

Put a (Limbal) Ring on It: Women Perceive Men's Limbal Rings as a Health Cue in Short-Term Mating Domains

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Abstract

Limbal rings are dark annuli encircling the iris that fluctuate in visibility based on health and age. Research also indicates their presence augments facial attractiveness. Given individuals' prioritization of health cues in short-term mates, those with limbal rings may be implicated as ideal short-term mates. Three studies tested whether limbal rings serve as veridical health cues, specifically the extent to which this cue enhances a person's value as a short-term mating partner. In Study 1, targets with limbal rings were rated as healthier, an effect that was stronger for female participants and male targets. In Study 2, temporally activated short-term mating motives led women to report a heightened preference for targets with limbal rings. In Study 3, women rated targets with limbal rings as more desirable short-term mates. Results provide evidence for limbal rings as veridical cues to health, particularly in relevant mating domains.

Keywords

limbal rings, short-term mating, facial attractiveness, health, evolutionary psychology

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When selecting the optimum short-term mate, physical attractiveness is vital. Research extensively indicates that humans prioritize physical attractiveness in short-term mating (STM) over traits desirable in a long-term partner, including investment potential and paternal ability (e.g., Buss & Schmitt, 1993; Kenrick, Groth, Trost, & Sadalla, 1993; Li & Kenrick, 2006; Li et al., 2013), because of the former's communicative function of heritable fitness (Scheib, Gangestad, & Thornhill, 1999). Various facial features deemed attractively dually connote health to a perceiver, including symmetry and sex typicality (e.g., Penton-Voak & Chen, 2004; Smith et al., 2006; Thornhill & Gangestad, 2006) to which sensitivity toward these features would be reproductively advantageous for identifying prospective mates with greater heritable fitness. However, given humans' historical reliance on face-to-face communication, which invokes mutual eye gaze, certain features of the eye may offer additional value in communicating underlying health.

Eyes have evolved to communicate social information between conspecifics, with mutual gaze being necessary to facilitate cooperation and attraction (Argyle & Cook, 1976; Stass & Willis, 1967). Unlike other primates, humans' eyes have a salient distinction between the iris and sclera that elicits a contrast between the two features from which one can infer a conspecific's behavioral intentions and health (e.g., Kobayashi & Kohshima, 2001). Humans infer health

through perceptions of certain sclera colorations as healthier than others (Provine, Cabrera, & Nave-Blodgett, 2013), which would therefore be immediately perceived as a health cue during initial stages of interactions (Willis & Todorov, 2006). One distinct eye feature that has recently gained attention for its augmentative properties is the limbal ring, a dark ring around the iris, which appears to enhance facial attractiveness (Peshek, Semmaknejad, Hoffman, & Foley, 2011). Indeed, limbal rings are most apparent in clear eyes for individuals relatively free from chronic health issues and afford brighter sclerata (e.g., Fernandez et al., 2009; Zheng & Xu, 2008), which logically connects them to attractiveness. In fact, there are contact lenses available that augment and create the presence of vibrant limbal rings to enhance attractiveness and are marketed to “take years off [one's] face” (Freeman, 2015). The basis of their attractiveness may be as a good genes indicator, such that their presence may communicate health. Thus, those with limbal rings may appear desirable as short-term mates, given STM's emphasis on good genes. The present research addresses the communicative

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properties of limbal rings as a veridical health cue and seeks to provide novel evidence of their influence in STM-related perceptions.

Facial Cues to Health

Human faces are social stimuli capable of communicating valuable information to conspecifics, including biological health (Rhodes, 2006). Humans prioritize cues indicating good genes for prospective short-term mates, as these genes afford resultant offspring heritable fitness. It would thus be advantageous for those interested in STM to be sensitive to facial features connoting good health, which would manifest as preferences for those exhibiting them and aversion to those not. For example, facial symmetry is a veridical cue to overall health. Individuals with higher levels of facial symmetry have better immunological function and are more resistant to upper respiratory infections, compared with those with lower levels of symmetry (Shackelford & Larsen, 1997; Thornhill & Gangestad, 2006). Symmetrical individuals are also healthier and perceived as more attractive (e.g., Fink, Neave, Manning, & Grammer, 2006), thus implicating them as desirable short-term mates. Furthermore, those with dispositional interest in STM demonstrate heightened preferences for such features (Sacco, Hugenberg, & Sefcek, 2009). Successfully identifying good genes through these cues would thus ensure optimum reproductive opportunities following identification. Because short-term mate choice ultimately relies on several fitness cues (e.g., Jonason, Raulston, & Rotolo, 2012), it would seem sensible that other facial features may contribute to these decisions, especially features around the eyes.

When evaluating facial attractiveness through health cues, ratings have some contingency to the presence of health features based on proximity to the eyes (e.g., Jones, Porcheron, Sweda, Morizot, & Russell, 2016). Given eye contact's primacy during social interactions (Davies & Hoffman, 2002), it would seem sensible for certain eye features to provide veridical health cues. Previous research has identified several features in and around the eyes that cue health, which could subsequently be deemed attractive. For example, the sclera appears especially influential in health perceptions, with whiter sclerata connoting good health and resistance to infection, whereas decreases in whiteness connote advanced age and chronic health concerns (Murphy, Lau, Sim, & Woods, 2007; Russell, Sweda, Porcheron, & Mauger, 2014). Sclera brightness decreases with age, potentially from the accumulation of pathologies (e.g., jaundice; Gründl, Knoll, Eisenmann-Klein, & Prantl, 2012; Russell et al., 2014). Furthermore, white sclerata are subsequently perceived as more attractive (Provine, Cabrera, Brocato, & Krosnowski, 2011) and healthier, and those with whiter sclerata appear younger than those with yellow or red sclerata (Russell et al., 2014). One reason for this attractiveness may be the contrast between the sclera and darker facial

features, as whiter sclerata afford contrasts with darker features, typically skin, which augments attractiveness perceptions (Russell et al., 2016).

However, the contrast between skin and sclera can be similarly augmented through phenotypic extensions that make the surrounding area around the sclera dark, thereby making the sclera appear brighter by default (e.g., eyeliner; Etcoff, Stock, Haley, Vickery, & House, 2011). This would implicate certain contrasts as false cues to health. In response to potential phenotypic extensions, humans may have evolved heightened sensitivity toward contrasts around the eye that are less possible through phenotypic extensions. Features *within* the eye may ultimately serve as a more authentic phenotype connoting fitness based on their contrast with the sclera, as they would have been historically difficult to enhance artificially.

Limbal Rings and Attraction

One contrast that may provide a veridical health cue within the eyes, and therefore communicate short-term mate quality, could be limbal rings. Limbal rings are dark annuli encircling the iris where the sclera meets the iris, which accentuates the brightness of the sclera in comparison with the referent iris (Shyu & Wyatt, 2009). Limbal ring presence is largely contingent on one's health, as declining health ultimately reduces its visibility, including Pterygium from unhealthy limbal stem cells (Sangwan, 2001; Zheng & Xu, 2008), cloudiness of corneal cells (e.g., Fernandez et al., 2009), and degenerative diseases (Cavallotti & Cerulli, 2008). Limbal rings' presence further diminishes with age, such that older adults' limbal rings are less vibrant compared with younger, thereby reducing the sclera-iris contrast (Peshek, 2013). Another ring (arcus senilis) composed of phospholipid deposits may also appear around the iris as a light ring that reduces the visibility of limbal rings even further (e.g., Ang et al., 2011); interestingly, the presence of this arcus senilis has been associated with cardiovascular diseases. Without limbal rings, the coloring from the iris blends into the sclera, creating the illusion of the sclera being less white and therefore inferred as unhealthy. It would seem sensible to suggest that the bright sclera-dark iris contrast afforded by limbal rings may augment perceptions of a person as healthy and implicate limbal rings as a veridical health cue to perceivers.

Additional research implicates limbal rings as enhancing attractiveness. There is an overall heightened preference for faces with limbal rings in favor of those without (Peshek et al., 2011), as well as heightened favorability toward brands with advertisements featuring models with limbal rings (Ilicic, Baxter, & Kulczynski, 2016). These results demonstrated a basis for limbal rings' augmentative properties in terms of a contrast effect; specifically, target eyes with limbal rings allow greater contrast affordance, thereby facilitating a perceiver's ability to detect health from sclerata (Ilicic

et al., 2016). This further suggests limbal rings' attractiveness appears rooted in being a health cue, as they are most apparent in eyes of individuals in better physical health. Those who prefer eyes with limbal rings would ultimately be at a reproductive advantage from identifying high-quality prospective mates. Given the emphasis on good genes in STM, it is sensible to predict heightened sensitivity to limbal rings in STM domains.

Current Research

Although previous research indirectly indicates that limbal rings may communicate health, as indexed by faces with limbal rings being perceived as more attractive (e.g., Ilicic et al., 2016; Peshek et al., 2011), there are no studies explicitly demonstrating whether observers perceive faces with limbal rings as healthier than those without. In the current program of research, we sought to provide converging pieces of evidence indicating the communicative properties of limbal rings as a veridical health cue. We posited this enhanced health perception provides the basis of previous findings demonstrating an attractiveness advantage for faces with limbal rings. Importantly, we sought to contextualize this desirability through mating domains. We predicted faces with limbal rings would be perceived as healthier compared with those without (Study 1). Furthermore, given the priority placed on good genes in short-term mate selection, we predicted that individuals with salient interests in STM would be particularly sensitive to limbal ring presence such that observers would evaluate faces with limbal rings more favorably than those without (Study 2). Finally, heightened sensitivity to fitness cues among individuals interested in STM posits an overall favorability toward fitness cues in relevant domains. Thus, we predicted limbal rings' favorability would be most apparent in STM domains, but not long-term (Study 3).

Study 1

The goal of Study 1 was to extend past research indicating how limbal rings augment facial attractiveness (e.g., Peshek et al., 2011) by demonstrating their influence on health perceptions. That is, we predicted that participants would perceive faces with limbal rings as healthier than those without. Participants rated the perceived health of various faces with and without limbal rings. Importantly, this study accounted for both same- and opposite-sex perceptions to determine potential implications for limbal rings' communicative value for both mate selection and intrasexual competition (Brown & Sacco, 2017).

Method

Participants. We recruited 153 Amazon Mechanical Turk workers (Buhrmester, Kwang, & Gosling, 2011) who participated in exchange for US\$0.35. A power analysis (Cohen's

$d_s = 0.35$, $\beta = .95$) from G*Power (Faul, Erdfelder, Lang, & Buchner, 2007) indicated that 109 participants were sufficient to detect effects on the study's most basic parameter (i.e., comparing health scores of faces with and without limbal rings). We intentionally oversampled in a single wave of data collection to accommodate any necessary exclusion of participants who did not meet study requirements. No data warranted exclusion ($M_{age} = 31.33$ years, $SD = 18.53$; 77 men, 76 women; 78.4% White; 84.3% heterosexual).

Materials

Limbal ring targets. Participants viewed a series of images of faces containing 20 unique identities altered by Peshek and colleagues (2011) either to have limbal rings or not (Figure 1). There were 10 male and 10 female faces of young adult individuals with relatively neutrally expressive affect. Specifically, Peshek et al. altered these faces by cropping in an iris, from the Database of Human Iris Images (Dobeš & Machala, 2002), over their eyes to create two versions of each face, one with limbal rings and one without (i.e., 40 total faces), which prevented properties from the targets' original eyes from being visible in the altered images. For the limbal ring faces, the iris had a radial gradient imposed onto it to produce a ring with 50% opacity, which ostensibly created the appearance of a "natural" limbal ring (Peshek, 2013); the versions of faces without limbal rings did not have that gradient imposed. Participants viewed each face, individually, in random order with no chance of seeing both versions of the same unique identity in direct succession of each other. In this task, participants rated the extent to which they perceived each individual face as healthy using a single-item, 7-point Likert-type scale (1 = *very unhealthy*; 7 = *very healthy*) with higher scores indicating greater perceived health of that target. We aggregated the 10 health ratings for each face category (i.e., male-present, female-present, male-absent, female-absent).

Procedure. Following informed consent, participants indicated their health ratings in a self-paced task; they viewed each face for as long as they needed before continuing to the next face. Finally, participants completed demographics information before being debriefed and receiving a completion code to redeem for compensation.

Results and Discussion

We conducted a 2 (participant sex: male vs. female) \times 2 (target sex: male vs. female) \times 2 (limbal rings: present vs. absent) mixed-model ANOVA with repeated factors over the latter two factors. A significant main effect for Limbal Rings indicated that participants rated faces with limbal rings ($M = 5.01$, $SE = 0.06$) to be healthier than those without ($M = 4.91$, $SE = 0.06$), $F(1, 151) = 16.92$, $p < .001$, $\eta_p^2 = .101$. Effects were further qualified by a Limbal Rings \times Participant Sex interaction, $F(1, 151) = 3.91$, $p = .050$, $\eta_p^2 = .025$. Simple



Figure 1. Example faces without (*left*) and with limbal rings (*right*).

effect tests revealed women perceived targets with limbal rings ($M = 4.96$, $SE = 0.09$) as significantly healthier than those without ($M = 4.81$, $SE = 0.09$), $F(1, 151) = 18.43$, $p < .001$, $\eta_p^2 = .109$, 95% confidence interval (CI) = [0.08, 0.21]. Conversely, men perceived faces with limbal rings ($M = 5.06$, $SE = 0.09$) and without ($M = 5.01$, $SE = 0.09$) similarly, $F(1, 151) = 2.29$, $p = .132$, $\eta_p^2 = .015$, 95% CI = [-0.01, 0.11]. This suggests women's perceptions were especially impacted by limbal rings.

A second two-way interaction emerged for Limbal Rings and Target Sex, $F(1, 151) = 18.24$, $p < .001$, $\eta_p^2 = .108$. Simple effects tests revealed participants perceived male faces with limbal rings ($M = 5.04$, $SE = 0.07$) as significantly healthier than those without ($M = 4.87$, $SE = 0.07$), $F(1, 151) = 29.32$, $p < .001$, $\eta_p^2 = .163$, 95% CI = [0.11, 0.23]. However, no difference emerged between health ratings for female faces with ($M = 4.97$, $SE = 0.07$) and without limbal rings ($M = 4.95$, $SE = 0.07$), $F(1, 151) = 0.68$, $p = .410$, $\eta_p^2 = .004$, 95% CI = [-0.31, 0.07]. No other significant main effects emerged, nor were the three-way and Target Sex \times Participant Sex interactions significant ($ps > .130$).

These results provide converging evidence for limbal rings' role in communicating health-related information to conspecifics. Not only are limbal rings most apparent in eyes of healthier people (e.g., Zheng & Xu, 2008), but observers are also able to infer the overall health of another person based on the contrast effect in the eye afforded by limbal rings. This health inference places limbal rings in a similar

position to other well-established health cues, for example, facial symmetry, although remaining unique itself. Limbal rings' uniqueness as a health cue comes from the automaticity humans exhibit for eye contact in social perceptions (e.g., Davies & Hoffman, 2002), that it would be adaptive to use that initial moment in social interaction to infer an interpersonal value necessary for survival and reproduction. This study provided a potential basis for this facial feature's favorability.

Interestingly, only women's perceptions appeared contingent on limbal rings' presence. Such results seem sensible when considering women's advantage in face perception and recognition of social cues through faces (Cellerino, Borghetti, & Sartucci, 2004; Hampson, van Anders, & Mullin, 2006). Perhaps women were readily able to perceive the social information from these faces with their differential health assessments as a manifestation of this advantage. Their sensitivity to limbal rings as a health cue would be advantageous in identifying high-quality potential mates via cues in male faces while simultaneously identifying intra-sexual competition via cues in female faces (i.e., healthier potential interlopers).

Limbal rings also appeared more critical in evaluations of male, relative to female, target faces. One reason for limbal rings being able to connote biological health more readily in male faces, compared with female, could be the natural buffer estrogen provides against cardiovascular issues (Barrett-Connor & Bush, 1991). Estrogen mitigates accumulation of

phospholipids linked to cardiovascular diseases, as evidenced by an increase in heart disease incidents in women following menopause (e.g., McCrohon, Nakhla, Jessup, Stanley, & Celermajer, 1999; Shlipak et al., 2000). This mitigation of phospholipid accumulation would further reduce the appearance of the arcus senilis and connote earlier risk for cardiovascular issues (Ang et al., 2011; Fernandez et al., 2009). Thus, limbal rings may ultimately be a less reliable cue to women's health compared with men's, at least during women's reproductively viable years. Furthermore, considering men's heightened risk for cardiovascular issues (e.g., Yang & Clancy, 2011), limbal rings should be especially indicative of men's health. Specifically, absence of limbal rings in younger men may cue existing vulnerability to chronic diseases, and therefore be a cue that women use to identify and avoid suboptimal mates. When identifying optimum short-term mates, limbal rings may indicate that a man is relatively free of chronic health issues, or predispositions to such issues.

These sex-related findings could implicate limbal rings as providing an important cue to health for women in their short-term mate selection and navigation through competition. Because reproduction is more metabolically costly for women, they have evolved to be very judicious in mate selection (Trivers, 1972). Demonstrating greater sensitivity to such health cues could help women avoid making costly mate selection errors, thereby helping them offset higher reproduction costs. This judiciousness should elicit greater sensitivity to potential health issues, such that prospective mates exhibiting potential chronic health concerns would elicit aversion from a female perceiver. In our second study, we sought to demonstrate how activating STM goals heighten women's sensitivity to good genes. We focused specifically on women in Study 2 because men in Study 1 appeared insensitive to limbal rings as a health cue.

Study 2

STM interest elicits sensitivity toward cues to facilitate satisfaction of immediate reproductive goals, including individuals similarly interested in pluralistic mating strategies or those possessing heritable fitness cues (e.g., Brown & Sacco, 2017; Kruger & Piglowski, 2012; Sacco et al., 2009). For example, sociosexually unrestricted individuals exhibited heightened sensitivity toward good genes, as indexed by stronger preference for facial symmetry (Sacco et al., 2009). Furthermore, priming unrestricted individuals with mating motives elicits strong attentional adhesion to attractive members of the opposite sex (Maner, Gailliot, Rouby, & Miller, 2007).

Women's sensitivity to health cues in prospective mates should be especially apparent through perceiving facial cues connoting fitness, as women focus on men's faces in STM contexts, which would presumably contain the requisite

fitness indicators for optimum STM (Confer, Perilloux, & Buss, 2010; Currie & Little, 2009; Lu & Chang, 2012). Within this STM context, women should be especially sensitive to the presence of cues to identify optimum partners and likely rivals while discriminating from suboptimal partners and nonthreats. In this study, women were primed with STM motives (or not) before assessing health of targets with and without limbal rings. We predicted mating-motivated women would perceive limbal rings as especially healthy, in contrast to faces without.

Method

Participants. One hundred eighteen women from a public university in the southeastern United States completed this study for course credit as partial requirement for various psychology courses. A power analysis (Cohen's $f = 0.20$, $\beta = .95$) indicated that 84 participants would be sufficient to detect effects; we intentionally oversampled in a single wave of data collection. We excluded 15 participants from final analyses for identifying themselves as being outside an 18- to 40-year age range or not reporting opposite-sex attraction (the mating prime described a sexual experience with a man). This resulted in a final sample of $n = 103$ ($M_{\text{age}} = 20.02$ years, $SD = 3.66$; 71.8% White).

Materials

Mating prime. To elicit STM motivations, participants read an immersive narrative designed either to heighten their desire for mating or provide a similarly valenced, yet non-mating-related, arousal (Griskevicius et al., 2007). The mating prime recounted the events of a female protagonist on vacation where she met an attractive man with whom she had a romantic evening with the implication this experience was a short-term sexual affair. The control condition recounted a female protagonist going to a fun concert with a same-sex friend. After reading their respective primes, participants completed a manipulation check to indicate their activation of mating motivation through four questions assessing current romantic arousal, sexual arousal, desire for a relationship, and desire to have others be attracted to them, along 7-point Likert-type scales (1 = *not at all*; 7 = *very much*) with higher scores indicating greater arousal. Items demonstrated acceptable internal consistency (Cronbach's $\alpha = .87$). Participants also indicated their current mood ($-3 = \textit{very negative}$; $3 = \textit{very positive}$); higher scores indicated greater positive affect.

Procedure. Following informed consent, participants were randomly assigned to one of the primes before completing the manipulation check questions. Next, participants evaluated the individual faces based on health identically to Study 1. Finally, participants completed demographics information before being debriefed.

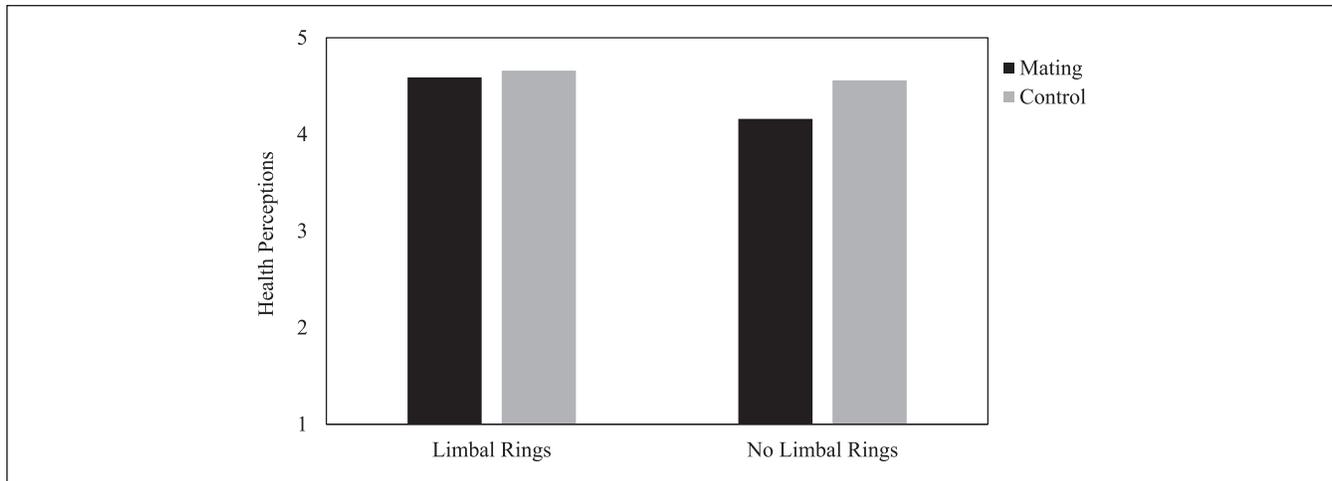


Figure 2. Women's health perceptions of faces with and without limbal rings following either a mating or control prime. [AQ: 2]

Results and Discussion

Manipulation check. Participants in the mating prime condition ($M = 4.23$; $SD = 1.31$) experienced greater activation of mating motives than the control ($M = 2.00$; $SD = 1.34$), $t(101) = 8.53$, $p < .001$, $d = 1.68$, 95% CI = [1.71, 2.75]. The mating ($M = 1.62$, $SD = 1.34$) and control conditions ($M = 1.73$, $SD = 1.14$) did not differ in general affect, $t(101) = 0.47$, $p = .637$, $d = 0.09$, 95% CI = [-0.60, 0.37].

Primary analysis. To analyze how the primes influenced participants' perception of targets' health, we conducted a 2 (condition: mating vs. control) \times 2 (target sex: male vs. female) \times 2 (limbal rings: present vs. absent) mixed-model ANOVA with repeated measures over the latter two factors. Condition elicited no main effect, $F(1, 101) = 2.19$, $p = .142$, $\eta_p^2 = .021$. However, a main effect for Limbal Rings indicated that participants perceived faces with limbal rings ($M = 4.63$, $SE = 0.08$) as healthier than those without ($M = 4.36$, $SE = 0.09$), $F(1, 101) = 17.51$, $p < .001$, $\eta_p^2 = .148$.

Effects were qualified by a Condition \times Limbal Rings interaction, $F(1, 101) = 6.68$, $p = .011$, $\eta_p^2 = .062$ (see Figure 2). Simple effect tests revealed that participants in the mating condition perceived faces with limbal rings ($M = 4.59$, $SE = 0.12$) as significantly healthier than those without ($M = 4.16$, $SE = 0.12$), $F(1, 101) = 22.27$, $p < .001$, $\eta_p^2 = .181$, 95% CI = [0.25, 0.61]. There was no difference in health perceptions for faces with ($M = 4.66$, $SE = 0.12$) and without limbal rings ($M = 4.56$, $SE = 0.12$) in the control condition, $F(1, 101) = 1.32$, $p = .254$, $\eta_p^2 = .013$, 95% CI = [-0.07, 0.28]. For faces with limbal rings, there was no difference in health ratings for the mating and control conditions, $F(1, 101) = 0.18$, $p = .670$, $\eta_p^2 = .002$, 95% CI = [-0.41, 0.26]. Participants rated faces without limbal ring as less healthy in the mating condition relative to the control, $F(1, 101) = 5.25$, $p = .024$, $\eta_p^2 = .049$, 95% CI = [0.05, 0.75], suggesting women primed with

STM are especially attuned to the absence of limbal rings, which would communicate underlying reduced fitness. No other interactions or main effects emerged ($ps > .110$).

Meta-analysis. Descriptively, women in Study 1 perceived male faces ($M = 5.00$, $SD = 0.86$) with limbal rings as healthier than those without ($M = 4.81$, $SD = 0.89$); female faces with ($M = 4.88$, $SD = 0.85$) and without limbal rings ($M = 4.80$, $SD = 0.87$) did not yield as large of a difference. In Study 2, women descriptively perceived male faces with limbal rings ($M = 4.64$, $SD = 0.90$) as healthier than those without ($M = 4.34$, $SD = 0.95$); women also perceived female faces with limbal rings ($M = 4.61$, $SD = 0.91$) as healthier than those without ($M = 4.38$, $SD = 0.96$), albeit to a lesser extent.

Because of the possibility that women are more sensitive to limbal rings in male faces, given the descriptive differences between either target, we conducted a brief meta-analysis to compare women's health ratings for both target sexes across Studies 1 and 2. We averaged the effect sizes (Cohen's d s) for women's health ratings for male and female faces separately from both studies, which resulted in an effect size for male faces as $d = 0.25$ and female faces as $d = 0.13$. Although both effect sizes are small, these scores indicate that the presence of limbal rings in male faces possesses cues health better than it does for female faces, which further bolsters the notion of limbal rings being especially useful in inferring men's short-term mate value.

Taken together, these data indicate that activation of mating motives in women upregulates sensitivity toward fitness cues, or lack thereof. When using the presence of limbal rings in social targets as a heuristic of overall health, mating motivations seemingly exaggerated women's perceptions of limbal rings' absence as less healthy compared with when such motives are not activated. Limbal ring absence is especially aversive when women are motivated by STM goals, a

result that aligns with previous findings suggesting that preferences for faces exhibited health cues may relate to an aversion to faces lacking such cues (Pound et al., 2014).

Activating STM motives appears to heighten women's sensitivity to limbal rings, resulting in motive-contingent evaluations of a target's health. That is, women demonstrated greater stratification in health ratings for targets with and without limbal rings upon activating such motives. Specifically, mate acquisition motives elicited perceptions of faces without limbal rings as less healthy compared with the control. When considering our meta-analysis, effects for male faces were more robust than for female, thus suggesting contrasts within men's eye have considerable influence in short-term mate selection. Motive activation could have led women to adhere to their minimal thresholds for what constitutes a short-term mate (e.g., Kenrick et al., 1993). For male faces, these motives would have made salient the emphasis on health and attractiveness cues requisite for optimum short-term mate acquisition that result in derogation of unattractive interaction partners (Li et al., 2013) and become a "dealbreaker" in STM (Jonason, Garcia, Webster, Li, & Fisher, 2015). Unattractiveness and poor health are two primary factors directing women to down-regulate interest in prospective short-term mates (Jonason et al., 2015). Women's derogation of the faces without limbal rings as less healthy could be a behavioral manifestation that would further restrict their interest in such targets in a short-term context.

Whereas women could have derogated male faces without limbal rings, women's ratings of female faces without limbal rings could have been their perception of such targets posing less of an intrasexual threat. That is, mating-motivated participants could have been communicating female faces without limbal rings as nonthreatening by rating them as less healthy, which would be consistent with previous research demonstrating sensitivity to fitness cues in same-sex targets among individuals with salient mating motives (Sacco et al., 2009).

Study 3

Although Study 2 provided evidence that STM motives elicit more favorable evaluations of faces connoting health versus those not, particularly in male faces, it ultimately does not tap the predicted desirability of limbal rings as a STM criterion. That is, these data do not directly demonstrate that limbal rings influence a STM desirability. Thus, Study 3 sought to reconcile this caveat by having women evaluate male faces on their desirability as either a long- or short-term mate based on their presence of limbal rings. Because limbal rings are perceived as a health cue and their presence appears to influence perceptions of women with activated STM goals, we predicted that women will perceive male faces with limbal rings as more desirable in a STM context, compared with those without limbal rings. Furthermore, because of the downregulated emphasis on good gene cues in long-term

partners (e.g., Kenrick et al., 1993; Li, Balley, Kenrick, & Linsenmeier, 2002), we predicted long-term mating (LTM) decisions would be unaffected by limbal ring presence.

Method

Participants. Ninety-four women from a public university in the southeastern United States participated in exchange for course credit in a single wave of data collection. A power analysis (Cohen's $f = 0.20$, $\beta = .95$) indicated that 84 would be sufficient to detect effects; we intentionally oversampled. Because we were interested in opposite-sex attraction, we excluded eight participants from the final analysis for not being within the 18- to 40-year age window or reporting opposite-sex attraction. This resulted in a final sample of $n = 86$ ($M_{\text{age}} = 20.40$ years, $SD = 4.32$; 68.6% White).

Materials

Context-dependent desirability. Participants indicated the extent to which they perceived each male target face as desirable in a LTM and STM context using a single-item measure on a 9-point Likert-type scale for both contexts (1 = *not at all desirable*; 5 = *average*; 9 = *very desirable*) with higher scores indicating greater desirability of the target for the given context. Participants evaluated faces on either dimension in succession with order of context counterbalanced on a between-participant basis. That is, half of the participants evaluated the faces as short-term mates first, whereas the other half evaluated them as short-term second. Much like the first two studies, there was no chance for participants to view the same two unique identities in direct succession. We aggregated the 10 desirability ratings for both versions of faces in either context.

Procedure. Following informed consent, participants evaluated the faces for their LTM and STM desirability in a self-paced fashion similar to the previous studies. This was followed by demographics and debriefing.

Results and Discussion

We conducted a 2 (limbal rings: present vs. absent) \times 2 (context: LTM vs. STM) repeated-measures ANOVA to determine the extent to which limbal rings influence desirability in either mating context. A significant main effect indicated that participants perceived faces with limbal rings ($M = 2.45$, $SE = 0.13$) significantly more desirable than targets without ($M = 2.40$; $SE = 0.13$), $F(1, 85) = 5.86$, $p = .018$, $\eta_p^2 = .064$. No main effect emerged for context, $F(1, 85) = 1.06$, $p = .305$, $\eta_p^2 = .012$. Effects were qualified by a significant Limbal Rings \times Context interaction, $F(1, 85) = 7.96$, $p = .006$, $\eta_p^2 = .086$ (see Figure 3). Simple effect tests revealed that faces with limbal rings ($M = 2.51$, $SE = 0.14$) were more desirable in STM than faces without ($M = 2.41$, $SE = 0.14$), $F(1, 85) = 11.03$, $p = .001$, $\eta_p^2 = .116$, 95% CI = [0.04, 0.16].

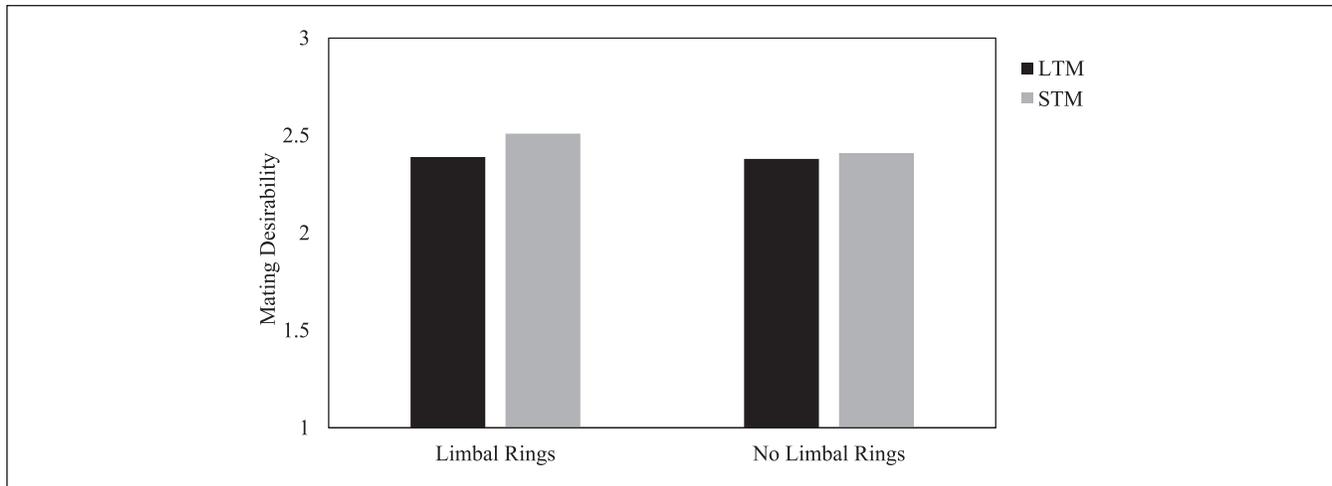


Figure 3. Targets' desirability as a long-term or short-term mate.

No difference emerged for faces with limbal rings ($M = 2.39$, $SE = 0.12$) and faces without ($M = 2.38$, $SE = 0.13$) in LTM, $F(1, 85) = 0.04$, $p = .840$, $\eta_p^2 = .000$, 95% CI = $[-0.04, 0.05]$. Given limbal rings' communicative properties to physical health in prospective mates, it would seem sensible that limbal rings would influence women's perceptions of short-term mates, whereas such perceptions would not be relevant for long-term mates.

Limbal rings appeared to influence women's perceptions of men's desirability in STM, such that limbal rings augmented the overall desirability of a target in a short-term context compared with those without rings. Given the emphasis women place on good genes for STM, these results seem sensible. In comparison, women's ratings of desirability did not differ when considering them for a long-term partnership; this is also sensible when considering that women downregulate their emphasis on mates' exhibition of fitness cues when considering them in long-term contexts. These results add to the literature of various facial features connoting health influence a prospective mate's overall desirability.

Despite the apparent limbal ring advantage in short-term contexts, this favorability for limbal rings was still ultimately well-below the midpoint on the scale. Compared with the first two studies, these faces were categorically not considered desirable. Because women incur greater reproductive costs from a single act of intercourse than do men, they are more judicious to select a mate who would help mitigate these costs (e.g., Haselton & Buss, 2000). Evaluations of targets in this study may have been a product of women's stringent criteria for a short-term sexual partner with those demonstrating any advantage in good genes, albeit slight, producing a preference (Kenrick et al., 1993). Nonetheless, our findings indicate that even when presented with faces not considered desirable in either context, limbal rings ultimately provided a buffer from absolute derogation in a short-term context, as participants were afforded the contrast that

provided an enhanced brightness for the sclera, thus a robust cue to that target's health.

General Discussion

Optimum mating is largely contingent upon individuals' ability to identify a prospective mate exhibiting traits communicating an ability to satisfy a partner's salient needs for a given context. In the context of STM, individuals seek to identify those exhibiting good genes above all other desirable traits (Li & Kenrick, 2006). In preferring mates with good genes, those with heightened STM interests better ensure that their offspring inherit health-promoting genes, thereby increasing the likelihood of their offspring surviving and themselves reproducing. Selecting a partner with good genes is based largely on identifying physical features that serve as veridical cues to health and fitness, including facial symmetry (Thornhill & Gangestad, 2006). The present research added limbal rings to the corpus of research examining various good gene cues and their influence in mate preferences.

These studies provide some context for the basis of previous findings that limbal rings augment facial attractiveness (e.g., Ilicic et al., 2016; Peshek et al., 2011). Specifically, this favorability appears at least partially due to the presence of limbal rings in heightening perceptions of a face as healthy. Given that limbal rings afford eyes the opportunity to have a contrast between the sclera and iris to make the sclera seem brighter, it seems sensible that limbal rings augment perceptions of a person as healthier. This seems especially likely when considering that limbal rings dissipate with chronic health issues (e.g., Ang et al., 2011) and that light-dark contrasts with the sclera provide an honest indicator of health (Russell et al., 2016). The attractiveness elicited by limbal rings appears to have contingency with the co-occurring health communicated by limbal rings (Study 1), thus implicating

limbal rings' communicative properties as dually enhancing a person as a more optimum short-term mate. Indeed, we contextualized limbal rings' favorability in STM by demonstrating the motive's ability to heighten sensitivity to fitness cues (Study 2) that may ultimately elicit comparably greater interest in such targets as a short-term mate (Study 3).

The possibility still exists for other facial features to provide a similar communicative function to health as limbal rings. For example, periodontal disease is a strong predictor of cardiovascular disease, which could suggest that the quality of one's teeth could communicate health and mate value (Holmlund, Holm, & Lind, 2006; Montoya, 2007). However, unlike limbal rings, the quality of one's teeth may also be significantly influenced by additional factors, such as hygiene; the presence of limbal rings may be more difficult to manipulate externally (see Ilicic et al., 2016). This could suggest limbal rings may provide an additional, novel cue to underlying cardiovascular health relative to other features connoting similar qualities.

Given the multitude of various facial features connoting health, limbal rings appear to offer a cue that is complementary, yet unique, to other features that contribute to an overall evaluation of one's quality as a short-term mate (Thornhill & Gangestad, 1999). For example, facial symmetry is a veridical cue to health but it is specifically associated with a reduced mutation load and resistance to communicable pathogens; this would suggest the health advantage communicated symmetry is associated more specifically with immunocompetence (Thornhill & Gangestad, 2006; Young, Sacco, & Hugenberg, 2011). Sex-typical facial features (i.e., masculine features in men and feminine features in women) communicate health by indicating to a perceiver that a prospective mate has been exposed to developmentally appropriate levels of sex hormones, thus connoting fertility (e.g., testosterone; Penton-Voak & Chen, 2004), and short-term mate value (Little, Jones, Penton-Voak, Burt, & Perrett, 2002; Sacco et al., 2009). Limbal rings' communicative properties appear more related to fitness as it pertains to chronic health, which would communicate novel information regarding conspecifics' heritable fitness. Limbal rings are particularly vibrant in eyes of individuals who have low levels of phospholipid accumulation, a risk factor associated with cardiovascular disease, a chronic health issue (Ang et al., 2011; Fernandez et al., 2009). Taken together, limbal rings provide a complementary aspect in developing criteria for an ideal mate for women.

These results also highlight a need to consider the role of eye contact in mate preferences and the implications of other veridical cues in forming attraction. Eye contact is instrumental when inferring a prospective mate's value. For example, women prefer direct eye gaze from men when assessing prospective mates' attractiveness in long-term domains (Conway, Jones, DeBruine, & Little, 2010) and find men with constricted eyelids more attractive in short-term contexts (Kruger & Piglowski, 2012), both of which may connote behavioral intentions consonant with the

respective desired mating strategies. Limbal rings may serve similar function in connoting mating quality with women's sensitivity to it having evolved to identify optimum short-term mates, consistent with evidence indicating that women's assessments of men's short-term mate value are guided by sensitivity to a variety of facial cues (Buss & Schmitt, 1993; Confer et al., 2010; Kenrick et al., 1993; Li & Kenrick, 2006).

Limitations and Future Directions

Although findings consistently implicate limbal rings as a veridical health cue, the generally small effect sizes require cautious interpretation. However, given the parameters of this research, our small effects could be seen as impressive in two ways (Prentice & Miller, 1992). First, although limbal rings provide a noticeable iris-sclera contrast, this contrast remains rather subtle; participants were likely not overtly aware of their presence, yet demonstrated sensitivity toward it. Second, in regard to Study 3, women indicated preferences for STM with minimal information about the targets, a rather difficult question to ask. In STM, women have stringent good gene criteria for prospective mates and typically underreport sexual interest (Kenrick et al., 1993; Perilloux & Kurzban, 2015), which could have truncated their perceptions of overall desirability for these targets. Furthermore, one should also consider the role of multiple factors influencing mate choices in either mating context (Jonason et al., 2012). Although limbal rings have utility in cuing STM quality, they remain a single cue among many others that indicate heritable fitness to prospective mates (e.g., facial masculinity, symmetry, muscularity). Nonetheless, the subtlety of limbal rings in their decisional influence makes them an impressive component of the superordinate ideal short-term mate gestalt.

Another major limitation of our study is that it was limited purely to self-reported evaluations of the targets. A more complete understanding of limbal rings' role in mate selection would involve investigations of specific behaviors. Considering women's sensitivity to limbal rings as a health cue, particularly when STM motives are salient, women may affix their gaze toward the eyes more readily when evaluating faces of prospective mates (e.g., Lu & Chang, 2012; Maner et al., 2007). Future studies would benefit from utilizing attentional paradigms to determine the extent to which participants attend to limbal rings and how women form health assessments and subsequent interest. Research would also benefit from investigating behavioral components of attraction. After evaluating a prospective mate's health, women should be willing to approach someone with limbal rings versus without (e.g., Montoya & Insko, 2008).

Future research would also benefit by considering the ovulatory cycle as a potential factor influencing women's sensitivity to limbal ring presence. Given that women at peak conception risk are particularly interested in good genes

from a prospective mate (e.g., Gangestad, Garver-Apgar, Simpson, & Cousins, 2007), it would seem sensible to predict that women would be especially attuned to the presence of limbal rings in male targets if they indeed connote health. The sensitivity to limbal rings (or lack thereof, based on Study 2) would aid in identifying optimum short-term mates, as women at peak conception risk are particularly interested in pluralistic mating and place heavy emphasis on good gene cues (e.g., Gildersleeve, Haselton, & Fales, 2014; Haselton & Gangestad, 2006). Specifically, ovulating women should be sensitive to limbal rings and demonstrate interest in men with them.

Although our results indicated women drove the effects of perceptions of limbal rings as a health cue, Peshek and colleagues (2011) found both men and women equally prefer faces with limbal rings over those without. This may suggest that men's basis for their preference could be rooted in their identification of another trait limbal rings communicate that is paramount to their mate selection (Confer et al., 2010; Jonason et al., 2012). Limbal rings are most vibrant in younger eyes (Peshek et al., 2011), which is also a trait that men prioritize in women, as youth is a reliable proxy for fertility (e.g., Buss & Schmitt, 1993; Kenrick et al., 1993). It is incumbent on future research to identify whether perceptions of youth may be the basis of limbal rings' desirability in female faces.

Conclusion

A common proverb suggests that the eyes are the gateway to the soul, meaning that humans are able to infer a considerable amount of information about an interaction partner by virtue of their eyes. This sentiment seems to have evolutionary roots, considering the acuity humans possess in recognizing the behavioral states and health of a person through specific features in the eyes to determine the social value of a conspecific or mate. The current research provided three studies showing how limbal rings can be utilized as a valuable and unique heuristic to infer someone's health and form the basis of mate selection.

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