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Menstrual Cycle Phase and Mood Effects on Perceptual Asymmetry

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Several studies have reported shifts in perceptual asymmetry during the menstrual cycle, but the potential confounding effect of mood changes has been largely ignored. In this study, 24 female subjects completed four visual laterality tasks and a mood questionnaire at three phases of the cycle. Results indicate no overall effect of cycle phase on any of the asymmetry or mood scores. However, results revealed significant associations between affect and perceptual asymmetry on a face perception task. Implications for mood effects on perceptual asymmetry and future research on cycle-related shifts in asymmetry are discussed. © 1997 Academic Press

The systematic changes in hormone levels that occur during the menstrual cycle provide a natural means for studying the effects of hormones on aspects of human cognition. Recently several groups of researchers have demonstrated cycle-related shifts in perceptual asymmetry, that is, changes during the menstrual cycle in the degree of hemispheric advantage measured by verbal and nonverbal laterality tasks. However, the results of these studies have been mixed. For example, on a tachistoscopic face perception task, Heister, Landis, Regard, and Schroeder-Heister (1989) found a left visual field (LVF) advantage at the menstrual phase of the cycle but not at the premenstrual phase of the cycle, whereas a tachistoscopic lexical decision task showed no change in visual field asymmetry across the cycle. On a verbal tachistoscopic task, Chiarello, McMahon, and Schaeffer (1989) found an increase in right visual field (RVF) response criterion during the menstrual phase of the cycle, but no changes in sensitivity; these same researchers found no shift in the visual field advantage for a line orientation task. More recently, Rode, Wagner, and Güntürkün (1995) found a shift during the cycle

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in the visual field advantage on a figural composition task, but not on a lexical decision task. In addition, these researchers found that levels of estrogen and progesterone were unrelated to the shift in visual field asymmetry on the figural composition task (Rode et al., 1995).

One possible interpretation of the findings that perceptual asymmetry varies during the cycle is that changes in hormonal state have a direct impact on hemispheric asymmetry in perceptual processing. For example, Kimura and Hampson (1993) hypothesize that high estrogen levels may facilitate left hemisphere processing relative to right hemisphere processing. This interpretation assumes that hormones can have activational, state-related effects on cerebral asymmetry as well as perinatal organizational effects. Abnormal perinatal hormonal environments have been shown to influence the development of handedness (Nass, Baker, Speiser, Virdis, Balsamo, Cacciara, Loche, Dumic, & New, 1987; Schachter, 1994), patterns of perceptual asymmetry (Hines & Shipley, 1984; Netley & Rovet, 1982, 1984), and cognitive abilities (Resnick, Berenbaum, Gottesman, & Bouchard, 1986). More recently, several investigators have linked changes in hormone levels in adulthood to changes in performance on spatial tasks in men (Kimura & Touissant, 1991) and in women (Hampson, 1990). Such findings indicate that gonadal hormone levels can have activational effects on some aspects of cognitive processing in adulthood. However, the failure to find a correlation between sex hormone levels and visual field asymmetry (Rode et al., 1995) calls into question the hypothesis that hormone levels directly influence perceptual asymmetry.

Given the mixed results from studies of perceptual asymmetry during the menstrual cycle, there is clearly a need for replication of these findings. In addition, given the failure to relate hormone levels and asymmetry directly, alternative hypotheses need to be considered. One factor that may influence perceptual asymmetry, and that may fluctuate during the menstrual cycle, is mood. In the studies of visual field asymmetries during the menstrual cycle, several studies did not measure mood (e.g., Chiarello et al., 1989; Heister et al., 1989) while others reported only a global mood score for each session without analyzing the relationship between specific mood states and visual field performance (e.g., Rode et al., 1995). Changes in mood during the cycle are especially relevant to cycle-related changes in perceptual asymmetry in light of evidence that induced negative mood differentially slows LVF response times and increases LVF errors (Banich, Stolar, Heller, & Goldman, 1992; Ladavas, Nicoletti, Umilta, & Rizzolatti, 1984; Liotti & Tucker, 1992).

Since changes in perceptual asymmetry result from artificially induced negative mood (Banich et al., 1992; Ladavas et al., 1984; Liotti & Tucker, 1992), it may be that naturally occurring mood changes during the menstrual cycle underlie some of the documented shifts in perceptual asymmetry during the cycle. For example, Heister et al. (1989) found a LVF advantage on a lateralized face perception task during the menstrual phase of the cycle, but a slight RVF advantage during a premenstrual measurement. The authors interpreted the results as evidence for hormonal effects on perceptual asymmetry and did not investigate the potentially confounding effects of mood. However, since the premenstrual phase is a time of emotional lability for some women (Golub, 1976; Hargrove & Abraham, 1982; Logue & Moos, 1986), the effects on perceptual asymmetry in this study may have resulted from mood changes and not from hormonal state per se.

The purpose of the present study is to investigate the relationships among cycle phase, perceptual asymmetry, and mood. Women completed four visual laterality tasks at the menstrual, follicular, and mid-luteal phases of the menstrual cycle. These phases were chosen because they are characterized by different hormonal states. If cycle-related changes are directly related to hormonal levels, the choice of these phases should maximize the likelihood of cycle-related findings. Testing at the mid-luteal rather than the late luteal (premenstrual) time period is liberal with respect to the hormonal hypothesis and conservative with respect to the mood hypothesis, since mood changes are more likely at the premenstrual phase while the hormonal profile is more distinct at the mid-luteal phase. Subjects made daily observations of basal body temperature (BBT) and cervical mucus secretions (CM) to confirm the timing of the testing sessions relative to the menstrual cycle, and so that data from subjects with positive indications of ovulation could be analyzed as a separate subset. In addition, subjects completed a mood questionnaire at each of the testing sessions so that relationships among mood, cycle phase, and perceptual asymmetry could be assessed directly.

METHOD

Subjects

Subjects were recruited from a university and hospital community. Women were considered eligible for the study if they met the following criteria: 18 to 35 years of age, right-handed, native English speakers, not currently taking oral contraceptives or other prescription medication, no history of neurological or endocrinological disorder, and possessing normal or corrected-to-normal vision.

Thirty-three women participated in the study, and of these, 27 completed all the procedures. Six subjects could not complete the study for various reasons: one for family health reasons, two for personal health reasons, one due to scheduling difficulties, and two for unspecified reasons. Of the 27 subjects completing requirements for the study, three were dropped from analyses because testing sessions did not correspond to intended cycle phases (see below).

Analyses were therefore conducted on data from 24 subjects. These subjects ranged in age from 19 to 34 years ($M = 24.04$, $SD = 4.74$). Laterality quotients on the Edinburgh Handedness Inventory (Oldfield, 1971) ranged from 33 to 100 ($M = 79.04$, $SD = 20.34$), reflecting moderately weak to strong right-handedness. Seven subjects indicated left-handed or ambidextrous first-degree relatives. Subjects were undergraduates ($N = 11$) or had completed some post-graduate study ($N = 13$). Fourteen of the 24 subjects had used oral contraceptives in the past, with the length of time since discontinuation ranging from 2 to 108 months ($M = 35.21$, $SD = 29.84$).

Times of Testing

Subjects each participated in four testing sessions intended to coincide with specific phases of the menstrual cycle. The timing of the menstrual phase session was targeted within 2–5 days following the onset of menstruation. This session was intended to occur during a time when levels of all sex hormones are relatively low. Subjects were tested twice during the follicular phase, when estrogen levels are rising but progesterone levels are relatively low. Target dates for follicular sessions were Day 8 and Day 11 following menstrual onset for subjects anticipating approximately 28-day cycles; these target dates were adjusted for subjects reporting cycles consistently shorter or longer than 28 days. Testing was administered twice during this phase because the desirability of testing several days before ovulation was complicated by the unpredictability of the timing of ovulation. Subsequently, when BBT and CM patterns were obtained from subjects (see below), the follicular testing session that occurred closest to 4 days prior to the estimated date of ovulation was identified and results from only this follicular phase session were submitted for statistical analysis. The fourth session was targeted for the middle of the luteal phase, when both estrogen and progesterone are typically elevated. This session was scheduled to occur within 5 to 8 days following the mid-cycle rise in basal body temperature, or approximately 19 to 22 days after menstrual onset in a standard 28-day cycle. One quarter of the subjects began the study at each of the four times of testing, to avoid confounding between practice effects and effects due to cycle phase.

BBT and CM Observations

Subjects were required to record daily observations of BBT and CM for the duration of their participation in the study. Each subject was given a digital thermometer and instructed to record her temperature immediately upon waking every morning. Additionally, subjects were instructed to monitor changes in CM during the cycle, by marking a daily checklist consisting of words describing the color, consistency, and amount of CM. Observation sheets for both the BBT and CM observations were collected at the end of the study. In addition, BBT observations were reported to the experimenter intermittently throughout the study so that the presence of a midcycle rise in BBT could be detected and utilized in the scheduling of the luteal phase testing session.

Tasks

Choice Reaction Time Tasks

Subjects completed three visual choice reaction time (choice RT) tasks, chosen to meet two criteria. First, one task (lexical decision) was expected to tap left-hemisphere-specialized processing capacities (Chiarello, Senehi, & Soulier, 1986; Chiarello, Nuding, & Pollock, 1988), and another (face decision) was expected to tap right-hemisphere-specialized processing capacities (Hay, 1981; Young, Hay, & McWeeny, 1985). Second, the tasks were chosen because they closely resembled those employed in an earlier study of perceptual asymmetry during the menstrual cycle (Heister et al., 1989), thus giving our results the advantage of direct comparability with at least one previous study. A second face decision task was added because of concerns, borne out by our pilot data, that the face decision task employed by Heister et al. (1989) may not be a strongly right-hemisphere-specialized task (cf. Young et al., 1985).

The choice RT tasks were presented on a computer monitor with a viewing distance of approximately 76 cm. The subject's head was centered in front of the monitor and held stationary by an adjustable chinrest. Each of the choice RT tasks consisted of 96 trials broken into two blocks of 48 trials each, preceded by a practice set consisting of 16 trials. Each trial began with a 2-sec presentation of a central X, which subjects were instructed to fixate. A stimulus was then presented to either the LVF or RVF for 150 msec. Stimuli were centered at 3.0° of visual angle to the left or right of fixation. Subjects were instructed to respond as quickly as possible using two center keys on a computer keyboard. Trial types were presented in a fixed pseudorandom order with the constraint that presentation to a given visual field did not occur more than three trials in succession, and similarly the correct response to the stimulus was not the same more than three times in succession. In the first block of each task, half of the stimuli were presented to each visual field; the second block consisted of the same stimuli as the first half, but presented in reverse order and to the opposite visual field. Four sets of stimuli were constructed for each task, to be used at each of the four testing sessions. The order of the sets was counterbalanced across subjects such that set was not confounded with either practice or cycle phase. The same practice set was used during all testing sessions.

Lexical decision (LX). Subjects indicated whether a laterally flashed four-letter string was an English word or a nonsense word. Letter strings were presented vertically to avoid left-to-right scanning bias. The strings subtended approximately 3.0° of vertical visual angle and 0.4° of horizontal visual angle; letters were typed in bold uppercase Geneva 24 point font. One quarter of the stimuli were high frequency nouns, verbs, and modifiers taken from the Kucera and Francis (1967) word frequency list and one quarter were low frequency words. For each of the four stimulus sets, the word list was paired with a pronounceable nonword list formed by changing one letter of each of the words of another set. Half of the subjects used the left index finger to indicate an English word and the right index finger to indicate a nonsense word; the other half of the subjects used the reverse stimulus–response mapping.

Face decision 1 (F1). Subjects indicated whether a laterally flashed drawing was a normal face or a scrambled face. Stimuli were created using the Mac-A-Mug Pro computer program and were 6.0° × 3.9° of visual angle in size. The same face frame, i.e., hair and chin, was used for each stimulus, but the internal features varied. Half of the stimuli were faces and half were nonfaces, created by switching the position of the eyes and the nose of a normal face. As in the LX task, half of the subjects used the left index finger to indicate a normal face and the right to indicate a nonface, and vice versa for the remaining subjects. For all subjects the stimulus–response mapping was consistent with that used in the LX task, such that, for example, all subjects who used the left finger to indicate words and the right finger to indicate nonwords in the LX task used the left finger to indicate faces and the right finger to indicate nonfaces in the F1 task.

Face decision 2 (F2). This task was identical to F1 except that nonfaces could be of several configurations. The configuration of features from the top to the bottom of the face could be: (1) nose, eyes, mouth (the nonface configuration used in F1); (2) mouth, eyes, nose; (3) eyes, mouth, nose; or (4) mouth, nose, eyes. Examples of face and nonface stimuli are presented in Fig. 1. The four nonface types each comprised 1/8 of the total number of stimuli, with the remaining half of the stimuli being normal faces. For all subjects, the stimulus–response mapping was identical to that used in F1.

Chimeric Faces (CF)

In this task (Levy, Heller, Banich, & Burton, 1983), subjects viewed pairs of chimeric faces in free vision. For each chimera, one half of the face is smiling and the other half bears a neutral expression. Pairs consist of a chimera and its mirror image, such that in one chimera the left half of the face bears the smile, while in the mirror image the right half bears the smile. For each pair, the subject is asked to choose which of the two faces looks happier. The dependent measure is the laterality score $(R - L)/(R + L)$ where R is the number of faces chosen with the smile in right visual space and L is the number chosen with the smile in left visual space. Right-handers typically display negative laterality scores, indicating a bias toward choosing the face with the smile in left visual space (e.g., Levine & Levy, 1986; Levy et al., 1983).

The order of the laterality tasks was counterbalanced across subjects such that half of the

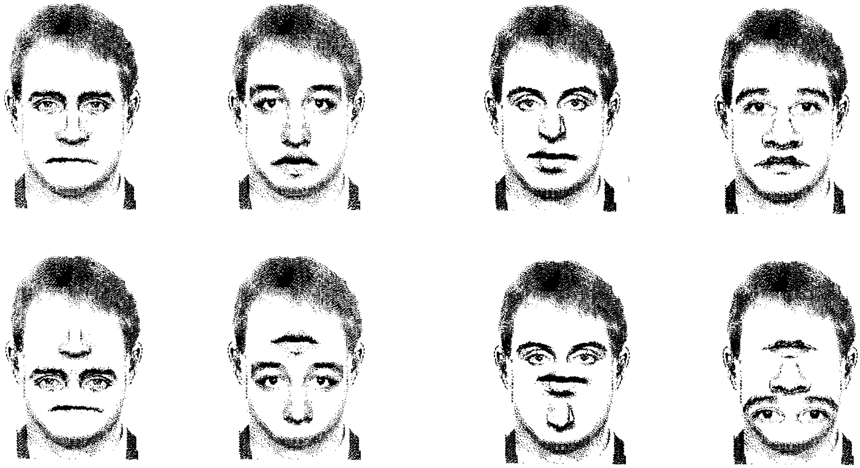

FIG. 1. Examples of face and nonface stimuli used in Face Decision Task 2.

subjects began with the LX task and half began with the face tasks. For the face tasks, half of the subjects completed F1 before F2 and the other half completed F2 before F1. CF was always presented following the other two face tasks. For a given subject, the task order remained the same across all four testing sessions.

Mood Questionnaire

Following a series of cognitive tasks, whose results are not included in this report,[1] subjects completed a computerized version of the Profile of Mood States (POMS) questionnaire (McNair, Lorr, & Droppleman, 1971). At each session, the subject used a five-point scale ranging from ''Not At All'' to ''Extremely'' to rate the degree to which each of 72 adjectives described her current mood. Scores on Anxiety, Depression, Anger, Vigor, Fatigue, Confusion, Friendliness, and Elation scales were tabulated from these responses. The POMS has been positively critiqued and widely used to measure transient mood states, with a high internal consistency of scale scores and test–retest reliability that is appropriate for a measure intended to tap mood changes (Peterson & Headen, 1984).

RESULTS

Cycle Characteristics

Mean cycle length was 28.89 days, with a range of 20–37 days. Three subjects (12.5%) did not return BBT records. For those subjects who did return records ($N = 21$), temperatures were graphed according to the smoothed curve method (McCarthy & Rockette, 1983). When

[1] Subjects completed a mental rotation task, two tasks of verbal fluency, and an anagram task after the laterality tasks and before the mood questionnaire. Completion of these tasks took approximately 15 min. Due to methodological difficulties equating alternative forms of the tasks given to the subjects, those results are excluded from the present report.

TABLE 1
Error Rates in Percentages for Three Cycle Phases on Lexical Decision (LX), Face Decision 1 (F1), and Face Decision (F2) Tasks

	Phase		
Task	Menstrual	Follicular	Luteal
LX	6.4	9.1	6.3
F1	2.8	3.7	3.2
F2	3.1	4.4	4.1

BBT data were graphed in this fashion, 16 of 21 subjects (76%) had clearly biphasic graphs, indicating an ovulatory cycle during the cycles(s) in which testing was administered. Though this percentage is substantially lower than the 97% of biphasic graphs in McCarthy and Rockette's (1983) sample, the discrepancy may be due in part to the relatively small sample size ($N = 21$ vs $N = 8496$ in McCarthy & Rockette, 1983). Each of the five subjects with a monophasic graph in this study was either 19 or 20 years old, consistent with evidence that monophasic cycles are more common in younger subjects (Vollman, 1977). Of those five subjects with monophasic cycles, three showed evidence of Spinnbarkeit or estrogenized cervical mucus.

Choice RT Tasks

Error Rates

Overall error rates were relatively low, averaging 7.3, 3.3, and 3.9% for the LX, F1, and F2 tasks, respectively. A repeated measures ANOVA with Task (LX vs F1 vs F2) and Phase (menstrual vs follicular vs luteal) as within-subjects factors revealed a main effect of Task ($F(2, 46) = 11.44$, $p < .002$)[2] as well as a main effect of Phase ($F(2, 46) = 9.28$, $p < .0005$). Means are presented in Table 1. Post-hoc means comparisons (Tukey's HSD) indicated that error rates were higher for the LX task than for either the F1 or the F2 task (p's $< .01$) and that error rates were higher during the follicular phase than during either of the other two phases (p's $< .05$). The interaction between Task and Phase was not significant ($p > .10$). Analysis of data from only the 16 subjects with clearly biphasic cycles revealed the same results.

Reaction Times

For each of the three choice RT tasks (LX, F1, and F2), median reaction times (RTs) of correct responses were subjected to three repeated measures analyses after logarithmic transformation to normalize values. The first ANOVA for each task was conducted on data from all subjects, and within-subjects factors were Phase, VF (LVF vs RVF), and Stimulus Type (high frequency words vs low frequency words vs nonwords for the LX task; faces vs nonfaces for F1 and F2). Second, for each task this ANOVA was repeated on only the subset of data from the 16 subjects with clearly ovulatory cycles as indicated by biphasic BBT graphs. Finally, for each task the data from all subjects were analyzed for practice effects, with Session (first vs

[2] In this and all subsequent analyses, the reported p values for effects involving repeated measures are corrected by the Greenhouse–Geiser method.

second vs third), VF, and Stimulus Type as within-subjects factors. Though all analyses were conducted on log transformed values, for ease of interpretation where means are reported they are means of the median untransformed reaction times.

Lexical decision. Results of the first analysis revealed a highly significant main effect of Stimulus Type ($F(1, 23) = 87.21$, $p < .0001$). Mean RTs were 643 msec for high frequency words, 653 msec for low frequency words, and 735 msec for nonwords. Means comparisons (Tukey's HSD) indicated that responses to nonwords were significantly slower than responses to either low or high frequency words (p's $< .01$), but the difference between low and high frequency words was not significant. Although RTs were on average slightly faster to stimuli presented in the RVF than the LVF (688 vs 694 msec), the difference was not significant ($p > .20$). No other main effects or interactions were statistically significant. When the analysis was repeated using only the subset of data from ovulatory subjects, the same effects were significant.

Analysis for practice effects revealed a main effect of Session, indicating that overall RTs decreased with practice ($F(2, 46) = 3.73$, $p < .05$). Session did not significantly interact with VF or Stimulus Type.

Face decision 1. The only statistically significant effect in the first analysis was a main effect of Stimulus Type ($F(1, 23) = 6.16$, $p < .03$), with faster RTs to nonfaces ($M = 538$ msec) than to faces ($M = 565$ msec). Although RTs were slightly faster in response to LVF trials ($M = 549$ msec) than to RVF trials ($M = 554$ msec) the main effect of VF was not significant ($p > .20$). No other main effects or interactions were statistically significant. Analysis of data from ovulatory subjects yielded the same significant effects.

The ANOVA investigating practice effects demonstrated a significant main effect of Session ($F(2, 46) = 3.39$, $p < .05$) with overall RTs decreasing over sessions. Session did not significantly interact with VF or Stimulus.

Face decision 2. As with F1, RTs were somewhat faster with LVF presentation ($M = 571$ msec) than with RVF presentation ($M = 577$ msec), but the effect was not significant ($p > .10$). There were no other significant main effects or interactions. Analysis of the data from the subset of subjects with ovulatory cycles revealed the same findings.

Analysis of practice effects revealed a main effect of Session ($F(2, 46) = 9.16$, $p < .002$), demonstrating that as with the LX and F1 tasks, overall RTs became faster with practice. There were no significant interactions of Session with Stimulus Type or VF.

Comparison of LX, F1, and F2. An analysis of log median RTs with Task, Phase, VF, and Response Type [yes (word or face) vs no (nonword or nonface)] as within-subjects factors revealed a significant effect of Task ($F(2, 46) = 80.48$, $p < .0001$); mean RTs for the three tasks were 691 for LX, 552 for F1, and 574 for F2. Post-hoc comparison of means using Tukey's HSD test indicated that responses were significantly slower on the LX task than on either F1 or F2 (p's $< .01$); however, the difference between F1 and F2 was not statistically significant ($p > .05$). The significant Task × Response Type interaction ($F(2, 46) = 76.94$, $p < .0001$) reflects the fact, already indicated in the above analyses, that for the LX task, ''yes'' responses (words) were faster than ''no'' responses (nonwords), whereas for the F1 task, ''no'' responses (nonfaces) were faster than ''yes'' responses (faces). This interaction replicates that found by Heister et al. (1989) using similar tasks. There were no significant interactions of Task with Phase or VF.

Chimeric Faces

The mean laterality score overall was $-.506$ ($SD = .497$), differing significantly from 0, the expected score if there were no asymmetry effect on the task ($t = -8.65$; $p < .0001$). This result indicates an overall bias toward left visual space when judging the happiness of the faces, suggesting differential right hemisphere involvement in making these judgments. Two subjects had positive laterality scores for all three of the sessions analyzed, indicating right visual space bias in these subjects. These two subjects were also the least strongly right-handed in the sample (Edinburgh laterality quotients 33 and 40). Repeated measures ANOVA of laterality scores with Phase as a within-subjects factor revealed no significant main effect of Phase in either the entire subject group or the subset of subjects with biphasic temperature curves. Furthermore, there was no effect of Session on laterality scores, indicating a lack of any practice effect.

Stability of Laterality Scores

To investigate within-individual stability of laterality scores across phases, intercorrelations were computed among the menstrual, follicular, and luteal phase scores for each of the four laterality tasks. For the LX, F1, and F2 tasks, visual field difference scores (RVF RT − LVF RT) served as the dependent measure. Correlations were nonsignificant among the three phases for the F1 and F2 tasks, indicating that subjects' asymmetry scores on these tasks were not stable across the repeated testings occurring at different phases. For the LX task, the only significant correlation was between the visual field difference scores in the menstrual and follicular phases ($r = .43$, $p < .05$). In contrast, subjects' laterality scores on the CF task were highly correlated across the three phases (r's .73–.83, p's $< .0001$), indicating that these scores were stable for individual subjects.

POMS

Scores on each scale (Anxiety, Anger, Depression, Vigor, Fatigue, Confusion, Friendliness, and Elation) were individually submitted to a repeated measures ANOVA with Phase as a within-subjects factor. There were no statistically significant effects of Phase on any of the scale scores. A composite Dysphoria score was constructed from scores on the Anxiety, Anger, and Depression scales, by normalizing each set of scores through log transformation, converting them to z-scores, and summing the z-scores across the three scales. This composite score was analyzed as a further check for premenstrual dysphoria, which is often characterized as a cluster of anxious, irritable, and depressive symptoms (Moos & Leiderman, 1978; Richardson, 1992). The effect of Phase on the composite Dysphoria scale was not significant ($p >$ .50). Separate analysis of scores from subjects with biphasic BBT graphs revealed no significant effects on any of the POMS measures.

Relationship of Mood and Laterality Tasks

The results presented above indicate that neither perceptual asymmetry nor mood varied systematically across the cycle in the subject group as a whole or in the subset of subjects with clearly biphasic cycles. However, the possibility remains that noncyclic changes in mood are associated with changes in perceptual asymmetry. To address this possibility, the three sessions for each subject were ranked as Most Dysphoric, Intermediately Dysphoric, and Least Dysphoric on the basis of the composite dysphoria score. Three subjects with tied dysphoria scores for two of the sessions were eliminated from this analysis, leaving 21 subjects. Amount of dysphoria was approximately evenly balanced across session number, such that effects associated with dysphoria were not confounded with practice. Mean dysphoria scores are presented in Table 2.

Once sessions were ordered according to amount of dysphoria, the relationship between dysphoria and visual field asymmetry was examined. For the choice RT tasks, ANOVAs were conducted on median RTs with Dysphoria (Most vs Intermediate vs Least) and VF as within-subjects factors. For the free vision CF task, a one-way ANOVA on laterality scores with Dysphoria as the within-subjects factor was conducted. The analyses revealed a significant effect involving Dysphoria for the F2 task, but not for the other tasks.

For the F2 task, the interaction between Dysphoria and VF was significant ($F(2, 40) = 8.51$, $p < .001$). This interaction is illustrated in Fig. 2. Simple effects analysis of the interaction indicated that in the Most Dysphoric session, RVF responses were significantly faster

TABLE 2
Composite Dysphoria Scores for Most, Intermediate, and Least Dysphoric Sessions

	Mean dysphoria	SEM
Most dysphoric	2.517	.671
Intermediate dysphoric	−.113	.312
Least dysphoric	−1.695	.267

Note. Dysphoria scores are a sum of *z* scores for Anxiety, Depression, and Anger subscales from the Profile of Mood States Questionnaire.

than LVF responses ($F(1, 40) = 5.19$; $p < .05$). However, in the sessions with Intermediate and Least amounts of dysphoria, LVF responses were significantly faster than RVF responses (F's$(1, 40) = 7.63$ and 7.75; p's $< .01$). Although both LVF and RVF responses changed with amount of dysphoria, simple effects analyses indicated that the difference reached statistical significance only for the RVF ($F(2, 40) = 7.16$; $p < .01$; for LVF, $F(2, 40) = 2.24$; $p > .10$).

Analyses of data from individual subjects, including only the 19 subjects who had no ties between sessions in either VF difference scores or dysphoria scores, revealed that for 11 of 19 subjects, the Most Dysphoric session was also the session with the most negative RVF −

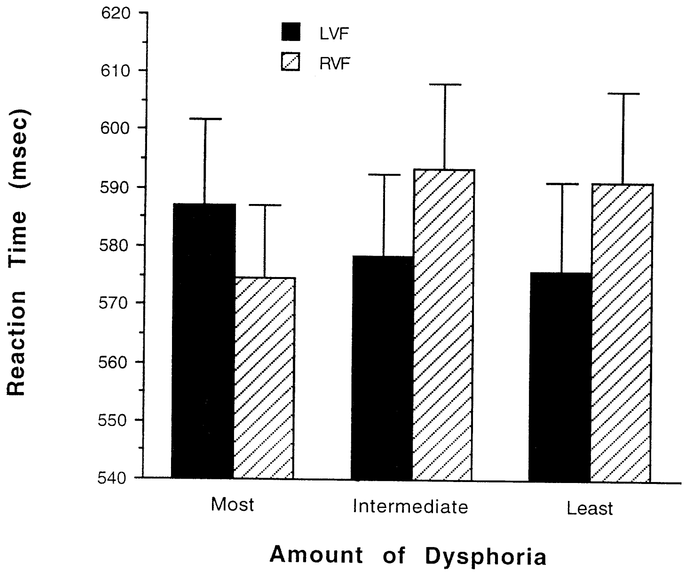

FIG. 2. Reaction time on Face Decision Task 2 to left visual field (LVF) and right visual field (RVF) stimuli at three sessions differing in amount of dysphoria. Within-subjects Dysphoria × VF interaction, $F(2, 40) = 8.51$, $p < .001$. The effect of VF is significant at each amount of Dysphoria (p's $< .05$).

LVF difference score or worst relative LVF performance ($\chi^2(4, N = 19) = 8.62, p = .07$).[3] Subjects whose Most Dysphoric session coincided with their lowest LVF advantage (Coincident Group) were significantly less strongly right-handed (Edinburgh scores, $M = 65.18$ vs 89.00; $t = 2.93, p < .01$) than those subjects whose Most Dysphoric session and lowest LVF advantage did not coincide (Discrepant Group). The average facebook laterality scores, visual field difference scores on LX, F1, and F2, or amount of mood change did not differ significantly between the Coincident and Discrepant groups.

To investigate whether the relationship between Dysphoria and VF advantage depends on the cycle phase in which the greatest dysphoria occurs, each subject was placed into one of three groups, based on the cycle phase in which she displayed her greatest dysphoria. Eight subjects were most dysphoric during the menstrual phase testing session (MD group), seven during the follicular phase session (FD group), and eight during the luteal phase session (LD group). One subject whose highest dysphoria score was tied between the menstrual and follicular phases was placed in the FD group to equate numbers of subjects in the three groups.[4] Session order was evenly balanced across the three groups, such that differences between the groups could not be attributed to differences in amount of practice at the various phases.

For the F2 task, an ANOVA was conducted on log median RTs with Phase, Stimulus, and VF as within-subjects factors and Group (MD vs FD vs LD) as a between-subjects factor. The analysis of the F2 data revealed a significant 3-way interaction among Phase, VF, and Group ($F(4, 42) = 6.45, p < .0005$). Means for each group are presented in Table 3. Analysis of each of the three groups separately indicated marginally significant Phase $\times$ VF interactions for each group (MD group: $F(2, 14) = 4.90$; FD group: $F(2, 14) = 5.83$; LD group: $F(2, 14) = 6.00$; $.10 > p$'s $> .05$, simultaneous test procedure; Kirk, 1982). As seen in Table 3, for each group the lowest RVF $-$ LVF difference, indicating slowest relative LVF responses, occurred at the cycle phase with the greatest degree of dysphoria. That is, the RVF $-$ LVF difference score is lowest in the menstrual phase for the MD group, in the follicular phase for the FD group, and in the luteal phase for the LD group.

DISCUSSION

The purpose of this study was to investigate the interrelationships among menstrual cycle phase, mood, and perceptual asymmetry. Two major findings were revealed in analyses of the data. First, there was no overall effect of menstrual cycle phase on any of the perceptual asymmetry scores examined, either in the entire subject group or in a subset of subjects with clear evidence of ovulatory cycles. Thus, results of this study do not support the hypothesis that hormones have activational effects on hemispheric functioning as indexed through perceptual asymmetry tasks. Furthermore, mood in this study varied independently of cycle phase, allowing for an independent assessment of the effects of mood on perceptual asymmetry. The results indicated that dysphoric mood was associated with a reversal of the expected

[3] Three subjects had ties in dysphoria scores among two or more of the sessions, and two subjects had ties in VF difference scores among two or more of the sessions. Of these five subjects, two were consistent and two were inconsistent with the pattern of association between most dysphoria and worst relative LVF performance. The fifth subject could not be classified as either consistent or inconsistent with the pattern because she had exactly the same VF difference score for all three sessions.

[4] Neither omission of this subject from the analysis nor inclusion of her scores in the MD group changed the pattern of results obtained in the analyses.

TABLE 3
Means of Median Reaction Times (ms) on Face Decision Task 2 by Dysphoria Group, Cycle Phase, and Visual Field

		Visual field		
Group[a]	Phase	LVF	RVF	RVF-LVF
MD	M	592	572	−20
	F	580	576	−4
	L	576	601	25
FD	M	591	607	16
	F	590	585	−5
	L	576	610	34
LD	M	550	552	2
	F	534	552	18
	L	550	541	−9

Note. LVF, left visual field; RVF, right visual field; M, menstrual; F, follicular; L, luteal; MD, menstrual dysphoria; FD, follicular dysphoria; LD, luteal dysphoria. Actual values are presented for convenience, though analyses were conducted on log-transformed values. Group × Phase × Visual Field interaction, $F(4, 42) = 6.45$, $p < .0005$.

[a] $N = 8$ for each group.

LVF advantage on a face perception task. These results are consistent with previous studies finding that induced negative mood results in a shift in perceptual asymmetry in favor of the RVF (Banich et al., 1992; Ladavas et al., 1984; Liotti & Tucker, 1992).

Though none of the perceptual asymmetry or mood scores varied consistently across the cycle, error rates on the three lateralized choice RT tasks were affected by cycle phase. For each of these tasks, error rates were slightly but significantly higher in the follicular phase than in either of the other two phases. The differences among phases were small in magnitude, ranging from approximately one to three percentage points. One possible explanation for this effect is a speed–accuracy trade-off, in which subjects respond more quickly and less accurately during the follicular phase. Such a result would be consistent with hypotheses that estrogen has an overall excitatory effect on the central nervous system (e.g., Backstrom, Bixo, & Hammarback, 1985; Broverman, Vogel, Klaiber, Majcher, Shea, & Paul, 1981). However, results of reaction time data provide no evidence of speeded responses during the follicular phase.

Our failure to find significant main effects of visual field on the choice RT tasks was surprising, given previous findings (e.g., Chiarello et al., 1986; Hay, 1981). It is unclear why we did not find a significant RVF advantage for the lexical task and significant LVF advantages for the face tasks. However, this failure to find significant visual field effects does not preclude examining changes in asymmetry scores in association with cycle phase or mood. Results from earlier studies suggest that significant overall asymmetries on a task are neither necessary nor sufficient to produce significant patterns of change in asymmetry across the cycle. For example, the lexical decision task used by Heister et al. (1989) showed an overall asymmetry, but this asymmetry did not vary over the cycle; in contrast, the face task used in the same study did not yield an overall asymmetry but did show changes in asymmetry during the cycle. Thus, the fact that there is not an overall significant visual field difference does not imply that variations around that mean are random or meaningless (see also Kim, Levine, & Kertesz, 1990).

The most important finding of this study is an association between negative mood and relative hemispheric performance, independent of cycle phase. When sessions were ordered according to the amount of dysphoria, the session with the most negative mood was associated with a reversal of the visual field advantage on a face perception task. On Face Decision Task 2, subjects displayed a RVF advantage when mood was most dysphoric and a LVF advantage when mood was intermediate or least dysphoric.

The association between negative mood and relative hemispheric performance does not necessarily imply that negative mood causes the change in perceptual asymmetry. Alternatively, one might argue that a change in visual field advantage causes subjects to feel more dysphoric. Results from this study cannot differentiate between these possibilities. However, previous studies demonstrate that experimental induction of negative mood differentially impairs LVF performance (Banich et al., 1992; Ladavas et al., 1984; Liotti & Tucker, 1992), arguing for a causal impact of mood on asymmetry scores. Mood in the present study was not experimentally manipulated, and thus the causes for variation in mood within an individual are not only unknown but probably multidimensional.

The current results extend those of the mood induction studies (Banich et al., 1992; Ladavas et al., 1984; Liotti & Tucker, 1992) by indicating that spontaneous as well as experimentally induced mood variations within an individual are associated with changes in visual field advantage. However, these results were evident only on the reaction time tasks involving face processing, not on the task measuring verbal processing. The discrepancy between the verbal and face task results may be viewed as consistent with hypotheses that dysphoric mood selectively affects performance by the right hemisphere (Heller, 1990; Tucker, 1988). Performance on the verbal task is likely to depend more on left hemisphere processes, and thus may be less susceptible to the effects of negative affect. Nevertheless, although Face Decision 2 performance in both the LVF and RVF changed with mood state, only the RVF changes were statistically significant. Thus our results are consistent with earlier studies in showing a shift in favor of the RVF with dysphoric mood, but the results are inconsistent with earlier studies in the degree to which the shift can be attributed to LVF versus RVF performance. Our results suggest that the shift involves changes in both right and left hemisphere processing, and greater shifts in left hemisphere processing, whereas earlier results suggested a more specific change involving the right hemisphere. Factors that may be responsible for the discrepant findings include task differences across studies and differences between spontaneous versus induced mood states. Further research is needed to clarify the nature of changes in left and right hemisphere performance as a function of mood state.

Performance on the free-vision chimeric faces task did not vary with changes in mood. Although clinically depressed patients display a reduced left visual space bias on this task in comparison with controls (Jaeger, Borod, & Peselow, 1987), studies of normal subjects have failed to find effects of mood variation on perceptual biases on similar chimeric face tasks (David, 1989; Harris & Snyder, 1992). Since the CF task has been shown to measure stable individual differences in characteristic perceptual biases (Levy et al., 1983), it may be relatively immune to effects of normal variations in mood.

In addition to the implications regarding hemispheric asymmetries and negative affect, results of this study have implications for future studies of perceptual asymmetry during the menstrual cycle. The present study found no evidence that perceptual asymmetry varies with the cycle, but rather found that asymmetry varies with mood changes. Future studies need to carefully separate mood and cycle phase. If the majority of subjects in our sample had been most dysphoric during the luteal phase, for example, we might have found an overall phase by visual field interaction, with a reversed visual field advantage in the luteal phase. Without an analysis of mood variables, this hypothetical result could be attributed to hormonal status when it should be attributed to mood. Thus, it seems important to include measurements of mood state in future studies of menstrual cycle-related changes in perceptual asymmetry.

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