# Within-woman hormone-attractiveness correlations are not simply byproducts of between-women hormone-attractiveness correlations

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**Abstract**

Havlicek et al. (Behavioral Ecology, 26, 1249-1260, 2015) proposed that increased attractiveness of women in hormonal states associated with high fertility is a byproduct (or “perceptual spandrel”) of adaptations related to between-women differences in sex hormones. A critical piece of their argument was the claim that between-women hormone-attractiveness correlations are stronger than corresponding within-woman correlations. We directly tested this claim by collecting multiple face images and saliva samples from 249 women. Within-woman facial attractiveness was highest when current estradiol was high and current progesterone was simultaneously low, as is the case during the high-fertility phase of the menstrual cycle. By contrast, between-women hormone-attractiveness correlations were not significant. Our results do not support Havlicek et al’s “perceptual spandrels” hypothesis of hormone-linked attractiveness in women. Rather, they present new evidence that women’s attractiveness subtly changes with fluctuations in sex hormones.

**Introduction**

How biological factors influence women's attractiveness has received a great deal of empirical scrutiny (reviewed in Haselton & Gildersleeve, 2016). Recently, Havlicek et al. (2015) proposed that increased attractiveness of women in hormonal states associated with high fertility (reviewed in Haselton & Gildersleeve, 2016) is simply a byproduct (or "perceptual spandrel") of adaptations related to between-women differences in sex hormones. This controversial proposal (see replies by Gangestad & Grebe, 2015; Haselton, 2015; Roney et al., 2015) was largely based on their claim that between-women hormone-attractiveness correlations (e.g., Jasienska et al., 2004; Law Smith et al., 2006) are stronger than within-woman hormone-attractiveness correlations.

Contemporaneous findings undermine Havlicek et al's claim, however. For example, Grillot et al. (2014) did not replicate Jasienska et al's (2004) finding of a between-women negative correlation between estradiol and waist-to-hip ratio (the latter being inversely related to women's body attractiveness). Similarly, Puts et al. (2013) did not replicate Law Smith et al's (2006) finding of a between-women positive correlation between estradiol and facial attractiveness.

In light of the above, we directly tested Havlicek et al's claim that between-women hormone-attractiveness correlations are stronger than within-woman hormone-attractiveness correlations in a study of 249 women's facial attractiveness. Each woman was photographed and provided saliva samples on five occasions, allowing us to test both between-women and within-woman hormone-attractiveness correlations.

Havlicek et al's "perceptual spandrels" hypothesis would be supported if between-women hormone-attractiveness correlations were stronger than (and in the same direction as) the corresponding within-woman correlations. However, if within-woman hormone-attractiveness correlations were stronger than (or in the opposite direction to) the corresponding between-women correlations, this would directly contradict Havlicek et al's hypothesis that

within-woman hormone-attractiveness correlations are byproducts of between-women hormone-attractiveness correlations.

## 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.

### *Face photography and ratings*

In each of the five test sessions, each participant first cleaned her face with hypoallergenic face wipes to remove any make up. 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.

***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).

To isolate effects of within-woman changes in hormones, values for each hormone were centered on their subject-specific means. They were then scaled so the majority of the distribution for each hormone varied from -.5 to .5 to facilitate calculations in the linear mixed models. These current (i.e., state) levels were used in our analyses to test for within-woman hormone-attractiveness correlations. To isolate effects of between-women differences in hormones, hormone levels were averaged across test sessions for each woman. They were then centered on the grand mean and scaled using the same scaling constants as above. These mean (i.e., trait) levels were used in our analyses to test for between-women hormone-attractiveness correlations.

**Results**

A linear mixed model was used to test for possible effects of estradiol and progesterone on women's attractiveness. 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). 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 |

The significant interaction between the effects of current estradiol and current progesterone (beta=-0.54, SE=0.24, t=-2.20, p=.030) indicated that within-woman attractiveness was highest when current estradiol was high and current progesterone was simultaneously low (see Figure 1). By contrast, no between-women hormone-attractiveness correlations were significant. Running separate models to test for within-woman and between-woman

hormone-attractiveness correlations showed the same pattern of results as this main analysis (see our supplemental materials, osf.io/qd9bv).

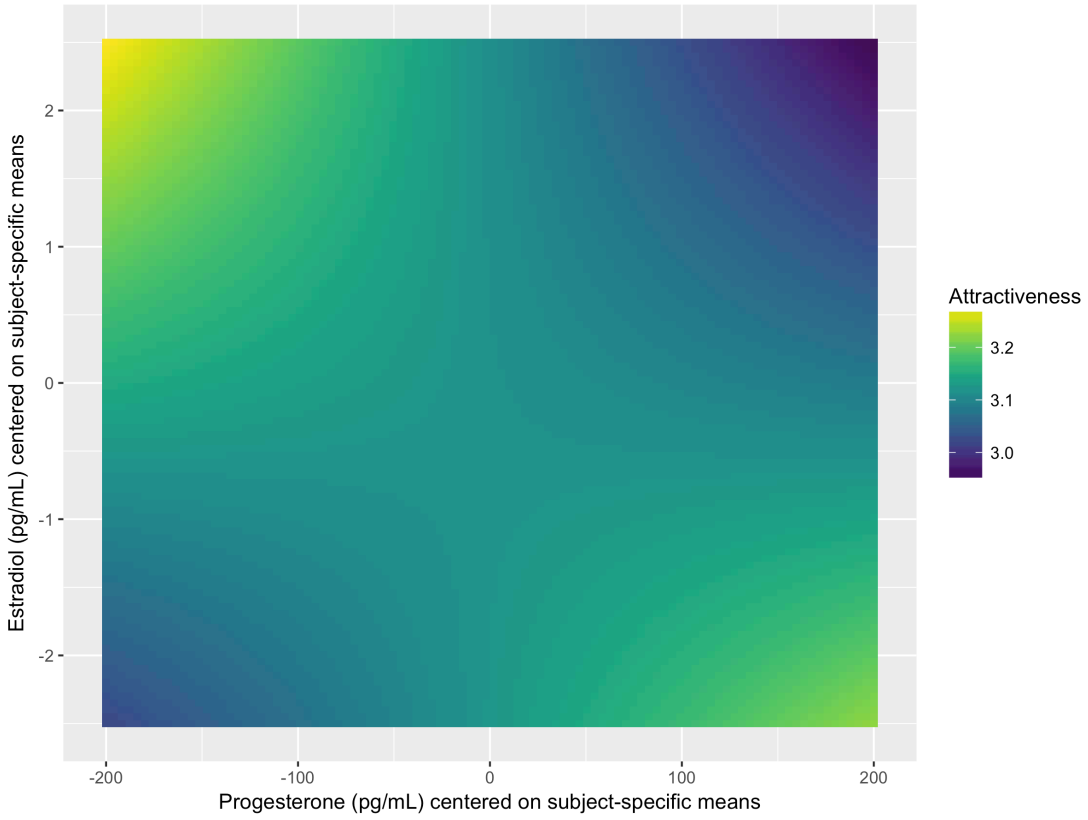


**Figure 1.** Heat map showing predicted attractiveness values from our model, illustrating the significant interaction between current progesterone and current estradiol. Mean progesterone, mean estradiol, and rater sex are held constant.

Note that the interaction between mean estradiol and mean progesterone, although not significant, was in the opposite direction to the significant interaction between current estradiol and current progesterone. Also note that the non-significant main effects of mean estradiol and mean progesterone are in the opposite directions to those proposed by Havlieck et al. (2015). Together, these results suggest that our results were not simply due to our study having greater power to detect within-woman hormone-attractiveness correlations than between-women hormone-attractiveness correlations.

## Discussion

Havlicek et al. (2015) proposed that increased attractiveness of women in

hormonal states associated with high fertility (reviewed in Haselton & Gildersleeve, 2016 and Puts et al., 2013) is simply a byproduct (or "perceptual spandrel") of adaptations related to between-women differences in sex hormones. A critical piece of their argument was the claim that between-women hormone-attractiveness correlations are stronger than corresponding within-woman correlations. Our results directly contradict this claim. We observed a significant within-woman hormone-attractiveness correlation. By contrast, no between-women hormone-attractiveness correlations were significant[1]. Moreover, the interaction between mean estradiol and mean progesterone, although not significant, was in the *opposite* direction to the significant interaction between current estradiol and current progesterone. This would not be expected if within-woman hormone-attractiveness correlations were simply a byproduct of adaptations related to between-women differences in ovarian hormones.

The significant interaction between current estradiol and current progesterone in our study indicated that within-woman attractiveness was highest when current estradiol was high and current progesterone was simultaneously low (see also Puts et al., 2013). In women not using hormonal contraceptives, this particular hormonal state (co-occurrence of high estradiol and low progesterone) is unique to the late follicular (i.e., high-fertility) phase of the menstrual cycle (Gangestad & Haselton, 2015; Puts et al., 2013). Thus, our results complement studies suggesting women's attractiveness increases during the late follicular phase of the menstrual cycle (reviewed in Haselton & Gildersleeve, 2016). Although our data present new evidence that women's facial attractiveness subtly changes with fluctuations in sex hormones, whether these changes influence others' behavior and whether they are currently functional, or simply vestigial, are questions requiring further study.

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[1] We also did not replicate the between-women negative correlation between estradiol and waist-to-hip ratio reported by Jasienska et al. (2004). See Supplemental Materials (osf.io/qd9bv).

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