PERFORMANCE OF WOMEN ON MEASURES OF ACTUAL AND PERCEIVED COGNITIVE FUNCTIONING ACROSS THE MENSTRUAL CYCLE

by

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Performance of Women on Measures of Actual and Perceived

Cognitive Functioning Across the Menstrual Cycle

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ABSTRACT

The present research investigated the performance of 32 adult women with regular menstrual cycles on measures of actual and perceived cognitive functioning using a repeated measures design. Measures of actual cognitive functioning included the Rod and Frame Test, the Paced Auditory Serial Addition Test, and the Serial Digit Learning Test; measures of perceived functioning included the Temporal Disorganization Scale and the Affect Grid. First, subjects completed all measures in a pretest session that was designed to minimize any subsequent practice effects. Subjects then completed the test battery once a week for the next four weeks. Using information about the date of her cycle onset, each subject's testing sessions were classified retrospectively according to the phase of the menstrual cycle in which they occurred: menstrual, early intermenstrual, late intermenstrual, or premenstrual. Repeated measures analysis of variance revealed significant cycle phase effects only on the Rod and Frame Test (RFT) and the Temporal Disorganization Scale (TDS). However, planned comparisons revealed no support for the hypothesis of a premenstrual deficit in performance; indeed, performance was significantly better in the premenstrual phase on the RFT and TDS. On the basis of the magnitude of observed effects, it appears that although the findings may have implications for scientific theory, their practical significance is minimal.

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INTRODUCTION

The influence of the menstrual cycle on mood, behaviour, and cognition has been investigated extensively. There exists a belief that during the premenstrual and/or menstrual phase a woman suffers from (mainly negative) symptoms that may interfere with her social and occupational performance. The large body of literature on premenstrual syndrome (PMS) has led to the proposal of a psychiatric disorder, Late Luteal Phase Dysphoric Disorder (LLPDD; DSM-III-R: American Psychiatric Association, 1987), which is under consideration for full diagnostic status in the upcoming DSM-IV. Most of the symptoms of LLPDD (see Appendix A) have some empirical basis; that is, there are studies that find significantly more anxiety, depression, and affective lability in the premenstrual period. However, there is one symptom included that lacks empirical justification; that of a subjective sense of difficulty in concentrating[1].

The belief that many women, not just those with PMS or LLPDD, are unable to concentrate, think clearly, or perform well intellectually during the premenstrual/menstrual phase of the cycle is a common one. A great deal of research has been done on actual and perceived cognitive performance as related to menstrual cycle phase, most of it motivated by little more than this common belief. In a later section I will question the rationale and justification for this kind of research. For now, I will focus on the answer to

[1] However, just recently the DSM-IV Task Force on LLPDD found that women who receive an LLPDD diagnosis report suffering from sleep disturbances and concentration difficulties more often than the other diagnostic symptoms (Severino et al.,1993). This finding was based on a reanalysis of data from five test sites. The work group continues to evaluate LLPDD in order to determine the optimal definition and placement of the proposed disorder in the DSM-IV.

a simple question: What evidence exists to support the claim that women's cognitive performance is affected by menstrual cycle phase? To put it simply, very little. A brief summary of the literature on cognitive changes during the menstrual cycle follows.

Background

There are two types of studies that investigate the relationship between the menstrual cycle and cognitive functioning. One type examines cognitive functioning at various phases of the menstrual cycle, and looks for any phase-related fluctuations. The second type compares performance during the premenstrual phase or paramenstrual phase (including the days just prior to and just after the onset of menstruation) to performance during the intermenstrual phase (usually defined as the week prior to and following ovulation), and tests for a hypothesized pre/paramenstrual performance deficit. For simplicity, these two types of studies will be reviewed together.

In several excellent reviews of this literature, Sommer (1973, 1982, 1992) has conducted exhaustive surveys of the studies that look for a menstrual cycle effect on various measures of cognitive performance. The scope of these studies is large, as can be seen by a brief overview of the dependent variables. These include:

1) Measures of complex cognition or intellectual performance including examination scores, tests of critical thinking, and standard cognitive batteries.

2) Measures of simple cognition including tests of abstract thinking, immediate and short term memory, simple arithmetic, verbal skills,

simple rote speed tasks, and simple decision making.

3) Measures of perceptual-motor performance including breaking set, visual spatial ability, and motor coordination.

4) Measures of sensory-motor function and central nervous system arousal including simple and complex reaction time, time-interval estimation, conditioned response acquisition, skin potential and conductance, and electroencephalography (EEG) frequency.

After reviewing this body of literature, Sommer concludes that "one finds an extensive literature covering objective measures of complex and simple cognition. The preponderance of findings in these area fails to support any hypothesis of an effect of the menstrual cycle upon cognition" (1992, p.53) and she points out that "the weight of evidence against menstrual cycle phase differences exists despite a publication bias towards positive results" (1982, p.101). So why does this research continue?

One reason is that despite a lack of empirical support for menstrual phase change on measures of actual cognitive performance, the belief that the menstrual cycle affects intellectual performance still prevails. Early research that looked at subjective (self-report) measures of perceived cognitive impairment indicated that a proportion of women, approximately 8-20%, did report a premenstrual impairment in concentration, judgement or work performance (Moos, 1968; Sommer, 1973). More recently, Kirstein, Rosenberg, and Smith (1980-81) found that scores on the Temporal Disorganization Scale (TDS), a self-report instrument focusing on perceived disruptions in cognitive function, varied across the menstrual cycle. Subjects completed the TDS weekly for one month, along with the Moos Menstrual Distress Questionnaire (MDQ; Moos, 1968) and a daily calender of menstrual status. Scores on the TDS, as well as concentration disturbances reported on the MDQ, were higher premenstrually and menstrually. There appeared to be two groups of subjects: women with higher premenstrual TDS scores reported the most concentration problems premenstrually, and women with lower premenstrual TDS scores reported the most concentration problems during menstruation.

The authors cite these findings as evidence of cognitive change during different phases of the menstrual cycle, despite the fact that their measure is not one of objective, or actual, cognitive performance. In fact, their data indicate only that women believe their thinking is impaired in relation to their menstrual cycle. This type of finding, of subjectively-reported cognitive change over the menstrual cycle, is often misrepresented by researchers and the popular media. The fact that it has become an LLPDD diagnostic criterion shows that it has gained credibility, but it is important to stress that these findings are not supported by objective measures of cognitive performance. Using them to support a claim of a menstrual cycle-performance causal link is incorrect, and, more importantly, may perpetuate a social myth that implies women cannot be expected to perform consistently in the workplace.

To further illuminate the current state of this area of research, a few of the important studies of cognitive performance over the menstrual cycle will now be reviewed.

Literature Review

I. Complex Cognition

Several studies have looked at performance on school or college examinations during different cycle phases. This interest was sparked by an early report by Dalton (1968) that British school girls had a lower pass rate and lower average marks during the premenstrual phase and the menstrual phase. However, this report has been criticized on the grounds that Dalton provided no statistical support for this finding. Although 27% of her subjects dropped in exam performance, 17% improved, and 56% did not change, and the observed variation may be attributable to chance (Sommer, 1973). Since this early report several studies have failed to find any menstrual phase related change on exam scores for university level psychology students (Asso, 1985/86; Bernstein, 1977; Sommer, 1972). However, it is important to note that these studies use a mixture of between- and within-subject designs, and this may mask any subtle within-subject variations. Walsh, Budtz-Olsen, Leader, and Cummins (1981) used a more powerful within-subject design. Scores for 244 medical students on all examinations taken during one year were identified with one of four menstrual cycle phases. No significant effects of menstrual cycle phase were found.

Yet again, we can find evidence that women do report that their cognitive performance is affected by their menstrual cycle. Richardson (1989) surveyed 218 women university students with a questionnaire on premenstrual symptoms and asked them whether they felt that premenstrual symptoms disrupted any of six identified aspects of their academic work (in lectures, seminars, examinations, interviews, reading, or writing essays). A majority of the subjects (73%) reported that at least one aspect of their academic work was disrupted by premenstrual symptoms, with examination performance being most affected; and 14% reported that their academic work was disrupted in all six respects. Yet, in a companion study,which used a double blind procedure and a within-subject comparison of the approach to studying (using the Approaches to Studying Questionnaire) during the paramenstruum and intermenstruum Richardson found that there was no cycle phase difference in objective studying orientation. He concluded that "cultural stereotypes to the effect that women tend to suffer from cognitive impairment during the paramenstruum are not grounded in any objective evidence of either quantitative or qualitative fluctuations in intellectual performance" (p. 232). Once again we see that measures of actual cognitive performance do not support the perceived changes reported by many women.

It does not seem surprising that measures reflecting complex cognition in real life situations, such as examination performance or studying, are not affected by the menstrual cycle; we would expect motivational and other compensatory factors to play a role in such tasks. The lack of change in high-level intellectual tasks during the menstrual cycle is further substantiated by studies using cognitive batteries (e.g., Graham, 1980; Wickham, 1958). For example, in a well designed study of premenstrual anxiety, depression and cognitive function, Golub (1976) used a complete cognitive battery that included measures of sensory-perceptual factors, memory, problem solving, induction, concept formation, and creativity. The cognitive tests were chosen based on their sensitivity to anxiety or depression, and alternate forms were used. Subjects were tested during the premenstrual and intermenstrual phases. The phase of initial testing was counterbalanced to control for practice effects. She found no statistically significant differences between the premenstrual and intermenstrual period on any of the cognitive tests, nor any correlations between premenstrual mood or complaints and the cognitive measures. In a subsequent investigation, Golub (1980) found small but inconsistent differences between premenstrual and intermenstrual phases (within subjects), but multivariate analysis revealed no overall significant menstrual cycle effects for the cognitive battery. Finally, Sommer (1972) found no significant differences on the Watson-Glaser Critical Thinking Appraisal during four quarterly menstrual cycle phases in either between-subjects or repeated measures investigations.

II. Simple Cognition

It appears, then, that investigations of complex cognition do not yield evidence of menstrual cycle effects. However, other researchers have looked for evidence of menstrual cycle effects, not on cognitive batteries, but on measures of simple cognition and/or perceptual-motor performance. It makes sense to investigate the various components of complex cognition, since a menstrual cycle effect on one aspect of cognitive performance might be masked or compensated for by other cognitive mechanisms if a measure of complex cognition is used.

Of interest here are some recent studies that do find cycle related changes on some measures. These studies tend to use more sensitive and specific measures of performance, and many of the significant findings or trends toward changes indicate that it may not be the premenstrual phase of the cycle that is related to performance fluctuations, but some other mid-cycle phase.

The first group of studies of interest indicate that there may be a relationship between cycle phase and performance on measures of perceptual disembedding or breaking set. There are some significant findings, but the evidence for the direction of effect, and in which cycle phase, is contradictory. Several researchers have looked at performance on the Rod and Frame Test (RFT), a perceptual-spatial measure of field independence in which the subjects' task is to align an illuminated rod in a plane perpendicular to the ground. As part of an investigation of the effect of ovarian hormones on cognitive tasks, Klaiber, Broverman, Vogel, and Kobayashi (1974) reported that women in the preovulatory phase of their cycle had less accurate perception of verticality on the RFT relative to their postovulatory phase (as measured by basal body temperature shift). This finding, although widely cited, should be regarded with great caution, since it is based on a sample of only six women. More recently Hampson and Kimura (1988) tested 34 women once during menstruation (between day 3 and 5) and once during the midluteal phase (approximately 7 days prior to menstrual onset). Order of testing was counterbalanced across subjects. They found that women were significantly less accurate on the RFT during the midluteal phase (assumed postovulatory) compared to the menstrual phase, which contradicts the findings of Klaiber et al. Concerning research design, it is worth noting that the way Hampson and Kimura define the midluteal phase means that it overlaps with the premenstrual phase defined by other investigators, a confound that plagues much of this literature. Finally, Graham (1980) used a repeated measures design to look at performance on several tests, including the RFT, at three cycle phases. Two of these phases coincide with those tested by Hampson and Kimura, yet Graham found no significant difference in performance on the RFT over menstrual cycle phase, nor did Snyder (1978).

Other researchers have used disembedding tasks that require finding hidden patterns or words, with mixed results. Komnenich, Lane, Dickey, and Stone (1978) tested women over four phases of the menstrual cycle, with phase of first testing counterbalanced across subjects. Blood measures and BBT were taken to confirm ovulation and cycle phase. Women performed less well on the Embedded Figures Test (EFT) prior to ovulation. Broverman et al. (1981) and Graham (1980) using within-subject designs, and Dor-Shav (1976) using a between-subjects design, found improved performance on the EFT in the postovulatory phase. However, Snyder (1978) found no significant differences.

So, rather than supporting the idea that women experience some performance deficit premenstrually or paramenstrually, these studies of perceptual disembedding indicate that there may be mid-cycle effects on performance, and possibly a performance enhancement in the postovulatory phase (third week of cycle).

A second group of studies, employing various measures of arithmetic ability, also show conflicting results that may indicate a menstrual cycle phase effect. Becker, Creutzfeldt, Schwibbe, and Wuttke (1982) found no difference on simple addition with simultaneous presentation, but did find that successive presentation scores, which required immediate memory and serial addition, were better during the follicular (preovulatory) phase than the menstrual. This study employed hormonal assays (blood measures) to determine phase of cycle, and subjects were tested every two days in a repeated measures design. Fourteen subjects were investigated. No significant phase effects were found when these same subjects were taking oral contraceptives. In an earlier report utilizing a similar design Wuttke et al. (1974) investigated performance on a task that required the subject to calculate the result for addition or subtraction problems displayed on a screen, which was assumed to involve both calculation time and spatial-visual orientation. Performance was significantly faster and more accurate during the luteal (postovulatory/premenstrual) phase than the follicular (preovulatory) phase, with optimal performance 2-3 days prior to menstruation.

In other investigations, Komnenich et al. (1978) found that women performed less well on backward subtraction prior to ovulation compared to three other phases ($\underline{N}$ = 4); and Graham (1980) found poorer performance mid-cycle (preovulatory/ovulatory) compared to menstrual or late-cycle (postovulatory) performance on subtraction, but not on addition.

While taken together these studies provide some evidence of mid-cycle change in simple arithmetic performance with a trend toward better performance in the postovulatory phase, they do not indicate a consistent menstrual or premenstrual deficit. And just to make the picture more confusing, several studies found no significant phase effects on tests of arithmetic (Wickham, 1958), numerical ability (Cormack & Sheldrake, 1974), or backward subtraction (Gordon, Corbin, & Lee,1986).

A third group of studies focus on short-term memory over the menstrual cycle using tests of immediate serial recall. Cooper, Blue, and Ross (1983) tested five subgroups of women who were classified depending on the phase of the menstrual cycle. They found no difference between the groups on either the forward or backward digit-span subtest of the WAIS-R. The design of this study can be criticized because women were tested twice, and were in different groups at each testing session. This means that the group scores were derived from a mixture of within- and between-subjects scores. A repeated measures design, where women were tested five times, would have provided a more powerful test of the hypothesis that women perform differently at different points in their menstrual cycle.

A subsequent investigation by Gordon et al. (1986) found a significant effect of menstrual cycle phase on the immediate serial recall of digit sequences. Twenty-four women were tested at three phases of the menstrual cycle (menstruum, early intermenstruum, and premenstruum) in a repeated measures design, with initial phase of testing counterbalanced. Performance was best during the menstruum, and worst during the early intermenstruum. Despite the provocative findings, the authors caution that it is difficult to interpret these results because nearly half the subjects had to be eliminated because hormonal assays indicated they were not in the expected cycle phase. There were also significant group by cycle interactions, which suggest that the pattern is not the same for the three groups of women.

Hartley, Lyons, and Dunne (1987) tested 30 women during ovulation, menstruation, and the premenstrual phase and found that immediate serial recall of lists of semantically similar words was significantly worse during ovulation. They also found that the recall of acoustically similar words was marginally better during ovulation than during the paramenstruum (premenstrual and menstrual phases).

Finally, Richardson (1991) tested women on the immediate serial recall of sequences of phonetically similar and distinct words. Subjects were tested in two sessions that occurred two weeks apart. Scores were reclassified with regard to four phases of the menstrual cycle, and a comparison of performance in the intermenstruum (early and late) and the paramenstruum (premenstruum and menstruum) was carried out. There was no evidence of a significant difference in immediate serial recall performance during the intermenstruum and the paramenstruum, nor during any of the four phases of the menstrual cycle. There was also no relationship between performance during the premenstruum and reports of premenstrual symptoms.

These studies provide inconclusive evidence of menstrual cycle effects on short-term memory, and no support for a premenstrual performance deficit.

Rationale for Present Research

This review of the literature makes it apparent that there is little empirical support for the widely held belief that women experience cognitive and performance deficits premenstrually or during the paramenstruum. However, some studies have found menstrual phase-related changes on specific measures. Given the current state of our knowledge the question remains: Is it worth exploring the relationship of the menstrual cycle to cognitive performance any further? I think that the answer to this question must be based on several factors.

First, we cannot ignore the power of the widely held yet unproven belief in a premenstrual or paramenstrual cognitive performance deficit. In order to lay this common belief to rest it may be necessary to continue building a solid base of well-designed and appropriate research that can refute this claim or, as it happens, identify what aspects of cognition are affected by the menstrual cycle, in which phase, and to what extent. Given the possibility that LLPDD may be accepted as a psychiatric disorder partly because of the incidence of self-reported cognitive disturbances, it seems justified and in fact necessary that this phenomenon be further explored in both clinical and nonclinical groups of women.

Second, it is important to recognize that the cognition and menstrual cycle phase literature to date has suffered from severe methodological problems. For one, the often-employed between-subjects designs may not be sensitive to intra-individual cyclical changes. It seems logical that if there are any phase effects on cognition, they must be quite subtle; if the differences were large, previous research would have identified them, and they would probably be apparent in daily life. In order to investigate hypothesized subtle changes we must use within-subjects designs, and measure women over at least one complete menstrual cycle. In addition, the measures that have been used to detect cognitive change are often inappropriate. We should not expect measures of general intellectual functioning to be sensitive to cyclical variation. Specific tests are needed.

Another methodological problem is the lack of consistency in the number and definition of menstrual phases that are examined. Subjects are tested at two, three, four or even five phases of the menstrual cycle, which makes comparisons between studies or meta-analytic procedures very difficult. Even if the same number of cycle phases are used in two studies, the phase definitions vary; one researcher looks at days 2-4 while another looks at days 3-6, one researcher specifies preovulatory and postovulatory phases and does not report days of cycle while another splits the cycle into phases based on the number of days from menstrual onset, or one researcher splits the cycle into equal quarterly phases while another specifies four unequal phases that range from 3 days to 10 days. Different researchers may determine the phase of the cycle by concurrent or retrospective self-report, BBT, and/or blood hormonal assay. Also, sample sizes are often extremely small, particularly with repeated measures designs. This brings into question the robustness of the few significant findings and invites questions about the statistical power of the research, that is, the probability that a true phase-related fluctuation, especially one with a small effect size, will show up on analyses.

Third, in order to justify further research, it is important that investigators no longer give all manner of cognitive performance tests to women "just so we can see what we find." There must be a clear rationale for menstrual cycle phase research, and cognitive measures must be chosen based on a theoretical rationale that predicts performance variations, and/or earlier suggestive findings using the same or similar measures. For example, Richardson (1991, 1992) argues that the problem with research on cognition and the menstrual cycle is that researchers are designing studies based on an assumption of change, rather than a logical hypothesis. To illustrate a more scientific approach, he develops two lines of reasoning that could predict a menstrual-cycle related change in memory. His first hypothesis is that long-term memory could be directly affected by the hormonal changes of the menstrual cycle and the effect of these hormones on the brain. His second hypothesis is that menstrual-related effects on cognition are due to the mood changes that are associated with the cycle. If the latter is the case, he proposes that tasks requiring short-term memory and encoding of stimuli should be particularly sensitive to these processes, since state anxiety and other affective states have been shown to interfere with working memory. However, in two studies testing these hypotheses he found no effect of menstrual cycle phase on memory tasks. It is worth noting that although his investigation of the first hypothesis employed a powerful repeated measures design over four phases of the menstrual cycle, his test of the second hypothesis looked at only two phases of the menstrual cycle. This follows from his theoretical rationale: direct hormonal effects might affect cognition at any phase of the cycle, since hormones fluctuate throughout, and so all four phases of the cycle must be measured; but if cognitive changes are secondary to the mood changes that are observed in the paramenstrual phase, only two phases (paramenstrual versus intermenstrual) need be tested.

Fourth, as the previous literature review illustrates, there are some interesting trends in the literature that indicate a cycle phase effect on measures of things like breaking set, arithmetic ability, and immediate serial recall. These contradictory findings warrant further investigation. For one thing, even a small change on these measures due to the menstrual cycle is of theoretical interest (although the caution remains that we must not over-interpret such findings as indicative of cognitive changes that may have a practical significance). For another, establishing a pattern or trend in research using normal women will provide a good baseline against which to investigate clinical groups and explore the validity of the LLPDD criteria.

It is now time to answer the question that opened this discussion, namely, is it worth exploring the relationship of the menstrual cycle to cognitive performance any further? Based on the previous four points, the answer is yes. Whether this study finds a cycle phase effect on cognition, or helps to lay the belief to rest once and for all, the findings are important. There is still a need for repeated measures research that tests subjects at several points in the menstrual cycle, employs specific cycle phase definitions, and has appropriate sample sizes (and therefore sufficient statistical power). Dependent measures must be chosen based on previous research and/or theoretical rationale, and they must be sensitive to small performance fluctuations. The current study was designed to meet these criteria.

The Current Study

This study was designed to explore two main questions.

1) Do the chosen measures of actual and perceived cognitive performance show fluctuations over four phases of the menstrual cycle?

2) Is there any support for the belief that women show a cognitive performance deficit in the premenstrual or paramenstrual phase of the cycle?

In order to address the first question, this research was designed so that women were tested during four phases of the menstrual cycle; menstrual, early intermenstrual, late intermenstrual, and premenstrual.

Three measures of actual cognitive performance were chosen, with care being taken to include measures that were sensitive enough to pick up subtle intra-individual differences. All of these objective performance measures were chosen based on the previously mentioned research that provides provocative but inconclusive evidence for a menstrual cycle phase effect on measures of breaking set, arithmetic ability, and immediate serial recall. The third measure was also chosen based on Richardson's (1992) hypothesis that short term memory may be affected by the hormonal fluctuations of the menstrual cycle or the associated mood changes.

A measure of perceived cognitive functioning and a self-report mood measure were included in order to see whether scores fluctuated over the menstrual cycle, whether they showed a premenstrual deficit, and whether they related to the objective performance measures. Careful consideration was given to the design of the study, in order that any subtle cycle phase related performance fluctuations would be detected.

Hypotheses

Due to the lack of consistent findings in the literature, directional hypotheses for the first research question were not formed. Rather, this investigation was designed to explore and elucidate previous research trends. The following are the hypotheses for the current exploratory investigation of the relationships between menstrual cycle phase, actual and perceived cognitive performance, and mood:

1. Based on the hypothesis of direct hormonal influence on cognitive performance, there was expected to be a difference in performance on the objective measures over the four phases of the menstrual cycle.
2. Based on the hypothesis of a premenstrual or paramenstrual performance deficit, it was expected that subjects would do better on the objective measures during the intermenstrual phases than during the premenstrual or paramenstrual (average of premenstrual and menstrual) phases.
3. Based on previous research on self-reported cognitive performance

and mood over the menstrual cycle, and the hypothesis of a premenstrual or paramenstrual deficit, it was expected that perceived cognitive performance and mood would be rated lowest premenstrually.

4. It was expected that women would report on the Performance Questionnaire that their menstrual cycle affects their cognitive processes.

METHOD

Subjects

Subjects were students and staff of Simon Fraser University recruited by way of posters requesting women to participate in a study of women's health. Women who were not using oral contraceptives and who were interested in finding something out about their moods and thinking processes were invited to participate.

Only women who reported no current use of oral contraceptives or other hormonal medications, who were not pregnant, and who reported regular menstrual cycles were included. The age range was limited to women from 18-35 in order to avoid teenage women with irregular cycles and women who might be nearing early menopause.

Power analyses conducted prior to the start of data collection indicated that 32 subjects were needed in order to provide an adequate test of the hypotheses. In total, 44 subjects were recruited and tested over a six-month period. Twelve subjects failed to complete the study, which left a final 32 subjects who completed the five week testing procedure. The women who completed this study had a mean age of 24.40 years with a range from 18 to 35 (SD = 4.96). Their average age at menarche (first menstrual period) was 13.00 years (SD = 1.24). Their average length of menstrual cycle was 28.97 days (SD = 5.10) with an average menstrual flow of 4.88 days (SD = 1.49). This data is presented in Table 1. Table 2 presents additional descriptive information (see following page).

Most of the subjects who dropped out completed only the first testing session. Those that were then contacted by telephone claimed that they withdrew because they felt unable to make the required time commitment. T-tests showed that there were no significant differences between these 32 subjects and the 12 subjects who failed to complete the study on the background or menstrual cycle characteristics.

Table 1.

Demographics and menstrual cycle history.

	Mean	SD
Age (years)	24.40	4.96
Age at Menarche (years)	13.00	1.24
Cycle Length (days)	28.97	5.10
Menstrual Flow (days)	4.88	1.49

Note. N = 32.

Table 2.

Background variables: Percentages.

	Yes	No
Previous use of oral contraceptives	65.6	34.4
Previous or current use of an intrauterine device	9.4	90.6
At least one previous pregnancy	12.5	87.5
Psychiatric history (self)	15.6	84.4
Psychiatric history (family)	25.0	68.8

Note. N = 32.

Measures

A background information questionnaire was administered once at the start of the study in order to obtain the basic demographic information needed to describe the subjects (see Appendix B). It also gathered information about the subjects' menstrual history and current menstrual status. Menstrual cycle data were used to determine which menstrual cycle phase each subject was in for each of the four subsequent testing sessions.

The following measures were completed during every testing session: a weekly check sheet, three measures of actual cognitive performance, a measure of perceived cognitive performance, and a self-report mood measure.

Weekly Check Sheet

This checklist, containing questions about menstrual cycle events of the past week, was used to confirm cycle phase at time of testing (see Appendix B). It also contains questions to determine whether the subject had begun taking any medication or suffered from any illness which might affect the test scores.

The Rod and Frame Test (RFT)

The RFT was administered according to standard procedure (Oltman, 1968; Witkin et al., 1962). This is a perceptual task that measures perception of verticality or breaking set. It is administered in a completely dark room. Subjects are seated opposite the RFT apparatus and asked to align an illuminated rod to the true vertical against an illuminated, tilted background within a frame, in the absence of peripheral cues. For the present study 16 trials were performed, with the frame tilted either 7.5 or 15 degrees from vertical in either the clockwise or counter clockwise direction. The measure of accuracy is the mean absolute (unsigned) error in degrees.

As well as the evidence of a possible menstrual cycle phase difference on the RFT that is discussed previously, there are reports of a sex difference on the RFT with males performing more accurately than females (Hampson & Kimura,1988; Witkin et al., 1962).

Paced Auditory Serial Addition Test (PASAT)

The PASAT (Spreen & Strauss, 1991) is a serial-addition test used to assess the rate of information processing and sustained attention. A pre-recorded tape delivers a random series of 61 single digit numbers. The subject is instructed to add each number to the one immediately preceding it, and state the total verbally. For example, if the numbers are 1, then 2, the subject should add these together and state the total as 3. If the next number in the sequence is 6, the subject should add this to the previous 2 to give the total 8, and so on.

The PASAT consists of four different trials of the same 61 numbers, each differing in the rate of digit presentation (2.4, 2.0, 1.6, and 1.2 seconds). By increasing the rate of stimulus input, processing demands are increased. Subjects are required to comprehend the auditory input, respond verbally, inhibit encoding of their own responses while attending to the next stimulus, and perform at an externally determined pace.

Instructions are recorded on the tape, along with a paced practice trial. The score is total correct for each test trial, and time per correct response for each trial is computed from a table. A mean time per response score can then be obtained. Spreen and Strauss (1991) suggest that if there is more than a 0.6 second difference between one time trial and the others, data from this trial should be discarded, and if more than one trial differs by 0.6 seconds, the whole session should be regarded as unreliable.

Psychometric properties and normative data for the PASAT are discussed by Spreen and Strauss (1991). There are significant practice effects between the first and second administrations, but after the second presentations practice effects are minimal (Gronwall,1977). The PASAT is thought to measure some central information processing capacity. It shows a modest correlation with general intelligence and numerical ability (Egan, 1988). The PASAT seemed like an excellent measure for the current study because it is a sensitive and specific test with a degree of difficulty that should be responsive to any subtle phase related changes.

Serial Digit Learning (SDL)

Serial digit learning, or "digit supraspan" is described by Benton, Hamsher, Varney, and Spreen (1983) as a useful method for assessing short-term memory. The test consists of the verbal presentation of 8 or 9 randomly selected digits for a varying number of trials up to a maximum of 12. Subjects are instructed to repeat the 8- or 9-digit number. This procedure is similar to traditional digit-span tests except that the digit sequence is longer and, presumably, more difficult; SDL is intended to present a test of digit learning rather than simple digit span capacity.

For the purposes of this study, a 10-digit number was used. The decision to increase the serial digit learning sequence by one was based on the pretest data for the first few subjects, which indicated a ceiling effect in that many subjects were getting the highest possible score. It was hoped that increasing the task difficulty would create more variability and allow any cycle phase effect to show up.

Scoring of the SDL task is as follows. Correct responses are given a score of 2 points; near-correct responses (single digit omitted, substituted or interchanged with adjacent digit) are be given a score of 1, incorrect responses receive a score of 0. Once the criterion of two consecutive correct repetitions is reached, the task is discontinued and two points credited for each of the remaining trials. The test score is the sum of the points obtained over 12 trials, to a maximum of 24.

Normative data for this test are reported by Benton et al. (1983). Level of education is positively correlated with performance. No sex differences have been reported.

The Temporal Disorganization Scale (TDS)

The TDS as described by Melges and Freeman (1977) is a measure of current subjective cognitive state. The TDS is a self-report instrument comprising twenty statements that focus on five dimensions of cognitive function; temporal indistinction, impaired goal directedness, tracking dysfunction, desynchronization, and rate change durations (see Appendix B). Subjects are instructed to reply in terms of their experiences on the day of testing on a 4-point scale ranging from "not at all" to "frequently". The TDS yields a total score, and a score for five subscales that reflect the five dimensions of cognitive functioning mentioned above.

The TDS was developed to investigate cognition in psychiatric patients (Freeman & Melges, 1977, 1978) and in normal volunteers administered intoxicating doses of alcohol or hashish (Melges, 1976; Melges, Tinklenberg, Hollister, & Gillespie, 1970; Melges et al., 1974). The TDS has face validity, and the items have been derived from a series of studies, but normative data and psychometric properties have not been reported. It was included in this study because Kirstein, Rosenberg, and Smith (1980-81) report that the TDS is a sensitive measure of perceived cognitive changes during the menstrual cycle, and that it correlates with the cognitive items of the Moos Menstrual Distress Questionnaire.

The Affect Grid (AG)

The Affect Grid (Russell, Weiss, & Mendelsohn, 1989) is a measure of self-reported mood. It is a single-item scale that assesses affect along the dimensions of pleasure-displeasure and arousal-sleepiness (see Appendix B). In the current study subjects were instructed to rate their current mood at each testing session ("How you feel right now".)

The psychometric properties of this scale as described by Russell, Weiss, and Mendelsohn (1989) indicate that is a reliable and valid instrument for repeated measures of mood. McFarlane, Martin, and Williams (1988) used the AG in a study of menstrual and other mood cycles where both men and women were asked to fill out the AG daily for two months. Women's retrospective accounts of mood showed negative premenstrual moods, but daily ratings did not confirm this; in fact, an analysis of the concurrent ratings indicated that women who were not on oral contraceptives reported more positive moods in the menstrual and follicular (preovulatory) phases. The data support the choice of the AG for the current study as a proven instrument that gives a quick, accurate assessment of current mood state.

Performance Questionnaire

This was administered once at the end of the study (see Appendix B). Subjects rated their performance on the objective measures for the present (final) and the three previous testing sessions on a scale ranging from 1-10.[2]

Procedure

All of the subjects who responded to the posters for this study were screened during the initial telephone contact in order to establish their eligibility for inclusion in this research. Those who met the inclusionary criteria, and agreed to participate in the study, were scheduled for a pretest session with one of two research assistants.

Pretest Session

During this first session the procedure was explained to each subject, and she was given a written description of the study (the document entitled Oral Contraceptives Study contained in Appendix C). This document also explained that she had a chance to win one of three $50.00 prizes, which would be awarded on the basis of a draw made at the end of the study. She then signed a Consent Form (see Appendix C) indicating that she understood the procedure of the study and giving her informed consent for participation.

Subjects were not fully informed of the purpose of this research. Instead, they were informed that they were serving as control subjects for an investigation of the effects of oral contraceptives on cognition and mood. The justification for this initial concealment of information from the subjects

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[2] Two other questionnaires were administered during the final testing session. They were the Premenstrual Assessment Form (Halbreich, Endicott, & Nee, 1983) which is a self-report inventory of premenstrual symptoms, and the Menstrual Attitudes Questionnaire (Brooks-Gunn & Ruble, 1980). These measures were included to test a separate hypothesis, and will not be analyzed here.

is as follows. Research has shown that the common belief of negative mood and cognitive impairment in the premenstrual phase can influence the self-reports of some women (Richardson, 1992). The demand characteristics for this study, if the subject was fully informed of the hypotheses, would have been high. The rationale that was used justified why the women were asked about their oral contraceptive use and to provide detailed information about their menstrual cycle. Subjects were fully informed about the nature of the measures and the time required; only the purpose of the research was disguised. This use of concealment was approved by the University Ethics Committee.

Subjects first filled out the background information questionnaire, then they had a practice session in which all of the subjective and objective measures were administered. This was done to acquaint subjects with the testing procedure and help eliminate the practice effects known to be most extreme between the first and second testing sessions.

Testing Sessions

Following the pretest session, subjects were tested every 7 days ($\pm$ 48 hours) for four weeks at the same time of day.

Order of Testing

During the pretest and each of the four testing sessions the measures were given in the following order:

1. Weekly Check Sheet
2. Temporal Disorganization Scale
3. Affect Grid

4. Rod and Frame Test

5. Paced Auditory Serial Addition Test

6. Serial Digit Learning

This order of testing was chosen to allow the subjects a few minutes of transition time during which they filled out the subjective measures, before they began the objective performance measures. Also, since the PASAT is a challenging and often frustrating task, I wanted to obtain the mood measure first in order to minimize reactivity.

Final Testing Session

At the end of the fourth and final testing session, each subject was asked to fill out the Performance Questionnaire, the Premenstrual Assessment Form, and the Menstrual Attitude Questionnaire. Following this, the subjects were fully debriefed regarding the deception, and any questions were answered.

A follow up telephone call and/or letter was used to confirm the date of the start of each subjects' next menstrual period.

Menstrual Cycle Phase Determination

Following data collection, each subject was allocated to one of four blocks, depending on the date during the five week testing sequence on which she reported that her menstrual flow began. Those whose periods began between the pretest session and test session 1 were assigned to Block 1; those whose periods began between test sessions 1 and 2 were assigned to Block 2; those whose periods began between test sessions 2 and 3 were assigned to Block 3; and those whose periods began between test session 3 and 4 were assigned to Block 4. The dates of the four sessions were then compared to the dates of each subject's last period, next reported period, and the average duration of her menstrual cycle to establish whether one and only one test session fell within each of four phases of the menstrual cycle, which were chosen as follows.

The menstrual cycle was divided into four equal phases, that is, I assumed that the duration of each of these four phases is one quarter of a whole cycle. If the first day of menstruation is called day 1, the four phases for a woman with a 28 day cycle would be the following:

1. Menstrual Phase (M), days 1-7.
2. Early Intermenstrual Phase (EIM), days 8-14.
3. Late Intermenstrual Phase (LIM), days 15-21.
4. Premenstrual Phase (PM), days 22-28.

The early and late intermenstrual phases should correspond with the preovulatory and postovulatory phases of the menstrual cycle for women with normal ovulatory cycles. However, as this study determined cycle phase based only on days from menstruation, I avoided the common error of labelling these cycle phases with names that imply some knowledge of the hormonal and/or ovulatory status of the woman. Phase names like preovulatory or luteal should be reserved for research using physiological confirmations of cycle status.

This procedure resulted in four nearly equal groups of women who differed by block, that is, the sequence of cycle phases (see Table 3). By blocking subjects in this manner any possible testing sequence by cycle phase interaction was controlled for. This design was adapted from those used by Richardson (1991) and Sommer (1972). The order of subjects' data was then reclassified from a testing session sequence (1 through 4) to a cycle phase sequence (M, EIM, LIM, PM).

Table 3.

Cycle phase associated with testing session for subjects in each block.

			Test Session			
Block	N	Pretest	1	2	3	4
1	8	PM	M	EIM	LIM	PM
2	8	LIM	PM	M	EIM	LIM
3	9	EIM	LIM	PM	M	EIM
4	7	M	EIM	LIM	PM	M

Note. M = Menstrual; EIM = Early Intermenstrual; LIM = Late Intermenstrual; PM = Premenstrual.

Statistical Analyses

Of the 32 subjects who completed the procedure, 28 had testing sessions that matched up with their cycle phases on a one-to-one basis. Four subjects had a questionable match; one had irregular cycles during and after the study, and three others had one test session that was slightly out of synchronization with one of her cycle phases. It was decided to analyze the data using both 32 and then 28 subjects in order to see if the exclusion of the four subjects with less than ideal cycle phase/testing session matches would make a difference in the results.

Correlations between the various performance and self-report measures were performed to investigate the relationships between actual and perceived cognitive functioning and mood. It was assumed that tests were not intercorrelated, and so cycle phase differences were tested for using multiple repeated measures ANOVA rather than MANOVA. Dependent variables consisted of three measures of actual cognitive performance, three measures of perceived cognitive performance and mood, and one self-report rating of performance on the objective measures. It was decided that since there were at most three tests of each hypothesis the Bonferroni correction was unnecessary.

The first set of repeated measures analyses was performed to address the first question; are there any consistent changes over the four phases of the menstrual cycle on the measures of cognitive performance and mood? This hypothesis was tested using repeated measures ANOVA with cycle phase as the within-subjects factor and total scores for the RFT, PASAT, SDL, AG pleasure, AG arousal, TDS and self-report performance as the dependent variables. The chosen criterion of significance was $p < .05$ using Wilks' Lambda, which is the pooled ratio of error variance to effect variance plus error variance (Tabachnick & Fidell, 1989). It was decided to test the subscales of the PASAT and TDS only if a significant main effect for cycle was found on the total score.

The second set of analyses were performed to address the second question, which predict a premenstrual or paramenstrual deficit in performance, using repeated measures ANOVA with planned comparisons of a) premenstrual phase against an average of early and late intermenstrual phases and b) an average of premenstrual and menstrual phases against an average of early and late intermenstrual phases. These analyses were performed on the total scores for the dependent measures, and, if a significant main effect for cycle was found, on the subscales of the PASAT and TDS.

RESULTS

Performance on Dependent Measures

Table 4 shows the means and standard deviations for the dependent measures for each of the four phases of the menstrual cycle. Tables 5 through 9 show the correlations between the measures at each of the four menstrual cycle phases and for the scores averaged over cycle phase.

Using a significance level of $p < .05$, we can see that in the menstrual phase performance on the PASAT is significantly negatively correlated with performance on the SDL (Table 5). Since a higher score on the PASAT indicates poorer performance, these two are actually positively correlated. The PASAT is also correlated significantly with arousal, in that high arousal is associated with lower scores (that is, quicker time/correct response) on the PASAT.

Table 4.

Cognitive and mood measures: Means and standard deviations for each menstrual cycle phase.

		M	EIM	LIM	PM	p
RFT[a]	Mean	1.64	1.72	1.54	1.38	0.041
	SD	1.03	0.72	0.73	0.62	
PASAT[b]	Mean	2.26	2.23	2.30	2.26	0.594
	SD	0.46	0.42	0.49	0.44	
SDL[c]	Mean	18.81	19.47	20.00	19.91	0.753
	SD	5.57	4.93	3.67	3.64	
AG - Pleasure	Mean	4.87	5.28	5.22	5.19	0.824
	SD	1.95	1.82	1.88	1.53	
AG - Arousal	Mean	5.19	5.47	5.16	5.75	0.590
	SD	1.91	2.16	1.92	1.80	
TDS[d]	Mean	43.38	40.56	39.66	37.81	0.038
	SD	10.40	8.99	8.68	7.83	
Performance[e]	Mean	5.71	6.26	6.00	5.13	0.395
	SD	2.10	2.00	2.08	2.26	

Note. N = 32. M=Menstrual, EIM=Early Intermenstrual, LIM=Late Intermenstrual, PM=Premenstrual. p values based on repeated measures ANOVA on cycle with F(3,29) using Wilks' Lambda.

[a] Mean time/correct response in seconds. [b] Mean absolute error in degrees. [c] Total score. [d] Total score. [e] Self-report scale 1-10.

Table 5.

Menstrual phase: Correlations between measures of actual and perceived cognitive performance and mood.

	RFT	PASAT	SDL	AG-P	AG-A	TDS
RFT	1.00	0.24	-0.09	0.20	-0.03	0.02
PASAT		1.00	-0.36*	-0.18	-0.50**	0.04
SDL			1.00	0.25	0.30	-0.06
AG-P				1.00	0.40*	-0.34
AG-A					1.00	-0.31
TDS						1.00

Note. * $p<.05$; ** $p<.005$

Table 6.

Early intermenstrual phase: Correlations between measures of actual and perceived cognitive performance and mood.

	RFT	PASAT	SDL	AG-P	AG-A	TDS
RFT	1.00	0.04	-0.08	-0.17	-0.10	0.22
PASAT		1.00	-0.20	0.01	-0.08	-0.01
SDL			1.00	-0.08	0.24	-0.17
AG-P				1.00	0.20	-0.62**
AG-A					1.00	-0.27
TDS						1.00

Note. ** $p<.005$.

Table 7.

Late intermenstrual phase: Correlations between measures of actual and perceived cognitive performance and mood.

	RFT	PASAT	SDL	AG-P	AG-A	TDS
RFT	1.00	0.05	0.07	0.24	-0.05	-0.02
PASAT		1.00	0.05	-0.04	-0.05	-0.14
SDL			1.00	0.28	0.22	-0.04
AG-P				1.00	-0.05	-0.15
AG-A					1.00	-0.03
TDS						1.00

Table 8.

Premenstrual phase: Correlations between measures of actual and perceived cognitive performance and mood.

	RFT	PASAT	SDL	AG-P	AG-A	TDS
RFT	1.00	-0.00	-0.64	-0.66	0.02	0.06
PASAT		1.00	-0.19	-0.33	0.19	0.08
SDL			1.00	0.07	-0.12	0.22
AG-P				1.00	-0.08	-0.06
AG-A					1.00	-0.14
TDS						1.00

Table 9.

Correlations between measures of actual and perceived cognitive performance and mood averaged over cycle phase.

	RFT	PASAT	SDL	AG-P	AG-A	TDS
RFT	1.00	0.10	-0.13	-0.03	-0.01	0.11
PASAT		1.00	-0.17	-0.20	-0.24	-0.00
SDL			1.00	0.17	0.25	-0.11
AG-P				1.00	-0.02	-0.22
AG-A					1.00	-0.24
TDS						1.00

This correlation is not surprising since the PASAT is a difficult test of concentration and information processing that we would expect to be affected by low arousal (i.e., sleepiness or fatigue). An interesting correlation that is significant only in the menstrual phase is that between the two AG dimensions of pleasure and arousal. These dimensions are supposed to be independent. Perhaps the correlation appears only during the menstrual phase because subjects report feeling both low arousal and negative affect (i.e., a depressed state). An inspection of the means in Table 4 shows that pleasure is lowest in this phase, and that arousal is also low.

In the early intermenstrual phase the only significant correlation is between AG Pleasure and the TDS (see Table 6). High scores on the TDS indicate a greater degree of perceived cognitive disruption, so the direction of this correlation indicates that positive affect is strongly correlated (p < .001) with better perceived cognitive functioning, and vice versa. It is worth mentioning here that a similar pattern with a trend toward significance is observed between AG Pleasure and the TDS in the menstrual phase (p = .054)

All of the correlations between the dependent measures in the LIM and PM phases failed to reach significance (Tables 7 and 8).

It is hard to interpret correlations between dependent measures that are significant during one phase and not another. When the scores on each dependent measure are averaged over phase the correlations fail to reach significance (Table 9). The best interpretation seems to be that overall, the measures are independent. This is not too surprising given that they were chosen to test different aspects of actual and perceived cognitive performance, and two separate dimensions of mood.

Investigations of Menstrual Cycle Effects

A. Cycle Phase Differences

Table 4 shows the p values for the repeated measures ANOVA on the dependent measures using all 32 subjects. There were no significant cycle phase differences on the PASAT[3], the SDL, the AG dimensions of pleasure

[3] PASAT: The score initially analyzed for the PASAT was the mean time/response value over the four time trials. Since I hoped that such a difficult task of information processing would be sensitive to any cycle phase effects I was surprised that there was no trend toward significance on this measure. Spreen and Strauss (1991) recommend that any trial which has a time/response more than 0.6 seconds slower than the rest be dropped from the calculated mean. I chose not to follow their recommendation because I am most interested in subtle phase changes on the PASAT, and did not want to discard trials on which the subject performed poorly; in fact, these are the trials of interest. However, for completeness, I then analyzed the corrected mean time/response score outlined by Spreen and Strauss. There were no significant

or arousal, or on subjects' rating of their performance. There was not even a trend toward significance on these measures (all $p > .20$).

There was a significant difference in performance on the RFT over cycle phase, $F(3,29) = 3.12$, $p = .041$. The score used is mean absolute error in degrees over 16 trials, and subjects performed better (i.e., were more accurate at aligning the rod to vertical) in the PM phase, and had their worst performance in the EIM phase. The difference between these two means is less than 0.5 of one degree.

A significant cycle phase effect was also found on the TDS total score, $F(3,29) = 3.21$, $p = .038$. As mentioned previously, high scores on this measure indicate more perceived temporal disorganization. Subjects scored highest in the M phase, and lowest in the PM phase. This finding is of great interest, given that the symptoms of both PMS and LLPDD include a subjective sense of difficulty concentrating in the PM phase. For this study the findings are opposite to this; women report that they think more clearly in the premenstrual phase. The difference between the two means is 5.6 points (total possible score on the TDS is 80).

Analyses were then performed on each of the five subscales of the TDS (see Table 10). There was a significant cycle phase effect for subscale 1 (rate and duration changes), $F(3,29) = 4.04$, $p = 0.016$. While three of the subscales showed no significant cycle phase effects, there was a trend

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cycle phase effects on this score. I then looked at the total correct and time/response scores for the fourth (most difficult) time trial, since any cycle phase fluctuations would be most likely to be revealed on the trial with the maximum information processing demands. No significant cycle phase effects were found.

Table 10.

Temporal disorganization subscales: Means and standard deviations for each menstrual cycle phase.

		M	EIM	LIM	PM	p
Subscale 1[a]	Mean	8.62	7.84	7.62	7.41	0.016
	SD	2.32	2.02	2.01	1.68	
Subscale 2[b]	Mean	7.94	7.19	7.03	6.72	0.195
	SD	2.72	2.63	2.04	2.02	
Subscale 3[c]	Mean	5.72	5.34	5.69	5.28	0.438
	SD	2.20	1.75	2.01	1.65	
Subscale 4[d]	Mean	7.88	7.09	6.97	6.47	0.142
	SD	2.59	2.36	2.25	2.08	
Subscale 5[e]	Mean	9.47	9.66	8.84	8.94	0.061
	SD	1.48	1.84	1.59	1.64	

Note. $N = 32$. M = Menstrual; EIM = Early Intermenstrual; LIM = Late Intermenstrual; PM = Premenstrual. p values based on repeated measures ANOVA on cycle with F (3,29) using Wilks' Lambda.

[a] Subscale 1 = Rate/Duration Changes (TDS items 1, 8, 11, 17).
[b] Subscale 2 = Tracking Difficulties (TDS items 5, 9, 14, 20).
[c] Subscale 3 = Temporal Indistinction (TDS items 4, 10, 15, 18).
[d] Subscale 4 = Impaired Goal Directedness (TDS items 3, 6, 13, 16).
[e] Subscale 5 = Desynchronization (TDS items 2, 7, 12, 19).

toward significance on subscale 5 (desynchronization) that failed to reach significance, F (3,29) = 2.75, p = 0.061. It is interesting that the subscale that seems to be the best measure of the PMS/LLPDD criteria of concentration difficulties (subscale 4, impaired goal directedness) showed no cycle phase effects.

The analyses described above were then repeated with N = 28, dropping the four subjects who had questionable cycle phase/testing session matches. The PASAT, SDL, AG and performance measures remained nonsignificant. What is surprising is that the previously significant cycle phase differences on the RFT and the TDS total and subscale 1 scores disappeared, although there was still a trend to significance on the TDS total score, F (3,25) = 2.83, p = 0.059.

So although cycle phase differences on the measure of perceived cognitive functioning remained marginally significant, dropping only four subjects meant that none of the objective measures of cognitive performance showed significant cycle phase effects. This does not support the hypothesis of cognitive changes across the menstrual cycle.[4]

B. Planned Comparisons: Premenstrual Deficit

This set of analyses used repeated measures ANOVA with a planned comparison of premenstrual phase scores and an average of the early and late intermenstrual scores as a test of the PMS or premenstrual deficit

[4] Given that the significant effects disappeared with the loss of only four subjects, and that pairwise comparisons with the appropriate Bonferroni correction for multiple tests were unlikely to reach significance, it was decided not to do post hoc comparisons among means.

hypothesis. The comparisons were tested with univariate F tests with df = (1,31). Table 11 shows the p values for each dependent measure.

Table 11.

Significance of planned comparisons testing the premenstrual and paramenstrual deficit hypotheses.

	p	
Dependent Measure	Premenstrual	Paramenstrual
RFT	0.05	0.20
PASAT	0.97	0.88
SDL	0.34	0.62
AG-P	0.44	0.51
AG-A	0.26	0.62
TDS Total	0.01	0.72
Subscale 1	0.00	0.38
Subscale 2	0.03	0.57
Subscale 3	0.15	0.95
Subscale 4	0.02	0.67
Subscale 5	0.07	0.84
Performance	0.26	0.10

Note. For all planned comparisons degrees of freedom are (1,31). Premenstrual = PM versus EIM + LIM/2. Paramenstrual = PM + M/2 versus EIM + LIM/2.

There were no significant differences between the premenstrual phase and the intermenstrual phases on the PASAT, SDL, AG pleasure or arousal, or on subjects' rating of their performance (all $p > .20$).

There was a significant difference between performance in the PM phase and the EIM/LIM phases on the RFT, $F(1,31) = 4.14$, $p = 0.05$. Inspection of the means in Table 4 reveals that these significant effects were in the opposite direction from those predicted by the premenstrual deficit hypothesis: subjects actually performed better on the RFT premenstrually (i.e., were more accurate at aligning the rod to vertical).

A significant difference was found on the TDS total score, $F(1,31) = 8.65$, $p = 0.006$, and subscales 1, 2, and 4 (all $p < .05$) between the premenstrual phase and the intermenstrual phases. There was a trend toward significance on subscale 5 ($p = .074$). As was the case with the RFT, these significant findings were in the opposite direction from those predicted by the premenstrual deficit hypothesis. TDS scores were lower (i.e., self-reported cognition was less disrupted) premenstrually than intermenstrually.

The analyses were then repeated with $N = 28$, dropping the four questionable subjects. The PASAT, SDL, AG and performance measures remained nonsignificant. Significance on the RFT was lost. Significant effects remained on the TDS total score, **$F(1,27) = 7.16$, $p = .012$ and** on subscales 1, 2 ,4, and 5 (all $p<.05$) in the opposite direction from that predicted by the hypothesis.

C. Planned Comparisons: Paramenstrual Deficit

This set of analyses was performed in the same manner as the previous set, using a planned comparison of an average of premenstrual and menstrual phase scores compared to an average of the early and late intermenstrual scores as a test of the paramenstrual deficit hypothesis. There were no significant effects on any of the dependent measures (see Table 11).

D. Self-report ratings of Performance

As mentioned previously, there were no significant cycle phase effects on subjects' recall rating of their performance during each testing session on the objective cognitive measures when these were reclassified to correspond with cycle phase (Performance Questionnaire). Yet when subjects responded to items that asked whether they thought their cognitive processes were affected by their menstrual cycle most months, 57% said yes. In addition, 52% believed their menstrual cycle had affected their cognitive processes that month, and 39% believed their menstrual cycle had affected their performance on the RFT, PASAT and SDL.

DISCUSSION

Cycle Phase Differences

When the results of this study are considered as a whole, they fail to support the hypothesis of an influence of the menstrual cycle on actual cognitive functioning. There were no cycle phase differences on the PASAT or SDL. If there is a fluctuation in cognitive performance over the menstrual cycle, we would expect it to show up on these types of measures; they are sensitive, specific, and place a high information processing demand on the subject. The fact that they were resoundingly nonsignificant further underlines the point that it is very unlikely that any cognitive fluctuations that do exist could affect a woman's daily performance on the job or in her life.

There were significant cycle phase effects on the RFT; but it is important to point out that this is more of a perceptual-spatial test than a cognitive task. There were also significant cycle phase effects on the TDS, which supports the idea that women do report changes in perceived cognitive functioning over the menstrual cycle. However, both of these findings disappeared when only four subjects were eliminated from the analyses.

What is the meaning of these findings? The TDS was included to test the premenstrual deficit hypothesis, and so will be discussed in the next section. For now, consider the RFT. The finding of a significant cycle phase difference is interesting, and bears further investigation. However, it is important to point out that the effect size is small, and this must be kept in mind when interpreting it. Hampson and Kimura (1988) report that there is a sex difference on the RFT with a magnitude of 2-3 degrees. The largest difference between cycle phases in the current study is less than one half of one degree. In other words, women's performance differs more from men's than from their own performance at different cycle phases. Given this, it seems inappropriate to claim that women's performance is somehow impaired during certain points in their menstrual cycle. Any such claims must be put in perspective by noting the effect size and interpreting the findings accordingly.

In these terms, the finding of a cycle phase difference on the RFT is of more theoretical than practical importance. In fact, the results of the current study fit the theory developed by Broverman et al., (1981) that attempts to explain how gonadal hormones could exert a direct influence on cognitive processes. They suggest that estrogens affect human behaviour in a way similar to adrenergic stimulants, with the result being that the hormonal changes of the menstrual cycle can be expected to influence performance on tests of automization and perceptual-restructuring. Automization refers to highly practised tasks that demand little conscious attention, and perceptual-restructuring refers to tasks where initial automized responses must be inhibited in favour of a response to less obvious stimulus attributes.

The RFT can be seen as an example of a task requiring this inhibition, since subjects must ignore the tilt of the frame when aligning the rod to vertical. The hormone hypothesis (Broverman et al., 1981; Klaiber et al., 1974; Richardson, 1992) proposes that the estrogen peak just prior to ovulation should enhance performance on automization tasks and interfere with performance on tasks of perceptual restructuring. In contrast, since progesterone seems to impair the actions of estrogen, the progesterone increase after ovulation should interfere with performance on automization tasks and enhance performance on perceptual-restructuring tasks.

To translate this into the terms used in the present study: the hormone hypothesis would predict that RFT performance would be best in the LIM/PM phase, when progesterone levels are high, and poorest in the EIM when estrogen levels are high. As the results show, RFT performance was best in the LIM and especially PM phases and worst in the EIM phase. This provides some tentative support for the hormone hypothesis, as do the findings of Klaiber et al. (1974) on the RFT, but it is important that these findings be replicated with bigger sample sizes and more measures of perceptual functioning and automization.

Once again, the caution must be made that although these findings may be of interest in terms of a neuroendocrine hypothesis of cognitive or perceptual functioning, they do not imply that there will be a functional difference in performance, especially of the magnitude that would result in a disruption of work or daily tasks.

Finally, it is important that future research is undertaken to test a hypothesis of a difference in performance over the menstrual cycle, and not a deficit at some phase. The latter approach is unsubstantiated (see next section) and perpetuates the myth that women are impaired by a natural biological process.

Premenstrual Deficit Hypothesis

The hypothesis that there is a premenstrual or paramenstrual deficit in cognitive performance and mood was not supported by this study. In fact, the significant findings were in the opposite direction; that is, the premenstrual phase was associated with the best performance on the RFT and TDS. Because these findings were in the opposite direction to those predicted, their meaning is difficult to interpret. This study certainly does not support the idea that women's cognitive processes are disrupted premenstrually; rather, the findings suggest that there may be a premenstrual enhancement on at least one measure of actual performance and on perceived cognitive functioning.

The findings on the RFT are discussed in the previous section.

The TDS was included in this study to test the belief, which is made explicit in the LLPDD criteria, that women report cognitive disruptions during the premenstruum or paramenstruum. The present study found that this was not the case. The design of this investigation minimized the possibility that subjects were aware of the purpose of the research, and this may partly explain why the PMS hypothesis was not substantiated, since many researchers suggest that demand characteristics lead to an increased reporting of premenstrual symptomatology (Halbreich et al., 1983).

The effect on the TDS was quite robust, and it would be of interest to try and replicate it. It might be useful to include a planned comparison of the menstrual phase against the intermenstrual phases, since an examination of the means in the present study indicates that performance on the TDS was in fact worst during the menstrual phase. The planned comparison done here was of the paramenstrual phase against the intermenstrual phase, and so a true menstrual deficit may have been masked. Either way, a menstrual deficit does not support the premenstrual deficit hypothesis. The caution should be made that the TDS is a scale without established psychometric data, and future studies of perceived cognitive functioning should include additional dependent measures.

It is interesting to note that despite the fact that concurrent reports of cognitive functioning (TDS scores) and recall ratings of cognitive performance (Performance Questionnaires) showed that there were no difference in performance at four menstrual cycle phases, when subjects responded to single item questions that asked whether they thought their cognitive processes were affected by their menstrual cycle a large percentage said yes, and then said that their performance was worst premenstrually. This was predicted by the fourth hypothesis of this study.

This belief that women are somehow disabled by the menstrual cycle, and that this natural biological rhythm should in fact be seen as a pathological event, continues. Perhaps future researchers should spend more time exploring the reasons for this belief, and less time conducting studies which yield mainly null results and often lack a solid theoretical or empirical justification.

Methodological Comments

The design used in the present study was an improvement on those used in much of the published research. Menstrual cycle phase was determined from concurrent reports of menstrual cycle status (i.e., each week) while other researchers using a similar design asked for a retrospective account of cycle phase only after all data was collected. Sufficient power was obtained by using an appropriate number of subjects and a within-subjects design. Subjects were not told the purpose of the research, which minimized the demand characteristics that are common in menstrual cycle and particularly PMS research.

Despite the good research design, the current study does have several limitations. For one, it would have been better to test more subjects. The final N of 32 was the minimum needed to obtain sufficient power for a medium effect size, and eliminating only 4 subjects from the analyses reversed the significant findings. Since the hypothesized fluctuations may be very subtle, (i.e., the expected effect size for some of the dependent variables is small), a much larger N would be needed to provide a powerful test of the hypotheses.

A second limitation of the present study is the imperfect cycle phase definition. In order to make any interpretations about the effect of ovarian hormones on task performance it is necessary to have some physiological confirmation of cycle phase. Basal body temperature or blood measures have been employed by some biomedical researchers, and these provide more information about the hormonal processes that may be underlying any significant cycle phase effects. Sommer (1992) points out that choosing cycle phases based on days from menstruation, as in the present study, may not be an accurate method of studying cycle related changes unless a large sample is used. However, Richardson (1992) reviews some studies that suggest that the present method is in fact quite reliable.

Practical limitations make it difficult for many researchers to obtain physiological measures. However, the present design might be improved by defining the four phases more precisely. For example, a cycle phase effect might be more likely to be uncovered if the menstrual phase is defined more specifically as days 2-4, rather than days 1-7 as in this study. Also, the 7-day cycle phase used here means that there may be considerable variability between the actual phase status of the subjects within each cycle phase designation. This is further complicated by the variability in cycle length and cycle flow between subjects. On the positive side, the week-long cycle phases defined here do coincide quite well with the major hormonal peaks and drops across the cycle for a woman with a 28 day cycle, and the phase lengths were adjusted for women with longer or shorter cycles (i.e. to 8- or 6-day phases).

Future research should utilize a similar design, with more specific cycle phase definitions and biological confirmation of cycle phases when possible. Since several significant findings and the hormone hypothesis both predict effects on perceptual and automization tasks, measures that test these abilities should be chosen. The lack of evidence on measures of other cognitive abilities, such as concentration, indicate that it may be time to stop looking in those directions. Finally, given that this whole area of research is filled with contradictory findings and poor methodology, any significant findings should be regarded with caution until they are replicated, and they should be interpreted and reported carefully.

Implications for LLPDD

The present study does not provide support for the idea that women experience a subjective sense in concentrating during the premenstrual phase. In fact, the results indicate that not only do normal women experience no deficit in subjective cognitive performance, they actually report an improvement in concentration during the premenstrual phase on concurrent reports. This is true even though in retrospect a large percentage of women claim that their cognitive processes were disrupted.

The important point here is that these are normal women. The next step is to investigate clinical groups against this baseline. While the present findings do not support the LLPDD cognitive criterion, perhaps clinical groups (women with a LLPDD diagnosis or high premenstrual symptom reporters) do experience premenstrual fluctuations in perceived or actual cognitive performance, given that they are defined as a distinct group with possible physiological and/or psychological abnormalities.

Until more research is carried out, the inclusion of a subjective sense of difficulty concentrating as a diagnostic criterion for LLPDD should be questioned. The present study indicates that even if women claim this symptom, concurrent measures of subjective cognitive ability do not support their claim. Simply claiming concentration or mood changes is not enough; the LLPDD criteria state that the symptoms must be confirmed by at least two months of prospective daily self-ratings (see Appendix A). This is an important point. Given that the acceptance of LLPDD as a psychiatric disorder means that women who believe they are affected by their menstrual cycle when they are really not could end up with a psychiatric diagnosis, and given that up to 70% of women believe that they experience some premenstrual symptoms (Moos, 1968), the dangers of possible over-diagnosis can be imagined. The evaluation of LLPDD for diagnostic status must include consideration of this issue.

A Final Comment

This study was designed as an exploration of the hypotheses outlined earlier. The idea that the menstrual cycle affects cognitive performance has ramifications for women everywhere. This common, although unproven, assumption can lead to discrimination against women in the workplace, and seriously affect women's self-perceptions as well as their place in society. This study had mainly null results, and hopefully puts us one step closer to laying this stereotype to rest. The only findings of cycle related changes on these measures are on subjective reports of cognitive functioning and a perceptual task, and they do not support the idea of a premenstrual performance deficit. We can assume that women are able to compensate for these fluctuations "in the real world," since researchers have been unable to find fluctuations on more global measures of intellectual functioning.

It is important that future research is judiciously planned and executed, and that any findings are not misappropriated by the media for inaccurate and potentially harmful headlines ("Women cannot think clearly once a month"). The way research is represented may lead the public to draw conclusions that can be harmful to women. For example, headlines like the one suggested here may support the belief that women are somehow less able than men to hold positions of power, make decisions that can influence corporations or countries, or pilot airplanes. It is our responsibility as scientists not only to give birth to interesting findings, but also to guide these findings as they make their way into the world.

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Appendix A.

DSM-III-R Criteria for Late Luteal Phase Dysphoric Disorder

A. In most menstrual cycles during the past year, symptoms in B occured during the last week of the luteal phase and remitted within a few days after onset of the follicular phase. In menstruating females, these phases correspond to the week before, and a few days after, the onset of menses. (In nonmenstruating females who have had a hysterectomy, the timing of luteal and follicular phases may require measurement of circulating reproductive hormones.)

B. At least five of the following symptoms have been present for most of the time during each symptomatic late luteal phase, at least one of the symptoms being either (1), (2), (3), or (4):

(1) marked affective lability, e.g., feeling suddenly sad, tearful, irritable, or angry
(2) persistent and marked anger or irritability
(3) marked anxiety, tension, feelings of being "keyed up", or "on edge"
(4) markedly depressed mood, feelings of hopelessness, or self-deprecating thoughts
(5) decreased interest in usual activities, e.g., work, friends, hobbies
(6) easy fatigability or marked lack of energy
(7) subjective sense of difficulty in concentrating
(8) marked change in appetite, overeating, or specific food cravings
(9) hypersomnia or insomnia
(10) other physical symptoms, such as breast tenderness or swelling, headaches, joint or muscle pain, a sensation of "bloating", weight gain

C. The disturbance seriously interferes with work or with usual social activities or relationships with others.

D. The disturbance is not merely an exacerbation of the symptoms of another disorder, such as Major Depression, Panic Disorder, Dysthymia, or a Personality Disorder (although it may be superimposed on any of these disorders).

E. Criteria A, B, C, and D are confirmed by prospective daily self ratings during at least two symptomatic cycles. (The diagnosis may be made provisionally prior to this confirmation).

(American Psychiatric Association, 1987, p. 369)

APPENDIX B
BACKGROUND INFORMATION

Identification Number:____________________ Date______________

1. Date of Birth:__________________ Age:______

2. Age at onset of first menstrual period:____________________

3. Average number of days of menstrual cycle, that is, from the beginning of one menstrual flow to the beginning of the next (eg. 28 days) : ______
____

4. If irregular, that is, if the number of days varies greatly, what is the range?:
Range from____to_____days

5. Please indicate the date of the first day of your last menstrual flow (or approximate date if not known exactly): ______________________

6. Please indicate the date of the last day of your last menstrual flow (or approximate date if not known exactly): ______________________

7. Please indicate when you expect your next menstrual flow to begin:
____

8. Average duration of menstrual flow (that is, the number of days from the beginning of your flow to the end of your flow) _______**days**

9. Number of pregnancies (whether carried full term or not):__________

10. Are you currently using, or have you ever used oral contraceptives?:
Yes__________ Never used________
If you answered "yes" please indicate dates and duration of all periods of use including current use____________________________________
____
____

BACKGROUND INFORMATION: Page 2

Identification Number________________

11. Are you currently using, or have you ever used an intra-uterine device (IUD)

    Yes__________ Never Used____________

    If you answered "yes" please indicate dates and duration of all periods of use including current use______________________________________

    ____

    ____

    ____

12. Are you currently using any medication?

    Yes__________ No________

    If you answered "yes" please indicate type of medication and reason taken

    ____

    ____

    ____

13. Have you ever been hospitalized or received any other form of treatment for depression?

    Yes__________ No________

    If you answered "yes please specify when and what type of treatment received______________________________________

    ____

    ____

14. Has any member of your family been hospitalized or received any other form of treatment for depression?

    Yes__________ No________

    If you answered "yes please indicate your relationship to this person:

    ____

    ____

    ____

APPENDIX B

Weekly Check Sheet

Identification Number:____________________ Date:_________________

1) Did your menstrual flow start last week: Yes____ No____
If yes please circle the appropriate day.
Mon Tues Wed Thurs Fri Sat Sun

2) Did your menstrual flow stop during the last week: Yes____ No____
If yes please circle the appropriate day.
Mon Tues Wed Thurs Fri Sat Sun

3) Are you aware if you ovulated last week: Yes____ No____
If yes please explain (ie. how do you know you ovulated) and circle the appropriate day.

____

____

____

____

Mon Tues Wed Thurs Fri Sat Sun

4) Did you begin using the pill this week: Yes _______ No _____

5) Did you begin using any medication this week: Yes_____ No ______
If Yes please specify

____

____

____

____

6) Did you suffer from any illness last week: Yes____ No____
If yes please explain (eg. cold, flu, etc.)

____

____

____

APPENDIX B

TDS Questionaire

Identification Number________________ Date__________________

Please respond to the following statements in terms of you experinces for **today only.**

Please circle one number using the following scale as a reference

1 = not at all
2 = occasionally (1-2 times per hour)
3 = often (5-10 times per hour)
4 = frequently (more than 20 times per hour)

1) My mind seems to be racing.

1 2 3 4

2) Some of my experiences seem to have happened before in the exact same way.

1 2 3 4

3) It's hard for me to direct my thoughts to what I intent to think or say.

1 2 3 4

4) My past, present, and future seem all muddled up and mixed together.

1 2 3 4

5) I tend to lose my train of thought.

1 2 3 4

6) My thoughts and actions are organized toward what I want to do or say next

1 2 3 4

7) I am having two or more trains of thought at the same time

1 2 3 4

8) My mind seems to be going slowly.

1 2 3 4

9) I forget what I've just said or intend to say.

1 2 3 4

10) My past and future seem to have collapsed into the present and it is difficult for me to tell them apart

1 2 3 4

11) I'm unsure how much clock time has gone by (unless I look at a clock).

1 2 3 4

12) My mind switches between speeding up and slowing down.

1 2 3 4

13) My sense of self-direction seems to be impaired

1 2 3 4

14) I can keep track of what I'm thinking about

1 2 3 4

15) Sometimes I feel absent from the present, swept into the past or future as if I were really there.

1 2 3 4

16) I lose control over my thinking.

1 2 3 4

17) My mind seems to be going at its usual rate.

1 2 3 4

18) It's easy for me to tell whether something is a memory, a perception, or an expectation

1 2 3 4

19) My mind swings back and forth in opposite directions

1 2 3 4

20) My mind goes blank at times

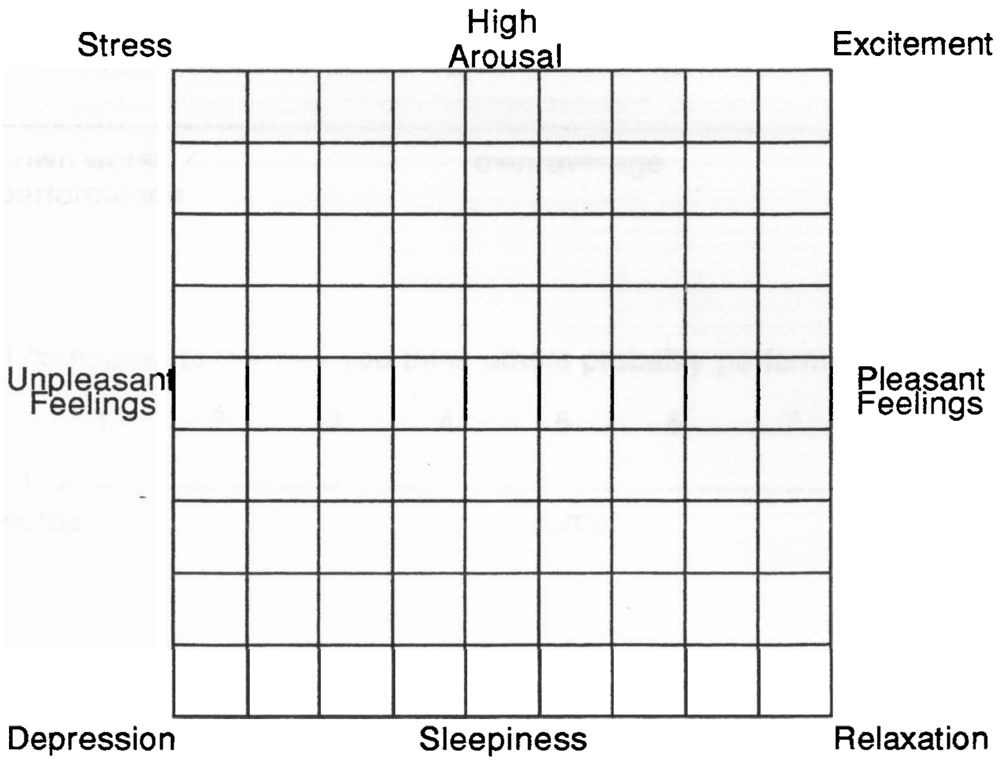
1 2 3 4

APPENDIX B

Affect Grid

Identification Number ______________________

Date ______________________



APPENDIX B

Performance Questionnaire

Identification Number______________________ Date___________________

How well do you think you did on the three tests

Fifth test session: (Today)

a) compared to your own best performance

0 1 2 3 4 5 6 7 8 9 10

----

own worst performance — own average — own best peformance

b) compared to the way you think others probably perform

0 1 2 3 4 5 6 7 8 9 10

----

worse — same — better

Second test session:

a) compared to your own best performance

0 1 2 3 4 5 6 7 8 9 10

----

own worst performance — own average — own best peformance

b) compared to the way you think others probably perform

0 1 2 3 4 5 6 7 8 9 10

----

worse — same — better

Third test session:

a) compared to your own best performance

0 1 2 3 4 5 6 7 8 9 10

----

own worst performance — own average — own best peformance

b) compared to the way you think others probably perform

0 1 2 3 4 5 6 7 8 9 10

----

worse — same — better

Fourth test session:

a) compared to your own best performance

0 1 2 3 4 5 6 7 8 9 10

----

own worst performance — own average — own best peformance

b) compared to the way you think others probably perform

0 1 2 3 4 5 6 7 8 9 10

----

worse — same — better

Performance Questionnaire (part 2)

1) Do you think your performance on any of these test was affected by your menstrual cycle

Yes____

No______

If yes please explain

____

____

____

2) Do you think your cognitive processes in general, other than those tested here, (ie. studying, concentration)

a) were influenced by your menstrual cycle **this last month**

Yes____

No______

If yes please explain

____

____

____

b) are generally affected by your menstrual cycle (ie. most months)

Yes____

No______

If yes please explain

____

____

____

3) Do you think your moods in general

a) were influenced by your menstrual cycle **this last month**

Yes____

No______

If yes please explain

____

____

____

b) are generally affected by your menstrual cycle (ie. most months)

Yes____

No______

If yes please explain

____

____

____

APPENDIX C

Oral Contraceptives Study

The study in which you are being asked to participate is investigating the effects of oral contraceptives on mood and cognition over one menstrual cycle. If you are not currently taking oral contraceptives, you will serve as part of the control group.

If you agree to participate in this study you will be asked to complete a number of questionnaires and tasks. Specifically:

a) At the beginning of the study you will be asked to complete an information sheet giving details of your menstrual history.

b) During the first session, and once a week for four weeks following the first session, you will be required to fill out a measure of you current mood, a questionnaire about your thinking processes, and a checklist of menstrual or health events of the past week. You will also be given three short tasks of cognitive performance. N.B. - These are NOT intelligence tests. You will be required to complete these measures weekly for five weeks, including today. The whole session should take approximately 30 to 40 minutes.

c) On the final session you will be asked to complete three additional questionnaires.

Your participation in this study is voluntary and you may withdraw from the study at any time. Your name will not be used on the data collected, and confidentiality is assured. The data collected from this study will be used only by the researcher.

If you are interested, detailed feedback will be given at the end of the study regarding your individual performance and the results of the study as a whole.

This study has been approved by the Ethics Committee of Simon Fraser University and is being conducted under the supervision of Dr. Richard J. Freeman of the Psychology Department, Simon Fraser University.

Upon completion of the study your name will be entered in a draw for 3 prizes of $50.00. Your chances of winning a prize are 1/15. These prizes are offered in appreciation of your assistance in this research.

APPENDIX C

Consent Form

I have read the procedure details of this study as outlined in the document entitled "Oral Contraceptives Study".

I understand the procedure and I also understand that I may withdraw from this study at any time.

My signature below certifies that I consent to participate in this study.

Name:_______________________________________

Signature: ___________________________________

Date: ____