Binocular Symmetry/Asymmetry of Scleral Redness as a Cue for Sadness, Healthiness, and Attractiveness in Humans

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Abstract: Among primates, only humans have the white sclerae that provide the ground necessary to display their own color and that of the overlying conjunctiva. Scleral color, primarily redness, provides cues of socially and biologically significant information about an individual. The present study examines the effect of the asymmetry of binocular scleral redness on perceived sadness, healthiness, and attractiveness by contrasting ratings of images of individuals who had one, both, or neither sclera reddened by digital editing. Building upon previous research, this study further defines the details of the scleral color display and contributes to the more general issue of facial and body symmetry, predictors of phenotypic condition and genotypic quality that are of interest to evolutionary theorists. Individuals with binocular and monocular redness were rated as sadder, less healthy, and less attractive than those with untinted control sclerae, with ratings corresponding to the degree of redness or whiteness. Bilaterally symmetrical (binocular) scleral redness or whiteness provided anchorage points for ratings, with ratings for bilaterally asymmetrical (monocular) redness or whiteness falling between them; there was no unique effect of asymmetry.

Keywords: conjunctiva, red-eye, beauty, mate choice, evolution

Introduction

Among primates, only humans have the white sclerae (Kobayashi and Kohshima, 2001) that provide the ground necessary for the display of their own colors, and those of the overlying transparent conjunctiva, which vary with emotion (Provine, Cabrera, Brocato,
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and Krosnowski, 2011; Provine, Nave-Blodgett, and Cabrera, in press), health (Provine, Cabrera, and Nave-Blodgett, 2013), age (Provine et al., 2013), and disease (Leibowitz, 2000; Watson, Hazelman, Pavesio, and Green, 2003; Watson and Young, 2004). The sclerae of other primates are typically brown or dark brown (Kobayashi and Kohshima, 2001), reducing or eliminating their effectiveness as a medium for chromatic displays. Scleral color, primarily red and yellow (Provine, 2011; Provine et al., 2011, 2013, in press), together with emotional tearing (Frey, 1985; Provine, 2011; Provine, Krosnowski, and Brocato, 2009; Vingerhoets and Cornelius, 2001) are uniquely human, eye-related, visual cues that display biologically and socially significant information about an individual (review in Provine, 2012).

Scleral color has been important in medical diagnosis from at least as early as the Hippocratic era, many centuries BCE (Papavramidou, Fee, and Christopoulou-Aletra, 2007), but its social significance has only recently been examined. Using digitally modified eye images, Provine et al. (2011) demonstrated that reddened sclerae display levels of sadness, healthiness, and attractiveness. Red eyes are caused primarily by the dilation of superficial blood vessels of the conjunctiva, the transparent membrane covering the sclera—the “white” of the eye (Provine et al., 2011, 2013). Broadening the color palette and adding age as a variable, Provine et al. (2013) found that individuals with reddened and yellowed sclerae were rated as less healthy, less attractive, and older than individuals with untinted control sclerae. In contrast to the vascular dilation responsible for reddened sclerae, yellowed sclerae are the result of the deposition of bilirubin in jaundice (Roche and Kobos, 2004) and lipids in aging (Broekhuyse, 1975). Individuals with whitened, “super-white” sclerae were rated as younger, although not more healthy or attractive than controls (Provine et al., 2013). Scleral color has consequences at the level of the individual and group. In humans, clear, white sclerae together with such traits as smooth skin, long, lustrous hair, and such sexually dimorphic traits as large eyes, full lips, and high cheekbones in women, and square chins and thick brows in men, are criteria for beauty and biological fitness (Etcoff, 1999; Johnston, 2006; Langlois et al., 2000; Little, Apicella, and Marlowe, 2007; Rhodes, 2006; Sugiyama, 2005; Symons, 1979; Thornhill and Gangestad, 1999).

Body and facial symmetry have emerged as themes of evolutionary research because symmetry is presumed to predict good phenotypic condition and genetic quality (Little et al., 2008). As with sexually dimorphic traits (Thornhill and Gangestad, 2006), symmetry is perceived as attractive because it is a cue of mate quality (Little et al., 2008). According to the predictions of “fluctuating asymmetry,” symmetry is attractive because it reflects an organism’s capacity to maintain a stable developmental trajectory in the face of random endogenous and exogenous challenges, from mutations and toxins to parasites and living conditions (Gangestad and Thornhill, 1999; Valen, 1962). Studies of real (Penton-Voak et al., 2001; Scheib, Gangestad, and Thornhill, 1999) and manipulated faces (Little and Jones, 2003; Perrett et al., 1999) demonstrate the attractiveness of symmetrical faces in Western and isolated hunter-gatherer human populations (Little et al., 2007), and the monkey Macaca mulatta (Waitt and Little, 2006).

The present study is the first evaluation of the perceptual impact of binocular asymmetry of scleral color. Images of individuals who had one, both, or neither sclera
digitally reddened were rated for perceived sadness, healthiness, and attractiveness. Scleral redness is ideal for studies of symmetry because the eyes are prominent, similar in form, and in close proximity, with one eye easily contrasted with its contralateral partner. Scleral redness is examined because red, “bloodshot” eyes are prominent in medical diagnosis (Leibowitz, 2000) and folk culture, and display emotion (sadness) (Provine, 2012; Provine et al., 2011, in press). Also, the sensitivity to red and trichromatic color vision in primates may be adaptations for the perception of socially significant changes in blood flow and oxygenation of the bare skin (Changizi, Zhang, and Shimojo, 2006) which is, like the sclera, a visual display medium. Sadness, healthiness, and attractiveness were selected as a representative sample of emotional, medical, biological, and social variables.

Materials and Methods

Subjects
 Subjects were 128 ethnically diverse students at the University of Maryland, Baltimore County (55 males, 73 females) with an average age of 21 years (SD = 3, range 18-43) who volunteered to participate in a study to receive extra credit in undergraduate psychology courses. Although ethnicity was not requested of study participants, the 2012 UMBC undergraduate population came from 84 countries and had the following selfreported ethnicity: white (47%), Asian (20%), black (16%) Hispanic (5%), international non US or permanent resident (4%), unknown (4%), two or more groups (3%). A given subject participated in only one of three studies, either an investigation of sadness, healthiness, or attractiveness (see Tab. 1).

Informed consent was obtained from all subjects prior to the start of the study. Appropriate procedures were followed in obtaining informed consent from subjects. The study was approved by the Institutional Review Board of the University of Maryland, Baltimore County.

Stimuli
 Stimuli were based on 50 high-resolution color images of pairs of normal-appearing eyes, obtained by photographing students, staff, and faculty at the University of Maryland, Baltimore County campus with a hand-held, flash-equipped Nikon D3000 digital SLR camera with a 105mm Micro-Nikkor lens at f/32. The strong flash (Sunpak Auto 422 D at full power) provided most illumination for exposures and ensured that all images had a similar level of illumination and color balance. Images were taken from a frontal perspective, with subjects instructed to look directly at the camera, distributed across sex (some images are sexually ambiguous), age (estimated 18 through 70 years of age), and racial groups. The images were cropped to provide a rectangular image of both eyes, from about mid-nose to just above the eyebrows, and were of similar scale (approximately 25 cm width by 7.5 cm height) when presented on a computer monitor about 50 cm from the eyes of the subject.

The 50 eye images were used to develop a set of 200 stimulus images, some of which had their sclerae digitally reddened with Adobe Photoshop CS2. Only the white portion of the eye to the right and left of the iris was reddened; the color of the iris and
pupil were not changed. Reddening was subtle and involved tints within the range of daily experience that did not notably change image brightness: Reddened and unmodified control images appeared identical when viewed in monochrome. The Photoshop color scale that was adjusted was cyan/red; no changes were made to image brightness or contrast. The 200 stimulus images were of four types: 50 with normal, unreddened control sclerae (C), 50 with reddened left sclera (L), 50 with reddened right sclera (R), and 50 with both sclerae reddened (B). Laterality (L or R) refers to the perspective of the person in the stimulus image. Thus, the left eye of the stimulus image appears on the viewer's right, and vice-versa. An image of a particular individual appeared four times throughout the study, once in each stimulus group (C, L, R, or B).

The images were presented individually on a computer monitor using an automated slideshow format, with each image appearing for a maximum of 5 seconds or until a rating was made, after which the next image would appear. The presentation order of the images was determined using a random number generator and only modified to prevent images of the same individual from appearing in adjacent images. Presentation order was identical for every subject.

Procedure
The same research team, the three coauthors and four research assistants, participated in all three studies.

Subjects rated 200 stimulus images (C, L, R, or B) presented on a computer monitor for sadness, healthiness, or attractiveness using a computer mouse by left-clicking on the digits of a seven-point scale that appeared beneath each image. Using the example of healthiness, the anchorage points at each end of the scale were labeled “1. Not Healthy At All” to “7. Extremely Healthy.” The computer recorded the 200 ratings from each subject.

Before beginning a study, subjects were given 10 training trials to provide practice with the mouse-based, point-and-click rating system. The normal eye images used in the training session were similar in format to the experimental images, but were not digitally edited and were not used in the experimental part of the study. Instructions to subjects were presented both on-screen and read aloud by the experimenter.

For example, instructions for the healthiness study were:

During each five-second trial you will be shown an image of a person’s face on this computer screen. Your task is to rate the healthiness of the person in the image using the seven-point rating scale of healthiness from 1 (Not Healthy At All) to 7 (Extremely Healthy) that appears beneath each person’s image. Using the mouse, you will record your response by moving the cursor to the number corresponding to how healthy the person in the image appears and clicking the mouse button.

The above instructions were modified to accommodate the different rating scale anchorage points for the studies of attractiveness and sadness.

The individual Likert-type ratings of images by each subject were presented as four continuous averages per subject, one each for C, L, R, and B, and contrasted with a mixed-design ANOVA, with average ratings for C, L, R and B as a within-groups factor and
gender as a between-groups factor. Planned contrasts were made using Bonferroni adjusted alpha levels of 0.0083 per test (0.05/6) to compare differences between C, L, R, and B.

**Results**

Subjects participated in one of three studies. Subjects used a seven-point rating system to rate the perceived sadness, healthiness, or attractiveness of 200 eye images of individuals whose sclerae varied in color. The sclerae were either unaltered control images (C), or had one (L or R) or both (B) sclerae digitally reddened. Greenhouse-Geisser corrected df were used in all analyses because the assumption of sphericity was not met. Assumptions of normality were met by the data of all but two variables. All data were within acceptable ranges of skewness/kurtosis for the application of a mixed-design ANOVA. Neither a main effect of subject gender nor an interaction of sclera color x subject gender was observed in any analysis. Sample size, $F$ statistics, and estimates of effect size ($\eta^2$ values) for all three studies are provided in Table 1. Results of the Bonferroni contrasts of mean differences between C, L, R, and B are provided in Table 2.

**Table 1.** Results of the three sub-studies, including sample size, $F$ statistic, and effect size

| Table 1. Results of the three sub-studies, including sample size, $F$ statistic, and effect size |
|---|---|---|
| Subjects | F | $\eta^2$ |
| Sadness | |
| Scleral Color | 34 (22) | 51.11** | 0.61 |
| Subject Gender | 34 (22) | 0.91 | 0.03 |
| Interaction | 34 (22) | 1.06 | 0.01 |
| Healthiness | |
| Scleral Color | 38 (18) | 230.14** | 0.86 |
| Subject Gender | 38 (18) | 0.32 | 0.01 |
| Interaction | 38 (18) | 0.09 | 0.0003 |
| Attractiveness | |
| Scleral Color | 56 (33) | 78.85** | 0.59 |
| Subject Gender | 56 (33) | 1.83 | 0.03 |
| Interaction | 56 (33) | 0.87 | 0.01 |

Notes: * = $p < .05$, ** = $p < .01$. No subject gender effects or interactions between sclera color and subject gender were observed. Scleral color accounted for most of the effects on perceived sadness, healthiness, and attractiveness. Subject gender and the interaction between subject gender and scleral color did not significantly influence ratings of sadness, healthiness, or attractiveness.
Table 2. Mean differences in ratings of perceived sadness, healthiness, and attractiveness of individuals with various levels of scleral redness (Control, Left, Right, and Both) assessed using the Bonferroni correction

|       | Control | Left | Right | Both |
|-------|---------|------|-------|------|
| Sadness |         |      |       |      |
| Control | -       |      |       |      |
| Left    | 0.72**  | -    |       |      |
| Right   | 0.69**  | -0.03| -     |      |
| Both    | 1.44**  | 0.72**| 0.75**| -    |
| Healthiness |       |      |       |      |
| Control | -       |      |       |      |
| Left    | -0.49** | -    |       |      |
| Right   | -0.37** | 0.12**| -     |      |
| Both    | -2.80** | -2.31**| -2.43**| -  |
| Attractiveness |     |      |       |      |
| Control | -       |      |       |      |
| Left    | -0.21** | -    |       |      |
| Right   | -0.15** | 0.07 | -     |      |
| Both    | -0.91** | -0.70**| -0.76**| -  |

Notes: * = p < .05, ** = p < .01

Sadness

Ratings of sadness were significantly influenced by scleral redness (C, L, R, or B), as determined by a mixed-method ANOVA, $F_{1.44, 45.99} = 51.11, p < .01, \eta^2 = 0.61$ (see Fig. 1).

Individuals with two reddened sclerae (B) ($M \pm SD = 4.65 \pm 0.54$) were rated as significantly sadder than those with a single reddened left (L) ($M \pm SD = 3.90 \pm 0.55$) or right sclera (R) ($M \pm SD = 3.92 \pm 0.56$), or those with two unreddened, control sclerae (C) ($M \pm SD = 3.15 \pm 0.79$). There was no significant difference between the rated sadness of individuals with a single reddened left (L) or right (R) sclera. Individuals with a single reddened sclera on the left (L) were rated as significantly sadder than those with unreddened control sclerae (C).

Healthiness

Ratings of healthiness were significantly influenced by scleral redness, $F_{1.18, 42.48} = 230.14, p < .01, \eta^2 = 0.86$ (see Fig. 1).

Individuals with two unreddened, control sclerae (C) ($M \pm SD = 4.96 \pm 0.77$) were rated as significantly healthier than those with a single reddened left (L) ($M \pm SD = 2.64 \pm 0.62$) or right sclera (R) ($M \pm SD = 2.52 \pm 0.62$), or those with two reddened sclerae (B) ($M \pm SD = 2.16 \pm 0.55$). Individuals with a single reddened sclera on the left (L) were rated as significantly healthier than those with unreddened control sclerae (C).
significantly healthier than those with a single reddened sclera on the right (R), the only laterality difference in scleral redness among the three present studies. Individuals with a single reddened sclera (L or R) were rated as healthier than those with two reddened sclerae (B).

Attractiveness

Ratings of attractiveness were significantly influenced by scleral redness, $F_{1.32, 71.30} = 78.85, p < .01, \eta^2 = 0.59$ (see Fig. 1).

Individuals with two unreddened, control sclerae (C) ($M \pm SD = 3.23 \pm 1.07$) were rated as significantly more attractive than those with a single reddened left (L) ($M \pm SD = 2.52 \pm 0.97$) or right sclera (R) ($M \pm SD = 2.46 \pm 0.94$), or those with two reddened sclerae (B) ($M \pm SD = 2.31 \pm 0.90$). There was no significant difference between the rated attractiveness of individuals with a single reddened left (L) or right (R) sclera. Individuals with a single reddened sclera (L or R) were rated as significantly more attractive than those with two reddened sclerae (B).

Figure 1. Mean ratings and standard errors of the sadness, healthiness and attractiveness of individuals with neither sclera reddened (Control) (left group), a single reddened left (L) or right (R) sclera (middle group), or both sclerae reddened (right group).

Discussion

Scleral redness had a progressive effect; individuals with two red eyes were
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perceived as sadder, less healthy, or less attractive than those with one red eye, and individuals with one red eye were perceived as sadder, less healthy, or less attractive than those with two white eyes. Although binocular scleral redness always had the greatest effect, monocular redness was sufficient to influence the perception of sadness, healthiness, and attractiveness. These results are consistent with previous reports that binocular scleral redness (monocular redness was not previously examined) is a cue for sadness (Provine et al., 2011, in press), unhealthiness, and unattractiveness (Provine, 2012; Provine et al., 2011, 2013). No significant gender effects or interactions between scleral color and subject gender were detected in the study.

The sufficiency of a single red eye to cue sadness, reduced healthiness, or reduced attractiveness indicates that these are not categorical, all-or-none percepts that require the observation of two red eyes. Monocular cues are important because only a solitary eye is visible when one eye is closed or in shadow, the face is observed in profile, or an individual has only one eye. The perceptual impact of monocular redness, whatever its cause, may be increased by binocular contrast, its redness relative to that of the contralateral eye. Other types of asymmetry that involve binocular contrast are pupil size and gaze direction, well known tests of neuropathology (Walton, 1993). Only one effect of laterality was detected among the contrasts of monocular redness; individuals with a left red eye were rated as healthier than those with a right red eye. It is unclear whether this modest but significant effect reflects a difference in the relative potency of the two eyes to display health cues, or if the effect lies within the rater, whose right and left eyes and associated brain regions are differentially sensitive to health-related information.

The sclera is a broadly tuned chromatic medium. In the present research, for example, binocular and monocular scleral redness were cues for sadness, healthiness, and attractiveness. Redness is also a symptom of other conditions (Provine et al., 2013), including (but not limited to) age (Broekhuysen, 1975), sleep deprivation, allergy (Donshik 1988), marijuana use (McLane and Carroll, 1986), chemical and physical irritation, eye trauma, dry-eye, glaucoma, conjunctivitis (Leibowitz, 2000), episcleritis, hypertension, diabetes, sickle cell disease (Paton, 1961), autoimmune disease, and rheumatoid arthritis. With so many correlates of scleral redness, contextual cues may be necessary to interpret its cause. Lacking context, it may be unclear whether a red-eyed friend is in need of medical assistance or emotional solace. Whatever its cause, we are exquisitely sensitive to scleral redness, evidence compatible with the proposal by Changizi et al. (2006) that trichromatic vision in primates was selected to discriminate socially significant changes in the color of bare skin associated with altered blood flow and oxygenation (e.g., blushing). Indeed, the sclera is superior to the skin as an hemodynamic display medium because the blood vessels of the conjunctiva that are primarily responsible for changes in scleral redness are more directly viewed than those buried beneath the skin.

The association between scleral color, healthiness, age, and attractiveness, in the present and previous studies, is not arbitrary (Provine, 2012; Provine et al., 2011, 2013). Healthy, young individuals are attractive because their traits predict reproductive fitness (Etoff, 1999; Johnston, 2006; Sugiyama, 2005; Symons, 1979, 1995), and individuals with white (non-red, non-yellow) sclerae are perceived as younger and healthier than those with red or yellow sclerae (Provine, 2012; Provine et al., 2011, 2013). Based on this evidence,
healthy eyes with white sclerae deserve a place on the list of universal traits signaling reproductive fitness and beauty (Provine, 2012; Provine et al., 2011, 2013). Scleral color cues are especially informative because they are involuntary, “honest” (hard to fake), and complement previously established measures of fitness. However, in modern times, naturally honest scleral cues can be modified somewhat by technology. Eye drops that “get the red out” can serve as beauty aids that really do make you look healthier, younger, and less sad. Unattractive sclerae can also be hidden behind an eye-patch (monocular) or dark eyeglasses (binocular).

The displays of scleral redness examined in the current study add to the range of phenomena that can be considered from the perspective of bilateral body symmetry/asymmetry, a research theme in human and biological evolution. Body and facial symmetry are of interest because they are presumed to predict good phenotypic condition and genetic quality, desirable features in mate selection (Little, Burt, Penton-Voak, and Perrett, 2001; Little et al., 2007; Little et al., 2008; Little and Jones, 2003; Penton-Voak et al., 2001; Perrett et al., 1999; Scheib et al., 1999; Waitt and Little, 2006). Symmetry also reflects an organism's success in maintaining a stable developmental trajectory, a theme of “fluctuating asymmetry” theory (Gangestad and Thornhill, 1999; Valen, 1962); asymmetry is presumed to signal the undesirable consequence of developmental or genetic disorder, injury or disease.

Scleral color differs from other manifestations of body form, in which bilateral symmetry may be desirable. For example, the symmetry of scleral color can be either positive, as when binocular white sclerae signal health, or negative, as when binocular red sclerae signal disease or sadness. Further, the asymmetry of scleral color can be relatively positive, as when only one eye is red, a less negative signal than when both eyes are reddened by trauma or disease. Also, in contrast to symmetry of the type noted above (e.g., fluctuating asymmetry), scleral color has neither direct roots in genotype and its phenotypic expression, nor in developmental trajectory. Redness, for example, may be the fleeting consequence of increased conjunctival blood flow, (e.g., sadness, sleeplessness, irritation, marijuana use, conjunctivitis) that can completely reverse within minutes to days, and not leave traces, as are present in dermal scaring or other disfigurements. Among scleral color cues, the redness of old age and disease are most likely to linger (e.g., glaucoma, sickle cell disease, autoimmune disease, rheumatoid arthritis), as is the yellowness of old age and liver disease (Provine et al., 2013). Although not yet examined from the perspective of symmetry/asymmetry, these system-wide, chronic conditions probably provide bilaterally symmetrical, chromatic displays.

The present investigation of symmetrical and asymmetrical scleral redness is one of a series of studies that introduce and explore the human trait of scleral color as a social display. Although in its early stages, this line of research suggests that scleral color joins other eye-related features (e.g., emotional tearing, directional gaze, pupil dilation, eye widening/narrowing) that contribute to the evolution of Homo sapiens as a social species.

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References

Broekhuysen, R. M. (1975). The lipid composition of the aging sclera and cornea, *Ophthalmologica*, 171, 82-85.

Changizi, M. A., Zhang, Q., and Shimojo, S. (2006). Bare skin, blood and the evolution of primate color vision. *Biology Letters*, 2, 217-221.

Donshik, P. C. (1988). Allergic conjunctivitis. *International Ophthalmology Clinics*, 28, 294-301.

Etcoff, N. (1999). *Survival of the prettiest*. New York: Doubleday.

Frey, W. H. (1985). *Crying: The mystery of tears*. Minneapolis, MN: Winston Press.

Gangestad, S. W., and Thornhill, R. (1999). Individual differences in developmental precision and fluctuating asymmetry: A model and its implications. *Journal of Evolutionary Biology*, 12, 402-416.

Johnston, V. S. (2006). Mate choice decisions: The role of facial beauty. *Trends in Cognitive Sciences*, 10, 9-13.

Kobayashi, H., and Kohshima, S. (2001). Unique morphology of the human eye and its adaptive meaning: Comparative studies on external morphology of the primate eye. *Journal of Human Evolution*, 40, 419-435.

Langlois, J. H., Kalakanis, L., Rubenstein, A. J., Larson, A., Hallam, M., and Smoot, M. (2000). Maxims or myths of beauty? A meta-analytic and theoretical review. *Psychological Bulletin*, 126, 390-423.

Leibowitz, H. M. (2000). The red eye. New England Journal of Medicine, 343, 345-351.

Little, A. C., Apicella, C. L., and Marlowe, F. W. (2007). Preferences for symmetry in human faces in two cultures: Data from the UK and the Hadza, an isolated group of hunter gatherers. *Proceedings of the Royal Society of London, Series B*, 274, 3113-3117.

Little, A. C., Burt, D. M., Penton-Voak, I. S., and Perrett, D. I. (2001). Self-perceived attractiveness influences human female preferences for sexual dimorphism and symmetry in male faces. *Proceedings of the Royal Society of London, Series B*, 268, 39-44.

Little, A. C., and Jones, B. C. (2003). Evidence against perceptual bias views for symmetry preference in human faces. *Proceedings of the Royal Society of London, Series B*, 270, 1759-1763.

Little, A. C., Jones, B. C., Waitt, C., Tiddeman, B. P., Feinberg, D. R., Perrett, D. I., . . . Marlowe, F. W. (2008). Symmetry is related to sexual dimorphism in faces: Data across culture and species. *PLoS ONE*, 3, e2106.

McLane, N. J., and Carroll, D. M. (1986). Ocular manifestations of drug abuse. *Survey of Ophthalmology*, 30, 298-313.
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Papavramidou, N., Fee, E., and Christopoulou-Aletra, H. (2007). Jaundice in the Hippocratic corpus. Journal of Gastrointestinal Surgery, 11, 1728-1731.

Paton, D. (1961). The conjunctival sign of sickle cell disease. Archives of Ophthalmology, 66, 90-94.

Penton-Voak, I. S., Jones, B. C., Little, A. C., Baker, S., Tiddeman, B., Burt, D. M., and Perrett, D. I. (2001). Symmetry, sexual dimorphism in facial proportions, and male facial attractiveness. Proceedings of the Royal Society of London, Series B, 268, 1617-1623.

Perrett, D. I., Burt, D. M., Penton-Voak, I. S., Lee, K. J., Rowland, D. A., and Edwards, R. (1999). Symmetry and human facial attractiveness. Evolution and Human Behavior, 20, 295-307.

Provine, R. R. (2011). Emotional tears and NGF: A biographical appreciation and research beginning. Archives Italiennes de Biologie, 149, 269-274.

Provine, R. R. (2012). Curious behavior: Yawning, laughing, hiccupping and beyond. Cambridge: Belknap Press of Harvard University Press.

Provine, R. R., Cabrera, M. O., Brocato, N. W., and Krosnowski, K. A. (2011). When the whites of the eyes are red: A uniquely human cue. Ethology, 117, 1-5.

Provine, R. R., Cabrera, M. O., and Nave-Blodgett, J. (2013). Red, yellow, and super-white sclera: Uniquely human cues for healthiness, attractiveness, and age. Human Nature, 24, 126-136.

Provine, R. R., Krosnowski, K. A., and Brocato, N. W. (2009). Tearing: Breakthrough in human emotional signaling. Evolutionary Psychology, 7, 52-56.

Provine, R. R., Nave-Blodgett, J., and Cabrera, M. O. (in press). The emotional eye: Red sclera as a uniquely human cue of emotion. Ethology.

Rhodes, G. (2006). The evolutionary psychology of facial beauty. Annual Review of Psychology, 57, 199-226.

Roche, S. P., and Kobos, R. (2004). Jaundice in the adult patient. American Family Physician, 69, 299-304.

Scheib, J. E., Gangestad, S. W., and Thornhill, R. (1999). Facial attractiveness, symmetry, and cues to good genes. Proceedings of the Royal Society of London, Series B, 266, 1913-1917.

Sugiyama, L. S. (2005). Physical attractiveness in adaptationist perspective. In D. Buss (Ed.), The handbook of evolutionary psychology (pp. 292-343). New York: John Wiley.

Symons, D. (1979). The evolution of human sexuality. Oxford: Oxford University Press.

Symons, D. (1995). Beauty is in the adaptations of the beholder. In P. Abramson and S. Pinkerson (Eds.), Sexual nature, sexual culture (pp. 80-118). Chicago: University of Chicago Press.

Thornhill, R., and Gangestad, S. W. (1999). Facial attractiveness. Trends in Cognitive Science, 3, 452-460.

Thornhill, R., and Gangestad, S. W. (2006). Facial sexual dimorphism, developmental stability, and susceptibility to disease in men and women. Evolution and Human Behavior, 27, 131-144.

Valen, L. V. (1962). A study of fluctuating asymmetry. Evolution, 16, 125-142.
Vingerhoets, A. J. J. M., and Cornelius, R. R. (Eds.) (2001). *Adult crying: A biopsychosocial approach*. Philadelphia: Brunner-Routledge.

Waitt, C., and Little, A. C. (2006). Preferences for symmetry in conspecific facial shape among *Macaca mulatta*. *International Journal of Primatology, 27*, 133-145.

Walton, J. (Ed.). (1993). *Brain's diseases of the nervous system (10th. ed.)*. Oxford: Oxford University Press.

Watson, P. G., Hazeleman, B. L., Pavesio, C. E., and Green, W. R. (2003). *The sclera and systemic disorders (2nd. ed.)*. London: Butterworth-Heinemann.

Watson, P. G., and Young, R. D. (2004). Scleral structure, organization and disease: A review. *Experimental Eye Research, 78*, 609-623.