



Associations of Facial Proportionality, Attractiveness, and Character Traits

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Background: Facial proportionality and symmetry are positively associated with perceived levels of facial attractiveness.

Objective: The aims of this study were to confirm and extend the association of proportionality with perceived levels of attractiveness and character traits and determine differences in attractiveness and character ratings between “anomalous” and “typical” faces using a large dataset.

Methods: Ratings of 597 unique individuals from the Chicago Face Database were used. A formula was developed as a proxy of relative horizontal proportionality, where a proportionality score of “0” indicated perfect proportionality and more negative scores indicated less proportionality. Faces were categorized as “anomalous” or “typical” by 2 independent reviewers based on physical features.

Results: Across the ratings for all faces, Spearman correlations revealed greater proportionality was associated with attractiveness ($\rho = 0.292$, $P < 0.001$) and trustworthiness ($\rho = 0.193$, $P < 0.001$), while lesser proportionality was associated with impressions of anger ($\rho = 0.132$, $P = 0.001$), dominance ($\rho = 0.259$, $P < 0.001$), and threateningness ($\rho = 0.234$, $P < 0.001$). Mann-Whitney U tests revealed the typical cohort had significantly higher levels of proportionality (−13.98 versus −15.14, $P = 0.030$) and ratings of attractiveness (3.39 versus 2.99, $P < 0.001$) and trustworthiness (3.48 versus 3.35, $P < 0.001$).

Conclusions: This study demonstrated that facial proportionality is not only significantly associated with higher ratings of attractiveness, but also associated with judgements of trustworthiness.

Proportionality plays a role in evoking negative attributions of personality characteristics to people with facial anomalies.

Key Words: Attractiveness, character traits, proportionality

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Facial structure and anatomy are important to our engagement with and perceptions of others.^{1,2} Facial features play a role when character traits and attractiveness are inferred, and facial attractiveness is associated with societal benefits to individuals in the economic and political realms.^{3,4} Additionally, proportionality and symmetry are positively associated with perceived levels of facial attractiveness.^{5,6}

Studies of human proportionality and symmetry are deeply rooted in art, design, and history – the first significant research into human anatomic proportions is generally attributed to the Greek sculptor Polykleitos of Argos in the fifth century BC, who characterized ideal human proportions.⁷ A number of sculptors, artists, and thinkers have since augmented these characterizations, including Leonardo da Vinci’s *Vitruvian Man* in 1490, coming to perhaps the most famous anthropometrist of the modern era, Leslie Farkas. Farkas’ large body of anthropometry research (colloquially known as “Farkas’ norms”) provides a set of facial soft tissue normal anatomic measurements for various demographic groups.

Previous studies associated facial symmetry with increased perceptions of attractiveness, sociability, intelligence, health, liveliness, and confidence. However, most studies have relied on relatively small sample sizes of both raters and facial images.^{9,10} Other studies have reported findings by manipulating facial anatomic relationships, but these studies used digitally altered images with varying degrees of artificiality.^{11,12} Few recent studies have characterized associations of facial proportionality with attractiveness and character traits.¹³ This gap in research may be due to the difficulty of obtaining standardized anatomic facial measurements in a large group of real humans. This gap may also follow from challenges in quantifying proportionality without manually or artificially altering facial anatomy by a known quantity (ie, increasing intercanthal distance by 10%).¹⁴

The aims of this study were to use a large dataset of human photos and ratings to:

- (1) describe a method to quantify relative degrees of proportionality across individuals without absolute anatomic measurements,
- (2) determine the association of proportionality with perceived levels of attractiveness and character traits, and
- (3) determine differences in attractiveness and character ratings between “anomalous” and “typical” faces.

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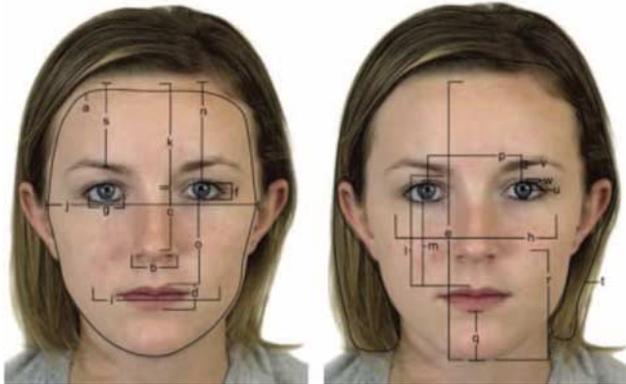


FIGURE 1. Facial Anatomic Measurements in Chicago Face Database. Facial thirds were calculated to determine relative horizontal proportionality: upper third = “s”; middle third = (“k” + “c”) – “s”; lower third = “e” – (“k” + “c”).

We predicted that higher levels of proportionality would be associated with increased levels of attractiveness and positive character traits (happiness, trustworthiness, etc) and that faces categorized as “typical” would have relatively higher ratings of attractiveness and levels of proportionality.

METHODS

Chicago Face Database

This study used publicly available data and was exempt from the Institutional Review Board at the Children’s Hospital of Philadelphia and the Perelman School of Medicine at the University of Pennsylvania. Five hundred and ninety-seven unique individuals were included from the Chicago Face Database (CFD), a publicly available domain of soft-tissue facial measurements and ratings by 1087 individuals on dimensions of attractiveness and social characteristics.¹⁵ Character traits assessed

Male weighted horizontal proportionality score

$$= - \frac{\left[\left| 1 - \left[0.310 \left(\frac{x_1}{x_1 + x_2 + x_3} \right) \right] \right| \times 100 + \left| 1 - \left[0.305 \left(\frac{x_2}{x_1 + x_2 + x_3} \right) \right] \right| \times 100 + \left| 1 - \left[0.385 \left(\frac{x_3}{x_1 + x_2 + x_3} \right) \right] \right| \times 100 \right]}{3}$$

Female weighted horizontal proportionality score

$$= - \frac{\left[\left| 1 - \left[0.295 \left(\frac{x_1}{x_1 + x_2 + x_3} \right) \right] \right| \times 100 + \left| 1 - \left[0.324 \left(\frac{x_2}{x_1 + x_2 + x_3} \right) \right] \right| \times 100 + \left| 1 - \left[0.382 \left(\frac{x_3}{x_1 + x_2 + x_3} \right) \right] \right| \times 100 \right]}{3}$$

included afraid, angry, disgust, dominant, feminine, masculine, happy, sad, threatening, and trustworthy, selected based on previous studies evaluating facial anomalies.¹⁶ Several anatomic measurements are reported in pixels, including face height and width, nose length and width, eye height and width, and brow to hairline, among others (Fig. 1). A comprehensive list of anatomic facial measurements and character traits included in this database can be accessed from: <https://www.chicagofaces.org/>.

Proportionality

Several formulas were developed to assess proportionality. Because the CFD reports anatomic measurements in pixels, several anatomic measurements within the same photo were used to create standardized proportions or ratios that could be

reliably compared across individuals. We calculated upper, middle, and lower thirds of the face using facial anatomic measurements in the Chicago Face Database: upper third “x₁” = “s”; middle third “x₂” = (“k” + “c”) – “s”; lower third “x₃” = “e” – (“k” + “c”) (Fig. 1). We developed the following formula as a proxy of relative horizontal proportionality to the 1:1:1 rule of thirds, where x₁, x₂, and x₃ correspond to upper, middle, and lower thirds of the face:

Proportionality score

$$= - \frac{\left[\left| 1 - \left(\frac{x_1}{\text{mean}_{x_1, x_2, x_3}} \right) \right| \times 100 + \left| 1 - \left(\frac{x_2}{\text{mean}_{x_1, x_2, x_3}} \right) \right| \times 100 + \left| 1 - \left(\frac{x_3}{\text{mean}_{x_1, x_2, x_3}} \right) \right| \times 100 \right]}{3}$$

A proportionality score of “0” indicates perfect horizontal proportionality and lower (more negative) scores indicate relatively less proportionality. We also assessed fitness to individual horizontal thirds proportionality with the formula:

$$\text{Upper proportionality score} = \left[1 - \left(\frac{x_1}{x_1 + x_2 + x_3} \right) \right] \times 100$$

Here, “middle proportionality score” and “lower proportionality score” used the same formulas with x₂ and x₃ in the numerator, respectively. These formulas are modeled on the neoclassical canon assumptions that ideal horizontal third proportions are in perfect 1:1:1 ratios. However, work by Farkas demonstrated normal proportions for males and females differ from the canon and each other, in that male proportions are 31.0%, 30.5%, and 38.5%, and female proportions are 29.5%, 32.4%, and 38.2% for the upper, middle, and lower thirds of the face, respectively.¹⁷ We developed additional proportionality formulas to assess fitness to these proportions:

Similar to the unweighted formula, scores closer to “0” indicated better fit to this model and more negative scores indicated decreased proportionality.

We also assessed fitness to the “Golden Ratio” of facial height to width ratio of 1.618.¹⁸ We used the formula:

$$\text{Golden ratio fitness} = \left[1 - \left(\frac{\text{facial height}}{\text{facial width}} \right) \right] \times 100$$

Attractiveness and Anomaly

Individuals were categorized as “anomalous” or “typical” by 2 independent reviewers. Anomalous features were determined

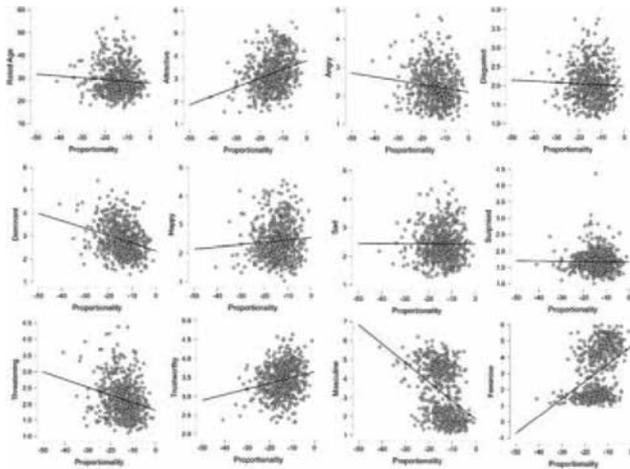


FIGURE 2. Proportionality, Age, Attractiveness, and Character Traits. Proportionality (unweighted) correlations with rated age, attractiveness, character traits, masculinity, and femininity. More negative proportionality indicates decreased proportionality, with “0” representing “perfect” proportionality. Character traits were rated on a 7 point Likert scale.

by consulting previous studies on facial anomalies.^{19,20} A list of anomalous features was constructed including: ptosis, scars, strabismus, micrognathia, nevi, acne, hyperpigmentation, jaw asymmetry, hair loss, rhytids, brow asymmetry, and orbital asymmetry, among others. Faces were classified as “anomalous” given the presence of 1 or more characteristics agreed upon by 2 independent doctoral student reviewers. In the case of a discrepancy, the photo was re-evaluated by the reviewers to reach a consensus. Individuals were also categorized into 2 groups, “more attractive” or “less attractive,” based on the top 50% scoring males and females.

Statistical Analyses

The demographics of the CFD face cohort were characterized with descriptive statistics. Interrater reliability for anomalous

categorization was calculated using Chronbach alpha. Spearman correlations tested hypotheses regarding associations of facial proportions with character traits. Mann-Whitney *U* tests tested hypotheses regarding differences between “anomalous” and “typical” faces. Multivariate logistic regression evaluated hypotheses regarding the interaction between attractiveness and proportionality to predict the presence of facial anomalies. Statistical analyses were performed in JASP 0.15 for Windows.²¹

RESULTS

Demographics

Demographic information of CFD facial stimuli is included in Supplementary Digital Content, Table 1, <http://links.lww.com/SCS/E34>. This cohort included 290 (48.6%) men and 307 (51.4%) women. One hundred and ninety-seven (33.0%) identified as Black, 183 (30.7%) identified as White, 109 (18.3%) identified as Asian, and 108 (18.1%) identified as Latino/a. The ages of participants are not included in this database. To provide a relative value for age, however, the average “rated age,” or age as predicted by layperson raters, was 28.9 ± 6.3 years.

Proportionality and Character Traits

In the overall cohort, Spearman correlations revealed unweighted proportionality was associated with attractiveness ($\rho = 0.292, P < 0.001$), trustworthiness ($\rho = 0.193, P < 0.001$), and femininity ($\rho = 0.408, P < 0.001$), while decreased unweighted proportionality was associated with anger ($\rho = -0.132, P = 0.001$), dominance ($\rho = -0.259, P < 0.001$), threateningness ($\rho = -0.234, P < 0.001$), and masculinity ($\rho = -0.421, P < 0.001$) (Supplementary Digital Content, Table 2, <http://links.lww.com/SCS/E34>) (Figs. 2 and 3). The weighted proportionality formula, which accounts for anatomic measurements reported by Farkas and differences between males and females, returned similar statistically significant results (Supplementary Digital Content, Table 2, <http://links.lww.com/SCS/E34>).

The Golden Ratio was most positively associated with sadness ($\rho = 0.123, P = 0.003$) and negatively associated with rated age ($\rho = -0.223, P < 0.001$). Upper third size was significantly associated with negative character traits, including anger ($\rho = 0.119, P < 0.004$), disgust ($\rho = 0.135, P < 0.001$), and threateningness ($\rho = 0.116, P < 0.005$), while middle third size tended to be associated with positive character traits, including attractiveness ($\rho = 0.262, P < 0.001$) and trustworthiness ($\rho = 0.254, P < 0.001$) as well as femininity ($\rho = 0.461, P < 0.001$). Similar to the upper third of the face, lower third face size was associated with negative character traits, including anger ($\rho = 0.116, P < 0.008$), dominance ($\rho = 0.252, P < 0.001$), and threateningness ($\rho = 0.220, P < 0.001$) as well as masculinity ($\rho = 0.423, P < 0.001$).

Men and women had significantly different weighted and unweighted horizontal proportionality scores (−16.33 versus −12.58 weighted, $P < 0.001$; −8.40 versus −6.94 unweighted, $P < 0.001$, respectively). Due to sex differences, the positive association of proportionality with femininity and negative association with masculinity, and known sex-character trait associations, an exploratory analysis was performed with subgroups of men only and women only to determine if associations of proportionality and character traits identified in the overall cohort persisted in single-sex groups.

Similar results to the overall cohort were observed in the single-sex cohorts: in women alone, unweighted and weighted



FIGURE 3. Faces by Proportionality Score. Faces of males (top) representing below average (left, −22.80) average (middle, −16.53) and above average (right, −8.20) proportionality scores and faces of females (bottom) representing below average (left, −22.35), average (middle, −12.30), and above average (right, −4.35) proportionality scores.

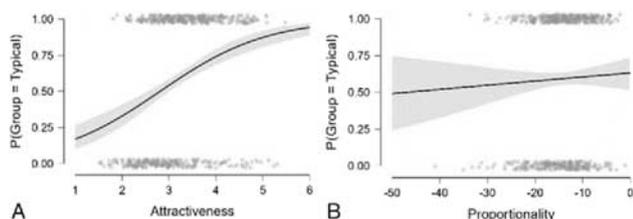


FIGURE 4. Attractiveness and proportionality in Anomalous and Typical Faces. (A) attractiveness and (B) proportionality conditional estimate plots with 95% confidence intervals.

proportionality were positively associated with attractiveness ($\rho = 0.340$, $P < 0.001$; $\rho = 0.314$, $P < 0.001$) and trustworthiness ($\rho = 0.174$, $P = 0.002$; $\rho = 0.195$, $P < 0.001$), and negatively associated with anger ($\rho = -0.130$, $P = 0.023$; $\rho = -0.179$, $P = 0.002$) dominance ($\rho = -0.149$, $P = 0.009$; $\rho = -0.104$, $P = 0.069$), masculinity ($\rho = -0.328$, $P < 0.001$; $\rho = -0.230$, $P < 0.001$), and threateningness ($\rho = -0.179$, $P = 0.002$; $\rho = -0.165$, $P = 0.004$), respectively. In men alone, unweighted and weighted proportionality were positively associated with attractiveness ($\rho = 0.090$, $P = 0.125$; $\rho = 0.128$, $P = 0.029$) and trustworthiness ($\rho = 0.060$, $P = 0.308$; $\rho = 0.121$, $P = 0.041$), and negatively associated with anger ($\rho = -0.121$, $P = 0.040$; $\rho = -0.140$, $P = 0.017$), dominance ($\rho = -0.139$, $P = 0.018$; $\rho = -0.142$, $P = 0.016$) and threateningness ($\rho = -0.060$, $P = 0.308$; $\rho = -0.143$, $P = 0.041$), respectively.

Attractive Cohort

Faces were grouped as “more attractive” or “less attractive” based on top 50% scores for males and females. Faces rated as “more attractive” had higher unweighted proportionality scores (-13.60 versus -15.31 , $P < 0.001$) and weighted proportionality scores (-7.03 versus -8.28 , $P < 0.001$). More attractive faces had significantly lower lower-third facial representation (15.70 versus 17.29 , $P = 0.002$). More attractive faces had significantly lower rated age (27.38 versus 30.33 years, $P < 0.001$).

Anomalous Cohort

Two hundred and twenty-one faces (37.0%) were grouped as “anomalous” and 376 (63.0%) as “typical” by 2 independent reviewers (DFV, CSW) (Supplementary Digital Content, Table 3, <http://links.lww.com/SCS/E34>). Anomalous categorizations were determined from previously published classifications.¹⁹ Cronbach alpha was calculated at 0.803 (95% CI: 0.773, 0.830). The most common facial anomalies were acne ($n = 44$, 7.4%), nevi (29, 4.9%), and hyper/hypopigmentation ($n = 24$, 4.0%). One hundred and ninety-six faces (32.8%) had one anomalous characteristic, 39 (6.5%) had 2 characteristics, and 6 (1.0%) had 3 characteristics. The 2 groups had similar compositions of men and women: there were 116 (52.5%) women in the typical group and 202 (53.7%) women in the anomalous group ($P = 0.925$).

Mann-Whitney U tests revealed the “typical” cohort had significantly higher levels of unweighted proportionality (-13.98 versus -15.14 , $P = 0.030$) and were lower in rated age (28.06 versus 30.08 , $P = 0.002$) (Supplementary Digital Content, Table 4, <http://links.lww.com/SCS/E34>). Typical faces were also rated higher in attractiveness (3.39 versus 2.99 , $P < 0.001$) and trustworthiness (3.48 versus 3.35 , $P < 0.001$).

A logistic regression determined whether attractiveness or proportionality predict the presence of facial anomalies. Lower ratings of attractiveness predicted the presence of facial anomalies (OR = 0.796, 95% CI = -0.445 to -0.011 ; $\beta = -0.228$, SE = 0.111,

$z = -2.062$, $P = 0.039$), as did lower proportionality (OR = 0.967, 95% CI = -0.063 to -0.005 ; $\beta = -0.034$, SE = 0.015, $z = -2.317$, $P = 0.021$). Figure 4 depicts conditional estimate plots with 95% confidence intervals for (A) attractiveness and (B) proportionality for “anomalous” and “typical” groups.

DISCUSSION

Our faces are our presentation to the world.²² Research suggests people harbor “beauty-is-good” and “anomalous-is-bad” stereotypes, with higher levels of bias against those with facial anomalies.²⁰ Previous studies have also demonstrated positive associations of facial symmetry with attractiveness. However, less work has evaluated associations between proportionality, attractiveness, and character traits. Using a large set of human photos and perceived character ratings, this study aimed to determine associations between proportionality and perceived character traits and to determine differences in perceived character traits for anomalous and typical faces.

Results from our study suggest increased proportionality is associated with greater attractiveness and positive character traits, including trustworthiness, and negatively associated with negative character traits including anger and threateningness. Interestingly, when evaluated in separate facial thirds, the relative sizes of the upper and lower third of the face were associated with negative character traits, such as anger, disgust, and threateningness, while the relative size of the middle third of the face was associated with attractiveness and positive character traits, including trustworthiness. Such results are consistent with studies evaluating the influence of lower face proportion on facial attractiveness in artificially augmented faces.²³ These data are also interesting to consider in the background of increasing amounts of “proportion changing” facial surgery in plastic surgery sub-specialties such as gender affirming surgery, cranio-maxillo-facial surgery, and aesthetic surgery. Surgeons actively practicing and patients requesting surgery in these realms may benefit from a more thorough understanding of the effects of changing proportionality of the face on character traits.

This study also supports previous work alleging that people harbor an “anomalous is bad” stereotype. Perhaps unsurprisingly, faces categorized as “anomalous” had significantly lower ratings of attractiveness. These faces also had lower ratings of “positive” character traits, including trustworthiness and happiness, and higher ratings of “negative” character traits, including disgust and sadness. Such findings align with previous studies, including in orthognathic patients,^{24,25} and in anomalous faces in general.²⁰ The presence of facial anomalies in this study was predicted by lower ratings of attractiveness and lower levels of proportionality.

Interesting results regarding sex differences and masculinity-femininity emerged from this study. The overall cohort had roughly equal proportion of women (51.4%) and men. Paradoxically, attractiveness, character traits, and masculinity-femininity were generally similar, or even more strongly associated with the unweighted proportionality formula (1:1:1 proportional assumption) than the weighted proportionality formula, which accounts for known differences in cis-male and cis-female anatomy.¹⁷ In fact, when this canon was evaluated by Farkas in 1985, none of the subjects fit the canon for horizontal thirds, which led to the values incorporated into the weighted proportionality formulas described above. This difference could suggest the original canon described for horizontal thirds is more ideal for assessing levels of perceived attractiveness, despite actual anatomic norms, which differs slightly from this canon.

Based on the strong associations of masculinity and femininity with proportionality, an exploratory subgroup analysis was performed to test if associations of character traits and proportionality persisted in single-sex cohorts. Our results demonstrated nearly all the same associations in single sex cohorts, suggesting proportionality is associated with character traits independent of sex alone. Additionally, although the anomalous and typical groups had similar compositions of men and women, the typical group received significantly higher ratings of femininity. This observation suggests that facial typicality is associated with femininity, or possibly, that facial anomalies are associated with masculinity. These results raise additional questions surrounding masculinity-femininity, sex, proportionality, facial ratios, attractiveness, and character ratings, which may form the basis of future investigations.

This study used a publicly available database and thus has several limitations. Firstly, although there are many benefits of using a large database of human images, we were constrained by the stimuli and associated information presented in the database, including actual age. We attempted to mitigate this shortcoming by using “rated age”, or age as rated as layperson observers, as a proxy. The rated age of the typical cohort (28.06) was significantly lower than the anomalous cohort (30.08), which could be a confounder in this analysis, although the cohorts differed by 2 years. Another limitation of this study is the subjective classification of faces into anomalous and typical categories. We included a variety of anomalous features. However, some may not consider some common features (eg, acne, nevi) as “anomalous.” To reduce subjectivity, we used 2 independent reviewers and specified various criteria to categorize each face (Supplementary Digital Content, Table 2, <http://links.lww.com/SCS/E34>). Additionally, the reported Cronbach alpha was 0.803 (95% CI: 0.773, 0.830), demonstrating good interrater reliability. It has also been demonstrated that variations of the same anomaly (eg, scar location) may have different effects on perceptions of attractiveness and character traits.²⁶ Finally, our formula for unweighted and weighted proportionality quantifies fit to horizontal thirds. However, this “fit” may be quantified more optimally by other measures, and our formula does not account for racial or ethnic differences. Furthermore, based on measurements available in this database, it was impossible to calculate vertical proportionality according to the rule of fifths.

Despite these limitations, this study identified associations of proportionality, anomaly, and character traits using a large data set of human images and ratings. Such findings are useful in further clarifying the influence on proportionality and anomaly on our perceptions of attractiveness and character traits.

CONCLUSIONS

This study demonstrated significant associations between facial proportionality and ratings of attractiveness as well as perceived positive social character traits using a large dataset. Additionally, proportionality and perceived attractiveness predicted the presence of facial anomalies.

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