HETEROSEXUAL ACTIVITY: RELATIONSHIP WITH OVARIAN FUNCTION

MARY H. BURLESON, W. LARRY GREGORY, and WENDA R. TREVATHAN

Department of Psychology, Arizona State University, Tempe, Arizona, USA and Departments of Psychology and Sociology and Anthropology, New Mexico State University, Las Cruces, New Mexico, USA

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SUMMARY

Previous research demonstrated a relationship between the temporal pattern of heterosexual activity and an index of ovarian functioning. In the current study, this relationship was investigated in 147 menstruating heterosexual women (aged 19–53). They kept prospective daily records of menses, basal body temperature, sexual activity, and other behaviors for three consecutive menstrual cycles. In contrast to previous findings, women with intermediate levels of sexual activity displayed more frequent optimal menstrual cycles. Pheromones, semen absorption, and orgasm-related changes were tested as mediators for a causal influence of sexual activity on ovarian functioning; none was supported. Exploratory analyses tested the hypothesis that anovulatory cycles (with presumably lower progesterone) would display more sexual activity than ovulatory cycles. This hypothesis was supported, and the difference in sexual activity was limited to the second half of the cycle, after ovulation would have occurred. Thus, the findings incorporate temporal precedence of ovulation to support the idea that physiological processes influence the level of sexual activity in heterosexual women.

Keywords—Sexual activity; Menstrual cycle; Human pheromones; Ovulation; Reproductive cues; Orgasm.

INTRODUCTION

EXTERNAL FORCES can have powerful and subtle influences on women's menstrual cycles. Aerobic exercise, for example, can inhibit progesterone production, even in women who run as little as 20 km/week (Ellison & Lager, 1986). Similarly, dieting (Pirke et al., 1989) and psychosocial stress (Matteo, 1987) can interfere with internal reproductive processes. There is also abundant evidence that social and/or sexual contact may affect reproductive functioning in animals, often through olfactory signals called pheromones. This type of effect has been demonstrated in rodents (McClintock, 1983) and nonhuman primates (Wallis et al., 1986). The potential for similar influences also exists in humans, because of the nature of ovarian regulation.

The hypothalamic–pituitary–gonadal axis is a complex system with both positive and
negative feedback aspects. There are multiple two-way connections between this axis and different parts of the cerebral cortex and limbic system. Emotional state, pheromones, and/or sexual behavior may alter the level or balance of activity in cortical and limbic structures. Neurochemical signals from these areas influence the activity and secretions of the hypothalamus and anterior pituitary, which in turn control circulating levels of reproductive hormones. Thus, a plausible established pathway exists for the influence of social or sexual behavior on reproductive physiology. A number of studies, which have received a great deal of attention in the popular press, appear to have demonstrated this phenomenon in humans. Closer scrutiny has called into question much of this research.

One example of a proposed sociosexual effect on reproductive function is menstrual synchrony, in which women who live together report co-occurring menses onsets (see Graham, 1991, for review). Critical examination of the previous literature, as well as recent studies, suggest this phenomenon may not be typical of mature women (Trevathan et al., 1993; Wilson, 1992; Wilson et al., 1991).

It has also been proposed that heterosexual activity causes changes in ovarian functioning (Cutler, 1991). If this effect could be confirmed, it might have ramifications for improving fertility, as short cycles are associated with poor outcomes in infertility treatment (e.g., Pampiglione et al., 1988). A better understanding of the relationship between sexual activity and ovarian functioning also might help explain the evolution of nonovulatory sexual activity in human females.

Because of the correlational nature of the studies in this area of research, however, the direction of causality has not been established. Most commonly, field studies of the relationships between ovarian function and sexual activity in women have interpreted any association as evidence for an influence of hormones on sexual behavior (see Steklis & Whiteman, 1989, for a summary of many of these studies). In the studies reviewed below, however, the researchers tended to interpret their findings to suggest that social or sexual contact with men can change women's menstrual cycles—in other words, that sexual behavior affects hormone levels.

**Previous Research**

Two prior studies reported that women who engaged in heterosexual activity (including either intercourse or genital stimulation) at least once in every week had a higher proportion of fertile-type cycles than women who abstained for at least one week or women who were celibate. In both studies, cycles were classified as fertile-type if they (1) displayed a biphasic basal body temperature (BBT) pattern, which indicates ovulation, and (2) had a luteal phase of at least 12 days in length, long enough for implantation of a fertilized egg. Using a sample of 60 infertility patients, Cutler et al. (1979) reported that a higher incidence of fertile-type cycles was found in the weekly sexually active women. A similar result was reported in a sample of 83 college students (Cutler et al., 1985).

In contrast to the Cutler studies, Veith et al. (1983) found no difference in the BBT patterns of 29 college women who had intercourse two or more times during a 40-day study vs. those who did not. On the other hand, women who spent two or more nights with a man (co-sleeping) during the study were more likely to exhibit biphasic BBT patterns than were those who did not, regardless of their sexual activity.

The results summarized above are somewhat contradictory. Two studies seem to support a relationship between heterosexual activity and ovarian function, whereas the
third found a relationship only with co-sleeping. Several unresolved issues may have contributed to these discrepancies. Further, the question of causal direction should be addressed. Because experimentation in this area is problematic, we used a strategy of testing for relationships that might be implied by a causal effect. In other words, we developed and tested a nomological network of theoretically expected relationships. We carried out these tests in a group of 147 heterosexual women.

**Possible Mechanisms**

For example, if sexual activity influences ovarian functioning, there has to be a mechanism by which the effects occur. We tested three possible mechanisms for an influence of sexual activity on ovarian functioning. First, the reports discussed above postulate the existence of a pheromonal (probably olfactory) effect mediating the observed relationships with women's reproductive cycles. In fact, Cutler et al. (1986) directly tested this hypothesis using apocrine sweat extract. The experiment was later found to be flawed, however, leaving the question unresolved (Wilson, 1988).

We reasoned that, if pheromones were causing the effect, then intimate but nonsexual contact with a partner would reveal a pattern of findings similar to sexual activity. Previous work has not clarified whether this link exists, although Veith et al.'s (1983) finding of a positive association between ovulatory BBT curves and sleeping with a man supports the idea. Therefore, in designing our study, we asked our participants to report whether they spent the night sleeping with a partner, as well as incidents of close nonsexual contact such as hugging and massage.

Another possible mechanism may be through the vaginal absorption of seminal fluid, which contains follicle-stimulating hormone (FSH), luteinizing hormone (LH), and testosterone (Schoenfeld et al., 1978), along with a high concentration of prostaglandins (Setchell & Brooks, 1988). Vaginal absorption of these substances occurs and may have systemic action on female endocrine status (reviewed in Ney, 1986), possibly resulting in some of the cycle changes associated with regular heterosexual activity. If this were the source of the effect, we reasoned that the relationship between sexual activity and ovarian function should be altered by the use of condoms or coitus interruptus for birth control. Thus, participants in our study monitored these birth control behaviors.

A third possible pathway might be through endocrine or neural processes associated with sexual activity. Sexual arousal, especially orgasm, leads to a number of physiological changes, including alterations in autonomic dominance, somatic muscle activity, and cortical arousal (Davidson, 1980). Changes in the circulating levels of LH and testosterone (in men), and oxytocin (in women and men) have also been documented following orgasm (reviewed in Rosen & Beck, 1988). Although these changes are not well understood, they may nevertheless influence ovarian function. If this were the cause, we reasoned that the changes in ovarian function should occur as a function of orgasm, regardless of whether it were self- or partner-stimulated. Hence, we asked our participants to report the occurrence of orgasm and sexual self-stimulation.

**Methodological Issues**

Problems with extraneous variables. Because we are dealing with correlational research, we have to be especially alert to the possibility of causation by extraneous variables. As described above, ovarian functioning can be influenced by many factors. Therefore, we believed that the failure of previous studies to measure and control for
any variables other than sexual behavior rendered their findings less convincing. To address this problem, we measured the following variables that have been related to ovarian functioning in previous research: age at menarche (Vihko & Apter, 1984), gynecological age (Treloar et al., 1967), exercise (Ellison & Lager, 1986), alcohol intake (Greenwood et al., 1983), diet (Pirke et al., 1986), tobacco usage (Hill, 1982; reviewed in Thomas et al. 1993), and stress (Matteo, 1987; Peyser et al., 1973). These variables were then examined in our statistical analyses.

Problems with measurement of ovarian function. In their definition of a fertile-type cycle, Cutler et al. (1979, 1985) included the occurrence of both ovulation and luteal phase of adequate length. However, they did not eliminate cycles that were clearly of abnormal total length. Cycles that are too short for normal follicular development, or so long as to indicate a failed conception or other unusual occurrence, should be excluded. Further, their assessments were made using only one menstrual cycle. Because any given cycle may not be representative of a woman's typical level of function, a more reliable measure would include data from a series of cycles.

To avoid the problems associated with measuring only one cycle, we collected data for at least three complete menstrual cycles for each participant. Our index of optimal fertility potential comprised three components, as noted above: (1) ovulation, (2) luteal phase, and (3) total cycle length. Taking all three factors into account enhanced the validity of fertility potential measurement in this study.

Problems with sexual activity measurement. The findings from the previous research do point up the importance of the temporal aspect of sexual activity (variability over time), because measurement of the simple frequency or rate of sexual behavior did not reveal the same associations.

Categorizing women as celibate, sporadic, or regular, however, may actually mask any important effects associated with the timing of sexual behavior, because of the loss of information inherent in the categorization process. In other words, previous researchers lumped together patterns of behavior that were actually quite different, and separated patterns of behavior that were actually very similar. For example, using the Cutler et al. (1979, 1985) classification scheme, the sporadic category would include both the women who had sexual intercourse daily but abstained during one week, and the women who had sex once during the entire study. Although these behavior patterns are distinct, the women would be treated identically in categorical statistical analyses.

On the other hand, measuring just the overall frequency of sexual activity ignores the issue of timing of intercourse experiences. For example, this method would confound women who have intercourse twice per week for 12 weeks with women who have intercourse daily for 24 days, but never again during a 12-week interval. A better measure would be an index of sexual activity that takes into account both the frequency and the timing of sexual activity.

Behavioral patterning index. For this study, we designed a measure of behavioral patterning that takes into account both frequency and timing. The method can be used to quantify any behavior that is recorded at set intervals for which timing, in addition to frequency, may be important. In this case, we used the index to quantify the temporal pattern of sexual activity, as well as other daily recorded behaviors. A "moving window" summation technique is used to derive an index of the temporal spacing of sexual behavior across time. Use of this continuous scale avoids the problem of information loss associ-
ated with categorization. It also allows the examination of nonlinear (e.g., quadratic) relationships between sexual activity and the outcome variables. The Behavioral Patterning Index (BPI) is further described in the Appendix.

**Current Study**

The main purpose of this study was to examine a possible causal relationship between sexual activity and ovarian function by testing the three mechanisms (pheromonal, seminal, and orgasm-related) proposed to account for the relationship. We also wished to resolve the contradictions posed by the research reviewed above, using improved measures of ovarian function and sexual activity pattern in a more representative sample, and controlling for extraneous variables.

**METHOD**

**Participants**

Prospective participants were informed of the project through announcements that appeared in women’s publications and health centers. A brief description of the study and the $50 payment was presented, and eligible women who were interested in taking part were invited to contact us. To be eligible for participation, a woman could not (1) be taking oral contraceptives or have an intrauterine device (IUD); (2) be pregnant, lactating, or menopausal; (3) have had a hysterectomy; or (4) be less than 7 years past menarche. Because of the focus on heterosexual activity, lesbian women were excluded from this sample. Of the 284 packets sent out to heterosexual women, 166 were completed and returned to us. To increase the reliability of the data, a backfilling questionnaire was sent to the participants with their payment. Eleven were eliminated for extensive backfilling. Of the remaining participants, five returned incomplete data, one used birth control pills, one had cervical surgery during the study, and one became pregnant after her first cycle, leaving 147 participants. Six of these were not used in the current analyses, because the three cycles for which they provided data were not contiguous.

The addresses of the participants were distributed widely across the United States. They were between 19 and 53 years old (mean = 34.2, SD = 7.2). Their age at menarche ranged from 10 to 16 years (mean = 12.4, SD = 1.3); the number of years postmenarche (gynecological age) ranged from 7 to 42 (mean = 21.7, SD = 7.5). Age at first coitus ranged from 13 to 40 years (mean = 18.5, SD = 3.3). Menstrual cycle lengths ranged from 13 to 56 days (mean = 28.7, SD = 3.7). Twenty-three (16%) of the 147 women reported cycles that varied by more than 7 days; eight (5%) had cycles that varied by more than 11 days. Ninety-one (62%) of the women were nulliparous, 16 (11%) had one child, 30 (20%) had two children, nine (6%) had three children, and one (1%) had four children. Weight ranged from 88 to 291 lbs (mean = 138.8, SD = 30.5). Height ranged from 59 to 77 inches (mean = 65.1, SD = 2.9). All had completed high school; 49% had bachelor’s degrees. Almost 75% reported family incomes of greater than $15,000 per year.

**Materials**

After enrollment, each participant was mailed a packet including an Initial Questionnaire, six Daily Checklists, a basal thermometer, a chart for recording the menstrual cycles of other women living in her household, a checkout questionnaire, and a set of detailed instructions.
Initial questionnaire. The Initial Questionnaire comprised the following items: age, height, weight, age of menarche, age at first coitus, birth control methods currently used, number of pregnancies of more than 6-mo duration, household composition, tobacco, caffeine, alcohol, and other drug usage, normal duration of sleep, size of bed slept in, food restriction, dietary composition, and frequency of crying and of illness. Questions regarding current experience with cramps, mood changes, and other physical changes the participants believed to be associated with their menstrual cycles were also included.

The Initial Questionnaire also included four psychological scales. Social support was measured using the Perceived Social Support from Friends and Family scale (Procidano & Heller, 1983). Locus of control was assessed using the Collins format of Rotter’s Locus of Control Scale (Collins, 1974). Five subscales from the Symptom Checklist-90 (Derogatis, 1977) were included: anxiety, obsessive-compulsive tendency, depression, interpersonal sensitivity, and somatization. Finally, level of stress was measured with the Perceived Stress Scale (Cohen et al., 1983). These scales were scored according to standard protocols.

Daily checklists. To enhance both participation and reliability, the Daily Checklists were designed to be as simple as possible to complete. They were in a chart format, with 40 columns provided for daily recording during a menstrual cycle of up to 40 days in length (longer cycles required two Checklists).

The following items were marked if they had occurred during the previous 24-h period: stress, illness, exercise (20 min or more of aerobic exercise), sleeping in the same bed with a man, genital stimulation from a partner, intercourse, condom use, withdrawal, sexually related breast stimulation, other intimate behavior (included kissing, cuddling, giving or receiving a massage), sexual self-stimulation (not during sex with a partner), orgasm, menses, cramps, and breast tenderness believed to be associated with the menstrual cycle. Participants were asked to give a subjective assessment of the quality of the day (good, bad, neutral, or “up and down”), as an additional indicator of stress. The number of alcoholic drinks consumed and the number of hours of sleep were recorded.

On the bottom of the Daily Checklist was a standard BBT chart and space for recording cervical mucus condition. Detailed instructions were provided. Weight was recorded on a weekly basis.

Procedure

Upon receiving her packet, the participant completed the Initial Questionnaire. She was informed that the study concerned “factors affecting the menstrual cycle.” Beginning on the first morning of her first menses after enrolling in the study, each participant recorded her basal body temperature and filled out the Daily Checklist for the previous 24 h. Later in that day, she recorded her cervical mucus condition. To complete the study, the women had to provide these data for three full menstrual cycles.

When data recording was finished, each woman completed a checkout questionnaire regarding any changes in birth control methods, living arrangements, and drug, alcohol, tobacco, caffeine, and food use. All of the materials were then returned in the envelope provided. The backfilling questionnaire was then sent with the $50 payment.

Measurement Strategy

Predictor variables. As described in the Appendix, a Behavioral Patterning Index (BPI) was developed and used to derive a continuous measure of the temporal pattern of sexual behavior. We defined sexual activity as any instance of either genital or breast
stimulation by a man or intercourse with or without a condom. Self-induced orgasm was
defined as orgasm that occurred when no sexual activity with a partner was indicated.

For this study, the period of time chosen for the "moving window" was 7 days. This
interval was chosen for two reasons: it was the time unit used to classify temporal pattern
of sexual behavior in most of the studies reviewed above; and 7-day cyclical patterns
are common in studies of psychological and behavioral variables in Western populations.
In general, the moving window yields an index that is more indicative of the temporal
spacing of a behavior than of its total frequency. Thus, higher scores on the BPI indicate
sustained levels of sexual activity without lengthy gaps of abstention; low scores indicate
lengthy gaps or clustering; and scores of zero indicate no sexual activity.

We also wished to control for the effect of the overall amount of sexual behavior.
The rate of sexual activity was calculated by dividing the total number of occurrences
by the number of recording days for each woman.

Both BPI and rate scores also were created for the other behaviors (extraneous
variables) that were monitored on the Daily Checklists.

**Outcome measures.** Three components comprised the criterion measure of fertility
potential for a given cycle. To be considered "optimal" (potentially fertile), a cycle had
to be ovulatory, have a luteal phase at least 12 days long, and have a total cycle length
between 20 and 45 days. The number of cycles judged optimal was summed for each
subject; the scores ranged from zero (no optimal cycles) to three (all reported cycles
were optimal).

Ovulation was determined based on BBT pattern and cervical mucus condition,
according to established protocols (Moghissi, 1976, 1980). Ovulation was assumed to have
occurred within four days following the BBT nadir (Vermesh et al., 1987).

Luteal phase length was measured by counting the days from the day following the
BBT nadir up to and including the day before the onset of the next menstrual cycle. A
luteal phase length of less than 8 days is considered short (Lee, 1987). Because ovulation
can occur from 0 to 4 days after the BBT nadir, the most conservative criterion for
adequate luteal phase length is 12 cycle days beyond the BBT nadir. For our analysis,
a short luteal phase was defined as less than 12 days long.

Total cycle length was determined by counting from the first day of menstrual bleeding
for a given cycle up to, but not including, the first day of bleeding for the next cycle.
Because 8 days are required for the luteal phase, and 12 days is the minimum length for
a normal follicular phase (Greenwald & Terranova, 1988), cycles less than 20 days long
were considered too short. On the other hand, cycles of more than 45 days were excluded
because of the possibility of failed conception or other abnormality.

**RESULTS**

**Extraneous Variables**

Our initial approach was to use multiple regression to assess the predictive value of
sexual activity pattern on the occurrence of optimal cycles, while controlling for the
effects of important background variables. Thus, we collected data on multiple extraneous
variables (as described above) expected to be related to our variables of interest. An
initial screening of these variables was carried out to avoid placing all of them into a
regression equation. Only variables for which the correlation with optimal cycle (OC)
score produced alpha levels of .10 or less were retained for further analyses.

Four variables met the criterion for inclusion: (1) age at menarche, $r(124) = -.19$;
TABLE I. STANDARDIZED PARAMETER ESTIMATES FOR INITIAL REGRESSION MODEL WITH SIX PREDICTORS

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Beta</th>
<th>SE</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quadratic sex BPI</td>
<td>-.19</td>
<td>.09</td>
<td>4.59</td>
<td>.034</td>
</tr>
<tr>
<td>Linear sex BPI</td>
<td>-.04</td>
<td>.09</td>
<td>&lt;1.0</td>
<td>NS</td>
</tr>
<tr>
<td>Age at menarche</td>
<td>-.18</td>
<td>.09</td>
<td>4.36</td>
<td>.039</td>
</tr>
<tr>
<td>Neutral day BPI</td>
<td>.16</td>
<td>.11</td>
<td>2.14</td>
<td>.146</td>
</tr>
<tr>
<td>Good day minus bad day rate</td>
<td>.03</td>
<td>.11</td>
<td>&lt;1.0</td>
<td>NS</td>
</tr>
<tr>
<td>Age at first intercourse</td>
<td>-.04</td>
<td>.09</td>
<td>&lt;1.0</td>
<td>NS</td>
</tr>
</tbody>
</table>

BPI = Behavioral Patterning Index.

$p < .03$; (2) neutral days BPI, $r(128) = .16, p < .06$; (3) age at first intercourse, $r(124) = -.15, p < .09$; and (4) good day minus bad day rate score, $r(128) = -.14, p < .10$. Age at menarche and first intercourse were taken from the Initial Questionnaire, and the other two variables were from the quality of the day rating on the Daily Checklists. Sample sizes vary between correlations due to the deletion of cases for which a woman failed to report the requested information.

Multiple Regression

We had two theoretical variables of interest: (1) the sexual activity BPI and (2) a variable representing the quadratic component of the sexual activity BPI (square of the BPI score). The quadratic component was used to examine the possibility that the relationship between sexual activity and optimal cycles was U-shaped—in other words, that very low and very high levels of sexual activity were more similar to each other than to moderate levels of sexual activity. These two variables, plus the four background variables listed above, were simultaneously forced into a regression model with OC score as the criterion variable.

The model was significant, $F(6, 118) = 2.33, p < .037$, with a Cp of 7.00, and accounted for 10.6% of the variance in the criterion. The standardized parameter estimates, standard errors, $F$ values, and significance levels for the six variables in the model are shown in Table I.

The modeled relationship between optimal cycles and age at menarche was similar to that revealed in previous research. That is, women who were older at menarche had fewer optimal cycles than those who were younger at menarche (Vihko & Apter, 1984). More importantly, the quadratic component of the sexual activity variable was a significant predictor of the number of optimal cycles. The nonsignificant relationship between the linear sexual activity BPI and OC score appears to indicate that the temporal pattern of sexual activity is not associated with fertility level. The significant quadratic component must be examined, however, because it qualifies the linear relationship. To best understand the relationship between the quadratic component of the sexual activity BPI and the OC scores, we divided the women into four groups: those who were sexually celibate (BPI = 0), and three approximately equally sized groups based on their sexual activity BPI scores. As can be seen from Fig. 1, both the celibates and the highest BPI women had approximately equal OC scores.
The middle range and lowest BPI women displayed OC scores similar to one another but much higher than the celibates and high BPI women. This relationship is not at all what was expected based on the previous research in this area. Earlier work suggested either no relationship between sexual activity and fertility potential (Veith et al., 1983), or that the women with the most regular sexual activity would have the highest OC scores (Cutler et al., 1979, 1985), with “sporadics” (here represented as the moderate range and low BPI women) having OC scores similar to the celibates. Clearly, neither of these results is the case in this sample.

We wanted to explore the relative predictive ability of the temporal pattern of sexual activity pattern compared to the overall amount of sexual activity. Thus, the regression was recomputed adding the sexual activity rate score to the equation. The resulting model was less significant than the six-predictor model, \( F(7, 117) = 1.98, p < .064 \). The significance levels of the six previously tested predictors were relatively stable, with only minor fluctuations in alpha levels. Importantly, however, the rate of sexual activity was not a significant predictor, \( F < 1 \). This means that, even while statistically controlling for the effects of the rate of sexual activity, the quadratic component of the temporal patterning of sexual activity was significantly related to the number of optimal cycles.

**FIG. 1:** Optimal cycle means of four subgroups. Created to illustrate significant quadratic component of sexual activity Behavioral Patterning Index (from regression analysis).
Tests of Possible Mechanisms

Our next step was to explore the three proposed mechanisms for the relationship between sexual activity and ovarian function. The pheromone mediator was tested by examining the effects of intimate nonsexual contact, including sleeping with a partner and physical affection such as hugging. The correlations between the BPI and rate scores for these variables and the OC score were all nonsignificant (all $p$'s > .15), thus the hypothesized pheromone mechanism was not supported by the data.

To determine if semen absorption might be the mechanism, we compared the OC scores of two groups of women with high sexual activity BPI scores--those who regularly used condoms or withdrawal (OC mean = 1.63, $n = 8$) vs. those who never used condoms or withdrawal (OC mean = 1.85, $n = 26$). The result was not significant, $F < 1$.

To make the most stringent test of the role of orgasm-related changes, we examined the relationship between self-induced orgasm and OC. The bivariate correlation was not significant, which does not support orgasm as a mediator. On the other hand, most of these women lived with their sexual partners and had a low rate of self-induced orgasm, so we tested the correlation between optimal cycles and all orgasms, regardless of their source. This correlation also was nonsignificant.

In summary, none of the hypothesized mechanisms for mediating the effect of sexual activity on ovarian function were supported by our data. In light of these results, we decided to carry out exploratory analyses which probed the hypothesis that the causal effect went in the opposite direction—that hormone levels could explain sexual activity pattern.

Tests of Alternative Causal Relationships

Prior research has suggested that progesterone may be associated with lowered sexual interest in nonhuman primates (Michael & Zumpe, 1993; Steklis et al., 1983; Steklis & Fox, 1988) and in humans (Sanders & Bancroft, 1982; reviewed in Carter, 1992). Anovulatory cycles lack a corpus luteum, which is the primary source of progesterone; thus, on balance, ovulatory cycles have higher progesterone levels than anovulatory cycles (Niswender & Nett, 1988). We therefore classified each of the participants' three cycles as either anovulatory or ovulatory, to explore the relationship between progesterone level and sexual activity in our data.

Progesterone may influence either the temporal patterning of sexual activity or its overall frequency. Thus, we used both sexual activity BPI scores and sexual activity rate scores as outcome variables. The rate scores were derived separately for each cycle. Two separate sets (for BPI and rate scores) of three ANOVAs (Cycle 1, Cycle 2, and Cycle 3) were computed, using type of cycle as the classification variable.

In the analyses of BPI scores, the contrast of the ovulatory group to the anovulatory group was not significant for any of the three cycles: Cycle 1, $F(1, 123) = 1.48, p > .20$; Cycles 2 and 3, $F$'s $< 1.00$. For the rate score, the contrast of the ovulatory group to the anovulatory group was significant for Cycle 1, $F(1, 123) = 2.54, p < .05$, one-tailed; and for Cycle 3, $F(1, 104) = 2.80, p < .05$, one-tailed. The Cycle 2 contrast was not significant. Cycle means for both variables are provided in Table II, and generally parallel each other.

Overall, anovulatory cycles were associated with higher rates of sexual activity. In other words, the most sexual activity occurred during the cycles likely to have the lowest progesterone levels. The greater effect on the rate score is consistent with the idea
TABLE II. INDIVIDUAL CYCLE MEANS OF SEXUAL ACTIVITY BPI AND SEXUAL ACTIVITY RATE AS A FUNCTION OF PUTATIVE CYCLE PROGESTERONE LEVEL CLASSIFICATION

<table>
<thead>
<tr>
<th>Cycle type</th>
<th>Anovulatory</th>
<th>Ovulatory</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Cycle 1 (n = 10)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BPI</td>
<td>.73</td>
<td>.40</td>
</tr>
<tr>
<td>Rate</td>
<td>.25</td>
<td>.21</td>
</tr>
<tr>
<td>Cycle 3 (n = 6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BPI</td>
<td>.60</td>
<td>.55</td>
</tr>
<tr>
<td>Rate</td>
<td>.26</td>
<td>.29</td>
</tr>
</tbody>
</table>

that progesterone reduces the overall frequency of sexual activity without necessarily influencing its temporal patterning.

Although these results supported our exploratory hypothesis, they do not speak definitively to the issue of causal direction. We wanted a more stringent test. In a typical ovulatory cycle, progesterone is lowest during the follicular phase and highest during the midportion of the luteal phase, when the corpus luteum is most active. When ovulation does not occur, no corpus luteum is formed and progesterone levels remain lower throughout the cycle. Thus, we reasoned that if progesterone levels were driving sexual behavior, the difference in the rate of sexual activity between ovulatory and anovulatory cycles should be greatest during the luteal phase (or the equivalent time period for the anovulatory cycles which lack an actual luteal phase) and smallest during the follicular phase.

Accordingly, for the ovulatory cycles, we computed the sexual activity rate score for the 12 days beginning with the first day of menses (follicular phase), and a separate rate score for the midportion of the luteal phase, beginning 4 days after the BBT nadir and ending 5 days before the next menses (midluteal phase). For the anovulatory cycles, the rate scores for the follicular phase were derived in the same manner as for the ovulatory cycles. The mean midluteal phase length for the ovulatory cycles was 4.0 days. Thus, for the anovulatory cycles, “midluteal phase” rate scores were computed for the 4 days prior to the 5 days before the following menses.

Three 2 × 2 mixed ANOVAs on the rate of sexual activity, with phase of cycle as the repeated measure and type of cycle as the classification variable, were computed. The phase by type of cycle interaction was marginally significant for Cycle 1, $F(1, 123) = 2.47, p < .15$; not significant for Cycle 2, $F < 1.00$; and significant for Cycle 3, $F(1, 104) = 10.08, p < .01$. The means can be seen in Table III.

Overall, in the anovulatory cycles, the mean rate of sexual activity was higher during the “midluteal phase” of the cycle, although the difference was significant only for Cycle
TABLE III. INDIVIDUAL CYCLE MEANS OF SEXUAL ACTIVITY RATE AS A FUNCTION OF TYPE OF CYCLE AND PHASE OF CYCLE

<table>
<thead>
<tr>
<th>Cycle type</th>
<th>Cycle phase</th>
<th>Anovulatory</th>
<th>Ovulatory</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>Cycle 1</td>
<td>(n = 10)</td>
<td></td>
<td>(n = 115)</td>
</tr>
<tr>
<td>Follicular</td>
<td>.23</td>
<td>.23</td>
<td>.17</td>
</tr>
<tr>
<td>Midluteal</td>
<td>.28</td>
<td>.28</td>
<td>.11</td>
</tr>
<tr>
<td>Cycle 2</td>
<td>(n = 9)</td>
<td></td>
<td>(n = 117)</td>
</tr>
<tr>
<td>Midluteal</td>
<td>.08</td>
<td>.18</td>
<td>.11</td>
</tr>
<tr>
<td>Cycle 3</td>
<td>(n = 6)</td>
<td></td>
<td>(n = 100)</td>
</tr>
<tr>
<td>Follicular</td>
<td>.07</td>
<td>.13</td>
<td>.13</td>
</tr>
<tr>
<td>Midluteal</td>
<td>.33</td>
<td>.38</td>
<td>.13</td>
</tr>
</tbody>
</table>

3. Further examination of the means revealed that during the follicular phase, there was no difference in rate of sexual activity between ovulatory and anovulatory cycles. During the midluteal phase, however, anovulatory cycles had higher rates of sexual activity than did ovulatory cycles for both Cycle 1, \(F(1, 123) = 5.83, p < .05\), and Cycle 3, \(F(1, 104) = 4.86, p < .05\). Thus, the rate of sexual activity differed significantly between ovulatory and anovulatory cycles only during the portion of the cycle when the difference in progesterone levels was likely to be the greatest, and after ovulation would have occurred. Because of the temporal relationships involved, a mechanism in which sexual activity causes changes in ovarian functioning cannot explain these findings.

In order to increase the power to detect effects in these data, we also performed an ANOVA in which all three reported cycles for each participant were entered into a single analysis as separate data points. For this analysis, the assumption of independence was violated, which may lead to bias in the results (Kenny & Judd, 1986). However, in this instance, the overall analysis essentially replicated the findings of the separate analyses, showing that no bias exists in the overall analysis. The means are shown in Table IV.

The interaction was significant, \(F(1, 355) = 6.92, p < .01\), as was the ovulatory to anovulatory contrast for the midluteal phase, \(F(1, 355) = 5.24, p < .02\). One additional finding was significant—in the ovulatory cycles, there was less sexual activity during the midluteal phase than during the follicular phase, \(F(1, 330) = 6.39, p < .01\). This aspect of the results is consistent with previous field research showing lowered sexual activity during the luteal phase (reviewed in Steklis & Whiteman, 1989), and also with the idea that progesterone reduces sexual activity.

DISCUSSION

We set out to test the idea that sexual activity can influence ovarian functioning. In building our model, we controlled for many possible extraneous causes. We think it worth noting that out of 27 psychosocial and behavioral factors that were considered,
Table IV. Overall means of sexual activity rate as a function of phase of cycle and type of cycle

<table>
<thead>
<tr>
<th>Phase of cycle</th>
<th>Follicular</th>
<th></th>
<th></th>
<th>Midluteal</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of cycle</td>
<td>n</td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
<td></td>
</tr>
<tr>
<td>Anovulatory</td>
<td>25</td>
<td>.14</td>
<td>.19</td>
<td>.22</td>
<td>.28</td>
<td></td>
</tr>
<tr>
<td>Ovulatory</td>
<td>332</td>
<td>.14</td>
<td>.18</td>
<td>.12</td>
<td>.21</td>
<td></td>
</tr>
</tbody>
</table>

only six (linear and quadratic sexual activity BPI, age at menarche, age at first intercourse, neutral days BPI, and rate of good days minus bad days) had significant or marginal zero-order correlations with the number of optimal cycles in this sample. This suggests that ovarian cycling may be less susceptible to psychosocial influences than are some other aspects of physiology and health, at least in mature women.

Our primary interest was the relationship between sexual activity and optimal cycles. A significant relationship was found; in fact, sexual activity pattern was the strongest predictor of optimal cycles in our model. Contrary to our expectation, however, high scores on the sexual activity behavioral patterning index (BPI) were not associated with high scores on the index of ovarian functioning employed in this study. In fact, women with the highest BPI scores, along with celibate women, displayed a lower number of optimal cycles than did women who had intermediate levels of sexual activity. These results are in clear contrast to previous research, which suggested that weekly heterosexual activity was associated with the highest fertility potential. Several possibilities may explain this inconsistency.

The first is that the previous studies may have provided results that were misrepresentative of the true nature of the relationship, because they excluded other possible influences on the menstrual cycle, categorized women according to sexual activity pattern, and used a less valid measure of ovarian function. For comparison purposes, we analyzed our data using the same protocol as did Cutler et al. in their research. It made no difference—in our sample, regardless of the method of analysis and the number of other variables entered into the model, women with sporadic sexual activity displayed the most optimal cycles. Thus, the inconsistency cannot be explained by our use of a different model, analysis, or measure of sexual activity or ovarian function.

The explanation we think most likely is that the women in our sample differed in at least two ways from those in other studies. Most of the previous studies used college-aged women ranging in age from 19 to 22 years. Our sample was much more mature. The only previous sample comparable to ours in age was the infertility sample from Cutler et al. (1979). However, they were, by definition, abnormal in ovarian function. Unfortunately, only 11 of our participants were between 19 and 25 years old, so we were unable to test this explanation. We plan to examine the issue further in future studies.

Our exploration of the possible mediators of the observed relationship between sexual activity and fertility potential provided no support for the pheromonal, seminal, or or-
gasmic mechanisms. However, the very question of mechanism in this context presupposes a direction of causality in which sexual contact influences reproductive function.

On the other hand, the idea that hormones drive sexual behavior provides an alternative explanation of our results. To explore the other side of this issue, we carried out analyses using an index of ovarian function to "predict" the level of sexual activity. Progesterone inhibits sexual interest; thus we hypothesized that the highest levels of sexual activity would occur during cycles likely to display the lowest progesterone levels. This prediction was supported by the results. The rate of sexual activity was significantly higher in anovulatory cycles, and the sexual activity BPI showed a nonsignificant trend in the same direction.

Previous field research associating progesterone with lowered sexual interest or behavior was purely correlational. In contrast, our exploratory analysis examined the issue of temporal precedence. The analysis revealed that in this sample of women, the frequency of sexual activity differed significantly between ovulatory and anovulatory cycles only during the second half of the cycle. This is when differences in progesterone levels are likely to be maximized, and is after ovulation would have occurred. This finding cannot be explained by a mechanism in which sexual activity influences ovarian function, because a difference in the rate of sexual activity during the second half of a cycle cannot alter the prior occurrence of ovulation for that same cycle. A more likely explanation is that hormonal or other physiological changes associated with ovulation (or the lack thereof) influence women's sexual behavior, or that a third factor causes both effects.

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APPENDIX

Behavioral Patterning Index

The Behavioral Patterning Index (BPI) uses a moving window averaging technique to derive a continuous measure of the temporal pattern of an activity. The time interval for the window is variable. For clarity, and to increase applicability to the current paper, this example will use a window of 7 days, and the behavior assessed will be sexual activity.

Three vectors of raw data can be seen in Fig. 2. If a woman reported the occurrence of sexual activity on a given day, a "Y" was entered, otherwise an "N" was entered. In an iterative fashion, the 7-day window advances by 1 day at a time across the 28 days of the recording period for a given participant. For each iteration in which the window encompasses a day when sexual activity occurred (a "Y" is visible), a running total is incremented by 1. This sum score of sexual activity is then divided by the total number of days in the recording period to yield the BPI.

For example, to derive the participant's BPI score for the first 28-day period illustrated (Series A), the following steps would be performed:

1. The leading "end" of the 7-day window would overlap Day 1 of the data series. Because there is no "Y" visible, the running total would remain at zero.
2. The leading end of the window would advance by 1 day, thus two "N"s would be visible. Again, the running total would not be incremented.
3. This process would be repeated seven times, until the 7-day window fully overlapped
1) N N N N N N Y Y Y Y Y Y Y Y Y Y Y Y Y Y Y Y Y Y Y Y

RATE = 21/28 = .75

BPI = 27/28 = .96

2) N N N N N N Y N Y N Y N Y N Y N Y N Y N Y N Y N Y N

RATE = 11/28 = .39

BPI = 27/28 = .96

3) N N N N N N Y Y Y Y Y Y Y Y Y Y Y Y N N N N N N N N N N

RATE = 11/28 = .39

BPI = 17/28 = .61

Fig. 2: Raw data for illustrating moving window averaging technique for computing Behavioral Patterning Index, using a 7-day window with a 1-day increment.

the first 7 days in the recording period. Because there are no ‘‘Y’s in these 7 days, the running total would remain at zero.

4. The next iteration would result in the 7-day window overlapping the first ‘‘Y’ in the series, so the running total would be incremented by 1.

5. The next iteration would result in the window overlapping the second ‘‘Y’ in the series, so the running total would again be incremented by 1, yielding a sum of 2.

6. This process would be repeated until the window no longer overlapped any of the data series. Because sexual activity was reported for all of the rest of the days in the series, the running total would be incremented by 1 for each iteration, yielding a final sum of 27.

7. This sum would be divided by 28 (the number of recording days), yielding a BPI score of .96.

In general, the moving window yields an index that is more indicative of the temporal spacing of a behavior than of its total frequency. Thus, higher scores on the BPI indicate sustained levels of sexual activity without lengthy gaps of abstention; low scores indicate lengthy gaps or clustering; and scores of zero indicate no sexual activity.

Compare the BPI and rate scores for the three data series in Fig. 2. Series A yields a BPI of .96 and a rate of .75. Series B has about half as many days of sexual activity as does Series A, so the rate score is about half as large. However, the occurrences of sexual activity span the same time period and are evenly spaced in both series, suggesting that scores reflecting their sexual activity level should be more similar. Accordingly, the BPI scores are identical. On the other hand, Series C has the same number of days of sexual activity as does Series B, but the occurrences are clustered together, and span a much shorter time period. Reflecting this, the rate scores are identical, but the BPI for Series C is only .61.

REFERENCES


