

# Ovulatory Shifts in Female Sexual Desire

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*Women's reproductive biology imposes heavy obligatory costs of parental investment, creating strong selective forces hypothesized to shape female mating psychology around critical decisions such as the choice of partner, the timing of sexual intercourse, and the timing of reproduction. We propose that female sexual desire has evolved as one adaptation among several designed to regulate these decisions. We hypothesize (a) an increase in desire as conception probability increases, but only among women who are in committed long-term relationships; and (b) a shift in the desire for a primary partner as compared with extra-pair partners as ovulation approaches, dependent upon a woman's evaluation of her primary partner's relative quality. We tested several predictions derived from these hypotheses in a study of 173 women who were not taking oral contraceptives. Results confirmed Hypothesis 1: An ovulatory peak in sexual desire was found only for mated women; for unmated women, conception probability and sexual desire were uncorrelated. Hypothesis 2 was partially supported. Among mated women, those with higher conception probability exhibited higher levels of in-pair sexual desire relative to those at lower conception probability. Conception probability and relationship length interacted significantly to predict extra-pair desires, such that women in longer relationships were more likely to experience desire for extra-pair partners during periods of high conception probability. The pursuit of an in-pair conceptive strategy (as opposed to an extra-pair conceptive strategy) was also associated with the occurrence of sexual activity in the relationship.*

Given the profound reproductive importance of mate choice, female sexual psychology has likely been shaped by reproductive constraints and opportunities. The high energetic costs of pregnancy and an extended period of juvenile dependency in humans have limited the total lifetime reproductive output to only a few offspring (Daly & Wilson, 1983; Low, 2000). In modern hunter-gatherer communities, for example, lifetime reproductive output ranges from a low of about 4.5 children among the !Kung of Southern Africa to just over 8 children among the Aché of Paraguay (Hawkes, O'Connell, & Blurton-Jones, 1997; Hill & Hurtado, 1996; Howell, 1979). Moreover, opportunities for conception are restricted to a small window within a woman's monthly cycle (Wilcox, Weinberg, & Baird, 1995), and over the long course of human evolutionary history, such ovulatory events necessarily would have been rare in a woman's life. Most women of reproductive age spent many years pregnant or lactating, states that suppress ovulation (Symons, 1995). High infant mortality required more frequent pregnancies to reproduce successfully. Menarche occurred later in life, shortening ancestral women's reproductive years compared with those of modern women. Earlier age of death abbreviated the reproductive span. In women living today, ovulation

is sometimes a monthly event that recurs for roughly 2 decades, resulting in perhaps 200 to 300 hundred ovulatory episodes. In ancestral women, older age of menarche, frequent episodes of pregnancy, many years of lactation, and shorter lifespans would have drastically reduced the number of these episodes to perhaps as few as a dozen, rendering each of vital importance. Given its significance, it would be surprising if selection had not fashioned specialized adaptations in women to guide mating decisions surrounding the time of ovulation. In this article, we propose that specific design features of female sexual desire have been shaped by selection and function to regulate shifts in the intensity and object of desire linked to the ovulation cycle.

Sexual desire should be clearly distinguished from sexual activity (Regan & Berscheid, 1999; Symons, 1979). Sexual behavior can occur or not occur for many reasons other than sexual desire: to accommodate a mate's wishes, to fulfill a perceived obligation, to express love, or as a consequence of coercion (Impett & Peplau, 2003). Sexual desire, in contrast, can be conceptualized as a motivational and regulatory adaptation. In both sexes, desire might have evolved design features that motivate selecting an appropriate mate (the object of one's desire) and judiciously timing the occurrence of sexual intercourse. In this research project, we explored several hypothesized functions of sexual desire for women and tested predictions based on these hypothesized functions.

## THE TIMING OF WOMEN'S SEXUAL DESIRE

Although researchers have been examining the relationship between the menstrual cycle and fluctuations in female

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sexual desire for almost a century (see Hedricks, 1994; Regan & Berscheid, 1999; Schreiner-Engel, 1980, for reviews), this research has largely been carried out without being explicitly informed by evolutionary theories of human mating. The results are often inconsistent. Although most of the previous research on the topic has discovered distinguishable peaks of sexual desire within the menstrual cycle, there has been little consensus about the cycle phase in which this is most likely to occur. Some studies find peaks during nonconceptive phases of the cycle (e.g., Bancroft, Sanders, Davidson, & Warner, 1983; Englander-Golden, Chang, Whitmore, & Dienstbier, 1980; Shader, Dimascio, & Hartz, 1968; Warner & Bancroft, 1988), and others find peaks at or around ovulation (e.g., Cavanagh, 1969; Dennerstein, Gotts, Brown, & Morse, 1994; Stanislaw & Rice, 1988; Van Goozen, Wiegant, Endert, & Helmond, 1997).

One difficulty in interpreting the results of previous research is the wide range of methods and measures that have been used. Researchers have examined widely varied phases of the cycle. Across different studies, the menstrual cycle has been divided into two (e.g., Hertz & Jensen, 1975), three (e.g., Englander-Golden et al., 1980), four (e.g., Graham & Sherwin, 1993), five (e.g., Hart, 1960), and six (e.g., Bancroft et al., 1983) phases. Furthermore, the chosen phases have been assessed using a variety of different methods. Many studies have left cycle phase determination up to the participants, who relied solely on broad categories provided by the researchers, such as "premenstrual," "post-menstrual," or simply "associated with your period" (e.g., Graham & Sherwin, 1993; Hart, 1960; Warner & Bancroft, 1988). Recent studies have used improved measures to determine cycle point, such as methods used to estimate specific cycle day (Penton-Voak & Perrett, 2000; Thornhill & Gangestad, 1999) and physiological methods including basal body temperature (BBT; e.g., Church, Hedricks, LeFevre, & McClintock, 1994; Stanislaw & Rice, 1988), blood assays (e.g., Slob, Ernste, & Van der Werff ten Bosch, 1991; Van Goozen et al., 1997), cervical mucus characteristics (e.g., Church et al., 1994), and urine tests (e.g., Dennerstein et al., 1994).

Previous researchers have also often failed to assess or report potentially important nonmenstrual variables in their research. Many studies do not report the relationship status of the participants (e.g., Cavanagh, 1969; Englander-Golden et al., 1980; Hertz & Jensen, 1975; Luschen & Pierce, 1972; Shader et al., 1968). Of those studies that do report relationship status, none have analyzed women separately by relationship status. The overall trends in these studies indicate ambiguous results, such that the researchers did not find a single peak in sexual desire but instead found either no discernible peak (e.g., Slob et al., 1991; Van Goozen et al., 1997) or multiple phases in which there was an increase in desire (e.g., Dennerstein et al., 1994; Tinklepaugh, 1933). Other studies that did not differentiate relationship status found peaks of sexual desire at nonconceptive phases such as post-

menstruation (e.g., Bancroft et al., 1983; Graham & Sherwin, 1993; Warner & Bancroft, 1988). Finally, the studies that have found an unambiguous peak of sexual desire during the ovulatory phase, using reliable methods of determining cycle phase, have looked solely at women in committed relationships (Stanislaw & Rice, 1988; Van Goozen et al., 1997). One of the primary purposes of the current study was to test the hypothesis that women's sexual desire contains design features that function to motivate intercourse during the high-conception phase of the ovulation cycle, but only if their current environment includes cues to probable resource availability and stability in the future, such as the presence of a committed relationship partner. Confirmation of this hypothesis may explain the inconsistent pattern of results from prior studies that failed to distinguish mated and unmated women.

#### THE OBJECT OF WOMEN'S SEXUAL DESIRE: IN-PAIR VERSUS EXTRA-PAIR PARTNERS

Because of the tremendous investment required to produce a child and raise him or her to reproductive maturity, women appear to have evolved a preference for mates with the ability and willingness to provide resources to offspring (Buss, 1989, 1994; Symons, 1979). As Buss (1989) predicted and found, women across a wide range of cultures do place a greater emphasis on a mate's resources than do men. Emerging evidence suggests that women may also have evolved preferences for mates displaying indicators of good genes such as facial masculinity and bilateral symmetry (e.g., Gangestad & Thornhill, 1998; Johnston, Hagel, Franklin, Fink, & Grammer, 2001; Penton-Voak et al., 1999). Although both provisioning and good genes may be preferred by a woman, it may be difficult for her to find a mate with both of these qualities. Men displaying indicators of good genes will be highly sexually attractive and therefore able to successfully pursue a short-term, multiple-mate strategy rather than one of long-term resource investment (Gangestad & Simpson, 2000). As a consequence, the best sires may not be the best providers, and women must sometimes make tradeoffs.

One strategy a woman might pursue is to attract a good provider as a long-term mate, and, if possible, surreptitiously seek good genes from an affair partner (e.g., Smith, 1984). Several studies support this dual-strategy hypothesis. Men who exhibit hypothesized fitness indicators, such as high levels of bilateral symmetry, are selected more often by women as affair partners than men with lower levels of symmetry (Gangestad & Thornhill, 1997). Findings from image-rating studies suggest that mated women, who presumably have secured an investing mate, may display stronger preferences for facial masculinity than unmated women (Little, Jones, Penton-Voak, Burt, & Perrett, 2002). Also, women's preferences for hypothesized good-genes indicators, including both symmetry and masculinity, are elevated during the highest fertility phase of a woman's cycle—the time at which the genetic benefits of extra-pair mating are maximized (Gangestad

& Thornhill, 1998; Johnston et al., 2001; Penton-Voak et al., 1999).

Perhaps the strongest piece of evidence supporting this hypothesis comes from a recent study by Gangestad et al. (Gangestad, Thornhill, & Garver, 2002). They found that women in the ovulatory phase of their cycle felt elevated desire for and had more fantasies about men other than their partners, whereas their desire for their own partner changed relatively little across the menstrual cycle.

Pursuing a dual-mating strategy, however, is extremely risky. Extra-pair mating by a woman imposes high costs on her long-term mate, and evidence supports the hypothesis that men have evolved an array of mate-guarding tactics designed to deter infidelity (e.g., Buss, 1988; Daly, Wilson, & Weghorst, 1982; Shackelford & Buss, 1997). Indeed, women in peak reproductive years tend to be more closely monitored by their mates than are older women (Shackelford & Buss, 1997), and discovered infidelity can result in abandonment by a woman's partner, violence, or even homicide (Daly & Wilson, 1988; Flinn, 1988). Whether a woman pursues a dual-mating strategy should, therefore, be dependent upon a number of important variables, including the degree to which her current mate displays indicators of good genes, the quality of her relationship with her mate, and the availability of potential extra-pair mates offering superior genes. In their study, Gangestad et al. (2002) found that increased desire for extra-pair partners appeared to be driven by the subset of women who regarded their relationship as "non-exclusive." Perhaps these are the women for whom a dual-mating strategy might be most beneficial, either because their primary partners are relatively low in quality or because their partners were less likely to discover or impose costs on extra-pair mating. This reasoning leads to a second goal of the current study: to investigate whether women's desire for extra-pair partners near ovulation is dependent upon specific relationship variables, such as satisfaction and relationship length.

#### HYPOTHESES ABOUT THE FUNCTIONS OF WOMEN'S SEXUAL DESIRE

We propose that women's sexual desire is designed to vary in several ways in response to critical environmental variables, including whether or not she is involved in a committed mateship, the value of her partner, the ease with which she can replace the current partner, the number and quality of potential additional mates who indicate interest, and the discrepancy between available partners in mate value. In this study we tested two hypotheses about the interaction between these types of variables and a woman's current fertility status in predicting sexual desire.

##### *Hypothesis 1: Sexual Desire at Ovulation as a Function of Probable Offspring Support*

This hypothesis states that women's sexual psychology is designed to adjust the intensity of sexual desire in response to their current probability of conception and to cues indi-

cating offspring support, such as the presence of an investing long-term partner.

Without the additional resources provided by an investing partner, women in the ancestral past would likely have had a reduced probability of successfully bearing and raising offspring. In modern hunter-gatherer populations, father absence has been shown to have a significant negative effect on child survival before the age of 10. For example, Aché children between 1 and 5 years of age are 2.6 times as likely to die if their fathers are dead than if their fathers are living, and 2.9 times as likely to die if their parents are divorced than if they are together (Hurtado & Hill, 1992). We hypothesized, therefore, that women's mating psychology should be sensitive to the presence or absence of a stable investing partner. For most of human history, the costs of pregnancy may have outweighed its benefits in the absence of support from a long-term mate. We propose that for a mated woman, preferentially concentrating sexual activity within the fertile phase of her cycle would improve the probability that a pregnancy would be timed to coincide with investment, regardless of whether she is pursuing an in-pair or an extra-pair conceptive strategy. We derived a specific prediction from this hypothesis: Compared with unmated women, mated women will be more likely to experience an increase in sexual desire as the probability of conception increases.

##### *Hypothesis 2: Women's Sexual Desire at Ovulation as a Function of the Quality of Partner Relative to Alternatives*

This hypothesis proposes that women's sexual psychology is designed to be sensitive to the relative costs and benefits of in-pair versus extra-pair mating, causing only those women who perceive their primary partner to be relatively low in genetic quality to increasingly desire extra-pair partners as ovulation approaches.

For mated women, factors including their current relationship status (e.g., commitment to the relationship, length of relationship, conception within the relationship, etc.), their partner's mate value, their own mate value, the available pool of alternative partners, and the level of risk in pursuing those alternatives should affect the likelihood that a woman will pursue extra-pair conceptive opportunities. Women who perceive their partners to be low in quality relative to other obtainable mates, for example, should be more likely to pursue an extra-pair strategy than women who perceive their partners to be high in quality. A woman's evaluations of her partner's relative mate quality may be manifested in her subjective feelings of satisfaction with him as a partner. Such global assessments should therefore predict the degree to which a woman experiences desire for extra-pair partners. These assessments may also predict whether a woman experiences increases in desire for her own partner or for an extra-pair partner as the probability of conception increases. More specifically, women who are not satisfied with their partners may experience an increase in extra-pair

sexual desires as the probability of conception increases, whereas women who are highly satisfied with their partners may experience an increase in in-pair sexual desires as the probability of conception increases.

As relationship length increases, the relative costs and benefits of pursuing extra-pair sexual opportunities may also change. For example, in the ancestral past, many months of non-conceptive sex may have signaled infertility within a couple. Fertility studies have shown that approximately one third of the instances of couple infertility are due to male-factor infertility (Fraser Lynn, 1999; Sertic, Cvitkovic, Myers, Saiki Randall, & Rukavina Ana, 2001; Suzumori, 2001). Given that the locus of infertility would often have been within a woman's partner, natural selection may have shaped psychological designs that motivate women to increasingly pursue extra-pair mates near midcycle as their relationships with their partners lengthen but do not result in in-pair conception. In undergraduate populations, in which most couples attempt to avoid pregnancy (e.g., by using condoms or other forms of contraception), relationship length should therefore be a predictor of the degree to which women experience extra-pair desires in the high fertility phase of the cycle.

Two recent studies provide partial support for this proposal. In a study of nearly 1,000 college-age mated women in Germany, the women in longer relationships reported significantly lower levels of sexual desire for their partners than did the women in newer relationships (Klusmann, 2002). Not all forms of desire decrease with relationship length, however. A second study of 214 female university students and staff in the United States demonstrated that as relationship length increased, women experienced more extra-pair sexual fantasies (Hicks & Leitenberg, 2001). We tested the additional prediction that the relationship length will interact with conception probability to predict extra-pair desires.

## METHOD

### Participants

Participants in this study were 202 female students at a large university in the southwest United States who were not taking a contraceptive pill or using other hormonal contraceptives. Participants received partial credit toward a course requirement in exchange for taking part in the study. The mean age of participants was 18.5 years ( $SD = 1.2$  years, range = 17-24 years); 53% identified themselves as Caucasian, 28% as Hispanic, 14% as Asian American, 2% as African American, and 3% as another ethnicity. Sixty-five (37.6%) of the women in our sample had never had sexual intercourse with a man, including 16 (18.1%) of the 88 women currently involved in romantic relationships. The average number of sex partners per participant was 2.00 ( $SD = 2.72$ ).

### Procedure

Participants completed a questionnaire including assessments of their relationship and menstrual history and a series

of questions designed to test the hypotheses about relationship status and quality and sexual desire. The first part of this instrument consisted of 9 items related to subjective feelings of sexiness, attractiveness, and desire: "[Relative to other days...] how sexy do you feel today?"; "...how many sexual fantasies have you had today?"; "...how fashionable is your style of dress today?"; "...how 'dressed up' do you feel you are today?"; "...how sexy is your style of dress today?"; "...how physically attractive do you feel your face looks today?"; "...how physically attractive do you feel your body looks today?"; "...have you noticed many attractive men around campus today?"; and "...how flirtatious have you been today?" These items were embedded in a set of more general items concerning mood and other social interactions. Participants rated each of these items on a scale of 1 to 9, with 1 = *far less than usual* and 9 = *far more than usual* (the midpoint of 5 = *about average*). A varimax-rotated principal components analysis yielded a reasonable approximation of simple structure with these items loading moderately to highly on a single factor (.35 to .89), with the exception of "noticing many attractive men," which loaded only modestly on this factor (.15). This item was nevertheless retained because of its theoretical centrality and because inclusion of it did not reduce the statistical reliability of the composite. We arithmetically averaged the items to create a single index (sexual desire composite,  $\alpha = .88$ ).

The second part of the questionnaire was designed to assess current relationship experiences and was completed only by those women who reported that they were currently involved in a romantic relationship. This section included 3 items designed to assess women's extra-pair sexual desires—" [Relative to other days, in the last 24 hours...] how much have you flirted with men other than your partner?"; "...how much interest would you have in having a date with someone other than your partner, if someone you found interesting asked you out on a date?"; and "...how much interest would you have in having sex with someone other than your partner if you met someone you were very attracted to and who was also very attracted to you?"—and 2 items to assess their in-pair sexual desires—" [Relative to other days, in the last 24 hours...] how much have you desired to have sexual intercourse with your partner?" and "...how sexually attracted to your partner have you been?"<sup>1</sup> Each of these items was also rated on a 1 to 9 scale, with 1 = *far less than usual*, 5 = *about average*, and 9 = *far more than usual*. We used these items to construct two composite variables: extra-pair desires ( $\alpha = .71$ ) and in-pair desires ( $\alpha = .76$ ).

<sup>1</sup> As one reviewer pointed out, there was a minor but potentially important discrepancy in wording between one of the in-pair desire items and one of the extra-pair desire items. When referring to in-pair desire, one item read "...how much have you desired to have sexual intercourse with your partner?" whereas the extra-pair item was worded "...how much interest would you have in having sex with someone other than your partner...?" It is possible that individuals may have interpreted the latter question more broadly, for example to include anal or oral sex. However, because this was only one of three items involved in tests of extra-pair desires and one of two items involved in tests of in-pair desires, it seems unlikely that a differential desire for one form of sexual activity over others (independent of partner identity) could account for the pattern of results we observed.

Following Gangestad and Thornhill (1998) and others (e.g., Macrae, Alnwick, Milne, & Schloerscheidt, 2002; Penton-Voak & Perrett, 2000; Stanislaw & Rice, 1988), we calculated conception probability using Jöchle's (1973) estimations of the probability of conception on each day of the menstrual cycle. Because most variation in cycle length is due to variation in the follicular phase, using reverse cycle day rather than forward cycle day to predict the day of ovulation allows an estimation of conception probability that is independent of cycle length (Hodges, 1987; Lenton, Landgren, & Sexton, 1984; Lenton, Landgren, Sexton, & Harper, 1984). Many studies have used women's self-reports of the start day of their last period for the researchers to estimate day of ovulation using a forward count (e.g., Penton-Voak & Perrett, 2000; Penton-Voak et al., 1999; Thornhill & Gangestad, 1999) or for the researchers to estimate the onset of the next period so they could use a reverse count to predict the day of ovulation (e.g., Thornhill & Gangestad, 1999). We have used women's self-reports of both the start day of their last period and their own estimation of the start date of their next period to estimate the day of ovulation using the more reliable reverse count.<sup>2</sup> Following Thornhill and Gangestad (1999), we assume that the day of ovulation is 15 days prior to the onset of a woman's next menstrual cycle.

Although physiological assessments of cycle point offer high degrees of precision, these measures require multiple visits to the laboratory by participants (e.g., for up to 7 days; Gangestad et al., 2002), effectively placing low limits on the number of participants from whom data can be collected. Thus, there is a trade-off between the precision of the method used to estimate cycle point and the number of participants involved in a study. In this research, we opted for a larger number of participants, and hence more variation between participants in relationship variables, with less precise measure of cycle day. Our assignment of day of cycle and the resulting probability of conception, based on self-reported cycle variables and overall fertility probability as reported in the medical literature, has likely produced some error in the estimation of fertility. One reason to use a probabilistic measure of fertility, however, is that the continuous nature of the variable reduces the effect of these errors. For example, an estimation error of 2 days may change the conception probability from 32.6 to 28.3, but the same error could result in a complete misattribution of cycle phase, for example from ovulatory to follicular phase.

Given this method of cycle day estimation, three important factors should be borne in mind. First, our relatively large sample size should help to reduce the effects of errors

<sup>2</sup> The regular cycle length of participants was within the normal range (Matsumoto, Nogami, & Ohkuri, 1962) and varied from 25 to 38 days ( $M = 30.3$ ,  $SD = 3.10$ ). Analyses conducted using a forward cycle day estimate of conception probability, while resulting in effects similar to those found using reverse cycle day, did not reach significance. When we limited the sample to those participants with a cycle length of 28 to 30 days ( $n = 53$ , 31.2%)—that is, the only cycle length for which a forward count is appropriate—we found no appreciable difference in results from analyses using reverse cycle day. Therefore, we used reverse cycle day estimations in all analyses.

in cycle reporting in the data. Second, error in our estimations of conception probability should create a bias toward failing to confirm our hypotheses, since such error is expected to be random with respect to the predictions (and hence it will create only nonsystematic variation, which reduces power). It is therefore unlikely that any such error would spuriously generate significant relationships. Third, in addition to practical disadvantages, there are some scientific disadvantages to using longitudinal methods in studies such as this one; for example, fatigue associated with repeated assessments can result in increased error variation and sometimes bias in the data collected.

## RESULTS

### *Relationship Variables*

Of the 202 women who participated in the study, 12 did not provide an expected date for the start of their next period and were dropped from the analyses. Eight participants were omitted because they did not provide the date of their last period, and an additional 9 participants were dropped because incorrectly reported or illegible dates made cycle phase calculations impossible or unreliable (e.g., some women misread the instructions and reported their estimated start of next period as occurring before the current date; others provided a date that was more than 40 days from the current date, indicating either error or a nonnormal cycle length). All analyses were performed on data from the remaining 173 participants. Of those women, 77 (44.5%) responded "yes" to the question "Are you currently in a romantic relationship?," while 11 (6.4%) answered "unsure," and 85 (49.1%) reported that they were not currently in a romantic relationship. All women who answered either "yes" or "unsure" to this question completed the current relationship questionnaire and were therefore included in the mated category in the analyses.<sup>3</sup> Within this subset of women, the mean relationship length was 13.2 months ( $SD = 14.3$  months, range = .5 – 72 months, median = 7.5 months).

<sup>3</sup> Analyses of variance indicated that there were significant between-group differences on all measures of commitment and satisfaction, such that those women who responded "yes" to the question about whether they were in a romantic relationship rated their levels of commitment ( $F = 31.38$ ,  $p < .001$ ), emotional satisfaction ( $F = 13.36$ ,  $p < .001$ ), sexual satisfaction ( $F = 7.86$ ,  $p < .01$ ), and overall satisfaction ( $F = 13.69$ ,  $p < .001$ ) as significantly higher than those women who responded "unsure." There were no significant between-group differences either in length of relationship ( $F = 1.42$ ,  $p = .12$ ) or in sexual activity within the relationship ( $F = 1.26$ ,  $p = .13$ ). There are a variety of reasons why women may classify their relationships status as "unsure," for example if it is a new relationship, a relationship that may be ending, or even a long-distance relationship. Although we interpret this subset of women as representing an important point on the continuum of relationship quality and satisfaction rather than a distinct category, we conducted regression analyses to test the effect of relationship confidence on our model, with the intention of creating a separate "unsure" group in subsequent analyses if statistically warranted. This analysis resulted in no significant interactions with any of the predictor variables, indicating that the effect of the predictor variables on extra-pair and in-pair sexual desires was not significantly affected by whether a participant responded "yes" or "unsure" to the current relationship question. We therefore included all women who answered either "yes" or "unsure" in the reported analyses. Analyses using only those women who responded "yes" produced very similar coefficients and  $p$  values to those conducted using the entire subset of mated women; results are available from the authors upon request.

The average level of relationship commitment and satisfaction in the sample was high. In four separate 7-point scales (1 = *extremely dissatisfied*, 4 = *neutral*, 7 = *extremely satisfied*), all of the means were above 5: Women's ratings of commitment averaged 5.16 ( $SD = 1.79$ ), ratings of emotional satisfaction averaged 5.42 ( $SD = 1.48$ ), sexual satisfaction averaged 5.58 ( $SD = 1.49$ ), and overall satisfaction averaged 5.68 ( $SD = 1.27$ ). We used the arithmetic average of the three satisfaction variables ( $\alpha = .75$ ) in analyses involving relationship satisfaction.

Among women in relationships, 77.3% ( $n = 68$ ) had had sexual intercourse with their current partners at the time of the study while 22.7% ( $n = 20$ ) had never had sexual intercourse with their current partners. We conducted a regression analysis to test the interaction of sexual activity with other predictor variables and found no interactions, with the exception of the interaction of sexual activity and relationship length on in-pair sexual desires (see below). The sexual activity variable was therefore not included in the regression model. There was a significant main effect of sexual activity on both extra-pair and in-pair sexual desires, such that those women who had never had sex with their current partners were more likely to report experiencing desire for non-pair partners ( $B = .68$ ,  $SE = .36$ ,  $t = 1.91$ ,  $p < .05$ ,  $\beta = .17$ ) and less likely to report experiencing sexual desire for their current partner ( $B = -2.83$ ,  $SE = .60$ ,  $t = -4.70$ ,  $p < .001$ ,  $\beta = -.58$ ).

### Regression Analyses

We performed all analyses using the three composite variables described above (sexual desire composite, extra-pair sexual desire, and in-pair sexual desire) as the dependent measures.

We conducted regression analyses separately to test the first hypothesis for all women (changes in sexual desire composite) and the second hypothesis pertaining only to mated women (variation in extra-pair and in-pair desires). Because there are relatively few days of high conception probability within the menstrual cycle, current fertility status is not normally distributed. All analyses were therefore performed using a robust estimate of variance (Huber, 1967; White, 1980; Wilcox, 1997). All tests of predictions were one-tailed, unless otherwise noted. All variables were zero-centered (i.e., the variable mean was set at zero) prior to performing the interaction tests.

### The Timing of Sexual Desire

We conducted an analysis regressing relationship status and conception probability on the sexual desire composite using data from all study participants, including both mated and unmated women ( $N = 173$ ). Results from this analysis are presented in Table 1. We found a significant interaction of conception probability and relationship status on levels of composite sexual desire, such that differences in conception probability predicted differences in sexual desire only among currently mated women. Among women currently in romantic relationships, those with

**Table 1. Sexual Desire Composite as a Function of Conception Probability and Relationship Status**

	Regression coefficient	Standardized coefficient	Robust standard error	<i>t</i>
Conception Probability x Relationship Status	.03	.30	.01	2.41***
Conception probability: mated women	.03	.20	.01	3.01***
Conception probability: unmated women	-.00	-.04	.01	-0.46

\*\*\*  $p < .001$ .

high conception probability reported significantly more composite sexual desire than those with low conception probability. As predicted, however, this relationship was not observed for unmated women, who showed no differences in composite sexual desire as a function of conception probability (see Figure 1). In an examination of the individual items in the desire scale, we found that this effect was driven primarily by three components of women's desires and subjective feelings of desirability: number of sexual fantasies, self-assessed facial attractiveness, and being "dressed up."

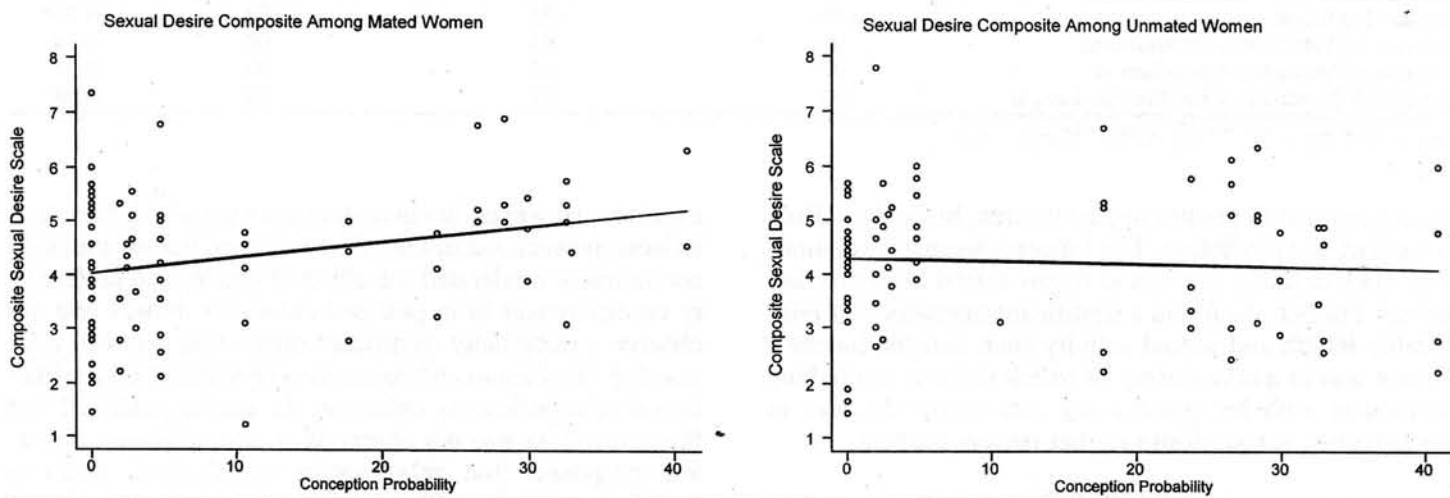
Relationship status was not related to overall levels of composite sexual desire ( $B = .25$ ,  $SE = .25$ ,  $t = 1.02$ ,  $p = .31$ ,  $\beta = .10$ , two-tailed). Women in relationships reported a mean composite sexual desire of 4.34 ( $SD = 1.28$ ), while unmated women reported a mean composite sexual desire of 4.30 ( $SD = 1.27$ ). Thus, relationship status would not appear to be confounded with, or functioning as a proxy for, overall sexual desire.

### The Object of Sexual Desire

We conducted the following analyses to examine variability in sexual strategies as a function of conception probability and relationship characteristics among women currently in relationships. All analyses in this section included data from mated women only ( $n = 88$ ).

*Extra-pair sexual desires.* To test the hypothesis that extra-pair sexual desire will vary as a function of the interaction of conception probability and relationship characteristics (e.g., satisfaction, relationship length), we constructed a single regression model to test the effects of conception probability, relationship satisfaction, relationship commitment, relationship length, and the interactions of conception probability with each of the other predictor variables on desire for non-pair partners. The results from this analysis are presented in Table 2. We found significant negative relationships between satisfaction and extra-pair desires and relationship commitment and extra-pair desires. We found no significant relationship between conception probability and extra-pair desires ( $p = .19$ , two-tailed). Commitment did not interact significantly with

**Figure 1.** Relationship between conception probability and sexual desire composite as a function of mateship status. The left panel depicts the relationship between composite sexual desire and conception probability for mated women ( $\beta = .20$ ,  $p < .001$ ). The right panel depicts this relationship for unmated women ( $\beta = -.04$ ,  $p = .32$ ). The composite sexual desire scale (vertical axis) ranges from 1 to 9; higher numbers indicate more desire. The full range of conception probability (horizontal axis) is depicted.



conception probability to predict extra-pair desires, but there was a marginally significant interaction of satisfaction and conception probability on extra-pair desires, such that lower levels of extra-pair desire at midcycle were observed in women with higher relationship satisfaction. Although there was no main effect of relationship length on extra-pair sexual desires, the interaction of relationship length and conception probability showed a significant positive relation to extra-pair sexual desires, such that higher levels of extra-pair desires near midcycle were observed for longer relationships, as predicted.

These findings indicate that, overall, extra-pair desires are lower when subjective feelings of relationship quality are high. Although the predicted interaction between relationship quality and conception probability was only marginally significant, the predicted interaction between relationship length and conception risk was found. This result suggests that the effect of conception probability on extra-pair desires shifts as the relationship length increases, such that women in longer relationships are more likely to report such desires when the probability of conception is high compared to when it is low.

*In-pair sexual desires.* We followed the same procedures for examining the effects of conception probability

and relationship quality on in-pair desires. These results are presented in Table 3. We found a significant positive effect of conception probability on in-pair desires. The relationship between commitment and in-pair desires was also positive, but only marginally significant ( $p = .09$ ), and the relationship between satisfaction and in-pair desires, while exhibiting a positive trend, was not statistically significant ( $p = .13$ ). Relationship length, on the other hand, exhibited a significant negative relationship with in-pair sexual desires. We found no significant interactions between conception probability and any of the other independent variables on the frequency of in-pair desires.

Sexual activity (i.e., whether or not a woman had ever had sexual intercourse with her current partner) interacted significantly with relationship length, such that as relationship length increased, women who had never had sex with their partners were less likely to express in-pair sexual desires than were those who had sex with their partners ( $B = -.18$ ,  $SE = .05$ ,  $t = -3.59$ ,  $p = .001$ ,  $\beta = -1.50$ ).

In summary, women were more likely to feel sexual desire for their current partners if conception probability was high. Trends in the data also suggest that women were more likely to feel sexual desire for their partners when commitment to the relationship was high. These factors

**Table 2.** Effects of Conception Probability and Relationship Variables on Extra-Pair Sexual Desires

	Regression coefficient	Standardized coefficient	Robust standard error	<i>t</i>
Conception probability	-.02	.12	.01	-1.32
Satisfaction	-.52	-.35	.16	-3.38***
Commitment	-.19	-.20	.10	-1.87*
Relationship length	.01	.06	.01	0.60
Conception Probability x Satisfaction	-.02	-.16	.01	-1.55†
Conception Probability x Commitment	.00	.06	.01	0.51
Conception Probability x Relationship Length	.00	.17	.00	1.93*

† =  $p < .1$ . \* =  $p < .05$ . \*\* =  $p < .01$ . \*\*\* =  $p < .001$ .

**Table 3. Effects of Conception Probability and Relationship Variables on In-Pair Sexual Desires**

	Regression coefficient	Standardized coefficient	Robust standard error	<i>t</i>
Conception probability	.05	.32	.02	3.17***
Commitment	.21	.19	.16	1.33†
Satisfaction	.27	.16	.24	1.14
Relationship length	-.03	-.23	.02	-1.75*
Conception Probability x Commitment	.00	.03	.02	0.14
Conception Probability x Satisfaction	.01	.05	.02	0.27
Conception Probability x Relationship Length	-.00	-.07	.00	-0.68

† =  $p < .1$ . \* =  $p < .05$ . \*\* =  $p < .01$ . \*\*\* =  $p < .001$ .

did not interact to predict in-pair desires, however, failing to support our prediction. The longer a woman's relationship, the less likely she was to report sexual desire for her partner. Further, we found a significant interaction of relationship length and sexual activity such that the longer a woman was in a relationship in which she was not having intercourse with her partner, the less likely she was to report feeling sexual desire for her current partner.

### DISCUSSION

Sexual desire is an emotion that may track adaptive costs and benefits in the environment, coordinate a variety of psychological mechanisms, and ultimately direct behavior (Buss, 1994; Gonzaga, Keltner, Londahl, & Smith, 2001; Symons, 1979). We have proposed that women's sexual desire should have been shaped by natural selection to contain specific design features, such as sensitivity to the presence or absence of an investing mate who can assist in rearing offspring and the availability of superior additional or alternative mates. In this study we tested the prediction that fluctuations in the intensity of sexual desire occur as a joint function of conceptive probability and current relationship status. We found, as predicted, significantly more reported composite sexual desire with higher conception probability among mated women only. Unmated women exhibited no differences in composite sexual desire as a function of conception probability. This finding may help to explain why some studies have demonstrated an ovulatory peak in sexual desire whereas others have not, since prior studies have not analyzed mated and unmated women separately and thus may have had unknown and varying samples of women with respect to this dimension.

We also tested predictions about the specific targets of women's sexual desire by examining the impact of relationship variables on a woman's desire for her primary partner and extra-pair partners as a function of fertility status. A prior study by Gangestad et al. (2002) found that attraction to and fantasy about extra-pair partners increased as women neared ovulation, whereas their in-pair attraction varied little across the cycle. We found a different pattern of results: We observed a positive relationship between conception probability and in-pair desires, but no significant relationship between fertility and desire for extra-pair partners.

Women's relationship commitment and satisfaction were negatively related to overall levels of extra-pair desires, as

expected. However, in interaction tests (in which there was reduced power), we did not find evidence that relationship commitment moderated the effect of conception probability on differences in in-pair and extra-pair desires. We did observe a marginally significant interaction between relationship satisfaction and conception probability on the likelihood of experiencing extra-pair desires, as predicted, but this interaction was not observed in tests of in-pair desire. We proposed that relationship satisfaction tracks a woman's evaluation of her current partner's quality relative to other men in the environment. However, our measure of satisfaction may not have adequately assessed the parameters most relevant to extra-pair versus in-pair mating decisions. For example, a partner's quality as a long-term provider may differ from his quality as a sexually attractive sire. The good genes model predicts that variation along the latter dimension may weigh most heavily in extra-pair mating decisions: If the function of extra-pair mating is to secure good genes, women with less sexually attractive partners should be those most likely to pursue an extra-pair conceptive strategy. A weakness of the current study was the failure to differentiate between partner investment and partner sexual attractiveness. This suggests a clear avenue for future research.

Relationship length was also related to extra-pair and in-pair sexual desires. As relationship length increased, women were more likely to report desires for non-pair partners and less likely to report experiencing sexual desire for their current partners. We also observed an interaction between relationship length and conception probability, which demonstrated that women in longer relationships experienced greater extra-pair desires in the high fertility phase of the cycle than did women in shorter relationships. These findings may reflect design for seeking extra-pair partners when conception with the primary partner has not occurred. Additional support for this proposal may be found in data showing that women increasingly fantasize about non-pair sexual partners as the length of the relationship increases (Hicks & Leitenberg, 2001).

Women who had never had sexual intercourse with their current partners were also significantly more likely to experience sexual desire for extra-pair partners and less likely to experience sexual desire for their current partners than were those women who had engaged in sexual intercourse with their partners. Because we lack critical information about why some women were having intercourse



with their partners but others were not, it is difficult to interpret this effect, but one possibility is that women who have not ever had sex with their current partners are, in essence, still “shopping” (that is, continuing to evaluate the field of possible mates).

As noted above, the results observed in this study do not replicate the pattern of extra-pair desires documented by Gangestad et al. (2002). Also in contrast to Gangestad et al. (2002), we documented a positive relationship between conception probability and in-pair desires. How can the results of these two studies be reconciled? In the Gangestad et al. study, the increase in extra-pair desires at midcycle appeared to be driven by the subset of women in the study who regarded their relationship with their primary partner as nonexclusive. Nearly all of the women in the current study, however, exhibited high commitment to and satisfaction with their partners, and their relationships tended to be relatively new, with the average relationship length just over a year and a skew toward shorter relationships (relationship length data was not reported in the Gangestad et al. study). There was also a potentially important difference in the ages of the two samples (Gangestad et al.,  $M = 19.6$ , range of 18-34 years; current study,  $M = 18.5$ , range of 17-24).

Given these differences, the results of these two studies could be taken together to indicate that the extra-pair conceptive strategy is pursued primarily by the subgroup of women who are dissatisfied with their partners or have been in their relationships for a longer period of time. Women who are highly satisfied with partners or have been in their relationships for a relatively short period of time (those represented in our sample) may pursue an in-pair conceptive strategy. This explanation should be regarded as provisional at present, but it does suggest several important directions for future work. For example, it suggests that researchers should attempt to capture broad variation in relationship exclusivity, length, and partner quality (along dimensions of both partner investment and partner sexual attractiveness) and then identify the subgroups of women who pursue these different sexual strategies.

### *Limitations and Directions for Future Research*

There are several limitations of the current study. First, this research used a cross-sectional assessment of women's fertility status. This method is associated with more error in determining cycle point than are longitudinal methods. Some of the subgroup analyses also suffered from reduced power. It is possible, therefore, that we may have missed important patterns that would be revealed using other research designs. Nonetheless, because these features of the study increase random error, the positive results we documented, such as the predicted interaction between mateship status and conception risk on sexual desire, cannot be attributed to these limitations.

Second, there are other important contextual variables to which a woman's mating psychology may be attuned that were not investigated. For example, in addition to the

resources and support that a woman's mate might provide, close female kin may have played a large role in the success of ancestral women's pregnancies and support for their children (Daly & Wilson, 1983). Moreover, a woman's mating psychology may be sensitive to her current health status, nutritional status, age, the status of existing offspring, and the harshness of the local environmental conditions (e.g., climate), all of which could strongly impact her success in caring for a child. A task for future research is to investigate the degree to which these cues affect the strength and timing of women's sexual desire.

Third, in our examination of changes in extra-pair mating desires across the cycle, we examined only relationship length and two very broad moderating variables, commitment and satisfaction. The choice of these variables was partially motivated by the wish to capture a global assessment of a woman's perception of her partner, which is affected by her perception of her partner's desirability, her own desirability relative to his, and the desirability of others (e.g., Rusbult & Buunk, 1993). Future work may use more direct assessments of these variables individually, including assessment of types and motivations of commitment and satisfaction with different aspects of the current partner—that is, satisfaction with important long-term qualities such as generosity, status, and reliability, and satisfaction with desired short-term mate qualities such as sexual attractiveness—to test specific hypotheses about the benefits to women of pursuing an in-pair or extra-pair conceptive strategy. For example, if desire for extra-pair mating is designed to secure good genes, women whose partners are less symmetrical or facially masculine should be more likely to desire extra-pair mating than those whose partners are more symmetrical or masculine. On the other hand, if these variables do not predict extra-pair desires, but features such as a partner's status or access to resources do, then an extra-pair strategy could serve an alternative function, such as mate switching or resource acquisition (Greiling & Buss, 2000).

Fourth, as noted above, our ability to test Hypothesis 2 adequately may have been hindered by the lack of variation along the critical dimensions of relationship satisfaction. Nearly all of the women in our sample appeared to be highly satisfied in their relationships and committed to their partners. Because an extra-pair conceptive strategy can be extremely costly, only women who find themselves with partners who are low in quality or who are presented with exceptional affair partners should be expected to pursue it. It appears that very few of these women may have been represented in our sample.

### *Conclusions*

This study demonstrated that mated women but not unmated women experience greatest sexual desire when most fertile. To our knowledge this effect had not been documented previously. The mated women in this study, nearly all of whom were highly committed to and satisfied with their partners, appeared to be pursuing an in-pair conceptive

strategy. They experienced greater desire for their current partners and they did not experience elevated desire for other partners as conception probability increased. Conception probability interacted significantly with relationship length and relationship satisfaction to predict extra-pair desires, as hypothesized. Taken together, these findings support the proposal that female sexual desire is an adaptation that contains several specific design features.

Future research could be directed at other potential design features of female sexual desire. Does the presence of supporting kin increase women's likelihood of pursuing reproductive opportunities even in the absence of a committed long-term romantic partner? Does female sexual desire for a partner diminish when the partner experiences a sudden decrement in mate value (e.g., as a result of injury or a major loss of professional status) and correspondingly increase when he experiences a sudden increase in mate value? Does female sexual desire for a partner increase when other women show interest in him, posing the problem of possible defection from the relationship? Does female sexual desire increase during pregnancy, which might function as a mate-retention tactic when she is most vulnerable to resource loss? Given the pivotal importance of sexual decisions for women and the current work that points to special design linked with ovulation, it is reasonable to hypothesize that selection has fashioned other richly designed features of women's sexual desire that serve specific motivational and regulatory functions.

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