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The Heredity of Beauty

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Although the idea that beauty is hereditary seems commonsensical, considering that other facial features have been shown to be affected by genes, it is not clear what the overall effect on attractiveness these inherited features have. The purpose of the study was to investigate the veracity of the statement that beauty is hereditary. This paper presents both the results of an experiment on the heredity of facial ratios and discusses the impact of these ratios on the real world. The golden ratio has long been a measure of beauty. Thus, facial ratios were used as a measure of attractiveness. In the experiment, the facial ratios of 19 families, each containing six family members, were calculated by making six measurements for each face and creating an average facial ratio (AFR) for each individual. These results were then statistically analyzed using an ANOVA test (analysis of variance). The null hypothesis of the experiment was that there is no statistically significant difference in the facial ratios of people related to each other compared to people who are not related to each other. The ANOVA rejected the null hypothesis, suggesting that there was a significant difference between the facial ratios of family members and non-family members. This result suggests that facial ratios and thus attractiveness are hereditary. The results of such a study provide the insights into human behavior and society.

INTRODUCTION

Although it is may be assumed that beauty is hereditary, few studies actually prove this. There are findings showing that facial features are affected by genes, such as those affecting the development of the nose (Adhikari et al., 2016) and facial shape (Shaffer et al., 2016), but it is not clear what the overall effect of these features on facial attractiveness is. The objective of this study was to test the null hypothesis, "there is no statistically significant difference between facial beauty, as expressed by having a similar facial ratio, of people related to each other as compared to people who are not related to each other", thus expanding our understanding of human beauty.

Features that are attributed to the beauty of an individuals can be quantified. The golden ratio, also written as $(1 + \sqrt{5})/2$ and can be denoted by τ or ϕ (Carlson, 2007), has been found throughout the history of art and science and is considered to be an indicator of beauty. It is also closely associated with the human body. It has been shown that throughout gestation, the ratio of nasal width to nasal bone length is approximately equal to ϕ (Goynumer, Yayla, Durukan, & Wetherilt, 2011). A recent study found that the golden ratio can be observed even in the way people walk. Several ratios involving the timings of different phases of the gait cycle were measured. They were all found to be very close to the golden ratio and revealed an "intrinsic harmonic structure" (Iosa et al., 2013). Moreover, in another research paper about the appearance of the golden ratio in the human body, the researchers concluded that they would continue to use this measurement in their experiments because it had a clear connection to aesthetic appearance (Narasimha-Shenoi, 2012).

When considering facial beauty, the golden ratio remains an indicator of attractiveness and may significantly impact human behavior. It has been established as a measure of natural symmetry and has been said to "characterize symmetrical forms" (Prokopakis et al., 2013). Facial symmetry has a significant effect on attractiveness (Fink, Neave, Manning, & Grammer, 2006). Considering that attractiveness grows along with facial symmetry and perfectly symmetric faces are considered to be more attractive than less symmetric versions of the same person's face (Rhodes, Proffitt, Grady, & Sumich, 1998), it is argued that the golden ratio can significantly impact facial attractiveness. Moreover, it has been suggested that people with greater facial symmetry are judged to be better life partners. This may indicate that mate selection is considerably impacted by facial symmetry (Rhodes et al., 1998), and thus facial ratios. Having already established that the golden ratio is found throughout the human body and is a measure of facial attractiveness or aesthetic appeal, this study aims to demonstrate the heredity of beauty, and thus provide further insight into human nature and beauty.

MATERIALS AND METHODS

Data Collection/Participants

During the experiment to determine the heredity of facial ratios, families with six members were sampled. Data from 19 such families were collected, and thus the facial ratios of 114 individuals

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were analyzed using six of the ratios used in a 2012 national U.K. competition to find the most beautiful face (Phimatrix, 2013). Ratios 3, 4, 6, 12, 14 and 16 from the competition were chosen. An average of all these ratios (AFR) was calculated for each individual.

Ratio 3: Middle eye, base nose, base lip
Ratio 4: Middle eye, center lip, bottom of chin
Ratio 7: Top of lips, bottom of lips, bottom of chin
Ratio 12: Side of face, outside of iris, tear duct/inside of eyebrow
Ratio 14: Side of face, tear duct, space between tear ducts
Ratio 16: Side of face, inside/ tear duct of opposite eye, opposite side of face.

These ratios were selected since they had already been used in a previous situation (to find the prettiest woman in England) and because they could be more accurately measured. These facial ratios were used instead of others from the source because they had a wide range and together covered the whole face. The goal was to measure the overall attractiveness of a person through their facial ratios; therefore, the whole face had to be taken into account. Ratios 3, 4, and 7 were lateral ratios (from forehead to chin) while ratios 12, 14 and 16 are transverse (from right to left). Ratios 3, 4, 14 and 16 took into account more than 50% of the person's face. A mean ratio was used to condense the data and provide one value instead of many per individual. This was key since the groups to be compared through statistically compared were meant to be families, not the individuals themselves.

Various methods were used to collect the data. The project was promoted online and in person. Online, the project website was promoted on Facebook. All three collaborators posted statuses and/or sent messages promoting the website. A Gmail account was created specifically for this project and was promoted alongside it. A project website was created at: https://facialratio-project.squarespace.com. This website has since been deactivated as we are no longer collecting data and it was costly to maintain. The main purpose of the website was to give the participants of the experiment a clear idea of the project goals and what was required of them.

The following information was available on the website. It was explained that the objective of the project was to collect data about facial ratios in order to test the hypothesis: "there is no statistically significant correlation between being related to someone and having a similar facial ratio."

The instructions explained to participants that they were to "send an email to facialratio456@gmail.com email address with pictures (jpg or pdf) of as many family members as you can, giving the degree of relation of each member (e.g. father, grandfather, brother, uncle). We are looking for six or more photos from each family in order to make it possible to interpret the results properly." In the cases where photos of more than six family members were sent, the photos of family members who were less closely related to the nuclear family (i.e. great aunt as opposed to sister) were removed. Additionally, the requirements for the photos were clarified. The requirements for the photos were:

1. The person's mouth should be closed.
2. The person should be facing towards the camera.
3. The person's eyes should be open.
4. The person's irises and eyebrows must be visible.

Alongside the online promotion, in-person promotion was also used. Project members visited the classrooms of classes from 9th-12th grade at the Cambridge School of Bucharest and explained the aims of the project, asked students to participate and wrote the domain of the website on the whiteboard. Small letters/ leaflets were written and handed out at the school.

Potential participants were provided with a description of the project as well as the procedure for collecting the photos. Signed consent forms to analyze the photographs and present the data obtained from the analysis in a paper were obtained. It was also made clear that none of the photos or personal information would be published, ensuring the privacy of the participants. Additionally, the responsibilities of each member of the project were delineated so that participants would feel that they would understand the chain of command as well as the way in which the data would be analyzed.

Data Analysis

The application Pixelstick (Mac) and MB-Ruler (Windows) was used to measure the ratios. These applications were especially helpful because they had the ability to change and freeze the angle at which the measurements were taken. This helped prevent a certain amount of error. Each face was measured with these applications and the six above ratios were calculated for each face with a calculator. These six ratios were then averaged to calculate an AFR for each face. The measurements and the calculations of the ratios were all taken to three significant figures, except the AFR which was calculated to four significant figures. The AFR values of all the participants were recorded in Table 1. An ANOVA test was then used to compare the AFR values of the groups (families).

In order to verify the reliability of the results of the ANOVA, the main assumption of the test was tested that the data is normally distributed. Since previous studies of facial symmetry have been found to have a normal distribution (Muñoz-Reyes, Iglesias-Julios, Pita, & Turiegano, 2015), it was believed that our data would also follow this trend. This assumption was tested and confirmed by the Q-Q Plot in Fig. 2, the histogram in Fig.1 and an additional Shapiro-Wilk normality test.

The histogram in Fig. 1 also showed a roughly normal distribution and symmetrical about a central value. A Q-Q plot was performed, which compared all the AFR values obtained to the expected values of a normal distribution. The Q-Q plot in Fig. 2 suggested a distribution other than normal since too many points were not on the first bisector.

The Shapiro-Wilk normality test conclusively showed that the distribution was ($W = 0.98454$, p-value = .2146), the p-value being significantly greater than 5%. These findings revealed that the null hypothesis of the Shapiro-Wilk normality test was not rejected that the data is normally distributed, supporting the idea that this data is normally distributed and verifying the assumption of the

Family	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
Member 1 AFR	1.607	1.707	1.583	1.592	1.592	1.602	1.413	1.457	1.668	1.496	1.718	1.642	1.58	1.527	1.51	1.508	1.436	1.638	1.495
Member 2 AFR	1.585	1.7	1.613	1.6	1.59	1.578	1.572	1.688	1.672	1.65	1.505	1.545	1.638	1.525	1.463	1.467	1.336	1.441	1.497
Member 3 AFR	1.588	1.718	1.608	1.602	1.617	1.572	1.54	1.507	1.533	1.838	1.62	1.54	1.557	1.515	1.456	1.513	1.427	1.427	1.474
Member 4 AFR	1.61	1.672	1.613	1.617	1.62	1.585	1.577	1.447	1.565	1.562	1.53	1.605	1.516	1.608	1.591	1.474	1.403	1.575	1.594
Member 5 AFR	1.598	1.715	1.602	1.618	1.602	1.588	1.43	1.578	1.683	1.54	1.717	1.717	1.584	1.611	1.446	1.452	1.492	1.458	1.333
Member 6 AFR	1.592	1.727	1.572	1.612	1.593	1.595	1.533	1.697	1.592	1.792	1.483	1.678	1.525	1.53	1.58	1.418	1.478	1.526	1.442

Table 1. The AFR values of all the participants. Each column represents a different family named A, B, C,... etc., respectively. Each number is an AFR value of a different family member.

ANOVA test.

RESULTS

An ANOVA was used to compare the AFR values in Table 1. This test compared the families to each other to find if there was a statistically significant difference in the means of the AFR values of the families. The ANOVA rejected the null hypothesis since the p-value was lower than 5%. These were the results of the ANOVA:

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Letter:	18	0.5085	0.028249	6.289	7.57e-10 ***
Residuals:	95	0.4267	0.004492		

The p-value was less than .05 ($p < .05$). This means that the chances of these results being due to chance are less than 5%. Since the test was carried out to a 5% significance level, the null hypothesis of the ANOVA was rejected and the alternative hypothesis was accepted. The null hypothesis for this test is that the mean AFR values of all the families are the same. The alternative hypothesis is that the mean AFR values of all the families are not the same. Therefore, the above results showed that the mean AFR values of the families differed significantly, and thus there was a correlation between being related and having a similar facial ratio.

DISCUSSION

Implications

Although it may seem obvious that family members have closer AFR values than non-family members, such assumptions must be backed up by evidence. It is imperative that future studies into the subject are not based on false assumptions. Thus, this study aims to provide such evidence and act as a stepping stone towards a better understanding of the heredity of beauty.

Our findings may have several potential ramifications. They could even have implications for a better understanding of the heredity of social status. It is currently believed that social status is handed down the family due solely to social conventions. However, a person's attractiveness can bias people's first impressions about them and make them seem more or less capable than they really are. This has the potential to considerably affect a person's chances of getting a good education or job considerably (Talamas, Mavor, & Perrett, 2016). This is called the Halo Effect. Perhaps due to interactions between the Halo Effect and the hereditary facial ratios, attractive people are able to attain high positions in society and through passing down their 'attractive genes' allow their children to maintain this position.

Likewise, from a behavioural genetics point of view, a form of reactive gene-environment correlation stemming from a per-

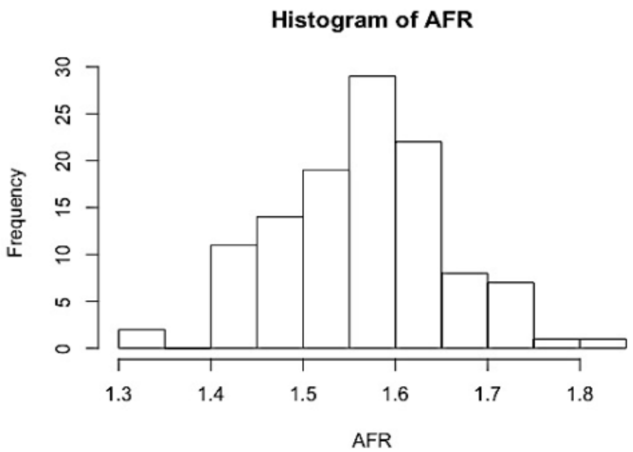

Figure 1. Histogram of AFR values. This shows the distribution of all the AFR values collected during the study.

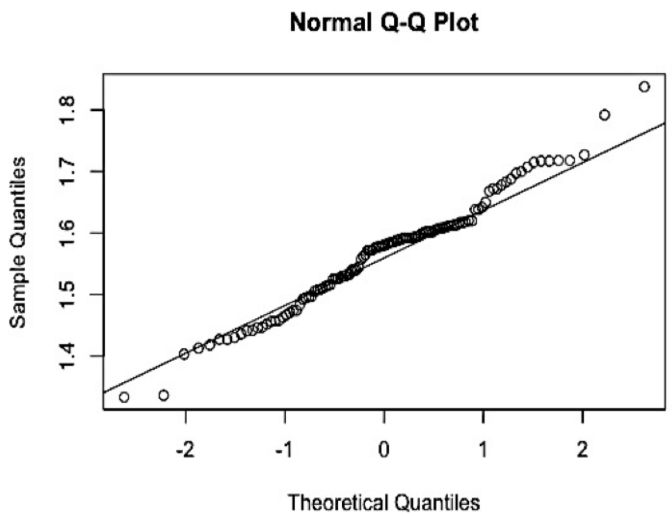

Figure 2. Normal Q-Q Plot of AFR values. This compares the data collected to the expected data trend if the data were normally distributed.

son's attractiveness could lead them to become better-developed citizens. Gene-environment correlation (GE correlation) is "a situation in which genetic variation leads individuals to be differentially exposed to environments" (Kim, 2009). There are three types of GE correlation. Passive GE correlation arises from parents with a gene, promoting an environment which fosters the gene's effect. Reactive or evocative, GE correlation springs from social environments being reflections of our social behavior. Active GE correlation comes from individuals shaping the environments they experience by making decisions (Kim, 2009). More attractive individuals may become more productive members of society due to the fact that their beauty shapes a more favorable environment for them. They may grow up in environments which support their intellectual and personal development more (i.e. with more receptive teachers and parents) due to their appearance. In the UK, more attractive children were found to have higher IQs (by 12.4 points) (Kanazawa, 2011). People in one study were found to be more honest and moral when they saw the face of a more attractive person (Wang et al., 2017). This suggests that people respond to and treat attractive people differently than others. Consequently, this shapes the way children who are deemed "beautiful" grow up. Again, our results open up avenues of questioning into the hereditary nature of social status, personality traits and success.

Research into facial ratios could, for example, help predict who a person will be attracted to. Considering that people are more likely to trust people who look similar to them (Farmer, Mckay, & Tsakiris, 2014), it is plausible that people with similar facial ratios are more likely to trust and thus be attracted to or marry each other. Moreover, since it has been shown that cultural background does not significantly affect assessments about facial attractiveness (Perrett, May & Yoshikawa, 1994), understanding the connection between facial ratios and mate selection can be relevant to a diverse population. Studies on this topic have the potential to unearth interesting insights into human nature as well as have applications in the online dating industry and other matchmaking services.

Limitations

This section will analyze the sources of uncertainty in and discuss improvements for the experiment. The sample would not have been representative of the human population and no further extrapolations could have been made from the findings had all the families only been from Bucharest. Thus, to make the study more representative of an international population, photographs were also collected from countries including Egypt, Vietnam, Japan and Malaysia. For the participants from outside Bucharest, the same collection methods were used as for those in Bucharest whose data was collected online. These participants were directed towards the project website using Facebook as the Bucharest participants were. They were asked to send the photos via email to the project email account.

However, since the sample was multiracial, this fact may have skewed the results. Considering that most of the studies previously cited, connecting attractiveness to the golden ratio, were carried out on Caucasians, this raises the question of whether Caucasians and other ethnicities such as Asians have different preferences for the certain facial ratios or not. One study comparing the ratios of Malaysian Chinese, Malaysian Malay and Malaysian Indian individuals revealed that there was no clear connection between the perceived attractiveness of the faces in the study and the golden ratio. The same study suggested that the facial index was not significantly affected by race (Alam, Mohd Noor, Basri, Yew, & Wen, 2015). Facial index is defined as "the ratio of the breadth of the face to its length multiplied by 100" (Facial index, n.d.), meaning that though the general face shape remained relatively constant, attractiveness did not depend on facial ratios.

On the other hand, other studies into Asian populations and facial ratios have concluded that facial ratios and the golden ratio do in fact have a significant bearing on the attractiveness of an individual. In one study conducted on North-Indian participants, it was concluded that because attractive females in the population had facial ratios close to ϕ, the golden ratio could have a significant effect on the individual's attractiveness (Khan, Nagar, Tandon, Singh, & Singh, 2016). Additionally, a study on Southern-Indian facial features, using the Marquardt mask stated that the facial ratios were close to those of the mask although it did not fit perfectly (Veerala et al., 2016). Marquardt's mask is a facial mask that "contains… one-dimensional and two-dimensional geometric golden elements formed from the golden ratio" (Kim, 2007). Thus, it is unclear if the sampling on a multiracial population had any impact on the study.

A further point of discussion is the fact that men and women look different and therefore, having groups/families with both men and women may have affected the statistical results. Humans show sexual dimorphism. Sexual dimorphism represents the visible differences between females and males of the same species ("Sexual Dimorphism", 2016). Sexual dimorphism may increase facial appeal by amplifying sex-hormone-related hints related to youth, fertility, dominance and additional factors related to mate selection (Perrett et al., 1998). This suggests that further research into the topic of how sex affects their ratios is required.

CONCLUSION

An ANOVA, conducted on the AFR values of 114 individuals, revealed a significant difference between the facial ratios of members of a family compared to those outside the family. This supports the theory that beauty is hereditary. However, further research on the effect of ethnicity and sex on facial ratios and more accurate studies using computer programmes for facial analysis are required. The relevance and importance of the study of the hereditary nature of beauty are often understated. Research into this relatively untouched field is necessary not only for a deeper understanding of the genetics behind facial structure, but also for insights into the basis of human interaction.

ABBREVATIONS

GE Correlation: Gene-environment correlation
AFR: Average facial ratio

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