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Reported jealousy differs as a function of menstrual cycle stage and contraceptive pill use: a within-subjects investigation

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Abstract

Previous research suggests that female jealousy is sensitive to hormonal variation and, more specifically, potentially moderated by estrogen levels. Here, we tracked self-reported jealousy using a within-subjects design, comparing jealousy when the same women were regularly cycling and using hormonal contraceptives. Results show that fertile cycle phases are associated with higher levels of jealousy than nonfertile cycle phases in both single and partnered women. However, patterns of jealousy reported when using hormonal contraceptives, as compared to when regularly cycling, differed between single and partnered women. In single women, levels of jealousy while on the pill fell between those reported when fertile and nonfertile but were not significantly different from either. In partnered women, levels of jealousy while using the pill were significantly higher than those reported during the nonfertile cycle phase and similar to those during the brief period of fertility. We discuss possible reasons for differences between single and partnered women in reported jealousy while using the pill. This research is the first to definitively show that a psychological characteristic, for example, jealousy, may be influenced differentially by endogenous hormones vs. exogenous hormones administered via hormonal contraceptives.

Keywords: Jealousy; Menstrual cycle; Within-subject design; Hormonal contraceptive pill; Oral contraception

1. Introduction

A growing body of literature suggests that women have evolved subtle changes in behavior and preferences across the menstrual cycle as a function of conception risk (e.g., Jones et al., 2008; Penton-Voak et al., 1999). Many of these studies focus on testing cyclical shifts in preferences for indicators of male genetic quality (reviewed in Garver-Apgar, Gangestad, & Thornhill, 2008; Roberts & Little, 2008). For example, masculinity and body odor are argued to function as honest signals of genetic health (e.g., Roberts et al., 2005; Thornhill & Gangestad, 1999; but see also Getty, 2002). Female attraction toward these "good gene" traits is thought to increase during the fertile phase of the cycle because during this time, obtaining genetic benefits for future offspring is most relevant (e.g., Thornhill & Gangestad, 1999).

Research has also documented shifts in female attractiveness across the menstrual cycle. For instance, female faces (Roberts et al., 2004), voices (Pipitone & Gallup, 2008), and choice of dress (Haselton, Mortezaie, Pillsworth, Bleske-Rechek, & Frederick, 2007) are judged to be most attractive when women are at fertile cycle stages. Heightened attractiveness during fertility could be seen as adaptive as it may allow women to attract a larger pool of potential partners, or partners of higher quality, when conception risk is highest (Roberts et al., 2004). Evidence indicating that men show increased mate guarding toward fecund female partners suggests that menstrual shifts in attractiveness have consequences for male behavior as well (Flinn, 1988;

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Gangestad, Thornhill, & Garver, 2002). Similarly, the literature suggests that male mate guarding of fecund partners is moderated by female attractiveness: with more attractive women experiencing higher degrees of mate guarding (Haselton & Gangestad, 2006). In line with these findings, women in relationships, particularly those who assess their male partner not to have "good genes," are more likely to report extrapair flirtation when fertile (Garver-Apgar, Gangestad, Thornhill, Miller, & Olp, 2006).

The plethora of recent studies documenting female menstrual cycle shifts, and corresponding male behavioral adjustment prompts a key question: do these hormonally induced adaptive changes in preferences or behavior matter, in the sense that they have consequences within relationships? If there is a benefit to cyclical variation in preferences and behavior, it becomes important to ask what consequences hormonal contraceptive use has on these processes.

Indeed, some research that supports the notion that contraceptive use disrupts mating processes exists. Relative to nonusers, women who use hormonal contraceptives demonstrate decreased preferences for indicators of genetic quality or compatibility in men (e.g., Little, Jones, Penton-Voak, Burt, & Perrett, 2002; Roberts, Gosling, Carter, & Petrie, 2008; Wedekind, Seebeck, Bettens, & Paepke, 1995) and overall decreased attractiveness in their behavior (Miller, Tybur, & Jordan, 2007). If menstrual cycle shifts play a meaningful role in allowing women to select quality partners or to obtain, attract, or retain mates, then the use of hormonal contraception may have consequences for the selection of new partners as well as for the stability of existing pair bonds (e.g., Alvergne & Lummaa, 2009; Roberts et al., 2011).

Apart from influencing partner preferences and attractiveness, research also suggests that hormonal contraceptive use and menstrual cycle shifts in hormones may influence relationship jealousy. Relationship jealousy can be defined as thoughts, emotions, or behaviors that occur as a result of the perceived threat of losing a potential mate to an actual or imagined rival (Buunk, 1991). Jealousy can be adaptive in that it allows women to monitor their partner and to foresee any potential threats to her monopolization of his resources or direct paternal care. While there is no direct evidence, jealousy may be greater during the fertile stage, as it is especially during this stage that women are salient of female–female competition for mates and may therefore monitor their partner to a greater extent. Geary, DeSoto, Hoard, Skaggs Sheldon, and Lynne Cooper (2001) correlated jealousy with estimated levels of estrogen in regularly cycling women. While they found no mean differences in jealousy scores across cycle weeks, levels of estradiol and jealousy were correlated during the fertile window. They also reported that women who used oral contraceptives had higher levels of sexual jealousy than nonusers. Taken together, these findings suggest a role for estrogen in female jealousy responses. However, the interpretation of cyclical shifts in jealousy is not entirely clear. Geary and colleagues hypothesized that this finding might be explained as a result of increased sexual desire during times of high estrogen. It remains an empirical question as to whether such shifts in jealousy are adaptive, or if they are indeed a byproduct of other processes such as sexual desire or intrasexual competition.

Using a within-subject design, we test how female relationship jealousy varies, first, as a function of fertility status across the menstrual cycle and, second, as influenced by the use of hormonal contraceptives. To our knowledge, the vast majority of research on pill-induced behavioral effects, including that of Geary and colleagues (2001), is limited by the fact that they draw conclusions based on between-subject designs. The use of between-subject designs is problematic in that there may be preexisting differences in culture, personality, sexual experience, relationship status, socioeconomic status, and conscientiousness between those women who choose to use hormonal contraception and those who do not (Alvergne & Lummaa, 2009; Roberts et al., 2008). To address these methodological issues, here we use a within-subject design in which participants are tracked both while they are regularly cycling and after they have commenced oral contraceptive use.

This study also benefits from an accurate process of detecting and, therefore, defining periods of fertility. Previous menstrual cycle studies have typically made crude estimates of the timing of ovulation, in many instances, relying on female self-reports of menstrual onset, from which researchers count forward or backward to establish an estimate of fertility. Beyond the potential for errors in self-report, the time frame on which fertility is defined is highly inconsistent across studies (e.g., backward counting to day 15; Garver-Apgar et al., 2008; forward counting to days 9–15, Miller et al., 2007; forward counting to days 6–14, Penton-Voak & Perrett, 2000). More recently, luteinizing hormone (LH) test strips have been used in an effort to better estimate fertility (e.g., Pillsworth & Haselton, 2005). However, this method is limited by the fact that it fails to account for anovulatory cycles in which luteinized follicles remain unruptured (Metcalf & Mackenzie, 1980; Qublan et al., 2006). Furthermore, there is variation in the definition of the duration and timing of the fertile period with reference to the detection of an LH surge (e.g., 1 day prior and 5 days after, Gangestad et al., 2002; 2 days prior and 3 days after, Haselton et al., 2007). Use of transvaginal ultrasonography allowed us to overcome the abovementioned obstacles.

Based on previous results reported by Geary et al. (2001), we predicted that, when regularly cycling, fertility (e.g., phases with relatively high estrogen) would be associated with significantly higher levels of jealousy relative to nonfertile cycle stages. Similarly, based on previous research, we predicted that hormonal contraceptive use would be associated with increased levels of jealousy as compared to scores obtained during nonuse.

2. Methods

2.1. Subjects

Participants were 29 females of white European descent aged between 20 and 33 years (M=22.59 years; S.D.=2.63 years). Participants were taking part in one of two clinical drug trials that tracked the inhibition of ovulation when using hormonal contraceptives. Participants were not given placebos or any other medication during their participation in either of the trials. Both trials had been ethically approved by an independent medical ethics committee. Criteria for participant exclusion included the following: pregnancy; lactation; irregular menstruation (cycle length greater than 42 days); a history of drug or alcohol abuse; the use of depot progestogen preparations, injectables, or biodegradable implants (within the past 6 months); clinically relevant abnormal cytology within the past 3 years as assessed by a cervical smear; or clinically significant abnormalities in routine hematology, serum biochemistry, and urinalysis at screening.

Women were recruited for the purpose of the present study via advertisements and word of mouth. This research was approved by the University of Groningen Ethics Committee. Participants were paid for their participation or, alternatively, entered into a draw to win an iPhone (or its equivalent in monetary value) in compensation for their time taking part. Of those who chose to take part, 13 women were presently in a relationship, while 16 reported to be presently single.

2.2. Measures

The study consisted of three sessions: two that occurred when participants were regularly cycling (first at a high- and then at a low-fertility period) and one when participants were using hormonal contraceptives. During each of the three scheduled sessions, the participants were asked to complete a computer-based survey**.** Seventeen of the participants, those recruited from Trial 1, completed the surveys on their home computer. They were specifically instructed to complete the online survey in private and in the absence of potential distractions. The remaining 12 participants, recruited from the second trial, completed their surveys on a personal computer in a laboratory of a psychology department at a large European University.

The survey was completed in Dutch (by native Dutch speakers) and contained basic demographic measures and the original Dutch version of a Jealousy Scale (Buunk, 1997) [Cronbach's α's=.86 (fertile), .89 (nonfertile), .87 (pill use)]. This is a 15-item questionnaire in which answers are reported on a one to five scale, with higher scores indicating higher levels of jealousy. Example items include the following: "I am concerned that my partner finds someone else more attractive than me," "It is unacceptable to me that my partner has friends of the opposite sex," and "How would you feel if your partner would dance intimately with someone of the opposite sex?"

2.3. Session scheduling

To accurately schedule participants for their three sessions, each individual was tracked for a period of at least 4 months. Participants were tracked for 1 month while spontaneously cycling. Participants who had been using hormonal contraceptives underwent a washout cycle in which no measurements were taken prior to being observed for a full menstrual cycle. Previous research has shown that hormone levels return to baseline well before 2 months after ceasing contraceptive use (e.g., Duijkers, Engels, & Klipping, 2005). Ovarian function is restored within a few days of stopping hormonal contraceptives. Moreover, ethinyl estradiol and progestogens have half-lives of 10 h and 8 to 24 h, respectively, and would thus have been eliminated well before we took our regularly cycling measures (Goldzieher, 1989; Täuber, Tack, & Matthes, 1989).

During this time, the participants underwent transvaginal ultrasonography (GE Voluson E8 device, with a 4- to 8-MHz vaginal transducer) readings every 3±1 days, starting on day 9 of the menstrual cycle, to determine their proximity to ovulation. As indicated in Duijkers et al. (2004), follicles were measured in two directions, and a mean size was calculated. The participants were instructed to complete their "fertile" survey within 48 h of their regular transvaginal ultrasonography measurements indicating that they had a follicle that was greater than or equal to 13 mm in size, demonstrating that the dominant follicle had developed, and therefore, the fertile phase had been entered. We then continued to monitor participants via transvaginal ultrasonography to ensure that ovulation took place. Fertility was also confirmed by the measurement of serum progesterone levels. In line with Hoogland and Skouby's (1993) classification system for measuring ovarian activity using ultrasound technology, all participants were observed to have a progesterone level greater than 5 nmol/l at the time they completed their fertile survey. According to the scoring system of Hoogland and Skouby, this indicates either a luteinized follicle or a ruptured follicle, suggesting that risk of conception is high.

The second survey, the "non-fertile" survey measure, was completed during the luteal cycle phase. Participants were instructed to complete this survey 6 days or more after we had observed, via transvaginal ultrasonography, that they had ovulated.

For the purpose of the hormonal contraceptive survey, the participants had to have been using contraceptives for a minimum duration of 3 months. Participants were using a wide variety of brands of combined oral contraceptives, all of which were low ethinyl estradiol dose formulations administered through a 28-day regimen with 21 days of active pills, followed by a 7-day dose-free week. Participants completed the "pill use survey" on an active pill day at least 15 days into the third month of continuous hormonal contraceptive use.

The order in which the surveys were administered was not completely randomized, as this was constrained by the clinical trial. However, there was variation in the order of completion based on which of the two trials participants were recruited from. Twelve women completed the surveys in the order pill use survey, fertile survey, and nonfertile survey; while, 17 women completed the surveys in the order fertile survey, nonfertile survey, and pill use survey.

2.4. Data analysis

Results were analyzed using hierarchical linear-mixed modeling (SPSS, 15.0; SPSS, 2005) with measurements nested for each subject. Data were log transformed to obtain a normal distribution (raw data: skewness statistic=1.06, S.E.=0.26; transformed data skewness=0.363, S.E.=0.26). Results reported are consistent with those found when analyzed using nontransformed data.

We first analyzed the model with jealousy as the dependent variable, fertility status (fertile, nonfertile, pill use), relationship status, and the order in which participants completed their surveys as fixed factors and age as a covariate. We also included the interaction of fertility status and relationship status in this model. Parameters were estimated by maximum likelihood, and the model had absolute convergence in terms of log likelihood, parameter, and Hessian convergence. A random intercept was included at the participant level. We report F test and t tests for the post hoc comparisons. After this overall model, we report the same test conducted independently among single and partnered women.

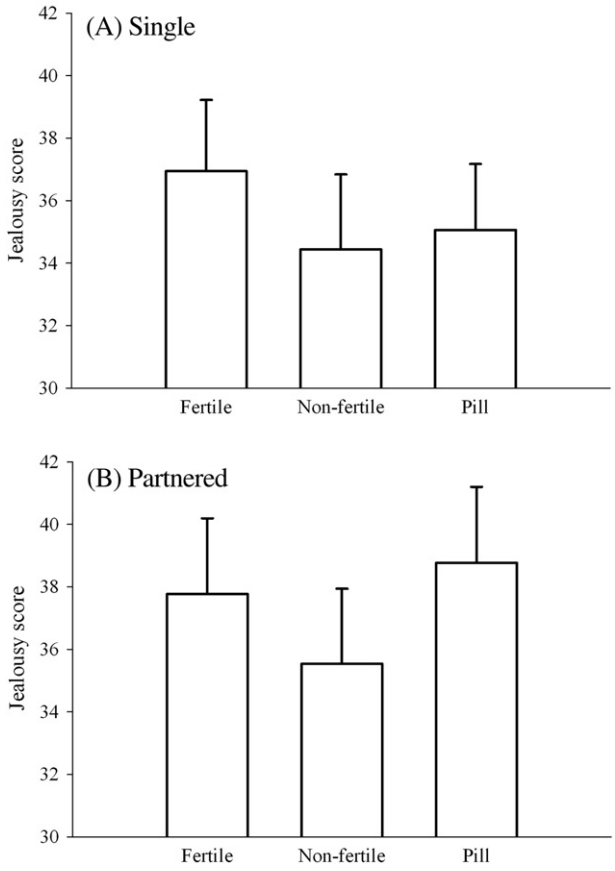

Fig. 1. Mean scores+S.E. for jealousy during fertile, nonfertile, and pill use measures for single (A) and partnered women (B). Scores reported when fertile were higher than those reported when nonfertile. Among partnered women, there was a significant difference between nonfertile and pill use measures.

3. Results

The overall model indicated a significant effect of fertility status on jealousy scores ($F(2, 58)=4.02$, $p=.02$) (see Fig. 1). Relationship status, the order that the surveys were completed in, and the interaction of fertility and relationship status were all nonsignificant (all $F<1.39$, all $p>.26$). Age had a marginal influence on the model ($F=2.81$, $p=.10$). Pairwise comparisons revealed that levels of jealousy reported when fertile were significantly higher than those reported when nonfertile (mean difference±S.E.=0.068±0.026, $p=.01$). Levels of jealousy reported when using the pill were not significantly different from those reported when fertile (mean difference±S.E.= −0.013±0.026, $p=.61$) but were significantly higher than those found when nonfertile (mean difference±S.E.=0.055±0.026, $p=.035$).

Relationship status was considered a priori to be an important factor that may differentially influence the expression of jealousy. Therefore, although the interaction between fertility status and relationship status in the overall model was nonsignificant, given our small sample size, we also considered single and partnered women separately. Results for single and partnered women differed somewhat, in spite of the nonsignificant interaction between fertility status and relationship status in the overall model. Among single women, jealousy scores were significantly higher when fertile than nonfertile (mean difference±S.E.=0.074±0.035, $p=.04$); however, there was no difference between levels of jealousy reported when regularly cycling and when using the pill (fertile vs. pill: mean difference±S.E.=0.053±0.035, $p=.14$; nonfertile vs. pill: mean difference±S.E.=−0.021±0.035, $p=.55$). Similarly, although marginally significant, among partnered women, levels of jealousy were higher when fertile than nonfertile (mean difference±S.E.=0.063±0.037, $p=.10$). However, levels of jealousy reported by partnered women were higher when using the pill than when nonfertile (mean difference±S.E.=0.089±0.037, $p=.02$) but not different when using the pill vs. being fertile (mean difference±S.E.=0.026±0.037, $p=.48$). In neither the model for single or partnered women was there a significant effect of age or order of completing the surveys (all $F<2.98$, all $p>.1$).

4. Discussion

Using a within-subject design, we investigated whether self-reported female jealousy varies across the menstrual

cycle and what effect hormonal contraceptive use had on this behavior. Results indicate that jealousy varies as a function of menstrual phase, with higher levels of jealousy reported when fertile than when nonfertile, in both single and partnered women. To date, research documenting cyclical effects in behavior and preferences is typically framed within the ovulatory shift hypothesis (e.g., Durante, Li, & Haselton, 2008; Gangestad, Simpson, Cousins, Garver-Apgar, & Christensen, 2004), which proposes that women can benefit from multiple matings to obtain genetic benefits for offspring but that this comes at a cost of potentially losing a long-term partner. Therefore, selection is assumed to have shaped women to express pronounced preferences for genetic indicators in men that they evaluate as short-term sex partners only when conception risk is high (Gangestad & Thornhill, 1998; Gangestad et al., 2002). While substantial evidence exists in support of the ovulatory shift hypothesis, we do not feel that the present results are best explained within this framework.

While we believe jealousy may be adaptive to ensure monopolization of partner resources and paternal care, it may not seem directly obvious how cyclical shifts in jealousy could be advantageous to women. One might argue that the size of potential threats in a relationship does not differ for women when fertile vs. nonfertile. In men, it is clear that shifts in jealousy with respect to partner fertility serve an adaptive function. Given the fitness loss associated with cuckoldry and the high cost (e.g., time) of remaining vigilant of one's partner at all times, it is adaptive for men to display more jealousy during times when female conception is possible. By contrast, for women, who risk being deserted by their partner and left with the burden of parenting in the absence of male resource investment, the costs of jealousy may depend less on fertility status. Moreover, our findings seem at odds with previous literature on cyclical effects, which suggests that fertile periods are associated with increased extrapair interest rather than fear of partner infidelity (e.g., Jones et al., 2005; Pillsworth & Haselton, 2005).

For a trait to be considered an adaption, it must enhance the fitness of its possessor relative to individuals who do not possess the trait. It does not seem directly obvious that women who experience strong cyclical shifts in jealousy gain a direct fitness benefit from these changes. Likewise, it is not very likely that, in the absence of cyclical variability in jealousy, women would suffer a fitness disadvantage and produce fewer offspring. It seems most likely that our scale for jealousy taps into some other aspect of mate choice processes, which is, itself, adaptive. For example, jealousy may be involved in the process of selecting and competing to obtain a mate. Previous research has shown that women increase levels of female–female competition when fertile (Fisher, 2004). Such shifts might be adaptive in that they allow women to obtain a partner of higher quality than they otherwise would. It may be that women find themselves feeling more jealous when fertile because mating competition is most salient at this time. A limitation to our study is that the items on the scale used to measure jealousy are specific to a real or imagined partner. It may be that overall levels of jealousy, or specifically jealousy toward attractive females, are driving the effects we report. Future research is needed to explore this hypothesis.

Geary et al. (2001) suggested a further possible explanation for cyclical shifts in jealousy: that they are a byproduct of higher levels of sexual desire when fertile as compared to when nonfertile. This does not appear to be a consistent explanation for our results as it is thought that hormonal contraceptive use lowers overall levels of sexual desire (e.g., Graham & Sherwin, 1993). Our finding that levels of jealousy among partnered women are similar when fertile and when using hormonal contraceptives suggests that levels of sexual desire are not likely to explain our effects.

One might also argue that female shifts in jealousy are a byproduct of male shifts in jealousy. That is to say, women may respond to increases in partnered male jealousy through increasing their own expression of jealousy. This, however, appears not be an adequate explanation, given that we find similar effects among single and partnered women. Given that both single and partnered women shift levels of jealousy across the menstrual cycle suggests that this shift is unlikely to be adaptive, as it would be costly to evoke in situations that are not appropriate. At this stage, it is difficult to specify a strong causal interpretation of what cyclical variation in jealousy may be a byproduct of. Nonetheless, we find that periods of high estrogen are associated with higher affective responses to partner jealousy, a finding that is consistent with previously reported data (Geary et al., 2001).

Two important implications arise from our results. First, the demonstration that there are clear temporal changes in jealousy across the menstrual cycle hints that fertility may correspond to periods of relationship conflict. Future research in which couples are tracked on features such as relationship satisfaction and jealousy across the menstrual cycle may help to further disentangle temporal changes in jealousy. Second, we show that among partnered women, hormonal contraceptive use increases levels of jealousy from the nonfertile baseline to a level comparable to that experienced during the fertile phase. Higher overall levels of jealousy in women on the pill may have negative consequences on their relationships but also, perhaps, on self-esteem and overall well-being. That we only find this pill effect among partnered women may suggest that pill use initiation has altered the dynamics of the partnership, causing increased tension between couples. Men may be responding to changes in their female partner, which occur as a result of contraceptive use, causing jealousy among women. Future work is needed to explore the real-world implications of these findings in more detail. It remains an empirical question as to whether or not the shifts in jealousy documented are noticeable to male partners or indeed driven by partner behavior and/or how they might influence relationship dynamics or levels of male partner investment.

There are several limitations to our findings. First, our design was not fully randomized. Future research should aim to completely randomize the fertile, nonfertile, and pill measures, so as to avoid the possibility of any order effects. Furthermore, as alluded to previously, the scale we used to assess jealousy asked participants to respond to items that required them to imagine their partner in a variety of different contexts. Our study included both single and partnered women, but it is possible that single women in our sample have no previous relationship experience. However, we feel that this is unlikely because research conducted within The Netherlands shows that 91% of Dutch individuals between the ages of 20 and 24 years report having had at least one romantic relationship (De Graaf, Meijer, Poelman, & Vanwesenbeeck, 2005). Alternatively, women who were recently partnered may have been better able to imagine how they would react to the scale items than those who have been single for a longer period of time. It is, therefore, somewhat unclear how single women answered the jealousy questions; for example, we do not know whether they were imagining a love rival for a current love interest or recalling a love rival. Future research should seek to collect information with respect to previous partnerships to account for these limitations.

As they stand, our results suggest that jealousy may be influenced differentially by endogenous and exogenous hormones. However, it is difficult to specifically distinguish between the effects of the hormones contained within hormonal contraceptives and the resulting effect of suppressing natural hormones. What is clear is that there may be more variables than often assumed that are involved in explaining cyclical shifts as well as hormonal contraceptive-induced behavioral changes. Future research on this topic could consider differential effects of hormonal contraceptives based on differences in concentrations or derivative forms of synthetic hormones used. Indeed, preliminary evidence exists, which suggests that jealousy levels may be sensitive to higher doses of synthetic estrogen contained within combined oral contraceptives (Cobey, Pollet, Roberts, & Buunk, 2010). Finally, our study is limited by the fact that participants chose to take part in a clinical trial and may, therefore, differ in some way from women within the general population. Although participants were unaware of the predictions of the study, they were cognizant of the fact that we were interested in contraceptive pill-induced behavioral changes. A future study using a double-blind placebo control design could circumvent this issue (see, e.g., Yonkers et al., 2005).

In summary, this study shows that regularly cycling women report higher levels of jealousy during the fertile as compared to nonfertile cycle phases, and it indicates that use of hormonal contraceptives results in significantly higher absolute levels of jealousy than when nonfertile. If either temporal shifts in jealousy or increased baseline levels of jealousy have consequences on relationship quality or mate choice, then the use of hormonal contraceptives may be disrupting these processes.

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References

Alvergne, A., & Lummaa, V. (2009). Does the contraceptive pill alter mate choice in humans? *Trends in Ecology and Evolution*, *25*, 171–179.

Buunk, A. P. (1991). Jealousy in close relationships: an exchange theoretical perspective. In P. Salovey, Ed. *Psychological perspectives on jealousy and envy* (pp. 148–177). New York: Guilford Publications.

Buunk, B. P. (1997). Personality, birth order and attachment styles as related to various types of jealousy. *Personality and Individual Differences*, *23*, 997–1006.

Cobey, K. D., Pollet, T. V., Roberts, S. C., & Buunk, A. P. (2010). Hormonal birth control use and relationship jealousy: evidence for estrogen dosage effects. *Personality and Individual Differences*, *50*, 315–317.

De Graaf, H., Meijer, S., Poelman, J., & Vanwesenbeeck, I. (2005). *Seks onder je 25e: seksuele gezondheid van jongeren in Nederland anno 2005.* "Sex under 25: sexual health among Dutch youth in 2005". Delft, Netherlands: Eburon.

Duijkers, I. J. M., Engels, L., & Klipping, C. (2005). Length of the menstrual cycle after discontinuation of oral contraceptives. *Gynecological Endocrinology*, *20*, 74–79.

Duijkers, I. J. M., Louwé, L. A., Braat, D. D. M., & Klipping, C. (2004). One, two or three: how many directions are useful in transvaginal ultrasound measurement of ovarian follicles? *The European Journal of Obstetrics & Gynecology and Reproductive Biology*, *117*, 60–63.

Durante, K. M., Li, N. P., & Haselton, M. G. (2008). Changes in women's choice of dress across the ovulatory cycle: naturalistic and laboratory task-based evidence. *Personality and Social Psychology Bulletin*, *34*, 1451–1460.

Fisher, M. (2004). Female intrasexual competition decreases female facial attractiveness. *Proceedings of the Royal Society Series B-Biological Sciences*, *271*, 283–285.

Flinn, M. V. (1988). Mate guarding in a Caribbean village. *Ethology and Sociobiology*, *9*, 1–28.

Gangestad, S. W., Simpson, J. A., Cousins, A. J., Garver-Apgar, C. E., & Christensen, P. N. (2004). Women's preference for male behavioral displays change across the menstrual cycle. *Psychological Science*, *15*, 203–207.

Gangestad, S. W., & Thornhill, R. (1998). Menstrual cycle variation in women's preferences for the scent of symmetrical men. *Proceedings of the Royal Society of London Series B-Biological Sciences*, *262*, 727–733.

Gangestad, S. W., Thornhill, R., & Garver, C. E. (2002). Changes in women's sexual interests and their partners' mate retention tactics across the menstrual cycle: evidence for shifting conflicts of interest. *Proceedings of the Royal Society of London Series B-Biological Sciences*, *269*, 975–982.

Garver-Apgar, C. E., Gangestad, S. W., & Thornhill, R. (2008). Hormonal correlates of women's mid-cycle preference for the scent of symmetry. *Evolution and Human Behavior*, *29*, 223–232.

Garver-Apgar, C. E., Gangestad, S. W., Thornhill, R., Miller, R. D., & Olp, J. J. (2006). Major histocompatibility complex alleles, sexual responsivity, and unfaithfulness in romantic couples. *Psychological Science*, *17*, 830–835.

Geary, D. C., DeSoto, C. M., Hoard, M. K., Skaggs Sheldon, M., & Lynne Cooper, M. (2001). Estrogens and relationship jealousy. *Human Nature*, *12*, 299–320.

Getty, T. (2002). Signaling health versus parasites. *The American Naturalist*, *159*, 363–371.

Goldzieher, J. W. (1989). Pharmacology of contraceptive steroids: a brief review. *American Journal of Obstetrics and Gynecology*, *160*, 1260–1264.

Graham, C. A., & Sherwin, B. B. (1993). The relationship between mood and sexuality in women using an oral contraceptive as treatment for premenstrual symptoms. *Psychoneuroendocrinology*, *18*, 273–281.

Haselton, M. G., & Gangestad, S. W. (2006). Conditional expression of women's desires and men's mate guarding across the ovulatory cycle. *Hormones and Behavior*, *49*, 509–518.

Haselton, M. G., Mortezaie, M., Pillsworth, E. G., Bleske-Rechek, A., & Frederick, D. A. (2007). Ovulatory shifts in human female ornamentation: near ovulation, women dress to impress. *Hormones and Behavior*, *51*, 41–45.

Hoogland, H. J., & Skouby, S. O. (1993). Ultrasound evaluation of ovarian activity under oral contraceptives. *Contraception*, *47*, 583–590.

Jones, B. C., DeBruine, L. M., Perrett, D. I., Little, A. C., Feinberg, D. R., & Law Smith, M. J. (2008). Effects of menstrual cycle phase on face preferences. *Archives of Sexual Behavior*, *37*, 78–84.

Jones, B. C., Little, A. C., Boothroyd, L., DeBruine, L. M., Feinberg, D. R., & Law Smith, M. J., et al. (2005). Commitment to relationships and preferences for femininity and apparent health in faces are strongest on days of the menstrual cycle when progesterone level is high. *Hormones and Behavior*, *48*, 283–290.

Little, A. C., Jones, B. C., Penton-Voak, I. S., Burt, D. M., & Perrett, D. I. (2002). Partnership status and the temporal context of relationships influence human female preferences for sexual dimorphism in male face shape. *Proceedings of the Royal Society of London Series B-Biological Sciences*, *269*, 1095–1100.

Metcalf, M. G., & Mackenzie, J. A. (1980). Incidence of ovulation in young women. *Journal of Biosocial Science*, *12*, 345–352.

Miller, G., Tybur, J. M., & Jordan, B. D. (2007). Ovulatory cycle effects on tip earnings by lap dancers: Economic evidence for human estrus? *Evolution and Human Behavior*, *28*, 275–381.

Penton-Voak, I. S., & Perrett, D. I. (2000). Female preference for male faces changes cyclically: further evidence. *Evolution and Human Behavior*, *21*, 39–48.

Penton-Voak, I. S., Perrett, D. I., Castles, D. L., Kobayashi, T., Burt, D. M., & Murray, L. K., et al. (1999). Menstrual cycle alters face preference. *Nature*, *399*, 741–742.

Pillsworth, E. G., & Haselton, M. G. (2005). Male sexual attractiveness predicts differential ovulatory shifts in female extra-pair attraction and male mate retention. *Evolution and Human Behavior*, *27*, 247–258.

Pipitone, R. N., & Gallup, G. G. (2008). Women's voice attractiveness varies across the menstrual cycle. *Evolution and Human Behavior*, *29*, 268–274.

Qublan, H., Amarin, Z., Nawasreh, M., Diab, F., Malkawi, S., & Al-Ahmad, N., et al. (2006). Luteinized unruptured follicle syndrome: incidence and recurrence rate in infertile women with unexplained infertility undergoing intrauterine insemination. *Human Reproduction*, *21*, 2110–2113.

Roberts, S. C., Gosling, L. M., Carter, V., & Petrie, M. (2008). MHC-correlated odour preferences in humans and the use of oral contraceptives. *Proceedings of the Royal Society of London Series B-Biological Sciences*, *275*, 2715–2722.

Roberts, S. C., Havlicek, J., Flegr, J., Hruskova, M., Little, A. C., & Jones, B., et al. (2004). Female facial attractiveness increases during the fertile phase of the menstrual cycle. *Proceedings of the Royal Society of London Series B-Biological Sciences*, *271*, S270–S272.

Roberts, S. C., Klapilová, K., Little, A. C., Burriss, R. P., Jones, B. C., & DeBruine, L. M., et al. (2011). Relationship satisfaction and outcomes in women who meet their partner while using oral contraception. *Proceedings of the Royal Society B-Biological Sciences*, doi:10.1098/rspb.2011.1647.

Roberts, S. C., & Little, A. C. (2008). Good genes, complementary genes and human mate choice. *Genetica*, *132*, 309–321.

Roberts, S. C., Little, A. C., Gosling, L. M., Perrett, D. I., Jones, B. C., & Carter, V., et al. (2005). MHC-heterozygosity and human facial attractiveness. *Evolution and Human Behavior*, *26*, 213–226.

SPSS. (2005). Linear mixed-effects modeling in SPSS: an introduction to the MIXED procedure. Chicago, IL: SPSS Inc.

Täuber, U., Tack, J. W., & Matthes, H. (1989). Single dose pharmacokinetics of gestodene in women after intervenous and oral administration. *Contraception*, *49*, 461–479.

Thornhill, R., & Gangestad, S. W. (1999). The scent of symmetry: a human sex pheromone that signals fitness? *Evolution and Human Behavior*, *20*, 175–201.

Wedekind, C., Seebeck, T., Bettens, F., & Paepke, A. J. (1995). MHC-dependent mate preferences in humans. *Proceedings of the Royal Society of London Series B-Biological Sciences*, *260*, 245–249.

Yonkers, K. A., Brown, C., Pearlstein, T. B., Foegh, M., Sampson-Landers, C., & Rapkin, A. (2005). Efficacy of a new low-dose oral contraceptive with drospirenone in premenstrual dysphoric disorder. *Obstetrics and Gynecology*, *106*, 492–501.