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Article

Perception of Human Age from Faces: Symmetric Versus Asymmetric Movement

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Abstract: Dynamic movements of a face affect human perception of a person's identification, emotional expression, speech, and so on. Findings of studies related to age perception, however, have mainly been obtained from static features of texture such as wrinkles and spots on the skin. Our goal is to investigate the perception of human age related to dynamic information. Systematically manipulated bilateral symmetric and asymmetric facial movements were utilized as stimuli in the age perception experiment. All images were low-pass filtered so that the judgment would not depend on detailed texture information. In the experiment, viewers judged the age level (the first half (indicating 20–24 and 60–64) or the latter half (indicating 25–29 and 65–69) of two age groups: 20's and 60's. Results revealed that faces with symmetric dynamic movements of expression (from a neutral face to one pronouncing "*i*") were not only judged at the level of chance, but were also perceived to be statistically significantly younger than faces with asymmetric dynamic movements. It was also found that types of asymmetry were also effective in age perception, which might be a reflection of laterization of facial processing in a human brain.

Keywords: facial age perception; symmetry or asymmetry of motion; lateralization; dynamic facial expression

1. Introduction

Human faces always change due to motions such as facial expressions, blinks, and so on, and are likely to become somewhat temporarily asymmetric. From an ecological point of view or a developmental point of view, it can be said that a person who appears to have retained high facial symmetry is likely to have grown up in an environment with minor distortion elements in life [1]. Distortion of engagement, for example due to poor nutritional habits or abandonment of tooth treatment, or excessive load to the left or right of another body part, may be considered to gradually generate distortion of the face, including bones and muscles [2,3]. Penke et al. [4] measured the fluctuating asymmetry (FA) from facial images and indicated that FA can be a good marker for the common cause of differential senescence. In addition, Kurosumi and Mizukoshi [5] applied PCA (a principal component analysis) for facial shapes three dimensionally in different age groups and found that changes of facial shape in older people were an increased volume of the lower cheeks and around the chin, sagging skin, and jaw distortion. This distortion around lower side of a face may become key indicators for human perceivers to judge facial age.

Many psychological or other scientific studies have revealed that, in general, symmetric faces are perceived as attractive [6–8]. Considering that nutritional habits are related to symmetry as described above, body and face symmetry can be indicators of a person's wealth and may be highly related to human mating behavior as animals. For example, Burt and Perrett [9] utilized chimeric faces, constructed from different sources bilaterally, with different expressions, genders, ages, attractiveness, and during speech. Their results and other studies which they referenced suggested that there are perceptual biases for the left side of a face (from the viewer's perspective) on age, gender, and expression judgments. Interestingly, the left hemisphere of the brain (viewing more on the right side of a face) seems to predominate during the processing of facial information about speech (lip-reading). In their study, however, there was no significant perceptual bias on the lateral side of a face for attractiveness. On the other hand, perceived ages should also be related to the physical attractiveness of people's faces; we tend to try to maintain youthful faces and many people (recently, not only women but also men) use cosmetics, aesthetic treatments, and relevant machines to do so. The effects, with or without cosmetics, in attractiveness judgments had also been discussed, for example, by Jones and Kramer [10,11]. Body symmetry is also related to attractiveness and females perceive men with highly symmetrical bodies as having good smells [12].

Facial age perception is well-studied based on textural characteristics on the face, such as spots and wrinkles [13–16]. According to previous studies, wrinkles are generally considered the most visible signs of facial aging and well-studied textural visible parts for age perception [17]. There have also be some discussions on own-race, own-gender, and own-age biases for age perception. On the other hand, there might be a possibility that faces look slightly older when they move bilaterally asymmetrically irrespective of facial texture. The majority of studies on symmetrical or asymmetrical faces have utilized static faces, but dynamic symmetry has not been systematically tested. The dynamic expression of emotions with the face is natural, and viewers receive perceptual cues such as symmetricities, on all types of judgments of the face. Consequently, our study focused on the relationship between dynamic facial symmetry and perceived age.

In order to investigate human perceptual sensitivity to asymmetric movement of faces, a preliminary experiment was conducted using the manipulation of a temporal delay of left or right facial movements. In addition, an experiment was conducted to investigate whether there is a difference in the estimated age group (in the first half indicating 20–24 and 60–64 years old, or the latter half indicating 25–29 and 65–69 years old) of each age group when presenting clear asymmetric and symmetric motions obtained in the preliminary experiment, respectively. Texture information on faces, including wrinkles and spots, are obvious signs of aging [9–11], so in the experiments, all faces were degraded by filtering so that texture information related to estimating ages, such as colors, spots, and wrinkles, were almost invisible during the stimulus presentations. Therefore, participants had to make an estimation of facial age relying only on dynamic information. If the asymmetric motion component of the face made the person look older, it is expected that the estimated age bracket will be higher even if texture information, such as spots and wrinkles, cannot be confirmed.

2. Materials and Methods for the Age Perception Experiment

2.1. Participants

Twenty-three university students were randomly chosen [18] and participated in this experiment as viewers. All the viewers were naïve to the experiment and had normal or corrected-to-normal visual acuity.

2.2. Stimuli

Dynamic stimuli that controlled the symmetry of the expression movements were used in this experiment. In a symmetry condition, both lateral sides of a face move simultaneously. On the other hand, in an asymmetric condition, either the left or right side of a face moves in advance compared to the other side. In the preliminary test, we confirmed a threshold of 50% in dynamic symmetry or asymmetry judgment, consisting of a 4-frame gap between the criteria and the delayed side. We made the gap in such a way that as the face movement was clearly asymmetric, subsequently, a longer duration of a 6-frame gap was adopted. See details in the Appendix A.

In the experiment, 32 female facial models (16 in each of the 20's and 60's groups) were used as stimuli. The latter faces were newly recorded for this experiment.

For the fundamental motion of stimulus creation, we used two original static faces which consisted of a neutral face (while closing mouth) at the start of one movie clip, and a facial image pronouncing "*i*," with the mouth corners moving upwards, making the face appear wider. Therefore, in the movie, the created facial motion appeared to be pronouncing "*i*" (looks somewhat like a smiling face; see a sample face in Appendix A, bottom-left of Figure A1a). Stimuli of lateral symmetric or asymmetric motions were created by moving both sides of a face simultaneously (symmetry condition) and a movement of the left/right half of a face was delayed as compared to the other side (asymmetry condition). See Appendix A for detailed creation of stimuli: initial image manipulations and creating dynamic symmetric and asymmetric faces. Each of the dynamic stimuli was presented for 1 sec, then immediately withdrawn after the presentation.

2.3. Procedures

In each age group, a 2AFC task was conducted, in which viewers were asked to select one of the age halves as soon as the dynamic stimulus was withdrawn. If a viewer perceived that a face was younger and belonged to the first half of a group (around 20 to 24 years old for 20's; around 60 to 64 years old for 60's) then they pressed "F" on a keyboard. If the viewer perceived that the face belonged to the latter half (25 to 29 years old for 20's; 65 to 69 years old for 60's) then they pressed "J." Responses were recorded via keyboard and saved.

The experiment was divided into two age-group sessions, since the models ages were either in their 20's or 60's in terms of age. In each session, 72 trials consisting of 24 models × 2 levels of asymmetry (with either L or R leading) or symmetry were performed. Symmetry trials were doubled so that the ratio of stimuli observed could be controlled; however, half of them were randomly assigned as targets for symmetry trials (used for analysis). The conditions of asymmetry were assigned as either L or R movement-in-advance facial halves. Please note that "L" means the left side of a model's face (right side from viewer's sight). If it was an L leading trial, the left side of the face moved in advance, then 6 frames later, the right side of the face (left side from viewer's sight) would start moving at the same speed. One hundred and forty-four trials were performed for both age group sessions for one viewer.

The experiment was performed in a dark room. The distance between the position of a viewer's eye and the display was 57.3 cm. This is in order to apply the calculation of standard human vision study. One degree in visual angle is obtained from the size of 1 cm as a stimulus on the display if the viewer's eyes are about 57.3 cm away from the display. MATLAB (The MathWorks Inc., MA, USA) and its Psychophysics ToolBox were used for stimuli presentation and for obtaining viewers' responses (answer and response time).

3. Results

The ratio of answering "latter half" of the target age group was calculated for each viewer. Response time data of over 2000 ms (from the end of movie) were excluded from the analysis as this was regarded as an extremely long duration taken to make a judgment. This criterion was adopted from the histograms of responses.

Figure 1 indicates the average ratio of conditions, symmetry (assigned as target), asymmetry L→R (left side of the model's face moves in advance), and asymmetry R→L (right side of the model's face moves in advance). As indicated in the figure, face symmetry was rated as 50% of the latter half (25 to 29 years old for 20's; 65 to 69 years old for 60's) in both age groups. In contrast, asymmetric motion induced a higher than 50% ratio.

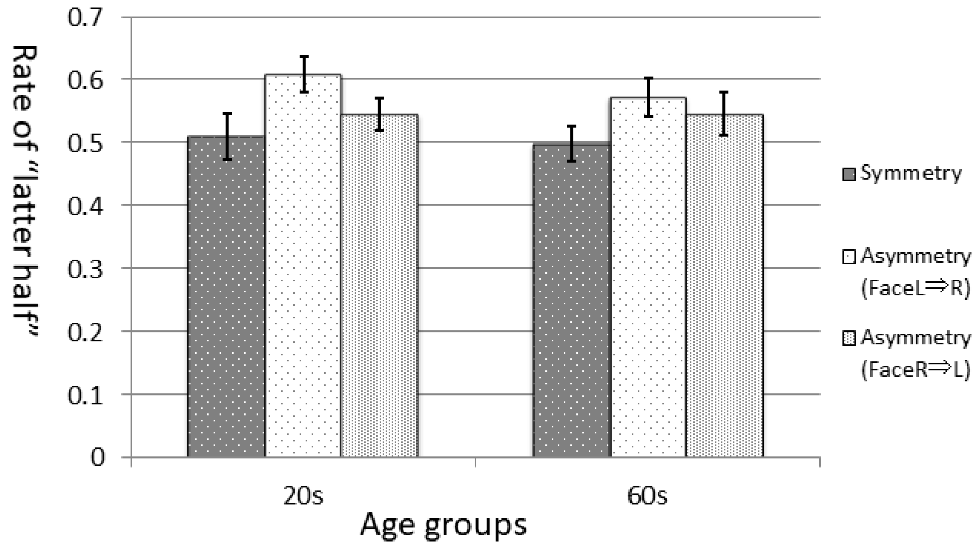

Figure 1. Average rate of "latter half" in each condition. The dark gray bar on the left in each age group indicates the average in terms of symmetry condition. The bright bar in the middle indicates asymmetry (the left side of the face moves first, and subsequently, the right side moves after a 6-frame delay). The grayish bar on the right in each age group indicates asymmetry (right to left).

A two-way ANOVA of age groups (2: 20s and 60s) and symmetry-types (3: symmetry, asymmetry-L→R, and asymmetry-R→L) was conducted for the subjects' average ratio of the latter half (25 to 29 years old for 20's; 65 to 69 years old for 60's) responses. The results revealed that there was a significant main effect of symmetry-types ($F(2,44) = 4.88$, $p = 0.012$, *partial* $\eta^2 = 0.182$), and multiple comparison by Bonferroni analysis indicated that asymmetric movement of L→R was higher than the symmetric one ($p = 0.031$); however, there was no significant difference between symmetric and asymmetric R→L ($p = 0.686$). It is also interesting to mention that there was a significant difference between the two types of asymmetries ($p = 0.019$). Some previous studies have revealed that there is a right hemisphere advantage in terms of face processing. Asymmetry of facial motion might also have lateral preferences because of the laterality of brain processing.

On the other hand, there was no significant main effect in terms of age groups ($F(1,22) = 0.371$, $p = 0.549$, *partial* $\eta^2 = 0.017$) and in the interaction between age group and symmetry-type ($F(2,44) = 0.531$, $p = 0.592$, *partial* $\eta^2 = 0.024$), proving that the role of temporal symmetry/asymmetry had the same level of sensitivity for both young and old facial features. This might be because all the images were degraded by filtering, subsequently displaying no or few spots or wrinkles on the face.

4. Discussion

In this study, we conducted experiments to investigate whether dynamic symmetry affects the perception of human age from faces. It was shown that dynamically symmetric faces were judged to be younger in each age group compared to faces with asymmetric movement.

At a glance, the perception of human age is highly related to texture information such as the density and numbers of spots and wrinkles in a human face [13–16]. The age difference within the age groups, such as early (20's) or late (60's) can be judged according to such texture information in advance. However, our results indicated that, in each age group, dynamic symmetrical motion is important for faces to be perceived as younger.

It is also worth mentioning that there might be differences regarding which side of the face moves faster, in other words, the effect of asymmetric movement differs laterally. Facial shapes are distorted in its symmetrical development by distortion of engagement due to poor nutritional habits or abandonment of tooth treatment, or excessive load to the left or right of another body part, and so forth [1–3]. Results of Burt and Perrett [9] and other studies using static faces suggested that there are perceptual biases for left side of a face (from viewer's perspective) on age, gender, and expression judgments. There seems general agreement of facial lateral movement showing that, during expressing emotion, a face moves left side more intensively than the right side. Therefore, viewers look at the right-side view of a face with higher intensity, or seeing it as more expressive than the left-side view [17,19]. Our results indicated that a face with a side movement of L→R (from a face's perspective, left side of a face moves first, then right side of a face follows, therefore the right side face moves in advance from the viewer's perspective) was judged as significantly older than one with a R→L movement. This condition is natural for human to perceive expressive faces. Note that the movement of asymmetry condition in our experiment was manipulated as sufficiently higher than perceivers' threshold of detecting asymmetry of a face (6 frames gap between left side and right side). In daily communication, people might be naturally viewing faces with their somewhat asymmetries as approximately symmetric. Nevertheless, if the dynamic asymmetry is too strong, it would be detected as asymmetric, then being judged as an elder face than a symmetric or weak asymmetric (not noticeable) one.

We speculate this tendency might be stronger for the 20's group (and the actual average rate for asymmetrical L→R movements in the 20's age group was the highest in all conditions). The left side of a person's face generally moves smoothly and expressively [17,19]; consequently, it can be outlined as indicating that humans notice asymmetric L→R movements in daily life. On the other hand, if the face moves R→L then it is unnoticeable and the gap between the L and R side of a face is ignored. Our results may indicate that humans' sensitivities of lateral symmetry/asymmetry for faces are affected by such a tiny temporal gap and the perceived symmetricity influences age perception.

The facial databases we used are both having only female models so all the faces which were presented as stimuli were only females so far. We think it is necessary to expand our research focus to male faces in near future.

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Appendix A Image and Dynamic Stimuli Creation

A.1. Initial Image Manipulations

Before applying dynamic stimuli, some static image manipulations were undertaken for all the static facial images. The necessary manipulation steps were as follows.

1. For each face image, the position was normalized so that the vertical axis, which roughly defines facial symmetry (the center line of the face from the middle of both eyes to the chin through the nose tip), was a vertical (Image A; see Figure A1a). During the stimuli creations, all the images were processed in 512 × 512 pixels.
2. A mirror reversed image of each image of Image A was created. (Image B; Figure A1b)
3. In Image A and B, facial features such as eye, mouth, nose, and so on, were landmarked (using FUTON system (ATR Promotions Inc.) [20,21]), and were morphed to be 50% of each other. (Image S; Figure A1c). This manipulation makes the face area appear perfectly symmetric. The system can be used by selecting the area to be morphed by target features; all other areas other than the facial parts (such as hairstyles) were maintained as indicated in Image A. The XY coordinates on the image of the landmarks, such as "right lip corner" and "top of the nose," were all saved and used in the subsequent movie making step.

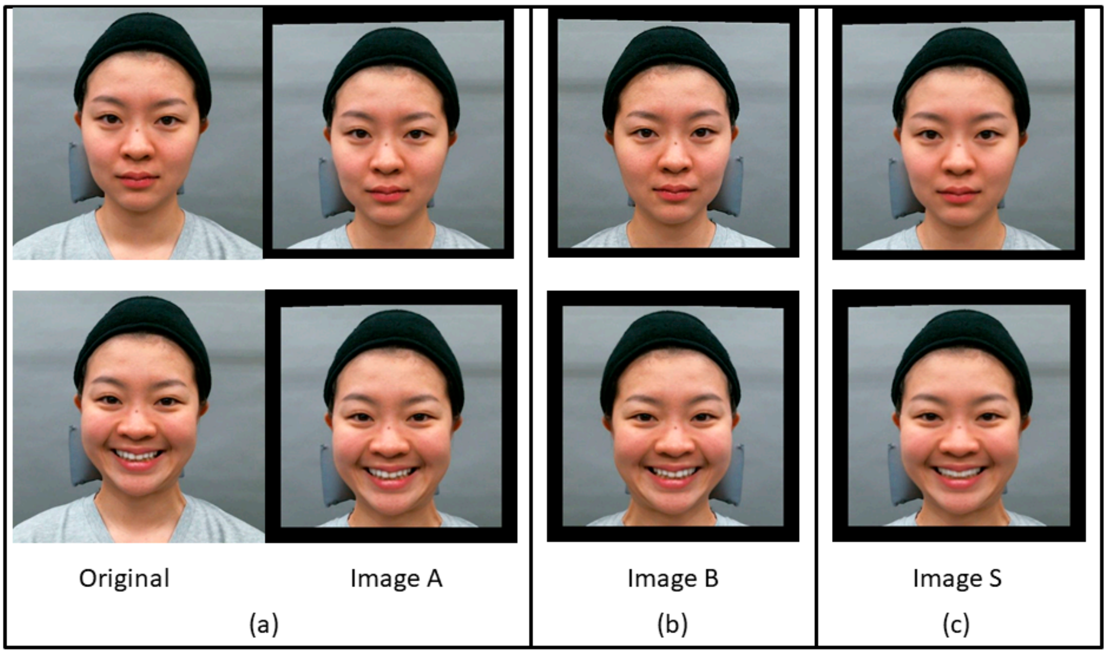

Figure A1. Initial image manipulations. (**a**) Original faces of neutral (top) and pronouncing "*i*" in normalized positions (Image A); (**b**) mirror reversed images of Image A; (**c**) morphed images of Image A and Image B as perfectly symmetrical faces.

- Note that the face model shown in this article was recorded in the same situation as the ones used in experiment 1; however, they are not from JAFFE [22] nor have we used the same faces in our experiments.

A.2. Creating Dynamic Faces of Symmetry and Asymmetries

After the initial steps of image manipulation as mentioned above, symmetric and asymmetric dynamic stimuli were created. Figure A2 shows the continua of morphed symmetric images. The neutral face had a 0% morphing rate, and it was morphed at 100% while pronouncing "*i*." Morphing steps were 4% linear in all combinations. A total of 26 images were continuously presented as dynamic stimuli at a rate of 30 fps.

A.2.1. Preliminary Test for Threshold of Perceiving Asymmetry

After that, left or right-side movements of the face were delayed and combined to make a continuum with the steps of the alternative side of the face. For example, if the left side of a face was defined as the criteria, the right side of the same face would start moving in a temporarily delayed timing of 6 frames. In the preliminary test, 6 models were selected from the JAFFE database [22] and their neutral and happy expressions were used as the starting and finishing faces, respectively. Other than that, image creation and visible areas of faces in this preliminary experiment were almost the same as the condition of our age perception experiment. The delay time was adjusted by one frame (1/30 ms) step, from 1 clip to a maximum of 10 clips. If one half of the face was raised to 100%, the same state was maintained until the movie came to an end (total presentation time of 1000 ms). In this preliminary test, the presented participants' faces were judged on whether they moved asymmetrically or almost symmetrically. We classified the items of selection as "almost" symmetric, since the face itself is quasi symmetric and if not, we were concerned that the viewers might be more sensitive of symmetric judgements compared to asymmetric judgments.

We found that at a certain threshold (50% symmetry) we were able to notice asymmetry in the gap at approximately 4 frames. Consequently, we adjusted the gap in such a way that the asymmetric movements of the face were clear; subsequently, a longer gap duration of 6 frames was adopted.

A.2.2. Dynamic Stimuli Creation for the Age Perception Experiment

In the age perception experiment, 32 female facial models (16 in each of the 20's and 60's groups) were used as stimuli. The faces were newly recorded for this experiment. In the asymmetric movements in the age perception experiment, the delayed time was only 6 frames since we obtained the criterion of human threshold to perceive asymmetry of a face.

The precise explanation for creating dynamic asymmetries is as follows;

1. Using Photoshop CS 5 (Adobe Inc.), right and left asymmetric images were created by combining left and right halves of images with different rates of change for each model. The left or right asymmetric images were combined with the left-right symmetric images. However, the images, at this time, were clearly unnatural since the contours and transitions on the left and right were sometimes visible. Therefore, for each stimulus, all images were low-pass filtered (each pixel was averaged in 21×21 pixel size which was approximately 7.8% of visible face width, 272 pixel).
2. Facial areas were cut into ellipse shapes so that the areas unrelated to the face perception could be invisible. The ellipse size was 272 pixels horizontally and 350 pixels vertically. The center of the ellipse was set as the mid-point of each image.
3. All the 30 facial images, including 26 changing from neutral to smiling or pronouncing "*i*" and some 100% images, were presented in a continuum of 30 fps, and the presentation time of one video clip was 1000 ms in total.

The sample images of the continua are listed in Figure A3. Frames 0, 10, 20, and 30 were shown in each continuum for L→R symmetry and asymmetry. You can see the differences in frame 10 and 20 in the continua.

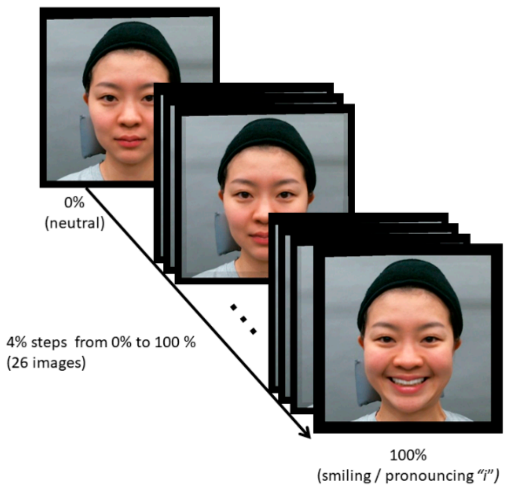

Figure A2. Dynamic symmetry clips before filtering and ellipse cut.

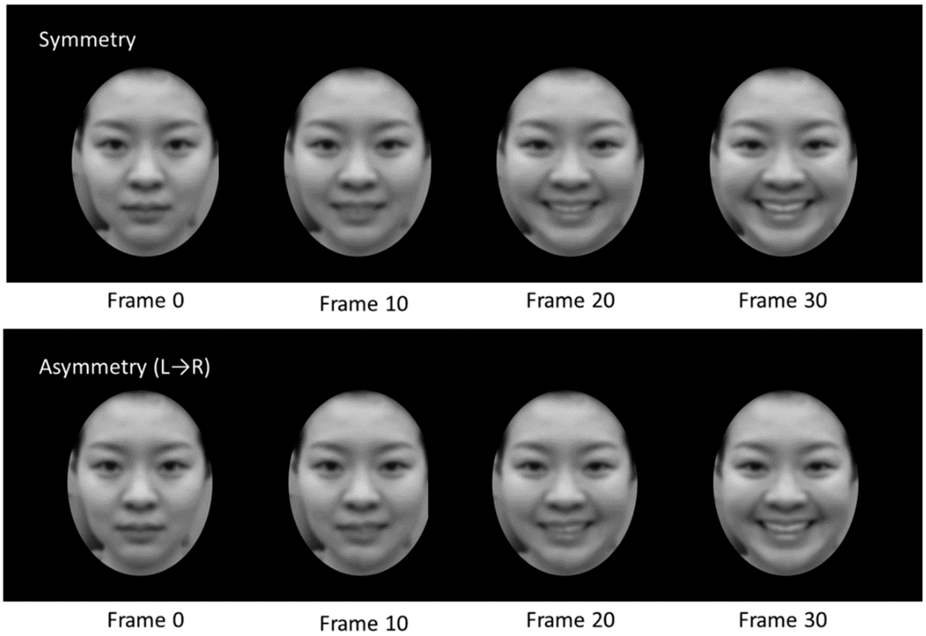

Figure A3. Sample image clips of symmetry (upper frames) and asymmetry (left-side movements in advance, lower frames). Images were selected from each continuum as shown in frame numbers 0, 10, 20, and 30, respectively.

References

1. Özener, B.; Fink, B. Facial symmetry in young girls and boys from a slum and a control area of Ankara, Turkey. *Evol. Hum. Behav.* **2010**, *31*, 436–441. [CrossRef]
2. Little, A.C.; Paukner, A.; Woodward, R.A.; Suomi, S.J. Facial asymmetry is negatively related to condition in female macaque monkeys. *Behav. Ecol. Sociobiol.* **2012**, *66*, 1311–1318. [CrossRef]
3. Gangestad, S.W.; Merriman, L.A.; Emery Thompson, M. Men's oxidative stress, fluctuating asymmetry and physical attractiveness. *Anim. Behav.* **2010**, *80*, 1005–1013. [CrossRef]
4. Penke, L.; Bates, T.C.; Gow, A.J.; Pattie, A.; Starr, J.M.; Jones, B.C.; Perrett, D.I.; Deary, I.J. Symmetric faces are a sign of successful cognitive aging. *Evol. Hum. Behav.* **2009**, *30*, 429–437. [CrossRef]
5. Kurosumi, M.; Mizukoshi, K. Principal component analysis of three-dimensional face shape: Identifying shape features that change with age. *Skin Res. Technol.* **2018**, *24*, 213–222. [CrossRef] [PubMed]
6. Little, A.C.; Jones, B.C. Evidence against perceptual bias views for symmetry preferences in human faces. *Proc. R. Soc. Lond. B Biol. Sci.* **2003**, *270*, 1759–1763. [CrossRef] [PubMed]
7. Jones, B.C.; Little, A.C.; Penton-Voak, I.S.; Tiddeman, B.P.; Burt, D.M.; Perrett, D.I. Measured facial asymmetry and perceptual judgements of attractiveness and health. *Evol. Hum. Behav.* **2001**, *22*, 417–429. [CrossRef]
8. Scheib, J.E.; Gangestad, S.W.; Thornhill, R. Facial attractiveness, symmetry, and cues of good genes. *Proc. Biol. Sci.* **1999**, *266*, 1913–1917. [CrossRef] [PubMed]
9. Burt, D.M.; Perrett, D.I. Perceptual asymmetries in judgements of facial attractiveness, age, gender, speech and expression. *Neuropsychologia* **1997**, *35*, 685–693. [CrossRef]
10. Jones, A.L.; Kramer, R.S.S. Facial cosmetics and attractiveness: Comparing the effect sizes of professionally-applied cosmetics and identity. *PLoS ONE* **2016**, *11*, e0164218. [CrossRef] [PubMed]
11. Jones, A.L.; Kramer, R.S.S. Facial cosmetics have little effect on attractiveness judgments compared with identity. *Perception* **2015**, *44*, 79–86. [CrossRef] [PubMed]
12. Rikowski, A.; Grammer, K. Human body odour, symmetry and attractiveness. *Proc. R. Soc. B Biol. Sci.* **1999**, *266*, 869–874. [CrossRef] [PubMed]
13. Burt, D.M.; Perrett, D.I. Perception of age in adult Caucasian male faces: Computer graphic manipulation of shape and colour information. *Proc. Biol. Sci.* **1995**, *259*, 137–143. [CrossRef] [PubMed]
14. Mark, L.S.; Pittenger, J.B.; Hines, H.; Carello, C.; Shaw, R.E.; Todd, J.T. Wrinkling and head shape as coordinated sources of age-level information. *Percept. Psychophys.* **1980**, *27*, 117–124. [CrossRef]

15. Nkengne, A.; Stamatas, G.; Bertin, C. Facial skin attributes and age perception. In *Textbook of Aging Skin*; Springer: Berlin/Heidelberg, Germany, 2010; pp. 973–980. ISBN 9783540896555.
16. Chellappa, R.; Wilson, C.L.; Sirohey, S. Human and machine recognition of faces: A survey. *Proc. IEEE* **1995**, *83*, 705–741. [CrossRef]
17. Lindell, A. Lateralization of the expression of facial emotion in humans. *Prog. Brain Res.* **2018**, *238*, 249–270. [CrossRef] [PubMed]
18. Shang, Y. Subgraph Robustness of Complex Networks Under Attacks. *IEEE Trans. Syst. Man Cybern. Syst.* **2019**, *49*, 821–832. [CrossRef]
19. Mandal, M.K.; Ambady, N. Laterality of facial expressions of emotion: Universal and culture-specific influences. *Behav. Neurol.* **2004**, *15*, 23–34. [CrossRef] [PubMed]
20. FUTON System, ATR Promotions Inc. Available online: https://www.atr-p.com/products/futon_w.html (accessed on 9 May 2019).
21. Kamachi, M.; Bruce, V.; Mukaida, S.; Gyoba, J.; Yoshikawa, S.; Akamatsu, S. Dynamic properties influence the perception of facial expressions. *Perception* **2001**, *30*, 875–887. [CrossRef]
22. Lyons, J.; Akamatsu, S.; Kamachi, M.; Gyoba, J. Coding Facial Expressions with Gabor Wavelets. In Proceedings of the Third IEEE International Conference on Automatic Face and Gesture Recognition, Nara, Japan, 14–16 April 1998; pp. 200–205. [CrossRef]