# Estimation of Subjective Age Based on the Facial Images of Others:

## Experimental Verification of a Younger Identity Caused by the Effect of Delusions of the Accumulated Memory of a Known Face

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***Abstract*—This study assesses how people interpret human ages based on images of faces. We assigned the age of the people imagining how old they are as the "subjective age" and proposed an experiment to identify its mechanism. The participants in the experiment were presented with the facial images of other people and asked to estimate the ages of those in the images as either younger or older than their own ages. Then, we calculated the difference between the subjective ages given by participants that matched their own ages and the actual ages of the people in the images. Results showed that subjective age was generally underestimated by Japanese, Korean, and American groups. The results also suggest that the factors of a younger identity include 1) the effect of delusions of the accumulated memory of self-image, and 2) sociopsychological parameters. To examine the effect of delusions of the accumulated memory of faces, we conducted the experiments of relative age comparison between well-known others' faces (own brothers/sisters) and unknown others' faces. The results confirmed that people tended to underestimate the ages of well-known others' faces compared with unknown faces. These results are consistent with our hypothesis that a younger identity is influenced by the effect of delusions of the accumulated memory of known faces.**

***Keywords—Facial images, Subjective age, Non-linear Regression Analysiss***

## I. INTRODUCTION

When individuals engage in communication, they tend to make judgments about the attributes (e.g., age, gender, etc.) of those with whom they communicate based on their appearance or voice. Age is one of the most important factors in forming attitudes during social interactions; we use this to establish the appropriate attitude and language to adopt. However, we often overestimate the age of people with whom we are communicating. We then tend to feel surprised when we learn their actual age.

We assumed that this tendency of overestimating age of others' faces was not caused by an erroneous estimate of the other person's age, but caused, instead, by the mistaken underestimation of one's own age image than actual age. We conducted this research using three distinct and homogeneous groups: (1) Japanese, (2) Americans, and (3) Koreans [1]-[4], and indicated the possibility that there is a prevailing tendency toward indicating a younger identity regardless of race or nationality, and that a younger identity is related to the memory of facial images from the past.

In this study, to examine one's own memory of past facial images (we call it the effect of delusions of the accumulated memory), we propose a new method for age comparison between well-known others and unknown others. Using the memory of past brothers or sisters faces, notwithstanding the memory of one's own face, it was possible to verify that, indeed, the attribution of a younger identity arises from the effect of delusions of the accumulated memory.

## II. PREVIOUS WORKS

Numerous studies explored age estimation using faces [5]-[13]. In particular, much of the research focused on automatic age estimation by computer [5]-[14]. The applications of this technology have recently been extended to a variety of fields including biometrics, security, and digital consumer electronics. However, because of the particularity and complexity of faces, various technical issues with automatic age estimation remain that relate to sociology and psychology as well as the biological or anthropometric perspective [15] [16].

One of the most significant results to emerge from these studies is "subjective age bias," where individuals tended to overestimate the ages of the facial images of others. Although the tendency to perceive another person's face as older was often pointed out in various areas, it was not an intended topic of the research [7]-[9].

We focused on the tendency of claiming younger identity and assumed that the perception that participants viewed other people as older than their actual ages was because of the

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perception that participants felt themselves younger than their actual ages. In our previous study, 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 calculated the subjective age of each participant.

Thus, we could apply the bias value of the subjective age of each participant to ANOVA and observe the relationship between the subjective age and the profile (gender and age group). The ANOVA analysis revealed that Japanese and Americans tended to perceive themselves as younger (i.e., perceive other people as older), as shown in Figures 1 and 2. Moreover, when we considered age perception on the basis of profile differences, Japanese males tended to underestimate their ages to a greater extent than did Japanese females. The tendency to underestimate age was strongest in the age group 25-34. The older the participants were, the closer the subjective ages were to the real ages.

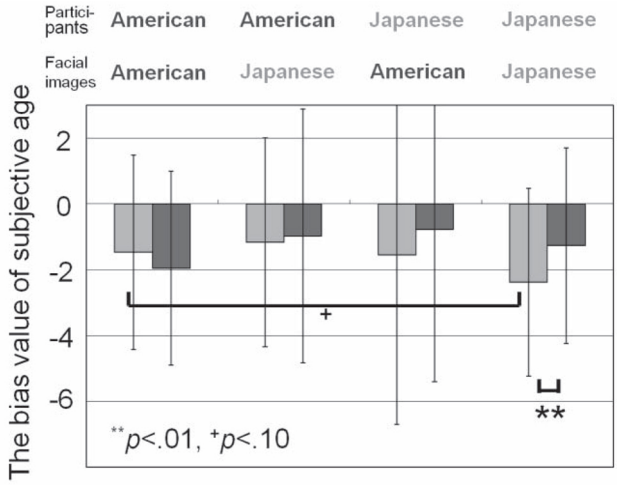


Fig. 1. Bias values of subjective age (Japanese and American).

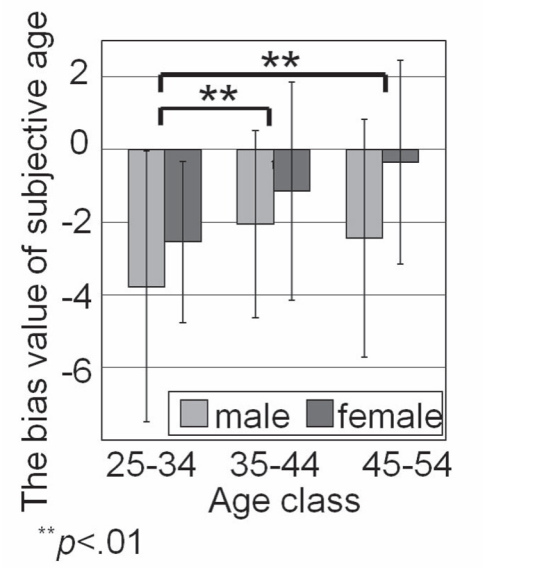


Fig. 2. Bias values of subjective age.(age class)

The scale used to determine the bias values of the subjective ages in Figure 2 is entirely different from that used traditionally; that is, the subjective ages of young people were lowest, and males tended to underestimate their own ages to a greater extent than did females.

The template is used to format your paper and style the text. The subjective ages were obtained by estimating the actual ages of other people whom the participants considered to be of the same age by rating whether they perceived the subjects as older or younger. These subjective ages were described as "relative imaginary ages." Moreover, we found that the subjective ages remained the same regardless of stimulus expression, gender, or age group. Using the results stated above, we were able to narrow down the factors responsible for the underestimation of one's own age to the following two factors from the original four factors [4].

– Accumulated memories from one's own past (younger) facial images may have a deluding effect, and people may not remember the most recent image of themselves. In face-to-face communication, other people's images are always current, but our own facial image needs to be remembered.

– As Barak and Stern made clear, there seems to be a link between age and socio-psychological parameters; for example, confidence and social rank of an individual are related to other people's perceptions of their age.

To clarify the effect of delusions of the accumulated memory, we proposed a new method for age comparison between well-known others and unknown others. While our final goal was to separate and extract the bias caused by the memory of our own faces from estimating the age of others, this is quite difficult. Thus, in spite of the possible effect of the memory of one's own face, we used the memory of past brothers and sisters. Here, comparing between unknown others' faces and well-known brothers/sisters faces, we verified whether younger identity arose as a result of the effect of delusions of the accumulated memory.

## III. AGE COMPARISON EXPERIMENT

For the purpose of experimental verification of a younger identity caused by the effect of delusions of the accumulated memory of one's own face, we conducted the following experiments:

Experiment I: Facial-image-based age comparison experiment between well-known others (brothers and sisters) and unknown others.

Experiment II (control): The same age comparison experiment between unknown others and unknown others.

These experiments followed other important experiments pertaining to the estimation of subjective age [1]-[4].



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### A. Participants

Experiment I and II were conducted with 19 people of Japanese descent (9 males and 10 females). Each participant was between 25 and 54 years old, and had brothers or sisters. (The absolute value of age difference of participants and brothers/sisters was 5.3 years, on average.).

### B. Stimuli

Stimuli in the experiments were facial images of unknown others, which were all adults between 20-59 years of age. The same number of facial images was prepared for each gender. These facial images were classified in 5-year increments. Each classification included at least 15 facial images for each gender. Figure 3 shows a sample of the facial images used. Then, each participant in the experiment prepared well-known others' (brothers and sisters) facial images. All facial images were prepared to 300×350 pixels using a digital system, and saved as full-color images.

To collect facial images easily, no special conditions for shooting and lighting were set; this policy is consistent with the collection of facial images in our previous research. In this study, we prepared more than enough facial images to complete the experience (i.e., more than 250 images of Japanese faces, which was 3-4 times the amount needed). We then chose facial images at random to make the influence by using various facial images taken under different conditions, at a minimum.

Also, to avoid influence from the time and cultures, we attempted to renew the stock of facial images render such influence minimal. We avoided using facial images taken several years ago, or that tended to receive biased evaluation from participants.

Furthermore, the facial images of brothers and sisters were used as unknown other facial images for other participants to maintain balance in the number of images used for each participant.

Fig. 3. Example of facial images

### C. Procedure

Regarding Experiment I, 3 groups of unknown others' facial images were selected at random as the images of comparison according to the following classifications: A) same age group to which participants' well-known others (brothers and sisters) belonged, B) older age group, and C) younger age group compared with the actual age group of well-known others (brothers and sisters). In total, 5 facial images per age classification group × 3 (age classified groups) × 2 (gender) = 30 total facial images selected for comparison.

The facial images of well-known others and one of an unknown other were selected at random for comparison and put side-by-side in a computer (PC) display. Then, participants were asked to evaluate which images looked younger or older using 5 ratings. Figure 4 shows the computer display of this evaluation system. We conducted this method for each comparison of facial images, and obtained a total of 30 evaluation values per participant.

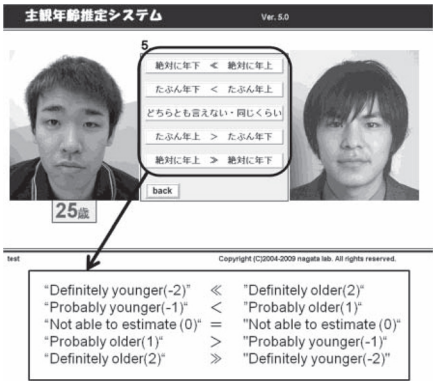


Fig. 4. An example of the choice screen of the estimation system

For Experiment II, we selected 5 unknown others' facial images which were of the same gender and ±2 years' age difference of the participants' well-known others.

Next, among 30 unknown others' facial images of the same age as participants' well-known others, we selected 25 facial images as comparison facial images. Five facial images were already selected as standard facial images.

One unknown other facial image from 5 standard images and 25 comparison images were selected at random, then, made 25 pairs of unknown other facial images. Furthermore, from 5 standard facial images, we selected 2 images at random, and made 5 pairs of standard facial images.

In the PC display, these pairs of facial images were set and showed side-by-side. Participants were then required to evaluate which facial image looked older or younger using 5 rating criteria. Participants made 30 individual evaluations (25+5). The reason we arranged 5pcs of standard unknown other facial images was to prevent imbalanced evaluation of the standard facial images.

During these two experiments, actual ages were indicated at the bottom of the well-known others' facial images in Experiment I and the standard unknown facial images of Experiment II (when comparing an image to the standard facial images, the subject's actual age was indicated at the bottom of one of the facial image, which was much closer to the actual age of the participant's brother or sister). This eliminated the difference between Experiment I and Experiment II; for example, the participants knew the actual age of well-known others in Experiment I, but they did not know the actual age of standard facial images.

### D. Analysis

Evaluation data consisted of pairs of actual age difference (Experiment I: comparison images - well-known others' facial images; Experiment II: comparison images - standard images) and the evaluation value for facial images, which was calculated from evaluation value rating points, such as "definitely older (2)", "probably older (1)", "unable to estimate (0)", "probably younger (-1)" and "definitely younger (-2)."



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These were rated based on whether they were well-known others' facial images or standard facial images.

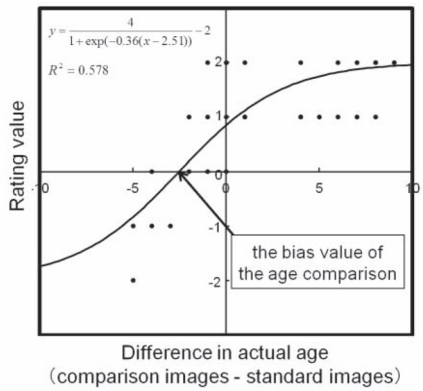
As was the same in our method for the subjective age quantification, we plotted these results on a two-dimensional grid with the x-axis as the difference in actual age and the y-axis as the evaluation value. Then, we applied a non-liner regression analysis for the distribution of each participant (30 evaluation points per participant) using the logistic function. Figure 4a shows the result.

The logistic function of this study converged at a rating value of 2 or -2, therefore, we assumed following the mathematical formula;

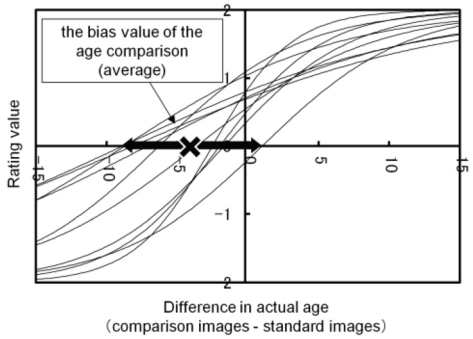
$$y = \frac{4}{1+\exp(-a(x-b))} - 2 \quad (1)$$

Here, parameter a) is the slope of the curve, and parameter b) is the zero crossing point in the approximation curve with the x-axis.

By a nonlinear regression analysis, parameter a) and b) are estimated, then, we defined parameter b) as "the bias value of the age comparison" of well-known others facial images or standard facial images.




(a) An example of non-liner regression analysis (each dot shows evaluation value and the curve shows the approximate results by the logistic function.)




(b) Calculation of the bias value of the age comparison of 10 participants

Fig. 5. Calculation method of the bias value of the age comparison

Figure 5b depicts the calculation results of the bias value of the age comparison for 10 participants.

The data with extreme low value of multiple coefficient of determination in the estimated regression curve was removed as an outlier (R2 < 0.1) at first, then, we calculated average value and standard deviation from the rest of the data (Experiment I : 19 participants, Experiment II: 19 participants).

The reason we applied the logistic function for the approximate model is that it is possible to directly calculate the same age that the participants estimated as parameter b). This is the definition of the bias value, and it is the zero crossing point for older and younger estimation. The outlier was extracted using multiple coefficient of determination.

### *E. Result and Discussion*

Table I and Figure 6 show the results of the age comparison experiments between facial images of well-known others (brothers/sisters) and facial images of unknown others (Experiment I), and between unknown others' facial images (Experiment II).

TABLE I. STATISTICS ASSOCIATED TO THE EXPERIMENTS I AND II. ('M', 'SD' AND 'N' REPRESENT MEAN OF THE BIAS VALUES OF SUBJECTIVE AGE, STANDARD DEVIATION AND THE NUMBER OF PARTICIPANTS, RESPECTIVELY)

| | Experiment I | Experiment II |
|---|---|---|
| *M* | -3.87 | -1.95 |
| *SD* | (3.39) | (2.12) |
| *N* | 19 | 19 |

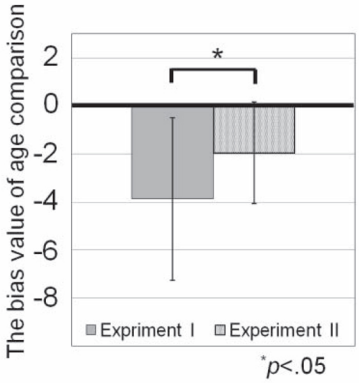



Fig. 6. The bias values of the age comparison in the experiment I and II

To examine whether the difference between the experimental methods affected the bias values, a one-way factor analysis of variance ANOVA, a method of statistical hypothesis testing to determine the effect of the factor was performed by using the experimental methods as a factor and the bias value of age comparison as a dependent variable.

The ANOVA revealed a significant main effect of the experimental method ($F [1, 21] = 6.83$, $p < .05$), which was the simple effect of the factor on the dependent variable.

This result indicates the tendency toward identifying the facial images of well-known others as younger, compared to the facial images of unknown others. That is, it was confirmed that the accumulated memory of well-known faces pulled the images of well-known facial images or the images of age toward the younger direction. The results obtained in this study are consistent with the hypothesis that predicted that the



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accumulated memory of one's own face caused the younger identity of the subjective age.

On the other hand, in Experiment II, the tendency toward younger identity itself was also observed in the age comparison between unknown others' facial images. According to our hypothesis, it was expected that the effect of the delusions caused by the accumulated memory would have no effects regarding the age comparison between unknown others' facial images; thus, there would be no tendency toward younger identity.

This unexpected result suggests the possibility of other factors for younger identity; however, the result could be caused by the method of the experiment, in which information included within experimental stimuli differed between the standard facial images and the comparison facial images: the former included age information.

To investigate this possibility, we conducted additional experiments. The details of these experiments are described in the next chapter.

## IV. AGE COMPARISON EXPERIMENT 2 *(ADDITIONAL)*

The purpose of this experiment was to examine the factor that caused the bias value in the age comparison experiment between unknown others' facial images, as mentioned above. Based on the method of Experiment II, we conducted the following two experiments, in which the information included in the standard facial images was manipulated:

[Experiment III] Facial-image-based age comparison experiment between unknown others without labels of age indications for the standard facial images.

[Experiment IV] An age comparison experiment between un-known others' facial images and the standard stimuli consisted of labels of age indications only.

If the bias values in the age comparison between unknown others were induced by labels of age indications added to the standard facial images, the bias values were observed only in Experiment IV, but not in Experiment III.

We would now like to discuss the experiments in detail.

### A. Participants

Experiments III and IV were conducted with 12 (3 male and 9 female) and 13 (3 male and 10 female) participants, respectively, all of whom were Japanese. All of the participants were between 25 and 54 years old.

### B. Stimuli

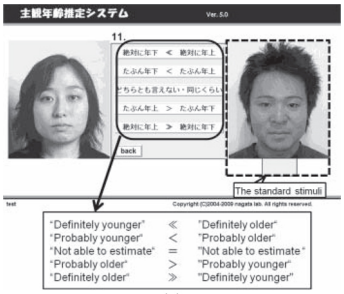
The stimuli used in the experiments were facial images identical to those used in Experiments I and II.

### C. Procedure

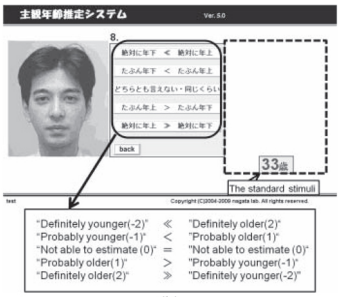
The selection procedure of facial images was the same as in Experiment II, and the only difference from Experiment II was in the display methods of the standard stimuli. To examine the relationship between bias value and labels of age indications, only unknown others' facial images were displayed as the standard stimuli in Experiment III, and only labels of age indications in Experiment IV (Figures 7a and 7b). Then, the participants were required to evaluate whether the comparison images looked younger or older than the standard stimuli by five-point scale rating.

### D. Results and Discussion

Table II and Figure 8 show the results of the age comparison experiments in Experiments III and IV. The bias value observed in Experiment III was close to 0, and there was a negative bias value in Experiment IV. Given these results, it is considered that the negative bias value in Experiment II arose from the influence of the labels of age indications.




(a)




(b)

Fig. 7. The standard stimuli used in the experiment III (a) and IV (b)

To examine the influence of labels of age indications on the bias value, a one-way factor ANOVA was performed by using the experimental methods, including Experiment II as a factor and the bias value of age comparison as a dependent variable. The ANOVA revealed a significant difference between the Experiments II and III, and between Experiments III and IV (all $p < .01$). This finding suggests that the bias value observed in Experiment II was caused by labels of age indications added to the standard facial images.

The reason why labels of age indications affected the bias values could be explained as follows: When labels of age indications were presented, participants might imagine people whose ages were close to the labels of age indications, and they utilized those imagined people as the standard for age comparison. Because these images consisted of accumulated memories pertaining to acquaintances, a tendency toward a younger identity arose. Then, the comparison images were rated relatively older than the standard stimuli.

Furthermore, the fact of the bias value in Experiment I being significantly stronger than in Experiment II would be



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caused by the strengthened effect of the delusions caused by the accumulated memory. Because the well-known others introduced in Experiment I consisted of the closest family member — the brother/sister of the participant — the accumulated memories about them were established on a very long time scale. Therefore, the effect of the delusions caused by the accumulated memory for well-known others was stronger than the effect for imagined people evoked by labels of age indications.

TABLE II. STATISTICS ASSOCIATED TO THE EXPERIMENTS III AND IV. ('M', 'SD' AND 'N' REPRESENT MEAN OF THE BIAS VALUES OF SUBJECTIVE AGE, STANDARD DEVIATION AND THE NUMBER OF PARTICIPANTS, RESPECTIVELY)

| | Experiment III | Experiment IV |
|---|---|---|
| *M* | -0.40 | -3.15 |
| *SD* | (2.31) | (3.21) |
| *N* | 12 | 13 |

## V. GENERAL DISCUSSION

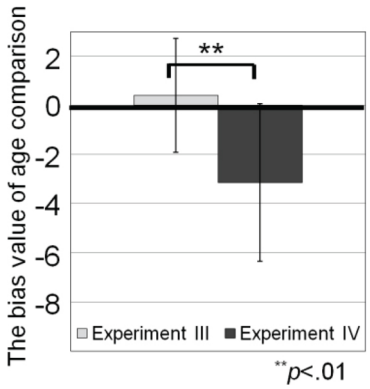


Fig. 8. The bias values of the age comparison in the experiment III and IV

In Experiments I and II, to examine younger identity associated with well-known others' faces by observing the effects of delusions caused by the accumulated memory of faces, we conducted an experiment that involved relative age comparison. This experiment confirmed that a stronger tendency toward younger identity occurred in association with well-known others' faces.

On the other hand, in the experiment on age comparison between unknown others' faces, it was confirmed that younger identity occurred more strongly than we had expected. From the results of Experiments III and IV, it was assumed that younger identity associated with the standard facial images was incurred due to the influence of the labels of age indications on facial images.

The reason for this effect was that the facial images based on the memory produced in the process of looking at labels of age indication were used for age comparison. However, such facial images came from the participant's own previous memories; thus, an effect of delusion was caused by the accumulated memory.

From these explanations, to examine the factor of delusions caused by the accumulated memory of well-known others' faces, it is appropriate to compare the results between Experiments I and III. In Experiment I, the younger identity occurred to a great degree, compared with Experiment III. Then, it was confirmed that a younger identity-the result of the effect of delusions caused by the accumulated memory-also occurred with respect to well-known others.

In the results of Experiments I and II, a significant difference occurred. It was assumed that if the participants had long-term memories of their own brothers/ sisters, then such accumulated memories caused a strong effect of delusions.

## VI. CONCLUSIONS

In this study, we conducted experiments on relative age comparison between the faces of well-known others (own brothers/sisters) and the faces of unknown others (Experiment I); as well, a relative age comparison experiment between the faces of unknown others (Experiment II) was conducted, and we discussed the effects of delusions caused by the accumulated memory of facial images considered as one of the factors of a younger identity.

As a consequence, we found a tendency toward identifying the facial images of well-known others as being younger, compared to the facial images of unknown others. Similarly, we found a tendency toward identifying standard facial images as being younger in a relative age comparison experiment between unknown others' faces. The results from additional experiments (Experiments III and IV) suggested, however, that the manipulation of age information caused the tendency toward younger identity of standard facial images.

On the whole, the results of this study suggest that the tendency toward younger identity confirmed in the previous studies on subjective age is also found in the case of facial images of well-known others. These results are consistent with our hypothesis that a younger identity is influenced by the effect of delusions associated with the accumulative memory.

In future works, it would be important to increase the number of samples. We could thereby examine the influence of age-group and gender of participants and of well-known others' faces. Moreover, it is necessary to examine in particular the relationship with sociopsychological parameters pointed out as one of the factors of a younger identity, for example, as by including participants of other nationalities in the study.

Finally, we will address the challenge of development of a method to measure the effects of delusions caused by the accumulated memory not of well-known other' faces, but of one's own face.

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