Journal of Personality and Social Psychology

Ovulation as a Male Mating Prime: Subtle Signs of Women's Fertility Influence Men's Mating Cognition and Behavior

Saul L. Miller, and Jon K. Maner

Online First Publication, September 6, 2010. doi: 10.1037/a0020930

Journal of Personality and Social Psychology

0022-3514/10/$12.00 DOI: 10.1037/a0020930

Ovulation as a Male Mating Prime: Subtle Signs of Women's Fertility Influence Men's Mating Cognition and Behavior

Saul L. Miller and Jon K. Maner
Florida State University

Women's reproductive fertility peaks for a few days in the middle of their cycle around ovulation. Because conception is most likely to occur inside this brief fertile window, evolutionary theories suggest that men possess adaptations designed to maximize their reproductive success by mating with women during their peak period of fertility. In this article, we provide evidence from 3 studies that subtle cues of fertility prime mating motivation in men, thus facilitating psychological and behavioral processes associated with the pursuit of a sexual partner. In Study 1, men exposed to the scent of a woman near peak levels of fertility displayed increased accessibility to sexual concepts. Study 2 demonstrated that, among men who reported being sensitive to odors, scent cues of fertility triggered heightened perceptions of women's sexual arousal. Study 3 revealed that, in a face-to-face interaction, high levels of female fertility were associated with a greater tendency for men to make risky decisions and to behaviorally mimic a female partner. Hence, subtle cues of fertility led to a cascade of mating-related processes—from lower order cognition to overt behavior—that reflected heightened mating motivation. Implications for theories of goal pursuit, romantic attraction, and evolutionary psychology are discussed.

Keywords: evolutionary psychology, romantic relationships, attraction, menstrual cycle

When people are asked why they have strong feelings of romantic attraction to someone, they often point out the person's positive characteristics—his/her kindness, sense of humor, good looks, and so on. But what about the times when people respond with uncertainty—when they say "we just clicked" or "it was chemistry." What is it that "clicked"? What is that "chemistry"?

In the current article, we use an evolutionary perspective to generate and test predictions about some of the hidden undercurrents of sexual attraction. An evolutionary perspective provides a powerful framework with which to understand the subtle—and sometimes even invisible—processes shaping human mating. From this perspective, the factors affecting attraction are those that, throughout evolutionary history, have recurrently influenced differential reproductive success (Buss & Schmitt, 1993; Gangestad & Simpson, 2000; Kenrick & Keefe, 1992).

One area of evolutionarily inspired research that has shown great promise pertains to social psychological changes linked with women's level of fertility across the menstrual cycle (Gangestad, Thornhill, & Garver-Apgar, 2005a; Haselton & Gangestad, 2006; G. Miller, Tybur, & Jordan, 2007; Penton-Voak et al., 1999; Roney & Simmons, 2008). Examining changes across the menstrual cycle provides unique and powerful opportunities to assess the presence of adaptive, biologically based psychological mechanisms. Indeed, examining those mechanisms provides some of the best insight into the evolved underpinnings of close relationships.

Saul L. Miller and Jon K. Maner, Department of Psychology, Florida State University.

Correspondence concerning this article should be addressed to Saul L. Miller, Department of Psychology, Florida State University, 1107 West Call Street, Tallahassee, FL 32306-4301. E-mail: smiller@psy.fsu.edu

In this article, we integrate theories from biology, evolutionary psychology, and social cognition to test the overarching hypothesis that subtle cues of women's fertility prime mating motives in men. In the following sections, we describe an adaptationist approach to human mating and present hypotheses about how subtle cues of women's fertility cause men to display a functionally organized cascade of mating-related processes—ranging from lower order cognition to overt behavior—that reflect the activation of a mating motive.

An Evolutionary Perspective on Women's Fertility

Sexual intercourse is necessary for reproduction, but it is by no means sufficient. Any single act of sexual intercourse (even excluding instances in which contraception is used) will, on average, lead to pregnancy only 3% of the time (Tietze, 1960; Wilcox, Dunson, Weinberg, Trussell, & Baird, 2001). Although many factors influence the probability of conception (e.g., sperm motility; sperm number; problems with the ovaries, fallopian tubes, or uterus), one of the more critical factors is a woman's current level of fertility.

Women's fertility levels shift dramatically throughout the menstrual cycle. Typically, there are only a few days in a woman's cycle when sexual intercourse can result in fertilization of an egg—the few days before ovulation (the late follicular phase) and the day of ovulation itself (Wilcox, Weinberg, & Baird, 1995). Outside this brief fertile window, the probability of conception is practically nil. Thus, the period surrounding ovulation is extremely important from a reproductive standpoint, because it represents the peak period of reproductive fertility.

Given the centrality of fertility to reproduction, evolutionary theories suggest that men and women possess adaptations designed to promote mating behavior during the period surrounding ovula-

tion (Gangestad et al., 2005a). Indeed, in myriad species, fluctuations in female fertility play a key role in shaping sexual attraction and mating behavior (Kendrick & Dixson, 1983; Ziegler, Schultz-Darken, Scott, Snowdon, & Ferris, 2005).

Relevant social psychological research on humans has tended to focus on menstrual cycle shifts in behavior and psychology that occur within women. During the few days when conception risk is highest, for example, women report increases in sexual self-stimulation, overall sexual desire, and number of sexual fantasies (Bullivant et al., 2004; Harvey, 1987; Regan, 1996). Women also report greater interest in activities associated with finding and attracting new romantic partners, such as attending social gatherings (Haselton & Gangestad, 2006) and wearing more sexually provocative clothing (Durante, Li, & Haselton, 2008; Haselton, Mortezaie, Pillsworth, Bleske-Rechek, & Frederick, 2007; Hill & Durante, 2009). During peak fertility, women show a particular preference for men displaying indicators of good genes (e.g., Feinberg et al., 2006; Gangestad, Garver-Apgar, Simpson, & Cousins, 2007; Gangestad, Thornhill, & Garver-Apgar, 2005b; Little, Jones, & Burris, 2007; Penton-Voak et al., 1999; Thornhill & Gangestad, 1999). Mating with a genetically superior man around the time of ovulation increases the likelihood of bearing genetically fit offspring. Consequently, when approaching ovulation, women engage in activities designed to secure genetic benefits from potential mates (Gangestad et al., 2005a), in turn, maximizing the reproductive fitness gains afforded by their high level of fertility.

Just as cues of fertility are important for the mating psychology of women, they are also important for the mating psychology of men. Males of many species spend an extraordinary amount of time, energy, and resources attempting to gain sexual access to females, and humans are no exception (Baumeister & Vohs, 2004). From an evolutionary perspective, men who were able to put their resources and energy toward courting fertile women would have gained a significant reproductive advantage over other men. As a result, men may possess adaptations that lead them to identify and engage in courtship with women who are at their peak level of fertility. Consistent with this perspective, in numerous species, females' fertility plays a primary role in heightening males' mating behavior (e.g., Kavaliers, Choleris, & Colwell, 2001; Ziegler et al., 2005). Relatively few studies, however, have examined whether similar adaptations exist in humans.

A handful of studies have examined the association between shifts in women's fertility and men's ratings of women's attractiveness. Those studies reveal that men tend to rate certain characteristics of women (e.g., their scent, their voice, their face) as most attractive during periods of peak fertility (Pipitone & Gallup, 2008; Roberts et al., 2004; Thornhill et al., 2003). Although this suggests that men subjectively prefer certain features at women's peak level of fertility, such studies have fallen short of testing the more general hypothesis that signs of women's fertility prime mating motives in men. Indeed, to be adaptive, cues of fertility should have effects in men that go well beyond subjective assessments of attractiveness.

A small number of studies have examined whether men's behaviors change as a function of women's fertility levels. Gangestad, Thornhill, and Garver (2002) and Haselton and Gangestad (2006) found that women report heightened mate-guarding behaviors (e.g., possessiveness and monopolization of the women's time) by their male romantic partners during periods of peak fertility (see also Burriss & Little, 2006). Additionally, G. Miller et al. (2007) reported that female dancers received greater tips from men when near ovulation compared with other phases of their cycle. Although these studies are consistent with the hypothesis that women's fertility shapes men's mating behavior, the cause of men's behavior in these studies was unclear. The findings could reflect men's responses to changes in women's overt attraction tactics (e.g., increases in flirtation), rather than a more direct attunement to subtle cues of women's fertility.

The purpose of the current research, therefore, was to rigorously assess whether subtle fertility cues (uncoupled from shifts in women's overt behavior) directly influence men's mating cognition and behavior. Moreover, we extended previous research that has examined subjective ratings of attractiveness to provide a more complete picture of men's responses to women's fertility. In the following sections, we describe the potential cues that signal women's level of fertility, as well as predictions pertaining to the types of responses that men display when exposed to those cues.

Cues of Women's Fertility: Scent and Other Subtle Signs

Women, unlike the females of many other species, do not exhibit highly overt physical indicators of fertility, such as the sexual swellings that appear on the hindquarters of other primate females. Consequently, for quite some time, scientists presumed that women's ovulation was concealed (Burley, 1979). However, an emerging body of evidence suggests otherwise. A small number of studies have indicated that men subjectively evaluate the odors of women close to ovulation as more pleasant-smelling than the odors of women far from ovulation (Havlíček, Dvořáková, Bartoš, & Flegr, 2006; Singh & Bronstad, 2001; Thornhill et al., 2003). Moreover, scents of women near ovulation can lead men to display heightened levels of testosterone—a hormone closely tied to men's mating behavior (S. L. Miller & Maner, 2010). Olfaction, therefore, may serve as one key medium by which men are capable of detecting shifts in women's fertility.

The idea that olfaction serves as a mechanism by which men can detect women's level of fertility is consistent with research on olfactory processes. In many animals, chemosensory signaling serves as a principal medium by which females' fertility shapes males' mating behaviors (Pankevich, Baum, & Cherry, 2004; Ziegler et al., 2005). More generally in humans, scents have been shown to influence thought accessibility, decision making, and behavioral intentions (Bone & Ellen, 1999; Holland, Hendriks, & Aarts, 2005; Mitchell, Kahn, & Knasko, 1995). In sum, several lines of research indicate that olfaction plays an important role in shaping psychological and behavioral processes. Consequently, in two of the current studies (Studies 1 and 2), we focus on scent as one cue by which fertility may shape men's mating-related cognition and behavior.

In addition to scent, women's level of fertility may be signaled by a variety of other subtle cues. For example, shifts in women's facial skin tone, vocal pitch, body symmetry, and waist-to-hip ratio have all been linked with shifting fertility levels (Kirchengast & Gartner, 2002; Manning, Scutt, Whitehouse, Leinster, & Walton, 1996; Pipitone & Gallup, 2008; Roberts et al., 2004). Consequently, any combination of these subtle cues may influence men's

mating-related cognition and behavior. Thus, in Study 3, we move our focus beyond scent and examine men's mating-related responses to a wider range of potential fertility cues.

Ovulation as a Mating Goal Prime

What responses might men display in response to subtle cues of women's fertility? An integration of social cognitive and evolutionary theories provides a framework for generating hypotheses about the specific cognitive and behavioral responses men display when exposed to women's fertility cues. From an evolutionary perspective, fertility cues should increase a man's mating motivation (particularly short-term mating motivation), as indicated by increases in cognitions and behaviors reflecting his increased interest in mating (Gangestad et al., 2005a; G. Miller et al., 2007). Indeed, men's responses to fertility cues should not be limited to any single psychological process but, instead, should be observed across a variety of processes that facilitate mating (see Griskevicius, Cialdini, & Kenrick, 2006; Griskevicius, Goldstein, Mortensen, Cialdini, & Kenrick, 2006; Maner, Gailliot, Rouby, & Miller, 2007; Maner et al., 2005). In the following sections, we outline hypotheses for four psychological processes that reflect the presence of mating motivation and that we expect will be responsive to signs of women's fertility. The four processes—accessibility of sexual concepts, interpersonal perception, risky decision making, and behavioral mimicry—reflect a range of motivated responses from lower order cognition to higher order social behavior.

The Accessibility of Sexual Concepts

A vast literature in social cognition indicates that stimuli in one's environment can prime particular concepts (e.g., Holland et al., 2005). This process brings goal-relevant concepts to mind, thus motivating people to respond adaptively to the eliciting stimulus (Ferguson & Bargh, 2004). The smell of a hamburger, for example, may promote a state of hunger, in turn eliciting thoughts of food. This, in turn, has consequences for perception (e.g., perceiving food as more pleasant) and behavior (e.g., seeking out sources of nourishment; Aarts et al., 2005; Bargh, Chen, & Burrows, 1996). Similar goal-driven processes have been shown to occur in interpersonal contexts (e.g., Fitzsimons & Bargh, 2003). Applying this literature to the current research suggests that, to the extent that fertility primes mating motives in men, cues of fertility should increase the cognitive accessibility of sexual concepts. We test this prediction in Study 1.

Interpersonal Perception

How one perceives others is shaped by one's own motives. In particular, several studies have documented that one's current motivational state influences the types of emotions and intentions one perceives in others (e.g., Kawada, Oettingen, Gollwitzer, & Bargh, 2004). For example, when motivated to protect themselves from harm, people are biased toward perceiving anger in heuristically threatening others (Maner et al., 2005). By perceiving another person as angry even when he is not, people are more likely to engage in specific behaviors aimed at satisfying their desire for self-protection.

Biases in interpersonal perception can serve similar functions within the realm of romantic relationships (e.g., Maner, Miller, Rouby, & Gailliot, 2009). Several studies, for example, have suggested that men tend to overestimate the degree of sexual interest displayed by attractive women (Abbey, 1982; Haselton & Buss, 2000). By perceiving sexual interest in a woman, a man is more likely to pursue her as a romantic partner and thus not miss out on a potential sexual opportunity (Haselton & Nettle, 2006). Although men exhibit a general tendency to overperceive women's sexual intent, this bias becomes exaggerated when situational cues prime men to experience strong sexual motives (Maner et al., 2005). Therefore, if cues of women's fertility prime mating goals, one would expect cues of fertility to increase men's perceptions of women's sexual interest. We test this prediction in Study 2.

Risky Decision Making

Motives also have important consequences for the types of decisions people make. In particular, one's current motivations can influence the extent to which one makes risky decisions (Fessler, Pillsworth, & Flamson, 2004). A large literature suggests that being motivated to attract a mate leads men to make risky choices (e.g., Baker & Maner, 2008, 2009; Daly & Wilson, 2001). This is consistent with research suggesting that women (particularly women near ovulation) find personality characteristics signaled by risk taking (e.g., confidence, dominance, and ambition) to be particularly attractive (Buss, 1989; Gangestad et al., 2007; Li, Bailey, Kenrick, & Linsenmeier, 2002). The risk-taking displays of men therefore can increase the likelihood of attracting a mate. Thus, if cues of fertility activate male mating motives, then those cues should lead men to display a proclivity for risk taking (we test this prediction in Study 3). Indeed, this would be consistent with nonhuman animal research demonstrating increased risk taking among males exposed to female estrous cues (Kavaliers et al., 2001).

Goal-Directed Behavior

An adaptationist perspective implies that fertility cues should influence not only men's psychology but also their overt behavior as well. One type of behavior that has received attention among relationship researchers is behavioral mimicry. Several studies have suggested that one's current affiliative and mating-related goals can significantly influence the degree to which people mimic one another's nonverbal behavior (Lakin & Chartrand, 2003). For example, increases in men's short-term mating desires are associated with increases in men's tendency to mimic attractive women (van Straaten, Engels, Finkenauer, & Holland, 2008). Additionally, compared with individuals already in a relationship, single individuals (who presumably are more motivated than committed individuals to find a new romantic partner) are more likely to mimic an attractive, opposite-sex partner (Karremans & Verwijmeren, 2008). As a result of this mimicry, single individuals may increase the probability that an opposite-sex partner will evaluate them favorably (Chartrand & Bargh, 1999; Lakin, Jefferis, Cheng, & Chartrand, 2003), thereby moving closer to satisfying their affiliative and romantic goals. Thus, if cues of women's fertility activate mating motives in men, those cues should lead men to

display behavioral mimicry toward a female partner. We tested this prediction in Study 3.

The Current Research

In three experiments, we tested the hypothesis that women's fertility cues prime mating motives in men, as indicated by changes in their psychology and behavior. In Study 1, we examined whether a cue of women's fertility (the scent of a woman in the late follicular phase, near ovulation) increased the accessibility of sexual concepts. In Study 2, we examined whether the scent of a woman at the peak of her fertility would increase men's perceptions of a woman's sexual interest. In Study 3, we moved our analysis to a more naturalistic (yet still highly controlled) setting in which men interacted with a naturally cycling female confederate and examined whether shifts in her level of fertility across the menstrual cycle influenced men's risky decision making and behavioral mimicry.

Study 1

In Study 1, we examined whether scent cues of a woman's fertility would lead men to display heightened implicit accessibility to sexual concepts. To measure the accessibility of sexual concepts, we asked men to perform a word-stem completion task. We predicted that men would generate more sexually tinged words after exposure to the scent of a woman in her fertile window than after exposure to a control scent or scent of a woman outside her fertile window.

In addition to predicting an effect of fertility condition on the accessibility of sexual concepts, we also explored the potential moderating effect of individual differences in smell sensitivity. People vary considerably in their conscious sensitivity to smells in the environment (Nordin, Millqvist, Löwhagen, & Bende, 2003). Consequently, scent cues of fertility may influence men who report being highly sensitive to odors more so than men who report being less sensitive to odors. Thus, although cues of fertility are expected to affect responses among men in general, the influence of certain cues (e.g., scent) may depend upon the degree to which men are aware of those cues.

Method

Participants. Sixty-eight undergraduate men (age range: 18–23 years) participated for course credit. Three men were excluded because they were assigned to a T-shirt worn by a woman who did not follow instructions (see next section).[1]

Odor collection. Eleven women (age range: 18–21) not on hormonal contraceptives participated for course credit and $10. In a pretesting session, these women indicated that they had regular menstrual cycles of approximately 26–34 days in length. Odor collection procedures were similar to those used in previous studies (Singh & Bronstad, 2001). On the basis of the date of onset of menstrual blood flow (Day 0), women wore a T-shirt during the nights of Days 13, 14, and 15 (late follicular phase, near ovulation) and wore another T-shirt during the nights of Days 20, 21, and 22 (luteal phase, far from ovulation). The order in which women wore the T-shirts was counterbalanced. During each day, the T-shirt was placed in a sealed freezer bag. To reduce extraneous odors, during each 3-day session women showered with unscented soap and shampoo and refrained from (a) using perfumes, deodorants, and antiperspirants; (b) eating odor-producing food (e.g., chili, garlic, pepper, vinegar, asparagus); (c) smoking cigarettes, drinking alcohol, and using drugs; and (d) engaging in sexual activity and sleeping in the same bed as someone else. After each 3-day session, women returned the T-shirt to the experimenter and reported on whether she had refrained from the aforementioned activities. One woman indicated that she had used drugs during both T-shirt sessions, so her data were excluded from analyses. All other women adhered to instructions. Additionally, a trained research assistant smelled the T-shirts and confirmed that none smelled of extraneous odors (e.g., perfume, smoke). Shirts were kept in a freezer when not in use. All shirts were used within 6 days of being worn.

Procedure. Participants were told by a female experimenter that the purpose of the study was to examine how scent influences cognition. Participants were informed that they would smell a T-shirt worn previously by a woman; no mention was made of ovulation or fertility status. Each participant was randomly assigned to one of three conditions: late follicular, luteal, or control. Men in the late follicular and luteal conditions smelled a T-shirt worn by a woman during the respective nights of her cycle (late follicular = Days 13–15; luteal = Days 20–22). T-shirts were randomly assigned to participants with the constraint that, for each T-shirt supplier, a similar number of men (within 1) smelled her T-shirt supplied during the late follicular phase and her T-shirt supplied during the luteal phase (e.g., if three men smelled supplier A's T-shirt worn during the late follicular phase, then two–four men smelled supplier A's T-shirt worn during the luteal phase). Men in the control condition were also told that they would smell a T-shirt worn previously by a woman; however, they actually smelled a T-shirt not worn by anyone. Each participant was instructed to put his nose to the opening of a plastic bag containing a T-shirt and to take three large inhalations. Both experimenters and participants were blind to the T-shirt condition.

Participants were then given a word-stem completion task for which they were asked to complete 10-word fragments (s _ x; _ _ ck; _ ips; _ i _ k; _ ak _ d; _ um; _ l _ t; _ ouch; p _ n _ s; o _ al). Each word fragment could be completed in such a manner as to make at least one sexual word and at least one nonsexual word. The number of sexual word completions was calculated for each participant and served as the dependent variable.

Last, participants completed the Chemical Sensitivity Scale (CSS; Nordin et al., 2003). The CSS is a 21-item measure examining individual differences in smell sensitivity. Participants rated their agreement to items (e.g., "I am easily alerted by odorous/pungent substances") on a 6-point scale ranging from 1 (*Disagree Strongly*) to 6 (*Agree Strongly*). Scoring high on this measure indicates greater awareness of odors in one's environment. Total scores, after reverse-scoring appropriate items, were calculated for each participant ($\alpha = .72$). CSS scores did not vary by condition, $F(2, 62) < 1$.

[1] The participants from Studies 1 and 2 were part of studies reported elsewhere (S. L. Miller & Maner, 2010). However, none of the data presented in this article were reported in that article.

Results

Four participants failed to complete the CSS measure; we imputed the mean for those participants. Using regression, we predicted the number of sexual word completions from an a priori contrast comparing men in the late follicular condition with men in the luteal and control conditions (contrast vector: 2 –1 –1), an a priori contrast comparing men in the luteal condition with men in the control condition (contrast vector: 0 1 –1), the CSS, and the centered interactions between the CSS and each contrast. As predicted, we observed an effect of the first contrast, such that men in the late follicular condition generated more sexual words than did men in the luteal and control conditions ($\beta = .26$, $p = .04$, partial $r = .26$; see Figure 1). No other effects approached significance (all ps $> .20$).

Post hoc comparisons between each pair of conditions were assessed with dummy coding (because no effects of CSS were found, it was omitted from the model). Those comparisons indicated that men exposed to the scent of a woman in the late follicular phase generated a (marginally) greater number of sexual words than did men exposed to the scent of a woman in the luteal phase ($\beta = .24$, $p = .09$, partial $r = .21$) and significantly more sexual words than did men exposed to a control scent ($\beta = .28$, $p = .05$, partial $r = .25$; late follicular: $M = 5.32$, $SD = 2.10$; luteal: $M = 4.29$, $SD = 2.19$; control: $M = 4.05$, $SD = 1.68$). Men in the luteal and control conditions did not differ from one another ($\beta = .05$, $p = .70$, partial $r = .05$).

Discussion

Exposure to the scent of women's fertility led men to display greater implicit accessibility to mating-related concepts. Men exposed to the scent of a woman in the late follicular phase (i.e., close to ovulation) generated more sexually tinged words on a word-stem completion task than did men exposed to the scent of a woman in the luteal phase (i.e., far from ovulation) or a control scent. This was true regardless of men's self-reported sensitivity to odors. These findings are consistent with other studies indicating that olfactory signals serve as an important means by which women's fertility is detected by others (Singh & Bronstad, 2001; Thornhill et al., 2003). Moreover, the heightened accessibility to sexual concepts is consistent with the presence of an activated mating motive. These findings thus provide preliminary support for the general hypothesis that fertility cues prime mating motivation in men.

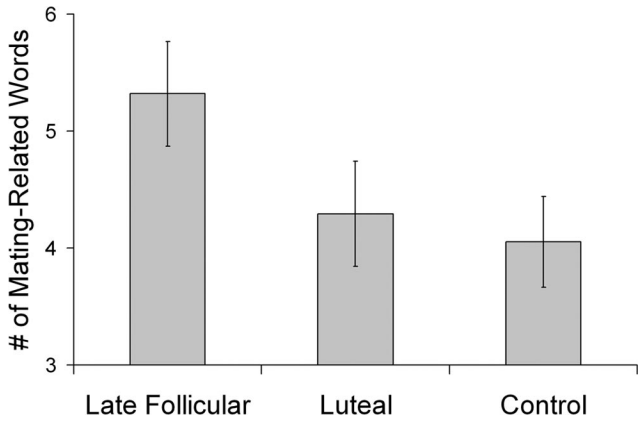

Figure 1. In Study 1, men exposed to the scent of a woman in the late follicular phase generated more mating-related words on a word-stem completion task than did men exposed to the scent of a woman in the luteal phase or a control scent. Errors bars represent standard errors.

Study 2

In Study 2 we examined how cues of fertility influence men's perceptions of women. Evidence suggests that activating a mating motive leads men to see greater levels of sexual arousal in women (Maner et al., 2005). Thus, in the current study we examined whether exposure to the scent of a woman close to peak fertility would increase men's perceptions of women's levels of sexual arousal.

In the current study, men were exposed to the scent of a woman in the late follicular phase or luteal phase and asked to rate the degree to which that woman was feeling sexually aroused. To demonstrate the specificity of the hypothesized effect, we also measured perceptions of a number of other emotions (i.e., fear, anger, happiness). We predicted that the scent of fertility would increase men's perceptions of women's sexual arousal but not the other emotions. As in Study 1, we also examined the potential moderating role of men's self-reported sensitivity to odors by testing whether the effects of fertility status on perceptions of sexual arousal would be more pronounced among men high in odor sensitivity than among men low in odor sensitivity.

Method

Participants. Thirty-seven undergraduate men (age range: 18–23) participated for course credit.

Odor collection. Four women (age range: 18–19) with regular menstrual cycles and not on hormonal contraceptives participated for course credit and $10. All women first wore a T-shirt during the nights of Days 13–15 (late follicular phase) and then wore another T-shirt on Days 20–22 (luteal phase).[2] All women indicated that they had adhered to instructions for remaining odor-neutral. Additionally, a trained research assistant confirmed that none smelled of extraneous odors. As noted earlier, women tend to experience greater levels of sexual desire when ovulating (e.g., Regan, 1996). Therefore, we asked women to indicate how sexually desirous they felt during the time they wore the T-shirts on a 9-point scale ranging from 1 (*Not at all*) to 9 (*Very much*).

Procedure. Procedures for smelling the T-shirt were identical to those in Study 1 with one exception. Given that there was no difference between the luteal and control condition in Study 1, the control condition was dropped from the current experiment. Thus, participants were randomly assigned to one of two conditions: the late follicular condition or the luteal condition. Both experimenters and participants were blind to the T-shirt condition.

[2] Ancillary analyses from Study 1 revealed that the order in which T-shirts were supplied (late follicular first vs. luteal first) had no effect on the number of mating-related words completed by male participants, $F(1, 44) < 1$. Therefore, to simplify the design, we did not counterbalance the order in which the women wore the T-shirts.

After smelling the T-shirt, participants completed an emotion perception task used in previous research to investigate effects of mating motivation on interpersonal perception (Maner et al., 2005). As part of the cover story, participants were informed by a female experimenter that, while wearing the T-shirt, the female shirt supplier was asked to relive in her mind an emotionally arousing event. We told participants that people can sometimes identify another person's emotional state through scent. Participants were asked to rate the degree to which they thought the shirt supplier was feeling each of four emotions—angry, happy, scared, and sexually aroused—on 9-point Likert-type scales ranging from 1 (*Not at all*) to 9 (*Very much*).

Last, participants completed the CSS (Nordin et al., 2003). Total scores, after reverse-scoring appropriate items, were calculated for each participant ($\alpha = .81$). CSS scores did not vary by condition, $F(1, 35) < 1$.

Results

Using a mixed-design general linear model, we predicted participants' ratings of emotional intensity from T-shirt condition (late follicular vs. luteal; between-subjects), CSS (between-subjects), and emotion (sexual arousal vs. other emotions; within-subjects); to account for variance across the four T-shirt suppliers, we included T-shirt supplier (dummy-coded) as a covariate in all analyses. Results revealed a main effect of emotion, an interaction between emotion and T-shirt condition, an interaction between emotion and CSS, and an interaction between T-shirt condition and CSS (all ps $< .05$). However, these were all qualified by a three-way interaction between T-shirt condition, emotion, and CSS, $F(1, 30) = 6.75$, $p = .01$, partial $\eta^2 = .18$.

For each of the four emotions, we performed multiple regression analyses in which emotion ratings were predicted from T-shirt condition, CSS, and their centered interaction. No significant main effects or interactions emerged for perceptions of happiness, anger, and fear. For sexual arousal, we observed nonsignificant main effects of CSS ($\beta = –.16$, $p = .32$, partial $r = –.18$) and T-shirt condition ($\beta = .15$, $p = .32$, partial $r = .18$). Although nonsignificant, the effect of T-shirt condition was in the expected direction: Participants tended to perceive the T-shirt supplier as more sexually aroused in the late follicular condition than in the luteal condition. Importantly, though, we did observe an interaction between T-shirt condition and CSS on perceptions of sexual arousal ($\beta = .52$, $p = .002$, partial $r = .52$). To interpret the interaction, we assessed the simple effect of the T-shirt condition at high (1 standard deviation above the mean) and low (1 standard deviation below the mean) levels of CSS ($M = 69.03$, $SD = 11.87$). These analyses revealed that the scent of a woman in the late follicular phase (compared with the scent of a woman in the luteal phase) caused odor-sensitive participants (high CSS) to rate the T-shirt wearer as substantially more sexually aroused ($\beta = .69$, $p < .01$, partial $r = .49$; late follicular: estimated $M = 5.43$, $SE = 0.40$; luteal: estimated $M = 3.31$, $SE = 0.53$). Participants scoring low on the CSS scale, in contrast, did not show this effect ($\beta = –.38$, $p = .09$; late follicular: estimated $M = 4.41$, $SE = 0.44$; luteal: estimated $M = 5.59$, $SE = 0.46$).

As in previous research (e.g., Regan, 1996), women tended to rate their level of sexual desire as higher during the late follicular phase ($M = 2.59$, $SD = 1.50$) than during the luteal phase ($M = 1.50$, $SD = 0.43$). Thus, the effect of fertility cues on men's perceptions of sexual arousal could reflect a couple of different mechanisms. Changes in men's perceptions of sexual arousal could simply reflect actual changes in women's sexual desire; perhaps men accurately detected women's level of sexual interest and altered their perceptions of sexual arousal accordingly. Alternatively, if men's perceptions of sexual arousal reflected the activation of mating motives, one would expect to see increases in men's perception of sexual arousal over and above any actual changes in women's sexual interest. This would be consistent with research demonstrating that mating motives lead men to overperceive sexual interest: They see women as sexually aroused even when those women display no actual arousal at all (Maner et al., 2005).

Thus, we conducted additional analyses in which we controlled for the T-shirt wearer's actual level of sexual arousal. Results revealed a main effect of T-shirt condition that approached significance ($\beta = .40$, $p = .07$, partial $r = .33$), such that men exposed to the scent of a woman in the late follicular phase rated that woman as more sexually aroused than did men exposed to the scent of a woman in the luteal phase, over and above any actual changes in the woman's actual level of sexual arousal. This suggests that changes in men's perceptions reflected the activation of mating motives, rather than simply the accurate detection of women's sexual arousal. There was no main effect of CSS ($\beta = –.14$, $p = .38$). We again observed an interaction between CSS and T-shirt condition ($\beta = .56$, $p = .001$, partial $r = .56$). As seen in Figure 2, over and above any actual changes in women's self-reported sexual desire, the scent of a woman in the late follicular phase (compared with the luteal phase) caused high CSS participants to rate the T-shirt wearer as more sexually aroused ($\beta = .97$, $p = .002$, partial $r = .54$; late follicular: estimated $M = 5.84$, $SE = 0.47$; luteal: estimated $M = 2.86$, $SE = 0.58$). Low CSS participants, in contrast, did not show this effect ($\beta = –.18$, $p = .47$; late

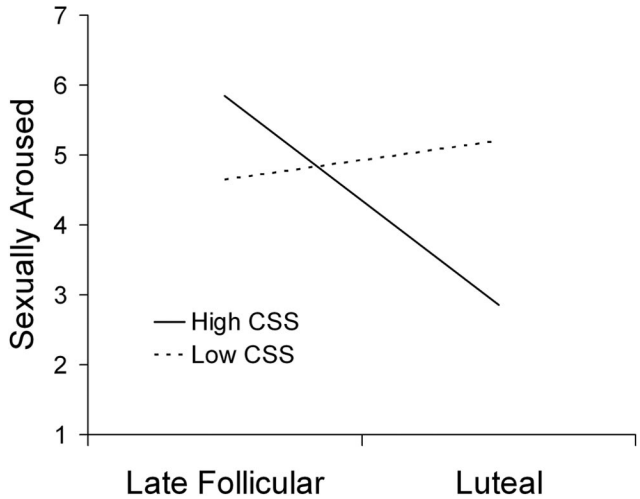

Figure 2. In Study 2, among men who reported being particularly sensitive to smells (high CSS), exposure to the scent of a woman in the late follicular phase led to increased perceptions of sexual arousal in that woman. No such effect was observed for perceptions of other emotions or for participants scoring low in CSS. CSS = Chemical Sensitivity Scale.

follicular: estimated $M = 4.64$, $SE = 0.45$; luteal: estimated $M = 5.19$, $SE = 0.51$).

Meta-analysis of Studies 1 and 2. The similar designs of Studies 1 and 2 allowed us to meta-analyze their findings. To provide an overall estimate of the size and reliability of the effect of fertility scent cues, we performed a meta-analysis of the effect of T-shirt condition (late follicular vs. luteal) across the first two studies. Consistent with Rosenthal and Rosnow (1991), we first converted to z scores the one-tailed p values for the effect of T-shirt condition. The z-standardized significance levels (and df) for the two studies follow. Study 1: $z = 1.69$ ($df = 62$); Study 2 (without controlling for women's self-reported levels of sexual desire): $z = 0.99$ ($df = 30$). Calculating the overall significance of the effect (weighting by each study's df) revealed a reliable effect of T-shirt condition ($z = 1.95$, $p = .05$); men in the late follicular condition displayed greater mating-related cognitions than did men in the luteal condition. When we used the effect of T-shirt condition from Study 2 while controlling for the T-shirt suppliers' self-reported level of sexual desire ($z = 1.8$, $df = 29$), the overall effect across the two studies was even stronger ($z = 2.29$, $p = .01$).

Discussion

The scent of women's fertility and individual differences in sensitivity to odors interacted to affect men's perceptions of women's sexual arousal. Olfactory cues of fertility (relative to lack of fertility) increased men's perceptions of sexual arousal. This was particularly true for men who reported being sensitive to odors in their environment. Indeed, this effect was not present among men with lower self-reported sensitivity to odors. When controlling for women's self-reported levels of sexual arousal, we again observed the interaction between T-shirt condition and CSS, along with a (marginal) main effect of T-shirt condition. Thus, scent cues of fertility led men to perceive heightened sexual interest in women, and this effect occurred over and above the actual increase in sexual desire experienced by women around ovulation. Moreover, effects in this study were observed only for perceptions of sexual arousal and not for other emotions (happy, angry, scared), thus confirming the specificity of the effect. Enhanced perceptions of women's sexual arousal have been shown to reflect the activation of mating motives in men (Maner et al., 2005). Thus, the current results provide further support for the general hypothesis that cues of fertility prime a mating goal in men. Indeed, a meta-analysis of Studies 1 and 2 confirmed that scents of women in the late follicular phase led men to display greater mating-related cognitions than did scents of women in the luteal phase.

It is interesting that individual differences in CSS moderated effects of scent on perceptions of women's sexual arousal (see Study 2) but not on implicit accessibility to sexual concepts (see Study 1). One potential explanation may involve the conscious nature of the CSS in relation to the different dependent variables in the two studies. Scents can be detected at both implicit and explicit levels; at an implicit level, scents can affect fundamental processes, such as basic physiology and behavior, without the scent ever registering in conscious awareness (Mujica-Parodi et al., 2009). Thus, the extent to which conscious awareness of a scent moderates psychological responses may depend on whether the response involves conscious processes. Because the CSS measures the extent to which people are consciously aware of their ability to perceive scents, it might be expected to exhibit the strongest moderating effects on conscious psychological processes (e.g., explicit judgments and choices). Indeed, in the current study CSS moderated effects on explicit judgments of sexual interest, a variable that involves a substantial degree of conscious processing. The dependent variable in Study 1, in contrast, was a word-stem completion task designed to tap accessibility to more implicit concepts—those that may not be fully conscious (Gilbert & Hixon, 1991). The lack of CSS moderation in Study 1 suggests that men in general are sensitive to fertility cues at an implicit level. Taken together, these findings may suggest a pattern in which the sensory detection of fertility cues primes mating motives at an implicit level, and conscious awareness of the scent promotes further downstream changes in explicit and conscious psychological processes.

Study 3

The previous two studies demonstrated that exposure to scent cues of fertility influenced men's accessibility to sexual concepts and perceptions of women's sexual arousal. One goal of Study 3 was to extend these findings by examining the ways in which fertility cues shape men's decision making and behavior. If cues of fertility enhance men's mating motivation, then cues of fertility should promote decisions and behaviors that reflect the presence of mating motives. Thus, we investigated whether cues of fertility increase men's tendency to mimic a woman (a behavior that reflects attraction between people) and men's tendency to make risky decisions (a decision-making strategy men use to display desirable traits to women).

In addition to expanding the investigation to decision making and behavior, we expanded it by bringing the study into a more naturalistic context (face-to-face interaction). Rather than seeking to isolate scent as the critical cue, we allowed men to be exposed to a variety of cues that might signal a woman's fertility status. Previous research has suggested that, in addition to scent, a range of other subtle characteristics—including facial appearance, vocal pitch, body symmetry, body temperature, skin tone, and waist-to-hip ratio—might change across a woman's menstrual cycle (Kirchengast & Gartner, 2002; Manning et al., 1996; Pipitone & Gallup, 2008; Roberts et al., 2004; Van den Berghe & Frost, 1986). Thus, in face-to-face interactions men may be able to detect shifts in women's fertility via a number of subtle cues. Therefore, in the current study, rather than using T-shirts as stimuli, we had participants interact directly with a female confederate. Moreover, rather than simply exposing men to one of two points in a woman's cycle (late follicular vs. luteal), we assessed men's risk-taking and behavioral mimicry across the female confederate's entire menstrual cycle. Thus, the current study represents a more ecologically valid test of our hypothesis that women's fertility cues influence men's mating motivation.

Method

Participants. Thirty-eight undergraduate men (age range: 18–26) participated for course credit.

Confederate fertility. A woman (age: 21) with a regular menstrual cycle and not taking hormonal contraceptives served as a confederate in the current experiment. The confederate interacted

with male participants on various days across three of her menstrual cycles. Menstrual cycles lasted, on average, 28.7 days (first cycle: 31 days; second cycle: 27 days; third cycle: 28 days). To minimize extraneous odors, the confederate prepared for each session by showering with unscented soap and shampoo and refraining from using deodorant or perfume. In addition, we wanted to ensure that effects would be caused by covert cues (scent, skin tone, vocal pitch, etc.) rather than by overt behaviors on the part of the confederate. Therefore, the confederate underwent extensive training on how to remain expressively neutral when interacting with participants. During each interaction, she was trained to keep conversation to a minimum, only responding with brief answers to any questions that the participants asked. Thus, she appeared polite but not overly interested in the participants. To further minimize variability, on days in which she interacted with participants, the confederate did not wear makeup, pulled her hair back into a ponytail, and wore jeans and a plain T-shirt. Although the confederate was aware that the study had something to do with her menstrual cycle (as we had her track each time she began to menstruate), she was unaware of the specific hypotheses.

Procedure. Male participants arrived at a waiting room where another female student (the confederate) was waiting. A female experimenter, blind to the day of the confederate's cycle, guided the participant and confederate to a lab room with a table, computer, and two chairs. The female confederate always sat in the chair to the left, whereas the participant sat in the chair on the right, closer to the computer. The experimenter explained that the purpose of the study was to examine how groups of individuals worked together.

The confederate and participant first completed a Lego building task. For this task, they were given a box of Legos and asked to build a structure in 5 min. The experimenter then left the room, and the participant and confederate began working on the structure. During the building task, the confederate put her left elbow on the table and placed her left hand on her chin and cheek. She then used her right hand to slowly piece together Legos. The interaction was surreptitiously recorded via a camera on the wall so that coders could evaluate whether participants mimicked the confederate's posture.

The experimenter then informed them that because the initial study was so short, they would perform another task on the computer for a different study. However, because there was only one computer, they would have to take turns completing the task. The experimenter asked the male participant whether he could go first because he was closer to the computer. All participants agreed to this request. The experimenter then told the confederate, in the presence of the participant, that she could wait in the room while the participant completed the task. At this point, the confederate moved her chair back, about 3 feet away from the table. She positioned herself so that it was apparent that she could see the participant's responses on the computer screen.

The participant then performed a computerized blackjack task used in previous research to assess risky decision making (Baker & Maner, 2008; Galinsky, Gruenfeld, & Magee, 2003). This task consisted of 11 trials of blackjack.[3] For each trial, participants indicated whether they would like to "hit" (take another card and risk going over 21) or "stay" (not take another card). Because losing or winning on a given trial could affect decisions for subsequent trials, they were informed that they would not see the outcomes of their decisions immediately after each trial but that they would see the outcomes at the end of the experiment. On three of the trials, it was clear that the best decision was to hit (i.e., the participant had a low score, and thus going over 21 was improbable). On three other trials, it was clear that the best decision was to stay (i.e., the participant had a very high score, and going over 21 was highly probable if he hit). On the remaining five trials, the best choice was more ambiguous. For these trials, the participant had a score of 16. Hitting on 16 reflects a risky choice, as it entails a reasonable likelihood that the participant will go over 21. Staying reflects a safe choice. As in previous research (Baker & Maner, 2008; Galinsky et al., 2003), the number of times participants indicated hit on these five trials constituted the measure of risk taking. The order in which trials occurred was randomized.

After completing the blackjack task, participants filled out a brief questionnaire alone. They were asked to indicate how intelligent, flirtatious, outgoing, and attractive the confederate was on 5-point scales ranging from 1 (*Not at all*) to 5 (*Extremely*). Participants were then debriefed and dismissed.[4]

Results

Calculation of conception risk. Consistent with previous research examining psychological changes across the menstrual cycle (Navarrete, Fessler, Fleischman, & Geyer, 2009), conception risk values (generated by Wilcox et al., 2001) were estimated according to the day of the confederate's cycle on which the interaction took place. Higher values on this measure indicate a higher likelihood of conception after sexual intercourse and thus higher levels of fertility.

Behavioral mimicry. Due to software malfunction or experimenter error, four participants were not recorded while performing the Lego building task. Two independent raters who were blind to hypotheses and phase of the confederate's menstrual cycle watched the remaining videos and indicated whether the participant put his elbow on the desk and touched his face at some point during the interaction (i.e., whether he mimicked the posture of the confederate). The raters agreed 79% of the time. In cases of disagreement, a third, independent rater, also blind to hypotheses and phase of the confederate's cycle, made the final determination. Descriptive analyses revealed that 27% of participants mimicked the confederate's behavior.

To test the hypothesis that men would be more likely to mimic the confederate as fertility levels increased, we used logistic regression to predict behavioral mimicry from the confederate's probability of conception. Consistent with predictions, increased probability of conception was associated with an increased probability of behavioral mimicry ($b = 24.4$), Wald $\chi^2(1) = 3.65$, $p = .05$, Nagelkerke $r^2 = .16$ (see Figure 3). Of the participants who interacted with the confederate between Days 10 and 15 of her

[3] All participants indicated on a follow-up questionnaire that they were familiar with the rules of blackjack and had at some point either watched others play blackjack or played it themselves.

[4] The CSS was omitted from the study protocol primarily because Study 3 was not set up to focus specifically on scent as a fertility cue. Additionally, the demanding procedure of the study, coupled with time constraints, limited our ability to collect information about individual differences.

cycle (days of highest fertility), 63% mimicked the confederate's behavior; of the participants who interacted with the confederate before Day 10 or after Day 15 (lower fertility), only 15% mimicked her behavior.

Risky decision making. To examine whether men's risky decision making was influenced by fertility status, we regressed the number of times participants hit in the critical trials of the blackjack task on the confederate's probability of conception. As hypothesized, as conception risk increased, participants made more "hit" responses ($b = 20.98$, $p = .01$, $r^2 = .16$; see Figure 4). Between Days 10 and 15 of the confederates cycle, men made, on average, 3.2 hits ($SD = 1.5$), whereas during other days of her cycle, men made, on average, 2.07 ($SD = 1.63$) hits.

Ancillary analyses. We performed additional analyses to rule out the possibility that changes in men's behaviors across the menstrual cycle were produced by changes in the confederate's overt behavior (as opposed to more subtle fertility cues). Two raters, blind to hypotheses and phase of the confederate's cycle, indicated how flirtatious and outgoing the confederate appeared to be in the videotaped interaction. On average, the raters perceived the confederate to be slightly less outgoing ($M = 2.58$, $SD = 0.79$) and flirtatious ($M = 2.57$, $SD = 0.76$) than average. More importantly, regressing the raters' averages onto conception risk revealed that the confederate's behavior did not vary as a function of her conception risk (outgoingness: $\beta = -.06$, $p = .75$; flirtatiousness: $\beta = -.19$, $p = .27$).[5]

As another test, participants' perceptions of the confederate's intelligence, attractiveness, outgoingness, and flirtatiousness were all regressed on conception risk; none of these analyses produced significant results (intelligence: $\beta = .16$, $p = .35$; attractiveness: $\beta = .05$, $p = .75$; outgoingness: $\beta = .21$, $p = .20$; flirtatiousness: $\beta = .02$, $p = .86$). Indeed, participants consistently rated the confederate as slightly more attractive ($M = 3.45$, $SD = 0.79$) and intelligent ($M = 3.39$, $SD = 0.54$) than average but slightly less outgoing ($M = 2.68$, $SD = 0.87$) and much less flirtatious ($M = 1.92$, $SD = 0.74$) than average. Thus, neither objective coders nor the participants themselves perceived any changes in the confederate's overt behavior across the menstrual cycle.

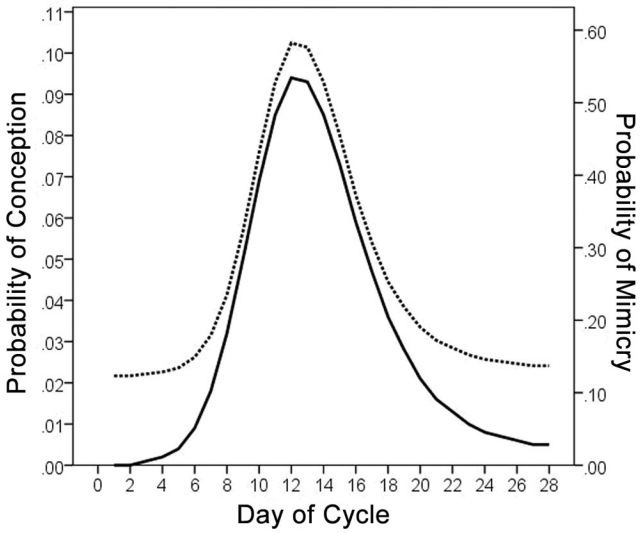

Figure 3. In Study 3, the female confederate's conception risk significantly predicted male participants' tendency to mimic her. The solid line indicates the probability of conception risk for each day of the female confederate's cycle. The dotted line indicates the estimated probability of the male participants' behavioral mimicry of the female confederate from the logistic regression equation.

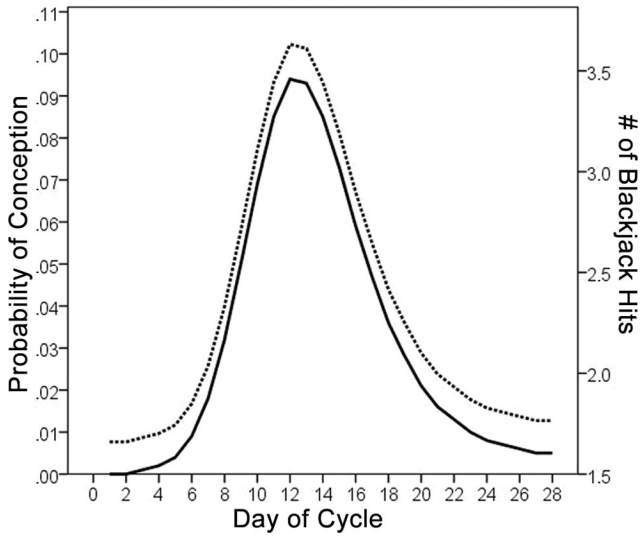

Figure 4. In Study 3, the female confederate's conception risk significantly predicted male participants' number of hits in a blackjack task. The solid line indicates the probability of the female confederate's conception risk for each day of her cycle. The dotted line indicates the estimated number of hits from the regression equation.

Discussion

Study 3 supports the hypothesis that cues of women's fertility promote psychological and behavioral processes associated with mating motivation. When interacting with a woman at times of high fertility (i.e., high conception risk), men were more likely to mimic that woman's posture and were more likely to make risky decisions. Both mimicry (Karremans & Verwijmeren, 2008) and risk taking (Baker & Maner, 2009) have been shown to reflect high levels of mating motivation. Mimicry and risk taking can increase a man's desirability to a potential partner, and thus these responses may reflect a man's desire to attract a partner.

Unlike the previous two experiments, this experiment did not isolate scent as the key cause of men's responses. Indeed, there are other subtle cues—such as subtle changes in facial appearance or vocal tone—that vary with a woman's level of fertility (Pipitone & Gallup, 2008; Roberts et al., 2004). Nevertheless, the experiment did rule out the possibility that men's responses were caused by overt aspects of the confederate's behavior. Neither participants nor objective coders noticed differences in the confederate's be-

[5] Including the video raters' average ratings of outgoingness and flirtatiousness as covariates in the primary regression analyses did not reduce the relationship between conception risk and mimicry ($b = 32.9$, $p = .04$) and only slightly reduced the relationship between conception risk and risk taking ($b = 16.18$, $p = .08$).

havior as a function of her fertility status, and participants rated her level of flirtation as quite low. Thus, data from this study demonstrate that, even in a carefully controlled face-to-face interaction, men's behavior was influenced by relatively subtle signs of a woman's fertility. The current study, therefore, provides evidence that subtle fertility cues influenced men's mating motivation in an ecologically valid context.

General Discussion

Across a wide range of species, social interactions between males and females are shaped by the female's level of fertility. Females' fertility motivates males to adopt an orientation toward mating, thus enhancing the likelihood of sexual courtship. The current research provides new evidence that a similar process occurs in humans. Across three studies, subtle cues of fertility produced cognitive and behavioral processes in men reflecting heightened mating motivation. In Study 1, the scent of women near peak levels of fertility heightened the men's implicit accessibility to sexual concepts. Study 2 demonstrated that, among men who reported being particularly sensitive to odors, scent cues of fertility triggered heightened perceptions of women's sexual arousal. Study 3 revealed that in a face-to-face interaction, cues of fertility increased men's tendency to make risky decisions and to behaviorally mimic a female partner. Previous research has linked each of these responses to the presence of mating-related motives. The current studies thus demonstrate a consistent pattern whereby subtle fertility cues elicited a cascade of motivationally tinged responses—from lower order cognition to overt behavior—reflecting activation of men's mating goal.

Although previous research has suggested that men possess adaptations designed to detect and respond to women's shifting fertility levels, previous studies have provided only limited evidence for the hypothesis that fertility cues shape men's mating motivation. Some studies have reported that men subjectively rate facial characteristics, voices, and odors of women close to ovulation as particularly pleasant and attractive (Havlíček et al., 2006; Pipitone & Gallup, 2008; Roberts et al., 2004; Singh & Bronstad, 2001; Thornhill et al., 2003). However, by focusing rather exclusively on subjective assessments, those studies have in certain respects fallen short of investigating the fuller range of cognitive and behavioral consequences designed to facilitate mating. Other studies have examined men's behavioral reactions to shifts in fertility (Gangestad et al., 2002; Haselton & Gangestad, 2006; G. Miller et al., 2007), but those studies have tended to lack the experimental control needed to pinpoint the role of subtle fertility cues (as opposed to women's overt behavior) as the cause of men's reactions. The current research, therefore, builds on previous research to provide the first rigorous, controlled experimental investigation of the effects of women's fertility on men's cognition and behavior. Findings from this research provide convergent evidence for the hypothesis that women's fertility primes mating motivation in men.

The Utility of an Evolutionary Psychological Framework

Evolutionary psychology provides a metatheoretical framework for understanding and predicting social psychological processes. It provides an overarching approach for understanding the nature of social interactions in a variety of domains, including conflict (Daly & Wilson, 1988), altruism (Burnstein, Crandall, & Kitayama, 1994), kinship (Davis & Daly, 1997), social exchange (Cosmides & Tooby, 1992), and prejudice (S. L. Miller, Maner, & Becker, 2010). Nowhere, though, has an evolutionary perspective been applied more extensively than in the realm of mating and romantic relationships (e.g., Buss, Larsen, Westen, & Semmelroth, 1992; Buss & Schmitt, 1993; Kenrick & Keefe, 1992). This makes abundant sense, given that success in mating is the sine qua non of reproductive success.

Within the realm of mating and romantic relationships, studies of psychological changes across the menstrual cycle provide powerful support for an evolutionary approach. Those psychological changes are firmly rooted within evolved biological processes and thus provide a unique window into the adaptive foundations of social relationships.

The current findings provide evidence for men's adaptation to shifting levels of women's fertility. Whereas women may have been selected to suppress cues of ovulation in order to sustain men's commitment, men have been selected to identify fertility cues in order to enhance a short-term mating endeavor's probability of reproductive success (Gangestad et al., 2005a). Although women may have evolved so that they no longer display overt indicators of fertility (e.g., they lack sexual swellings), it is unlikely that all indicators of fertility could be suppressed, because some detectable shifts in hormones are needed to facilitate ovulation. Consequently, men must rely on fairly subtle cues (e.g., changes in scent and skin tone) associated with those hormonal shifts to help them respond adaptively to women's changing levels of fertility (see Little et al., 2007; Penton-Voak et al., 1999; Thornhill & Gangestad, 1999). The current research, therefore, represents a unique examination of how men's and women's mating-related adaptations have coevolved and adds to an emerging body of evidence providing support for evolutionary theories of mating.

It should be noted that an evolutionary perspective does not imply that adaptive psychological processes are immune to cultural context or reflexively driven without input from a dynamic and changing environment. Although people may possess basic mechanisms designed to detect reproductively relevant characteristics in others, the specific ways in which those characteristics elicit overt psychological and behavioral responses likely depend on a number of proximate moderating variables. For example, the extent to which a woman's fertility status elicits a man's mating behavior may depend on the man's orientation toward short-term versus long-term mating (Simpson & Gangestad, 1991), whether the people are already committed to a long-term relationship (Maner, Gailliot, & Miller, 2009), or the availability of other potential partners in the community (Gangestad & Simpson, 2000; Guttentag & Secord, 1983). Indeed, evolved psychological mechanisms work in necessary conjunction with developmental, ecological, and cultural variables to shape cognition and behavior (Kenrick, Li, & Butner, 2003).

Implications for Subtle Processes of Romantic Attraction

Romantic relationships are an essential part of social life. They provide important benefits for mental and physical health and help

satisfy people's basic need for positive social relationships (Baumeister & Leary, 1995). Consequently, understanding the processes that promote romantic attraction is of great theoretical and practical importance. Research has revealed that people prioritize a number of traits when attending to and evaluating potential romantic partners (Cunningham, Barbee, & Pike, 1990; Fletcher, Simpson, Thomas, & Giles, 1999; Li et al., 2002). Most previous studies have focused on the prioritization of traits that are overt and highly recognizable. People typically know, for example, that they prefer attractive, funny, and kind romantic partners and thus can consciously seek those traits in others (cf. Eastwick & Finkel, 2008).

The current research, however, adds to an emerging literature suggesting that romantic attraction is shaped in part by more subtle characteristics possessed by a potential romantic partner—characteristics that may be invisible to the naked eye but that nevertheless produce powerful effects on romantic attraction. The current findings suggest that signs of fertility may promote romantic attraction and, moreover, that these signs can be extremely subtle (e.g., faint scents). Indeed, although men may be romantically attracted to fertile women, we suspect that men are not consciously aware of the degree to which their attraction is influenced by subtle fertility cues such as scent. The current research, therefore, has implications for understanding relatively hidden aspects of romantic attraction and the initiation of romantic relationships.

Implications for Theories of Motivation and Priming

The current research also has implications for the literature on motivation and goal priming. Several studies have suggested that goals can be primed through nonconscious means (e.g., Bargh, Gollwitzer, Lee-Chai, Barndollar, & Trötschel, 2001) and that, when those goals are activated, they affect the way people perceive, evaluate, and behave toward goal-relevant stimuli (Aarts et al., 2005; Bargh et al., 1996; Ferguson & Bargh, 2004). Although this literature provides a valuable foundation for understanding the cognitive processes through which goals are activated and pursued, an evolutionary perspective provides a content-rich framework for specifying the particular goals and goal-relevant stimuli that play a prominent role in everyday social life. From an evolutionary perspective, the goals having the most immediate impact on the perception of social environments are those that, over the course of human history, have been closely linked to solving adaptive social challenges and that ultimately have been linked with reproductive success. Thus, the integration of social cognitive and evolutionary perspectives provides a powerful framework for understanding the specific goals likely to affect social cognition, the specific stimuli likely to prime those goals, and the processes through which those goals are activated and pursued.

The current research also extends a growing literature demonstrating that situational factors can prime mating-related goals. The activation of those goals has been shown to exert profound effects on a vast array of psychological processes including attention (Maner et al., 2007), social perception (Maner et al., 2005), memory (Becker, Kenrick, Guerin, & Maner, 2005), decision making (Daly & Wilson, 2001), consumer spending (Griskevicius et al., 2007), aggression (Griskevicius et al., 2009), and prosocial behavior (Griskevicius et al., 2007). The current research extends this literature by identifying a specific ecologically valid factor (fertility) capable of priming a mating motive. Whereas previous research has tended to prime mating motivation through the use of relatively artificial laboratory tasks such as films, sentence-unscrambling tasks, or hypothetical imagery (e.g., Griskevicius, Cialdini, & Kenrick, 2006; Maner et al., 2007, 2005), the current research used priming techniques that fit better within an adaptationist framework and more closely approximate the processes through which mating goals are activated in actual social situations. An evolutionary approach, therefore, can be useful for generating hypotheses about both the types of goals most relevant to human social interaction and the types of ecologically relevant stimuli likely to activate those goals.

Limitations and Future Directions

Several limitations of the current studies provide useful avenues for future research. One limitation is that these studies focused exclusively on measures of cognition and behavior associated with romantic attraction. Cues of fertility may also be expected to shape other processes as well, such as intrasexual competition, aggression, and mate guarding, particularly in the context of long-term relationships (Burriss & Little, 2006; Daly & Wilson, 2001; Gangestad et al., 2002; Haselton & Gangestad, 2006). Future studies would benefit from examining other conceptually relevant responses to fertility cues.

A second limitation is that we examined the effects of fertility cues only among college-age men. The initiation of new sexual and romantic relationships may be a particularly salient concern for men in this age range (Rowland, Greenleaf, Dorfman, & Davidson, 1993). Whether the current findings generalize to other age groups remains unclear. Effects could be weaker among older or younger (i.e., prepubescent) men, who tend to be less concerned with meeting new partners. Examining moderating effects of age or other relevant individual differences associated with mating (e.g., sociosexual orientation, relationship commitment) provides several valuable avenues for future research.

A third limitation of the current work is that it lacked an analysis of the specific biological compounds associated with women's fertility that men are capable of identifying via scent. Some have suggested that men's responses to women's scents are influenced by copulins in vaginal secretions (Doty, Ford, Preti, & Huggins, 1975), whereas others have argued that steroid hormones and pheromones secreted in sweat play a primary role (Kohl, Atzmueller, Fink, & Grammer, 2007). With respect to the current findings, the latter seems to be a more plausible explanation, given that the scents came from T-shirts worn on the upper half of women's bodies and, furthermore, the T-shirt suppliers reported refraining from sexual behaviors during the nights they wore the T-shirts. Still, identifying the precise compounds influencing women's odors across the cycle remains an important topic for future research.

Conclusion

Romantic attraction is a powerful element of the human experience. In some circumstances, the attraction people feel for one another seems logical and straightforward (e.g., the other person possesses an abundance of positive characteristics and shares sim-

ilar interests). In other cases, however, the reason for the attraction may seem rather bewildering and based on some intangible chemistry. The current research may help explain some of those instances in which chemistry seems to pull people together. By integrating the metatheoretical perspective of evolutionary psychology with theories of motivation and relationship cognition, the current research unveils a relatively hidden undercurrent underlying romantic attraction. Upon encountering subtle cues of fertility, men in the current studies displayed a host of psychological and behavioral responses that reflect activation of a mating motive. These findings bring to light just how finely tuned the mind is to subtle, yet highly reproductively relevant, shifts in biology. The continued integration of theories from evolutionary psychology, social cognition, and close relationships provides a fertile ground for the advancement of psychological science.

References

Aarts, H., Chartrand, T. L., Custers, R., Danner, U., Dik, G., Jefferis, V. E., & Cheng, C. M. (2005). Social stereotypes and automatic goal pursuit. *Social Cognition, 23,* 465–490. doi:10.1521/soco.2005.23.6.465

Abbey, A. (1982). Sex differences in attributions for friendly behavior: Do males misperceive females' friendliness? *Journal of Personality and Social Psychology, 42,* 830–838. doi:10.1037/0022-3514.42.5.830

Baker, M., & Maner, J. K. (2008). Risk-taking as a situationally sensitive male mating strategy. *Evolution & Human Behavior, 29,* 391–395. doi:10.1016/j.evolhumbehav.2008.06.001

Baker, M. D., & Maner, J. K. (2009). Male risk-taking as a context-sensitive signaling device. *Journal of Experimental Social Psychology, 45,* 1136–1139. doi:10.1016/j.jesp.2009.06.006

Bargh, J. A., Chen, M., & Burrows, L. (1996). Automaticity of social behavior: Direct effects of trait concepts and stereotype activation on action. *Journal of Personality and Social Psychology, 71,* 230–244. doi:10.1037/0022-3514.71.2.230

Bargh, J. A., Gollwitzer, P. M., Lee-Chai, A., Barndollar, K., & Trötschel, R. (2001). The automated will: Nonconscious activation and pursuit of behavioral goals. *Journal of Personality and Social Psychology, 81,* 1014–1027. doi:10.1037/0022-3514.81.6.1014

Baumeister, R. F., & Leary, M. R. (1995). The need to belong: Desire for interpersonal attachments as a fundamental human motivation. *Psychological Bulletin, 117,* 497–529. doi:10.1037/0033-2909.117.3.497

Baumeister, R. F., & Vohs, K. D. (2004). Sexual economics: Sex as female resource for social exchange in heterosexual interactions. *Personality and Social Psychology Revie*w, *8,* 339–363. doi:10.1207/s15327957pspr0804_2

Becker, D. V., Kenrick, D. T., Guerin, S., & Maner, J. K. (2005). Concentrating on beauty: Sexual selection and sociospatial memory. *Personality and Social Psychology Bulletin, 31,* 1643–1652. doi:10.1177/0146167205279583

Bone, P. F., & Ellen, P. S. (1999). Scents in the marketplace: Explaining a fraction of olfaction. *Journal of Retailing, 75,* 243–262. doi:10.1016/S0022-4359(99)00007-X

Bullivant, S. B., Sellergren, S. A., Stern, K., Spencer, N. A., Jacob, S., Mennella, J. A., & McClintock, M. K. (2004). Women's sexual experience during the menstrual cycle: Identification of the sexual phase by noninvasive measurement of luteinizing hormone. *Journal of Sex Research, 41,* 82–93. doi:10.1080/00224490409552216

Burley, N. (1979). Evolution of concealed ovulation. *American Naturalist, 114,* 835–858. doi:10.1086/283532

Burnstein, E., Crandall, C., & Kitayama, S. (1994). Some neo-Darwinian decision rules for altruism: Weighing cues for inclusive fitness as a function of the biological importance of the decision. *Journal of Personality and Social Psychology, 67,* 773–789. doi:10.1037/0022-3514.67.5.773

Burriss, R. P., & Little, A. C. (2006). Effects of partner conception risk phase on male perception of dominance in faces. *Evolution and Human Behavior, 27,* 297–305. doi:10.1016/j.evolhumbehav.2006.01.002

Buss, D. M. (1989). Sex differences in human mate preferences: Evolutionary hypotheses tested in 37 cultures. *Behavioral and Brain Sciences, 12,* 1–49. doi:10.1017/S0140525X00023992

Buss, D. M., Larsen, R. J., Westen, D., & Semmelroth, J. (1992). Sex differences in jealousy: Evolution, physiology, and psychology. *Psychological Science, 3,* 251–255. doi:10.1111/j.1467-9280.1992.tb00038.x

Buss, D. M., & Schmitt, D. P. (1993). Sexual strategies theory: An evolutionary perspective on human mating. *Psychological Review, 100,* 204–232. doi:10.1037/0033-295X.100.2.204

Chartrand, T. L., & Bargh, J. A. (1999). The chameleon effect: The perception-behavior link and social interaction. *Journal of Personality and Social Psychology, 76,* 893–910. doi:10.1037/0022-3514.76.6.893

Cosmides, L., & Tooby, J. (1992). Cognitive adaptations for social exchange. In J. Barkow, L. Cosmides, & J. Tooby (Eds.), *The adapted mind: Evolutionary psychology and generation of culture* (pp. 163–228). New York, NY: Oxford University Press.

Cunningham, M. R., Barbee, A. P., & Pike, C. L. (1990). What do women want? Facialmetric assessment of multiple motives in the perception of male facial physical attractiveness. *Journal of Personality and Social Psychology, 59,* 61–72. doi:10.1037/0022-3514.59.1.61

Daly, M., & Wilson, M. (1988). *Homicide.* Hawthorne, NY: Aldine.

Daly, M., & Wilson, M. (2001). Risk-taking, intrasexual competition, and homicide. *Nebraska Symposium on Motivation, 47,* 1–36.

Davis, J. N., & Daly, M. (1997). Evolutionary theory and the human family. *Quarterly Review of Biology, 72,* 407–435. doi:10.1086/419953

Doty, R. L., Ford, M., Preti, G., & Huggins, G. R. (1975, December 26). Changes in the intensity and pleasantness of human vaginal odors during the menstrual cycle. *Science, 190,* 1316–1318. doi:10.1126/science.1239080

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. doi:10.1177/0146167208323103

Eastwick, P. W., & Finkel, E. J. (2008). Sex differences in mate preferences revisited: Do people know what they initially desire in a romantic partner? *Journal of Personality and Social Psychology, 94,* 245–264. doi:10.1037/0022-3514.94.2.245

Feinberg, D. R., Jones, B. C., Smith, M. J. L., Moore, F. R., DeBruine, L. M., Cornwell, R. E., . . . Perrett, D. I. (2006). Menstrual cycle, trait estrogen level, and masculinity preferences in the human voice. *Hormones and Behavior, 49,* 215–222. doi:10.1016/j.yhbeh.2005.07.004

Ferguson, M. J., & Bargh, J. A. (2004). Liking is for doing: The effects of goal pursuit on automatic evaluation. *Journal of Personality and Social Psychology, 87,* 557–572. doi:10.1037/0022-3514.87.5.557

Fessler, D. M. T., Pillsworth, E. G., & Flamson, T. J. (2004). Angry men and disgusted women: An evolutionary approach to the influence of emotions on risk-taking. *Organizational Behavior and Human Decision Processes, 95,* 107–123. doi:10.1016/j.obhdp.2004.06.006

Fitzsimons, G. M., & Bargh, J. A. (2003). Thinking of you: Nonconscious pursuit of interpersonal goals associated with relationship partners. *Journal of Personality and Social Psychology, 84,* 148–164. doi:10.1037/0022-3514.84.1.148

Fletcher, G. J. O., Simpson, J. A., Thomas, G., & Giles, L. (1999). Ideals in intimate relationships. *Journal of Personality and Social Psychology, 76,* 72–89. doi:10.1037/0022-3514.76.1.72

Galinsky, A. D., Gruenfeld, D. H., & Magee, J. C. (2003). From power to action. *Journal of Personality and Social Psychology, 85,* 453–466. doi:10.1037/0022-3514.85.3.453

Gangestad, S. W., Garver-Apgar, C. E., Simpson, J. A., & Cousins, A. J. (2007). Changes in women's mate preferences across the ovulatory

cycle. *Journal of Personality and Social Psychology, 92,* 151–163. doi:10.1037/0022-3514.92.1.151

Gangestad, S. W., & Simpson, J. A. (2000). The evolution of human mating: Trade-offs and strategic pluralism. *Behavioral and Brain Sciences, 23,* 573–587. doi:10.1017/S0140525X0000337X

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, B, 269,* 975–982. doi:10.1098/rspb.2001.1952

Gangestad, S. W., Thornhill, R., & Garver-Apgar, C. E. (2005a). Adaptations to ovulation: Implications for sexual and social behavior. *Current Directions in Psychological Science, 14,* 312–316. doi:10.1111/j.0963-7214.2005.00388.x

Gangestad, S. W., Thornhill, R., & Garver-Apgar, C. E. (2005b). Women's sexual interests across the ovulatory cycle depend on primary partner fluctuating asymmetry. *Proceedings of the Royal Society of London, B, 272,* 2023–2027. doi:10.1098/rspb.2005.3112

Gilbert, D. T., & Hixon, J. G. (1991). The trouble of thinking: Activation and application of stereotypic beliefs. *Journal of Personality and Social Psychology, 60,* 509–517. doi:10.1037/0022-3514.60.4.509

Griskevicius, V., Cialdini, R. B., & Kenrick, D. T. (2006). Peacocks, Picasso, and parental investment: The effects of romantic motives on creativity. *Journal of Personality and Social Psychology, 91,* 63–76. doi:10.1037/0022-3514.91.1.63

Griskevicius, V., Goldstein, N. J., Mortensen, C. R., Cialdini, R. B., & Kenrick, D. T. (2006). Going along versus going alone: When fundamental motives facilitate strategic (non)conformity. *Journal of Personality and Social Psychology, 91,* 281–294. doi:10.1037/0022-3514.91.2.281

Griskevicius, V., Tybur, J. M., Gangestad, S. W., Perea, E. F., Shapiro, J. R., & Kenrick, D. T. (2009). Aggress to impress: Hostility as an evolved context-dependent strategy. *Journal of Personality and Social Psychology, 96,* 980–994. doi:10.1037/a0013907

Griskevicius, V., Tybur, J. M., Sundie, J. M., Cialdini, R. B., Miller, G. F., & Kenrick, D. T. (2007). Blatant benevolence and conspicuous consumption: When romantic motives elicit strategic costly signals. *Journal of Personality and Social Psychology, 93,* 85–102. doi:10.1037/0022-3514.93.1.85

Guttentag, M., & Secord, P. F. (1983). *Too many women? The sex ratio question.* Beverly Hills, CA: Sage.

Harvey, S. M. (1987). Female sexual behaviour: Fluctuations during the menstrual cycle. *Journal of Psychosomatic Research, 31,* 101–110. doi:10.1016/0022-3999(87)90104-8

Haselton, M. G., & Buss, D. M. (2000). Error management theory: A new perspective on biases in cross-sex mind reading. *Journal of Personality and Social Psychology, 78,* 81–91. doi:10.1037/0022-3514.78.1.81

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. doi:10.1016/j.yhbeh.2005.10.006

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,* 40–45. doi:10.1016/j.yhbeh.2006.07.007

Haselton, M. G., & Nettle, D. (2006). The paranoid optimist: An integrative evolutionary model of cognitive biases. *Personality and Social Psychology Review, 10,* 47–66. doi:10.1207/s15327957pspr1001_3

Havlíček, J., Dvořáková, R., Bartoš, L., & Flegr, J. (2006). Non-advertised does not mean concealed: Body odour changes across the menstrual cycle. *Ethology, 112,* 81–90. doi:10.1111/j.1439-0310.2006.01125.x

Hill, S. E., & Durante, K. M. (2009). Do women feel worse to look their best? Testing the relationship between self-esteem and fertility status across the menstrual cycle. *Personality and Social Psychology Bulletin, 35,* 1592–1601. doi:10.1177/0146167209346303

Holland, R. W., Hendriks, M., & Aarts, H. (2005). Smells like clean spirit: Nonconscious effects of scent on cognition and behavior. *Psychological Science, 16,* 689–693. doi:10.1111/j.1467-9280.2005.01597.x

Karremans, J. C., & Verwijmeren, T. (2008). Mimicking attractive opposite-sex others: The role of romantic relationship status. *Personality and Social Psychology Bulletin, 34,* 939–950. doi:10.1177/0146167208316693

Kavaliers, M., Choleris, E., & Colwell, D. D. (2001). Brief exposure to female odors "emboldens" male mice by reducing predator-induced behavioral and hormonal responses. *Hormones and Behavior, 40,* 497–509. doi:10.1006/hbeh.2001.1714

Kawada, C. L. K., Oettingen, G., Gollwitzer, P. M., & Bargh, J. A. (2004). The projection of implicit and explicit goals. *Journal of Personality and Social Psychology, 86,* 545–559. doi:10.1037/0022-3514.86.4.545

Kendrick, K. M., & Dixson, A. F. (1983). The effect of the ovarian cycle on the sexual behaviour of the common marmoset (*Callithrix jacchus*). *Physiology and Behavior, 30,* 735–742. doi:10.1016/0031-9384(83)90171-3

Kenrick, D. T., & Keefe, R. C. (1992). Age preferences in mates reflect sex differences in reproductive strategies. *Behavioral and Brain Sciences, 15,* 75–133.

Kenrick, D. T., Li, N. P., & Butner, J. (2003). Dynamical evolutionary psychology: Individual decision rules and emergent social norms. *Psychological Review, 110,* 3–28. doi:10.1037/0033-295X.110.1.3

Kirchengast, S., & Gartner, M. (2002). Changes in fat distribution (WHR) and body weight across the menstrual cycle. *Collegium Antropologicum, 26,* 47–57.

Kohl, J. V., Atzmueller, M., Fink, B., & Grammer, K. (2007). Human pheromones: Integrating neuroendocrinology and ethology. *Activitas Nervosa Superior, 49,* 123–135.

Lakin, J. L., & Chartrand, T. L. (2003). Using nonconscious behavioral mimicry to create affiliation and rapport. *Psychological Science, 14,* 334–339. doi:10.1111/1467-9280.14481

Lakin, J. L., Jefferis, V. E., Cheng, C. M., & Chartrand, T. L. (2003). The chameleon effect as social glue: Evidence for the evolutionary significance of nonconscious mimicry. *Journal of Nonverbal Behaviour, 27,* 145–162. doi:10.1023/A:1025389814290

Li, N. P., Bailey, J. M., Kenrick, D. T., & Linsenmeier, J. A. W. (2002). The necessities and luxuries of mate preferences: Testing the tradeoffs. *Journal of Personality and Social Psychology, 82,* 947–955. doi:10.1037/0022-3514.82.6.947

Little, A. C., Jones, B. C., & Burriss, R. P. (2007). Preferences for masculinity in male bodies change across the menstrual cycle. *Hormones and Behavior, 51,* 633–639. doi:10.1016/j.yhbeh.2007.03.006

Maner, J. K., Gailliot, M. T., & Miller, S. L. (2009). The implicit cognition of relationship maintenance: Inattention to attractive alternatives. *Journal of Experimental Social Psychology, 45,* 174–179. doi:10.1016/j.jesp.2008.08.002

Maner, J. K., Gailliot, M. T., Rouby, D. A., & Miller, S. L. (2007). Can't take my eyes off of you: Attentional adhesion to mates and rivals. *Journal of Personality and Social Psychology, 93,* 389–401. doi:10.1037/0022-3514.93.3.389

Maner, J. K., Kenrick, D. T., Becker, D. V., Robertson, T., Hofer, B., Neuberg, S. L., . . . Schaller, M. (2005). Functional projection: How fundamental social motives can bias interpersonal perception. *Journal of Personality and Social Psychology, 88,* 63–78. doi:10.1037/0022-3514.88.1.63

Maner, J. K., Miller, S. L., Rouby, D. A., & Gailliot, M. T. (2009). Intrasexual vigilance: The implicit cognition of romantic rivalry. *Journal of Personality and Social Psychology, 97,* 74–87. doi:10.1037/a0014055

Manning, J. T., Scutt, D., Whitehouse, G. H., Leinster, S. J., & Walton,

J. M. (1996). Asymmetry and the menstrual cycle in women. *Ethology and Sociobiology, 17,* 129–143. doi:10.1016/0162-3095(96)00001-5

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,* 375–381. doi:10.1016/j.evolhumbehav.2007.06.002

Miller, S. L., & Maner, J. K. (2010). Scent of a woman: Men's testosterone responses to olfactory ovulation cues. *Psychological Science, 21,* 276–283. doi:10.1177/0956797609357733

Miller, S. L., Maner, J. K., & Becker, D. V. (2010). Self-protective biases in group categorization: Threat cues shape the psychological boundary between "us" and "them." *Journal of Personality and Social Psychology, 99,* 62–77.

Mitchell, D. J., Kahn, B. E., & Knasko, S. C. (1995). There's something in the air: Effects of congruent and incongruent ambient odor on consumer decision-making. *Journal of Consumer Research, 22,* 229–238. doi:10.1086/209447

Mujica-Parodi, L. R., Strey, H. H., Frederick, B., Savoy, R., Cox, D., Botanov, Y., . . . Weber, J. (2009). Chemosensory cues to conspecific emotional stress activate amygdala in humans. *PLoS ONE, 4,* E6415. doi:10.1371/journal.pone.0006415

Navarrete, C. D., Fessler, D. M. T., Fleischman, D. S., & Geyer, J. (2009). Race bias tracks conception risk across the menstrual cycle. *Psychological Science, 20,* 661–665. doi:10.1111/j.1467-9280.2009.02352.x

Nordin, S., Millqvist, E., Löwhagen, O., & Bende, M. (2003). The Chemical Sensitivity Scale: Psychometric properties and comparison with the Noise Sensitivity Scale. *Journal of Environmental Psychology, 23,* 359–367. doi:10.1016/S0272-4944(03)00002-1

Pankevich, D. E., Baum, M. J., & Cherry, J. A. (2004). Olfactory sex discrimination persists, whereas the preference for urinary odorants from estrous females disappears in male mice after vomeronasal organ removal. *Journal of Neuroscience, 24,* 9451–9457. doi:10.1523/JNEUROSCI.2376-04.2004

Penton-Voak, I. S., Perrett, D. I., Castles, D., Kobayashi, T., Burt, M., Murray, L. K., & Minamisawa, R. (1999, June 24). Menstrual cycle alters face preference. *Nature, 399,* 741–742. doi:10.1038/21557

Pipitone, R. N., & Gallup, G. G. (2008). Women's voice attractiveness varies across the menstrual cycle. *Evolution and Human Behavior, 29,* 268–274. doi:10.1016/j.evolhumbehav.2008.02.001

Regan, P. C. (1996). Rhythms of desire: The association between menstrual cycle phases and female sexual desire. *Canadian Journal of Human Sexuality, 5,* 145–156.

Roberts, S. C., Havlíček, J., Flegr, J., Hruskova, M., Little, A. C., Jones, B. C., . . . Petrie, M. (2004). Female facial attractiveness increases during the fertile phase of the menstrual cycle. *Proceedings of the Royal Society of London, B, 271,* S270–S272. doi:10.1098/rsbl.2004.0174

Roney, J. R., & Simmons, Z. L. (2008). Women's estradiol predicts preferences for facial cues of men's testosterone. *Hormones and Behavior, 53,* 14–19. doi:10.1016/j.yhbeh.2007.09.008

Rosenthal, R., & Rosnow, R. L. (1991). *Essentials of behavioral research: Methods and data analysis.* New York, NY: McGraw–Hill.

Rowland, D. L., Greenleaf, W. J., Dorfman, L. J., & Davidson, J. M. (1993). Aging and sexual function in men. *Archives of Sexual Behavior, 22,* 545–557. doi:10.1007/BF01543300

Simpson, J. A., & Gangestad, S. W. (1991). Individual differences in sociosexuality: Evidence for convergent and discriminant validity. *Journal of Personality and Social Psychology, 60,* 870–883. doi:10.1037/0022-3514.60.6.870

Singh, D., & Bronstad, P. M. (2001). Female body odour is a potential cue to ovulation. *Proceedings of the Royal Society of London, B, 268,* 797–801. doi:10.1098/rspb.2001.1589

Thornhill, R., & Gangestad, S. W. (1999). The scent of symmetry: A human sex pheromone that signals fitness? *Evolution and Human Behavior, 20,* 175–201. doi:10.1016/S1090-5138(99)00005-7

Thornhill, R., Gangestad, S. W., Miller, R., Scheyd, G., McCollough, J. K., & Franklin, M. (2003). Major histocompatibility complex genes, symmetry, and body scent attractiveness in men and women. *Behavioral Ecology, 14,* 668–678. doi:10.1093/beheco/arg043

Tietze, C. (1960). Probability of pregnancy resulting from a single unprotected coitus. *Fertility and Sterility, 11,* 485–488.

Van den Berghe, P. L., & Frost, P. (1986). Skin color preference, sexual dimorphism and sexual selection: A case of gene-culture evolution. *Ethnic and Racial Studies, 9,* 87–113.

van Straaten, I., Engels, R., Finkenauer, C., & Holland, R. W. (2008). Sex differences in short-term mate preferences and behavioral mimicry: A semi-naturalistic experiment. *Archives of Sexual Behavior, 37,* 902–911. doi:10.1007/s10508-007-9179-y

Wilcox, A. J., Dunson, D. B., Weinberg, C. R., Trussell, J., & Baird, D. D. (2001). Likelihood of conception with a single act of intercourse: Providing benchmark rates for assessment of post-coital contraceptives. *Contraception, 63,* 211–215. doi:10.1016/S0010-7824(01)00191-3

Wilcox, A. J., Weinberg, C. R., & Baird, D. D. (1995). Timing of sexual intercourse in relation to ovulation: Effects on the probability of conception, survival of the pregnancy and sex of the baby. *New England Journal of Medicine, 333,* 1517–1521. doi:10.1056/NEJM199512073332301

Ziegler, T. E., Schultz-Darken, N. J., Scott, J. J., Snowdon, C. T., & Ferris, C. F. (2005). Neuroendocrine response to female ovulatory odors depends upon social condition in male common marmosets (*Callithrix jacchus*). *Hormones and Behavior, 47,* 56–64. doi:10.1016/j.yhbeh.2004.08.009

Received December 15, 2009
Revision received July 1, 2010
Accepted July 2, 2010 ■