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Influence of age-independent facial traits on adult judgments of cuteness and infantility of a child's face

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Abstract

Traits that are characteristic of children's faces make a face appear to be cute. Therefore, infantile facial features have been considered a trigger for care-giving behavior. However, few studies have investigated the effect of age-independent traits of a child's face on adult preferences for a child. In this study, ninety-six Japanese undergraduates and ninety-six preschool children provided the facial images used in this study. We divided children's facial variations into age-related and age-independent traits using methodologies of geometric morphometrics. The age-independent variations were summarized using a principal component analysis. The facial pictures corresponding to theoretical values from −3SD to +3SD along with both the age-related dimension and age-independent principal components were made by warping the average facial texture of the children's faces. A pairwise comparison method was used to investigate the relationship between cuteness/infantility and facial shape differences along with the age-related and age-independent components using the facial pictures. The results suggest that an evaluation of a child's cuteness depends on both age-independent and age-related facial features.

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Keywords: Cuteness; Baby Schema; Geometric Morphometrics.

1. Introduction

Human faces transmit a variety of information, such as gender, individual identity, emotions, averageness, and age. A number of studies have shown how facial morphological traits affect social responses to a face. Facial averageness and symmetry have been considered cues in determining facial attractiveness [1, 2]. Sexual dimorphic facial traits are used as indices of sexual maturity and reproductive potential [3]. Several theorists have claimed that these facial traits are related to judgments of the biological quality of an individual as a sexual mate [3, 4].

On the other hand, facial traits that are characteristic of children's faces are associated with parental care of the child. Such physical traits are referred to as "baby-schema" ("Kindchenschema"): a protruding forehead, large head, round face, big eyes, and a small nose or mouth. These traits make a face appear cute and lovable. Consequently, such tendency is adaptive and enhances offspring survival [5-7]. The ethologist Konrad Lorenz hypothesized that infant facial features evolved to elicit parental care in adults [8].

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The behavioral effects of baby schema have been experimentally confirmed with line drawings of faces [9] and naturalistic photographs of faces [10-12]. The effect of baby schema is not limited to the infancy period. Cranial-facial structures undergo gradual transformations, rather than dramatic ones, during childhood [13]. Recently, Volk and his colleagues [14] used 12 children's photos at 8 different age points from 6 months to 6 years and found that adults preferred to select younger infants and rated them as cuter. These studies suggest that judgments regarding cuteness would continuously vary with respect to a child's age.

While many studies have pointed out the perceptual importance of age-related traits on the judgment of cuteness, little attention has been paid to the effect of age-independent traits of a child's face on adult preferences for a child. The present study investigates the effects of age-related (morphological infantility) and age-independent facial traits on perceived cuteness. If perceived cuteness is related to both age-related and age-independent features, judgments regarding cuteness are not equal to judgments about age. To extract age-related facial components and age-independent components from each photograph, we used a generalized Procrustes analysis (GPA), a methodology that converts shapes into normally distributed values that can be statistically analyzed [15], and that has recently been applied to psychological research on human faces [2,16]. The locations of facial landmarks in each photograph were measured and converted into a multi-dimensional vector using the children's average face as a starting point. Each facial vector was resolved into an age-related sub-vector (parallel to the adult-child axis) and an age-independent sub-vector (orthogonal to the age-related sub-vector). We examined the influence of both age-related and the age-independent facial traits on perceived cuteness and infantility using paired comparisons with photographs made by using thin plate spline (TPS) transformation technique [17]. Investigations designed to assess the effect of age-independent traits on facial cuteness have the potential to offer clues to understanding how facial preferences might arise.

2. Computational analysis of facial images

2.1. Materials

Japanese undergraduates (n = 96, 48 men and 48 women; age 18 to 26 years mean age = 20.88, SD = 1.70) and preschool children (n = 96, 48 boys and 48 girls; age 3 to 4 years, mean age = 3.98, SD = 0.55) provided the facial frontal images used in this study. A neutral expression of each face was captured using a digital camera. The foreheads of the models were exposed using a headband, after removing accessories such as eyeglasses.

Eighty facial landmarks were selected based on a previous study [18]. These landmarks consisted of morphological and functional points such as the pupils, contours of eyes, eyebrows, nose, and mouth, among others (Fig. 1). All landmarks were visually measured by the authors for each of the 96 photographs using a program written by the authors.

2.2. Facial shape standardization

Each face differed in location, size, and orientation. To standardize them, we performed a generalized Procrustes analysis (GPA) on the facial landmarks of all faces without regard to the gender and age of the facial owner. This method preserves information about the relative spatial relationships of landmarks throughout the standardization.

For the standardization of location and size, we used the centroid size technique [17]. All facial shapes were translated to the same origin (centroid) and scaled to the unit centroid size, which is the sum of the squared distances from the centroid to each feature point. For alignment of the orientation, rotations around the centroid of the faces were performed [15] to minimize the sum of the squared distances among corresponding feature points between samples (Fig 1.). The "Shapes" statistical package [15], which runs in an R statistical analysis environment, was employed for the analyses.

To exclude facial variations derived from facial asymmetries, in addition to the coordinates of original facial images, the mirror-reversed versions of the same images were used in the facial shape analysis. Through a GPA, each of the facial shapes and their mirror-reversed versions were represented as a point in a multi-dimensional space. The standardized "symmetrical version" of each individual was computed by averaging each face with its standardized mirror-reversed image based upon the coordinates in the multi-dimensional space. The resulting "symmetrical version" can be regarded as the mid-point between the original and its mirror-reversed face in the multi-dimensional. In this study, we refer to this space as "face space," see Fig. 2. As a result, each "symmetrical version" of the individuals was represented as a point on a linear space of 166 dimensions (x- and y-coordinates × 83 landmarks), which allowed us to treat the faces as multidimensional, normally distributed values.

2.3. Calculation of geometric infantility

The average adult face was computed by averaging the "symmetrical version" of the adult faces; the average child face is the average of the "symmetrical version" of the child faces. The axis that passes through both the average adult and the average child's face defines the axis of morphological infantility, along which age increases. The age-related features of each child's face can be given by projections of individual faces on the adult-child axis.

2.4. Plane orthogonal to the adult-child dimension

The remaining components (other than the age-related differences) of each child face represent age-independent facial characteristics from an average child face (Fig. 2): characteristics that are not related to facial growth. These remaining components of each child's face can be regarded as a multi-dimensional vector on a 165 dimensional (166-1) hyper-plane. Variations on the hyper-plane were summarized using a principal component analysis (PCA). The results of the PCA indicated that the contributions of the first two principal components (PCs) for the total variance were relatively large (PC1: 31.8%; PC2: 20.7%). The cumulative contribution ratio of both the adult-child component and principal components (up to the 2nd PC) was 64.9%. The first and second PC scores of average female and average male child's face were calculated (Table 1).

2.5. Facial image syntheses

To visualize the age-relevant and the age-independent facial shape differences of children's faces, facial deformations along adult-child dimensions and the principal components were calculated using thin plate splines transformation (TPS), which is a nonlinear image deformation technique. The process of using TPS in image warping involves minimizing a bending energy function for a transformation over a set of given landmark points.

Based on the distributions of children's facial shapes, the facial pictures corresponding to the theoretical values of -3SD, -2SD, -SD, average, +SD, +2SD and +3SD along adult-child axis and each principal component were made by warping the average facial texture of the children's faces. The color facial images were converted into grey-scale images (Fig. 3).

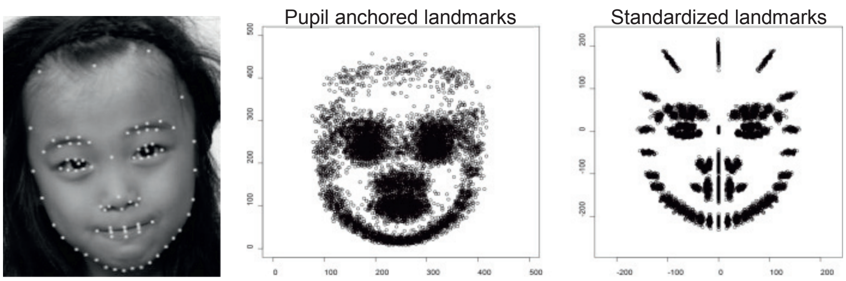

Fig. 1. Set of 80 facial landmarks and facial shape symmetrization and standardization

Table 1. Averaged principal component scores of male female children faces

	Male children	Female children
PC1	2.22	-2.22
PC2	-4.57	4.57

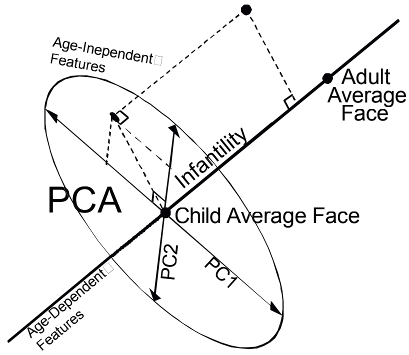

Fig. 2. Schematic illustration of "face space": The age-related features of each face can be given by projections of individual faces on the adult-child axis. The projections onto the hyper-plane, which is orthogonal to the adult-child axis, represent age-independent features.

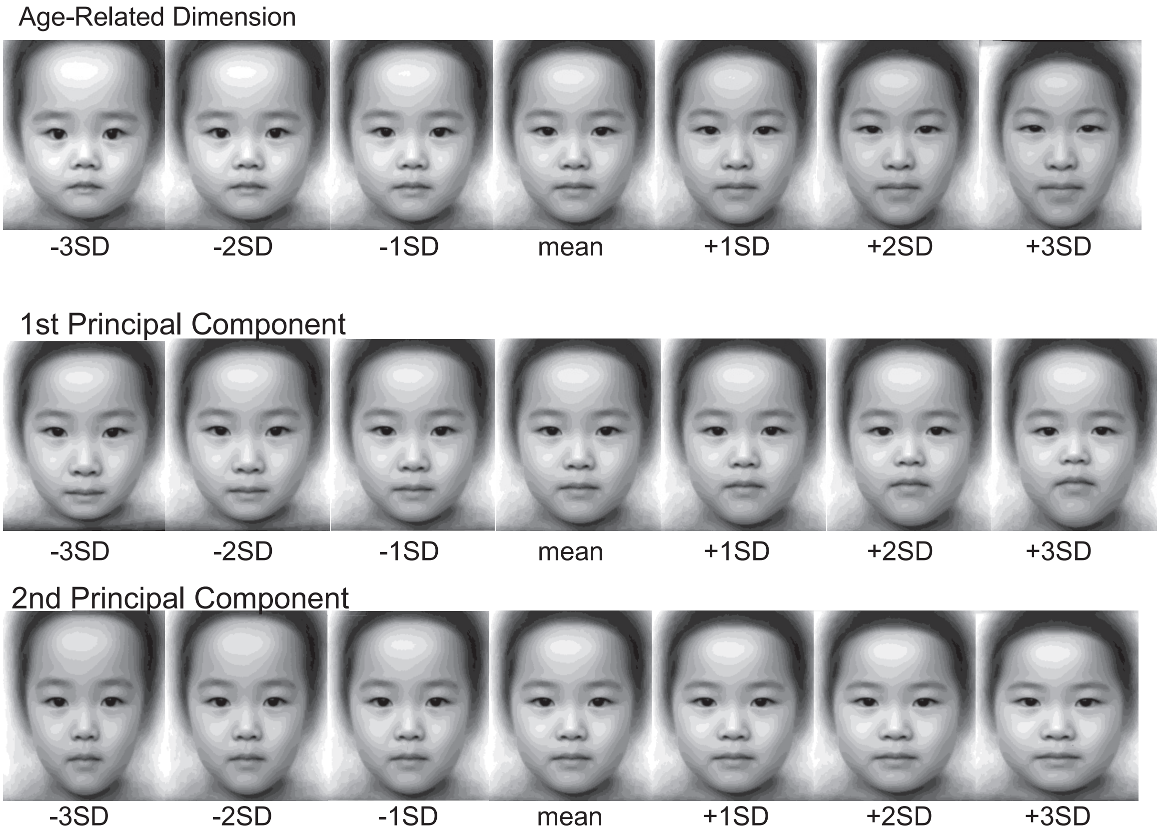

Fig. 3. Facial shape variations along the axis of infantility (age-related Features), the 1st principal component (age-independent features) and the 2nd principal component (age-independent features): The theoretical values of -3, -2, -1 SD, average, +1, +2, +3 SD.

3. Assessment of cuteness and infantility

3.1. Method

Fifty undergraduates (22 men and 28 women; age 18 to 20 years, mean age = 19.07, SD = 0.84) participated in the assessment of facial cuteness. Forty-eight undergraduates (21 men and 27 women; age 18 to 35 years, mean age = 19.56, SD = 3.12) participated in the assessment of facial infantility.

A pairwise comparison method was used to investigate the relationship between cuteness/infantility and the facial shape differences along age-related and age-independent components. In each trial, participants were presented with a sheet of paper on which a couple of facial images was printed and asked to judge which facial image was cuter/younger. The combinations of the seven images (-3SD, -2SD, -SD, mean, SD, +2SD and +3SD) were repeated twice, providing 42 pairs of images for each of three stimulus categories (age-related, the 1st PC (age-independent), the 2nd PC (age-independent)). The trials were self-paced and the order of the trials was counterbalanced across participants.

3.2. Results

The changes of perceived cuteness/infantility scores along the age-related axis were calculated using the Bradley-Terry Model. It is clear from Fig. 4 that infantility was a monotonically decreasing function of the age-related morphological changes. The cuteness score also shows a roughly decreasing function of the age-related changes. χ^2 tests revealed agreement between participant responses for both cuteness and infantility (cuteness: $\chi^2(15)= 225.78$, $p < .01$; infantility: $\chi^2(15) = 544.42$, $p < 0.01$).

The scores against the PC1 are shown in Fig. 5. If morphological differences were the only factor that determined perceived infantility, the contour of the infantility score would show a flat distribution. However, the infantility score follows a roughly inverted-U curve with a peak in +SD, suggesting that the distribution of infantility cannot be explained by age-related morphological traits alone. The cuteness score also followed an inverted U-shaped curve against PC1. However, the peak was in -SD, suggesting that perceived infantility is not the only factor in determining facial cuteness. In the case of PC2, both cuteness and infantility followed an inverted U curve with a peak in the mean (Fig. 6). χ^2 tests showed agreement between participant responses for both PC1 (cuteness: χ^2 (15) = 123.41, p<.01; infantility: $\chi^2$15) = 46.59, p<.01) and PC2 (cuteness: χ^2 (15) = 121.95, p<.01; infantility: χ^2 (15) = 55.04, p<.01).

4. Discussion

In accord with previous studies [9-12, 14], facial differences along the adult-child axis was established as a decisive factor in cuteness evaluations. The facial shape variation along the age-related dimension obtained in this study reflects the morphological differences of the roundness of face, size of eyes, nose and mouth that have been proposed as features of "baby-schema," indicating that the adult-child dimension was properly fixed by the procedure used in our study.

On the first PC of the age-independent dimensions, it was shown that the perceived cuteness followed an inverted U-shaped curve and peaked at -SD. This suggests that morphologically age-independent facial features affect perceived cuteness as age-related facial traits. On the other hand, the perceived infantility peaked at +SD against the first PC, suggesting that cuteness perception of a face does not completely depend upon perception of infantility traits.

This study assumed that the age-related axis corresponds to a single linear scale along which infantility decreases. However, it is possible that adult-child differences in facial shape are not only the result of bone growth caused by growth hormones, but are also caused by complex interactions between growth hormones and sex hormones. This suggests that the age-independent facial features linked to cuteness ratings may reflect morphological facial growth. However, on the first PC, the contour of the distribution of cuteness is different from that of infantility. Thus, the first PC cannot be regarded as dimensions linked to facial growth over time (and, thus, perceived age).

Our result implies that perception of facial cuteness reflects multiple processes. A possible explanation for the results is that perceptions of cuteness are affected by the facial masculinity or femininity of the child; i.e., feminized faces were rated as cuter. Further studies investigating the effects of facial sex-differences on the perceived cuteness should help clarify the discrepancy between infantility and cuteness.

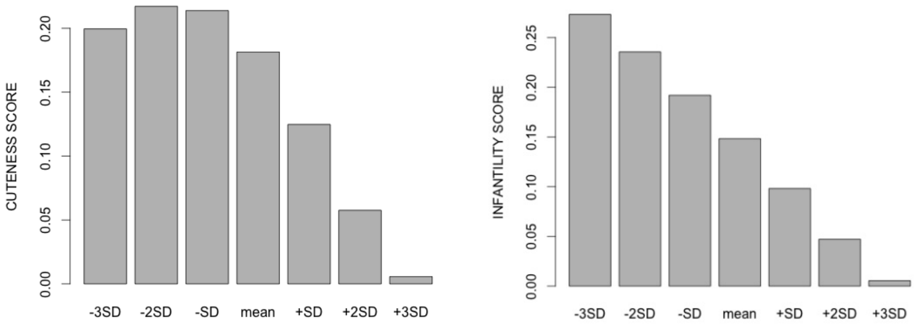

Fig. 4. Cuteness and infantility scores on age-related axis

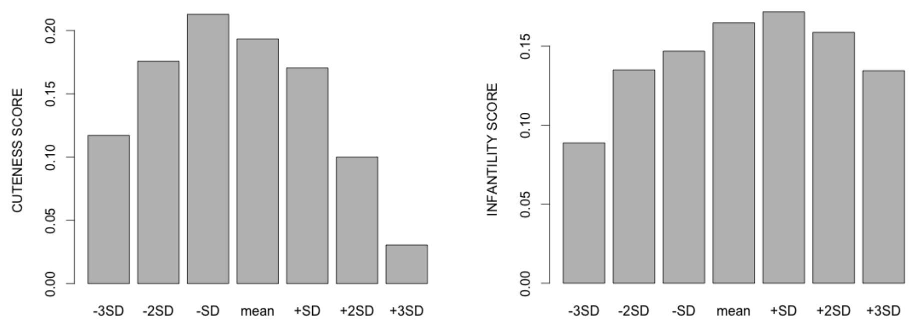

Fig. 5. Cuteness and infantility scores on the first PC

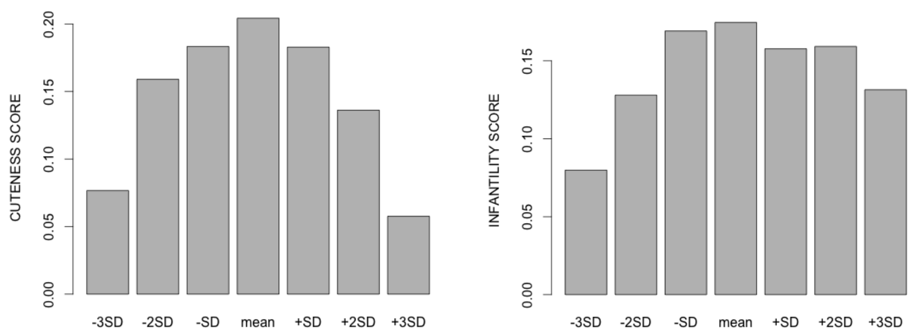

Fig. 6. Cuteness and infantility scores on the second PC

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