No evidence that more physically attractive women have higher estradiol or progesterone

Benedict C Jones[1], Amanda C Hahn[2], Claire I Fisher[1], Hongyi Wang[1], Michal Kandrik[1], Chengyang Han[1], Anthony J Lee[1], Iris J Holzleitner[1], & Lisa M DeBruine[1]

1. Institute of Neuroscience & Psychology, University of Glasgow, UK.
2. Department of Psychology, Humboldt State University, USA.

Corresponding author
Benedict C Jones (ben.jones@glasgow.ac.uk), Institute of Neuroscience & Psychology, University of Glasgow, UK.

This research was supported by ERC grants awarded to BCJ (OCMATE) and LMD (KINSHIP)

Data files and analysis scripts are publicly available at osf.io/qd9bv

No evidence that more physically attractive women have higher estradiol or progesterone

Abstract

Putative associations between sex hormones and attractive physical characteristics in women are central to many theories of human physical attractiveness and mate choice. Although such theories have become very influential, evidence that physically attractive and unattractive women have different hormonal profiles is equivocal. Consequently, we investigated hypothesized relationships between salivary estradiol and progesterone and two aspects of women's physical attractiveness that are commonly assumed to be correlated with levels of these hormones: facial attractiveness (N=249) and waist-to-hip ratio (N=247). Our analyses revealed no evidence that women with more attractive faces or lower (i.e., more attractive) waist-to-hip ratios had higher levels of estradiol or progesterone. These results do not support the influential hypothesis that between-woman differences in physical attractiveness are related to estradiol and/or progesterone.

Introduction

Many researchers have hypothesized that human attractiveness judgments are psychological adaptations for identifying high-quality mates (Grammer et al., 2003; Little et al., 2011; Thornhill & Gangestad, 1999). Researchers have also hypothesized that fertility, as indexed by high levels of estradiol and/or progesterone, is a particularly important aspect of women's mate quality (Grammer et al., 2003; Little et al., 2011; Thornhill & Gangestad, 1999). Although this proposal has become very influential in the human attractiveness and mate choice literatures, evidence that more physically attractive women have higher estradiol or progesterone is equivocal (Grillot et al., 2014; Jasienska et al., 2004; Law Smith et al., 2006; Puts et al., 2013).

Two studies have investigated putative relationships between women's facial attractiveness and hormone levels. Law Smith et al. (2006) reported a significant positive correlation between ratings of women's facial

attractiveness and estradiol. They also reported a positive correlation between facial attractiveness and progesterone, although this relationship was not significant. By contrast with Law Smith et al's results, Puts et al. (2013) found no evidence that women with higher levels of either estradiol or progesterone possessed more attractive faces. To date, evidence that more facially attractive women have higher estradiol or progesterone is therefore inconclusive.

Other studies have tested for evidence that women's physical attractiveness is positively correlated with estradiol or progesterone by investigating the hormonal correlates of women's waist-to-hip ratio. Jasienska et al. (2004) reported that women with lower (i.e., more attractive) waist-to-hip ratios had higher estradiol and higher progesterone. However, Grillot et al. (2014) found no evidence for these relationships. To date, evidence that waist-to-hip ratio is associated with sex hormones is therefore also inconclusive.

Given the importance of associations between hormone levels and attractiveness for theories of women’s attractiveness and mate choice, we tested for the hypothesized correlations between salivary estradiol and progesterone and both women's facial attractiveness and waist-to-hip ratio. To date, our sample is the largest to be used to investigate these hypothesized relationships.

Methods

Participants

We recruited 249 young adult white women for the study (mean age=21.5 years, SD=3.30 years). All participants were students at the University of Glasgow and each completed five weekly test sessions. Participants were recruited only if they were not currently using any hormonal supplements (e.g., oral contraceptives), had not used any form of hormonal supplements in the 90 days prior to their participation, and had never used sunbeds or tanning products. None of the participants reported being pregnant, having been pregnant recently, or breastfeeding. Women participated as part of a

larger study on hormonal correlates of women's behavior (Jones et al., 2017a, 2017b, 2017c).

Face photography and ratings

In each of the five test sessions, each participant first cleaned her face with hypoallergenic face wipes to remove any makeup. Makeup was removed because Law Smith et al. (2006) reported that estradiol and progesterone predicted facial attractiveness in a sample of women not wearing makeup, but not in a sample of women wearing makeup. A full-face digital photograph was taken a minimum of 10 minutes later. Photographs were taken in a small windowless room against a constant background, under standardized diffuse lighting conditions, and participants were instructed to pose with a neutral expression. Camera-to-head distance and camera settings were held constant. Participants wore a white smock covering their clothing when photographed to control for possible effects of reflectance from clothing. Photographs were taken using a Nikon D300S digital camera and a GretagMacbeth 24-square ColorChecker chart was included in each image for use in color calibration.

Following Jones et al. (2015), face images were color calibrated using a least-squares transform from an 11-expression polynomial expansion developed to standardize color information across images (Hong et al., 2001). Each image was standardized on pupil positions and masked so that hairstyle and clothing were not visible. The 1245 face images (five images for each of the 249 women) were then rated for attractiveness using a 1 (much less attractive than average) to 7 (much more attractive than average) scale by 14 men and 14 women. Trial order was fully randomized. The screen was calibrated using an xRite i1 Display Pro colorimeter prior to testing.

Hormone assays

Participants provided a saliva sample via passive drool (Papacosta & Nassis, 2011) in each test session. Participants were instructed to avoid consuming alcohol and coffee in the 12 hours prior to participation and avoid eating, smoking, drinking, chewing gum, or brushing their teeth in the 60 minutes

prior to participation. Saliva samples were frozen immediately and stored at -32°C until being shipped, on dry ice, to the Salimetrics Lab (Suffolk, UK) for analysis, where they were assayed using the Salivary 17β-Estradiol Enzyme Immunoassay Kit 1-3702 (M=3.42 pg/mL, SD=1.33 pg/mL) and Salivary Progesterone Enzyme Immunoassay Kit 1-1502 (M=143.90 pg/mL, SD=93.33 pg/mL). Hormone levels more than three standard deviations from the sample mean for that hormone or where Salimetrics indicated levels were outside the assay sensitivity range were excluded from the dataset (~1.5% of hormone measures were excluded). Intraclass correlation coefficients were .46 for estradiol and .58 for progesterone.

Body measures

In one of the five test sessions, waist and hip circumference were measured from 247 of the women. Two women chose not to be measured. Waist and hip circumferences were used to calculate waist-to-hip ratio (M=0.75, SD=0.05).

Results

A linear mixed model was used to investigate the relationship between facial attractiveness and hormone levels. Analyses were conducted using R version 3.3.2 (R Core Team, 2016), with lme4 version 1.1-13 (Bates et al., 2014) and lmerTest version 2.0-33 (Kuznetsova et al., 2013). To create mean (i.e., trait) hormone values for our analyses, hormone levels were averaged across test sessions for each woman, centered on the grand mean, and scaled so the majority of the distribution for each hormone varied from -.5 to .5 (this was done simply to facilitate calculations in the linear mixed models). To create current (i.e., state) hormone values for our analyses, values for each hormone were centered on their subject-specific means and scaled using the same scaling constants as above. The linear mixed model predicted face image ratings with current (i.e., state) estradiol, current (i.e., state) progesterone, rater sex (effected coded so that +0.5 was male and -0.5 was female), and their interactions entered as predictors. Mean (i.e., trait) estradiol, mean (i.e., trait) progesterone, rater sex, and their interactions were also entered as predictors. Interactions between estradiol and progesterone were included

following Puts et al. (2013). Random intercepts were specified for rater, stimulus woman (i.e., each woman whose face images were used as stimuli), and individual face image. Random slopes were specified maximally, following Barr et al. (2013) and Barr (2013). The model is fully described in our supplemental materials (see osf.io/qd9bv). Data are also available at osf.io/qd9bv. Full results are shown in Table 1.

Table 1. Results of linear mixed model testing for within-woman and between-women hormone-attractiveness correlations.

	beta	SE	t	p
current estradiol	-0.01	0.05	-0.23	.82
current progesterone	-0.07	0.04	-1.66	.10
rater sex	-0.70	0.26	-2.73	.01
mean estradiol	-0.15	0.21	-0.73	.47
mean progesterone	-0.06	0.29	-0.21	.83
current estradiol x current progesterone	-0.54	0.24	-2.20	.03
current estradiol x rater sex	0.02	0.08	0.23	.82
current progesterone x rater sex	-0.02	0.07	-0.36	.72
mean estradiol x mean progesterone	0.69	1.22	0.56	.57
mean estradiol x rater sex	-0.00	0.05	-0.01	.99
mean progesterone x rater sex	-0.09	0.08	-1.17	.24
current estradiol x current progesterone x rater sex	0.42	0.44	0.94	.36
mean estradiol x mean progesterone x rater sex	0.23	0.45	0.52	.61

No between-women hormone-attractiveness correlations were significant. However, there was a significant interaction between the effects of current estradiol and current progesterone (beta=-0.54, SE=0.24, t=-2.20, p=.030). This interaction indicated that within-woman attractiveness was particularly high both when current estradiol was high and current progesterone was simultaneously low and when current estradiol was low and current progesterone was simultaneously high (see Figure 1).

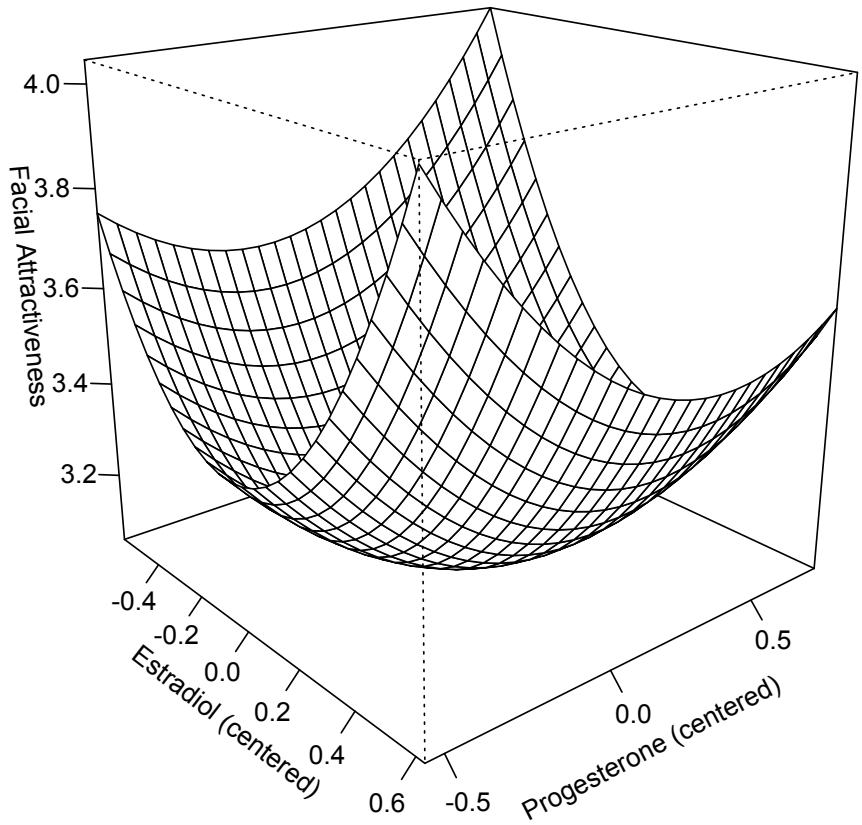

Figure 1. The interaction between current estradiol and current progesterone. Created using the RSM package (Lenth, 2009) in R.

Since we had only one waist-to-hip ratio measure for each woman, we simply tested for significant correlations between waist-to-hip ratio and both mean estradiol and mean progesterone. There was a significant positive correlation between waist-to-hip ratio and mean estradiol ($r=.23$, $N=247$, $p<.001$). The correlation between waist-to-hip ratio and mean progesterone was not significant ($r=-.07$, $N=247$, $p=.24$).

Discussion

Here we investigated possible relationships between salivary estradiol and progesterone and both women's facial attractiveness and waist-to-hip ratio. We carried out these analyses to test the influential hypothesis that more

physically attractive women have higher estradiol and progesterone (Jasienak et al., 2005; Law Smith et al., 2006). We found no evidence that women with higher facial attractiveness or lower (i.e., more attractive) waist-to-hip ratios had higher levels of estradiol or progesterone. In fact, we actually found that women with higher (i.e., relatively unattractive) waist-to-hip ratios had higher levels of estradiol. Thus, our results do not replicate those of previous studies with much smaller sample sizes reporting significant correlations between hormone levels and either facial attractiveness (Law Smith et al., 2006) or waist-to-hip ratio (Jasienska et al., 2004). Our results do not support the influential hypothesis that between-woman differences in physical attractiveness are correlated with estradiol and/or progesterone.

We observed no evidence that more attractive women had higher estradiol or progesterone levels. However, our analysis of facial attractiveness ratings suggested that within-woman changes in facial attractiveness were associated with within-woman changes in hormone levels. Women's facial attractiveness subtly increased both when current estradiol was high and current progesterone was simultaneously low and when current estradiol was low and current progesterone was simultaneously high. This result partially replicates Puts et al. (2013), who found that attractiveness was increased when current estradiol was high and current progesterone was simultaneously low. The combination of high estradiol and low progesterone is characteristic of the fertile phase of the menstrual cycle (Gangestad & Haselton, 2015). Consequently, Puts et al. (2013) proposed that the increased attractiveness that they observed when women were in this hormonal state supported the hypothesis that women's attractiveness subtly increases during the fertile phase of the menstrual cycle. However, Puts et al. (2013) compared attractiveness during the late follicular and mid-luteal phases of the menstrual cycle only. Because the mid-luteal phase of the menstrual cycle is characterized by relatively high levels of both progesterone and estradiol, Puts et al. (2013) are unlikely to have sampled women when estradiol was low and progesterone was simultaneously high. By contrast, we sampled women at weekly intervals over an entire menstrual cycle, allowing us to capture a greater range of hormonal states. Importantly, our results showing

that attractiveness increased both when current estradiol was high and current progesterone was simultaneously low and when current progesterone was high and current estradiol was simultaneously low suggest that hormone-linked increases in facial attractiveness are not necessarily unique to hormonal states associated with high fertility. Thus, our results for within-woman attractiveness-hormone correlations do not appear to support the hypothesis that hormone-linked within-woman changes in attractiveness are fertility signals.

Havlicek et al. (2015) posited that within-woman attractiveness-hormone correlations might simply be functionless byproducts of between-woman attractiveness-hormone correlations. That we observed significant within-woman, but not between-woman, attractiveness-hormone correlations for facial attractiveness does not support Havlicek et al's (2015) hypothesis.

In conclusion, our analyses provide no evidence that women with more attractive faces or waist-to-hip ratios have higher estradiol or progesterone. Importantly, these null results do not support the popular and influential hypothesis that women's physical attractiveness is a correlate of their estradiol and/or progesterone.

References

Barr, D. J. (2013). Random effects structure for testing interactions in linear mixed-effects models. *Frontiers in Psychology*, 4, 328.

Barr, D. J., Levy, R., Scheepers, C., & Tily, H. J. (2013). Random effects structure for confirmatory hypothesis testing: Keep it maximal. *Journal of Memory and Language*, 68, 255-278.

Bates, D., Mächler, M., Bolker, B., & Walker, S. (2014). Fitting linear mixed-effects models using lme4. *Journal of Statistical Software*, 67, 1-48.

Gangestad, S. W., & Haselton, M. G. (2015). Human estrus: implications for relationship science. *Current Opinion in Psychology*, 1, 45-51.

Grammer, K., Fink, B., Møller, A. P., & Thornhill, R. (2003). Darwinian aesthetics: Sexual selection and the biology of beauty. *Biological Reviews, 78,* 385 – 407.

Grillot, R. L., Simmons, Z. L., Lukaszewski, A. W., & Roney, J. R. (2014). Hormonal and morphological predictors of women's body attractiveness. *Evolution and Human Behavior*, 35, 176-183.

Havlicek, J., Cobey, K. D., Barrett, L., Klapilová, K., & Roberts, S. C. (2015). The spandrels of Santa Barbara? A new perspective on the peri-ovulation paradigm. *Behavioral Ecology*, 26, 1249-1260.

Hong, G., Luo, M. R., & Rhodes, P. A. (2001). A study of digital camera colorimetric characterisation based on polynomial modelling. *Color Research and Application*, 26, 76-84.

Jasienska G., Ziomkiewicz A., Ellison P. T., Lipson S. F., & Thune I. (2004). Large breast and narrow waist indicate high reproductive potential in women. *Proceedings of the Royal Society of London B: Biological Sciences.* 271, 1213–1217.

Jones, B. C., Hahn, A. C., Fisher, C. I., Wincenciak, J., Kandrik, M., Roberts, S. C., ... & DeBruine, L. M. (2015). Facial coloration tracks changes in women's estradiol. *Psychoneuroendocrinology*, 56, 29-34.

Jones, B. C., Hahn, A. C., Fisher, C. I., Wang, H., Kandrik, M., Han, C., … DeBruine, L. M. (2017a). Women's preferences for facial masculinity are not related to their hormonal status. *bioRxiv*. doi.org/10.1101/136549.

Jones, B. C., Hahn, A. C., Fisher, C. I., Wang, H., Kandrik, M., & DeBruine, L. M. (2017b). General sexual desire, but not desire for uncommitted sexual relationships, tracks changes in women's hormonal status. *bioRxiv*. doi.org/10.1101/155788.

Jones, B. C., Hahn, A. C., Fisher, C. I., Wang, H., Kandrik, M., Tybur, J. M., & DeBruine, L. M. (2017c). Hormonal correlates of pathogen disgust: Testing the Compensatory Prophylaxis Hypothesis. *bioRxiv*. doi.org/10.1101/156430.

Kuznetsova, A., Bruun Brockhoff, P., Haubo Bojesen Christensen, R. (2013). lmerTest: Tests for random and fixed effects for linear mixed effect models (lmer objects of lme4 package). R package version 2.0-3. http://CRAN.R-project.org/package=lmerTest.

Law Smith, M. J., Perrett, D. I., Jones, B. C., Cornwell, R. E., Moore, F. R., Feinberg, D. R., ... & Pitman, R. M. (2006). Facial appearance is a cue

to oestrogen levels in women. *Proceedings of the Royal Society of London B: Biological Sciences*, 273, 135-140.

Lenth, R. V. (2009). Response-surface methods in R, using RSM. *Journal of Statistical Software*, 32, 1 – 17.

Little, A. C., Jones, B. C., & DeBruine, L. M. (2011). Facial attractiveness: Evolutionary based research. *Philosophical Transactions of the Royal Society B, 366,* 1638 – 1659.

Papacosta, E., & Nassis, G. P. (2011). Saliva as a tool for monitoring steroid, peptide and immune markers in sport and exercise science. *Journal of Science and Medicine in Sport*, 14, 424-434.

Puts, D. A., Bailey, D. H., Cárdenas, R. A., Burriss, R. P., Welling, L. L., Wheatley, J. R., & Dawood, K. (2013). Women's attractiveness changes with estradiol and progesterone across the ovulatory cycle. *Hormones and Behavior*, 63, 13-19.

R Core Team (2016). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.

Thornhill, R. & Gangestad, S. W. (1999). Facial Attractiveness. *Trends in Cognitive Sciences, 3,* 452 – 460