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Variations in risk taking behavior over the menstrual cycle An improved replication

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Abstract

Evidence that women are less likely to be raped near ovulation than at other times in the ovarian cycle may reflect behavioral adaptations against the risk of fertile insemination by rapists. Chavanne and Gallup [Evol. Hum. Behav. 19 (1998) 27] proposed that women selectively reduce behaviors that expose them to a risk of rape during the ovulatory phase of their menstrual cycle, and reported supportive evidence. However, their study suffered from certain methodological shortcomings. In an improved test involving 51 subjects, repeated measurement, and an explicit distinction between risky and nonrisky activities, we confirmed all predictions: During the ovulatory phase, naturally cycling women reduced risky behaviors and increased nonrisky ones. Women using contraceptives causing hormonal suppression of ovulation showed neither effect.

Keywords: Rape; Adaptation; Methodology

1. Introduction

Forced copulation is taxonomically widespread, and in many cases it clearly represents an evolved reproductive tactic (Cox & Le Boeuf, 1977; Gowaty & Buschhaus, 1998; Smuts & Smuts, 1993; Thornhill, 1980; Thornhill & Thornhill, 1987). Whether the same is true in humans is controversial (e.g., Lalumière & Quinsey, 1996; Lalumière, Chalmers, Quinsey, &

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Seto, 1996; Thornhill & Palmer, 2000; Thornhill & Thornhill, 1983), but regardless of whether rape is an adaptation or a byproduct of other aspects of male sexuality, it is not rare, and it is costly to its victims, particularly when a resultant pregnancy deprives a woman of the benefits of mate choice and partner support (e.g., Shields & Shields, 1983).

If rape is a reproductive strategy, or perhaps even if it is a byproduct of other aspects of male sexuality, we might expect rapists to selectively target fertile women. However, Rogel (1976) and Morgan (1981) reported that women were less likely to be raped during the fertile (ovulatory) phase of their menstrual cycle than at other times (cited in Chavanne & Gallup, 1998). To explain this, Chavanne and Gallup (1998) proposed that women may possess behavioral counteradaptations that protect them against rape during the ovulatory phase. More specifically, they proposed adaptive variation over the menstrual cycle in the extent to which women engage in risky behavior.

Fetchenhauer and Rohde (2002) have shown that attitudes towards risk-taking are correlated with the probability of victimization, and it is certainly reasonable to speculate that shifts in anxiety and caution might alter one's chances of being victimized. Another possibility is that women exhibit a general reduction in activity around the time of ovulation, thus reducing encounters with potential rapists, but this seems unlikely since several researchers have shown that motor activity (Morris & Udry, 1970) and sexual activities (Morris & Udry, 1982) actually increase during this phase of the cycle, as does sexual desire (Stanislaw & Rice, 1988). Hence, Chavanne and Gallup (1998) proposed that women selectively reduce the sorts of risky activities that are relatively likely to expose them to sexual assaults, and the findings of their study seemed to support this hypothesis. This study had certain weaknesses, however, which we seek to rectify.

In the Chavanne and Gallup (1998) study, 300 female college undergraduates completed a questionnaire in which they were asked to check those activities, out of a given list of 18, that they had carried out within the last 24 h, and also to identify the first day of their last menstruation. An independent sample of 40 undergraduate women had ranked the 18 activities and rated them on a seven-point scale with respect to their attendant risk of sexual assault; the items were then ranked with respect to their mean ratings and rankings and a "composite risk score" for each item was defined as the average of these two (almost identical) ranks, with low ranks corresponding to the lowest risk.

The dependent variable for the questionnaire respondents was a "risk-taking score," computed as the sum of the composite risk scores of all the activities that the respondent checked. The forward-cycle method (e.g., Morris & Udry, 1982) was used to assess ovarian cycle stage, with Days 13–17 defined as the ovulatory phase. The results were apparently clear-cut: In naturally cycling women, the risk-taking score was significantly lower during the ovulatory phase than at other cycle stages, whereas no such drop was seen in women using oral contraceptives. Chavanne and Gallup (1998) concluded that their prediction of selective reduction of risky activities was upheld, and that this behavioral upshot might be hormonally mediated. However, methodological weaknesses threaten the validity of these conclusions.

The most important problem concerns the risk-taking score. Because this measure was a sum of the "composite risk scores" for all checked activities, it potentially confounds the riskiness of the respondent's behavior with diversity of activities. For example, a subject who ticked the five lowest risk activities ("watched television," "stayed home," "church," "class," and "library") would get the same risk-taking score as one who ticked only the highest risk activity ("walk in dimly lit area"), and if two subjects ticked an identical list except that one of them ticked one additional low-risk item, that subject would get the higher risk-taking score. Hence, the lower scores of women in the ovulatory phase cannot conclusively be attributed to a selective reduction of risky activities; they could, in principle, result simply from engaging in fewer activities, or even from a reduction in only the nonrisky activities. Chavanne and Gallup (1998) dealt with this issue by citing evidence of increased general activity during the ovulatory phase of humans and other mammals, but this is only weak evidence against the possibility that the observed cycle stage effects reflect something other than a selective reduction of risky activities. Moreover, their measure was log-transformed before statistical analyses to deal with variance inhomogeneity, which makes the dependent variable even more dubious. It would obviously be preferable to compare risky and nonrisky activities directly, which we decided to do. Furthermore, we use simple frequencies as the dependent variables, without constructing an arbitrary index or log-transforming data.

Another potential problem in the Chavanne and Gallup (1998) study concerns possible selection effects: It is conceivable that the groups of women who volunteer to participate at different cycle stages are somehow different. Comparing the proportions expected by a random distribution to the actual ones results in $\chi^2(3) = 7.78$, which almost reaches a conventional significance level (P = .051). This suggests that selection effects were probably present in the Chavanne and Gallup study. Moreover, the possibility of memory errors concerning the last menstruation increases with its temporal distance, making the forward-cycle method potentially unreliable in ways that may not be merely random. To address these problems, we used a within-subjects, repeated-measures design in which participants were tested four times in successive weeks, and were asked to record when menstruation began during the four weeks of the study.

2. Methods

2.1. Materials

In a preliminary study, 23 women (age 15 to 39 years, $M = 26$, S.D. = 6) rated the riskiness of 64 activities on a five-point scale ["not risky at all" (1) to "very risky" (5)]. They were explicitly instructed to rate the riskiness of being sexually assaulted in the situations described. The raters were also asked how often they carried out each of these activities ("never" to "frequently"), and to avoid baseline effects, eight items to which more than 50% of the participants assigned the frequency "never" were excluded from the final list. The remaining 56 items were sorted according to the mean risk rating, and the 20 least risky activities ($M = 1.21$, range: 1–1.57) and the 20 most risky activities ($M = 2.90$, range: 2.26–4.35) were selected as the "nonrisky" and "risky" items for the main questionnaire, respectively. To test whether males and females show the same interpretation of situations as risky or nonrisky, 25 males (age 18 to 25, $M = 24.28$) additionally rated the riskiness of the

64 activities. The correlation between mean ratings of women and men was $r = .97$, suggesting extremely similar interpretations. In the final questionnaire, the 40 items appeared in a random order, and the participants were asked to mark all activities they had carried out within the last 24 h. The items as well as their mean risk ratings are displayed in Table 1.

2.2. Participants and exclusion criteria

Eighty-five women (age 15 to 44 years, $M = 24.3$, S.D. = 6.1) participated in the study. Thirty-four were excluded from the analysis because they failed one or more of the following criteria: Attending all four occasions of measurement (11), being in the 5-day ovulatory phase at least once during the study (25), providing information about the last menstruation (2), having an estimated cycle length between 23 and 33 days (2), or using a contraceptive with known effects on ovulation (5). Thus, 51 participants remained, 26 of whom did not use contraceptives suppressing ovulation. All were students at the University of Bonn.

2.3. Procedure and design

Participants filled out the same questionnaire on four occasions at 1-week intervals. On each occasion, they were asked to check each of the 40 activities in which they had

Table 1
List of 40 activities in the final questionnaire and their respective mean risk ratings by independent raters (possible range 1 to 5)

Nonrisky activities	Risky activities
1. Learn at home (1.00)	1. Visit a rock concert (2.26)
2. Work or surf at the computer (1.00)	2. Take the garbage out in the evening (2.30)
3. Telephone friends (1.00)	3. Go out dancing with friends (2.39)
4. Watch TV at home (1.04)	4. Invite a man for dinner (2.39)
5. Visit relatives (1.04)	5. Jogging (2.43)
6. Read a book at home (1.04)	6. Go by taxi (2.48)
7. Visit a museum (1.09)	7. Get to know a man when going out (2.52)
8. Take a bath at home (1.09)	8. Go to a public restroom (2.61)
9. Go to church (1.09)	9. Go to a party alone in the evening (2.74)
10. Go to the library (1.09)	10. Get dressed sexily when going out (2.74)
11. Do housework at home (1.13)	11. Be accompanied home after a date with a man (2.83)
12. Go to university (1.17)	12. Invite a man for a coffee after a date (2.96)
13. Shopping (1.26)	13. Come home late alone (3.04)
14. Go out for lunch (1.26)	14. Wait for the train in the evening (3.17)
15. Go to the theater/opera (1.30)	15. Stop at a remote rest stop (3.17)
16. Invite several friends (1.30)	16. Get drunk while going out (3.30)
17. Go to work (1.35)	17. Walk alone in the park or forest (3.30)
18. Visit a doctor (1.48)	18. Let a stranger (e.g., salesman) into the house (3.35)
19. Visit friends (1.48)	19. Park in a dark corner of an underground garage (3.65)
20. Change clothes at the baths (1.57)	20. Walk through dimly lit area in the evening (4.35)

participated during the preceding 24 h, and to indicate the first day of their last menstruation. Questionnaire completion required about 3–5 min, and took place at the same time of day and on the same day of the week, under the supervision of the experimenter. Six participants who could not appear at the university on one or more occasions were allowed to fill out the questionnaire at home (at the usual time of day).

Depending on when menstruation occurred during this 4-week interval, the forward- or reverse-cycle method was used to assess the ovulatory phase (forward: Days 13 to 17, backward: Days −12 to −16). Although recent research suggests that the "fertile window" is somewhat larger (e.g., Wilcox, Dunson, & Baird, 2000), we used these times to maintain comparability with Chavanne and Gallup (1998). By averaging the data for the nonovulatory occasions and comparing them to the data from the ovulatory phase, we constituted ovarian cycle phase (ovulatory vs. nonovulatory) as one repeated-measures factor. We divided the sample into those who used hormonal contraceptives suppressing ovulation (e.g., pill) and those who did not, excluding those participants using contraceptives with unclear effects on ovulation ("Minipille"), and we treated this binary variable as a quasiexperimental between-subjects factor. Thus, the three independent variables were "riskiness of activities" (within subjects), "ovulatory phase" (within subjects), and "method of contraception" (between subjects). The dependent variables were the frequencies of risky and nonrisky activities marked at each measurement point.

2.4. Hypotheses

Chavanne and Gallup's (1998) hypothesis was that there is a selective reduction of risky activities in the ovulatory phase. We interpret this to mean that nonrisky activities should not decrease, and might even increase (cf. Morris & Udry, 1970, 1982), hence that there should be a Riskiness × Ovarian Cycle Phase interaction. Moreover, Chavanne and Gallup claimed that hormonal contraceptives prevented this selective risk reduction effect, implying that there should be a three-way interaction of riskiness, ovarian cycle phase, and contraceptive method.

Because we wanted to test whether Chavanne and Gallup's (1998) main result was an artifact of their methods, we needed adequate statistical power to detect any substantial genuine effect of ovarian cycle stage. A post hoc power analysis revealed that our final sample size was sufficient to detect medium effect sizes following the conventions of Cohen (1988; f^2=.15 which is equivalent to partial r^2=.13) with a high power of .97 when the conventional significance level of $\alpha = 05$ is used (Buchner, Faul, & Erdfelder, 1997).

3. Results

The mean frequencies of risky versus nonrisky activities in the ovulatory and nonovulatory phases were computed for each woman and analyzed by means of a three-way ANOVA with riskiness (risky vs. nonrisky) and menstrual phase (ovulatory vs. nonovulatory) as within-subjects factors and contraceptive method (ovulation suppressing vs. not suppressing) as a

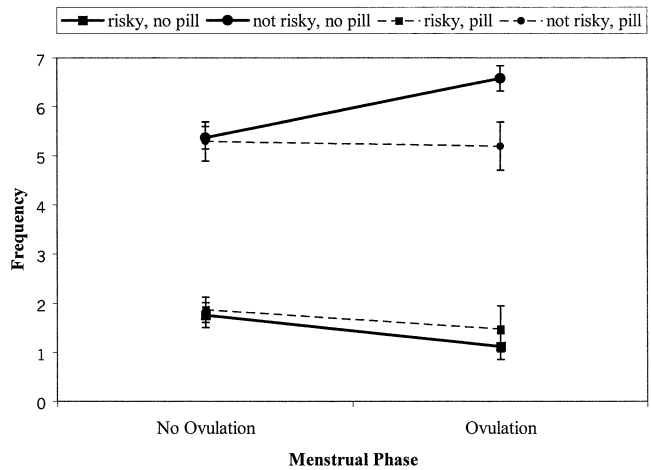

Fig. 1. Mean number of risky and nonrisky activities carried out during the ovulatory and nonovulatory phases of the ovarian cycle (Error bars represent S.E.M.).

between-subjects factor. The means and standard errors are depicted in Fig. 1. Along with the ANOVA results, we report partial r^2 as a measure of effect size (Rosenthal, Rosnow, & Rubin, 2000).

There was a large significant main effect of riskiness [$F(1,49) = 235.61$, $r^2 = .83$, $P < .001$] showing that the nonrisky activities were generally carried out more often than the risky ones. There was no main effect of ovulatory phase [$F(1,49) = .01$, $r^2 = 0$, $P = .91$], but the predicted interaction between riskiness and ovulatory phase was significant [$F(1,49) = 8.77$, $r^2 = .15$, $P = .005$]. Hence, there was no overall increase or decrease in activities, but a selective increase in nonrisky activities accompanied by a selective decrease in risky ones.

The predicted three-way interaction of riskiness, ovulatory phase, and contraception method was also significant [$F(1,49) = 4.62$, $r^2 = .09$, $P = .04$]. Separate ANOVAs for the two groups using different contraceptive methods revealed the theoretically less interesting main effect of riskiness in both groups [$F(1,25) = 127.35$, $r^2 = .84$, $P < .001$, and $F(1,24) = 110.58$, $r^2 = .82$, $P < .001$] for nonsuppressing and ovulation suppressing contraceptives, respectively), but the theoretically interesting Riskiness × Phase interaction was significant only for the naturally cycling women [$F(1,25) = 10.55$, $r^2 = .29$, $P < .001$], and not for those using hormonal contraception [$F(1,24) = .45$, $r^2 = .02$, $P = .51$].

Finally, to explore the three-way interaction in greater detail, separate paired t tests were conducted for all four contraceptive-riskiness combinations. In the naturally cycling women, there was a clear tendency to reduce risky activities during the ovulatory phase [$t(25) = -2.17$, $P = .04$, $r^2 = .16$] while simultaneously increasing nonrisky activities [$t(25) = 3.00$, $P = .006$, $r^2 = .27$], whereas there were no such tendencies in those using hormonal contraceptives that suppress ovulation [$t(24) = -1.79$, $P = .09$, $r^2 = .11$ and $t(24) = -.19$, $P = .85$, $r^2 = .00$, respectively]. In sum, all effects are in accordance with Chavanne and Gallup's (1998) conclusions.

4. Discussion

The results of this within-subjects study indicate that individual women do indeed change their behavior over the ovarian cycle, by selectively reducing activities that expose them to risk of sexual assault at times close to ovulation. Although Chavanne and Gallup's (1998) results could have been due to some less selective behavioral change and/or to selective participation in relation to cycle stage, our results suggest that their conclusions were correct.

Of course, the methods that we used could be improved further, for example by establishing more measurement points and a longer duration of the study, and by using a more reliable method of assessing the ovulatory phase, such as urinary luteinizing hormone assessment (e.g., Petralia & Gallup, 2002). It is striking, however, that even the crude forward- and reverse-cycle method, which is expected to produce several misclassifications, allowed us to find a nontrivial interaction effect of a respectable size (partial r^2=.29). In absolute terms, this effect does not seem large: A look at Fig. 1 reveals that the risky activities are only reduced by about one activity per day. However, this effectively halves the rate of "risky" activities during the ovulatory phase and may thus have quite substantial effects. Nevertheless, we caution that this particular number depends on the sample of activities generated for this study, and should not be overinterpreted.

If further research confirms women's selective avoidance of risky activities during ovulation, the next step is to ask what psychological processes mediate this behavioral change. Fetchenhauer and Rohde (2002) showed that risk attitudes predict individual differences in behavior and victimization, and the temporary behavioral changes reported here might also be mediated by changes in risk attitudes. In addition, one might test whether there are temporary shifts in perceptions of threat from males or risky situations and accompanying fears over the ovarian cycle. However, before asking about potential mechanisms of these effects, their robustness should perhaps be further established.

References

Buchner, A., Faul, F., & Erdfelder, E. (1997). *G•Power: a priori, post-hoc, and compromise power analyses for the Macintosh (Version 2.1.2)*. Trier, Germany: University of Trier (Computer program).

Chavanne, T. J., & Gallup, G. G. (1998). Variation in risk taking behavior among female college students as a function of the menstrual cycle. *Evolution and Human Behavior*, *19*, 27–32.

Cohen, J. (1988). *Statistical power analysis for the social sciences* (2nd ed.). Hillsdale, NJ: Erlbaum.

Cox, C., & Le Boeuf, B. (1977). Female incitation of male competition: a mechanism of sexual selection. *American Naturalist*, *111*, 317–335.

Fetchenhauer, D., & Rohde, P. A. (2002). Evolutionary personality psychology and victimology: sex differences in attitudes and short-term orientation and their relation to sex differences in victimizations. *Evolution and Human Behavior*, *23*, 233–244.

Gowaty, P. A., & Buschhaus, N. (1998). Ultimate causation of aggressive and forced copulation in birds: female resistance, the CODE hypothesis, and social monogamy. *American Zoologist*, *38*, 207–225.

Lalumière, M. L., & Quinsey, V. L. (1996). Sexual deviance, antisociality, mating effort, and the use of sexually coercive behaviors. *Personality and Individual Differences*, *21*, 33–48.

Lalumière, M. L., Chalmers, L. J., Quinsey, V. L., & Seto, M. (1996). A test of the mate deprivation hypothesis of sexual coercion. *Ethology and Sociobiology*, *17*, 299–318.

Morgan, J. B. (1981). *Relationship between rape and physical damage during rape and phase of sexual cycle during which rape occurred.* Unpublished doctoral dissertation, University of Texas at Austin.

Morris, N. M., & Udry, J. R. (1970). Variations in pedometer activity during the menstrual cycle. *Obstetrics and Gynecology*, *35*, 199–201.

Morris, NM., & Udry, JR. (1982). Epidemiological patterns of sexual behavior in the menstrual cycle. In: RC. Friedman (Ed.), *Behavior and the menstrual cycle* (pp. 129–154). New York: Marcel Dekker.

Petralia, S. M., & Gallup, G. G. (2002). Effects of a sexual assault scenario on handgrip strength across the menstrual cycle. *Evolution and Human Behavior*, *23*, 3–10.

Rogel, M. J. (1976). *Biosocial aspects of rape*. Unpublished doctoral dissertation, University of Chicago, Illinois.

Rosenthal, R., Rosnow, R. L., & Rubin, D. B. (2000). *Contrasts and effect sizes in behavioral research. A correlational approach*. Cambridge, UK: Cambridge University Press.

Shields, W. M., & Shields, L. M. (1983). Forcible rape: an evolutionary perspective. *Ethology and Sociobiology*, *4*, 115–136.

Smuts, B., & Smuts, R. (1993). Male aggression and sexual coercion of females in nonhuman primates and other mammals: evidence and theoretical implications. *Advances in the Study of Behavior*, *22*, 1–63.

Stanislaw, H., & Rice, F. J. (1988). Correlation between sexual desire and menstrual cycle characteristics. *Archives of Sexual Behavior*, *17*, 499–508.

Thornhill, R. (1980). Rape in Panorpa scorpion flies and a general rape hypothesis. *Animal Behavior*, *28*, 52–59.

Thornhill, R., & Palmer, C. T. (2000). *A natural history of rape. Biological bases of sexual coercion* (2nd ed.). Massachusetts: MIT Press.

Thornhill, R., & Thornhill, N. W. (1983). Human rape: an evolutionary analysis. *Ethology and Sociobiology*, *4*, 137–173.

Thornhill, R., & Thornhill, N. W. (1987). Human rape: the strength of the evolutionary perspective. In: C. B. Smith, M. S. Smith, & D. Krebs (Eds.), *Sociobiology and psychology. Ideas, issues, and applications* (pp. 269–292). Hillsdale, NJ: Erlbaum.

Wilcox, A., Dunson, D., & Baird, D. (2000). The timing of the "fertile window" in the menstrual cycle: day specific estimates from a prospective study. *British Medical Journal*, *321*, 1259–1262.