Hormones and Behavior 90 (2017) 129–135

Contents lists available at ScienceDirect

Hormones and Behavior

journal homepage: www.elsevier.com/locate/yhbeh

No compelling positive association between ovarian hormones and wearing red clothing when using multinomial analyses

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ARTICLE INFO

Article history:
Received 11 March 2016
Revised 7 March 2017
Accepted 13 March 2017
Available online xxxx

Keywords:
Ovulation
Red clothing
Sexual proceptivity
Fertility
Ovarian hormones

ABSTRACT

Several studies report that wearing red clothing enhances women's attractiveness and signals sexual proceptivity to men. The associated hypothesis that women will choose to wear red clothing when fertility is highest, however, has received mixed support from empirical studies. One possible cause of these mixed findings may be methodological. The current study aimed to replicate recent findings suggesting a positive association between hormonal profiles associated with high fertility (high estradiol to progesterone ratios) and the likelihood of wearing red. We compared the effect of the estradiol to progesterone ratio on the probability of wearing: red versus non-red (binary logistic regression); red versus neutral, black, blue, green, orange, multi-color, and gray (multinomial logistic regression); and each of these same colors in separate binary models (e.g., green versus non-green). Red versus non-red analyses showed a positive trend between a high estradiol to progesterone ratio and wearing red, but the effect only arose for younger women and was not robust across samples. We found no compelling evidence for ovarian hormones increasing the probability of wearing red in the other analyses. However, we did find that the probability of wearing neutral was positively associated with the estradiol to progesterone ratio, though the effect did not reach conventional levels of statistical significance. Findings suggest that although ovarian hormones may affect younger women's preference for red clothing under some conditions, the effect is not robust when differentiating amongst other colors of clothing. In addition, the effect of ovarian hormones on clothing color preference may not be specific to the color red.

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1. Introduction

Females of many anthropoid primate species undergo marked external morphological changes prior to ovulation (Dixson, 2012). Many of these changes are estrogen dependent and attract sexual solicitations from males (Dixson, 2012). In contrast, women do not display such overt signals of ovulation, which has led to considerable debate surrounding a putative loss of estrus in modern humans (Havlíček, Cobey, Barrett, Klapilova, & Roberts, 2015). Some scholars have suggested that women "lost" estrus, either before or after the evolutionary divergence between humans and nonhuman primates (Dixson, 2012; Symons, 1979). Other researchers have argued that women do experience estrus, but that selective pressures have concealed the expression of estrus-related cues (Gangestad and Thornhill, 2008; Thornhill and Gangestad, 2008).

Although fertility does not dramatically shift female morphology, fertile women's morphology and physical appearance do change in ways that subtly increase their attractiveness to men. When fertile, women have more attractive voices (Fischer et al., 2011; Pipitone and Gallup, 2008), faces (Oberzaucher et al., 2012; Puts et al., 2013; Roberts et al., 2004), odors (Havlíček et al., 2006; Singh and Bronstad, 2001), and bodies (Kirchengast and Gartner, 2002; Manning et al., 1996). Some of these effects are driven by reproductive hormones. Changes in the attractiveness of women's facial shape and vocal pitch, for example, are positively associated with estradiol and negatively with progesterone (Puts et al., 2013). Reproductive hormones and higher potential fertility are also associated with feminine facial features (Smith et al., 2006, 2012), gynoid fat distribution, and enlarged breasts (Jasienska et al., 2004, but c.f. Grillot et al., 2014). All of these characteristics typically enhance female attractiveness (Dixson et al., 2011, 2015; Marcinkowska et al., 2014; Singh et al., 2010), suggesting a positive association between fluctuating reproductive hormones and attractiveness in women.

Women's decisions to culturally ornament their appearance also increases during periods of higher fertility and may support mate

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http://dx.doi.org/10.1016/j.yhbeh.2017.03.005
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attraction goals. When presented with full length photographs of women at high and low fertility, raters who were naive to fertility status rated the photographed women's clothing as more attractive when the women were fertile (Haselton et al., 2007; Durante et al., 2008). Fertile compared to non-fertile women were also judged by others as trying to look more attractive (Haselton et al., 2007) and demonstrated a stronger preference for wearing sexier, revealing clothing when imagining attending a large party (Durante et al., 2008). These studies suggest that fertility may augment women's likelihood of using cultural ornamentation to communicate sexual proceptivity and enhance attractiveness to potential mates (Haselton and Gildersleeve, 2016).

Wearing clothing of a certain color may also be integrated into courtship behaviors used by women to attract mates. Several studies report that wearing the color red increases women's attractiveness to men (Elliot and Niesta, 2008; Elliot et al., 2013; Guéguen, 2012; Young, 2015) and is preferred by women in courtship situations (Elliot et al., 2013; Prokop and Hromada, 2013). Some studies further report that wearing red increases alongside women's likelihood of conception throughout the menstrual cycle (Beall and Tracy, 2013; Tracy and Beall, 2014; but c.f. Prokop and Hromada, 2013). In contrast, men's red clothing enhances perceptions of their aggressiveness (Wiedemann et al., 2015) and is perceived as giving them an advantage in intra-sexual competition (Hill and Barton, 2005). Thus, using red to enhance attractiveness appears specific to women and may increase alongside periods of high fertility.

Despite some convergence across different studies, the hormonal mechanisms underpinning women's choice to wear red clothing have received little attention. A recent exception was a methodologically strong study by Eisenbruch et al. (2015). This study demonstrated that the probability of wearing red versus non-red clothing increased when women were fertile and was mediated by fluctuations in the ratio of estradiol to progesterone (hereafter referred to as the E:P ratio). A high E:P ratio characterizes the fertile phase of the menstrual cycle (Lipson and Ellison, 1996). By employing a within-subject design and collecting measures of estradiol and progesterone, Eisenbruch et al. rectified many of the limitations of past research and bypassed potential inaccuracies associated with less reliable fertility estimation methods (i.e., counting methods; see Blake et al., 2016).

In the current study, we sought to replicate findings from Eisenbruch et al. (2015) in a sample of ethnically diverse, naturally cycling women ranging from 18 to 36 years. Although the method in Eisenbruch et al. was strong, their sample was limited to women aged 18–22 years. Replication in a sample of varying ages is warranted because red may increase attractiveness only for younger women (Schwarz and Singer, 2013). If red is truly a universal cue of human ovulation (Beall and Tracy, 2013), then the effect of the E:P ratio on wearing red should be evident in women older than 22 years, but may also be moderated by age. We investigated this hypothesis using one within- and one between-subjects dataset containing photographs of women and hormone assays. We hypothesized that if red clothing is a cue of human ovulation, women should be more likely to wear red clothing when their E:P ratios are high.

Our second aim was to extend past work by investigating the association between the E:P ratio and red clothing when differentiating amongst all colors worn in the sample. All known past research examining red clothing preferences has investigated the probability of wearing red versus non-red by grouping all non-red colors together (i.e. 0 = non-red, 1 = red; Eisenbruch et al., 2015; Beall and Tracy, 2013; Prokop and Hromada, 2013; Tracy and Beall, 2014) or by comparing red to one color in each analysis (e.g., 0 = green, 1 = red; Elliot et al., 2013). To the best of our knowledge, no research has investigated associations between fertility and red clothing preferences using multinomial techniques. Testing the hypothesis that women choose to wear one color when E:P ratios are high should ideally include an investigation of all possible color choices as well. In the current study, we undertook this approach. Using multinomial analyses and binary analyses with different colors as the reference category, we determined the strength and uniqueness of the preference for wearing red when considering all colors worn by participants.

2. Methods

2.1. Participants and design

2.1.1. Ethics statement and data collection

This study was carried out in accordance with the Declaration of Helsinki and the UNSW Ethics Committee approved the protocol. Participants were recruited in two waves. After providing written informed consent, all participants were informed that they were contributing to a study investigating reproductive biology and self-concept (Wave 1) or steroid hormones and face shape (Wave 2). Wave 1 data were collected from August 2014 to May 2015 and were part of a larger two-part study investigating hormones and women's behavior (see Blake, Bastian, O'Dean, & Denson, 2017). Wave 2 data were collected from October 2015 to February 2016 and were part of a larger study on hormones and face morphology. Data are publicly available at osf.io/u7pmz.

2.1.2. Participants

All participants were women. Inclusion criteria for participating in either wave of the study were the absence of hormonal birth control usage (current or within the past two months; e.g., birth control pills, Norplant, vaginal ring, birth control patch, Depo-Provera, Mirena IUD); no pregnancy/breastfeeding (current or recent); no immune, cardiovascular, metabolic, or kidney disorders; no anabolic steroid use; no cancer/tumors; no recreational drug use within the past 30 days; and no smoking or alcohol use within the past 12 h. Participants refrained from consuming caffeine or eating/drinking anything except water within 1 h of their session. Eighty-two women participated in each wave of the study (Wave 1 M_{age} = 22.22, SD = 4.61, range 18–36 years; Wave 2 M_{age} = 21.80, SD = 3.91, range 18–37 years; total N = 164). Seventy percent (69.5%) of participants were Asian and 22.6% were Caucasian; the remainder were Middle Eastern (2.4%) or other ethnicities (5.5%). Wave 1 sample size was determined via a power analysis for the larger study, which required 60 participants for adequate statistical power. Because Wave 2 data were included to replicate initial findings from Wave 1, Wave 2 data collection ceased when the sample size matched the sample size in Wave 1.

Wave 1 participants were scheduled to attend two laboratory sessions: one when fertile and one when non-fertile. We used luteinizing hormone tests to approximate fertility and followed the standardized protocol for characterizing women's fertility outlined by Blake et al. (2016). We analyzed all data collected, although 19 women from Wave 1 attended only one session, leaving 81 non-fertile and 62 fertile observations in Wave 1. Wave 1 participants confirmed that their menstrual cycles were about the same length each month. Because Wave 2 participants attended one session only at any point during their menstrual cycle, we asked them to report their last cycle onset but did not ask them about cycle regularity. Five women (6.1%) who reported cycles starting >35 days prior to their laboratory day (range = 40–59 days) were excluded from further analysis for having long and potentially irregular cycles (final N = 159; Wave 1 n = 82, 143 sessions; Wave 2 n = 77, 77 sessions).

2.1.2.1. Menstrual cycle characteristics for Wave 1. Twenty-four percent (24.4%) of non-fertile sessions occurred in the early follicular phase (mean cycle day = 4.80, SD = 2.80, range = 1–10) and 71.6% occurred in the late luteal phase (mean cycle day = 26.15, SD = 3.47, range = 19–38). Four percent (3.7%) of non-fertile sessions were in the early luteal phase (mean cycle day = 16.33, SD = 0.58, range = 16–17). Roughly half of participants completed both fertile and non-fertile sessions (57.4%) in the same menstrual cycle, the remainder attended

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