages of faces of people belonging to their own age group than those outside their age group. Despite these findings, the mechanism of how humans estimate the ages of others remain unclear.

One of the most significant results to emerge from these studies is that the participants in each experiment tended to overestimate the age of the facial images they were shown. George and Hole [3] found that both younger and older participants tended to give more accurate estimations of age when assessing images of faces that were within their own age range. However, while younger participants tended to overestimate the age of older faces, older participants tended to overestimate the age of younger faces. Clearly, there is strong evidence that individuals tend to overestimate the age of those around them. Despite this, there has yet to be a sufficient discussion or systematic quantification about this tendency.

The term "subjective age" is used throughout developmental psychology and various studies expound upon the issue. Subjective age includes a variety of concepts. In the experiments that were conducted to determine subjective age, it was observed that, the older the participants were, the younger they felt themselves to be; that is, the tendency to construct a "younger identity" tended to develop as people got older.

We focused on the tendency of younger identity, and assumed that the perception that participants looked other people older than their actual age was because of the perception that participants felt themselves younger than their actual age. In our previous study [1], we processed data obtained from relative age estimation, such as the classification of other people by participants as older or younger than themselves, using nonlinear regression analysis and then

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calculated the subjective age of each participant. Figure 3.a that was depicted later shows the experimental result of previous works (participant: Japanese, facial image: Japanese).

The results indicated that Japanese subjective age generally tended toward the negative direction, and Japanese tended to underestimate their own age. Further, our results, that is Japanese subjective age was the lowest in the young age group and the subjective age given by males was lower than that given by females, suggested a different scale-based understanding of how subjective age may be more appropriate than the traditional understanding of subjective age. In addition, it was confirmed that the age and gender of the participants were factors that influenced their tendency to construct the subjective age. However, the level of accuracy with which participants made their estimations was constant regardless of their gender or age groups. These results suggested that the tendency of younger identity was influenced by the misleading memory of their own facial image and sociopsychological factors.

In this study, to investigate the tendency to underestimate one's own age, we carried out estimation experiments on the American participants using facial images of Americans and compared the subjective age on a nationality basis (American and Japanese). In addition, we experimented on the Japanese participants using facial images of Americans and vice versa, respectively, in order to investigate differences due to facial image stimuli.

In addition, we conducted experiments in estimating the age of others by sight, in which participants were asked "How old do you think the presented facial images look?" to investigate the factors determining the perception of ourselves as younger and the perception of others as older. Two factors were included in addition to subjective age: the tendency for participants to underestimate their own age and the tendency for them to overestimate the age of other people. We assumed that the experimental procedure in which participants evaluated whether the shown facial images looked older or younger than themselves would be influenced both by themselves and by the facial images, and that the age estimation experiment in which participants evaluated how old facial images looked would be influenced by only the facial images. We carried out the two comparative assessments and investigated self age image.

III. Prepare Your Paper Before Styling

We defined the three experiments in this study as follows:

[Experiment I] Experiments on Americans participants using facial images of Americans

[Experiment II] Experiments on Japanese participants using facial images of Americans

[Experiment III] Experiments on Americans participants using facial images of Japanese

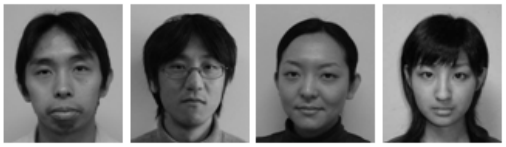
A. Participants

134 Americans (male: 62, female: 72) participated in experiment I, 136 Japanese (male: 65, female: 71) participated in experiment II, and 87 Americans (male: 45, female: 42) participated in experiment III. All participants were between 25 and 54 years old, and all American participants were Caucasians.

B. Experimental Stimuli

Facial images of both Americans and Japanese aged between 20 and 59 years were used as experimental stimuli. These images were divided into eight classes for each gender, and each class included more than five facial images. Figure 1 shows examples of the facial images.

(a) American



(b) Japanese

Figure 1. Examples of facial images (Class: 25–29 years)

C. Rating Experiment

For both male and female participants belonging to different age and gender groups, we selected facial images from their own age class as well as the next younger and older classes. Therefore, the total number of facial images used was 30 (5 images/class × 3 classes × 2 genders).

Next, we experimented with a rating scale for the facial images used as stimuli. The participants were shown random facial images on the computer monitor, and they evaluated whether the person shown in the image looked older or younger than themselves. The evaluation had 5 ranks: "Definitely older than myself (2)," "Probably older than myself (1)," "Not able to estimate (0)," "Probably younger than myself (–1)," and "Definitely younger than myself (–2)." Then, we limited the facial images to only of people who are around the same age in order to raise the efficiency of the experiments.

D. Subjective Age Quantification

In our relative age estimation experiment, the rating data consist of a combination of the difference in actual age (facial image - participant) and the estimation result. We plotted these results on a two-dimensional plane with the x-axis as the difference in actual age and the y-axis as the estimation result. We applied a nonlinear regression analysis to the distribution for each participant, using a logistic function. Figure 2 depicts an example of the non-linear regression analysis.

Here, the logistic function, which converged at a rating value of ±2, was defined by the mathematical formula

$$y = \frac{4}{1+\exp(-a(x-b))} - 2 \qquad (1)$$

where a is the slope of the curve and b is the zero crossing point in the approximation curve with the x-axis. a and b were estimated by a nonlinear regression analysis; we defined b as "the bias value of the subjective age" and the addition of the

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bias value to the actual age as "the subjective age". After the bias values of the subjective age were calculated on the basis of the data obtained from each participant, these values were categorized into six groups on the basis of gender (male and female) and age group (25–34 years old: young, 35–44 years old: young-middle, 45–54 years old: middle).

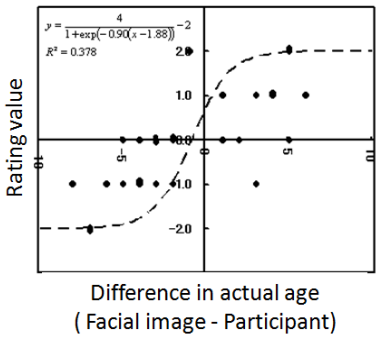


Figure 2. Example of non-linear regression

We eliminated data whose multiple coefficients of determination of the regression curve approximated for each participant were extremely low ($R^2 < 0.10$) and finally processed data of 103, 110, and 72 individuals in experiments I, II, and III, respectively.

E. Results

1) Experiment I

Table 1a and Figure 3d show the experimental results of experiment I (participant: American, facial images: American). The bias value of subjective age *b* generally tended to be in the negative direction despite the differences in nationality and cultures of participants and facial images. Thus, it was concluded that in a manner similar to the Japanese, the Americans also perceived themselves to be younger. In addition, a two-way ANOVA was performed using the gender and age group as independent variables and the bias value of subjective age *b* as the dependent variable. This analysis revealed that the main effects of each gender and age group were insignificant.

In addition, because we investigated the difference in subjective age between nationality, we combined the data obtained from a previous study (participant: Japanese, facial images: Japanese) and performed two-way ANOVA using the gender and nationality as independent variables. This analysis revealed a significant interaction between the gender and nationality ($F(1, 279) = 4.86$, $p < .05$). The simple main effect test was conducted on the interaction between gender and nationality, where a significant difference between an American male and a Japanese male was confirmed ($F(1, 279) = 2.87$, $p < .10$). This showed that an American male did not exhibit the tendency of underestimating his own age, unlike a Japanese male.

2) Experiment II

Table 1b and Figure 3b show the experimental results of experiment II (participant: Japanese, facial images: American). It was confirmed that the subjective age of Japanese people generally tended toward the negative direction despite the difference in the nationalities (Japanese and American) of the people whose facial images were used. In addition, two-way ANOVA was performed using the gender and age group as independent variables. This analysis revealed that the main effects of age group were significant ($F(2, 104) = 6.09$, $p < .01$) and a significant interaction did not exist between the gender and age group ($F(2, 104) = 1.55$, n.s.). In addition, Tukey's HSD test was performed for age group. This test revealed a significant difference between young (25–34) and young-

Table 1. Statistics related to the bias value of subjective age

(a) Experiment I (Participant: American, Facial images: American)

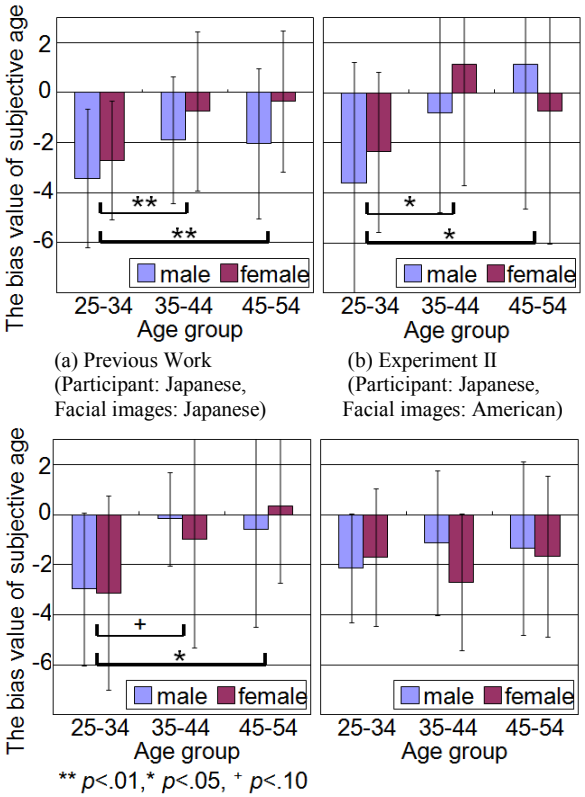
		25-34	35-44	45-54	total
male	*M*	-2.15	-1.13	-1.34	-1.47
	SD	(2.17)	(2.88)	(3.47)	(2.95)
	N	11	15	18	44
female	*M*	-1.71	-2.70	-1.66	-1.96
	SD	(2.75)	(2.73)	(3.21)	(2.94)
	N	17	16	26	59

(b) Experiment II (Participant: Japanese, Facial images: American)

		25-34	35-44	45-54	total
male	*M*	-3.60	-0.81	1.12	-1.55
	SD	(4.81)	(3.95)	(5.75)	(5.15)
	N	24	16	14	54
female	*M*	-2.36	1.14	-0.73	-0.77
	SD	(3.21)	(4.84)	(5.32)	(4.62)
	N	21	17	18	56

(c) Experiment III (Participant: American, Facial images: Japanese)

		25-34	35-44	45-54	total
male	*M*	-2.97	-0.17	-0.60	-1.16
	SD	(3.06)	(1.86)	(3.88)	(3.17)
	N	10	12	11	33
female	*M*	-3.13	-0.99	0.34	-0.98
	SD	(3.87)	(4.34)	(3.09)	(3.85)
	N	11	10	18	39



(a) Previous Work (Participant: Japanese, Facial images: Japanese)

(b) Experiment II (Participant: Japanese, Facial images: American)

** $p<.01$,* $p<.05$, $^{+}$ $p<.10$

(c) Experiment III (Participant: American, Facial images: Japanese)

(d) Experiment I (Participant: American, Facial images: American)

Figure 3. Bias values of subjective age

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middle (35–44) at 5%, and young (25–34) and middle (45–54) at 5%. Thus, it become clear that the Japanese tended to underestimate the age despite the nationality of the facial images shown, and the older the participants were, the closer the subjective ages were to the real age.

In addition, we combined the data obtained from a previous study (participant: Japanese, facial images: Japanese) and performed a two-way ANOVA using the gender and nationality of facial images as independent variables. This analysis revealed that the main effects of gender were significant ($F(1, 286) = 4.27$, $p < .05$), but the main effects of nationality of facial images and the interaction between the two were insignificant. Therefore, it was confirmed that the tendency for Japanese to underestimate subjective age identified in the previous study existed despite the difference in the nationalities (Japanese and American) of the people whose facial images were used.

3) Experiment III

Table 1c and Figure 3c show the experimental results of experiment III (participant: American, facial images: Japanese). A two-way ANOVA was performed using the gender and age group as independent variables. This analysis revealed that the main effects of age group were significant ($F(2, 66) = 4.88$, $p < .05$), and a significant interaction did not exist between the gender and age group ($F(2, 66) = 0.43$, n.s.). In addition, Tukey's HSD test was performed for age group, and a significant difference between young (25–34) and young-middle (35–44) at 10%, and young (25–34) and middle (45–54) at 5% was confirmed.

In addition, we combined the data obtained from experiment I (participant: American, facial images: American) and performed a two-way ANOVA using the gender and nationality of facial images as independent variables. This analysis could not confirm a significant difference between the two factors.

4) Summary Resuolts

It was confirmed that the subjective age was generally found to be in the negative region in all experiments, and the underestimation of age occurred despite the differences in the nationalities and cultures of Japanese and American participants and their facial images. However, American males did not exhibit a tendency to underestimate the age, unlike Japanese males, and it was indicated that a significant difference existed in nationality and culture between the males. During the estimation of the facial images of people of different nationalities, although the mean value of the ratings could not confirm a significant difference in the nationalities of the facial images, the variance generally tended to be large.

IV. Estimates of Look Age of Others

Here we conducted conventional look age estimates. As mentioned above, because the subjective age is defined relative to others, the subjective age is influenced by two factors: participants underestimate their own age, and they overestimate the age of other people. However, the estimation experiment of the look age of others is an absolute evaluation. Thus, it can be assumed that this result would be influenced by only facial images. By comparison between this result and the result of the subjective age, we investigated the self age image.

A. Participants

In all, 109 Japanese (male: 49, female: 56) and 74 Americans (male: 33, female: 41) participated in the experiment. All participants were between 25 and 54 years old.

B. Experimental Stimuli

We used the same facial images as in chapter 3B.

C. Rating Experiment

The participants were shown facial images selected in the same way as in Chapter 3C., which were presented randomly on the computer monitor. They were asked, "How old do you think he/she is?" and were to evaluate using integer values.

D. Look Age Quantification

For comparison with the subjective ages, the look ages of others were translated and plotted on the same scale as the subjective age. As we used the procedure of estimates of subjective age, as mentioned in chapter 3D, we plotted the obtained results on a two-dimensional plane with the x-axis as the difference in actual age (facial image - participant) and the y-axis as the estimation result for the facial image (rating value – the actual age of the participant). We applied a linear regression analysis to the distribution for each participant, instead of the logistic function. Figure 4 depicts an example of the linear regression analysis.

We defined the zero crossing point in the approximation line with the x-axis as "the bias value of the look age" and calculated this value for each participant. After the bias values of the look age were calculated on the basis of the data obtained from all participants, these values were classified into 12 groups, according to nationality (Japanese and American), gender (male and female) and age group (25–34: young, 35–44: young-middle, 45–54: middle).

We eliminated data whose determination coefficients of the regression line approximated for each participant were 0.1 or less, and finally calculated the average and variance of data for 99 Japanese and 73 Americans.

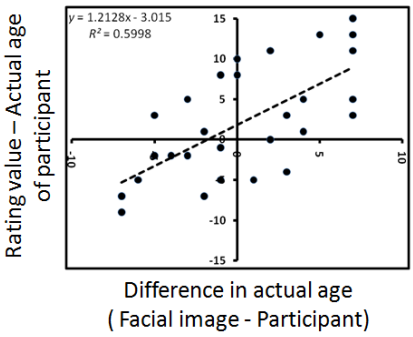

Figure 4. Example of linear regression

E. Results

1) Japanese Look Age

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Table 2a and Figure 5a indicated that the Japanese bias value of the look age generally tended toward the negative direction despite differences in the gender and age group. Therefore, it was confirmed the tendency of underestimation their own age (or, overestimation the age of other people). Moreover, a two-way ANOVA was performed using the gender and age group of the participants as independent variables and the bias value of appearance age as the dependent variable. This analysis revealed that the main effects of age group were significant (F (2; 93) = 20.31; p <.01) and a significant interaction did not exist between the gender and age group (F (2; 93) = 1.53; n.s.). In addition, Turkey's HSD test was performed for age group. This test revealed a significant difference between the young (25-34) and the young-middle (35-44) at 1 %, and young (25-34) and the middle (45-54) at 1 %.

In addition, we combined the data obtained from a previous study (the Japanese bias value of the subjective age) and performed two-way ANOVA using the gender and experimental procedure as independent variables. This analysis revealed that the main effects of each factor and the interaction were insignificant. This showed that a significant difference between the Japanese subjective age and appearance age of others were not confirmed.

2) American Look Age

Table 2b and Figure 5b indicated that American young age group (25-34) tended to underestimate their own age (or, overestimate other's age) as well as Japanese. However, the bias values of the look age were found to be in the positive region in young-middle (35-44) and middle (45-54). Thus, it was confirmed that American young-middle age group (35-44) and middle age group (45-54) tended to overestimate their own age (or, underestimate other's age). In addition, a two-way ANOVA was performed using the gender and age group as independent variables. This analysis revealed that the main effects of age group were significant (F (2; 67) = 6.05; p <.01) and the interaction was insignificant. Moreover, Turkey's HSD test was performed for age group. This test revealed that a significant difference between young (25-34) and young-middle (35-44) at 10%, and young (25-34) and middle (45-54) at 1%.

In addition, we combined the data obtained from previous study (the bias value of the American subjective age) and performed two-way ANOVA using the gender and experimental procedure as independent variables. This analysis revealed that the main effects of experimental procedure was significant (F (1; 172) = 18.96; p <.01) and the interaction did not exist.

Moreover, we combined the data obtained from bias value of the Japanese look age and performed two-way ANOVA using the gender and nationality as independent variables. This analysis revealed that the main effects of nationality was significant (F (1; 168) = 28.40; p <.01) and the interaction was not confirmed. Thus, it was indicated that the Japanese did not exhibit a tendency to underestimate their own age, unlike American (or, Japanese exhibit a tendency to overestimate the other's age, unlike American).

3) Summary of the Results

In estimates of the look age as well as the subjective age, the tendency to underestimate one's own age or to overestimate another's age was confirmed in the Japanese and American young age groups (25-34). However, overestimation of one's own age (underestimation of other's age) was confirmed in both the American young-middle age (35-44) and middle age groups (45-54), whereas Japanese exhibit a tendency to underestimate their own age (overestimate the other's age), unlike Americans. In addition, it was indicated that the older both Japanese and American participants were, the weaker their tendencies to construct an underestimation of own age (an overestimation of the others' age).

A comparison of the bias value of the look age and the subjective age did not confirm a significant difference in the Japanese. However, the Americans exhibited a significant difference.

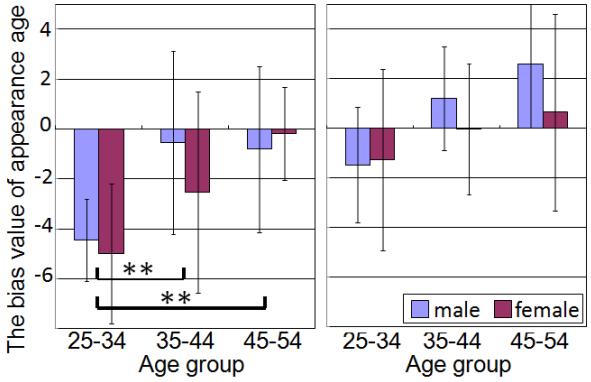
Table 2. Statistics related to the bias value of look age

(a) Japanese

		25-34	35-44	45-54	total
male	*M*	-4.44	-0.53	-0.81	-2.44
	SD	(1.64)	(3.66)	(3.34)	(3.31)
	N	22	12	13	47
female	*M*	-5.00	-2.54	-0.19	-2.39
	SD	(2.80)	(4.04)	(1.86)	(3.53)
	N	16	16	20	52

(b) American

		25-34	35-44	45-54	total
male	*M*	-1.47	1.22	2.59	0.82
	SD	(2.32)	(2.09)	(2.57)	(2.86)
	N	11	10	12	33
female	*M*	-1.26	-0.02	0.65	-0.12
	SD	(3.66)	(2.64)	(3.97)	(3.53)
	N	12	12	16	40



** p<.01

(a) Japanese (b) American

Figure 5. Look age of gender and age group

V. DISCUSSIONS

A. Subjective age of Japanese and American

1) Universality of the younger identity

First, we investigated the universal factors influencing the tendency to underestimate one's own age. Using the abovementioned results, it is confirmed that the bias value of the subjective age generally tends toward the negative direction despite the differences in the nationalities and cultures of Japanese and American participants and their facial images. It is suggested that remembering one's own facial image may be a factor influencing this tendency despite differences in

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nationality and culture. Estimating one's own age (or that of another known person) involves remembering previous facial images. However, when estimating the age of strangers, only currently observed information is available. We suggest that when estimating one's own age, although we remember our own image, we tend to perceive others as being older than they actually are.

A comparison of the mean rating values obtained in experiment II and the previous study as well as experiments I and III did not confirm a significant difference due to the nationality of facial images. Therefore, the factors resulting in the underestimation of own age may not be the facial images used as stimuli but the participants.

2) Socio-psychological effects

Next, we investigate the underestimation of age from the viewpoint of socio-psychological factors. Experiment I revealed that although Americans tended to underestimate their own age, American males did not exhibit a tendency of underestimating their own age, unlike Japanese males. We also observed the following: (1) In the case of Japanese people, it was observed that there was a difference in the bias values of the subjective ages of people according to gender. (2) It was also observed that, the older the Japanese participants were, the weaker the tendency of younger identity was. From the abovementioned results and the two additional observations, we conclude that the subjective age is related to socio-psychological factors such as an attitude of modesty or social rank. Modesty toward elderly people is more common in Japan than in American society; we suggest that this tendency is more significant in males in particularly. Further, whether modesty is considered to be a virtue depending on social and cultural factors may influence the age estimation of strangers.

3) Age estimation of different nationality

The following relationships between nationality and underestimation of age were evident:

(1) It is not confirmed whether the variance of the mean value of the ratings for the estimation of facial images of people of different nationalities (Japanese and American) is large.

(2) However, differences tend to exist between the variances. Specifically, the variance of estimation for a different nationality is higher than that for the same nationality.

We formed a hypothesis that the difference between variances (result (2)) is related to difficulty of age estimation for a different nationality. According to Meissner's study on the perception of faces and race, it is easier to perceive or memorize the face of a person belonging to the same race as opposed to that of someone from a different race; this is called own-race bias. Because the participants in this study were Caucasian Americans, the difficulty of age estimation cannot be attributed to factors such as nationality and culture or race. However, it is shown that own-race bias possibly affects age estimation. In the future, we will conduct estimation experiments involving Koreans belonging to the same race as the Japanese but having a different nationality, and investigate the differences between the two.

B. Look age of Japanese and American

In this study, also observed was the tendency to underestimate one's own age or overestimate another's age in the conventional look age estimation by sight experiment. We assumed that the look age estimates would be highly accurate as in previous work (the results of George et al. mentioned in chapter 2). However, with regard to the Japanese results, participants tended toward a younger identity in both the look age and subjective age estimates. In particular, in the case of both Japanese and Americans, the older the participants were, the less they tended toward a younger identity; this tendency was the most distinctive in the subjective age bias that we investigated. These results suggest that the tendency toward a younger identity may change by age in general age estimation as well.

A comparison of the bias values of the look age and the subjective age confirmed a significant difference in Americans, but not in Japanese. Thus, we could not divide two factors: the underestimation of the participant's own age and the overestimation of other people's age. In the future, we will carry out an estimation experiment of the look age of other people in which participants evaluate facial images of other age groups, and will investigate the abovementioned two factors.

VI. CONCLUSIONS

In this study, we compared the results of subjective age estimation by American and Japanese participants, and investigated the factors determining the tendency to underestimate one's own age. In addition, we conducted estimates of look age of others to investigate underestimation own age and overestimation other's age.

The results of this study indicate that the factors influencing the underestimation of age are (1) universal despite nationality or race because it is necessary to remember one's own facial image and (2) cultural factors such as modesty or social rank, or socio-psychological factors such as confidence. (3) It is possible that the tendency to underestimate one's own age is not influenced by the physical properties of the facial images but by the internal properties of the participants.

In the future, we intend to investigate circumstantial factors such as the ability of participants to remember their own facial image. In addition, we will conduct estimation experiments involving Koreans.

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