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The Relative Importance of Sexual Dimorphism, Fluctuating Asymmetry, and Color Cues to Health during Evaluation of Potential Partners' Facial Photographs

A Conjoint Analysis Study

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Abstract Sexual dimorphism, symmetry, and coloration in human faces putatively signal information relevant to mate selection and reproduction. Although the independent contributions of these characteristics to judgments of attractiveness are well established, relatively few studies have examined whether individuals prioritize certain features over others. Here, participants (*N* = 542, 315 female) ranked six sets of facial photographs (3 male, 3 female) by their preference for starting long- and short-term romantic relationships with each person depicted. Composite-based digital transformations were applied such that each image set contained 11 different versions of the same identity. Each photograph in each image set had a unique combination of three traits: sexual dimorphism, symmetry, and color cues to health. Using conjoint analysis to evaluate participants' ranking decisions, we found that participants prioritized cues to sexual dimorphism over symmetry and color cues to health. Sexual dimorphism was also found to be relatively more important for the evaluation of male faces than for female faces, whereas symmetry and color cues to health were relatively more important for the evaluation of female faces than for male faces. Symmetry and color cues to health were more important for long-term versus short-term evaluations for female faces, but not male faces. Analyses of utility estimates reveal that our data are consistent with research showing that preferences for facial masculinity and femininity in male and female faces vary according to relationship context. These findings are interpreted in the context of previous work examining the influence of these facial attributes on romantic partner perception.

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The influence of facial sexual dimorphism, symmetry, and color cues to health on an individual's attractiveness has received considerable attention from evolutionary researchers (e.g., Fink et al. 2006; Rhodes 2006; Stephen, Law Smith, Stirrat, and Perrett 2009). Sexual dimorphism (i.e., masculinity/femininity) signals sexual maturity and reproductive potential (e.g., Feinberg et al. 2006; Johnston and Franklin 1993; Law Smith et al. 2006; Penton-Voak and Chen 2004; Symons 1979; Thornhill and Gangestad 1996), is associated with heritable immunocompetence (e.g., Folstad and Karter 1992; Moller et al. 1999), and predicts susceptibility to disease (e.g., Thornhill and Gangestad 2006). In human faces, sexual dimorphism is related to pathogen resistance, general health, and fecundity (Rhodes 2006; Rhodes et al. 2003; Law Smith et al. 2006; Thornhill and Gangestad 2006). Several studies show that women report greater attraction toward masculine male faces during the high-fertility phase of their menstrual cycle (Johnston et al. 2001; Jones et al. 2005; Penton-Voak et al. 1999; Welling et al. 2007), which likely reflects adaptive shifts in women's prioritization of genetic partner benefits when conception is most probable (Gangestad et al. 2005; Gildersleeve et al. 2014; but see Rhodes et al. 2003; Little et al. 2008; Penton-Voak et al. 1999). By contrast, men report a relatively consistent preference for feminine female faces (e.g., Perrett et al. 1998), although their preferences for femininity do increase as a function of their testosterone level (Welling et al. 2008b) and sex drive (Jones et al. 2011), suggesting that men may prioritize this trait when mating motivation is high.

Similarly, individuals with more bilaterally symmetrical faces are rated as appearing more attractive and healthy than those with more asymmetrical faces (e.g., Little, Apicella, and Marlowe 2007; Rhodes et al. 2001; Zaidel et al. 2005). An organism's ability to develop successfully in the face of environmental pressures is a proposed indicator of genetic quality (Møller and Swaddle 1997). Thus, low fluctuating asymmetry (i.e., deviations from perfect bilateral symmetry) is considered a marker of developmental stability (Møller 1990) and heritable genetic quality (Møller and Thornhill 1997) in both sexes. Other research supports this claim; individuals with higher fluctuating asymmetry tend to have lower rates of growth, fecundity, and survivability (Møller 1997) and report experiencing more health problems (Thornhill and Gangestad 2006) than more symmetrical individuals. Accordingly, women's preferences for more symmetrical male faces increases around peak fertility (Little, Jones et al. 2007), particularly in short-term (i.e., purely sexual) mating contexts (Little and Jones 2012). Together this research suggests that human mate preferences have evolved to prefer cues to underlying genetic quality that may be passed on to offspring.

Unsurprisingly, people also prefer healthy-looking partners. Skin coloration and color homogeneity are markers of aging and exposure to environmental stressors (e.g., chronic sun exposure, disease) and are associated with a number of health outcomes (Matts and Fink 2010; Samson et al. 2010). Faces manipulated to have more homogenous skin color distribution are perceived as younger, more attractive, and healthier than faces with less homogeneous color distribution in both women (Fink et al. 2006) and men (Fink et al. 2012). Furthermore, cropped images of facial skin with more homogenous color are rated higher on attractiveness, youthfulness, and health than other images (Jones et al. 2004; Matts et al. 2007). Skin blood perfusion (i.e., red skin coloration) signals cues to better health, including higher levels of circulating estrogens in women (Charkoudian et al. 1999; Thornton 2002) and greater blood oxygenation (typically associated with aerobic fitness; Armstrong and Welsman 2001). By contrast, decreased facial blood perfusion is associated with poor health (Muhe et al. 2000) and may indicate infection (e.g., malaria; Muhe et al. 1999). Furthermore, when asked to increase a facial photograph's apparent health using color manipulation software, participants will increase skin redness and similar color cues to blood oxygenation (Stephen, Coetzee, Law Smith, and Perrett 2009; Stephen, Law Smith, Stirrat, and Perrett 2009). Similarly, the increased yellow skin tone associated with consuming the carotenoids found in fruits and vegetables (i.e., a healthy diet) is considered both healthy-looking and attractive (Lefevre and Perrett 2015; Stephen et al. 2011; Whitehead et al. 2012a, 2012b). Preferences for these cues to current physical health complement the research on preferences for cues to underlying genetic quality outlined above and add additional evidence to the supposition that we seek out high-quality people (i.e., those with healthy habits and good genes) with whom to reproduce.

Assessing Face Preferences

The methods used to assess the desirability of any particular trait are varied, but the majority of research either correlates facial metrics and attractiveness ratings (e.g., Baudouin and Tiberghien 2004; Penton-Voak et al. 2001; Cunningham et al. 1995) or experimentally manipulates facial features using digital morphing software (e.g., Fink et al. 2006; Jones et al. 2005; Little, Apicella, and Marlowe 2007; Welling, Jones and DeBruine 2008). For example, to assess the contribution of skin color homogeneity to ratings of attractiveness, Fink et al. (2006) digitally manipulated skin color homogeneity of three-dimensional face stimuli while standardizing each face's shape, texture, and topography. Likewise, Welling et al. (2008b) used composite-based transformations to alter the 2D shape of men's and women's facial photographs while controlling for changes in skin color and texture. Similarly, Scott et al. (2010) and Stephen et al. (2012) examined the contributions of masculinity and healthy color cues to perceptions of facial attractiveness by regressing attractiveness ratings of male facial photographs onto morphometric measures of face sex-typicality and skin coloration. These study designs allow researchers to draw conclusions about the individual value of a trait to overall perceptions of attractiveness while holding constant or statistically controlling for variation in other traits. However, no study has yet examined how these traits are prioritized relative to one another when evaluating multiple traits simultaneously.

One manner by which to assess how individuals weigh the value of one trait relative to other traits is to force them to make trade-offs between multiple traits. For example, when asked to design an ideal mate by allocating a limited pool of "mating dollars" to various partner attributes, people are more likely to prioritize evolutionarily predicted "necessities" (e.g., physical attractiveness for men, social status for women; Buss and Schmitt 1993) over "luxury" traits (e.g., kindness, creativity) when their mating dollar budget is more restricted (Li 2007; Li et al. 2002, 2011). When provided a more generous mating budget, participants will more evenly allocate their mating dollars among "luxury" and "necessity" traits. This mate preference priority model (Li et al. 2002) predicts that individuals will make trade-offs among multiple traits and prioritize more important traits when their ability to select an optimal mate is restricted. In face preference research, participants are typically asked to make trade-offs when assessing potential partners across a single facial dimension (e.g., choosing between a more versus less masculine version of a particular individual; Boothroyd et al. 2007). However, this type of design does not address how these trade-offs are made in the context of variation in other facial attributes. For example, is a mate higher in masculinity but lower in apparent health preferred over a mate lower in masculinity but higher in apparent health?

The process by which humans evaluate facial information highlights the importance of studying how individuals prioritize certain facial attributes over others during mate choice. Compared with most objects that are visually processed based on the qualities of their individual parts (i.e., part-based processing; see Biederman 1987), more holistic processing (i.e., where multiple facial features are integrated into a single perceptual representation; Hancock et al. 2000; Piepers and Robbins 2012; Rossion 2008) has been shown to underlie judgments of facial attractiveness (Abbas and Duchaine 2008). However, face perception appears to result from the combined output of concurrent holistic and part-based information processing (Schwaninger et al. 2004), suggesting that facial information is also decomposed into parts (McKone and Yovel 2009). Thus, it is possible that the part-worth values of some facial features are weighed more heavily than others during perception of a potential romantic partner. Understanding the relative signal value of various fitness cues may help address currently unresolved questions in the evolutionary study of physical attractiveness, such as the precise signal value of desirable facial features (Gangestad and Scheyd 2005). In their mathematical model of facial attractiveness, Said and Todorov (2011) show that the association between perceived attractiveness and measures of facial sexual dimorphism and averageness varies depending on which underlying component (e.g., facial shape versus lightness/darkness) is considered. Examining the value of a fitness indicator relative to other fitness indicators may help identify which indicators are relatively more salient during mate evaluation, and therefore which attributes contribute more to perceptions of partner attractiveness. Moreover, understanding whether people prioritize certain facial characteristics over others in various mating contexts (e.g., long- versus short-term; Buss and Schmitt 1993; Gangestad and Simpson 2000) may further parse the signal value of different facial attributes and thereby inform our understanding of the design underlying perceptions of attractive facial cues (e.g., Gangestad and Scheyd 2005; Puts 2010; Thornhill and Gangestad 1999).

Conjoint Analysis and Face Preferences

One technique researchers might use to assess the relative part-worth value of facial attributes is conjoint analysis (CA; Luce and Tukey 1964). CA is a multivariate analysis used primarily in marketing research (e.g., Gustafsson et al. 2007; Lohrke et al. 2010) to evaluate which attributes of a product influence consumers' purchasing decisions. Participants are provided several versions of a product, each of which has a unique combination of various product attributes, and are asked to rank the products by their purchasing preferences. From these rankings, CA provides the researcher with "importance values" which estimate the relative importance of each attribute to the overall evaluation of the product. This technique has recently been adapted for use in human mating research. Mogilski et al. (2014) used CA to assess the relative importance of a partner's history of sexual fidelity relative to four other mate attributes (physical attractiveness, financial stability, emotional relationship investment, and partner similarity) in men's and women's assessments of potential long- and short-term romantic partners. Using a fractional-factorial design (Hair et al. 1995), they generated an orthogonal array of 19 hypothetical partner profiles, each composed of a unique combination of mate attributes. Attributes were assigned three potential levels reflecting undesirable, moderately desirable, and highly desirable amounts. For example, an individual might be described as "high in physical attractiveness, low in financial stability, high in sexual fidelity, low in emotional investment, and medium in partner similarity." Participants were then instructed to rank these profiles by their preference to start a long- and short-term relationship with each individual. Using CA, they found that both men and women prioritized a potential long-term partner's history of sexual fidelity over every other attribute and prioritized a potential short-term partner's history of sexual fidelity, physical attractiveness, and financial stability over a potential partner's emotional investment and similarity.

The utility of CA to measure mate preferences comes from the manner in which data are collected from participants. Mate preference researchers typically use a "compositional" statistical approach whereby both independent and dependent variables are collected from participants and used to estimate a predictive model (Hair et al. 1995). By contrast, CA uses a "decompositional" approach in which the levels of each independent variable are specified beforehand. Different combinations of each attribute's levels are presented in profiles, which are subsequently assessed by participants. CA is then used to construct a predictive model by "decomposing" participants' assessments into the importance values for each attribute. Relative to a compositional approach, assessing decision-making in this way forces participants to consider the importance of an attribute relative to other attributes (i.e., to make trade-offs; Gustafsson et al. 2007; Lohrke et al. 2010), which can affect reported mate preferences (Li et al. 2002; Mogilski et al. 2014; Scheib 2001; Wayneforth 2001). Furthermore, participants are never asked to provide explicit reports of their preferences, which can be biased by social desirability, faulty memory, an inability to express decision-making processes, or difficulty articulating implicit preferences (Shepherd and Zacharakis 1997; Wilson and Dunn 1986).

Asking participants to assess facial photographs of potential mates in a conjoint ranking task would likewise reveal how individuals make trade-offs among various facial features when evaluating potential mates' faces. In the present study, we use CA to examine how individuals prioritize sexual dimorphism, symmetry, and color cues to health when evaluating photographs of potential long- and short-term romantic partners.

Methods

Participants

Participants ($N = 542$; 315 female; age: $M = 20.70$ years, $SD = 4.17$; range = 18–48) were recruited from a private university in the eastern United States and from various social media outlets (e.g., Facebook, Reddit, Twitter.). Almost all participants (98%) completed the study in the northeastern United States, as determined by participants' IP addresses. The majority of participants were white (76.2%; 8.1% black, 6.3% Asian, 3.3% Hispanic/Latino, and 6.1% other) and roughly half reported being single (56.6% vs. 43.4% who reported being in a relationship). Because sexual orientation affects preferences for sexually dimorphic facial cues (Glassenberg et al. 2010), participants who did not identify as exclusively heterosexual (n = 34) were excluded from analyses, leaving us with 508 participants (294 female; age: M = 20.68 years, SD = 4.20; range = 18–48).

Stimuli

First, we selected 3 white men and 3 white women who were of similar age (M = 19.0 years, SD = 0.63, range = 18–20 years) at random from a larger collection of facial photographs collected previously at a different large eastern United States university. Each of these individuals served as the base image for a set of 11 photographs that varied exclusively by a series of objective, composite-based image transformations applied to the original photographs. Up to three distinct facial characteristics were transformed per photograph variation: sexual dimorphism, symmetry, and color cues to health. To permit CA of participants' photograph rankings, each of the 11 photograph variations was planned using an orthogonal array generated with IBM SPSS 21. A fractional-factorial design was used to minimize the number of photograph variations that participants were required to rank (Hair et al. 1995). Each facial characteristic (i.e., sexual dimorphism, symmetry, and color cues to apparent health) was assigned three possible levels indicating which transformations would be applied to each photograph. Sexual dimorphism transformation levels were facial masculinization, unaltered (i.e., original) sexual dimorphism, and facial feminization. Symmetry transformation levels were increased facial symmetry, unaltered symmetry, and increased facial asymmetry. Color cues to health transformation levels were healthier, unaltered, and unhealthier color cues to health. Hair and clothing cues were masked prior to testing, and facial identity was held constant within each set (i.e., all eleven images in each set depicted the same person).

This produced an orthogonal array of nine photograph variations in each set, with each variation having a unique combination of the three facial characteristics. For example, a face might be masculinized, have increased asymmetry, and unaltered color cues to health. Two additional "holdout" images (for a total of 11 photographs) were included to test the validity of the CA utility estimates. These holdout photographs are created as part of the orthogonal array by the statistical package and are presented to participants alongside the other photographs but are not used in generating the predictive model. Rather, the predictive model is generated from participants' rankings of the nine original photographs and then used to predict how the holdout photographs should be ranked by each participant. This provides a correlation coefficient (tau) showing how accurately the model predicts participants' rankings of the holdout photographs relative to the other nine (see Hair et al. 1995 for a detailed explanation of holdout profiles). No holdout photographs were duplicates of the nine orthogonal photographs. The same orthogonal array was used for male and female facial photographs (Table 1). Example photograph variations for male and female faces are presented in Figs. 1 and 2.

Table 1 Orthogonal array of facial transformations and the respective image variations to which they were applied. The number listed in the "Image variation" column corresponds to the each image's numerical label in Figs. 1 and 2

Image variation	Sexual dimorphism	Symmetry	Health
1	Masculine	High symmetry	High coloration
2	Neutral	Low symmetry	Neutral coloration
3	Feminine	Natural symmetry	Low coloration
4	Masculine	Low symmetry	Low coloration
5	Masculine	Natural symmetry	Neutral coloration
6	Neutral	Natural symmetry	High coloration
7	Neutral	High symmetry	Low coloration
8	Feminine	High symmetry	Neutral coloration
9	Feminine	Low symmetry	High coloration
10 (Holdout)	Feminine	Low symmetry	Low coloration
11 (Holdout)	Feminine	High symmetry	Low coloration

Using well-established methods (e.g., Little, Jones et al. 2007; Jones et al. 2005; Welling et al. 2008a), each base image was manipulated in terms of sexual dimorphism, symmetry, and color cues to health to create each of the eleven variations (Table 1). To alter facial sexual dimorphism, we first created male and female composite faces by

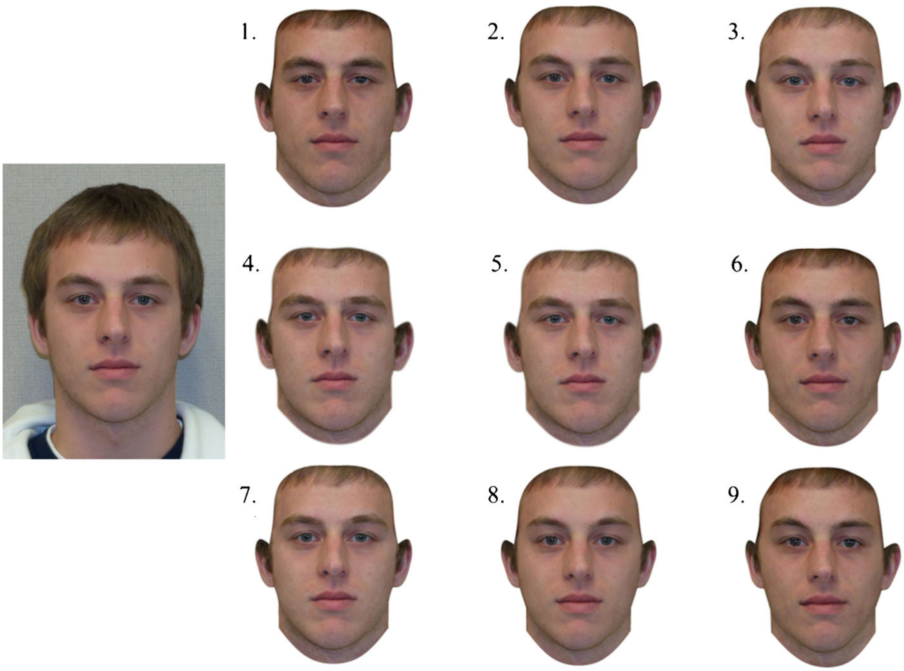

Fig. 1 Example of an unaltered male photograph (left) and the nine masked, orthogonal image variations to which one or more of the three composite-based facial transformations were applied according to an orthogonal array (see Table 1)

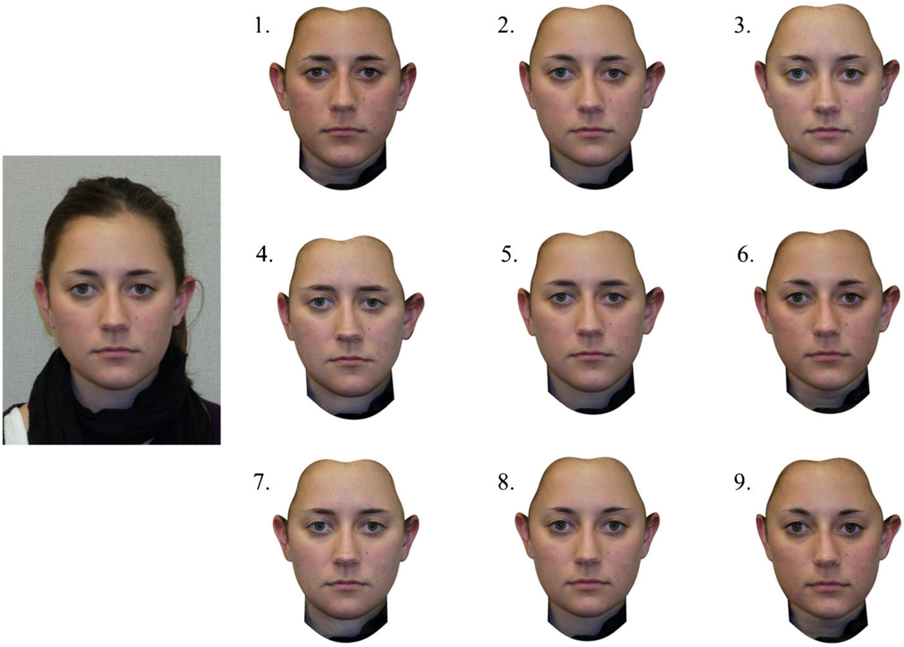

Fig. 2 Example of an unaltered female photograph (left) and the nine masked, orthogonal image variations to which one or more of the three composite-based facial transformations were applied according to an orthogonal array (see Table 1)

averaging the shape, color, and texture of a group of 60 male faces and a group of 60 female faces. Transformations were then applied to the base images as applicable as per prior research (e.g., DeBruine et al. 2006; Welling et al. 2007; Welling et al. 2008a) by taking 50% of the linear differences in 2D shape between symmetrized versions of the male and female composite faces and adding to (to masculinize) or subtracting from (to feminize) corresponding points on the original, unaltered photograph (for details, see Rowland and Perrett 1995; Tiddeman et al. 2001). These manipulations have been shown to influence perceptions of masculinity and femininity in the predicted way (DeBruine et al. 2006; Welling et al. 2007).

To alter symmetry, base images were either made symmetrical in 2D face shape or the asymmetries were exaggerated by 50% (for the high symmetry and low symmetry face versions, respectively). To make a face symmetrical, the positions of corresponding feature markers on the left and right sides of an individual's face were averaged, and these averaged X-Y coordinates were applied to the corresponding points on both sides of the original face (e.g., Little, Jones et al. 2007; Perrett et al. 1999). To make a face more asymmetrical, 50% of the linear differences between the unaltered base image's face shape and a symmetrized version of that same individual were added to corresponding points on the base image, effectively exaggerating the natural asymmetries in the face. Symmetry and sexual dimorphism manipulations alter 2D face shape only, leaving other facial traits, such as identity, skin color, and skin texture, unchanged (Rowland and Perrett 1995; Tiddeman et al. 2001).

To alter facial color cues to health, we first created "high health" and "low health" composite faces for each sex using color-calibrated base images as per previous research (Jones et al. 2005). Briefly, composites were created by averaging the shape, color, and texture of the 25 faces with highest and 25 faces with the lowest perceived health within each sex out of a group of 234 White faces (117 male; age: $M = 20.03$ years, $SD = 1.24$, range = 18–35) that were rated by 98 participants (37 male; age: $M = 21.81$ years, $SD = 2.10$, range = 18–32) for perceived health on a 7-point Likert scale (anchors: 1 = not at all healthy, 7 = extremely healthy). Healthy and unhealthy stimuli were then manufactured by transforming images by ±50% of the difference in color between the same-sex healthy and unhealthy prototypes while controlling for differences in 2D facial shape and texture. Similar manipulations have been shown to influence perceptions of apparent health in the predicted way (Jones et al. 2005).

Procedure

All experimental materials were presented using Qualtrics, an online browser-based survey software program. After indicating their consent, participants provided demographic information (age, sex, ethnicity, relationship status, and sexual orientation) and then completed a series of 12 face-ranking tasks. For each task, participants were presented with one of the 6 sets of 11 digital facial photographs. Participants were asked to rank the images in each set relative to one another twice: once according to their preference for a long-term relationship and once according to their preference for a short-term relationship. Long- and short-term relationships were defined for participants as follows:

- *Long-term relationship:* You are looking for the type of person who would be attractive in a long-term relationship. Examples of this type of relationship would include someone you may want to move in with, someone you may consider leaving a current partner to be with, and someone you may, at some point, wish to marry (or enter into a relationship on similar grounds as marriage).
- *Short-term relationship:* You are looking for the type of person who would be attractive in a short-term relationship. This implies that the relationship may not last a long time. Examples of this type of relationship would include a single date accepted on the spur of the moment, an affair in a long-term relationship, and the possibility of a one-night stand.

Participants were instructed to rank same-sex photographs by how they thought a heterosexual person of the opposite-sex would rank them. The order in which the face-ranking tasks and photographs within sets were presented was randomized.

Results

CA was performed to assess the relative importance of each of the three facial attributes in participants' ranking decisions. Importance values and part-worth utility estimates were calculated for each of the six sets of faces, and participants' rankings of holdout profiles were accurately predicted by the utility estimates (all $\tau = 1.00$) for all six sets of faces. Importance values from each of the six sets were averaged across the sex of the face and relationship context to create four importance values per facial attribute: (1)

long-term male importance values, (2) short-term male importance values, (3) long-term female importance values, and (4) short-term female importance values (see Table 2 for descriptive statistics). All post-hoc analyses and pairwise comparisons were adjusted using the Bonferroni correction.

Importance Values

A 2 (sex of face [male, female]) × 2 (relationship context [long-term, short-term]) × 3 (facial attribute [sexual dimorphism, symmetry, color cues to health]) × 2 (sex of participant [male, female]) mixed-model ANOVA was used to examine differences in importance values for sexual dimorphism, symmetry, and color cues to health for male and female faces ranked for desirability as long- and short-term mates by male and female participants. There was a main effect for facial attribute, $F_{2,1012} = 162.70$, $p < 0.001$, $\eta^2 = 0.24$, whereby importance values for sexual dimorphism were significantly higher than importance values for symmetry and coloration. This was moderated by a significant interaction between sex of face and facial attribute, $F_{2,1012} = 41.57$, $p < 0.001$, $\eta^2 = 0.08$. Importance values for sexual dimorphism were higher for male faces than for female faces, $t_{507} = 8.00$, $p < 0.001$, $d = 0.36$, whereas importance values for symmetry and color cues to health were higher for female faces than for male faces (symmetry: $t_{507} = -3.83$, $p < 0.001$, $d = 0.18$; coloration: $t_{507} = -6.14$, $p < 0.001$, $d = 0.28$).

There was also a significant three-way interaction between sex of face, relationship context, and facial attribute, $F_{2,1012} = 5.915$, $p = 0.00$, $\eta^2 = 0.01$ (Fig. 3). For female faces, importance values for color cues to health were higher for a long-term

Table 2 Means, standard deviations, and standard errors for analyses of male, female, and average importance values and utility estimates

	Male		Female		Average	
	M	*SD*	*M*	*SD*	*M*	*SE*
Importance values						
Sexual dimorphism	41.44	10.73	37.15	9.76	39.30	0.38
Symmetry	28.99	7.69	30.69	9.26	29.64	0.31
Coloration	29.57	7.76	32.16	8.24	30.86	0.29
Utility estimates						
Masculinized	−0.42	1.12	−0.70	0.96	−0.56	0.04
Unaltered	0.22	0.53	0.21	0.48	0.22	0.02
Feminized	0.20	1.08	0.49	0.79	0.34	0.03
Symmetrized	0.37	0.62	0.47	0.72	0.42	0.03
Unaltered	−0.19	0.54	−0.14	0.51	-0.17	0.02
Asymmetrized	−0.18	0.55	−0.33	0.63	-0.25	0.02
Healthier	0.41	0.67	0.70	0.69	0.44	0.03
Unaltered	0.07	0.46	0.13	0.46	0.10	0.03
Unhealthier	−0.48	0.62	−0.83	0.71	−0.65	0.03

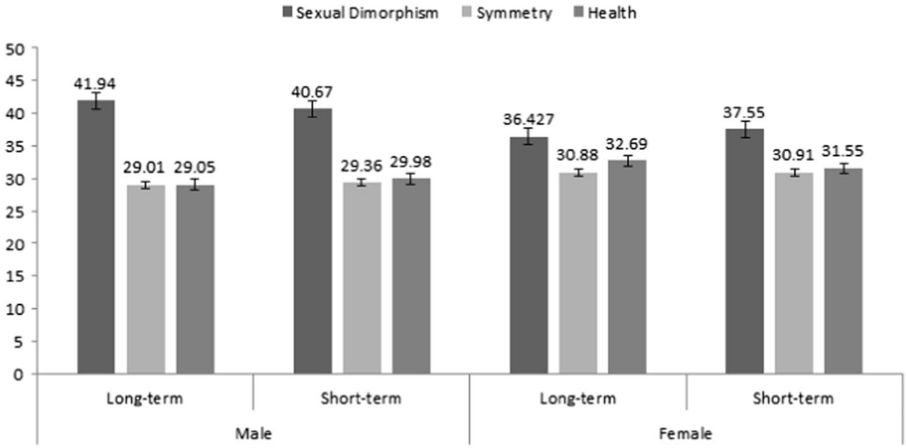

Fig. 3 Mean importance values for sexual dimorphism, symmetry, and health for male and female faces in long- and short-term romantic relationships

relationship than for a short-term relationship, $t_{507} = 2.29$, $p = 0.023$, $d = 0.09$, whereas sexual dimorphism importance values were higher for a short-term relationship than a long-term relationship, although this latter difference was only marginally significant, $t_{507} = -1.85$, $p = 0.065$.

There was also a significant interaction between attribute and participant sex, $F_{2, 1012} = 8.18$, $p < 0.001$, $\eta^2 = 0.02$. Averaged across the sex of the face and relationship context, importance values for sexual dimorphism were higher for female participants ($M = 40.10$, $SD = 8.20$) than for male participants ($M = 38.18$, $SD = 8.28$), $t_{506} = -2.60$, $p = 0.010$, $d = 0.22$. By contrast, importance values for symmetry were higher for male participants ($M = 31.29$, $SD = 6.51$) than for female participants ($M = 28.79$; $SD = 6.95$), $t_{506} = 4.103$, $p < 0.001$, $d = 0.35$. There was no significant difference between male and female participants' importance values for health, $t_{506} = -1.00$, $p = 0.320$, and no other significant main effects or interactions (all $F < 1.70$, all $p > 0.191$).

Utility Estimates

Whereas importance values provide an estimate of the relative importance of each overall attribute (i.e., sexual dimorphism, symmetry, and color cues to health), part-worth utilities provide an estimate of the relative importance of each *level* within an attribute (e.g., healthy, original, and unhealthy coloration). In other words, importance values give information about the value of a trait, but not the direction of that value (e.g., masculine versus feminine), whereas a higher utility estimate indicates greater preference for a particular attribute level and a lower utility estimate indicates lower preference. For example, higher utility estimates for facial masculinization indicate greater preference for facial masculinization and lower utility estimates for facial masculinization indicate lesser preference for facial masculinization. Likewise, positive values indicate preference for an attribute whereas negative values indicate an aversion to an attribute. Utility estimates for each of the six sets of facial profiles were averaged across sex of the face and relationship context, providing four variables (long-term male, short-term male, long-term female, short-term female) for each level of the three facial attributes (see Table 2 for descriptive statistics).

Sexual Dimorphism A 2 (sex of face [male, female]) × 2 (relationship context [long-term, short-term]) × 3 (attribute level [masculinized, original, feminized) × 2 (sex of participant [male, female]) mixed-model ANOVA revealed a main effect for attribute level, $F_{2,1012} = 163.42$, $p < 0.001$, $\eta^2 = 0.24$. Utility estimates for facial feminization were significantly higher than for facial masculinization ($p < 0.001$) and unaltered sexual dimorphism ($p < 0.001$), regardless of sex of face. Likewise, utility estimates for unaltered sexual dimorphism were higher than for facial masculinization ($p = 0.002$). However, there was also a significant interaction between sex of face and attribute level, $F_{2,1012} = 20.75$, $p < 0.001$, $\eta^2 = 0.039$. Averaged across relationship context, utility estimates for facial masculinization were greater for male faces than for female faces ($M = -0.70$, $SD = 0.96$), $t_{507} = 5.08$, $p < 0.001$, $d = 0.22$, whereas utility estimates for facial feminization were greater for female faces than for male faces, $t_{507} = -5.36$, $p < 0.001$, $d = 0.25$. There was no significant difference between utility estimates for unaltered male and female faces, $t_{507} = 0.45$, $p > 0.65$.

There was also a significant interaction between relationship type and attribute level, $F_{2,1012} = 5.23$, $p = 0.006$, $\eta^2 = 0.01$. Averaged across sex of face, utility estimates for facial masculinization were higher for a short-term relationship ($M = -0.50$, $SD = 0.95$) than for a long-term relationship ($M = -0.61$, $SD = 0.94$), $t_{507} = -2.97$, $p = 0.003$, $d = 0.13$. Utility estimates for unaltered sexual dimorphism were higher for a long-term relationship ($M = 0.25$, $SD = 0.51$) than for a short-term relationship ($M = 0.18$, $SD = 0.52$), $t_{507} = 2.53$, $p = 0.012$, $d = 0.10$.

There was also a significant interaction between attribute level and participant sex for sexual dimorphism utility estimates, $F_{2,1012} = 3.53$, $p = 0.030$, $\eta^2 = 0.01$, which was moderated by a three-way interaction with the sex of the face, $F_{2,1012} = 7.31$, $p < 0.001$, $\eta^2 = 0.01$ (Fig. 4). Female participants' utility estimates for masculinized and unaltered male faces were higher than for masculinized, $t_{293} = 4.81$, $p < 0.001$, $d = 0.29$, and unaltered, $t_{293} = 2.49$, $p = 0.013$, $d = 0.18$, female faces, respectively. Similarly, women's utility estimates for feminized male faces were lower than for feminized female faces, $t_{293} = -5.97$, $p < 0.001$, $d = 0.38$. For men, utility estimates were higher for male faces than female faces for masculinized and unaltered faces, but these differences were nonsignificant after Bonferroni correction (all $p > 0.072$). There were no other significant main effects or interactions, (all $F < 1.26$, all $p > 0.285$).

Symmetry A 2 (sex of face [male, female]) × 2 (relationship context [long-term, short-term]) × 3 (attribute level [symmetrical, original, asymmetrical]) × 2 (sex of participant [male, female]) mixed-model ANOVA revealed a main effect for attribute level, $F_{2,1012} = 193.45$, $p < 0.001$, $\eta^2 = 0.28$. Utility estimates were higher for symmetrical faces than for unaltered ($p < 0.001$) and asymmetrical ($p < 0.001$) faces. Utility estimates were also greater for unaltered faces than for asymmetrical faces ($p = 0.017$). This main effect was qualified by a significant interaction between sex of face and attribute level, $F_{2,1012} = 14.07$, $p < 0.001$, $\eta^2 = 0.027$. Utility estimates for facial symmetry were greater for female faces than for male faces, $t_{507} = -3.26$, $p < 0.001$, $d = 0.15$, whereas utility estimates for facial asymmetry were lower for

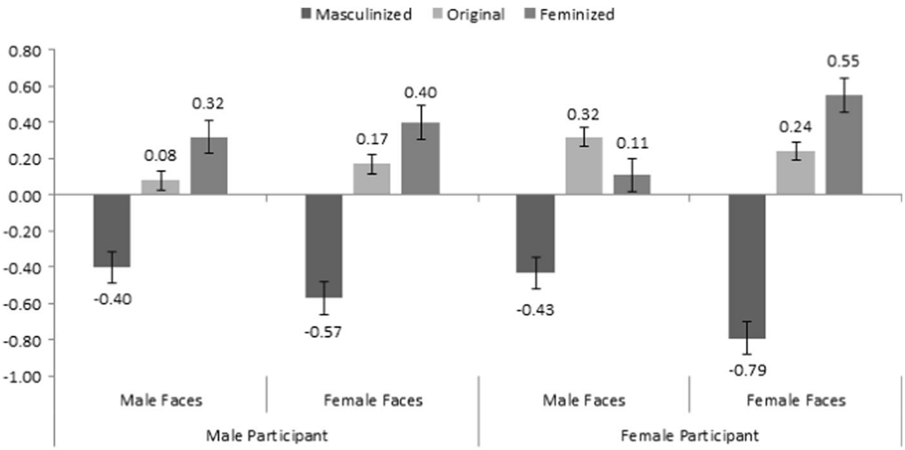

Fig. 4 Mean sexual dimorphism utility estimates for men's and women's ratings of male and female faces

female faces than for male faces, $t_{507} = 5.40$, $p < 0.001$, $d = 0.24$. This relationship was further moderated by a significant three-way interaction with relationship context, $F_{2,1012} = 3.97$, $p = 0.019$, $\eta^2 = 0.01$ (Fig. 5). Utility estimates for facial asymmetry were lower for a long-term relationship than for a short-term relationship for female faces, $t_{507} = -3.01$, $p = 0.001$, $d = 0.15$. Likewise, utility estimates for facial symmetry were higher for a long-term relationship than for a short-term relationship for female faces, $t_{507} = 1.82$, $p = 0.069$, $d = 0.09$, though this difference was only marginally significant. There was no significant difference between utility estimates for unaltered male and female faces, $t_{507} = -1.78$, $p = 0.076$.

There was also a significant interaction between attribute level and participant sex, $F_{2,1080} = 10.68$, $p < 0.001$, $\eta^2 = 0.02$. Averaged across the sex of the face and relationship context, men's utility estimates for increased symmetry ($M = 0.53$, $SD = 0.57$) were higher than women's ($M = 0.34$, $SD = 0.56$), $t_{506} = 3.82$, $p < 0.001$, $d = 0.30$. By contrast, men's utility estimates for unaltered symmetry

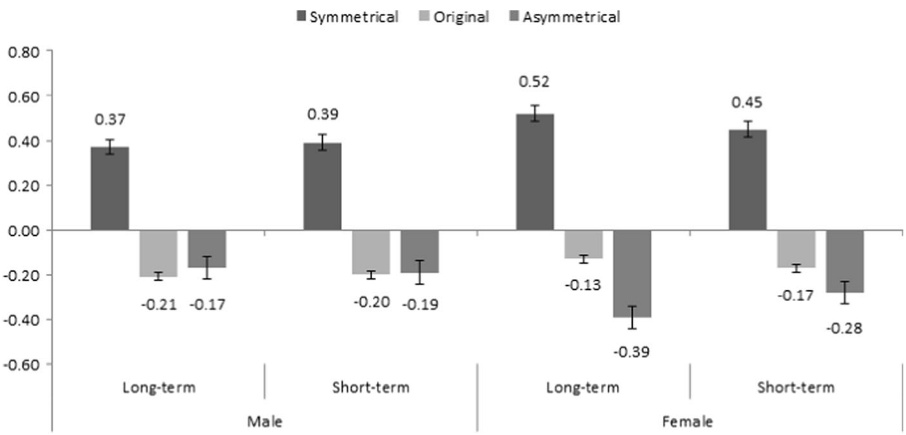

Fig. 5 Mean symmetry utility estimates for male and female faces in long- and short-term romantic relationships

($M = -0.26$, $SD = 0.44$) were lower than women's ($M = -0.10$, $SD = 0.40$), $t_{506} = -4.21$, $p < 0.001$, $d = 0.33$. There were no other significant main effects or interactions (all $F < 1.23$, all $p > 0.29$).

Color Cues to Health A 2 (sex of face [male, female]) × 2 (relationship context [long-term, short-term]) × 3 (attribute level [healthy, original, unhealthy]) × 2 (sex of participant [male, female]) mixed-model ANOVA revealed a main effect for attribute level, $F_{2,1012} = 466.37$, $p < 0.001$, $\eta^2 = 0.48$. Utility estimates were higher for healthy versus unaltered and unhealthy ($p < 0.001$) facial coloration. Utility estimates for unaltered coloration were also higher than for unhealthy coloration ($p < 0.001$). This relationship was qualified by a significant interaction between sex of face and attribute level, $F_{2,1012} = 79.55$, $p < 0.001$, $\eta^2 = 0.14$. Utility estimates for healthy coloration were greater for female faces than for male faces, $t_{507} = -9.04$, $p < 0.001$, $d = 0.41$, whereas utility estimates for unhealthy coloration were lower for female faces than for male faces, $t_{507} = 10.87$, $p < 0.001$, $d = 0.49$. Utility estimates for unaltered coloration were also higher for female faces than for male faces, $t_{507} = -2.36$, $p = 0.019$, $d = 0.11$. Furthermore, there was a significant interaction between relationship context and attribute level, $F_{2,1012} = 3.18$, $p = 0.042$, $\eta^2 = 0.01$. However, all pairwise comparisons were non-significant after Bonferroni adjustment (all $p > 0.075$).

Finally, there was a three-way interaction between sex of face, relationship context, and attribute level, $F_{2,1012} = 5.55$, $p < 0.004$, $\eta^2 = 0.011$ (Fig. 6), whereby utility estimates for healthy facial coloration were greater for a long-term relationship than for a short-term relationship for female faces, $t_{507} = 3.16$, $p = 0.002$, $d = 0.14$. Similarly, utility estimates for unhealthy facial coloration were lower for a long-term relationship ($M = -0.89$, $SD = 0.81$) than for a short-term relationship ($M = -0.76$, $SD = 0.86$) for female faces, $t_{507} = -3.41$, $p < 0.001$, $d = 0.15$. Adding participant sex as a between-subjects factor revealed no significant effects of participant sex on health utility estimates (all $F < 2.27$, $p > 0.104$).

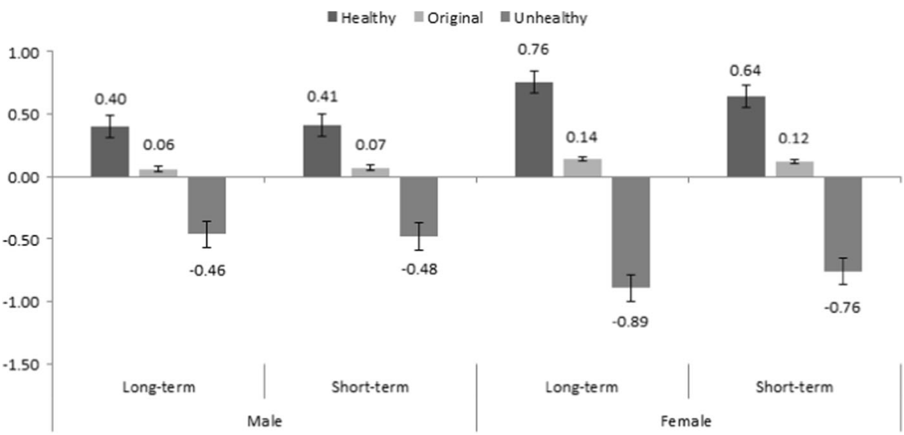

Fig. 6 Mean color cues to health utility estimates for male and female faces in long- and short-term romantic relationships

Discussion

We assessed the relative importance of sexual dimorphism, symmetry, and color cues to apparent health during participants' evaluations of static, 2D facial photographs of potential long- and short-term romantic partners. CA was used to calculate importance values (i.e., estimates of each facial attribute's importance in participants' ranking decisions relative to each other attribute) and utility estimates (i.e., estimates of the importance of each level within each attribute). With respect to importance values, a potential mate's facial sexual dimorphism was prioritized over facial symmetry and facial coloration. Although the importance of these three attributes in romantic partner perception is well-established (e.g., Matts and Fink 2010; Rhodes 2006; Samson et al. 2010), these data are the first to show that sexually dimorphic facial cues are more salient during mate choice decisions than symmetrical or healthy cues. This appears to contrast with previous research showing that sexually dimorphic cues are relatively poor predictors of facial attractiveness compared to facial color cues (Scott et al. 2010; Stephen et al. 2012), skin reflectance, and facial averageness (Said and Todorov 2011), particularly in male faces. However, it is essential to consider that CA importance values measure the *total* importance of masculinized and feminized facial manipulations (whereas utility estimates indicate the importance of particular *levels* within each variable). Indeed, participants who value masculinization *or* feminization will have higher importance values for sexual dimorphism. Given that facial masculinization and feminization are indicative of different mate qualities (e.g., formidability versus parenting quality; Perrett et al. 1998), and that importance values for sexual dimorphism measures the combined signal value of facial masculinity and facial femininity during partner perception, this suggests that sexual dimorphism is relatively more important than symmetry and color cues to health insofar as the total signal value (see Gangestad and Scheyd 2005) of masculine *and* feminine facial attributes is relatively greater than the signal values of symmetry and healthy coloration.

It is possible that sexual dimorphism provides the chooser with more mate-choice-relevant information than symmetry or color cues to health, and our findings may reflect the relative importance of deciding between a relatively masculine versus feminine partner. Evidence suggests that facial symmetry signals genetic quality (e.g., developmental stability, fertility; Møller 1990; Møller and Thornhill 1997; Thornhill and Gangestad 2006), and facial coloration signals current health (e.g., Matts and Fink 2010; Samson et al. 2010). Sexually dimorphic cues signal similar information (e.g., Fink and Penton-Voak 2002; Folstad and Karter 1992; Moller et al. 1999; Rhodes et al. 2003) but also contribute to sex classification, which is important for initially detecting viable mates (O'Toole et al. 1998). Certainly, women are more accurate in identifying male targets as men when they are rated as more masculine, but only at peak fertility when cues to masculinity should be more salient (Johnston et al. 2008). Furthermore, sexually dimorphic cues are associated with a number of social and sexual attitudes and behaviors. In women, facial femininity is associated with a less restricted sociosexual orientation (Boothroyd et al. 2008) and may signal social status (Moore et al. 2011), cooperativeness (Gladstone and O'Connor 2014), compassion, honesty (Keating et al. 2003), and even the likelihood of winning an election (Hehman et al. 2014). In men, facial masculinity is associated with perceptions of social dominance and unsuitability as a long-term mate (Boothroyd et al. 2007), and more masculine faces are rated as having a less restricted sociosexual orientation (Boothroyd et al. 2008). Likewise, masculinity is associated with physical strength, body size, and fighting ability (e.g., Fink et al. 2007; Gallup et al. 2007; Zilioli et al. 2014), attributes that may facilitate success during intrasexual competition (Little et al. 2015; Puts 2010). Thus, compared with symmetry and color cues to health, cues to sexual dimorphism may signal relatively more information about an individual's social status, personality, and biological quality, potentially explaining why it is prioritized above other important attractiveness cues.

In terms of utility estimates, facial masculinization was preferred less than unaltered sexual dimorphism and facial feminization for both male and female faces. This is consistent with previous research showing that men and women generally show greater preference for feminized faces (Boothroyd et al. 2008; Penton-Voak et al. 2004; Rhodes 2006; Rhodes et al. 2000), although preferences for male facial masculinity are somewhat variable (see DeBruine et al. 2006; Little and Mannion 2006). This variability may stem from the personality traits masculine- versus feminine-faced men are assumed to possess. Masculine male faces are perceived as more dominant and older, but less warm, emotional, honest, cooperative, and worse parents than feminine male faces (Perrett et al. 1998), whereas relatively feminine male faces are perceived to possess better long-term partner traits (Boothroyd et al. 2007). Thus, the preference for masculinized versus feminized male faces may reflect how people resolve the trade-off between preferences for indirect genetic benefits and more immediate, socially valued traits in a potential mate. Correspondingly, facial masculinization was preferred more for a short-term relationship than for a long-term relationship, whereas facial feminization was no more preferred for one relationship context versus the other. This is consistent with the hypothesis that male facial masculinity signals heritable immunocompetence and should be preferred by women in short-term (i.e., purely sexual) mating contexts (Fink and Penton-Voak 2002; Gangestad and Simpson 2000; Little et al. 2002). That masculinity in women's faces is more important for a short- versus long-term relationship is less clear, but it may reflect differences in perceptions of masculine versus feminine women. Future research should investigate this further.

Although sexual dimorphism was overall more important than symmetry and color cues to health for both male and female faces, sexual dimorphism was relatively more important for male faces than for female faces, whereas symmetry and color cues to health were relatively more important for female faces than for male faces. Correspondingly, symmetry and color cues to health were more important to male versus female raters, whereas sexual dimorphism was more important to female versus male raters, which may reflect sex differences in the signal value of these cues in evaluating potential mates. Women's preferences for masculinity in potential male partners vary in a manner consistent with a cost-benefit trade-off between finding a partner with "good genes" versus one who is likely to invest in potential offspring (e.g., DeBruine, Jones, Smith, and Little 2010). Perhaps cues to sexual dimorphism are prioritized during evaluation of male faces because information relevant to this cost-benefit trade-off is more important during mate selection than information provided by symmetry and facial color cues. By comparison, sexual dimorphism, symmetry, and color cues to health may be comparatively redundant in signaling mate quality in women (i.e., fertility, developmental health, current health). Indeed, women with greater body symmetry have higher levels of estradiol than less symmetrical women, particularly near ovulation (Jasienska et al. 2006). Likewise, increased facial blood perfusion signals higher levels of circulating estrogens in women (Thornton 2002). Perhaps color cues to health and symmetry are relatively more important signals of mate quality for women than for men by virtue of their ability to honestly signal fertility.

Preference for increased facial symmetry and healthy coloration were also greater in a long- versus short-term relationship context for female faces, but not male faces. This suggests that facial symmetry and healthy coloration influence long-term partner evaluations more than short-term partner evaluations, particularly for women. It may be that symmetry and color cues to health are signals not only to a woman's fertility, but also social and personality attributes that are more desirable in a long-term female partner. However, this hypothesis is speculative and requires future research.

Limitations and Future Directions

The manipulations we used may not reflect natural variability of facial sexual dimorphism and symmetry in the general population. Although we used procedures that are common to this area of research and that have been shown to affect face perception in predicted directions (e.g., DeBruine et al. 2006; Little, Jones et al. 2007; Jones et al. 2005; Welling et al. 2008a), the anchors we used to construct our stimuli may not be directly comparable (i.e., a 50% increase in facial masculinization may not be proportionate to a 50% increase in symmetry in the general population). Likewise, sexual dimorphism transformations were based on population averages of male and female features and do not account for potential within-sex variation. Future studies should consider presenting participants with faces that naturally resemble each photograph variation generated by the orthogonal array. For example, rather than present a face that has been artificially manipulated to appear high in masculinity, low in symmetry, and high in apparent health, researchers could present an unaltered face that has been rated as conforming to these traits. Likewise, naturally "high" or "low" sexual dimorphism, symmetry, and health could be quantified by whether a face is a standard deviation greater or less than average on geometric morphometric measures of these attributes (e.g., Scott et al. 2010; Stephen et al. 2012). Moreover, our manipulations may have affected the facial attractiveness of some identities more drastically than others. To control for variation between facial identities, future studies should consider applying manipulations to composite faces rather than individual faces.

Here participants evaluated static, 2D images of potential mates, yet dynamic movement also influences perceptions of mate quality (Fink et al. 2015). Future studies could address how attractiveness cues from dynamic movement influence overall perception of facial attractiveness. Furthermore, CA could be used to examine which types of body movements are more desirable than others. For example, Fink et al. (2014) found that women's ratings of virtual male dancers' attractiveness were fairly consistent between Brazilian and German samples, suggesting that certain body movements or dance styles may be universally attractive. Researchers could begin to identify which styles of body movement are most attractive by systematically altering which body movements are used and have participants rank the attractiveness of each dance style.

The present study also examined perceptions of facial attractiveness independent of other attractive cues, such as body morphology and voice. Peters et al. (2007) found that facial and body attractiveness contribute independently to overall attractiveness, and that the interaction between facial and body attractiveness did not significantly predict variance in overall attractiveness, suggesting that perceptions of facial and body attractiveness vary orthogonally. CA could be used to examine which types of attractiveness cues (e.g., body versus facial cues) are prioritized during holistic evaluation of potential mates. Similarly, Little et al. (2011) found that preferences for sexual dimorphism in potential long- and short-term mates are relatively consistent across visual, vocal, and olfactory cues. CA could be used to evaluate whether individuals rely on cues from one modality more heavily than cues from another during partner evaluation. Furthermore, our use of a fractional-factorial design did not permit us to examine interactions between each trait, as has been done in other studies (e.g., Boothroyd et al. 2009; Scott and Penton-Voak 2011; Smith et al. 2009).

We also did not examine how the relative importance of change in facial features across environmental context or as a function of individual differences. Although we found some differences in how people prioritize traits between a long- and short-term context, environmental cues (e.g., higher versus lower pathogen prevalence; DeBruine, Jones, Crawford, Welling, and Little 2010; DeBruine et al. 2011; Penton-Voak et al. 2004), hormonal profile (e.g., Welling et al. 2007; Welling et al. 2008b), menstrual cycle phase (e.g., Welling et al. 2007), own attractiveness (Penton-Voak et al. 2003), and age (e.g., Vukovic et al. 2009) can also affect mate preferences. Future studies should also vary the attribute by which faces are ranked. For instance, rather than rank faces according to their desirability as a potential long- or short-term mate, it might be revealing to ask participants to rank faces on partner attractiveness domains such as trustworthiness or social/physical dominance. Asking participants to rank faces based on these attributes may reveal the relative contribution of each facial attribute toward assessments of domain-specific perceptions of partner quality.

Conclusions

This study contributes to previous research examining perceptions of sexual dimorphism, symmetry, and color cues to health during evaluation of potential long-term and short-term mates. Our results suggest that facial cues to sexual dimorphism are relatively more important during mate evaluation than facial symmetry and color cues to health, particularly for male faces. Furthermore, symmetry and color cues to health appear to be relatively more important than sexual dimorphism during evaluation of female faces. We also replicate several findings demonstrating that preferences for masculinity and femininity in male and female faces vary across sex and relationship context. Studying how individuals make trade-offs among various facial cues may provide further insight into which attributes are most salient to mate choice decisions.

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