AN INVESTIGATION OF THE INFLUENCE OF GENDER AND MENSTRUAL CYCLE PHASE ON METACOGNITIVE JUDGMENTS OF EFFICACY

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ABSTRACT

Verbal memory, verbal working memory, processing speed and visual attention have been reported to be enhanced in the luteal phase of the menstrual cycle, as compared with the menstrual phase. However, many women report diminished cognitive abilities in the luteal phase, as compared with other phases of the menstrual cycle. This study attempted to examine the nature of the apparent discrepancy between cognitive functioning and self reported cognitive efficacy. Participants completed a battery of neuropsychological measures in each phase of the menstrual cycle and were asked to rate their perceived efficacy, both before and after performing each task. Male participants were included as a control group. Accuracy of perceived efficacy was calculated as the difference between efficacy ratings and actual performance. Results failed to replicate findings of cognitive facilitation in the luteal phase, and failed to find reliable differences in pre or postdiction accuracy between phase or sex.

DEDICATION

For Sarah, who has been a bright shining buoy on stormy seas. And for Will, who teaches me the meaning of wonder each and every day.

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INTRODUCTION

The rate at which cholesterol is synthesized into progesterone and estrogen and consequently the plasma concentration level of these bioavailable gonadal steroids is controlled through the action of the adenohypophyseal hormones follicle stimulating hormone (FSH) and luteinizing hormone (LH) (Spence and Mason, 1992). Cyclic fluctuations in the plasma level of these hormones contribute to the expression of the menstrual cycle. Although this cycle is regular and predictable for many women, the timing of these hormonal fluctuations can vary somewhat idiosyncratically across individuals in the preliminary stages. Typically, between the fifth and tenth day of the cycle, during the follicular phase, FSH levels rise and stimulate follicle development. The maturing follicle secretes estrogen. Increased estrogen production stimulates the initial thickening of the endometrial lining. Shortly thereafter, plasma levels of LH rise and work together with FSH to form the corpus luteum and induce ovulation (Spence and Mason, 1992). Ovulation typically occurs on day fourteen of the cycle, and is almost invariably fourteen days from the end of the cycle, and the beginning of the next. The formed corpus luteum produces high levels of estrogen and progesterone. Progesterone acts on the estrogen primed endometrium to further stimulate its development. This state of relatively high levels of progesterone and estrogen is referred to as the luteal phase (Spence and Mason, 1992). Plasma levels of estrogen and progesterone are highest between five and ten days prior to the end of the cycle, and precipitously drop off at the end of the cycle. As the influence of these hormones decreases, prostaglandins are released into the endometrium, causing blood vessels to constrict, thus reducing the blood supply to the endometrial lining and causing it to degenerate. The prostaglandins further

stimulate contractions of the uterine wall, which expel the degenerated endometrium. This is referred to as the menstrual phase. In the menstrual phase, which typically lasts between 3 and 5 days estrogen and progesterone levels are at their lowest point. Thus, the human female menstrual cycle is marked by fluctuations in estrogen and progesterone which are maximally available during the luteal phase of the menstrual cycle, and relatively minimized in the menstrual phase. The focus of this paper is on the metacognitive and neuropsychological effects of cyclic fluctuations in these gonadal steroids.

Human females often report a variety of cognitive, mood and behavioural changes in the luteal phase of the menstrual cycle, when these hormones are at their apex (Rapkin, 1999). Among the most common symptoms endorsed are depression, anxiety, irritability, emotional lability, and cognitive difficulties which may be severe enough to interfere with women's social and work abilities (Pires & Calil, 2000). The experience of some degree of premenstrual symptomatology is a prevalent and common phenomenon (Choi & McKeown, 1997). It has been estimated that 75% to 90% of women experience premenstrual symptoms as part of their regular experience of the luteal phase of the menstrual cycle (Marvan & Cortes-Iniestra, 2001; American Psychiatric Association, 1994) and that between 20 and 50% of women suffer from a variably defined "premenstrual syndrome" (American Psychiatric Association, 1994), which includes the subjective experience of symptoms such as impaired concentration, poor judgment, and the inability to think clearly during the luteal phase of the menstrual cycle (Morgan & Rapkin, 2002).

The cause of subjective reports of premenstrual cognitive symptoms has been called into question by findings which suggest that estrogen actually enhances certain cognitive processes and that progesterone has anxiolytic and neuroprotective properties (Hertzog, 1991; Rapkin, 1999; Stein, Roof, & Fulop, 1999; Wise et al., 2001; Wooley & McEwen, 1993; Warren, et al., 1995).

Indeed, animal models have shown that, in addition to their role in the reproductive system, estrogen and progesterone effect a wide array of autonomic and central nervous system functions (Stein, Roof, & Fulop, 1999; Wise et al., 2001; Wooley & McEwen, 1993; Warren, et al., 1995). Several investigators have further suggested that estradiol has neurotrophic and neuroprotective properties (Stein, Roof, & Fulop, 1999; Wise et al., 2001). Studies of rodents have illustrated that estrogen facilitates the growth of synapses and dendrites (Wooley, McEwen, 1993), and has been shown to aid in long term potentiation in the CA1 region of the rat hippocampus (Warren, et al., 1995; Cordoba Montoya and Carrer, 1997). Estrogens have also been shown to aid in neurogenesis in the dentate gyrus (Tanapat et al., 1999). In a study on female rats, Morse, Scheff and DeKosky, (1986) found that the 25% decrease in cortico-hippocampal connections caused by experimental lesion and ovariectomy was reversed through the administration of estradiol, which restored the cortico-hippocampal connections back to levels found in intact animals. Animal models have also illustrated that sex steroids change the electro-chemical properties of neurons (McEwen, 1988) and that estrogen has activational properties and enhances cholinergic function (Gibbs, 1998) due to its influence on the production of acetylcholine transferase (Luine, Khylchevskaya and McEwen, 1975). Several studies have observed deficits in spatial performance with acute increases in

al, 1995; Warren and Juraska, 1997). It has further been shown that gonadal steroid replacement is beneficial to aged ovariectomized rats in spatial reference memory, as measured by their ability to perform in the morris water maze (Markham, Pych and Juraska, 2002). The neurocognitive effects of gonadal steroids have also been illustrated in non-human primates. Visual attention has been shown to be relatively impaired after ovariectomy in cynomolgus monkeys (Voytko and Hinshaw, 1996). Further, postmenopausal rhesus monkeys have been shown to perform worse than age matched premenopausal rhesus monkeys on a delayed response task (Roberts et al., 1997). In aged and ovariectomized rhesus monkeys, Rapp, Morrison and Roberts, (2003) observed what they refer to as a "substantial" reversal of the ovariectomy related impairment in delayed spatial memory after administering a low dose regimen of cyclic estrogen. Lacreuse, Verreault and Herndon (2001) were the first researchers to show that spatial recognition memory, as measured by the spatial-Delayed Recognition Span Test is influenced by estradiol variations in regularly cycling rhesus monkeys, such that performance was worse in periods of high estradiol.

In human females, the neurocognitive effects of estrogen and progesterone have been noted to vary as a function of menstrual cycle phase. Although the literature is not unanimous on this issue, research findings generally suggest that the hormonal environment plays a significant role in the cognitive functioning of women (Sherwin, 1998). As evidenced by Table 1, estrogen and progesterone have been shown to be beneficial to most cognitive functions in humans, whilst being detrimental to a small subset of skills.

In light of the fact that many cognitive functions are improved in the high estrogen luteal phase, the common subjective complaints of impaired concentration, forgetfulness and mental slowness in this phase are counterintuitive. When these subjective reports have been evaluated in the context of objective data, several researchers have found no difference between individuals reporting high levels of premenstrual symptoms and controls on tests of working memory, information processing speed, sustained attention, cognitive flexibility, verbal or visual memory (Golub, 1976; Morgan et al. 1996; Keenan, Janowsky & Pederson, 1992, Resnick, Perry, Parry, Mostofi & Udell, 1998, Man et al., 1999, Morgan & Rapkin, 2002).

Given the lack of empirical data supporting premenstrual decreases in cognitive functioning, some have suggested that premenstrual complaints of cognitive difficulties are the result of socially or culturally mediated beliefs about cognitive functioning in the luteal phase (Morgan & Rapkin, 2002; Choi & McKeown, 1997). Although these altered perceptions of self efficacy (Hertzog, Dixon & Hultsch, 1990; Bandura, 1989; Berry et. al., 1989) are quite likely influenced by sociocultural factors, the findings that many cognitive functions are actually improved and not impaired in the luteal phase implies that females in the luteal phase may not be able to accurately monitor their cognitive ability, thus producing a disparity between perceived and actual functioning. Indeed, the high levels of ovarian hormones which occur in the luteal phase may lead to diminished capacity to monitor one's cognitive ability. (Fernandez-Duque, Baird & Posner, 2000; Shimamura, 2000; Hertzog, Dixon & Hultsch, 1990).

Metacognition is a term that has been used to refer to a number of processes through which we are capable of regulating and commenting on our own cognitive abilities

(Fernandez-Duque, Baird and Posner, 2000). Broadly, metacognition can be divided into two domains: a) metacognitive knowledge, and b) metacognitive monitoring. Although dissociable, these processes are not thought to be independent of each other, but are hypothesized to be interdependent on one another. Research has illustrated that several subcomponent processes make up metacognitive knowledge. One such process is defined as self efficacy.

Cognitive self efficacy refers to one's beliefs about one's ability to perform a given cognitive task. This factor is conceptualized to be further broken down into global and specific beliefs (i.e. a global belief that memory declines with age, a specific belief that the individual is more or less capable than their peers on a given task) (Hertzog, Dixon and Hultsch, 1990). Cognitive self efficacy is also influenced by affective factors, knowledge about past performance levels on similar tasks, as well as the nature of attributions made about past performance (i.e. internal or external locus of control) (Hertzog, Dixon and Hultsch, 1990).

It has been suggested that memory self efficacy, when assessed through self report of memory functioning is highly correlated with predictions of performance (Hertzog, Saylor, Fleece & Dixon, 1994). The correlations between self reported efficacy in general, and predictions of task performance in specific suggest that predictions of performance on specific tasks are rooted to a large degree in global beliefs about efficacy within a given cognitive domain (Berry et. al., 1989).

Metacognitive monitoring is typically conceptualized as a process wherein task performance is monitored through various feedback loops between medial frontal regions and limbic structures. These feedback loops perform tasks such as source monitoring,

error detection and the registration of emotional reactions to the difficulty of the task (Fernandez-Duque, Baird & Posner, 2000; Shimamura, 2000; Damasio, 1994; Casey, Trainor, Orendi, et. Al., 1997; Raichle et al., 1994; Carter et al., 1998; Bush, Luu, & Posner, 2000; Badgaiyan & Posner, 1998). The ability to monitor performance and detect errors plays an integral role in the maintenance of task specific metacognitive knowledge and self efficacy. (Fernandez – Duque, Baird, Posner, 2000).

The discrepancy between the subjective report of cognitive difficulty and actual cognitive functioning in the luteal phase may be due to attenuation of this ability to accurately monitor these metacognitive cues and use them to update perceptions of cognitive ability. Individuals have been shown to use feelings of "doing well" (i.e. positive affect/ few errors detected) or "doing poorly" (i.e. negative affect/ many errors detected) to increase the accuracy of performance estimates from pre to post test (Hertzog, Dixon & Hultsch, 1990). Devolder et al. (1990) suggested that differences between the accuracy of predictions of performance and estimates of performance after completing a task (postdictions) provide a measure of the ability to accurately monitor performance. This assertion derives from the well known and robust "postdiction superiority effect" (Pierce & Smith, 2001). The postdiction superiority effect refers to the tendency of postdictions to be better calibrated to actual performance than predictions (Pressley, Levin, & Ghatala, 1984; Maki, Foley, Kajer, Thompson & Willert, 1990; Perfect & Hollins, 1996). This effect has been demonstrated to be driven not by increased familiarity with test characteristics or test knowledge (Maki, 1998), but is the product of online monitoring during task performance and the retrieval of error detection and affective cues acquired during testing (Pierce & Smith, 2001; Devolder, Brigham &

Pressley, 1990; Connor, Dunlosky & Hertzog, 1997; Druckman & Bjork, 1994; Koriat, 1993; Winkielman, Schwarz & Belli, 1998).

If metacognitive monitoring is one of the skills which are sensitive to the effects of sex specific hormones, this may explain the discrepancy between the perceptions of cognitive ability and actual cognitive functioning in the luteal phase of the menstrual cycle. It has been suggested that where sex differences exist in cognitive abilities, these differences are exaggerated in times when a given sex specific hormone is optimally available (Kimura, 2002). For example; when performing a targeting task (which typically favours males), females in the luteal phase will perform worse than males and females in the follicular phase, due to the detrimental effects of female specific hormones on a male favouring task (Kimura, 2002). If metacognitive monitoring is such a sex specific ability, and the dissociation between perceived and actual cognitive ability reported in the literature is due to the influence of ovarian hormones on metacognitive monitoring, then this dissociation should be greatest for females in the luteal phase, and lessened for females in the menstrual phase and males. No study to date has examined the influence of sex and menstrual cycle phase on the accuracy of metacognitive ratings. To systematically investigate this issue, the current study was designed to examine metacognitive monitoring while replicating prior findings of sex and menstrual cycle related effects on cognitive functioning and symptom reporting.

Metacognitive Monitoring

It was hypothesized that the "postdiction superiority effect" would be robust for males and females in the menstrual phase, but attenuated for females the luteal phase. Males and females in the menstrual phase were hypothesized to improve the accuracy of their

ratings of cognitive ability after completing the cognitive tasks (postdiction superiority), whereas the accuracy of ratings for females in the luteal phase was hypothesized not to benefit from experience with the task.

Cognitive Performance

It was also hypothesized that females in the luteal phase would perform better than males and females in the menstrual phase on measures of verbal memory, verbal working memory, psychomotor speed, and visual attention. This finding would replicate previous findings that have shown menstrual cycle related changes in these cognitive abilities (see Table 1).

Self Report of Symptoms and Ratings of Cognitive Ability

Finally, it was hypothesized that females would endorse more symptoms than males (Eiser, Havermans &Eiser, 1995) and that females in the luteal phase would endorse more symptoms than in the menstrual phase. This finding would replicate previous findings that have suggested that endorsement of affective, somatic and cognitive complaints in the luteal phase of the menstrual cycle is a common and prevalent phenomenon (Choi & McKeown, 1997; Morgan & Rapkin, 2002; Marvan & Cortes-Iniestra, 2001; American Psychiatric Association, 1994). Further, it was hypothesized that females in general would rate their cognitive ability as lower than males. This finding would replicate previous work that has suggested that females have a negative bias when reporting on their own cognitive abilities (Reilly & Mulhern, 1995; Furnham, 2002; Beyer, 1998).

METHODS

Participants

Eighty-three volunteers (32 males and 51 females) were recruited from the subject pool at Simon Fraser University, and received course credit for participation in two testing sessions. For female participants, the timing of test sessions occurred once during the low estrogen, low progesterone menstrual phase (0 to 5 days following the onset of menstruation), and once during the high estrogen, high progesterone midluteal phase (10 to 5 days prior to predicted menstruation; Saucier and Kimura, 1998).

All potential participants completed a Health Screening Questionnaire. One male participant was excluded because he reported that he had a learning disability and a history of head injury. Potential female participants also completed a Menstrual Cycle Questionnaire, which was developed in our lab (Appendix 1) in order to characterise the regularity and predictability of their menstrual cycle, as well as to screen for potential hormonal confounds, such as the use of birth control or other steroidal medications. This questionnaire was completed once during a scheduling pre-interview, and for a small subset of female participants (n = 13) it was completed again during the first test session[1].

As a further check on the reliability of self reported menstrual cycle phase, female participants were asked to verify actual dates of menstruation via email or telephone call (Hampson, 1990; Hampson & Kimura, 1988; Saucier & Kimura, 1998).

Of the 51 females enrolled and tested, 19 (37%) were observed to have irregular or unpredictable menstrual cycles despite their initial report of regularity. Of those 19

[1] This repeated administration was undertaken upon observing that a significantly large proportion of potential participants were inconsistent in their report of the regularity and timing of their menstrual cycle.

females, eight verified that they were in the menstrual phase at the beginning of the first test session, and so contributed valid data during that session only. The remaining 11 participants with unpredictable cycles were excluded from the analyses. Additionally, eight of the male participants did not return for a second test session. Thus, 23 male and 32 female participants contributed data to both test sessions. Further, due to participant error or nonconformity with the stated instructions, administration error, and the late addition of some measures, only 17 of the males and 24 of the females contributed valid data for all of the measures in both test sessions. Of the 32 female participants, 16 were first tested in the midluteal phase, and 16 were first tested in the menstrual phase.

A power analysis was conducted for the ability to detect menstrual cycle related effects. Previous researchers have reported effect sizes in the moderate range (.57 for verbal skills, Maki, 2002; .63 for visual attention, Morgan and Rapkin, 2002) for menstrual cycle related effects. Thus, the sample of 32 women would provide 80% power to detect menstrual cycle phase differences that in the lower end of this range (d=.5) and 95% power to detect effects in the higher end (d=.63; Cohen, 1988).

Although it has been suggested that it is optimal to follow individuals across at least two menstrual cycles (Morgan and Rapkin, 2002), an attempt was made to adopt a two week intersession interval in order to facilitate the use of undergraduates as participants. Due to variations in menstrual cycle length, this strategy resulted in significant differences in the mean number of days between tests for the female group, depending on which phase of the menstrual cycle that they were in when they were first tested

$t(15) = 14.56$, $p<.01$ (two tailed). The mean length of intersession interval for females first tested in the menstrual phase was 19.31 days (SD = 3.38), and the mean length of intersession interval for females first tested in the luteal phase was 8.69 days (SD=2.15).

As such, females first tested in the luteal phase were observed to benefit more from practice than those first tested in the menstrual phase, because the length of time between tests was significantly shorter for this group. This confounded data interpretation, as performance across sessions could not be attributed to change in menstrual cycle phase. Preliminary investigations revealed significant order (menstrual vs. luteal at first test) by phase (menstrual performance vs. luteal performance) interactions on measures of both cognitive functioning and symptom reporting. These interactions clearly indicated that differential carry-over effects were inherent in the data due to the differential number of days between tests. It was not possible to use the number of days between tests as a covariate in order to control for this scheduling confound, because doing so would violate the assumption of homogeneity of the regression slopes necessary for Analysis of Covariance. Further, recall that several subjects did not contribute valid data for all measures in both test sessions. For these reasons, although the study was initially conceived as a within subjects, repeated measures design with large enough sample sizes to provide adequate power to detect moderate menstrual cycle related effects in cognition and metacognition, this design was modified in order to negate the confound of differential carry-over effects, while preserving as much power as possible.

Therefore, a set of between subjects analyses were conducted on all valid data collected in the first test session only. These analyses allowed for comparisons of performance in the first session across group (menstrual/luteal/male). The final sample for these analyses

was 40 females (24 in the menstrual phase and 16 in the luteal phase) and 31 males. Demographic information is presented in Table 2.

Subjects were comparable on age; but as is apparent, the years of education achieved differed between groups. Nonetheless, this variable was considered to be an incomplete measure of educational attainment as none of the participants had finished their education when they were evaluated. Because all participants were university students, all were considered to be reasonably comparable in education.

Procedure

Language and acculturation survey.

Given the multicultural nature of the sample, it was necessary to evaluate the influence of linguistic and acculturation related factors on the cognitive test battery (see below). After the data was collected in the lab, a follow up email based survey was sent to all participants to estimate fluency with the English language and level of North American acculturation. Thirty participants (6 males and 24 females) responded to this survey which combined the language and acculturation questions employed by Tulsky et al. (2003) with several questions from the General Ethnicity Questionnaire (Abridged; Tsai, Ying and Lee, 1998; Appendix 2).

In order to quantify the influence of linguistic and acculturation specific variance on the cognitive measures of interest, a set of variables were calculated according the procedures described by Tulsky et al (2003). These variables (North American experience, North American education and language preference) have been previously shown to be related to common measures of cognitive function (Tulsky et al., 2003). Subjective ratings of overall fluency were also calculated in order to index exposure to

and fluency with English. These language and acculturation variables were correlated with performance on the cognitive battery that was administered. As illustrated in Table 3, language and acculturation related variables were highly correlated with the ability to learn and recall the word lists on the California Verbal Learning Test, Second Edition (CVLT-II, Delis, Kramer, Kaplan & Ober, 1999). This observation, in concert with the fact that the true level of English fluency and North American Acculturation was unknown for the majority of the sample that did not respond to the survey (64%), indicated that the CVLT-II data could not be confidently analyzed for this study. The remaining measures, which were not observed to be significantly correlated with the language and acculturation variables, were retained as described below.

Cognitive Measures

Digit Symbol Coding.

The Digit Symbol Coding Test (Wechsler, 1981) is part of the Processing Speed Index of the Wechsler Adult Intelligence Scale, Third Edition (WAIS-III; Wechsler, 1997). The subject is given 120 seconds to fill in the symbols associated with an array of numbers, based upon a coding template which is in view throughout the test. The raw score on this test is the number of correctly transcribed digit-symbol pairings. This test has been shown to have good reliability in Canadian samples (.86-.93; Wechsler, 2001).

Letter Number Sequencing.

The Letter Number Sequencing Test (Wechsler, 1997) is part of the Working Memory Index of the Wechsler Adult Intelligence Scale, Third Edition (Wechsler, 1997). The subject is required to track a set of orally presented random number and letter strings and keep them in mind, whilst ordering them sequentially for a correct response. The raw

score of interest in this study was the number of correctly recalled trials. This test has been shown to have good reliability in Canadian samples (.81-.92; Wechsler, 2001).

Immediate Memory Test.

The Immediate Memory Test (Dougherty, 1999), is a continuous performance task which requires selective visual attention to respond to target stimuli whilst ignoring distractor items. In the test, a series of 5 digit numbers are shown one at a time. The digit strings are presented in black font on a white background on a computer monitor for 500 milliseconds at a time, with a 500 millisecond interstimulus interval, during which the monitor is completely white. Digits measure approximately 2.0 centimetres in width and 3.3 centimetres in height. Participants are asked to respond by clicking the left mouse button as quickly as possible when the digit string being presented is exactly the same as the digit string immediately preceding it. There are three distinct types of trials administered. Target trials occur when the digit string is exactly the same as the digit string immediately preceding it. Catch trials occur when the digit string is identical to the immediately preceding string except for one digit. Filler trials occur when the digit string is completely different (i.e. no common digits) from the immediately preceding trial. Digit strings are presented such that 33% of trials are target trials, 33% of trials are catch trials, and 34% of trials are filler trials. The measure of interest for this study was the Discriminability index, (d'), which characterizes the participant's ability to accurately respond to targets and ignore distracter stimuli. This test has been shown to have adequate reliability within session, across multiple sessions in one day, and across multiple days to weeks (Dougherty, Marsh & Mathias, 2002).

Self Report Measures

Premenstrual Assessment Form.

In order to quantify the experience of premenstrual symptoms across menstrual cycle phase, female participants completed the Premenstrual Assessment Form (PAF; Halbreich, Endicott, Schacht, & Nee, 1982). This test is a 95 item self report measure developed to assess whether retrospective reporting of premenstrual symptoms is representative of clinically significant cyclic changes. Each item is rated on a six point severity scale ranging from 'no change' to 'extreme change'. In addition, this questionnaire provides specific criteria for subcategories of premenstrual changes and measures of severity (Pires & Calil, 2000). Premenstrual symptom endorsement was calculated as the percentage of maximum possible endorsement of all symptom domains included in the PAF, as well as percentage of maximum possible endorsement on the "organic mentation" subscale of the PAF, which specifically inquires about symptoms related to concentration, attention and memory.

Memory Assessment Clinic Self Rating Everyday Memory Scale.

To further investigate changes in self reported memory ability, all participants completed the Memory Assessment Clinics Self Rating Everyday Memory Scale (MAC-S;Crook and Larrabee, 1990). The MAC-S consists of 49 items pertaining to specific everyday memory tasks, memory problems, and overall memory functioning. Participants were asked to rate their own ability to perform these common memory tasks on a five point scale ranging from 'very poor' to 'very good'. This test has a reported test-retest reliability of .80 at three week intervals (Sbordone & Long, 1996). Percentage of maximum possible endorsement values were calculated for the MAC-S ability subscale

only, which consists of items which inquire specifically about one's perceptions of one's own memory ability.

Postconcussion Symptom Checklist.

As a further measure of the breadth, severity, and types of common and non-specific symptoms endorsed, all participants also completed a 97-item symptom checklist (Gunstad & Suhr, 2001) consisting of items pertaining to the occurrence of general cognitive and memory problems, mood and affective changes and somatic complaints. Participants were asked to rate the frequency with which these symptoms were experienced in the last 24 hours on a 5-point Likert scale with choices ranging from never, to always. Symptom reporting was calculated as the percentage of maximum possible endorsement on this measure. This checklist has adequate internal reliability (.97) and test-retest reliability (.88) at two weeks (Gunstad & Suhr, 2001).

Metacognitive Measures

Ratings of Cognitive Ability.

In order to evaluate sex and menstrual cycle related differences in perceived cognitive efficacy, participants were required to predict how well they would perform on each of the cognitive measures, relative to others their age. Ratings of cognitive ability were thus based upon the individual's perception of his or her ability in relationship to normative standards (see Hertzog, Saylor, Fleece and Dixon, 1994). Ratings were made on six point Likert scales which ranged from "very poor" to "superior" performance in relation to others the same age as the participant (Appendices 3 through 5). Participants were also asked to provide these ratings of their ability upon completion of each task (postdictions). The completion of pre-and postdictions allowed for the comparison of the accuracy of

these ratings both before and after completing the task. Accuracy scores were calculated as both the simple difference between the rating of cognitive ability and actual performance, and as the absolute difference between ratings of cognitive ability and actual performance. The specific methodology used in the calculation of these difference scores is reported below.

Accuracy of ratings of cognitive ability: simple differences.

Given the hypothesis that females in the luteal phase would underestimate their true abilities more than males and females in the menstrual phase, it was necessary to characterize both the magnitude and direction (over or underrated) of the differences between actual performance and ratings of cognitive ability. In order to quantify the accuracy of ratings of cognitive ability in relationship to normative performance (see Hertzog, Saylor, Fleece and Dixon, 1994) simple difference scores were calculated in the following manner. Z score transformations were conducted on the ratings of cognitive abilities for each task in order to convert these rankings so that they would have the same mean and standard deviation as the raw performance scores pooled over all groups. Thus, the mean raw score on a given task for the entire sample was added to the standardised rating for that task multiplied by the standard deviation of task performance for the entire group. [i.e. converted ranking = pooled performance mean + ((rating-pooled rating mean)/ standard deviation of the ratings) * pooled standard deviation of performance)]. The inaccuracy of predictions and postdictions were then calculated as the simple difference between these converted ratings of cognitive ability and actual performance on the task [e.g. inaccuracy = converted prediction (or postdiction) - actual performance (raw score)].

Accuracy of ratings of cognitive ability: absolute differences.

The simple difference scores as described above are sensitive to the effects of increases or decreases in perceived efficacy. Also of interest was the effect of menstrual cycle phase on the sheer accuracy of ratings of cognitive ability, regardless of the direction of inaccuracy. As a further test of the hypothesis that the "postdiction superiority effect" would be attenuated in the luteal phase as compared with the menstrual phase and males, it was deemed necessary to compare the absolute differences between predicted and actual performance to the absolute differences between postdicted and actual performance. Researchers have suggested that comparisons of absolute differences are more sensitive measures of the "postdiction superiority effect" because the direction of individual subjects' inaccuracies (over or underestimates) at pre or postdiction do not cancel each other out (Devolder et al., 1990). As such absolute difference scores were considered to be a better estimate of the influence of metacognitive monitoring on ratings of cognitive ability. Thus, following the procedure of Hertzog et. al (1994) prediction and postdiction inaccuracies were also calculated as the absolute (unsigned) difference between the ratings of cognitive ability and actual (ranked) performance on the task [e.g. inaccuracy = absolute value of {converted predictions (or postdictions) - actual performance (raw scores}].

DESIGN AND STATISTICAL ANALYSES

To evaluate this data, a series of One Way ANOVA were performed with cognitive performance and symptom endorsement as dependent variables and group (menstrual/luteal/male) as the between subjects variable. Further, the raw ratings of cognitive ability as well as both the simple and absolute difference scores between ratings

of cognitive ability and actual performance were analysed in a series of 2 x 3 repeated measures ANOVA's with rating condition (pre vs. postdiction) as within subjects variables and group (menstrual/luteal/male) as a between subjects variable. This allowed for the inspection of a rating condition effect, (i.e postdiction superiority). Additionally, the interaction between rating condition and group provides a test for the hypothesis that the postdiction superiority effect is attenuated in the luteal phase of the menstrual cycle, as compared with the menstrual phase and males.

RESULTS

Symptom Reporting

As evidenced by the top panel of Table 4, females in the luteal phase were not observed to endorse significantly more premenstrual symptoms on the PAF as a whole, or on the PAF "organic mentation" subscale, than females in the menstrual phase (p's>.05). Further, the main effect of group (menstrual/luteal/male) was not observed to be significant for the MAC-S memory ability scale, or the PCSC (p's >.05).

Cognitive Performance

Across all cognitive measures, females in the luteal phase were not observed to perform better than females in the menstrual phase or males. The data presented in the lower panel of Table 4 indicates that the cognitive performance of each group (menstrual/luteal/male) was not reliably different from the other groups on any of the cognitive measures (all p's >.05).

Ratings of Cognitive Ability

Inspection of the means and standard deviations presented in the top panel of Table 5 indicates that ratings of cognitive ability tended to be clustered in the "Low Average" (rating of 3) to "Average" (rating of 4) range. Importantly, ratings of cognitive ability were not observed to vary across group (menstrual/luteal/male) on any measure (p's$>.05$).

With regard to changes in ratings of cognitive ability from pre to post test, a significant main effect of rating condition (pre vs. postdiction) was observed for ratings of cognitive ability on the Immediate Memory Test, $F(1, 66) = 9.80$, $p < .01$. Inspection of the means suggests that participants experienced this task as more difficult that they originally predicted, and thus rated their ability to perform the task lower at postdiction than they did at prediction. Postdictions were not observed to be reliably different from predictions on any of the other measures (p's$>.05$). No significant interactions were observed (p's$>.05$).

Accuracy of Ratings of Cognitive Ability: Simple Differences

Table 6 illustrates that postdiction superiority was not observed for ratings of cognitive ability on any of the cognitive measures (p's$>.05$). Further, all other group (menstrual/luteal/male) effects were non-significant (p's$>.05$). The critical interaction between group (menstrual/luteal/male) and rating condition (pre-or postdiction) was not significant for any of the measures (p's$>.05$).

Accuracy of Ratings of Cognitive Ability: Absolute Differences

Table 7 presents the absolute differences between ratings of cognitive ability and actual performance. Postdiction superiority was not observed for ratings of cognitive ability on any of the cognitive measures (p's>.05). Further, all other group (menstrual/luteal/male) effects were non-significant (p's>.05). The critical interaction between group (menstrual/luteal/male) and rating condition (pre-or postdiction) was also not significant for any of the measures (p's>.05).

DISCUSSION

This study was designed to evaluate sex and menstrual cycle related changes in symptom reporting, cognitive abilities and the accuracy of ratings of cognitive abilities. It was hypothesized that females would endorse more symptoms than males as a group (Eiser, Havermans &Eiser, 1995), and that within females, symptom endorsement would be greatest in the luteal phase of the menstrual cycle (Choi & McKeown, 1997; Morgan & Rapkin, 2002; Marvan & Cortes-Iniestra, 2001; American Psychiatric Association, 1994). It was further hypothesized that the cognitive performance of females would be enhanced in the luteal phase as compared with the menstrual phase and males (see Table 1). Also of interest was the hypothesis that females would produce lower ratings of their cognitive abilities than males (Reilly & Mulhern, 1995; Furnham, 2002; Beyer, 1998) and that ratings of cognitive ability would be lowest when females were in the luteal phase of the menstrual cycle (Morgan & Rapkin, 2002). Each of these hypotheses, if confirmed, would represent a replication of similar sex and menstrual cycle related effects that have been reported in the literature. As an extension of these findings, it was hypothesized that the "postdiction superiority effect" reported in the literature (Pierce &

Smith, 2001) would be attenuated for females in the luteal phase as compared with females in the menstrual phase and males. This attenuation would provide a possible explanation for the discrepancy between perceived cognitive efficacy and actual performance reported in the literature by indicating that females in the luteal phase were less able to use metacognitive cues to update their perceptions of cognitive ability. With few exceptions, none of the above stated hypotheses were confirmed in the present study.

The results of the current study failed to show the hypothesized attenuation of postdiction superiority in the luteal phase. Although examination of the absolute differences obtained in this sample between ratings of performance and performance on digit symbol coding show the hypothesized pattern of results, namely greater inaccuracy at postdiction than prediction in the luteal phase, concurrent with postdiction superiority for males and females in the menstrual phase, this effect was not found to be reliable. Further, this pattern of results was not observed for ratings of performance on either letter number sequencing or the immediate memory test, which both show a non-significant and unreliable pattern of postdiction superiority across groups. The interaction between rating condition and group that would have suggested sex or phase related changes in accuracy was not significant for the analyses of accuracy scores calculated using simple differences or those that employed absolute differences. The lack of reliable support for this hypothesis, or any of the hypotheses reported herein may be the result of limitations in the study. These limitations may have obscured any true variation due to sex and menstrual cycle phase in symptom reporting, cognitive ability and the accuracy of ratings of cognitive ability.

This study is perhaps most limited by the fact that it was necessary to forgo the original within subjects design in favour of a between subjects analysis of data collected only in the first session. Further, the sample sizes for each of the analyses were likely not large enough to provide sufficient power in a between subjects analysis to detect sex and menstrual cycle phase related effects. Given the lack of power due to subject attrition, the above stated design modification, and the fact that not all subjects provided valid data for each measure, it is difficult to interpret these results definitively.

Inspection of the effect sizes observed in Table 7 indicates that the current study was underpowered to detect the small to moderate effect sizes observed for accuracy of ratings of cognitive ability. Given the magnitude of some of the effect sizes, it may be likely that no true variation existed in the accuracy of these ratings, however, without adequate power to evaluate these effects, one cannot evaluate the tenability of these effects.

Another limitation of this study is the fact that absolute measures of hormonal variation were not collected. It is possible that some of the female participants did not ovulate during their cycle, or that some participants experienced variations in relative hormone levels throughout their menstrual cycle due to stress or some other factor. Although every attempt was made to verify actual dates of menstruation and to test individuals in high and low estrogen phases, without absolute measures of relative hormone levels, it is impossible to be certain that each participant was in fact in the correct hormonal condition at the time of testing. Further, although the majority of participants were tested in the morning, the time of day in which participants were tested was not held constant across all participants. Thus, variability in hormone levels due to

circadian changes may have influenced performance and contributed to the lack of significant findings.

The results of the current study failed to provide evidence of increased symptom reporting in the luteal phase of the menstrual cycle as compared with the menstrual phase. Although the pattern of results obtained in the sample are consistent with increases in both general premenstrual complaints and specific complaints about cognitive functioning in the premenstruum, as illustrated by the PAF results, these results are not generalizable to the population. Power analyses reveal that even for the PAF organic mentation scale, which yielded the highest effect size, only 45% of the power needed to detect this borderline moderate sized effect was achieved. Also, given the small differences observed between symptom endorsement on the PCSC and memory ability rating on the MAC-S observed in this sample, it is possible that no true variation due to menstrual cycle phase exists, however, as these analyses of the effects of sex and symptom reporting were also underpowered, it is difficult to interpret these results with clarity.

Some may argue that the lack of reliable differences in symptom endorsement across phase is due to the fact that none of these participants would meet criteria for Premenstrual Dysphoric Disorder. PMDD likely exists on the tail end of a much wider spectrum of symptomatology which most women would endorse to one degree or another. Research has shown that self diagnosis of PMS or PMDD is highly influenced by cultural stereotypes and individual belief systems and expectancies (Choi and McKeown, 1997, Olasov& Jackson, 1987). Thus, the comparison of PMDD groups with so called "control" groups may impose arbitrary labels on this population. However, if

approached as a continuous construct, a study of the relationship between self report of cognitive functioning and actual functioning as it pertains to the menstrual cycle was considered to potentially lead to more generalizable and ecologically valid findings.

It may also be argued that the females in this study would not be expected to endorse more symptoms because they were tested in the mid-luteal phase, and not closer to onset of menstruation, in the late luteal phase. The Diagnostic and Statistical Manual of the American Psychiatric Association, Fourth Edition, states in its diagnostic criteria for PMDD that symptoms may be present up to one week prior to onset of menstruation (American Psychiatric Association, 1994). Others have suggested that these symptoms can occur at any time in the two week period between ovulation and menstruation (Halbreich, Endicott, Schacht, & Nee, 1982; Morgan, Rapkin, D'elia, Reading and Goldman, 1996). Thus, the timing of luteal phase testing (10 to 5 days prior to onset of menstruation) was thought to be a time when premenstrual symptoms endorsement would occur. Further, this choice of test timing would also maximize any discrepancy between perceived and actual cognitive ability.

Regarding ratings of cognitive ability, it was expected that females in general would produce lower ratings of ability than males, and that these ratings in the luteal phase would be lower than in the menstrual phase. Ratings of cognitive ability in the luteal phase were not observed to be reliably different from ratings in the menstrual phase, or males. The borderline moderate effect size for ratings of cognitive ability on Digit Symbol Coding indicates that, given more power, the observation that females in the luteal phase may have produced higher ratings of cognitive ability than males and females in the menstrual phase only had 36% of the power necessary to discover the true

nature of the effect. Indeed, all other analyses had even less power to detect the effect sizes observed, however, the fact that many of the effects were quite small may suggest that these effects would remain non-significant.

Given the highly multicultural nature of the sample, it may be that the expected differences in symptom reporting and ratings of ability were not found because of cultural factors. It has been noted that different cultures experience menstrual cycle related symptoms in different ways (Marvan & Cortes-Iniestra, 2001; Lu, 2001; Chang, Holroyd & Chau, 1995). The vast majority of research into menstrual cycle related changes in symptom reporting and perceived cognitive efficacy has been conducted on North American samples. As such the predicted effects may not have been observed because the current sample is culturally different from samples on which the literature is based.

The pattern of results obtained in this study also failed to replicate previous findings of a menstrual cycle effect on the selected cognitive measures. These results failed to replicate findings of enhanced verbal working memory, visual attention, and processing speed in the luteal phase of the menstrual cycle as compared with the menstrual phase (see Table 1). It is thought that these effects may have reached significance if the sample size was large enough to provide adequate power to detect these effects. Also, as verbal memory is often cited as the cognitive measure most sensitive to cyclic changes in estrogen (Sherwin, 1998), the impact of language and acculturation related variability on analyses of performance on this measure presented an obvious roadblock to the discovery of true phase related effects in this sample. In this sample, digit symbol coding performance exhibited a non-significant and unreliable pattern that would have supported

the hypothesis of both a gender and phase effect favouring females over males and females in the luteal phase over females in the menstrual phase if it had reached significance. The borderline moderate effect sizes for Digit Symbol Coding indicate that these effects may have attained significance with adequate power. However, there was only 37% power to detect the difference between males and females in the menstrual phase and females in the luteal phase. With more power it is possible that this effect may have replicated findings of sex differences on this task (Barr, 2003; Harrison and Whissel, 1980; Snow, 1990; Dai, Ryan and Paolo, 1991). With regard to Letter Number Sequencing, although the non-significant and unreliable pattern obtained was in opposition to the hypothesized gender and menstrual cycle phase pattern of performance, the current sample had only 39% of the power necessary to detect an effect of the magnitude observed. Given more power, these analyses may have indicated that, contrary to the hypothesised pattern of findings, females in the luteal phase may have performed worse than females in the menstrual phase and males. If reliably observed, this finding would contradict the assertion made by Keenan et al. (2001) that working memory is enhanced in the presence of high levels of estrogen. The current sample also exhibited a non-significant and unreliable pattern indicating that females in the luteal phase may have performed better than females in the menstrual phase on the discriminability index of the immediate memory test, however, as stated previously, there is not sufficient evidence herein to make definitive statements about the nature of any effects in the population.

It was further hypothesised that postdictions would generally be more accurate than predictions (postdiction superiority). The lack of replication of this effect across analyses

and tests calls its robustness into question. However, given the limited sample sizes and constrained variability in the ratings of cognitive ability, it may be that there was simply not enough power to reliably detect the small effect sizes observed. Examination of the absolute differences between ratings of performance and actual performance in this sample does indicate a non-significant and unreliable pattern of postdiction superiority for most groups across tests. On digit symbol coding unreliable and non-significant postdiction superiority was observed for females in the menstrual phase and males. On both Letter Number sequencing and the Immediate Memory Test, examination of the absolute accuracy scores indicates that non-significant and unreliable postdiction superiority was observed for all groups. Again, while it is possible that these effects may have attained significance with adequate power, the current findings cannot reliably inform generalizations about the nature of these effects in the population as a whole.

Conclusions and Recommendations for Further Research

In conclusion, no reliable evidence was found in this study that females report more symptoms than males, or that symptom reporting varies as a function of menstrual cycle phase. Nor were cognitive functions found to be reliably enhanced in the luteal phase of the menstrual cycle as compared with the menstrual phase, and males. Further, there is no evidence herein which suggests that metacognitive accuracy is reliably influenced by sex or menstrual cycle phase. The lack of support for menstrual cycle related changes in metacognitive ability reported herein leaves the cause of the discrepancy between luteal phase perceptions of cognitive ability and actual functioning reported in the literature unanswered. Some have suggested that high endorsement of premenstrual symptoms is the result of abnormal reactivity of the neural substrate to normal changes in hormone

levels (Schmidt, et al., 1998). Given reports that the medial frontal, and limbic regions most involved in metacognition may well be influenced by phase related changes in ovarian hormone levels (Osterlund, Keller and Hurd, 1999; Rasgon et al., 2001), it may be that the current study was unable to detect these metacognitive changes because of limitations related to the sample and methodology. Further research, which adequately addresses the methodological limitations of the present study, is necessary in order to understand the nature of the influence of sex and menstrual cycle phase on the metacognitive ratings of ability.

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TABLE 1.

COGNITIVE EFFECTS OF OVARIAN HORMONES

Better Performance due to higher levels of Ovarian Hormones

Modality	Test(s)	Reference	Type
Manual Speed/Coordination	Finger Tapping	Hampson, 1990; Hampson and Kimura, 1988	Menstrual cycle
	Manual Sequence Box	Hampson, 1990; Hampson and Kimura, 1988; Saucier and Kimura, 1998	Menstrual cycle
	Purdue Pegboard	Hampson, 1990; Hampson and Kimura, 1988	Menstrual cycle
	Grooved Pegboard	Maki, Rich and Rosenbaum, 2002	Menstrual cycle
Verbal Memory	CVLT	Maki, Zonderman and Resnick, 2000; Keenan, Ezzat, Ginsburg and Moore, 2001	HRT
	CVLT-II	Kramer, Yaffe, Lengenfelder, Delis, 2003	Aging
	Verbal Paired Associates	Phillips and Sherwin, 1992	Menstrual Cycle
	Paragraph Recall	Sherwin and Tulandi, 1996	HRT
	Story Recall	Kampen and Sherwin, 1994	HRT
	Bushke Selective Reminding Test	Jacobs, Tang, Stern, 1998	HRT
Verbal Working Memory	Letter-Number Sequencing	Rosenberg and Park, 2002	Menstrual Cycle
	N-Back test	Keenan, Ezzat, Ginsburg and Moore, 2001	Menstrual cycle
Immediate Memory Span	Digit Span	Carlson and Sherwin, 1998	HRT
Verbal Fluency/Articulation	Speeded Counting	Hampson, 1990	Menstrual Cycle
	Reading Colors	Hampson, 1990	Menstrual Cycle
	Naming Colors	Hampson, 1990	Menstrual Cycle
	Single syllable repetition	Hampson, 1990	Menstrual Cycle
	Multisyllable repetition	Hampson, 1990	Menstrual Cycle
	Rhyme Fluency	Maki, Rich and Rosenbaum, 2002	Menstrual cycle
	Stroop Color naming	Keenan, Stern, Janowsky, Pederson, 1992	Menstrual cycle
Perceptual Speed	Subtraction and Multiplication	Hampson, 1990	Menstrual Cycle
	Identical Pictures	Hampson, 1990	Menstrual Cycle
Executive Functioning	Wisconsin Card Sorting Test	Solis-Ortiz, Guevara, Corsi-Cabrera, 2004	Menstrual cycle
	Trails B	Keenan, Stern, Janowsky, Pederson, 1992	Menstrual cycle
Expressive Vocabulary	Boston Naming Test	Jacobs, Tang, Stern, 1998	HRT
Visual Memory (Delayed)	Visual Reproduction	Phillips and Sherwin, 1992	Menstrual Cucle
Visuospatial Skills	Hidden Figures	Hampson, 1990	Menstrual Cycle
Attention/Concentration	Visual Selective Attention	Morgan and Rapkin, 2002	Menstrual Cycle
Abstract Reasoning	Similarities	Jacobs, Tang, Stern, 1998	HRT

Worse Performance due to higher levels of Ovarian Hormones

Modality	Test(s)	Reference	Type
VisuoSpatial Skills	Rod and frame Test	Hampson, 1990; Hampson and Kimura, 1988	Menstrual Cycle
	Mental Rotations	Maki, Rich and Rosenbaum, 2002	Menstrual Cycle
	Embedded Figures Test	Komenich, Lane, Dickey, Stone, 1978	Menstrual Cycle
Deductive Reasoning	Inference Test	Hampson, 1990	Menstrual Cycle
Perceptual Speed	Number Comparisons	Hampson, 1990	Menstrual Cycle
Perceptual Priming	Fragmented Object Identification	Maki, Rich and Rosenbaum, 2002	Menstrual Cycle
Spatial Working Memory	CANTAB	Man, MacMillan, Scott and Young, 1999	Menstrual Cycle

* refers to the type of manipulation used to study the effect of hormones: Menstrual Cycle = normally cycling females; HRT = Hormone Replacement Therapy users compared with nonusers; Aging = young females compared with older, postmenopausal females

TABLE 2.
DEMOGRAPHIC INFORMATION

		N	M	(SD)	F	df
age	male	31	19.81	(2.09)	2.07	2, 68
	menstrual	24	18.96	(1.65)		
	luteal	16	20.56	(3.86)		
education	male	31	13.52	(1.06)	4.8**	2, 68
	menstrual	24	12.71	(0.81)		
	luteal	16	13.38	(1.09)		

Mean length of menstrual cycle for females was 30.14 days
(SD=7.34)
67.5 % of the sample was of non-Caucasian origin, with the majority being of asian descent.
**p<.01

TABLE 3.

CORRELATIONS BETWEEN LANGUAGE AND ACCULTURATION VARIABLES AND COGNITIVE PERFORMANCE

	North American Experience	North American Education	Language Preference	Language Fluency
Raw CVLT-II Total Recall, Trials 1 to 5	0.67*	0.65*	0.66*	-0.71*
Raw Digit Symbol Coding	0.27	0.23	0.25	-0.12
Raw Letter Number Sequencing	0.20	0.12	0.19	-0.09
IMT Discriminability Index (d')	0.05	0.08	0.13	-0.05

* Correlation significant at the .01 level (2 tailed)

TABLE 4.

SYMPTOM REPORTING AND COGNITIVE PERFORMANCE

Symptom Reporting[1]		N	M	(SD)	F	df	d
PAF Total Score	menstrual	24	33.85	(10.19)	1.94	1, 38	0.45
	luteal	16	38.64	(11.33)			
PAF Organic Mentation	menstrual	24	32.52	(14.89)	2.23	1, 38	0.48
	luteal	16	40.28	(17.80)			
MAC-S Ability Scale[2]	male	31	27.52	(8.89)	1.68	2, 68	0.28**
	menstrual	24	31.36	(10.35)			
	luteal	16	32.08	(9.21)			
PCSC Total	male	31	40.95	(7.93)	0.27	2, 67	0.11**
	menstrual	23	39.49	(8.13)			
	luteal	16	41.16	(9.09)			
Cognitive Performance							
Digit Symbol Coding	male	29	90.72	(17.54)	1.25	2, 66	0.41**
	menstrual	24	93.38	(14.10)			
	luteal	16	98.50	(14.88)			
Letter Number Sequencing	male	21	11.52	(2.79)	1.85	2, 48	0.49**
	menstrual	18	10.61	(1.98)			
	luteal	12	9.92	(2.15)			
Immediate Memory Test[a]	male	26	1.81	(0.63)	0.41	2, 54	0.23**
	menstrual	19	1.69	(0.46)			
	luteal	12	1.89	(0.88)			

• sample sizes vary as some subjects did not receive the full battery of tests.

** effect sizes reflect magnitude of differences between the the mean performance of males and females in the menstrual phase, as compared with females in the luteal phase

[a] larger numbers indicate better discrimination between target and non target stimuli

[1] percentage of maximum possible endorsement

[2] high numbers indicate better self rated memory ability

TABLE 5.
RATINGS OF COGNITIVE ABILITY

			Prediction		Postdiction					
Ratings of Cognitive Ability		N	M	(SD)	M	(SD)	effect	F	df	**d****
Digit Symbol Coding	male	31	4.03	(0.84)	4.16	(0.82)	group	0.56	2, 68	a) .40
	menstrual	24	3.92	(0.78)	3.88	(0.90)	rating condition	0.01	1, 68	b) .19
	luteal	16	4.00	(0.52)	3.94	(1.06)	interaction	0.37	2, 68	
Letter Number Sequencing	male	21	3.24	(0.89)	2.95	(1.07)	group	0.03	2, 48	a) .06
	menstrual	18	3.06	(1.11)	3.17	(0.99)	rating condition	0.00	1, 48	b) .04
	luteal	12	3.08	(1.00)	3.25	(0.97)	interaction	1.10	2, 48	
Immediate Memory Test	male	26	4.12	(0.71)	3.96	(0.92)	group	1.17	2, 66	a) .04
	menstrual	19	3.95	(0.78)	3.53	(0.91)	rating condition	9.80*	1, 66	b) .27
	luteal	12	4.25	(0.45)	3.58	(0.90)	interaction	1.28	2, 66	

* p<.01

** effects sizes indicate the magnitude of differences observed between: a) mean combined ratings of males and females in the menstrual phase with females in the luteal phase across rating condition; b) differences between males and females across rating condition

***sample sizes vary as some subjects did not receive the full battery of tests.

TABLE 6.

Accuracy of Ratings of Cognitive Ability (Simple Difference)

Accuracy of Ratings of Cognitive Ability (Simple Difference)

			Prediction		Postdiction					
		N	M	(SD)	M	(SD)	effect	F	df	d**
Digit Symbol Coding	male	29	3.67	(22.06)	6.20	(19.51)	group	2.31	2, 66	a) .39
	menstrual	24	-1.48	(17.72)	-2.31	(17.23)	rating condition	0.00	1, 66	b) .47
	luteal	16	-4.84	(13.73)	-6.33	(17.69)	interaction	0.41	2, 66	
Letter Number Sequencing	male	21	-0.46	(3.46)	-1.06	(3.26)	group	1.42	2, 48	a) .41
	menstrual	18	0.00	(3.53)	0.37	(2.62)	rating condition	0.07	1, 48	b) .43
	luteal	12	0.76	(3.46)	1.26	(2.61)	interaction	1.10	2, 48	
Immediate Memory Test	male	26	0.00	(.94)	0.13	(.78)	group	0.23	2, 54	a) .18
	menstrual	19	0.00	(.78)	0.00	(.65)	rating condition	0.21	1, 54	b) .15
	luteal	12	0.00	(.84)	-0.22	(.70)	interaction	1.13	2, 54	

** effects sizes indicate the magnitude of differences in accuracy observed between: a) mean combined ratings of males and females in the menstrual phase with females in the luteal phase across rating condition; b) males and females across rating condition

***sample sizes vary as some subjects did not receive the full battery of tests.

TABLE 7.

ACCURACY OF RATINGS OF COGNITIVE ABILITY (Absolute Difference)

			Prediction		Postdiction					
		N	M	(SD)	M	(SD)	effect	F	df	d**
Digit Symbol Coding	male	29	17.43	(13.64)	16.27	(12.09)	group	1.04	2, 66	a) .10
	menstrual	24	13.83	(10.80)	13.32	(10.83)	rating condition	0.13	1, 66	b) .28
	luteal	16	12.31	(7.20)	15.85	(9.35)	interaction	0.61	2, 66	
Letter Number Sequencing	male	21	2.90	(1.85)	2.95	(1.63)	group	0.59	2, 48	a) .02
	menstrual	18	2.61	(2.29)	2.16	(1.45)	rating condition	0.80	1, 48	b) .22
	luteal	12	2.84	(1.96)	2.54	(1.25)	interaction	0.40	2, 48	
Immediate Memory Test	male	26	0.76	(.54)	0.63	(.46)	group	1.00	2, 54	a) .00
	menstrual	19	0.57	(.52)	0.50	(.39)	rating condition	1.36	1, 54	b) .25
	luteal	12	0.67	(.47)	0.56	(.44)	interaction	0.05	2, 54	

** effects sizes indicate the magnitude of differences in accuracy observed between: a) mean combined ratings of males and females in the menstrual phase with females in the luteal phase across rating condition; b) males and females across rating condition

***sample sizes vary as some subjects did not receive the full battery of tests.

Appendix 1.

Menstrual Cycle Questionnaire

Please answer Yes or No to the following questions by circling the appropriate answer.

Are you currently using oral, intramuscular or patch contraceptives? If yes please specify which one (type and brand):_____ Yes No

Have you taken oral, intramuscular or patch contraceptives in the past 4 months? If yes please specify which one (type and brand):_____ Yes No

Are you currently pregnant? Yes No

Are you currently going through, or have you gone through menopause? Yes No

Would you say that your menstrual cycle is regular/predictable? Yes No

Do you feel that you get PMS before your period? Yes No

7. Are you currently menstruating? Yes No

Have you ever menstruated? Yes No

9. Are you currently using hormone replacement therapy? Yes No

What is the length of your regular cycle (from date of first bleeding to date of first bleeding)? _____days.

For how long has your menstrual cycle been regular (eg. How many months, years)?

_____

Please write the day of the beginning of your last menstrual period. _____

Please write the estimated date of the beginning of your next menstrual period.

_____.

Appendix 2.

Language and Acculturation Questionnaire

1. How old are you? _____
2. What country were you born in?_____
3. What language was the first that you learned?_____
4. How long have you lived in North America?_____
5. At what age did you move to North America?_____
6. How many years of education have you completed? _____
7. How many years of education did you complete *outside* of North America?_____
8. What language do you prefer when **speaking**?_____
9. What language do you prefer when **thinking**?_____
10. What language do you prefer when **reading**?_____
11. What language do you prefer when **writing**?_____

Please indicate your use of English by circling the appropriate number below:

	Very much	**Much**	**Somewhat**	**A little**	**Not at all**
How much do you speak English *at home*?	1	2	3	4	5
How much do you speak English *at school*?	1	2	3	4	5
How much do you speak English *at work*?	1	2	3	4	5
How much do you speak English *with friends*?	1	2	3	4	5
How much do you view, read, or listen to English *on TV*?	1	2	3	4	5
How much do you view, read, or listen to English *in film*?	1	2	3	4	5
How much do you view, read, or listen to English *on the radio*?	1	2	3	4	5
How much do you view, read, or listen to English *in literature*?	1	2	3	4	5
How fluently do you *speak* English?	1	2	3	4	5
How fluently do you *read* English?	1	2	3	4	5
How fluently do you *write* English?	1	2	3	4	5
How fluently do you *understand* English?	1	2	3	4	5

Appendix 3.

Digit Symbol Coding Rating of Cognitive Ability

Prediction

1. After having heard the instructions for this test, compared with others your age, how would you rate your speed in this task (i.e. how many symbols you can finish in the time given)

very poor-------poor------low average------average------high average------superior
1 2 3 4 5 6

Postdiction

2. After completing this test, compared with others your age, how would you rate your speed in this task (i.e. how many symbols you finished in the time given)

very poor-------poor------low average------average------high average------superior
1 2 3 4 5 6

Appendix 4.

IMT Rating of Cognitive Ability

Prediction

1. After having heard the instructions for this test, how would you rate your ability to respond to numbers that were same as previous numbers quickly and accurately and NOT respond to numbers that were NOT the same as previously presented numbers? Your comparison should be with others your age.

very poor-------poor------low average------average------high average------superior
1 2 3 4 5 6

IMT Rating of Cognitive Ability

Postdiction

2. After doing the test, how would you rate your ability to respond to numbers that were same as previous numbers quickly and accurately and NOT respond to numbers that were NOT the same as previously presented numbers? Your comparison should be with others your age.

very poor-------poor------low average------average------high average------superior
1 2 3 4 5 6

Appendix 5.

Letter-Number Sequencing Rating of Cognitive Ability

Prediction

1. After having heard the instructions for this test, compared with others your age, how would you rate your ability to perform this task?

very poor-------poor------low average------average------high average------superior
1 2 3 4 5 6

Postdiction

2. After completing this test, compared with others your age, how would you rate your ability to perform this task?

very poor-------poor------low average------average------high average------superior
1 2 3 4 5 6