Abstract

Previous research has yielded seemingly contradictory evidence about shifts in women's mating psychology as a function of the ovulatory cycle. Some studies show that women engage in more frequent and intense mate attraction tactics, such as dressing in more sexually revealing clothing, around ovulation. Other studies find that ovulating women avoid activities that may pose a risk for sexual assault. In the present study, women (n = 284) reported whether they engaged in any of 74 different activities that varied on riskiness and also their reaction towards descriptions of cues of potential sexual assault. These variables were analyzed in light of women's conception risk, relationship status, and sexual strategy. Likelihood of conception was measured with an ovulation test that assessed luteinizing hormone and counting from a reported menstrual onset. Women taking hormonal contraceptives served as a control group for naturally cycling women. Consistent with prior research, we found a decrease in non-mating related behaviors considered risky for sexual assault as conception risk increases. Novel to this study, we found interactions between conception risk, relationship status, and sexual attitudes for short term mating variables Moreover, we found that as conception risk increased, women were more likely to mention rape as the content of their fear and anxiety, and expressed increased upset towards cues of a potential sexual assault. The control group of women on hormonal contraceptives did not display these phase-dependent shifts in mating behavior or sexual victimization context avoidance. Discussion focuses on study limitations, and on implications for interactions between ovulatory cycle, mating strategy, and women's defenses against sexual assault.

Women's Avoidance of Sexual Assault across the Menstrual Cycle

Behavioral changes over the course of the menstrual cycle have become an intense focus of study in psychology in the last few years. Researchers have found that women engage in mating-related behaviors, such as dressing in a more sexually provocative manner, with greater frequency during the most fertile days of the menstrual cycle (Durante, Li, & Haselton, 2008; Grammer, Renninger, & Fischer, 2004; Haselton, Mortezaie, Pillsworth, Bleske-Rechek, & Frederick, 2007). On the other hand, other researchers, such as Chavanne and Gallup (1998), found that women are less likely to engage in behaviors that put them at risk for sexual assault, including many mating behaviors, during this same fertile window. One goal of the current study was to reconcile these seemingly opposing findings by exploring simultaneously conception probability, relationship status, and individual differences in women's preferred sexual strategy.

Sexual Assault and Adaptive Costs

We define sexual assault, and rape as "the use of force or threat of force to achieve penile-vaginal penetration of a woman without her consent" (McKibbin, Shackelford, Goetz, & Starratt, 2008, p. 86). Evidence supports the hypotheses that women have evolved mate preferences for good genes indicators of phenotypic quality (Gangestad, 1993) and for characteristics that indicate an ability and willingness to invest time and resources in her and her offspring (Buss, 1989a). The greatest cost to her reproductive success would be an unwanted or untimely pregnancy by a man who bypassed a central feature of women's evolved psychology, female choice, by forcing unwanted sex. However, other mating costs exist. If a woman becomes

pregnant from the assault, it could also undermine her ability to attract an investing long-term mate, jeopardizing the survival and reproductive success of her offspring.

Attention and energetic expenditure used in the service of avoiding potential sexual assault are limited commodities which must be budgeted simultaneously toward multiple adaptive goals (Kaplan & Gangestad, 2005). Women do employ behavioral means of avoiding sexual assault, such as avoiding strange men, avoiding being alone, and dressing conservatively (McKibbin et al., 2009). However using these tactics can undermine solutions to other adaptive problems related to mating, particularly during the fertile window: the only time that successful conception is possible.

The Menstrual Cycle and Hormonal Contraceptives

The menstrual cycle is an approximately 28 day period of regularly recurring hormonal changes. After the ovum is released, towards the midpoint of the cycle, the egg is viable for fertilization for 12-24 hours (Barrett & Marshall, 1969). Based on when the ovum is released and the variable longevity of sperm, each day of the menstrual cycle has some likelihood of conception. The distribution of conception likelihood changes the balance of costs and benefits associated with mating behaviors, and with activities that may pose a risk for rape. Around ovulation, women may be especially attractive to men (e.g., Bryant & Haselton, 2009; Roberts et al., 2004; Singh & Bronstad, 2001), likely increasing the efficacy of their attraction strategies. Simultaneously, however, this phase also carries with it the highest probability that a woman will incur the steep cost of an untimely or otherwise non-optimal conception from a sexual assault.

Various aspects of mating psychology, such as women's preference for facial cues to masculinity, have been linked to high levels of estradiol (Durante & Li, 2009; Roney & Simmons, 2008). Rape avoidance psychology has also been associated with the fertile window

(Bröder & Hohmann, 2003; Chavanne & Gallup, 1998), a period of high estradiol (Ferin, Jewelewicz, & Warren, 1993). Hormonal contraceptives (HCs) keep a very low, steady amount of ethinyl estriadol and progestinone (e.g., Levonorgestrel) in the bloodstream; this blunts the levels of naturally-occurring estrogen, progesterone, testosterone, follicle stimulating hormone, and luteinizing hormone and precludes the rise in hormones that leads to ovulation (Drife, 1996; Fleischman, Navarrete, & Fessler, 2010). Because of this, women using HCs offer a quasi-control group for research on menstrual cycle effects on behavior (Miller, Tybur, & Jordan, 2007; Wedekind, Seebeck, Bettens, & Paepke, 1995) and will be similarly utilized in the present study

Mating Strategy, Relationship Status, and Sexual Assault Avoidance

The degree of conception likelihood across the menstrual cycle is hypothesized to interact with individual differences in mating strategy, as well as the presence or absence of an existing mate, in order to produce adaptive behavioral output. Mating strategy is often gauged by an individual's sociosexual orientation (SOI), which is a measure that reflects openness to engaging in short-term sexual relationships (Simpson & Gangestad, 1991). Women with higher (unrestricted) SOI are more likely to engage in short-term sexual relationships and prefer more masculine traits in their mates (Provost, Kormos, Kosakoski, & Quinsey, 2006; Provost, Troje, & Quinsey, 2008; Waynforth, Delwadia, & Camm, 2005), traits that have been hypothesized to be indicators of genes for good health (Scheib, Gangestad, & Thornhill, 1999). Additionally, Durante, Li, and Haselton (2008) found that women with higher SOI showed a larger shift toward wearing more revealing clothing on high fertility days than women with lower SOI. Taken together, these findings indicate that women with unrestricted SOI may be privileging markers of good genes. If women with higher SOI are choosier with regard to good genes

indicators, and they are more likely to engage in mating-motivated display behaviors around ovulation, sexual assault could interfere to a greater degree with their sexual strategy of garnering good genes through selective mate choice, compared to women with lower SOI. Finally, higher SOI has been associated with more unstable early environments including parental divorce (Barber, 1998), thus high SOI could indicate a behavioral phenotype that anticipates volatile social and environmental conditions including greater likelihood of sexual assault.

Relationship status is a significant predictor of the likelihood of sexual assault--single women are much more likely to be raped than married women (Wilson & Mesnick, 1997). The bodyguard hypothesis posits that women choose mates, in part, based on characteristics such as size and strength that can afford protection from sexual assault (Wilson & Mesnick, 1997). Proximity to a protective male decreases a woman's need for vigilance to contexts of sexual assault. Because women in long-distance relationships, however, lack proximity to the man who would otherwise function as a bodyguard, they may engage in as much vigilance as single women. Women with higher SOI and single women may be less likely to have a man around consistently to protect them, and they may be more likely to interact with unfamiliar males. For these reasons, women with higher SOI and women without a mate in proximity (i.e., single women and women in long distance relationships) may be more vigilant to contexts of sexual assault when in the most fertile phase of their cycle, compared to women in local relationships and women with lower SOI. In short, we predicted an interaction (see predictions section below) between sexual strategy, proximity to mate, and conception risk (CR; the probability of conception on a given day of the cycle).

Upset, Psychological Pain, and Fertility Status

In order to test whether women avoid activities with the risk of sexual assault, we measured not only self-reported behaviors, but also emotional reactions to cues to these situations. Buss (1989b) found that sexual aggression on the part of men, which undermines female choice, elicits more anger and upset in women than any of the other 146 male cost-inflicting actions examined. According to Strategic Interference Theory, negative emotions, such as anger or upset, occur when the actions of another person interfere with the successful enactment of one's current adaptive strategies (Buss, 1989b). These negative emotions create psychological pain which motivates individuals to avoid the same maladaptive contexts in the future. Thornhill and Thornhill (1999) found that young fertile women who are raped experienced more psychological pain than prepubescent or postmenopausal women. One interpretation of this finding is that younger women, with their higher conception risk, have the potential to incur greater costs as a result of rape and thus their degree of upset reflects these costs. Parallel to Thornhill and Palmer's (2000) result about the intensity of psychological pain in young fertile women, Pawson & Banks (1991)found that, when asked about the content and degree of fear of crime, younger women more often report fear of sexual assault while older women more frequently reported fear of theft (Pawson & Banks, 1991). The content of women's fears appears to reflect the assaults that are most costly to them, most likely to occur to them, or both. Sexual assault is both more common among young women (Thornhill & Palmer, 2000) and more costly to their reproductive success because of the greater risk of inopportune pregnancy. Women seem to possess some evolved psychological mechanisms related to rape avoidance. For example, women's handgrip strength appears to increase immediately after being exposed to cues of potential sexual assault, but only among women in the fertile window (Petralia & Gallup, 2002). The researchers explained this as a manifestation of an adaptive up-regulation of defenses

during the period of highest conception risk to defend against potential sexual assailants. Women also exhibit a bias toward inferring sexual coerciveness in men during the fertile window (Garver-Apgar, Gangestad, & Simpson, 2007).

Previous Studies Directly Investigating Fertility Effects on Avoidance of Sexual Assault

Two studies have directly investigated the phenomenon of avoidance of sexual assault during the fertile window. Chavanne and Gallup (1998) asked women whether they had engaged in any of 18 activities in the previous 24 hours (e.g., "date," "grocery store," "walked in a dimly lit area"), each of which was independently rated on its risk of potential sexual assault. They found that, among naturally-cycling women, those in their fertile window had a lower risk score than women outside their fertile window. Broder and Hohmann (2003) replicated Chavanne and Gallup's (1998) results using an improved methodology, consisting of a repeated measures design and ratings of 40 different activities chosen to represent a larger disparity in "risky" and "nonrisky" activities. These authors also found that risky activities were reported less frequently during the fertile phase of the menstrual cycle. As in these studies, we will use the word "risky" as shorthand for activities and contexts that are potentially risky for sexual assault. Though the effect was replicated once, both of these studies have some methodological limitations in the way they operationalized and measured risky activity levels. Chavanne and Gallup (1998) used only 18 activities, the ratings of which were log-transformed, to test their hypotheses. Also, by summing ratings rather than averaging, Chavanne and Gallup (1998) may have arrived at erroneous conclusions since women who engaged in many non-risky activities would have the same score as women who engaged in fewer highly risky activities. Broder and Hohmann (2003) included an increased pool of 40 activities, but many were extremely specific (e.g., "stop at a remote rest stop") and chosen for their riskiness, not for the degree to which they occurred in

everyday life, limiting ecological validity. In both of the previous studies, women were binned into menstrual phase categories, which could be problematic because CR is a continuous variable across the menstrual cycle.

Most importantly, previous studies did not distinguish between risky mating-related behaviors and risky behaviors unrelated to mating. In both studies, the researchers did not obtain information about the participants' companions, or potential 'bodyguards,' when they performed the activities in question. Neither study addressed women's relationship status, or distinguished between risky activities in the service of mate-seeking and risky activities unrelated to mating. Both Chavanne and Gallup (1998) and Broder and Hohman (2003) included potential mate-seeking activities (e.g., "invite a man for dinner," "date," "dancing," "get dressed sexily when going out") as risky activities. As researchers increasingly discover that women engage in certain mate attraction tactics with greater frequency around ovulation (Durante et al., 2008; Grammer et al., 2004; Haselton et al., 2007), a serious confound may exist in these studies between risky and mate-seeking behaviors.

Summary of Overarching Predictions

Previous research has shown an increase in mating-related behaviors, including tactics aimed at attraction, during the fertile window. The first test of our novel measure will be to show an increase in mating behaviors as CR increases. Also, based on previous studies (Broder & Hohmann, 2003; Chavanne & Gallup, 1998), risky behaviors, broadly defined, should decrease as CR increases. However, this kind of restriction would preclude mate-seeking and attraction behaviors, which are of key importance periovulatorily. Thus, we predicted that activities that pose a risk for sexual assault *and do not interfere with mate-seeking activities* will decrease as CR increases.

We also hypothesized that relationship status and sexual strategy would moderate this effect such that women with higher SOI (whose sexual strategy makes a sexual assault both more likely and more costly) and women without a mate in proximity (who have no "bodyguard) will show the largest increase in vigilance as fertility increases. Hormonal changes across the menstrual cycle are hypothesized to proximally calibrate the psychology of the sexual assault avoidance, thus we predicted that HCs that interfere with hormone fluctuations across the menstrual cycle will also prevent shifts in women's sexual assault avoidance psychology.

Menstrual cycle effects on activity patterns.

Prediction 1.1: Women will engage in more mating-related activities as CR increases, as shown in previous studies. However, women will also engage in fewer activities that pose a risk for sexual assault, after controlling for the degree to which they are mating-related. SOI will moderate this effect because women with high SOI may be more exposed to risk of sexual assault, assault could be more damaging to their sexual strategy and SOI may represent a phenotype aimed at adapting to volatile environments. Relationship status may moderate this effect because single women are both engaging in more risky mate-seeking behavior and less likely to have a protective male in proximity.

Prediction 1.2: Women who are taking HCs will not show these cycle effects such that their mating behaviors will not change across the cycle, and their behavior will be most similar to low CR naturally cycling women. Women on HCs and women outside of the fertile window have similar hormone profiles and thus may show similar levels of mate-seeking and risky activities.

Menstrual cycle effects on fear of sexual assault.

Prediction 2.1: As CR increases, women will report more fear and anxiety related to walking alone in a deserted area, a context of possible sexual assault, and this effect will be moderated by SOI and relationship status.

Prediction 2.2: As CR increases, women will be more likely to mention sexual assault when asked about the content of their fear and anxiety, and this effect will be moderated by SOI and relationship status.

Prediction 2.3: As CR increases, women will report more upset about unwanted physical contact from a male stranger, cues that represent a possible sexual assault, and this effect will be moderated by SOI and relationship status.

Method

Participants

The sample consisted of 379 women attending a large university in the Southern United States. To better control for hormonal contraception (HC), we excluded women who had been using a specific HC for less than 3 months (n = 16) and women who been naturally cycling for less than 3 months (n = 12). We also excluded women on Depo-Provera (n = 7), women who reported an age outside of the 17 to 45 range (n = 2), women who did not report being heterosexual (n = 9), women who were naturally cycling but did not have a valid ovulation test (n = 6), women who did not have a viable cycle day from which to estimate CR (cycle day greater than 40 or less than 0) nor a positive ovulation test (n = 31), and those women who left the majority of survey items incomplete (n = 12). The remaining sample consisted of 284 women: 177 naturally cycling women and 107 women on HC who ranged in age from 17 to 29

(*M* = 18.80). The sample was 57% White, 18% Hispanic/Latina, 13% East Asian, 5% Black/African American, 3% South Asian, and 4% other ethnicity.

Materials

Risky Activity Inventory. Initially, the experimenters collected nominations from acquaintances and research assistants to create an activity list of 111 items. Eight female undergraduates rated how likely young women would be to engage in each activity, on a scale from 1 (definitely would not occur) to 100 (definitely would occur). Items with mean ratings below 20 were considered too rare for inclusion, leaving 74 items. Four additional female undergraduates rated each of the 74 activities on three dimensions: short term mating (STM), long term mating (LTM), and riskiness for sexual assault (RISKY). For STM, they rated the likelihood that a young woman would engage in the activity with a STM motive in mind, defined as "a sexual encounter with someone with whom you do not expect to form a relationship." Raters were reminded that regular repeated casual sexual encounters with the same person did not qualify as STM, and that STM can also occur outside of an existing relationship. For LTM, they rated the likelihood that a young woman would engage in the activity with a LTM motive in mind, defined as "aimed at the goal of having regular romantic and sexual encounters with another person." For RISKY, they rated the likelihood that the act could result in sexual assault, defined as "having sex with someone you would not want to have sex with, especially having unwanted sex with a stranger or someone you know very little about"[1]. The agreement between the judges for the three criteria was good: LTM $\alpha = .84$, STM $\alpha = .92$, and RISKY $\alpha = .91$.

In the current study, for each activity (see Appendix), participants indicated whether they had engaged in that activity in the last 24 hours and whether they planned to engage in that activity in the next 24 hours[2]. For reportorial economy, and because there was good agreement

between the scores for the completed and planned items (average r = .42), we combined the activities reported by each participant. For each participant, the ratings for their activities (for LTM, STM, and RISKY, respectively) were added together and divided by the number of activities reported, yielding mean LTM, RISKY, and STM scores for each participant$_2$.

One of the weaknesses of the Chavanne and Gallup study (1998) was that they used the sum of activities rather than the mean. We used mean activity score rather than activity sum for two reasons. Many mammals increase their energy expenditure around ovulation in order to find a mate (Fessler, 2003), and women may likewise increase the total number of activities they engage in around ovulation. Additionally, activity sum was influenced by day of the week. All of our participants came in on a weekday but the day of the week had an effect on the number of activities participants reported with Monday and Thursday showing the highest number of activities and Wednesday showing the lowest number of activities. In line with Fessler (2003), and validating our assumptions, we conducted an ANCOVA with CR and day of the week as independent variables. There was a significant interaction between day of the week and CR on number of reported activities (F(4,156) = 2.46, p =.03 in addition to main effects of day of week F(4,156) = 2.14, p =.08 and CR, F(1,156) = 2.97, p =.09. Given the potential confound between CR and day of the week, together with the greater ease of interpretability when an average score is used, mean scores for each of the activity category will be used throughout the paper.

Table 1 lists 10 activities which received the highest ratings in each category to illustrate the types of items that best represent each construct. The activities rated as highly RISKY involved either being alone or interacting with strangers when unaccompanied by friends or kin. Acts rated high in LTM consisted of interactions with regular romantic partners or pre-approved men, not with strangers. Activities rated high on STM involved sexual interactions, or preludes

to sexual interactions, with strangers. Ratings of STM and LTM were weakly correlated ($r(74) = .24$, $p=.04$), indicating that they were viewed as largely, but not completely, independent forms of mating effort. STM ratings strongly correlated with RISKY ratings $r(74) = .69$, $p < .001$, however LTM ratings were not significantly correlated with RISKY ratings, $r = -.13$, $p = .26$, indicating that LTM activities were viewed as much safer with respect to sexual assault than STM activities by our raters. In order to demonstrate activities considered highly RISKY but not STM-motivated we created a new variable for this table called RISKY-STM which shows the items with the highest rating when STM is subtracted from RISKY ratings. As evidenced by the strong correlation between STM and RISKY, there is significant overlap between these two variables of key interest. In order to fully explore these differences, we created new variables controlling for the effects of these correlated variables. For example, the variable RISKY(STM) is the residual value of a linear regression predicting RISKY scores from STM scores. Likewise, the STM(RISKY) variable represents the residual values of a linear regression predicting STM scores from Risky scores. Table 2 shows the descriptive statistics for the three main activity ratings as well as these residual variables.

Sociosexuality Orientation Inventory (SOI). In addition to questions regarding relationships, relationship length, and satisfaction, we administered the SOI, a composite measure of attitudes and behaviors concerning willingness to engage in casual sex which served as our measure of mating strategy (Simpson & Gangestad, 1991). Higher scores on the SOI indicate more unrestricted sexuality, suggesting a short-term mating strategy; low scores suggest a long-term mating strategy.

Anxiety in a Rape Risk Context. Informed by Petralia and Gallup's (2002) vignette about a woman walking to her car late at night used to cue fear of sexual assault, we asked women "If

you had to park in a deserted, dark area tonight, how scared or anxious would you feel about your personal safety?" Women rated their degree of fear on a scale from 1 to 10 (1 being "not at all fearful" and 10 being "very fearful"). We also asked women "What is the main thing you would be afraid of or anxious about?" The second question was left open-ended and the answer was coded for content related to sexual assault. Mentioning rape, sexual assault or victimization, sexual predators, or "being taken advantage of" was coded as a 1 and all other responses were coded as 0.

Upset at Unwanted Sexual Attention. Women likely possess some threshold at which they perceive that consensual opposite-sex interaction has begun to show the potential for sexual assault, perhaps as a feeling of upset to motivate avoidance. We created a questionnaire to assess a woman's level of upset at unwanted contact from an unattractive male stranger containing four items rated on a scale of 1 ("not at all upset") to 10 ("extremely upset"): "How upset would you be if a male stranger to whom you are not attracted: (1) kissed you against your will, (2) purposefully touched your butt, (3) held you in such a way that you could not move, (4) purposefully grabbed your breast(s)?"; composite reliability was satisfactory ($\alpha = .70$).

Estimation of Conception Risk

CR is not a binary variable, and there several days on which conception is possible; one recent large-scale study found conception to be possible as early as seven days before ovulation (Bilian et al., 2009). Standard ovulation tests can only capture two of these fertile days, but selection pressures would have shaped women's psychological mechanisms to avoid sexual assault across the entire fertile window. Therefore, rather than using ovulation tests as our sole measure of CR, we used a table of CR across the menstrual cycle to capture the full variance (Wilcox, Dunson, Weinberg, Trussell, & Baird, 2001). We assigned a CR using the best method

of estimation available for each participant, in order of validity: a positive ovulation test result, backward counting from an actual date of next menstruation, and forward counting from a previous date of menstruation.

Ovulation tests. Princeton Biomeditech Corporation supplied tests used to detect ovulation; these standard urinalysis strips measure luteinizing hormone, the hormone that peaks 12 to 48 hours before ovulation. The tests themselves had no markings to indicate their purpose. We have viable ovulation test results from all the naturally cycling women; of these 177 tests, 42 (24%) were confirmed as ovulating. We incorporated the ovulation tests into the continuous CR variable by assigning ovulating women a CR of .07, indicating the highest probability of conception in Wilcox et al.'s (2001) actuarial table for irregularly cycling women (most of the naturally cycling women in our sample reported having irregular cycles lasting longer than 28 days).

Backward counting. For those participants for whom we had a confirmed date of next menstruation (from a postcard they returned at the onset of their next menstruation), we used a backward counting method (Haselton & Gangestad, 2006). Counting backward from the confirmed date of next menstruation is the best way to estimate menstrual cycle day aside from hormonal measures for two reasons : (1) giving a date of menstruation when it is actually occurring rather than relying on memory of a past date of menstruation is more reliable and (2) the luteal phase is less variable in length than the follicular phase (Hatcher & Namnoum, 2004), meaning that ovulation is more reliably pinpointed retrospectively. Using the backward counting method, we estimated that ovulation occurred 14 days before the date of next menstruation and then mapped this day onto the day with the highest CR on the conception probability table (day 17). The number of days before or after this date yielded the participant's CR on the day of

experimentation. We received a confirmed date of next menstruation for 19 of 107 (18%) of women on HC and 34 of 177 (19%) of naturally cycling women.

Forward counting. For those participants for whom we only had a previous date of menstruation, we used the forward counting method (Gangestad & Thornhill, 1998) which is simply counting the days from the start of the last menstrual cycle. To test the likely validity of this measure in our dataset, we compared the CR calculated via forward counting to the CR calculated using the backward counting and ovulation test for those participants for whom we had all information. These methods were highly correlated in this subsample, $r(341) = .93$, $p < .001$). In order to corroborate our counting methods, we looked at the calculated cycle day of women with positive ovulation tests. Ovulating women had an average cycle day of 15 and the modes of the distribution were 16 and 17. In Wilcox's (2001) table of conception likelihood for irregularly cycling women, day 16 and 17 have the highest CR associated with them.

Procedure

Participants reported to the lab once, gave informed consent, and then completed the materials on computerized surveys. On the first page of the survey, they were asked if they were currently taking HC; if they answered "no," they were instructed to see their experimenter who gave them instructions for urinalysis. Participants were told that they were being administered a test that measured normal hormone levels and were not told that it was actually an ovulation test until debriefing. After participants completed the survey materials, they were debriefed by the experimenter and given a pre-addressed, stamped postcard. They were told to return the card with their date of next menstruation to be entered into a drawing for a portable music player.

Results

Menstrual cycle effects on activity patterns.

Prediction 1.1. To assess activity levels across the cycle, women who reported three or fewer activities (n = 12) were excluded because it was inadequately representative given the large number of activities to choose from. Women who did not complete the entire SOI inventory (n = 10) and women on HC were also excluded from these analyses. For each major dependent variable, we conducted an omnibus ANCOVA using CR and SOI as covariates and relationship status (single, long distance relationship, or local relationship) as a fixed factor.

STM. There was a significant three-way interaction of CR, SOI, and relationship status on STM, see Table 3. Figure 1 shows distinct patterns for high and low SOI women in different relationships as CR increases. From the graphs it appears that both high and low SOI single women increased STM as CR increased, while high SOI (but not low SOI) women in long distance relationships increased their STM behavior as CR increased, and high SOI (but not low SOI) women in local relationships decreased their STM behavior as CR increased. We did a mean split on SOI and compared the correlations between conception risk and STM on women who scored above and below the mean of SOI in three different relationship categories. For single women there was not a significant difference between the correlation for high SOI single women $r(27)$= .41 p=.03 and low SOI single women $r(56)$=.11 p=.41, z=1.32 p=.19. For women in long distance relationships there was a large difference between the correlations between CR and STM in high SOI women $r(13)$= .54 p=.06 versus low SOI women $r(19)$= .08 p=.76, but this failed to reach significance because of small sample size , z=1.37 p=.17. For women in local relationships the correlation between STM and CR for high SOI women was $r(15)$= -0.47 p=.08 and for low SOI women was $r(24)$=.21 p=.22 which was significantly different, z=2.00 p<.05.

LTM. Neither the three-way interaction for LTM, nor the two-way interactions were significant; only the main effect of CR was significant and the interaction of CR and relationship status approached significance, see Table 3. The bivariate correlation between LTM and CR was $r(155) = .25$, $p = .002$.

RISKY. None of the interactions or main effects of RISKY were significant, see Table 3. The main effect of SOI approached significance; the bivariate correlation between SOI and RISKY was $r(155) = .33$ $p < .001$.

STM(RISKY). There was a significant three-way interaction of CR, SOI, and relationship status on STM(RISKY), see Table 3. The pattern was similar to the interaction found for STM above, Again, we did a mean split on SOI and compared the correlations between conception risk and STM(RISKY) on women who scored above and below the mean of SOI in three different relationship categories. For single women the correlation for high SOI single women r (27)= .48 p=.01 and low SOI single women r (56)=.19 p=.19 which was not significant z=1.39 p=.16. For women in long distance relationships the difference between the correlation of CR and STM(RISKY) in high SOI women r (13)= .52 p=.07 versus low SOI women $r(19)$= .10 p=.68 was not statistically significant z=-1.18p=.17. For women in local relationships the correlation between STM(RISKY) and CR for high SOI women was $r(15)$=-0.40 p=.13 and for low SOI women was $r(24)$=.04 p=.85 also did not reach significance, z=1.28 p=.20.

RISKY(STM). The three way interaction of CR, SOI, and relationship status was not significant, see Table 3. To test the replication of previous studies, we conducted a bivariate correlation between RISKY(STM) and CR, which was significant and in the predicted direction: $r(155) = -0.16$ $p = .04$. Women engaged in less RISKY(STM) activities as conception risk increased regardless of sexual strategy or relationship status.

Prediction 1.2. Women on HCs were more likely to be in a relationship than women who were naturally cycling χ^2 (1, N = 252) = 10.2, p = .001 and had a significantly higher SOI t(246) = 3.12 p = .002. To test predictions comparing cycle changes among women on and off of HC, we created a dummy CR for each of the women on HC based on forward or backward cycle day estimation methods. Women on HC did not exhibit any significant correlations between the dummy CR and any of the tested variables (all ps > .14). Conducting an omnibus ANCOVA, like the one above for naturally cycling women, yielded no significant main effects or interactions related to CR (analyses available from the first author upon request), supporting Prediction 1.2. This indicates that women on HC do not change their activity patterns over the cycle as naturally cycling women do, but we wanted to further determine whether their activity level was similar to that of naturally cycling women at high or low CR.

In order to compare women with high CR and low CR to women on HC, we divided all the participants (regardless of relationship status) into three categories: naturally cycling high CR, naturally cycling low CR, and women on HC. Women above the mean CR for naturally cycling women (M = 0.03) were designated as "high CR" and those below the mean as "low CR." Excluding women who engaged in fewer than four activities, as before, we conducted a MANOVA comparing these three groups on each main dependent variable, see Table 4. STM(RISKY) and LTM emerged as significant and RISKY(STM) trended towards significance. Women on HCs more closely resembled low CR women with the exception of LTM. The prediction was partially supported. Further analyses showed no moderating effect of relationship status or SOI on these relationships (analyses available from the first author upon request).

Menstrual cycle effects on fear of sexual assault.

Prediction 2.1. Women on HCs and women who did not complete this measure (n = 19) were excluded from this analysis. We first conducted an ANCOVA with fear as the dependent variable, CR and SOI as covariates, and relationship status as a fixed factor. No interactions were significant (all ps >.12 analyses available upon request from the first author). Furthermore, the bivariate correlation between CR and fear was not significant, $r(137) = .12$, $p = .16$. Prediction 2.1 was not supported.

Prediction 2.2. Of the naturally cycling women who described what they would be scared or anxious about when walking alone in a dark area (N = 153), 30% were coded as mentioning sexual assault in their answers. We ran a binomial logistic regression with SOI, CR, and their interaction as predictors for whether or not sexual assault was mentioned as the cause for fear. We found a significant two-way interaction of CR and SOI, χ^2 (1, N = 153) = 5.60, $p = .02$, with main effects of SOI, χ^2 (1, N = 153) = 8.14, $p < .01$, and CR, χ^2 (1, N = 153) = 2.89, $p = .09$. Women with higher SOI were more likely to specifically mention sexual assault-related fears as CR increased, compared to women with lower SOI.

Prediction 2.3. This analysis involved only naturally cycling women and women who completed this portion of the survey (n = 137). First, an ANCOVA was conducted with degree of upset as the dependent variable, relationship status as a fixed factor, and SOI and CR as covariates, see Table 5. Neither the three way interaction nor any two way interactions involving relationship status were significant, but there were significant main effects of CR and SOI. When relationship status was dropped from the model, the interaction of CR and SOI was significant, $F(1,133) = 7.81$, $p < .01$, as were the main effects of CR $F(1,133) = 8.40$, $p < .01$, and SOI $F(1,133) = 12.36$, $p < .001$ see Figure 3.

Discussion

The results provide support for the general hypothesis that women become more vigilant towards contexts of sexual assault during periods of increased fertility. At the same time, the novel interactions discovered in the current study provide a more complex understanding of women's psychology of sexual assault avoidance. The results of this study converge on the conclusion that women are managing mate-seeking activities while avoiding potentially risky encounters with unapproved males. Moreover, our analyses reveal that women, far from showing universal tendencies, appear to behave differently across the cycle based on preferred mating strategy and on their current relationship status. The data depicts women as possessing dynamic strategies that are consistent with the hypothesized evolved psychological mechanisms that mitigate risks while increasing potential benefits during the fertile window.

We found that single women tend to increase their mate-seeking behavior (even after controlling for riskiness) as conception risk increased, regardless of SOI. Among mated women, on the other hand, low SOI women do not fluctuate in mate-seeking behavior across the cycle. High SOI women show increased mate-seeking behavior during high conception risk, but only when their mate is geographically distant; when their mate is local, they actually decrease mate-seeking behavior at ovulation. This pattern may indicate that high SOI women are seeking or engaging in extra-pair mating, or perhaps engaging in behavior that keeps open the potential of 'back-up mates' or 'alternative mates' (Buss, 2003; Duntley, 2007). That they tend to decrease mate-seeking behaviors around ovulation when their mate is local might reflect increased vigilance and mate-guarding behavior on the part of their mate at peak fertility (Haselton & Gangestad, 2006).

Using the greatly expanded activity list and improved ovulation assays, we were able to replicate and extend the general effect found in previous research (Broder & Hohmann, 2003; Chavanne & Gallup, 1998): after controlling for short term mating-motivated behaviors, risky behaviors decreased at peak fertility. The fact that the interaction effects of CR, SOI, and relationship status were not significant failed to support our original hypothesis concerning the contextual and individual difference influences on sexual assault avoidance psychology. It does show, however, that all women are avoiding risky behavior that is unrelated to mate-seeking behavior as fertility increases across the menstrual cycle.

The cycle effects on sexual assault avoidance appear to be both behavioral and psychological in nature. Our assessment of the psychological mechanisms involved measuring fear ratings and content of a risky scenario, as well as upset at unwanted sexual contact from an undesirable man. Although the degree of fear in the deserted parking lot scenario remains the same throughout the cycle, the *content* of that fear changes reliably based on cycle and SOI. High SOI women were more likely to show increase vigilance to sexual assault risk at peak fertility while low SOI women showed the reverse pattern. There was no interaction with relationship status, so this does not seem to be driven by a bodyguard effect. Perhaps high SOI women, regardless of whether they are mated, possess mechanisms which are designed to provide greater protection and vigilance against sexual assault during increased fertility either due to the costs to their sexual strategy or simply because SOI is one marker of a phenotype designed to anticipate such outcomes.

Our study provides indirect evidence that hormones may mediate both vigilance and mate-seeking behaviors across the menstrual cycle. Although we did not directly measure estradiol, testosterone or other hormones that are down-regulated while using HCs, the

comparison of women on HC to naturally cycling women does indirectly gauge the moderating effects of these hormones. Naturally cycling women showed a direct correlation between the gradual variability of CR over the menstrual cycle and a decline in engaging in risky activities that were not short term mating motivated. The finding that women on HC do not show changes across the menstrual cycle on our measures indicates that changes in the avoidance of contexts of sexual assault may be hormonally mediated. Moreover, single women on HC and single naturally cycling women with low CR, who have a similar hormone profile with regard to estradiol, scored similarly on risky behaviors controlling for short-term mating and short term mating controlling for risky behaviors.

There were several limitations to the present study. Because we used a between-subjects design, we obtained a cross-sectional snapshot of the mating and sexual assault avoidance behavior of our participants. The actual degree to which these behaviors are altered over the course of the menstrual cycle and the specific ways in which individual differences in mating strategies alter the baseline of these behaviors cannot be discerned completely through this methodology. A longitudinal design could address this issue and could also reveal the way relationship status moderates mating-motivated and sexual assault-avoidance activities. Since we did not directly measure any reproductive hormones other than luteinizing hormone in naturally cycling women, our conclusions regarding how estradiol or other hormones might mediate our measures are tentative. Any hormone moderated by HC or even another unmeasured individual difference between naturally cycling women and women taking HC could be the mediator of mate-seeking behavior. Finally, women were given a set of choices of activities to choose from and had to choose who they engaged in the activity with (e.g. friend, romantic partner). Perhaps a more open-ended survey could provide a richer source of data.

This study builds upon previous research on menstrual cycle effects, but offers a more comprehensive and complex understanding of women's psychology of sexual assault-avoidance, incorporating contextual effects of relationship status and individual differences in the form of sexual restrictedness. Rather than a simple avoidance mechanism, which could subvert adaptive mate-seeking strategies, women's psychology of sexual assault avoidance and mate-seeking behavior appears to be sensitive to theoretically predictable interactions over the menstrual cycle between relationship context and preferred mating strategy.

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[deleted for review]

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Appendix

Risky Activity Inventory

1. Dance with a male stranger at a bar or nightclub
2. Drive alone at night.
3. Drive at night or ride in the car with a date in the car.
4. Drive at night or ride in the car with a female friend in the car.
5. Drive at night or ride in the car with a male friend in the car.
6. Drive at night or ride in the car with a romantic partner in the car
7. Drive through a poor section of town at night.
8. Fill up your gas tank at night
9. Go hiking with a friend
10. Go on a date with a man you've met before
11. Go on a date with your regular romantic partner.
12. Go out to eat dinner with a date
13. Go out to eat dinner with a female friend
14. Go out to eat dinner with a male friend
15. Go out to eat dinner with your regular romantic partner
16. Go outside (walk/walk the dog/take out the trash/jog) alone after dark
17. Go outside (walk/walk the dog/take out the trash/jog) alone during daylight hours
18. Go outside (walk/walk the dog/take out the trash/jog) with a date after dark
19. Go outside (walk/walk the dog/take out the trash/jog) with a date during daylight hours
20. Go outside (walk/walk the dog/take out the trash/jog) with a female friend after dark

21. Go outside (walk/walk the dog/take out the trash/jog) with a female friend during daylight hours
22. Go outside (walk/walk the dog/take out the trash/jog) with a male friend after dark
23. Go outside (walk/walk the dog/take out the trash/jog) with a male friend during daylight hours
24. Go outside (walk/walk the dog/take out the trash/jog) with a romantic partner after dark
25. Go outside (walk/walk the dog/take out the trash/jog) with a romantic partner during daylight hours
26. Go shopping at a mall or store
27. Go swimming at Barton springs alone
28. Go swimming at Barton springs with a date
29. Go swimming at Barton springs with a female friend
30. Go swimming at Barton springs with a male friend
31. Go swimming at Barton springs with a romantic partner
32. Go to a bar/nightclub alone
33. Go to a bar/nightclub with a date
34. Go to a bar/nightclub with a female friend
35. Go to a bar/nightclub with a male friend
36. Go to a bar/nightclub with your regular romantic partner
37. Go to a concert
38. Go to a party with a date
39. Go to a party with a female friend
40. Go to a party with a male friend

41. Go to a party with your regular romantic partner

42. Go to church

43. Go to the ballet/theater/opera

44. Go to the library

45. Go to the movies with a female friend

46. Go to the movies with a male friend

47. Go to the movies with a man on a date

48. Go to the movies with a man on a first date

49. Go to the movies with your regular romantic partner

50. Have coffee or lunch with a female friend

51. Have coffee or lunch with a male friend

52. Have sex with a date.

53. Have sex with a male romantic partner

54. Have sex with a man that you just met.

55. Hug a male that you just met.

56. Invite a female friend to your place.

57. Invite a male friend to your place.

58. Invite someone you met at a bar back to your place.

59. Kiss a male that you just met.

60. Meet a male in person whom a friend or family member set you up with

61. Study/read/or watch television in a shared space (e.g. suite)

62. Study/read/or watch television in your room or apartment

63. Take a city bus home alone at night

64. Take a city bus home alone during the day.

65. Take a shower at the gym.

66. Take a UT shuttle home alone at night

67. Take a UT shuttle home alone during the day.

68. Take the garbage out at night

69. Take the garbage out during the day

70. Talk to or accept a drink from male stranger at a bar or nightclub

71. Visit relatives

72. Walk down 6th Street alone at night.

73. Walk down 6th Street with a friend at night.

74. Workout at the gym

Footnotes

1. While date rape, acquaintance rape, and rape within relationships occur, women's mate choice is most undermined when they do not have the opportunity to assess the mate value of a given male, such as in stranger rape. Women raped by a strange male also have less opportunity for recourse via communicating the rape to their kin or community. Finally, throughout our ancestral past, rape commonly occurred in warfare situations in which females had no acquaintance with the males who sexually assaulted them. For these reasons, contexts in which rape committed by a stranger can occur are most likely to trigger evolved psychological mechanisms for vigilance.
2. As a simplistic example, a participant who reported two activities: going out to the movies with a male friend (RISKY rating: 2, STM rating: 3.25, LTM rating: 4.5) and taking the garbage out during the day (RISKY rating: 1.75, STM rating: 1, LTM rating: 1), would have a RISKY score of (2+1.75)/2= 1.88, a STM score of (3.25 + 1)/2 = 2.13 and a LTM score of (4.5+1)/2= 2.75.
3. Participants in one semester of the study were asked how likely they were to engage in the activity in the next 24 hours on a scale from 1 to 10. For the purposes of standardizing the data, we assigned any value greater than 5 as a 1 and values of 5 or less as a 0.
4. Results with both "likely" activities and completed activities are available by request from the first author.

Table 1

A selection of the highest rated items in each category

RISKY	STM	RISKY-STM	LTM
Invite someone you met at a bar back to your place.	Invite someone you met at a bar back to your place.	Take a city bus home alone at night	Have sex with a male romantic partner
Have sex with a man that you just met.	Have sex with a man that you just met.	Drive through a poor section of town at night	Go out to eat dinner with your regular romantic partner
Talk to or accept a drink from male stranger at a bar or nightclub	Talk to or accept a drink from male stranger at a bar or nightclub	Fill up your gas tank at night	Go on a date with your regular romantic partner.
Take a city bus home alone at night	Kiss a male that you just met.	Take the garbage out at night	Go to the movies with your regular romantic partner
Go outside (walk/walk the dog/take out the trash/jog) alone after dark	Dance with a male stranger at a bar or nightclub	Go outside (walk/walk the dog/take out the trash/jog) alone after dark	Go to a party with your regular romantic partner

Fill up your gas tank at night	Have sex with a date.	Go outside (walk/walk the dog/take out the trash/jog) with a female friend after dark	Go to a bar/nightclub with your regular romantic partner
Go to a bar/nightclub alone	Go to a bar/nightclub alone	Drive alone at night.	Go out to eat dinner with a date
Drive through a poor section of town at night	Go to a bar/nightclub with a date	Take a shower at the gym	Go outside (walk/walk the dog/take out the trash/jog) with a romantic partner after dark
Kiss a male that you just met	Go to the movies with a man on a first date	Take a city bus home alone during the day	Go on a date with a man you've met before
Go to the movies with a man on a first date	Go to a party with a date	Go outside (walk/walk the dog/take out the trash/jog) alone during daylight hours	Meet a male in person whom a friend or family member set you up with

Note: These activities are in the order in which they were rated and are a subset of the top 15 rated activities in each category; we excluded activities related to the particular city in which the study took place for the purposes of this table and included the most diverse set of 10 within that 15. RISKY = rating of riskiness for sexual victimization; STM = short term mating motivated behavior rating; RISKY-STM = short-term mating rating subtracted from riskiness for sexual victimization rating; LTM = long term mating motivated behavior rating.

Table 2

Descriptive Statistics for Activity Ratings

	Range	Mean(*SD*)
RISKY	1.60 – 3.42	2.44(0.31)
STM	1.42 – 4.01	2.15(0.39)
LTM	1.55 – 4.61	2.66(0.63)
RISKY(STM)	-0.71– 1.15	0.00(0.27)
STM(RISKY)	-1.04 – 1.47	0.00(0.35)

Note: Table includes data for women who reported at least three activities (*N* = 253). RISKY = rating of riskiness for sexual victimization; STM = short term mating motivated behavior rating; LTM = long term mating motivated behavior rating; RISKY(STM) = RISKY controlled for STM; STM(RISKY) = STM controlled for RISKY.

Table 3

ANCOVAs for Main Dependent Variables

Effect	STM	LTM	RISKY	STM(RISKY)	RISKY(STM)
CR	$F(1, 143) = 0.07$	$F(1, 143) = 7.69^{**}$	$F(1, 143) = 1.34$	$F(1, 143) = 0.69$	$F(1, 143) = 1.83$
Relationship status (R)	$F(2, 143) = 3.22^{*}$	$F(2, 143) = 1.15$	$F(2, 143) = 1.59$	$F(2, 143) = 1.71$	$F(2, 143) = 0.26$
SOI	$F(1, 143) = 1.19$	$F(1, 143) = 0.95$	$F(1, 143) = 3.40\dagger$	$F(1, 143) = 0.08$	$F(1, 143) = 2.09$
CR x R	$F(2, 143) = 0.40$	$F(2, 143) = 1.68$	$F(2, 143) = 0.10$	$F(2, 143) = 0.27$	$F(2, 143) = 0.00$
CR x SOI	$F(1, 143) = 0.34$	$F(1, 143) = 0.82$	$F(1, 143) = 0.74$	$F(1, 143) = 0.04$	$F(1, 143) = 0.41$
R x SOI	$F(2, 143) = 6.34^{**}$	$F(2, 143) = 2.84$	$F(2, 143) = 1.74$	$F(2, 143) = 4.20^{*}$	$F(2, 143) = 0.08$
CR x R x SOI	$F(2, 143) = 4.52^{**}$	$F(2, 143) = 2.30$	$F(2, 143) = 0.20$	$F(2, 143) = 4.27^{*}$	$F(2, 143) = 0.37$

$\dagger p \leq .10$; $^{*}p \leq .05$; $^{**}p \leq .01$.

Table 4

MANOVA of Behavior Scores by Cycling Status

		Mean(*SD*)		
	F	High CR	Low CR	HC
STM	1.67	2.21(0.40)	2.14(0.39)	2.10(0.37)
LTM	2.86**	$2.80(0.57)_a$	$2.46(0.53)_b$	$2.75(0.72)_a$
Risky	0.75	2.40(0.29)	2.45(0.30)	2.45(0.32)
Risky (STM)	2.54†	$-0.06(0.25)_a$	0.02(0.29)	$0.03(0.28)_b$
STM (Risky)	3.50*	$0.08(0.34)_a$	-0.01(0.37)	$-0.06(0.31)_b$

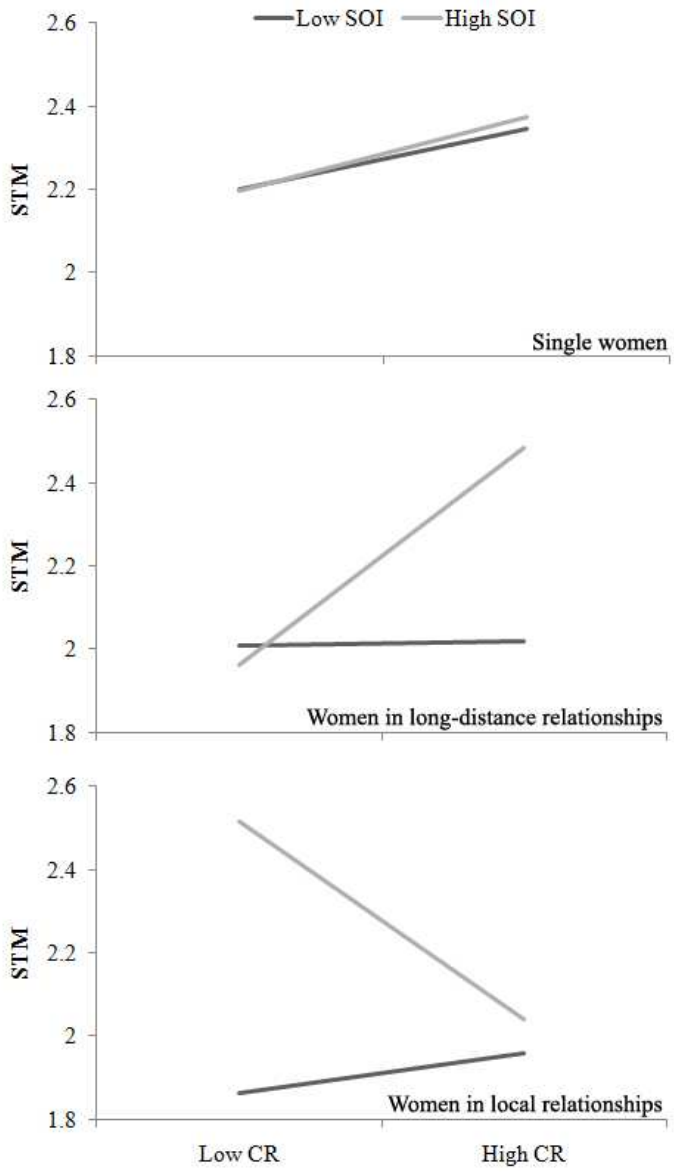
Note: Risky = rating of riskiness for sexual victimization; STM = short term mating motivated behavior rating; LTM = long term mating motivated behavior rating; Risky(STM) = Risky rating controlling for STM rating; STM(Risky) = STM rating controlling for Risky rating. †$p \leq .10$; *$p \leq .05$; **$p \leq .01$. Means with differing subscripts within rows are significantly different at the $p < .05$ based on Fisher's LSD post hoc paired comparisons.

Table 5

ANCOVA for Level of Upset at Unwanted Sexual Contact

Effect	*F*
CR	$F(1, 125) = 4.83$*
Relationship status (R)	$F(2, 125) = 1.33$
SOI	$F(1, 125) = 6.40$**
CR x R	$F(2, 125) = 0.34$
CR x SOI	$F(1, 125) = 2.32$
R x SOI	$F(2, 125) = 2.47$†
CR x R x SOI	$F(2, 125) = 0.31$

†$p \leq .10$; *$p \leq .05$; **$p \leq .01$.



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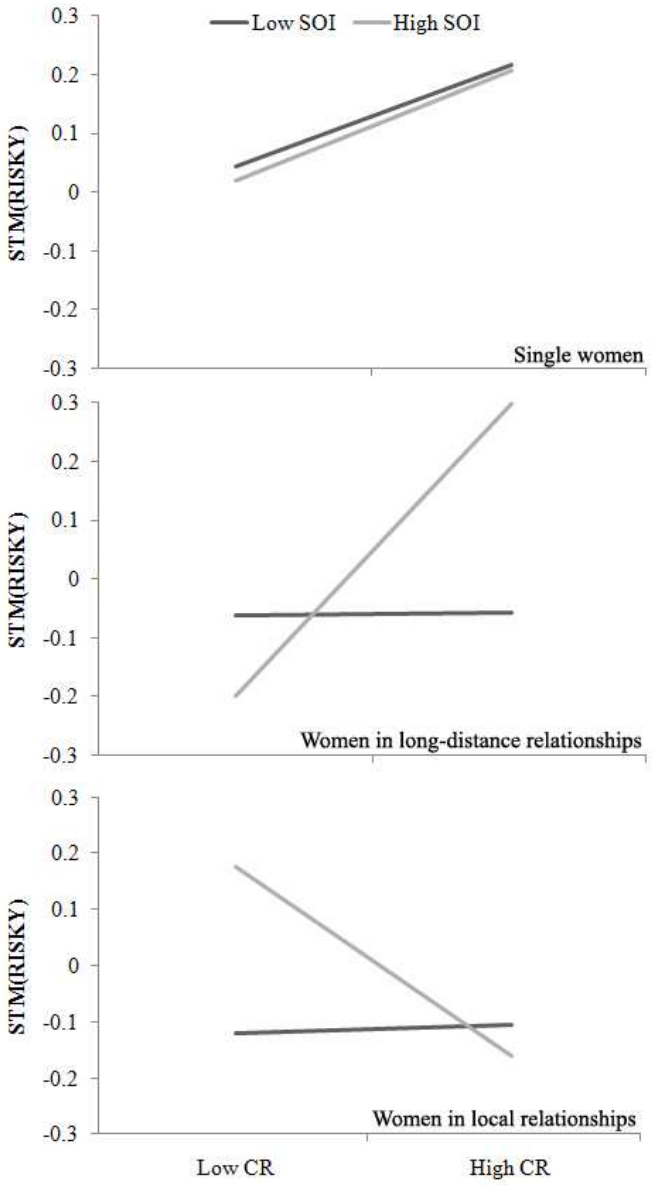

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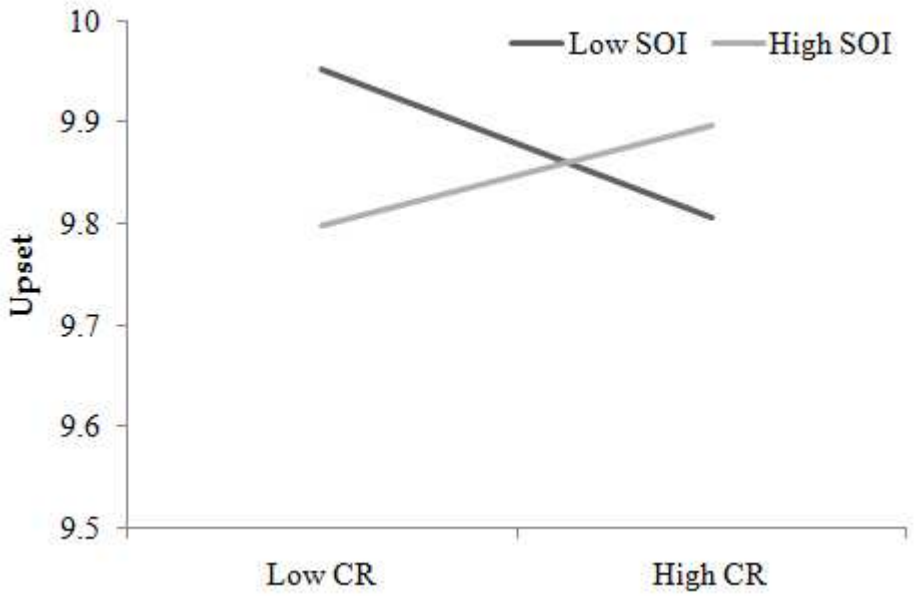

170x111mm (72 x 72 DPI)

Figure captions

Figure 1. The interaction of SOI, CR, and relationship status on STM ratings.

Note: STM represents short-term mating motivated ratings.

Figure 2. The interaction of SOI, CR, and relationship status on STM(RISKY) ratings.

Note: STM(RISKY) represents short-term mating motivated ratings after controlling for risky ratings.

Figure 3. The interaction of SOI and CR on reported upset in response to imagined unwanted sexual contact with an undesirable man.

Note: Binary CR variables represent conception risk, as measured by ovulation tests. Binary SOI variables represent a mean split of SOI.