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The Coolness Effect: What does your face say about you?

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Abstract

The human face seems to be giving off integral cues for conscious and unconscious first judgments. Just from looking at a snap shot of a face, raters can accurately predict someone’s intelligence and extraversion. Upon further investigating subjective traits perceived from the human face, revolving around the attractiveness ‘halo’ effect, there might also be support for extraversion having a halo effect of its own. This new extraversion halo is dubbed the “coolness” effect, befitting pop cultural ideas of extraverted individuals. Yet how humans make these subjective judgments from the human face has yet to be comprehensively explored. That being said, Generalized Procrustes analysis was implemented in a novel way to extract pure shape information from faces using 2D landmark data obtained for 1880 subjects. This is also the first study to measure facial feature areas in regards to subjective traits. The 31 facial landmarks were broken down into a multitude of triangular and quadrilateral areas that were selected to measure different facial feature areas. The results suggest that predicting attractiveness and femininity are related to larger areas concerning the eyes while predicting intelligence is related to areas of the upper lip areas and the area between this and the nose being smaller. Judgments about Extraversion and masculinity correspond to larger areas in the lower half of the face. Differences in sizes of each facial feature areas seem to be giving different cues into how others make subjective judgments, possibly giving support to the redundant signal hypothesis of sexual ornaments, which facial features are arguably the human equivalent.
The Coolness Effect: What Does Your Face Say About You?

Introduction

Why do we perceive certain people’s faces as more attractive than others? This issue has caught increasing interest in the 21st century, especially due to the high profit beauty industry. Even with modern advancements in genetics and technology, scientists still grapple with providing hard scientific evidence for exactly what it is that we find attractive and why.

The human brain makes judgments of people very quickly, as suggested by Solomon Asch (1946) and demonstrated by Lindgard et al. (2006), who showed that the brain unconsciously makes a judgment about a person within 0.05 seconds. Another study indicates that males can perceive accurately the fertility of a female based solely on external stimuli in approximately one-sixth of a second (Adamson & Galli, 2003). Other studies have shown the human brain can discern information from viewing a person’s face, from potential mating cues to signs of threat or emotional expression (Aharon et al, 2001; Haxby et al, 2002; Domes et al., 2007). One key assessment the brain seems to take away from this snap judgment is measures of attractiveness.

Although standards of attractiveness vary historically and cross-culturally, there is remarkable consistency in attractiveness judgments across differences in race, nationality, sex, and age (Cunningham et al, 1995; Langlois et al, 2000); even infants show a preference for attractive faces (Langlois et al, 1991). Thus, there appears to be some central perception of attractiveness shared by all humans, to which differing cultural standards add small random deviations. This is consistent with the hypothesis that the perception of attractiveness is innate and serves some biological purpose. Evolutionary psychologists
believe facial characteristics provide cues to aspects of human health; through sexual selection, humans have evolved the ability to pick up on these cues unconsciously, in the form of a preference for attractive faces (Gangestad & Buss, 1993; Kalick et al., 1998; Thornhill & Gangestad, 1999; Møller & Alatalo, 1999; Rhodes et al., 2001). Thus, our obsession with beauty may be an evolutionarily adaptive trait serving the purpose of creating successful offspring.

The preference for attractive faces can be explained by the good genes sexual selection theory: individuals have evolved preferences for mates whose traits advertise genes that enhance offspring vitality. However, this theory has consistently faced controversy. It has been argued that natural selection will remove heritable variation in fitness until all prospective mates possess the same high-fitness genes (Taylor & Williams 1982; Charlesworth, 1987), resulting in the so-called ‘lek paradox’ (Keller, 2007). Other studies discovered that traits are linked with fitness (e.g. life expectancy and fertility) have much more genetic variation compared to most morphological traits (Houle, 1992; Burt, 1995). This increased variation results from the accumulation of somewhat detrimental mutations in a large number of fitness-associated loci, resulting in significant genetic variation of fitness-related traits that is maintained by mutation-selection balance (Charlesworth, 1990; Charlesworth & Hughes, 1999). Good genes sexual selection models show sexually selected traits, like fitness related traits, also have a high genetic variation, which may mean that these traits evolved as signals of phenotypic health (Rowe & Houle, 1996). All this evidence supports the theory originally proposed by Charles Darwin (Darwin, 1871): differences in reproductive success, caused by competition over mates, result in the expression of specific sexually selected traits. Gangestad and Buss (1993)
provided evidence further upholding this theory, concluding that in societies with poor levels of health and high rates of parasitism, attractiveness is valued more in mates. Overall, it appears that facial attractiveness signals phenotypic fitness, increased availability of resources, lack of disease, and fewer harmful mutations; the adaptive value of attending to this information in others, especially prospective mates, may explain why attractiveness is a universally valued trait.

One particularly interesting study discovered that viewing an attractive face activates the brain's dopaminergic reward pathways, providing the viewer with a feeling of pleasure (Kampe et al., 2001). In other words, when seeing an attractive face, the brain interprets it as a reward. This might provide a biological basis for increasing gaze toward attractive people, illuminating why attractive individuals are intrinsically perceived as more desirable. It is conceivable that this reward activation carries some adaptive advantage, prompting the evolution of this pattern of mental coding.

Dion, Berscheid, and Walster (1972) showed that attractiveness, beyond signaling health, is also unconsciously associated with other positive qualities, such as more intelligence, popularity, and sociability. This illustrates the well-known psychological phenomenon of the 'halo effect' – the globally held stereotype that more attractive individuals possess other positive traits and live more desirable and advantageous lives. Attractive people are then treated differently from others, leading them to have more friends, marry earlier, have happy marriages, better jobs, and therefore receive higher incomes. In light of this, Aristotle's statement that “Beauty is a greater recommendation than any letter of introduction” may hold more than a grain of truth.

Upon exploring whether attractive people are only assumed to possess other
positive characteristics or truly demonstrate these traits, Langlois et al. (2000) found that in measures like physical health, self-confidence, and intelligence of attractive individuals, do in fact have higher scores as compared to less attractive people. However, these results need to be interpreted with care, as different explanations can be argued. For example, the higher scores could be due to the attractive participants being treated better and/or having had better opportunities made available to them. Also it could be that the genes that code for attractiveness might also code for other beneficial traits, resulting in the more attractive people scoring higher due to genetic pleiotropy. A consensus on what’s truly going on has yet to be resolved; however, currently the evidence supports an additive effect of both processes accounting for the higher scores (Langlois et al., 2000). This dilemma illuminates a problem faced by all previous studies examining the halo effect.

Other theories examine the possibility of adaptive traits enhancing attractiveness (good genes making you appear more attractive), or the self-fulfilling prophecy effect. The second theory refers to the idea whereby people’s attractiveness impacts their social and intellectual environment, which then affects their levels of other positive traits. Zebrowitz et al. (2002) analyzed this confounded relationship in a study of facial attractiveness and intelligence. Figure 1 captures some of the complex connections between attractiveness and intelligence (this model could also apply to other positive traits).

In Figure 1 (Zebrowitz et al. 2002), Path A depicts the biological factor influence on attractiveness and intelligence, supporting the good genes theory of adaptive facial features signaling mate quality. In the context of this model, people are perceived as attractive because of phenotypic signaling of adaptive traits, such as intelligence. However, it is possible the biological influence could be due from the reversal of this path – adaptive
traits are actually causing the phenotypic signaling of attractiveness. Path B illustrates the possible environmental factors contributing to attractiveness and intelligence (Zebrowitz et al. 2002), accounting for the effects of quality of life and available resources, primarily in stages of development, modify attractiveness and intelligence. For example, malnutrition can lead to many physical and mental deformities (Zebrowitz et al. 2002). Path C indicates a direct effect of intelligence on attractiveness. This relationship examines how more attractive individuals of reproductive age will use social and physical actions to increase their attractiveness, such as better grooming and being more extraverted. This also alludes to the belief that intelligent people have better health maintenance (lower BMI scores), resulting in them being perceived as more attractive. The second more direct relationship of Path D relates to the self-fulfilling prophecy or the halo effect. Attractiveness may change a person’s environment, including how others treat them, which may influence intelligence. Zebrowitz et al. (2002) emphasizes that these paths are not mutually exclusive nor all inclusive; the paths and their circular nature point out the multitude of possible bidirectional connections.

![Figure 1](image)  
**Figure 1.** Connections between Intelligence and Attractiveness
Symmetry in morphological characteristics has been shown as a measure of developmental stability, reflecting the ability to resist the harmful effects of parasites, genetic mutations, or toxins during development (Møller & Swaddle 1997). The face is anatomically complex, which makes it more susceptible to developmental stressors. Human expertise in perceiving faces may reflect the adaptive benefits of increased sensitivity to cues of a potential mate’s load of parasites or harmful mutations (Peterson & Rhodes 2003).

Symmetrical individuals are also reported to have greater levels of psychological and emotional health (Shackelford & Larsen 1997), leading them to be more desirable and have more opportunities for sexual reproduction. Koehler et al. (2002) discovered another fascinating aspect of attraction: female preference for facial symmetry is unaffected by the ovulatory cycle phase. This supports an innate preference for symmetry, as an important cue to physical fitness, independent of sex. This differs from the fluctuations of perceived attractiveness by females during ovulation cycles when looking at sexual dimorphism. More masculine traits are perceived as more attractive during the ovulatory stage (Penton-Voak et al. 2003), whereas facial symmetry preference remains consistent throughout the entire estrus cycle. This shows the importance of facial symmetry is not a central component to mate selection, since it is not dependent on human hormonal cycles.

Another important factor of facial attractiveness is facial averageness. An average face has mathematically average trait values for a population; faces that are high in averageness are low in distinctiveness, as defined by Rhodes (2006). Averageness tends to show a higher correlation to facial attractiveness than facial symmetry (Rhodes, 2006). Computer generated composite faces were made in an influential study done by Langlois
and her colleagues (1994). They found that, as more and more faces were added to the composite face (making the face more mathematically average), more people rated this face as attractive. This was particularly interesting since beauty tends to be associated with extraordinary, not ordinary traits. Several studies discovered similar results with un-manipulated faces closer to the population average again being rated as more attractive than more distinctive faces (O’Toole et al., 1994; Rhodes & Tremewan, 1996; Rhodes et al., 1999).

Theories delving deeper into the biological basis of facial averageness (Thornhill & Gangestad 1993) predict that facial averageness is related to the individual’s genetic heterozygosity (i.e., having two different alleles at one loci). Heterozygosity reflects higher genetic diversity of the individual and is associated with greater defense against disease and parasites. In general genetic diversity is connected to fitness and sexual reproduction. Specific genetic diversity within the major histocompatibility complex (MHC) has been linked to immunocompetence and mate preferences (Rhodes et al. 2008). Mate selection for heterozygosity (preferred by the mate) in the MHC would result in offspring with a stronger immune system, which provides better resistance to disease, increasing genetic fitness and ideally increasing sexual reproductive success (Garver-Apgar et al, 2006; Havlicek & Roberts, 2009). This fits Darwin’s model of sexual selection in the scheme of evolution.

Sexually dimorphic facial features have long been thought to be important in attractiveness (Mitchem et al, 2013). In women, it does indeed appear to be the case that feminine faces are considered more attractive (Johnston & Franklin 1993; Perrett et al., 1994). Although it stands to reason that highly masculine male faces would be considered
more attractive to women, most research suggests that men’s facial masculinity and attractiveness are uncorrelated (Mitchem et al., 2013; Cunningham et al., 1990; Jones & Hill, 1993; Swaddle & Reierson, 2002). Other studies, however, have found preferences in women for somewhat masculine faces (Keating, 1985; Johnston et al., 2001) and for more feminine faces (Perret et al., 1998; Penton-Voak et al., 1999).

Facial attractiveness is a complex trait to understand. It appears that symmetry, averageness and sexual dimorphism contribute to attractiveness independently (Fink & Penton-Voak, 2002). Understanding a system of signaling that has been constructed by mate selection over millions of years is no easy task, but perhaps researchers have been looking at the wrong signals in the human face, or looking at them in the wrong way. It is still unclear to what extent these broad aspects of human faces, as well as specific facial features, drive facial judgments. Answering these questions is the aim of the current study.

There is a clear gap in the literature when it comes breaking the face down on a feature level. There appears to be no research on how facial feature variance may be a signal to others; just as symmetry and averageness have been shown to be signs of decreased genetic mutational load and heterozygosity as previously mentioned. Some studies have looked at facial features by measuring them as one-dimensional lines or by digitally transforming faces (Cunningham, 1986; Gangestad & Thornhill, 1999; Perret et al., 1999; Ercan et al. 2008; Zhang et al., 2011). However, no studies seem to have investigated measured areas of human faces. This could be due to lack of finding, inability to so, or the belief that measuring such aspects borders on the pseudoscience’s of physiognomy and phrenology. Nonetheless, these measures are limited, either by not looking at the whole feature or by changing the feature in a way that usually makes it seem unrealistic. Based on
the literature and past studies within this lab, the face seems to be giving off significant signals, which raters seemingly can pick up on. It seems human can in fact judge a book by its cover, yet how they accurately make these judgments has yet to be comprehensively explored. That being said, using a relatively new approach to extract pure shape information from coordinate points, this study will investigate how variance in facial feature areas may act as cues to rater perception’s of traits like attractiveness, intelligence, extroversion, masculinity and femininity. Furthermore, the objective of looking at facial feature areas will hopefully present a more complete picture of these cues that will overcome the limited measures of the previous studies.

Past Studies

Other studies in this research lab have also investigated cues from the human face. Sexual selection theories state that maximizing fitness depends on mate choice. Inheritance is an important factor in understanding mate selection and fitness. One of the past studies of our lab investigated the heritability of facial attractiveness. In this study, Purkey (n.d.) found that additive genetic variation (A) accounted for 65% of the phenotypic variation in facial attractiveness and unique environmental (E) effects the remaining 35%. This means that facial attractiveness is indeed heritable. However, when using subjectively rated scores for grooming as a control variable; the significance of attractiveness went away. Ultimately leading to the decision to not use grooming as a control variable when looking at subjective attractiveness. These two ratings were likely conflated, since grooming explained 46% of the variance of facial attractiveness. This was likely due to a poor operational definition of grooming, resulting in raters rating participants as more groomed
simply because they perceived them to be more attractive.

Another recent study out of our lab by Tess Adams (n.d.) found that, when subjective ratings for extraversion and intelligence were compared to objective measures of the same traits, raters could accurately perceive extraversion and intelligence. Subjectively rated extraversion had a zero-order correlation with JEPQ-Extraversion (JEPQ-E) of $r = 0.17$ (df = 1063, $p < 1.09E-8$). The key mediators of the correlation were perceived attractiveness (positively associated with both rated extraversion and JEPQ-E) and perceived intelligence (negatively associated both). Perceived masculinity is also associated with rated extraversion but only marginally associated with intelligence (negatively in both cases); interesting in relation to this is that male participants tend to score somewhat higher than females in both rated and JEPQ-E. Measured extraversion is negatively associated with measured scores of IQ. Subjectively rated extraversion correlates positively with BMI, sex, smiling, attractiveness, grooming, and acne. Age, site (BATS vs. LTS), and zygosity are not related to either rated extraversion or JEPQ-E. The partial correlation between rated extraversion or JEPQ-E, controlling for all the above (including age, site, and zygosity), is $r_{\text{partial}} = 0.09$ (df = 1045, $p < 0.004$). Subjectively rated intelligence correlated with measure IQ at $r=0.1109$ before controls were added and $r_{\text{partial}}=0.1053$ ($p < 2.2e^{-16}$) after controlling for attractiveness, BMI, sex, smiling, grooming, acne, age, site, and zygosity.

In sum, facial attractiveness is inherited and is related to rater’s accurate perceptions of subject’s actual extraversion and intelligence. Adams’ data used the same subjectively rated grooming scores as Purkey’s; however, the current study uses newly
collected grooming scores that should allow grooming to be used as a more accurate control variable, potentially leading to different results. Looking at these same relationships with additional raters and subjects while comparing them to facial feature shape areas may shed light onto how humans are accurately able to perceive other’s extraversion and intelligence.

**Methods**

*Participants*

The original subject sample (group 1, n=1599) for this study consisted of two twin cohorts, the Longitudinal Twin Study (LTS; Rhea et al., 2006) in Colorado at the Institute of Behavioral Genetics (IBG) and the Brisbane Adolescent Twin Study (BATS; Wright & Martin, 2004) at QIMR-Berghofer in Queensland, Australia. An additional 281 participants from LTS (Rhea et al., 2013) were added to the sample (group 2), bringing the total sample size to 1880 participants. Differences in sex between both groups were approximately equal, 53.7% female and 46.3% male. Of the total sample, 700 were Monozygotic (MZ), and 1052 were Dizygotic (DZ) twins. The age of participants ranged from 15 to 22 years old for the BATS twins and 21-27 years old for the LTS twins. Due to poor standardization of photos, especially faces not facing straight on, 233 (mostly BATS) participants were removed from the data, bringing the total participants used to 1647. The final distribution of sex, and site are depicted in Figure 2.
What Does Your Face Say About You?

Figur 2. Sample Demographic of Sex and Twin Study Site

Photograph Procedure

The LTS photos used were taken one meter away with twins having no make-up, glasses, distracting objects, or hair covering their face, and a neutral facial expression. If errors like tilting away from camera, smiling, or blinking occurred, the photos were retaken. Resulting photos received were 300 X 400 pixels, with a size of 29.5 KB and formatted as JPGs. The photos received from QIMR were 419 X 587 pixels, in JPG format, and 18.5KB in size; however, these photos were not subjected to the same standardization procedures as the LTS were. All photos used were from shoulder up. Additionally, research assistants cropped photos to about a 2-inch margin around the face and tilted them so that each subject's pupils lined up along the same y-axis. This was done using GIMP, a GNU Image Manipulator Program.

Rating Procedure

Ratings were made by research assistants and were collected for subjective and
control traits. All research assistants were undergraduate and post-baccalaureate students from the University of Colorado Boulder. Subjective trait ratings used for this study included intelligence, extraversion, attractiveness, and masculinity/femininity. Faces were also rated on grooming, acne and smiling for use as control variables. Before rating for any trait began, research assistants (RAs) were trained on the specific trait’s definition and how to use the rating program, which was conducted on a computer within the lab at IBG. For subjective traits, RAs were asked to make ‘snap judgments’ and to keep in mind that ratings should be evenly distributed but still representative. To aid in this, the sample was segmented into blocks of 50, beginning with the instructional prompt, “In a moment you are going to rate a group of 50 faces on (trait). But first, you will see a slideshow of all 50 faces. Use this time to get a sense of the variation among the faces with respect to their (trait). Rate each face compared to the other faces in the same group, and try to distribute your ratings roughly (but not strictly) uniformly.” Each face in the set of 50 was displayed for 2 seconds and the slideshow was used by RAs to distribute ratings more uniformly within each set. The next screen of the program displayed the picture of a subject with the scale indicators of “1 = Low (Trait), 7 = High (Trait)” underneath. Figure 3 shows an example using a composite face obtained from facelab.org.
Additionally the rating procedure for each trait was broken up into two sets, which raters were instructed never to complete in the same day to prevent “bleed-over” effects due to both members of a twin pair being rated close together in time. Raters were also instructed to never do an entire program in one sitting or to spend more than two hours at a time in lab to prevent rater fatigue. For each trait, we tried to maintain equal numbers of male and female raters, to balance any sex differences among perceived ratings.

Cronbach’s $\alpha$ was used to measure reliability between raters for each trait. As seen in Table 1, reliability is relatively good, only intelligence and masculinity/femininity for group 1 having slightly lower measures. It is important to note that any conclusions drawn in relation to subjective ratings from this study are limited by the reliabilities between raters.
Table 1. 
*Inter-Rater Reliability*

<table>
<thead>
<tr>
<th>Trait</th>
<th>Cronbach’s α</th>
<th>Number of Raters</th>
<th>Average Correlation between Raters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attractiveness</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group 1</td>
<td>0.87</td>
<td>8</td>
<td>0.45</td>
</tr>
<tr>
<td>Group 2</td>
<td>0.91</td>
<td>16</td>
<td>0.39</td>
</tr>
<tr>
<td>Intelligence</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group 1</td>
<td>0.6</td>
<td>6</td>
<td>0.18</td>
</tr>
<tr>
<td>Group 2</td>
<td>0.82</td>
<td>15</td>
<td>0.24</td>
</tr>
<tr>
<td>Extraversion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group 1</td>
<td>0.9</td>
<td>11</td>
<td>0.47</td>
</tr>
<tr>
<td>Group 2</td>
<td>0.9</td>
<td>15</td>
<td>0.38</td>
</tr>
<tr>
<td>Masculinity/Femn.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group 1</td>
<td>0.67</td>
<td>7</td>
<td>0.21</td>
</tr>
<tr>
<td>Group 2</td>
<td>0.84</td>
<td>15</td>
<td>0.26</td>
</tr>
<tr>
<td>Grooming</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group 1</td>
<td>0.87</td>
<td>11</td>
<td>0.4</td>
</tr>
<tr>
<td>Group 2</td>
<td>0.94</td>
<td>15</td>
<td>0.5</td>
</tr>
<tr>
<td>Smiling</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group 1</td>
<td>0.97</td>
<td>13</td>
<td>0.74</td>
</tr>
<tr>
<td>Group 2</td>
<td>0.96</td>
<td>15</td>
<td>0.6</td>
</tr>
<tr>
<td>Acne</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group 1</td>
<td>0.94</td>
<td>13</td>
<td>0.38</td>
</tr>
<tr>
<td>Group 2</td>
<td>0.96</td>
<td>15</td>
<td>0.68</td>
</tr>
</tbody>
</table>

*Note: Group 1 refers to original sample and Group 2 refers to additional LTS*

*Subjective Traits*

All subjective traits were rated on a scale of 1-7, with 7 being the high score for that trait. Extraversion was described based on characteristic adjectives and questions used for the actual tests that measured for extraversion. For example, a highly extraverted person may be described as exuberant, spontaneous, talkative, jovial, rambunctious, and the life of the party, while someone with low extraversion is withdrawn, quiet, bashful, and would prefer staying home and reading. Masculinity/femininity was based on sexually dimorphic
traits that have been defined and supported consistently throughout scientific literature.
For example, more masculine traits include a broad jaw, defined brow, more facial hair,
more angular face, and broad/square chin. Feminine traits include high/defined
cheekbones, larger lips, more round face, and less facial hair. For Intelligence and
Attractiveness, raters were just asked to rate participants based on how intelligent or
attractive that person looked to them.

Control Variables

The same program setup was also used for rating control variable traits but
different instructions and scales were used. For both groups 1 and 2, RAs were instructed
to take their time in determining ratings for control traits. RAs were not instructed to
distribute control variable ratings uniformly, since facial acne and smiling appeared to be
highly skewed. For group 2, RAs were not shown a slideshow for acne and smiling; instead
the raters were shown a collage of representative faces for various levels of the scale,
which could be accessed at any point during the rating task, to serve as a reference guide
for their ratings.

Smiling

Both group 1 and 2 (n= 27, 18 females and 8 males) participants were rated for
smiling on a scale of 1-3 (1 = “No Smile”, 2 = Slight to Moderate Smile, and 3 = Full
Smile). Due to the poor standardization of photos taken, most participants in photos
do not have a neutral facial expression, making smiling an important variable to
control for, since the extend to which someone is smiling is shown to alter
perceptions of attractiveness and extraversion.
Acne

Both groups of participant photos (n = 26, 18 females and 8 males) were rated for acne on a scale of 1-7, (1 = No Acne to 7 = Heavy Acne). This is an important control as presence of acne is likely to negatively affect rater’s judgments, since it associated with indicators of poor health, diet, and/or genes.

Grooming

In order to prevent the issues that hampered Purkey’s study, grooming was meticulously defined and renamed as “Self-Presentation” to prevent rater misinterpretation. An accurate representation of subject’s self-presentation is key since grooming tends to be associated with attractiveness and thus has the potential to contribute to the halo effect. To eliminate this potential confound, RAs were specifically told to ignore the effects of attractiveness on self-presentation. Meaning they should not let a participant’s attractiveness influence their assessment of self-presentation. For this trait, raters (n = 15, 9 females and 6 males) were instructed to think critically about how much time the person spent getting ready (1 = least effort, 7 = most effort). For male participants, determining their score required very scrupulous attention to detail, since male often have less obvious cues for self-presentation effort than females tend to.

Socioeconomic Status

Another outcome proposed by the halo effect is that being more attractive is associated with being more successful and thus with a higher socioeconomic status (SES), entailing higher social class, income, education level (and perhaps IQ) and
occupation. To control for SES, Socioeconomic Index (SEI) measures for BATS and LTS income categories (Less than $15,000, $15,000-$30,000, $45,000-$60,000, $60,000-$75,000 and More than $75,000) were changed into numeric levels, then scaled separately. Finally, the results of combing the two standardized scores gave one complete measure for SES.

**Age, Sex, Site and BMI**
Additionally age, sex, site, and body mass index (BMI) were used as control variables to make sure any relationships found were not actually due to differences in these variables. BMI was calculated for each subject by using his or her recorded height (converted to meters), $h$, and weight (converted to kilograms), $w$. We did not control for race, because our sample only consisted of Caucasian participants.

**Measured Traits**
IQ scores from the Wechsler Adult Intelligence Scale (WAIS) had already been obtained for BATS and LTS twins, and these were used as measured scores for. For measured extraversion, pre-existing scores from personality tests were used. All subjects' (age range = 15 - 27) extraversion scores came from the Junior Eysenck Personality Questionnaire (JEPQ), which is a personality assessment designed for children and adolescents, ages 7-17.

**Landmark Procedure**
A landmark is a point with Cartesian coordinates $(x, y)$, which is used to represent shape information of a structure. A total of 31 landmarks were placed on the cropped and tilted photos for each subject face. For participants in group 1 the points were
independently identified by a total of 28 raters (13 males, 15 females) and 39 (19 males, 20 females) independent raters did the same for the subject’s photos in group 2. RAs spent one-hour intervals in training for several weeks, in where to meticulously place each landmark. Point placement was carried out on computers, taking advantage of ImageJ’s image processing and analysis software (Rasband, 1997-2014.). Figure 4 is an example face depicting the final result of properly placing all 31 landmarks.

Note: 31 landmarks placed appropriately.

Figure 4. Facial Landmarks Measured

Each photo was randomly assigned two raters, typically one male and one female. Each landmark consisted of x and y coordinates. The values of these points were compared among co-raters to determine between-rater disagreement. This was measured by comparing the distance in pixels between each of the corresponding points to determine if
points were to be re-placed. A final quality control measure was done to the final total landmark data, which reduced inter-rater point discrepancy to less than 3% of face width and face height.

*Face Shape Measurements*

The photographs of the participants were poorly standardized since they were not originally intended for shape analysis. Many of these resulting photo variations (participant’s having various facial expression or looking at the camera from different head angles) potentially leading to alterations of the shape information the landmark data was initially intended to capture. 2D face landmarks were corrected for this using the novel implementation of geometric morphometrics, the statistical analysis of geometric shapes and sizes of Cartesian coordinates (x, y). After removing all the effects of rotation, size and translation for an object what remains is the geometrical information of the objects shape, which includes angles and distances between the corresponding landmarks (Bookstein 1997). Thus transforming raw data points into informative shapes requires the removal of these effects, which can be done using a generalized Procrustes analysis (GPA) (Zelditch et al., 2004). GPA standardized all the face landmarks to a space of common shape. The result is pure shape information created by landmarks, which have now been transformed into Procrustes coordinates. Once the shape information is extracted, a mean face shape is created using the average of all the Procrustes coordinates. The face shape and mean shape results can bee seen in Figure 5.
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Figure 5. GPA Face Shape Results

The shape information can then be made into shape variables using principal component analysis (PCA). This generates principle components that explain the variance of shape. Unfortunately upon running PCA on the data, there appears to be no clear relationships of principle components to distinct facial features. With the aim of making the shape relationships more clear, Procustes coordinates can be subjected to a varimax rotation, which rotates the shape information into a different plane. This did help but the amount of shape information made it difficult to find clear patterns. However, one finding suggests that face shape is related to opposite sex twins, independent of gender or perceived masculinity and femininity. Further investigation of the rotated components lead to finding one of the components relating to subject faces tilting away from the camera. Since the face shape information from severely tilted faces is unreliable, removing subjects corresponding to high values of this principle component will hopefully increase reliability of faces left in the sample.
Since the results of PCA were ambiguous, the next step is further investigating facial features, which involves calculating geometric areas of interest from the landmark data using the shoelace formula. Johann Carl Friedrich Gauss (1777-1855), a German mathematician and scientist, invented this method, which allows exact determination of a polygon's area from its vertices. The name of this formula hints at the method it uses, which requires multiplying terms across a matrix diagonally (points are entered in counter clockwise direction) with one side using positive signs and the other negative. The resulting general equation is:

\[ A_p = \frac{1}{2} |x_1y_2 + x_2y_3 + \cdots + x_{n-1}y_n - x_ny_1 - \cdots - x_ny_{n-1} - x_1y_n| \]

The different facial features can be broken down into areas of triangles and quadrilateral using the 31 landmark points and the shoelace formula, which allows for area measurements of irregular polygons. Of the all the areas, which are shown in figures 6 and 7, only the ones with significant associations to subjective ratings have labels.
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Note: Only areas of significance are labeled.

Figure 6. Triangular Facial Feature Areas

Note: Only areas of significance are labeled

Figure 7. Quadrilateral Facial Feature Areas
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Statistical Analysis

To achieve one score for each trait, requires averaging the ratings of each trait for all the raters together. The next step involves standardizing (scaling to 1) all the subjective traits (intelligence, attractiveness, extraversion and masculinity/femininity) while mean centering all the control traits. To investigate if any facial feature areas were possible predictors for subjective and measured traits, multiple linear regressions are run using R statistical software (R Core Team, 2013). To investigate relationships between standardized feature areas and each standardized subjective and standardized measured trait (subjective attractiveness, intelligence, extraversion, and masculinity/femininity, and measured extraversion (JEPQ-E) and IQ), over 1300 multiple regressions were run. Each regression also includes each of the following mean centered covariates: age, sex, site, BMI, acne, grooming, smiling, and SES. Because so many investigator regressions were run, the probability of finding at least one significant result just by chance, (Type I error) was ~ 100%.

\[
\mathbb{P}_{(at \: least \: one \: significant \: result)} = 1 - \mathbb{P}_{(no \: significant \: results)} = 1 - (1 - 0.05)^{1314} \approx 1
\]

By implementing a Bonferroni correction, the study-wide probability of making a single Type I error is reduced back down to 5%, which sets a more appropriate significant cut-off, \(\alpha_{new}\). To achieve this correction the original alpha value, \(\alpha_{o}\), is divided by the total number of comparisons run, \(n\). The resulting \(\alpha_{new} = 3.805e^{-5}\) is now the cut off, meaning only p values less than 3.805e^{-5} can be statistically significant. Previously, over 400 regression results were statically significant (p value < 0.05) but after determining \(\alpha_{new}\),
only 48 regression results met the new cut off.

\[ \alpha_{new} = \frac{\alpha_0}{n} \]

The remaining significant relationships are then investigated for interactions with sex and mediation using the \( \alpha_0 = 0.05 \). It also important to specify that the Bonferroni correction is considered almost too conservative a correction, but the rigors of this statistic only aided in reducing finding of variance that might be related to variations in photos.

Preferences for or away from averageness for facial feature areas can also be investigated. This is achieved using the means points of the rotated Procrustes coordinates generated from GPA using the “shapes” package (Dryden, 2012) for R to create the mean test face of the data (as seen in Figure 5). To get an averageness measure for each feature, the following equation was used:

\[ \text{Avg}_{k,i} = (\text{Area}_{k,i} - E(\text{Area}_k))^2 \]

Where \( \text{Area}_{k,i} \) is the area for the \( k^{th} \) feature of the \( i^{th} \) person, and \( E(\text{Area}_k) \) is the expected (or average) area for the \( k^{th} \) feature across all individuals in the sample. \( \text{Avg}_{k,i} \) is therefore each individual’s averageness score for each feature \( k \). An \( \text{Avg}_{k,i} \) score of \( < 0 \) therefore indicates the person has an average feature after controlling for overall face size, whereas scores \( < 0 \) indicate increasingly atypical face feature size. In other words, the areas of the test face, \( E(\text{Area}_k) \), represent the average of all the faces combined, meaning the closer a feature area is to the corresponding area on the test face, the more average it is. The squared term tests whether averageness is best, which allows the best-fit line to bend.
Results

In all the tables below, only the significant results of the multiple linear regression analysis are reported. With $\beta^*$ referring to the standardized slope estimate, p value signifying the likely hood of relationship being due to chance, and all regressions were done with a 95% confidence interval. Lastly, $R^2$, stand for the variance explained by the relationship.

Average

The significant results for average facial features included subjective traits of attractiveness, subjective intelligence and extraversion; these relationships are seen in Table 2 and visually in Figure 8. These results show that raters perceive less average lower cheek areas as more attractive along with less average upper lip areas as more intelligent. On the other hand, a more average mouth shape leads raters to perceive individuals as more extraverted.

<table>
<thead>
<tr>
<th>Table 2. AVERAGENESS</th>
<th>Less Average = Higher Subjective Rating</th>
<th>$\beta^*$</th>
<th>p value</th>
<th>95 % CI</th>
<th>$R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATTR</td>
<td>R.LowCheekTriAVG</td>
<td>-0.084</td>
<td>2.86E-05</td>
<td>(-0.124, -0.045)</td>
<td>0.007</td>
</tr>
<tr>
<td></td>
<td>LowCheekTotalTriAVG</td>
<td>-0.055</td>
<td>8.43E-06</td>
<td>(-0.079, -0.031)</td>
<td>0.003</td>
</tr>
<tr>
<td>S.INTEL</td>
<td>UpLipTotalTriAVG</td>
<td>-0.108</td>
<td>2.08E-06</td>
<td>(-0.152, -0.063)</td>
<td>0.012</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>More Average = Higher Subjective Rating</th>
<th>S.EXTRAV</th>
</tr>
</thead>
<tbody>
<tr>
<td>S.EXTRAV</td>
<td>MouthTotalQuadAVG</td>
</tr>
</tbody>
</table>

Note: $\beta^*$ represents standardized partial regression coefficients
Negative $\beta^*$ means less average feature areas received higher subjective ratings while positive means the opposite.
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Figure 8. Average Areas

When examining the results of bigger features being favored, Table 3 and visually in Figure 9, it appears that they agree with the published findings of bigger eyes often being perceived as more attractive. Perceptions of extraversion seem to rely predominately on the lower half of the face. In this region, having bigger features, most notably a bigger jaw, is related to being perceived as more extraverted. Again, bigger feature areas in the lower half of the face are important but this time in relation to being perceived as more masculine. Here is it important to also point out that smaller features in the area may also predict being perceived as more feminine. These resulting patterns of sexually dimorphic facial feature preference are again in accordance with the bulk of the literature findings. Seeing many of the same significant features for both subjective extraversion and masculinity may make it tempting to think some type of mediation is going on, but this is unlikely since these traits were not significantly related ($p = 0.3$).
Table 3.  
*BIGGER is Better*

<table>
<thead>
<tr>
<th>Features by Trait</th>
<th>$\beta^*$</th>
<th>p value</th>
<th>95% CI</th>
<th>$R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ATTR</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EyeQuad</td>
<td>0.053</td>
<td>7.39E-06</td>
<td>(0.030, 0.076)</td>
<td>0.003</td>
</tr>
<tr>
<td>EyeTopTotalTri</td>
<td>0.064</td>
<td>4.39E-08</td>
<td>(0.041, 0.087)</td>
<td>0.004</td>
</tr>
<tr>
<td><strong>S.EXTRAV</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L.NoseLipTri</td>
<td>0.072</td>
<td>7.27E-06</td>
<td>(0.041, 0.104)</td>
<td>0.005</td>
</tr>
<tr>
<td>JawTri</td>
<td>0.112</td>
<td>2.19E-10</td>
<td>(0.078, 0.147)</td>
<td>0.013</td>
</tr>
<tr>
<td>NoseLipTotalTri</td>
<td>0.041</td>
<td>4.21E-06</td>
<td>(0.023, 0.058)</td>
<td>0.002</td>
</tr>
<tr>
<td>JawTotalQuad</td>
<td>0.072</td>
<td>5.33E-14</td>
<td>(0.053, 0.090)</td>
<td>0.005</td>
</tr>
<tr>
<td><strong>MASC/FEMN</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R.NoseLipTri</td>
<td>0.122</td>
<td>2.28E-07</td>
<td>(0.076, 0.168)</td>
<td>0.015</td>
</tr>
<tr>
<td>ChinTri</td>
<td>0.195</td>
<td>4.21E-07</td>
<td>(0.120, 0.270)</td>
<td>0.038</td>
</tr>
<tr>
<td>NoseLipTotalQuad</td>
<td>0.113</td>
<td>5.98E-06</td>
<td>(0.064, 0.161)</td>
<td>0.013</td>
</tr>
<tr>
<td>JawTri</td>
<td>0.11</td>
<td>1.68E-05</td>
<td>(0.060, 0.160)</td>
<td>0.012</td>
</tr>
<tr>
<td>NoseLipTotalTri</td>
<td>0.06</td>
<td>2.61E-06</td>
<td>(0.035, 0.085)</td>
<td>0.004</td>
</tr>
<tr>
<td>JawTotalQuad</td>
<td>0.059</td>
<td>1.71E-05</td>
<td>(0.032, 0.087)</td>
<td>0.004</td>
</tr>
</tbody>
</table>

*Note:* For Masc/femn smaller features = more Masculine which also mean larger feature areas = more feminine and $\beta^*$ represents standardized partial regression coefficients.

$\uparrow$ Bigger Area Size $= \uparrow$ Higher Subjective Rating

*Figure 9. Bigger Areas*
The results in Table 4 report the preferences for smaller features, which are only important for subjective intelligence and masculinity/femininity. Smaller features in the upper mouth area seem to be important in relation to perceiving participants as more intelligence. Compared to the features important for masculinity in Table 3, we now see that smaller top eye areas and areas between the top eye and eyebrow are an important factor in being perceived as more masculine. Thus larger top eye areas and areas representing space above this to the eyebrows, is also related to being perceived as more feminine. Both of these patterns are once again significant with previous literature finding on sexual dimorphic traits, but these results encompass more specific area aspects of the eye. The results for smaller areas of facial features are also represented visually in Figure 10.

### Table 4.
Smaller is Better

<table>
<thead>
<tr>
<th>Features by Trait</th>
<th>$\beta^*$</th>
<th>p value</th>
<th>95% CI</th>
<th>$R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>S.INTL</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UpLipTotalTri</td>
<td>-0.112</td>
<td>7.16E-06</td>
<td>(-0.161, -0.063)</td>
<td>0.013</td>
</tr>
<tr>
<td>NoseLipTotalQuad</td>
<td>-0.105</td>
<td>3.64E-05</td>
<td>(-0.154, -0.055)</td>
<td>0.011</td>
</tr>
<tr>
<td><strong>MASC/FEMN</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L.TopEyeQuad</td>
<td>-0.116</td>
<td>7.03E-07</td>
<td>(-0.162, -0.071)</td>
<td>0.014</td>
</tr>
<tr>
<td>TopEyeTotalQuad</td>
<td>-0.058</td>
<td>3.31E-06</td>
<td>(-0.083, -0.034)</td>
<td>0.003</td>
</tr>
</tbody>
</table>

*Note: For MASC/femn smaller features = more Masculine which also mean larger feature areas = more feminine and $\beta^*$ represents standardized partial regression coefficients*
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![Diagram of Smaller Areas]

**Figure 10. Smaller Areas**

*Left vs. Right Differences*

An interesting pattern, presented in Table 5, reveals that there are differences in features on one side of the face versus the other for differing subjective traits. For attractiveness, right side top eye area and lower cheek areas were significant, but not their matching left side areas. For subjective extraversion, the area between the nose and the lips was only statistically significant on its own for the left side. Table 3 shows that when the left and right side areas for features are added together, the sum of these areas can be significant, TotalQuad/Tri, but since the correlation and p value decrease, this may mean that most of the significance from their summed area is actually coming from a feature only on one side. Face-side differences in features for masculinity/femininity appear to be the most tantalizing. The left side has more significant features than the right, and the left side features correspond to smaller features and the right side to bigger features in relation to
being perceived more masculine (the reverse, for more feminine). Additionally the left side features pertain only to eye areas, while the right side features only pertain to the region above the mouth. These differences also would result in the face being less symmetrical and less average, on the verge of favoring asymmetry.

Table 5.

<table>
<thead>
<tr>
<th>Features by Trait</th>
<th>( \beta^* )</th>
<th>p value</th>
<th>95% CI</th>
<th>( R^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ATTR</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \text{RIGHT} )</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R.LowCheekTriAVG</td>
<td>-0.084</td>
<td>2.86E-05</td>
<td>(-0.124, -0.045)</td>
<td>0.007</td>
</tr>
<tr>
<td><strong>S.EXTRAV</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \text{LEFT} )</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L.NoseLipTri</td>
<td>0.072</td>
<td>7.27E-06</td>
<td>(0.041, 0.104)</td>
<td>0.005</td>
</tr>
<tr>
<td>( \text{MASC/FEMN} )</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \text{LEFT} )</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L.TopEyeQuad</td>
<td>-0.116</td>
<td>7.03E-07</td>
<td>(-0.162, -0.071)</td>
<td>0.014</td>
</tr>
<tr>
<td>( \text{RIGHT} )</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R.NoseLipTri</td>
<td>0.122</td>
<td>2.28E-07</td>
<td>(0.076, 0.168)</td>
<td>0.015</td>
</tr>
</tbody>
</table>

Note: For Masc/Femn keep in mind if +/- estimate for area predicts more masculine the opposite predicts more feminine \( \beta^* \) represents standardized partial regression coefficients

**Causal Mediation**

In order to determine causal mediation, the dependent variable (DV), facial feature, must be correlated with the independent variable (IV), subjective or measured trait, and the mediator (M), which must also be correlated with the IV. If the DV is no longer significant when using regression to control for the effect of M on the IV, full mediation has occurred; if the significance is only reduced, partial mediation has occurred. Figure 11 represents all the potential mediators that could be investigated. Note that the relationship between attractiveness and measured extraversion just misses the cut off for significance,
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at 0.05 with a p value of 0.07. Common significant facial features relating to measured intelligence and extraversion (along with many other common features for other subjective traits) were only found before the using the Bonferroni correction and thus were not investigated. The results of the Figure 11 mediation pathway diagram show a multitude of interesting relationships, some of which differ from the results obtained by Adams’ (n.d.). Subjective extraversion correlated with measured extraversion, but measured extraversion marginally but no longer significantly related to attractiveness and neither is related to subjective masculinity/femininity. Measured extraversion is still negatively related to perceived intelligence, but perceived extraversion is positively related. Unfortunately no features made the cut off for significant mediation of these traits.

Note: Paths are marked with standardize beta coefficients
p ~ 0 **** p < 0.001 *** p < 0.01 ** p < 0.05 * p<0.1 ‘.’

Figure 11. Path Analysis of Measured and Subjective Traits
Sex Differences

The interaction with sex for significant features was also tested to investigate features that differed by sex for traits; the results found are represented in Table 6 and visually represented in Figure 12. The positive relationships between eye areas and perceived attractiveness (L.EyeTopTri: $\beta = 0.112$, $p=9.36E-07$; L.EyeQuad: $\beta = 0.095$, $p = 4.39E-05$; EyeTotalQuad: $\beta = 0.050$, $p=2.46E-05$; and EyeTopTotalTri: $\beta = 0.062$, $p=1.34E-07$), denoted again that larger eye areas often have higher attractiveness scores. There is also a positive relationship between sex (males = +0.5, female= −0.5), which means that on average males are rated as more attractive than females. The negative interaction slopes for both triangular and quadrilateral areas for eyes suggest that having larger eye is associated with being perceived as more attractive in females than in males. Next looking at the results for subjective extraversion, which all have positive slope estimates, we see that having a larger jaw area makes you perceived as more extraverted and on average males are rated higher for extraversion than females. The positive interaction slope for this reflects that males with larger jaw areas will be perceived as more extraverted than females with larger jaw areas. The pattern seen before with eyes and attractiveness differs for masculinity/femininity. As L.TopEyeQuad area increases, perceived masculinity decreases (perceived femininity increases), more so for males than females. The interaction effect for chin areas is much larger for males, which results in males with larger chins being perceived as much more masculine than females with larger chins.
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Table 6. 
Interaction with Sex

<table>
<thead>
<tr>
<th>Traits &amp; Features</th>
<th>$\beta^*$</th>
<th>SE</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ATTRsd</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L.EyeTopTri</td>
<td>0.112</td>
<td>0.02</td>
<td>9.36E-07  ***</td>
</tr>
<tr>
<td>SEXmc</td>
<td>0.206</td>
<td>0.04</td>
<td>1.50E-06  ***</td>
</tr>
<tr>
<td>L.EyeTopTri:SEXmc</td>
<td>-0.105</td>
<td>0.04</td>
<td>1.34E-02  *</td>
</tr>
<tr>
<td>L.EyeQuad</td>
<td>0.095</td>
<td>0.02</td>
<td>4.39E-05  *</td>
</tr>
<tr>
<td>SEXmc</td>
<td>0.202</td>
<td>0.04</td>
<td>2.76E-06  ***</td>
</tr>
<tr>
<td>L.EyeQuad:SEXmc</td>
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<td>0.04</td>
<td>1.65E-02  ***</td>
</tr>
<tr>
<td>EyeTotalQuad</td>
<td>0.050</td>
<td>0.01</td>
<td>2.46E-05  ***</td>
</tr>
<tr>
<td>SEXmc</td>
<td>0.204</td>
<td>0.04</td>
<td>2.14E-06  ***</td>
</tr>
<tr>
<td>EyeTotalQuad:SEXmc</td>
<td>-0.047</td>
<td>0.02</td>
<td>2.85E-02  *</td>
</tr>
<tr>
<td>L.TopEyeTotalTri</td>
<td>0.062</td>
<td>0.01</td>
<td>1.34E-07  ***</td>
</tr>
<tr>
<td>SEXmc</td>
<td>0.213</td>
<td>0.04</td>
<td>7.46E-07  ***</td>
</tr>
<tr>
<td>L.TopEyeTotalTri:SEXmc</td>
<td>-0.046</td>
<td>0.02</td>
<td>3.65E-02  *</td>
</tr>
<tr>
<td><strong>S.EXTRsd</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>JawTri</td>
<td>0.105</td>
<td>0.02</td>
<td>5.64E-09  ***</td>
</tr>
<tr>
<td>SEXmc</td>
<td>0.409</td>
<td>0.03</td>
<td>&lt; 2e-16   ***</td>
</tr>
<tr>
<td>JawTri:SEXmc</td>
<td>0.083</td>
<td>0.03</td>
<td>9.86E-03  **</td>
</tr>
<tr>
<td>JawTotlaQuad</td>
<td>0.068</td>
<td>0.01</td>
<td>1.40E-12  ***</td>
</tr>
<tr>
<td>SEXmc</td>
<td>0.409</td>
<td>0.03</td>
<td>&lt; 2e-16   ***</td>
</tr>
<tr>
<td>JawTotlaQuad:SEXmc</td>
<td>0.051</td>
<td>0.02</td>
<td>2.35E-03  **</td>
</tr>
<tr>
<td><strong>MASC/FEMN</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>L.EyeQuad:SEXmc</td>
<td>0.096</td>
<td>0.05</td>
<td>4.28E-02  *</td>
</tr>
<tr>
<td>L.TopEyeQuad</td>
<td>-0.117</td>
<td>0.02</td>
<td>5.70E-07  ***</td>
</tr>
<tr>
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<td>0.05</td>
<td>1.46E-02  *</td>
</tr>
<tr>
<td>ChinTri</td>
<td>0.215</td>
<td>0.04</td>
<td>2.61E-08  ***</td>
</tr>
<tr>
<td>SEXmc</td>
<td>0.299</td>
<td>0.05</td>
<td>3.13E-10  ***</td>
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<tr>
<td>ChinTri:SEXmc</td>
<td>0.195</td>
<td>0.05</td>
<td>2.72E-05  ***</td>
</tr>
</tbody>
</table>

*Note:* Significance codes: 0 **** 0.001 *** 0.01 ** 0.05
Discussion

There is no doubt that human faces are used a key evaluations factors by other humans, from determining potential threats to finding potential mates. The validity of the latter draws upon whether or not the information we take away from human faces reflects successful mating or not. Essentially, do we find faces attractive because the faces are a “good genes” sign? Or have social biases swayed us in what we deem attractiveness to something more along the lines of a “coolness” halo effect, revolving around other social factors, rather than an effect derived from years of evolutionary determinism? The results of this study suggest the latter. Looking at the pathway analysis in Figure 11, we see that being more attractive does not actually make you more intelligent or extraverted (attractiveness is not a mediator) but it does make you perceived as such (attractiveness is a mediator).
To understand this “coolness” halo effect, think about celebrities or the grade school glory days of the popular kids. Most of the people in this group were attractive and/or extraverted; people idolized them, associating them with other positive personality attributes like being more intelligent or extraverted. Over generations of this happening, and more, especially in today’s generation, first impressions of attractiveness became inseparable from these other factors. This indivisible association also gave rise to a cyclic nature between attractiveness and perceived extraversion, with more attractive people always being perceived as extraverted. The reverse also began to become true, thus leading to people being perceived as more extraverted and additionally being perceived as more attractive and intelligent, ergo giving birth to the “coolness” effect. Figure 11 has been adapted to show this effect, seen below in Figure 13.

Extraversion is a key factor for humans, with extraverts having a strong evolutional history of success based on their standing in social hierarchy. For the ancestors of modern humans, standing in the group rank was very determinative of evolutionary success and having good genes was secondary, not primary. Lower social ranking decreased mating opportunities and access to food sources. However, apes that were extremely social often had more friendships, which often gave them access to more chances for mating and better quality/quantity of foods, sometime even allowing them to overthrow those who ranked at the top because they were so well liked by individuals of their social group (Silk, 2007; Nguyen et al, 2009). This makes extraversion an evolutionarily advantageous trait, potentially explaining why people perceive more extraverted individuals as more attractive.
Additional selective pressure for males to be more extraverted comes from the characteristics of this trait that may have originally resulted as a consequence of the strong response to naturally rewarding stimuli, like food, physical elation and sex (Depue & Collins, 1999). Extraverts spend more time seeking these rewards (Depue & Collins, 1999), which were mostly likely made rewarding in the first place because they increased reproductive success. In support of this, extraverted individuals are more likely to form and take advantage of opportunities to mate (Barnes et al., 1984; Heaven et al., 2000; Nettle, 2005; Schmitt & Shackelford, 2008; Smith & Blumstein, 2008).

**Figure 13. The “Coolness” Effect**

The cyclic nature of this relationship is depicted in the double arrows in Figure 13, highlighting the relationship between attractiveness and extraversion. These cyclic or bi-directional causation relationships may be explained by the previously presented “coolness” effect. Sometimes features that seem attractive do not actually individually
correlate to attractiveness, like fuller lips (Paunonen et al. 1999). The results of this study show that a fuller bottom lip is actually related to higher extraversion score, which then relates to higher perceived attractiveness scores, yet another example of how the intricacies of the path play out.

Another way in which perceived extraversion could feed into perceived attractiveness is through sexual dimorphism. As the results of this study and others (Scott et al., 2010; Cunningham et al., 1990; Jones & Hill, 1993; Swaddle & Reierson, 2002) have shown, higher subjectively rated masculinity scores predict lower attractiveness ratings or no relationship at all, leaving little room to explain the selective pressures that have led to sexual dimorphic facial features. Perhaps females have not selected for more masculine faces but more extraverted ones. Looking back at the results in Table 7 and Figure 13, both perceived extraversion and masculinity/femininity relate to bigger areas for total triangular area between the nose and lips and total jaw areas. Additionally only jaw areas for subjective extraversion were differentiated by sex, with larger jaw areas predicting higher extraversion scores for males than for females, also seen in Figure 13. This could potentially mean that stereotypically masculine traits are favored because they indicate that mates are more extraverted rather than more masculine, thus making them more desirable as mates and often being perceived as more attractive. Once again this could be considered part of the “coolness” halo effect, with females selecting for males with bigger jaws as a cue to how extraverted these individuals were, meaning they were better at social relations which could increase the female’s and offspring’s survival, especially during rough times.
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Based on the results of this study, on a facial feature level, averageness is not as preferred as compared to what literature suggests for whole face preference. No measures of symmetry passed the Bonferonni-corrected significance threshold, which is likely due to the poor standardization of faces, making it almost impossible to get a good measure of symmetry for the sample. The results do support directional preferences away from averageness, towards more extreme phenotypes, and for most subjective traits, larger phenotypes are preferred.

When looking at all of these results and thinking about them in the context of modern day advertisements for beauty, make-up and even animation focus on emphasizing, similar patterns appear: for the most part, bigger is better. Figure 14 emphasizes this point by showing examples of how females use makeup to accentuate their face or how to draw eyes for animation. More attention is drawn to making the upper areas of the eye seem larger, coinciding with the results of this study, increases in perceived attractiveness for larger eye areas. Also matching the data as shading is done to make the jaw and chin areas seem smaller, and more feminine, which is more attractive. In addition, more accentuation to the bottom lip makes it seem fuller and larger than the top lip. This technique corresponds to the results of perceiving someone with a larger lower lip area as more extraverted, while a smaller upper lip area relates to being perceived as more intelligent. Similar patterns can be seen for other significant features of this study as well as in relation to what is emphasized with makeup, like lip and above to the nose, cheek, top of the eyes and chin areas.
Facial perception is key for interpersonal communication, since critical information about potential sexual interest, threat and emotions can be derived from the faces of other humans. The results of this study suggest that the primary facial features related to predicting higher attractiveness and femininity are larger areas concerning the eyes, while smaller areas pertaining to the upper lip and between this and the nose are relate to higher perceived intelligence. Areas in the lower half of the face linked to perceptions about extraversion and masculinity. Attractiveness perceptions being related to the eye areas makes sense since studies have shown that increasing oxytocin levels increases gaze, first toward the eye regions of the human face, then the nose and mouth area, and lastly the peripheral sections (Guastella et al., 2008). Additionally there seems to be slight differences
in important features on the right vs. left side of the face, as seen in Table 5. Other studies have found the left side of the face to be more related to expression of emotion, stemming from lateralization in the brain of right hemisphere, which corresponds to expression of emotion (Borod et al. 1998; Haraguchi et al. 2002; Nicholls et al. 2004). This notion might also explain the differences seen in the results of this study. In light of this, the left nose lip triangular feature associated with perceived extraversion could be due to different expressions of the mouth (since most faces did not have neutral expressions), which might affect the areas of this feature. A study done by Smith et al. (2000) reported that differences in brain hemisphere dominance may influence asymmetries between sides of the face, making people who are dominant in one side of the face have a larger mean area measure for the contralateral side of the face. However this aspect was not measured for the current subject sample and thus actual relations to such for this study cannot be commented on.

Borrowing two hypotheses from the ecological literature on the sexual selection of ornaments, of which facial features are arguably the human equivalents, could explain how facial features relate to each other: multiple-message hypothesis and redundant-signal hypothesis (Møller & Pomianowski, 1993). The former proposes that variations of perceived attractiveness are not only on a single dimension but instead this perception varies across multiple dimensions, with a different aspect of mate value being signaled by each feature. This same notion is also the underpinning for the redundant-signal hypothesis, which additionally takes into account that each signal from each feature is considered against the others, with the final evaluation being based on a composite of these signals. Under this hypothesis, humans would be honing in on several facial features in combination to better capture a more accurate estimation of mate quality than if they only
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focused on any single feature. The results of the current study seem to be in support of this interpretation of the redundant-signal hypothesis. This is seen by the fact that the small $R^2$ values in Tables 2 – 6 depict that each feature alone only explains a small amount of variance in ability to predict subjective traits, but adding them up all together captures a more truthful perception of personality and mate quality. Additional evidence for this hypothesis comes from different sizes of facial feature areas correspond to different perceived aspects of personality, masculinity/femininity, and intelligence, which all relates to perceived attractiveness scores. This again relates to the “coolness” halo effect as different features that matter more for different personality aspects inevitably relate to the summed contribution of how attractive you are perceived to be, suggesting that “beauty” lies not only in the phenotypic but also the social adaption, or extraversion, of the beholder.

There is no doubt that human faces are used as key evaluation factors by other humans, from determining potential threats to finding potential mates. Humans also to accurately perceive information about certain subjective traits from the face like intelligence and extraversion. Breaking down these subjective relationships may shed light on new ways of looking at things, like how evolution of social aspects may have led to extraversion having its own halo effect, seen in modern day as a “coolness” effect. The results of this study suggest that looking at the whole face alone. Furthermore these results suggest that studies solely looking at whole face symmetry, averageness, or asymmetry are ignoring key perceptual cues that occur on an individual feature level, which doesn’t give you the full picture. Additionally, previous attempts to explore facial features using 1D lines or unnaturally morphed photos are not an accurate method for investigation as it misses or skews what is really happening on a feature level. Being the first study to look at individual
facial feature areas has shown the importance of how differences in feature areas may be used as potential cues, giving a more complete picture in how exactly it is “we judge a book by its cover”. Adding all the pieces together allows us to more completely understand the puzzling complexities of human facial cues. However this study does not complete the whole puzzle of the human face, but it does present new ways to find more pieces of the puzzle that have been previously missed.

_Potential Limitations_

The main limitation of the current study is the poor standardization of facial photos taken, since all possible different facial expression could not be controlled for, which may have lead to inaccurate finding despite rigorous efforts to control for error. Another factor that was not examined was the rater’s own self-perceptions for the traits investigated. This could be importance since Horton (2003) reported that raters own perceptions of self can affect their subjective ratings of others, leading them to rate participants more similar to how they perceived themselves. The Bonferroni correction may have been too conservative. Since the study was done on twins and siblings, the sample should have been broken up into two groups, separating family members, and used as a pseudo-replication study.

_Future Studies_

As the results show, breaking down faces to feature level, that represented in more than 1D lines or unnaturally morphed features presents a very different and more encompassing picture than before. Potential studies in the future should involve only photos that were properly standardized, to minimize any error this may have cause. Even
better yet would be to collect topographic measure of facial features, since their true shape is 3D. Additionally, having raters also rate themselves on the same traits could be a good control for any self-bias, or looking at the effects of raters’ menstrual cycle on all subjective ratings. A study entailing tracking of eye movements of raters while they are making subjective ratings to determine if eye attention is draw to the same features that were significant for each subjective rating would be particularly interesting. Recently raters were also asked to rate the participants on aspects of political views, with a scale of 1 being liberal and 7 being conservative, to investigate if certain facial features might predict your political views as well. For this study, raters also rated themselves on the same topics to look for any possible relationships to self-perceptions.
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