

Women's facial redness increases their perceived attractiveness: Mediation through perceived
healthiness

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Abstract

In the present research, we investigated whether the red-attraction relation that has been observed for men viewing women may also be observed with regard to women's facial redness. We manipulated facial redness by slightly increasing or decreasing the redness on the faces of baseline pictures of target women, and then had men judge the attractiveness of the women. We also examined healthiness perceptions as a mediator of the redness-attraction relation, along with several other candidate mediator variables. A series of experiments showed that increased redness led to increased ratings of attractiveness, and decreased redness led to decreased ratings of attractiveness. Perceived healthiness was documented as a mediator of the influence of female facial redness on male perceptions of attractiveness, and this mediation was independent of other candidate mediator variables. The findings highlight the importance of attending to facial coloration as an attraction-relevant cue, and point to interesting areas for subsequent research.

Keywords: facial coloration, red, attractiveness, healthiness, person perception

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The color red is associated with love, sex, and passion across a diversity of cultures (Aslam, 2006). This red-romance link has been present for millennia, and is particularly strong with regard to women. Red was used to symbolize lust, passion, and fertility in ancient mythology and ritual (Greenfield, 2005; Hutchings, 2004; Knight, Powers, & Watts, 1995), and red lipstick and rouge were used to enhance women's appearance as early as 10,000 years ago in ancient Egypt (Regas & Kozlowski, 1998). The red-romance association remains strong and pervasive in contemporary society, as seen in the red of Valentine's Day hearts and roses, the red of "red-light districts", red in the arts (literature, film, stage, song, e.g., *The Lady in Red*), red in fashion (lingerie, little red dress), and the red of cosmetics such as lipstick and rouge.

Noting the strength and pervasiveness of the red-romance link for women, researchers have posited that heterosexual men are particularly likely to find a woman attractive if she is displaying red (i.e., is wearing red clothing or lipstick, or is framed in or holding something red). Empirical support has been found for this premise, using both self-report and behavioral indicators of attraction (Elliot & Niesta, 2008; Elliot, Tracy, Pazda, & Beall, 2013; Guéguen 2012a; 2012b; 2012c; Guéguen & Jacob, 2012; 2103; 2014; Lin, 2014; Pazda, Elliot, & Greitemeyer, 2012; 2014; Re, Whitehead, Xiao, & Perrett, 2011; Roberts, Owen, & Havlicek, 2010; Stephen & McKeegan, 2010; cf. Lynn, Giebelhausen, Garcia, Li, & Patumanon, in press)¹. Moderators of this red-attraction relation have also been documented; red on or near a woman enhances men's attraction only when the woman has feminine features (Wen, Zuo, Wu, Sun, & Liu, 2014), is at least moderately attractive (Young, 2015), and is in her fertile years (Schwarz & Singer, 2013).

The face is a salient source of social information, and faces naturally undergo changes in color as a consequence of underlying physiological processes linked to both enduring conditions (e.g., physical health) and short term states (e.g., emotions). Such color changes are often subtle, but recent research suggests that human vision is particularly well-suited for detecting them (Changizi, Zhang, & Shimojo, 2006; Tan & Stephen, 2013). Surprisingly little research has examined the impact of manipulations of female facial redness on males' attractiveness perceptions. A few studies have focused on the lips, showing that redder female lips are viewed by males as particularly attractive (Guéguen 2012c; Guéguen & Jacob, 2012; Stephen & McKeegan, 2010). Re et al. (2011) showed that slight increases in the redness of female faces increased their attractiveness to perceivers, but the number of males in the sample was small (seven), and this relation was not the central focus of their investigation (which was discrimination thresholds for different facial characteristics).

In the present research, we designed experiments to explicitly test whether the red-attraction relation that has been documented for men viewing women extends to red displayed on the face. Specifically, we manipulated facial redness by slightly increasing or slightly decreasing the redness on the faces of baseline pictures of target women, and then had men judge the attractiveness of the women. We predicted that facial redness would positively influence men's perceptions of the women's attractiveness.

In addition to investigating the direct influence of female facial redness on male attraction, we also examined healthiness perceptions as a mediator of this relation. Reddened facial skin is objectively linked to women's physical health in several ways. Good physical fitness and healthy estrogen levels increase the vascularization and blood oxygenation of the skin, making it appear redder (Armstrong & Welsman, 2001; Charkoudian, Stephens, Pirkle,

Kosiba, & Johnson, 1999; Johnson, 1998; Stephen, Law Smith, Stirrat, & Perrett, 2009). On the other hand, diabetes, hypertension, and cardiac illness impair the vascularization and blood oxygenation of the skin, making it appear less red (Changizi, 2009; Charkoudian, 2003; Panza, Quyyumi, Brush, & Epstein, 1990; Ponsonby, Dwyer, & Couper, 1997). Thus, skin redness might be an indicator of a woman's healthiness. Furthermore, a few experiments have shown that men appear to be cognizant of this link between women's facial skin redness and their healthiness. For instance, in a study in which male participants were instructed to manipulate the color of women's facial skin in digital photographs to make them appear maximally healthy, they increased the redness on the faces (Stephen, Coetzee, Law Smith, & Perrett, 2009; see also Stephen, Law Smith, et al., 2009; Re et al., 2011). In accord with these findings, in the present work we predicted that an increase in red would raise and a decrease in red would lower men's perceptions of women's healthiness.

It is widely assumed that men's perceptions of a woman's healthiness contribute to (i.e., positively predict) their perceptions of her attractiveness because healthiness is an indicator of overall quality and reproductive potential (Etcoff, 1999; Perrett, 2010; Weeden & Sabini, 2005). Indeed, Rhodes et al. (2007) argued and provided evidence to support the premise that perceptions of healthiness underlie the documented positive links between facial symmetry, averageness, and sexual dimorphism on the one hand, and attractiveness judgments on the other. In accord with these findings, in the present work, we predicted that men's perceptions of women's healthiness would positively predict their perceptions of women's attractiveness. Furthermore, we predicted that the effect of female facial redness on males' attractiveness perceptions would be mediated by these healthiness perceptions.

The present research comprised four experiments. In Experiments 1 and 2, male participants chose which of two simultaneously-presented female faces containing differing amounts of redness was more attractive and sexually attractive. In Experiments 3 and 4, male participants rated both the healthiness and the attractiveness of female faces containing differing amounts of redness. We tested the indirect effect of red on attractiveness via perceived healthiness, and did so while controlling for the potential influence of other mediator variables. Healthiness is an indicator of a relatively enduring condition (compared with a temporary state, such as an emotional experience). While it is possible for attractiveness judgments to be influenced by transient states, such as emotion expression (Tracy & Beall, 2011) or sexual receptivity (Pazda, Elliot, & Greitemeyer, 2014), we chose to focus on alternative mediator candidates that likewise reflected an enduring condition (i.e., personality characteristics and values) for consistency.

Experiment 1

In Experiment 1, we conducted our initial test of the effect of female facial redness on males' perceptions of the female's attractiveness. We used two facial-color conditions, one in which facial redness was slightly increased, and one in which facial redness was slightly decreased, and examined the influence of this manipulation on judgments of attractiveness and sexual attractiveness.

Method

Participants. One hundred and thirty three men (mean age = 31.0, range = 18-67) were recruited from Amazon's Mechanical Turk and paid \$.10 for participating. We did not restrict our sample by geographic area, but the majority of participants (68%) resided in the U.S. Sample size was determined a priori by calculating the minimum number of participants required to

detect a small-to-medium effect (Cohen's $d = .35$) at 80% power ($n = 67$), and then establishing a minimum of 100 participants as our target sample size. Each of our experiments uses the same basic design, so meeting or exceeding 100 participants was the sample size guideline that we used for each experiment. Participation in this and all subsequent studies was restricted a priori to heterosexual and bisexual individuals without a color-vision deficiency. This was assessed through categorical self-report measures (e.g., "what is your sexual orientation?; are you red-green colorblind?").

Procedure. In each experiment, all data were collected before any analyses were conducted, and all data exclusions, manipulations (i.e., experimental conditions), and variables analyzed are reported. Participants followed a web link to gain access to a study entitled "ratings of human faces" which was said to entail judging faces on various characteristics. Participants completed six trials of a force-choice task in which they were instructed to select which of two faces appeared more *attractive*. Within each trial, the faces were of the same individual, but one version had increased facial redness, and the other had decreased facial redness. Faces were presented side-by-side, and each version had an equal probability of being displayed on the left or right side of the screen. The order of presentation for the six face identities was randomized. After completing trials for all six faces, the procedure was repeated, but participants were instructed to select the face that they found more *sexually attractive*.

Stimuli. Six target faces, all female, were used as face stimuli. Each target face was a composite of three moderately attractive Caucasian women in their early 20s. Matlab was used to produce color masks that were applied to the skin areas of the faces (i.e., excluding the hair, eyes, clothing, and background). Each face was manipulated on the CIELAB a^* (redness) color axis by +5 units or -5 units. See Figure 1 for examples of the face stimuli used. A change of $a^* =$

5 reflects a suprathreshold color difference (the average Δa^* threshold for facial redness discrimination is 0.67, $SEM = 0.16$, according to data from Re et al., 2011, although the precise threshold undoubtedly varies somewhat by context and sample). CIELAB is considered to be a perceptually uniform color space, meaning that a change in one unit is equivalent in perceptual magnitude across the entire space. Lightness, yellowness, hair, eyes, clothing, and background remained constant for each target.

Results

For each trial, the selection of the face with increased redness was coded as 1, and the selection of the face with decreased redness was coded as 0. Selections for each participant were averaged across the six trials for each dependent variable (attraction and sexual attraction), representing the proportion of increased redness selections over decreased redness selections.

A one-sample t-test was performed against 0.5 (chance), with the proportion of redder face selections for attractiveness as the dependent variable. The results showed that redder faces were selected ($M = 0.72$, $SD = 0.34$) significantly above chance level, $t(132) = 7.59$, $p < .001$, $d = .65$, indicating that participants perceived increased facial redness as more attractive than decreased facial redness.

We conducted another one-sample t-test (against .5) with the proportion of redder face selections for sexual attractiveness. The results showed that redder faces were selected ($M = 0.71$, $SD = 0.35$) significantly above chance level, $t(132) = 7.04$, $p < .001$, $d = .60$, indicating that participants perceived increased facial redness as more sexually attractive than decreased facial redness.

These results provide support for our hypotheses. Specifically, faces with increased facial redness were perceived as more attractive and more sexually attractive than the same faces with decreased facial redness.

Experiment 2

In Experiment 2, we focused on the direction of the observed effects. Specifically, it is not clear from the results of Experiment 1 whether increasing facial redness enhanced attractiveness or whether decreasing facial redness reduced attractiveness, or both. For instance, faces with decreased redness may be perceived as equally attractive to neutral faces, with increased redness bolstering attractiveness. However, it is conceivable that the opposite may be true, such that faces with increased redness are no more attractive than neutral faces, but decreased redness undermines attractiveness perceptions. In other words, the question of whether an increase of facial redness or a decrease of facial redness influences attractiveness perceptions remains to be tested. Thus we included a neutral condition in Experiment 2 to address this directionality question.

Method

Participants. One hundred and twenty seven men (mean age = 32.5, range = 18-70) were recruited on Amazon's Mechanical Turk and paid \$.10 for participating. We did not restrict our sample by geographic area, but the majority of participants (63%) resided in the U.S.

Procedure. The procedure was nearly identical to that of Experiment 1, except that participants made four types of judgments rather than two. Specifically, all participants judged the attractiveness and sexual attractiveness of the six pairs of faces for two separate comparison types: increased redness versus neutral and decreased redness versus neutral. This means that the difference in redness units between faces (i.e., original image vs. original image plus a^* =

+5) was much smaller than the difference in redness units from the previous experiment (i.e., original image plus $a^* = +5$ vs. original image plus $a^* = -5$).

Results

For each trial, a selection of the face with more redness was coded as 1, and a selection of the face with less redness was coded as 0. This means that the neutral faces were sometimes coded as 1 or 0, depending on whether the comparison face had increased or decreased redness. Scores were averaged across trials for each comparison type (increased vs. neutral and decreased vs. neutral) and for each question type (attractiveness and sexual attractiveness). A series of one-sample t-tests were conducted (against a value of .5), one for each question type at each level of comparison.

Attractiveness. For the increased redness versus neutral comparison, participants were more likely than chance to select the redder faces as more attractive ($M = .62$, $SD = .30$), $t(126) = 4.38$, $p < .001$, $d = .40$. For the decreased redness versus neutral comparison, participants were also more likely than chance to select the redder (i.e., neutral) faces ($M = .77$, $SD = .26$), $t(126) = 10.95$, $p < .001$, $d = 1.04$.

Sexual attractiveness. For the increased redness versus neutral comparison, participants were more likely than chance to select the redder faces as more sexually attractive ($M = .63$, $SD = .32$), $t(126) = 4.60$, $p < .001$, $d = .41$. For the decreased redness versus neutral comparison, participants were also more likely than chance to select the redder (i.e., neutral) faces ($M = .78$, $SD = .27$), $t(126) = 11.46$, $p < .001$, $d = 1.04$.

In ancillary analyses, we tested whether the effect was different for the increased redness versus neutral or the decreased redness versus neutral comparisons. We also tested whether there was any difference between general attractiveness and sexual attractiveness ratings. Specifically,

we conducted a repeated measures ANOVA with two within-subjects factors (type of color-comparison and type of rating) on the proportion of trials the redder face was selected. A main effect of comparison type was observed, $F(1, 126) = 35.27, p < .001$, indicating that the effect was stronger for the decreased redness versus neutral comparison ($M = .77$) relative to the increased redness versus neutral comparison ($M = .62$). No difference was observed between the response types ($F = .90, p = .35$), and no interaction was observed between comparison type and response type ($F = .04, p = .85$).

These results provide further support for our hypothesis. Increasing facial redness, relative to a neutral baseline, enhanced perceptions of attractiveness and sexual attractiveness. Likewise, decreasing facial redness, relative to a neutral baseline, reduced perceptions of attractiveness and sexual attractiveness. These effects were stronger in the decreased redness versus neutral comparison, indicating that decreased facial redness may undermine perceived attractiveness more than increased facial redness enhances it.

Experiment 3

In Experiment 3, we expanded our focus to include the effect of increased facial redness on perceived healthiness, and examined whether perceived healthiness mediates the effect of facial redness on perceived attractiveness. We also measured perceptions of intelligence and conservatism to determine whether the effect of red would be specific to perceived healthiness, would increase perceived positive characteristics in general, or would increase perceptions of any characteristic. Intelligence is a characteristic that men across countries value highly in women (Buss, 2008), but is not typically conceptually linked to facial redness. If reddened faces are found to be perceived as more intelligent, as well as attractive, this might indicate the presence of a halo effect. Facial redness could influence perceived conservatism, because in

the U.S., red is the color most strongly associated with the conservative political party (but does not necessarily contain a positive or negative valence). Including these variables should help clarify whether facial redness influences attractiveness specifically via perceived healthiness, or whether facial redness exerts its influence on perceptions of other characteristics (positive or neutral) as well. We examined increased versus decreased facial redness in this experiment.

Method

Participants. One hundred and fifty two men were recruited on Amazon's Mechanical Turk and paid \$.10 for participating. We did not restrict our sample by geographic area, but a plurality of participants (49%) resided in India, and 36% resided in the U.S. Data on participant age were not collected in Experiment 3.

Procedure. The procedure was similar to that of the previous experiments, but with several important distinctions. First, we discarded the forced choice response option in favor of 9-point scales in the form of a slider (anchored from "not at all" to "very much") for each stimulus. This allowed participants to make separate ratings for each face rather than choosing one or the other. Second, we added blocked trials assessing perceived healthiness ("How healthy does this face look?"), perceived intelligence ("How intelligent does this face look?"), and perceived political conservatism ("How politically conservative does this face look?"). The order in which these blocks were completed was randomized. Following these ratings, participants rated each face on perceived attractiveness ("How attractive does this face look?"). Composite scores were created by averaging the ratings for all 6 faces for each variable (see Tables 1 and 2 for descriptive statistics and correlations, respectively). The CIELAB values for facial stimuli were identical to those in Experiment 1.

Results

We used *MEMORE* (Montoya & Hayes, 2015) for SPSS to test the effect of facial redness on attractiveness through several parallel mediators. *MEMORE* uses ordinary least squares regression in a path-analytic form, following the methodology of Judd, Kenny, and McClelland (2001). It is optimal for data sets with repeated measurements of the dependent variable in within-subjects designs, and it has the advantage of examining the indirect effect of each mediator while controlling for the indirect effects of the others. This is ideal in cases where mediating variables may potentially be correlated with each other. *MEMORE* also allows the size of indirect effects to be directly compared, which provides insight regarding which mechanisms have the strongest influence on the dependent variable (Montoya & Hayes, 2015). Ninety-five percent confidence intervals were generated from 5,000 bootstrap samples and are reported in brackets for each result below. Color condition was entered as a dummy coded variable (1 = increased redness; 0 = decreased redness).

Total effect (c path). The total effect of increased redness on perceived attractiveness was significant, ($c = .95 [.71, 1.19], p < .001$), meaning that the faces with increased redness, on average, were rated as .95 points higher on attractiveness than faces with decreased redness.

Individual effects (a paths are effects of the IV on potential mediators; b paths are effects of mediators on the DV). The faces with increased redness were perceived as healthier ($a_1 = 1.54 [1.23, 1.84], p < .001$) and more intelligent ($a_2 = .38 [.16, .61], p = .001$) than the faces with decreased redness (see Figure 2). A significant difference was not observed for political conservatism ($a_3 = .10 [-.17, .38], p = .47$). Perceived healthiness was positively related to perceived attractiveness (controlling for the effect of redness and the other potential mediating variables; $b_1 = .36 [.26, .46], p < .001$). A similar relation was found between perceived intelligence and perceived attractiveness ($b_2 = .41 [.27, .54], p < .001$). No significant relation

was observed between perceived political conservativeness and attractiveness ($b_3 = .03 [-.07, .14]$, $p = .56$).

*Indirect effects (a paths*b paths).* The indirect effect of facial redness on perceived attractiveness via perceived healthiness was significant ($a_1b_1 = .55 [.37, .77]$, $p < .001$). The indirect effect through perceived intelligence was also significant ($a_2b_2 = .16 [.05, .30]$, $p = .008$). The indirect effect via political conservatism was zero ($a_3b_3 = .00 [-.01, .04]$). Next, we compared the size of each indirect effect to determine whether the path through perceived healthiness differed from the other indirect paths. Pairwise contrasts of each indirect effect showed that perceived healthiness made a stronger contribution to perceived attractiveness than did perceived intelligence or political conservatism. Additionally, perceived intelligence significantly differed from perceived political conservatism (see Table 3).

Direct effect (c path after accounting for the influence of mediating variables). The direct effect of facial redness on perceived attractiveness (controlling for the influence of the mediators) remained significant ($c' = .24 [.01, .46]$, $p = .04$), indicating that facial redness still accounts for variance in perceived attractiveness over and above the effect of the mediators.

In accord with our hypothesis, we found that perceived healthiness mediated the relationship between facial redness and perceived attractiveness. We also observed an unexpected indirect effect through perceived intelligence, although this effect was smaller than the path through perceived healthiness.

Experiment 4

In Experiment 4, we again examined perceived healthiness as a mediator variable, this time focusing specifically on the contrast between increased redness and the neutral baseline. We also added an additional potential mediator variable, perceived honesty; like intelligence, honesty

(and, more broadly, trustworthiness) is a characteristic that men across countries value highly in women (Fletcher, Simpson, Thomas, & Giles, 1999). Thus, examining whether perceived honesty is a mediator of the relation between facial redness and perceived attractiveness should provide more information regarding a possible halo effect of female facial redness. Finally, we conducted the experiment in the lab rather than on the web to afford more rigorous control of color presentation (see Elliot, 2015).

Method

Participants. One hundred and one men (mean age = 20.1, range = 18-35) were recruited from a university in the northeastern United States and compensated with extra course credit for participating.

Procedure. The procedure was similar to that of Experiment 3, but with the following changes. First, the face stimuli consisted of increased facial redness versus a neutral condition. Second, we added another potential mediator, perceived honesty (“How honest does this face look?”). Participants completed trials in blocks for each potential mediator, followed by a block of perceived attractiveness ratings. Composite scores were created across all six faces for each variable at each color level (see Tables 4 and 5 for descriptive statistics and correlations, respectively).

Results

We used *MEMORE* (Montoya & Hayes, 2015) for SPSS to test the effect of facial redness on attractiveness through several parallel mediators. Ninety-five percent confidence intervals were generated from 5,000 bootstrap samples and are reported in brackets for each result below.

Total effect. The total effect of increased redness on perceived attractiveness was significant, ($c = .47$ [.26, .68], $p < .001$), meaning that the faces with increased redness, on average, were rated as .47 points higher on attractiveness than the neutral faces.

Individual paths. The faces with increased redness were perceived as healthier ($a_1 = 1.24$ [.95, 1.53], $p < .001$) and more honest ($a_4 = .53$ [.28, .78], $p < .001$) than the neutral faces (see Figure 3). No significant differences were observed for perceived intelligence ($a_2 = .12$ [-.09, .34], $p = .25$) or conservatism ($a_3 = -.16$ [-.41, .09], $p = .22$). Perceived healthiness was positively related to perceived attractiveness (controlling for the effect of redness and the other mediators; $b_1 = .37$ [.25, .49], $p < .001$). A similar relation was found between perceived intelligence and perceived attractiveness ($b_2 = .22$ [.05, .38], $p = .01$). No significant relation was observed between perceived conservatism and attractiveness ($b_3 = .11$ [-.02, .24], $p = .10$) or perceived honesty and attractiveness ($b_4 = .11$ [-.03, .24], $p = .13$).

Indirect effects. The indirect effect of increased facial redness on perceived attractiveness via perceived healthiness was significant ($a_1b_1 = .46$ [.27, .63], $p < .001$). None of the other indirect effects were significantly different from zero (intelligence, $a_2b_2 = .03$ [-.01, .11], $p = .42$; conservatism, $a_3b_3 = -.02$ [-.06, .03], $p = .41$; honesty, $a_4b_4 = .06$ [-.05, .22], $p = .41$). Next, we compared the size of each indirect effect to determine whether the path through perceived healthiness differed from the other indirect paths. Pairwise contrasts of each indirect effect showed that perceived healthiness significantly differed from all three of the other potential mediators, and that perceived intelligence, honesty, and conservatism did not significantly differ from each other (see Table 6).

Direct effect. The direct effect of increased facial redness on perceived attractiveness (controlling for the influence of the mediators) was not significantly different from zero ($c' = -$

.06 [-.28, .16], $p = .61$), indicating that perceived healthiness accounted for most of the variance in the redness-attraction relation.

These results are mostly consistent with those of the previous experiments. Facial redness was a strong predictor of perceived attractiveness, and perceived healthiness was responsible for this relation. In contrast with the results from Experiment 3, none of the other potential mediating variables had a statistically significant effect on perceived attractiveness.

General Discussion

The results of the present research provide support for the premise that female displays of red on the face are viewed positively by heterosexual male perceivers. Increased redness on the face of female targets led to increased ratings of attractiveness and sexual attractiveness, and decreased redness on the face of female targets led to decreased ratings of attractiveness and sexual attractiveness. This same pattern of findings was also observed for perceived healthiness. Finally, perceived healthiness was documented as a mediator of the influence of female facial redness on male perceptions of attractiveness, and this mediation was shown to be independent of other candidate mediator variables.

In social situations, including mate evaluation situations, the face is a focal point of attention, and facial cues convey important information that can influence person perception (Perrett, 2010; Rhodes, 2006). The present work shows that color on the female face can be perceived by men to convey healthiness information, and this has implications for attractiveness judgments. These findings both highlight the importance of attending to facial coloration as an attraction-relevant cue in general (see Stephen & Perrett, 2015, for a review of this growing area of research), and extend prior work on the red-attraction relation (see Pazda & Greitemeyer, 2015, for a review) to the domain of the face.

Perceived healthiness was documented as a mediator of the red-attraction link herein, but there was some evidence, albeit inconsistent evidence (from one of two experiments), that intelligence also served a mediational role. That red might influence another positive characteristic (or characteristics) beside healthiness should not be surprising, because good health is undoubtedly integrally intertwined with and necessary for optimal functioning, including intellectual functioning. It is also possible that there is a halo effect surrounding healthiness, such that “what is healthy is good” (much like “what is beautiful is good”; Dion, Berscheid, & Walster, 1972); this might lead to multiple positively valenced variables being documented as mediators, with none standing out as more important than the others. Importantly, in both of our mediation experiments, perceived healthiness was statistically documented as the strongest of all of the mediators tested. So, regardless of any possible conceptual overlap or halo bias, our data clearly support perceived healthiness as the most potent mediator of the variables measured.

In our research, we focused on mediator variables that represent enduring characteristics of the person, namely healthiness, intelligence, honesty, and conservatism. In each of these instances, facial redness would represent a relatively consistent, stable indicator of the relevant characteristic. However, facial redness can also represent immediate, emotion-based reactions to temporary events or situations. For example, women (and men) often blush when experiencing sexual interest or excitement, which is manifest as a reddening on the face, neck, and upper chest. Research has shown that males’ perceptions of women’s sexual receptivity can mediate the influence of women’s red clothing on men’s attractiveness judgments (Guéguen 2012a; Pazda et al., 2012; 2014). Subsequent research would do well to integrate these different lines of work on stable and ephemeral color cuing. Furthermore, subsequent work would also do well to attend to

the issue of the context in which person judgments are taking place (Elliot, 2015). For example, if in the present research we had informed participants that the target persons were photographed while experiencing an interpersonal conflict, increased redness may have been viewed as a negative cue of anger and danger, rather than a positive cue of health and attractiveness. Manipulating context would undoubtedly lead to a deeper, more nuanced understanding of the effects that we observed.

We manipulated facial color in our experiments with an increment or decrement of $a^* = 5$. This value represents a relatively small change in redness but, critically, it also represents a change that clearly exceeds human visual detection thresholds (Re et al., 2011). Additional research is needed to examine a broader range of changes and their effects. With regard to lower limits, there is certainly a point at which the degree of change in redness would be so small as to be undetectable (for related work see Tan & Stephen, 2014), and there may be a point above the detection threshold that is nevertheless so minimal that it has no effect on perceptions of health and attractiveness. With regard to upper limits, there is certainly a point at which increments in redness shift from conveying healthiness (Stephen et al., 2009) to conveying something negative (e.g., anger) or unhealthy (e.g., fever), and likewise there is certainly a point at which additional decrements in redness would no longer produce additional decrements in healthiness and attractiveness perceptions (i.e., the curve would asymptote). Documenting these parameters would nicely extend the present findings.

The present research has limits that may be used to guide subsequent work. First, we exclusively utilized Caucasian target stimuli, and did not systematically collect data that would afford rigorous investigation of the influence of same versus other ethnicity on target judgments (e.g., Coetsee, Greeff, Stephen, & Perrett, 2014; Stephen, Coetsee, & Perrett, 2011). We also

used a small number of female targets, which were relatively young and moderately attractive. This may limit the generalizability of our findings across different age groups and attractiveness levels. Second, the target stimuli that we used were static pictures with red added throughout the face; video clips with precisely imputed redness would be difficult to produce, but may be seen as a worthy aim given the enhanced ecological validity of such stimuli. Third, several of our studies were conducted online, meaning the color presentation could not be rigorously controlled. Specifically, each participant's computer monitor undoubtedly displayed color in a unique manner, which led to deviations in the color presentation across participants. Importantly, Experiment 4 was conducted on a single color-calibrated monitor in a laboratory setting and yielded results similar to the web-based experiments. Nonetheless, we recommend interpreting the present (and all) web-based color research with this limitation in mind. Finally, each of our experiments utilized a within-subjects design, where the same participants rated numerous faces in multiple color conditions. This has the drawback of potential carry-over effects, such that ratings of one stimulus influence ratings on subsequent stimuli. The order in which the target faces were presented in these experiments varied randomly, which helps address, but does not eliminate, this issue.

In conclusion, the present research contributes to our growing understanding of color's influence on social perception. This work particularly highlights the value of investigating facial coloration as an influence on important, adaptation-relevant evaluative judgments. Facial coloration seems a rich, relatively underexplored research area that could yield many important insights in the future.

Footnotes

1. In these citations we do not include studies with extremely small samples sizes (< 20 per condition), unless the focal finding has also been documented independently with a larger sample. In addition, we do not include correlational studies that involved no manipulation of red, as such studies neither control the nature of the red stimulus nor the context in which it is displayed.
2. With enormous samples (e.g., 1 million people), Δa^* values of an extremely small magnitude may nevertheless be statistically detectable.

References

- Armstrong, N., & Welsman, J. (2001). Peak oxygen uptake in relation to growth and maturation in 11- to 17-year-old humans. *European Journal of Applied Physiology*, 85, 546–551. <http://doi.org/10.1007/s004210100485>
- Aslam, M. M. (2006). Are you selling the right colour? A cross-cultural review of colour as a marketing cue. *Journal of Marketing Communications*, 12, 15-30.
- Buss, D. M. (2008). *Evolutionary Psychology: The new science of the mind (3rd Ed.)*. Boston: Allyn & Bacon.
- Changizi, M. (2009). *The vision revolution*. Dallas, TX: Benballa.
- Changizi, M., Zhang, Q., & Shimojo, S. (2006). Bare skin, blood and the evolution of primate colour vision. *Biology Letters*, 2, 217–21. <http://doi.org/10.1098/rsbl.2006.0440>
- Charkoudian, N. (2003). Skin blood flow in adult human thermoregulation: how it works, when it does not, and why. *Mayo Clinic Proceedings*, 78, 603–12. <http://doi.org/10.4065/78.5.603>
- Charkoudian, N., Stephens, D. P., Pirkle, K. C., Kosiba, W. A., & Johnson, J. M. (1999). Influence of female reproductive hormones on local thermal control of skin blood flow. *Journal of Applied Physiology*, 87, 1719–1723. Retrieved from <http://www.jappp.org/content/87/5/1719.short>
- Coetzee, V., Greeff, J. M., Stephen, I. D., & Perrett, D. I. (2014). Cross-cultural agreement in facial attractiveness preferences: the role of ethnicity and gender. *Plos One*, 9, e99629.
- Dion, K., Berscheid, E., & Walster, E. (1972). What is beautiful is good. *Journal of Personality and Social Psychology*, 24, 285–290. <http://doi.org/10.1037/h0033731>

- Elliot, A. J., & Niesta, D. (2008). Romantic red: red enhances men's attraction to women. *Journal of Personality and Social Psychology, 95*, 1150–64. <http://doi.org/10.1037/0022-3514.95.5.1150>
- Elliot, A. J. (2015). Color and psychological functioning: A review of theoretical and empirical work. *Frontiers in Psychology, 6*, 1-8.
- Elliot, A. J., Tracy, J. L., Pazda, A. D., & Beall, A. (2013). Red enhances women's attractiveness to men: First evidence suggesting universality. *Journal of Experimental Social Psychology, 49*, 165-168.
- Etcoff, N. (1999). *Survival of the prettiest*. New York: Doubleday.
- Fletcher, G. J. O., Simpson, J. A., Thomas, G., & Giles, L. (1999). Ideals in intimate relationships. *Journal of Personality and Social Psychology, 76*, 72-89.
- Guéguen N. 2012a. Color and women attractiveness: When red clothed women are perceived to have more intense sexual intent. *Journal of Social Psychology, 152*, 261-265.
- Guéguen N. 2012c. Does red lipstick really attract men? An evaluation in a bar. *International Journal of Psychological Studies, 4*, 206-209.
- Guéguen, N. (2012b). Color and women hitchhikers' attractiveness: Gentlemen drivers prefer red. *Color Research and Application, 37*, 76–78.
- Guéguen, N., & Jacob, C. (2013). Color and cyber-attractiveness: red enhances men's attraction to women's internet personal ads. *Color Research and Application, 38*, 309-312.
- Guéguen, N., & Jacob, C. (2014). Clothing color and tipping: Gentlemen patrons give more tips to waitresses with red clothes. *Journal of Hospitality & Tourism Research, 38*, 275-280.
- Guéguen, N., & Jacob, C. (2012b). Lipstick and tipping behavior: When red lipstick enhance waitresses tips. *International Journal of Hospitality Management, 31*, 1333–1335.

- Greenfield, A. B. (2005). *A perfect red: Empire, espionage, and the quest for the color of desire*. New York, NY: HarperCollins Books.
- Hutchings, J. (2004). Colour in folklore and tradition - The principles. *Color Research & Application, 29*, 57-66.
- Johnson, J. M. (1998). Physical training and the control of skin blood flow. *Medical Science in Sports and Exercise, 30*, 382–386.
- Judd, C. M., Kenny, D. A., & McClelland, G. H. (2001). Estimating and testing mediation and moderation in within-subjects designs. *Psychological Methods, 6*, 115-134.
- Knight, C. D., Powers, C., & Watts, I. (1995). The human symbolic revolution: A Darwinian account. *Cambridge Archeological Journal, 5*, 75-119.
- Lin, H. (2014). Red-colored products enhance the attractiveness of women. *Displays 35*, 202-205.
- Lynn, M., Giebelhausen, M., Garcia, S., Li, Y., & Patumanon, I. (in press). Clothing color and tipping: An attempted replication and extension. *Journal of Hospitality and Tourism Research*.
- Montoya, A. K., & Hayes, A. F. (2015). Two condition within-participant statistical mediation analysis: A path-analytic framework. *Manuscript submitted for publication*.
- Panza, J. A., Quyyumi, A. A., Brush, J. E., & Epstein, S. E. (1990). Abnormal endothelium-dependent vascular relaxation in patients with essential hypertension. *The New England Journal of Medicine, 323*(1), 22–7. <http://doi.org/10.1056/NEJM199007053230105>
- Pazda, A. D., Elliot, A. J., & Greitemeyer, T. (2012). Sexy red: Perceived sexual receptivity mediates the red-attraction relation in men viewing woman. *Journal of Experimental Social Psychology, 48*, 787–790. <http://doi.org/10.1016/j.jesp.2011.12.009>

- Pazda, A. D., Elliot, A. J., & Greitemeyer, T. (2014). Perceived sexual receptivity and fashionableness : Separate paths linking red and black to perceived attractiveness, *Color Research and Application*, 39, 208-212. <http://doi.org/10.1002/col.21804>
- Pazda, A. D., & Greitemeyer, T. (2015). Color in romantic contexts in humans. In A. Elliot, M. Fairchild, & A. Franklin (Eds.), *Handbook of color psychology*. Cambridge, England: Cambridge University Press.
- Perrett, D. (2010). *In your face: The new science of human attraction*. Palgrave Macmillan.
- Ragas, M. C., & Kozlowski, K. (1998). *Read My Lips: A Cultural History of Lipstick*. San Francisco, CA: Chronicle Books.
- Re, D. E., Whitehead, R. D., Xiao, D., & Perrett, D. I. (2011). Oxygenated-blood colour change thresholds for perceived facial redness, health, and attractiveness. *PloS One*, 6, e17859. <http://doi.org/10.1371/journal.pone.0017859>
- Rhodes, G. (2006). The evolutionary psychology of facial beauty. *Annual Review of Psychology*, 57, 199–226. <http://doi.org/10.1146/annurev.psych.57.102904.190208>
- Rhodes, G., Yoshikawa, S., Palermo, R., Simmons, L. W., Peters, M., Lee, K., Halberstadt, J., & Crawford, J. R. (2007). Perceived health contributes to the attractiveness of facial symmetry, averageness, and sexual dimorphism. *Perception*, 36, 1244-1252.
- Roberts, S. C., Owen, R. C., and Havlicek, J. (2010). Distinguishing between perceiver and wearer effects in clothing color-associated attributions. *Evolutionary Psychology*, 8, 350-364.
- Schwarz, S. and Singer, M. (2013). Romantic red revisited: Red enhances men's attraction to young, but not menopausal women. *Journal of Experimental Social Psychology*, 49, 161-164.

- Stephen, I. D., Coetzee, V., Law Smith, M., & Perrett, D. I. (2009). Skin blood perfusion and oxygenation colour affect perceived human health. *PloS One*, *4*, e5083.
<http://doi.org/10.1371/journal.pone.0005083>
- Stephen, I. D., Coetzee, V., & Perrett, D. I. (2011). Carotenoid and melanin pigment coloration affect perceived human health. *Evolution and Human Behavior*, *32*, 216-227.
- Stephen, I. D., Law Smith, M. J., Stirrat, M. R., & Perrett, D. I. (2009). Facial Skin Coloration Affects Perceived Health of Human Faces. *International Journal of Primatology*, *30*, 845–857. <http://doi.org/10.1007/s10764-009-9380-z>
- Stephen, I. D., & McKeegan, A. M. (2010). Lip colour affects perceived sex typicality and attractiveness of human faces. *Perception*, *39*, 1104–1110. <http://doi.org/10.1068/p6730>
- Stephen, I. D., & Perrett, D. I. (2015). Color and face perception. In A. Elliot, M. Fairchild, & A. Franklin (Eds.), *Handbook of color psychology*. Cambridge, England: Cambridge University Press.
- Tan, K. W., & Stephen, I. D. (2013). Colour detection thresholds in faces and colour patches. *Perception*, *42*, 733–741. <http://doi.org/10.1068/p7499>
- Weeden, J., & Sabini, J. (2005). Physical attractiveness and health in Western societies: A review. *Psychological Bulletin*, *131*, 645-653.
- Tracy, J. L., & Beall, A. T. (2011). Happy guys finish last: The impact of emotion expressions on sexual attraction. *Emotion*, *11*, 1379-1387.
- Young, S. G. (2015). Fast track report The effect of red on male perceptions of female attractiveness : Moderation by baseline attractiveness of female faces. *European Journal of Social Psychology*, *151*, 146–151.

Wen, F., Zuo, B., Wu, Y., Sun, S., & Liu, K. (2014). Red is romantic, but only for feminine females: Sexual dimorphism moderates red effect on sexual attraction. *Evolutionary Psychology, 12*, 719-735.

Table 1. Descriptive statistics for variables in Experiment 3 averaged across faces and color conditions.

	Mean	SD	Range
Healthiness	5.60	1.17	1.0 – 8.4
Intelligence	5.44	1.24	1.0 – 9.0
Conservatism	4.95	1.23	1.0 – 7.7
Attractiveness	5.36	1.41	1.0 – 9.0

Table 2. Correlations between variables in Experiment 3.

	Intelligence	Conservatism	Attractiveness
Healthiness	.66	.37	.67
Intelligence	--	.47	.61
Conservatism	--	--	.45

Table 3. Pairwise contrasts of indirect effects in Experiment 3.

	Effect	SE	Lower CI	Upper CI
Healthiness vs. intelligence	.40	.12	.17	.64
Healthiness vs. conservatism	.55	.10	.36	.75
Intelligence vs. conservatism	.15	.06	.04	.29

Table 4. Descriptive statistics for variables in Experiment 4 averaged across faces and color conditions.

	Mean	SD	Range
Healthiness	5.50	1.04	2.9 – 8.0
Intelligence	5.47	0.96	2.3 – 7.7
Conservatism	4.95	1.09	1.0 – 9.0
Honesty	5.28	1.06	2.6 – 7.6
Attractiveness	4.77	1.20	1.9 – 8.1

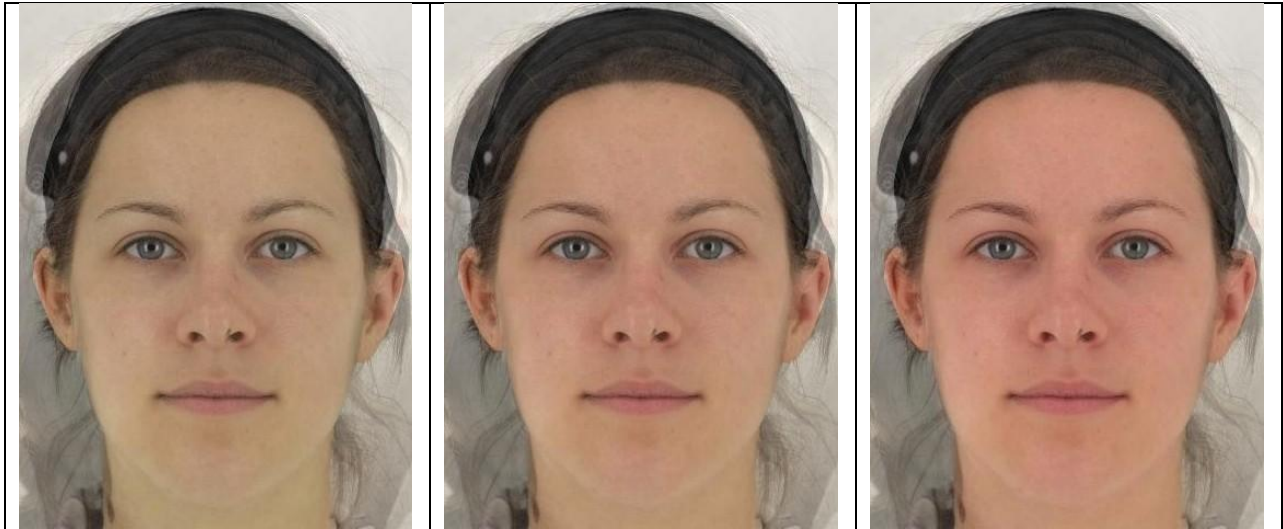
Table 5. Correlations between variables in Experiment 4.

	Intelligence	Conservatism	Honesty	Attractiveness
Healthiness	.57	.31	.60	.57
Intelligence	--	.39	.71	.53
Conservatism	--	--	.43	.33
Honesty	--	--	--	.57

Table 6. Pairwise contrasts of indirect effects in Experiment 4.

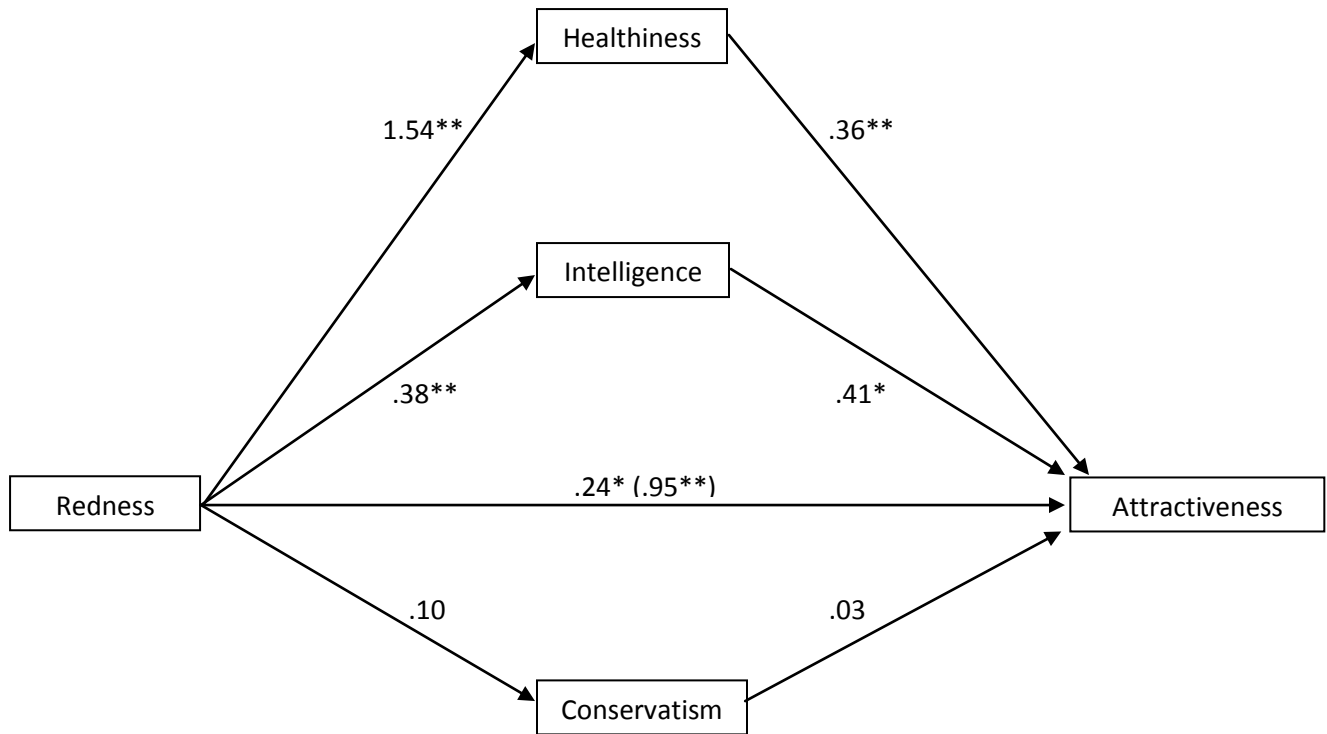
	Effect	SE	Lower CI	Upper CI
Healthiness vs. intelligence	.43	.09	.24	.61
Healthiness vs. conservatism	.48	.09	.29	.64
Healthiness vs. honesty	.40	.12	.14	.61
Intelligence vs. conservatism	.04	.04	-.02	.13
Intelligence vs. honesty	-.03	.08	-.22	.13
Conservatism vs. honesty	-.07	.07	-.24	.05

Figure 1.



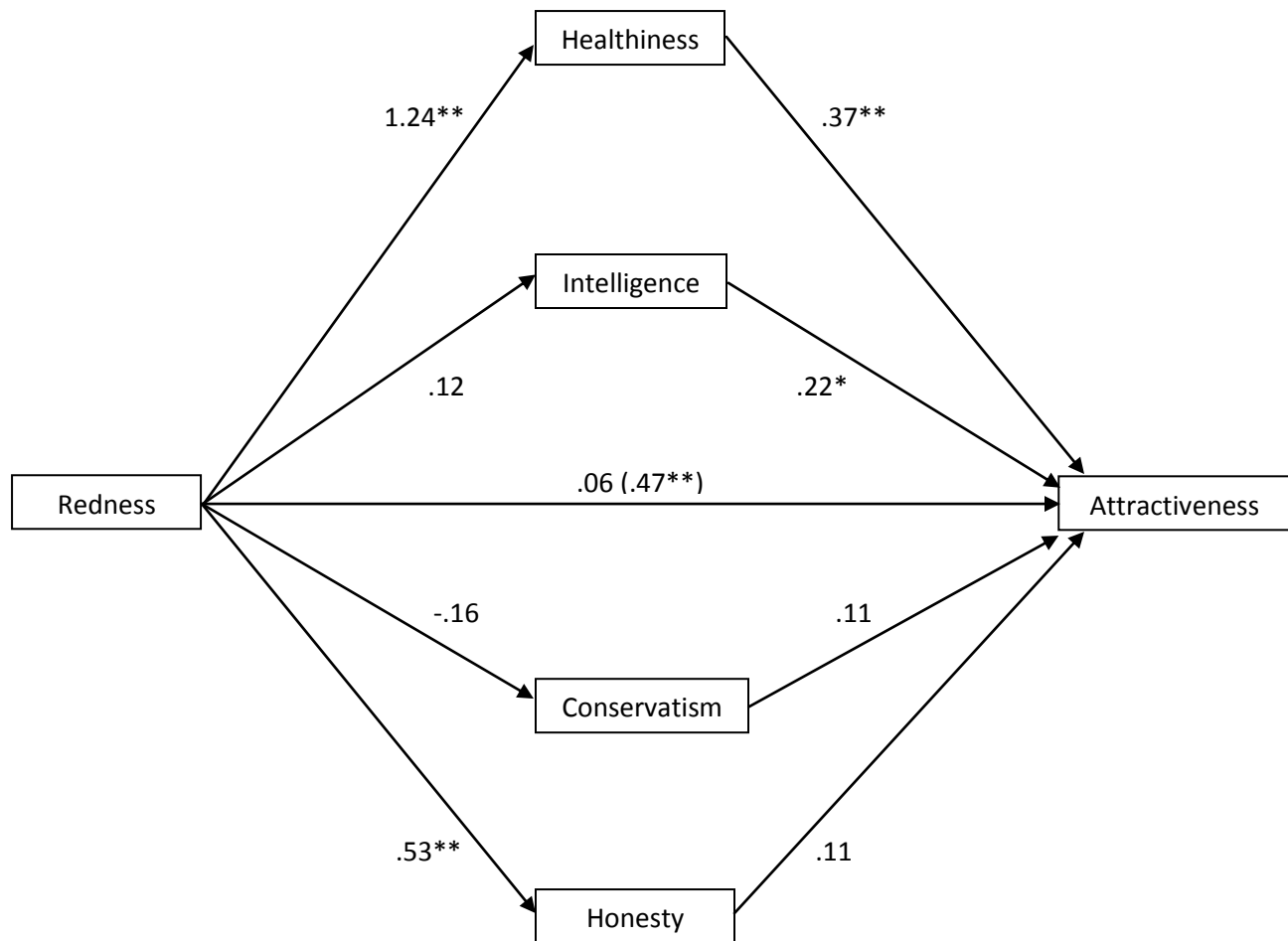
Example of the face stimuli used. Faces were manipulated on the CIELAB a^* (redness) color axis by -5 units (left) or +5 units (right).

Figure 2.



* $p < .05$; ** $p < .01$. Effects of increased redness on perceived attractiveness through three potential mediators in Experiment 3; coefficients are unstandardized estimates and the coefficient in parentheses is the total effect. Indirect effects of redness on perceived attractiveness through each potential mediator [95% confidence intervals in brackets] are as follows. Healthiness: .55 [.37, .77]; Intelligence: .16 [.05, .30]; Conservatism: .00 [-.01, .04].

Figure 3.



* $p < .05$; ** $p < .01$. Effects of increased redness on perceived attractiveness through four potential mediators in Experiment 4; coefficients are unstandardized estimates and the coefficient in parentheses is the total effect. Indirect effects of red on perceived attractiveness through each potential mediator [95% confidence intervals in brackets] are as follows. Healthiness: .46 [.28, .63]; Intelligence: .03 [-.02, .11]; Conservatism: -.02 [-.06, .03]; Honesty: .06 [-.05, .22].