The Menstrual Cycle, Sex Differences and Sensitivity to Intermittent Light

by

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Abstract

Sex differences in critical flicker frequency (CFF) have been found by Hartmann (1934) and Ginsburg et al. (1982), with men appearing to be more sensitive than women. The nature of these sex differences has been questioned. Ginsburg et al. (1982) have suggested that these differences may be due to hormonal influences that could be further explored by studying CFF across the menstrual cycle. It has been proposed by Bem (1974) that sex role perception might be a variable involved in sex differences. The present study was designed to explore the sex difference in CFF and two interpretations of it: the influence of hormones and the influence of sex role perception. The former variable was investigated by looking for changes in sensitivity during the menstrual cycle, since any such found would imply a hormonal basis. The latter variable was studied thru the use of the Bem Sex Role Inventory, which includes both femininity and masculinity scales.

Two experiments were conducted using a CFF task based on the method of limits. In Experiment I, three female volunteers with menstrual regularity were tested three times a week for two complete menstrual cycles. In Experiment II, 50 male and 55 female subjects were tested once on the CFF task and the Bem inventory. In addition, all females answered a questionnaire concerning their menstrual cycle.

A significant sex difference in CFF was found, with men more sensitive. No clear relationship was found between CFF and the menstrual cycle, either in subjects tested repeatedly over the cycle or in the larger group tested once. Sex role perception showed no relation to CFF among females. However, among males some relationship was observed which suggests further study.

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Recent research on the menstrual cycle has dealt with questions of whether or not phase differences affect sensory modalities, performance efficiency on psychomotor tasks and cognitive ability. Dalton (1977) speculated that women are significantly affected both physically and mentally, by phase changes. She proposed a theory of "raging hormones" implying that women fall victim to hormonal based biological changes which cause feelings of depression, headaches, and somatic symptoms during different cycle stages. Opposing this theory is Curtis (1981) who suggested the view that observed cyclic behavior changes are due to cultural stereotypes and myths concerning the menstrual cycle. Both hypothesis currently hold a substantial number of supporters.

Jurenovskis (1979) favored Dalton's analysis in speculating that significant differences she found between the males and females in critical flicker frequency (CFF) may have been due to hormonal influences. Jurenovskis found men to be significantly more sensitive to intermittent light than women.

The present study is designed to examine two possible explanations for this sex difference in CFF. One explanation attributes it to the influence of hormones. Any difference found over the menstrual cycle would tend to support such an interpretation. The second explanation is that the difference is due to psychological factors associated with differences on socialization of males and females. If this latter explanation is correct, CFF scores should be related to scores on a sex role inventory.

Critical Flicker Frequency (CFF)

The rate of any source of intermittent illumination where the stimulus appears to be transformed from a state of fluctuation to a steady sensation is called the critical flicker frequency (CFF). With CFF values, high numbers indicate a high sensitivity while low numbers represent a low sensitivity. CFF may be altered by stimulus variables, methodology, organismic and subject variables.

The stimulus variables which may alter CFF include luminance, the pulse- to- cycle fraction (PCF) and wave length. The Ferry-Porter law suggests that retinal persistance varies inversely with the logarithm of stimulus luminance. (Brown, 1965). Therefore, changes in luminance cause fluctuations in CFF. Bartley and Nelson (1960) studied the relations between PCF and CFF. They found that CFF varies as PCF varies. Hecht and Shlaer (1936) have determined CFF using seven different wavelengths. They found that their data for the various wavelengths indicated that CFF was primarily dependent on luminance rather that wavelength.

With CFF studies, frequency, intensity and modulation are important dependent variables. As the frequency of the stimulus changes, the perception of the stimulus changes until the observer notes the CFF. Flicker is determined by the fundamental frequency. The role of intensity or the apparant brightness of the light is important. Increases in intensity cause increases in CFF. However, as Nelson and Bartley (1965) suggest, at extreme intensities, CFF is reduced. Modulation is also a factor in CFF studies. Modulation refers to the changes in wave form. The modulation amplitude indicates how high the peak of the sinusoid is above the mean amplitude. CFF is dependent upon the percent of modulation. Modulation can be calculated based on the maximum and minimum luminance levels of the wave at different points (Scharf, 1975).

The effect of organismic variables in CFF such as adaptation, chemical factors, and fatigue have been explored. Several studies of CFF show the affect of adaptation . With short exposures to CFF (less than 100 msec.) no CFF can be measured. With increased exposure, CFF can be measured with a maximum occuring at approximately one second. It has been found that CFF tends to be lower in the light-adapted eye than in the dark-adapted eye. (Brown, 1965). Landis (1954) suggested that chemical variables may influence CFF. Vitamin A, oxygen and glycogen levels of the blood supply which goes to the retina should be at optimal levels. Good health and nutritional status will help ensure appropriate levels. Also, some chemical agents such as strychnin, thyroxin, benzedrine, adrenalin, glucose, dinitrophenal, pervintin and testosterone increase CFF while others decrease CFF such as chloral, insulin, atrophin, nicotine, pilocarpin, and barbiturates. Fatigue is another organismic variable that affects CFF. Hartmann (1934) suggested that CFF is reduced by fatigability of the motor nervous systems.

The final group of variables which influence CFF are subject variables. Hartmann (1934) and Misiak (1947) both studied age differences in CFF. Misiak found significant differences in CFF between young and old people. CFF value tends to decrease with age. Brown (1965) has reviewed several studies and noted that many have reported a significant correlation between CFF and intelligence. Landis (1954) has noted that clinical investigators have found a decreased CFF with a wide array of pathological states such as anemia, brain injury, depression, and hypothyroidism.

Several theories have been devised to explain the CFF phenomenon. To fully grasp the concept of CFF some of these theories will be presented here. Scharf (1975) reviewed the system analysis approach. This theory conceptualizes the observer as a black box to which the stimulus is applied and a response is forthcoming. The subject is believed to process the information through a series of linear transformations. The input to the organism is a sinusoidal wave of some particular frequency and the output is a sinusoidal wave of the same frequency but it may have a different amplitude.

Calloway and Alexander (1960) presented two theories of the temporal coding of sensory data, the scan theory and the neutronic shutter theory. The scan theory assumes visual images have a spatial display in the calcarine cortex. Coding or processing of the stimulus material takes place by a repetitive sampling or scan. The neutronic shutter theory is similar to the scan theory in the ordering of temporal sampling. However, it differs from the scan theory in suggesting an intermittent gating of sensory data into the central nervous system (CNS) rather than an extended perceptual field. This is achieved through cyclic changes in the excitability of the CNS and EEG rhythm reflects this.

The alternation - of - response theory studied by Nelson and Bartley (1965) suggests that cortical processes control CFF and brightness. A certain temporal distribution of these cortical processes is important to explain discriminations of size, edge and colour.

Brown (1965) has explored two theories to further explain the CFF phenomenon. The first is Ives' diffusion theory. He proposed three steps in the perception process; a reversible photochemical reaction, the conduction of the substance formed by this reaction, and the rate of change of a transmitted reaction must exceed a critical value which is constant. The second theory is a photochemical theory in which during prolonged stimulation decreases the concentration of photosensitive material will be compensated by the increase during the dark phase of the illumination cycle.

Sex Differences in CFF

Hartmann (1934) was one of the first investigators to look at sex of the subject as a variable in the study of CFF. His study was originally designed to determine whether children and adults differ in sensitivity to the CFF for rotating disks. He hypothesized that adults would report the CFF to be lower than children. After testing 12 children and 12 adults he found that youngsters reported the presence of flicker at lower values than adults but the difference was not significant. He also found a sex difference. The results indicated that males did better than females in in both age groups and adult females did poorer than the other three groups.

Misiak (1947) reviewed Hartmann (1934) and conducted a more detailed study on age and sex differences in critical flicker frequency. He used 100 subjects, male and female, aged 19 to 30 years and 63 to 87 years. He found significant age differences with the young participants doing better. There was evidence in his results that indicated males in the lower age range had a higher sensitivity than females of the same age. The older subject's results were reversed with the females displaying a higher sensitivity. These sex differences were not significant. However, the age by sex interaction was significant.

Ginsburg, Jurenovskis, and Jamieson (1982) tested 59 female and 42 male subjects ranging in age from 16 to 33 years to explore sex differences in CFF. They found that there was a significant sex difference with men appearing to be more sensitive than women.

Sex differences in perception are documented in areas other than critical flicker frequency. Corso (1959) found that women have more acute hearing than men. Gandelman's (1982) review of the literature noted that females were more sensitive than males in two-point touch thresholds, taste and olfaction.

Males were found to be more sensitive to pain, to color, and in visual threshold detection tasks. These sex differences found in CFF and other areas may be an indication of some basic differences in perceptual sensitivity between the sexes.

Physiological and Psychological effects of the Menstrual Cycle

The menstrual cycle is the cyclic discharge of blood and sloughed off uterine material that occurs in mature females. The cycle is typically 28 plus or minus two days and is influenced by a changing hormonal pattern in which estrogen levels fluctuate.

> Although there is some variation in the timing of the critical events of this cycle, follicular growth commences around the ... (beginning of each) ... cycle in response to the secretion of follicle stimulating hormones (FSH) by the pituitary gland, and the growing follicles begin to secrete estrogens. The estrogens, in turn, stimulate the hypothalamus to cause the production and release of surges of luteinizing hormones (LH) by the anterior pituitary. The LH surges cause the rupture of a follicle, which then releases an ovum.... The estrogen level remains relatively low during the first eight days. of the cycle, rises sharply to peak levels around the 14^{th} day (ovulatory phase), subsides moderately for three or four days, rises again more gradually

for three or four days, rises again more gradually to a smaller peak accompanied by a rise in progesterone (luteal phase), and finally falls to the level characteristic of the menstrual phase. (Wells and Payne, 1979, p.198).

Dalton (1977) has divided the cycle into seven, four day phases: one to four menstruation, five to eight early postmenstrum, nine to 12 late postmenstrum, 13 to 16 ovulation, 17 to 20 early luteal, 21 to 24 late luteal, and 25 to 28 premenstrum. Day one for Dalton is the onset of blood flow. Dalton gives evidence for a premenstrual syndrome which is a period of premenstrual tension characterized by the psychological symptoms of depression, lethargy, and irritability. Somatic symptoms such as asthma, epilepsy, and headaches may be more pronounced during this period as well. These symptoms were found to peak during the last four days of the premenstrum.

The menstrual cycle has been used to study hormonal effects which may alter sensory-perceptual mechanisms. Parlee (1983) in a literature review of menstrual rhythms in sensory processes noted that visual and olfactory thresholds appear to be lower at ovulation (day 14). Oral contraceptive use regulates the menstrual cycle and reduces hormone fluctuations.

Friedman and Meares (1979), Hicks and Cavanaugh (1982), and Banks and Beresford (1979) found that oral contraceptive users showed no changes across the menstrual cycle while non-users showed phase differences, in a visual discrimination task, in the need for sleep, and in symptoms as recorded in health diaries. They noted that in studying sex differences pill-users performed on tasks similarly to the male group. Significant differences have been found between pill-users and non-users with the users performance resembling male control groups. Therefore, when studying the menstrual cycle, pill users should be eliminated.

Physiological changes caused by the menstrual cycle are more readily observable than the psychological components. Psychological correlates are studied primarily around the premenstrual period with tests such as the Premenstrual Assessment Form (PAF) by Halbreich, Endicott and Schacht (1981) and the more popular MOOS Menstrual Distress Questionnaire (MDQ) reviewed by Rouse (1977). Both instruments of assessment have found that a significant number of women are affected by a premenstrual syndrome. The degree of severity of such a syndrome fluctuates from woman to woman. However, as Halbreich et al. (1981) suggested, very few women have premenstrual changes severe enough to seek treatment. They reported that less than one percent of those who complete the PAF report no change across their cycle.

Maloney et al. (1982) reported that some personality measures were significantly different as a function of stage of the menstrual cycle. Friedman et al. (1980) have reviewed the literature on behavior and the menstrual cycle. They found that the existing evidence points to mood disturbances related to the menstrual cycle. These disturbances were most prominant during the premenstrual period along with irritability, depression, anxiety, and hostility. Their review also concluded that at ovulation women performed their best, both physically (on reaction time tasks) and psychologically (on measures of anxiety, depression, irritability and self-perception). The above findings indicate that hormonal influences affect women both physically and psychologically and this influence may be altered by oral-contraceptive use.

Sex Differences and the Menstrual Cycle

The menstrual cycle has been frequently studied as a variable in a variety of tasks where a sex difference is observed. It is an intricate phenomemon where biological, social, and psychological variables interact. As Wittig and Peterson (1979) state, "It begins with an indisputable sex difference: women menstruate and men do not" (p.241). Changes in activity level, sensory thresholds, mood and cognitive performance are frequently attributed to the menstrual cycle. Direct relations between hormonal and psychological variables have been proposed to account for sex differences that have been found (Wittig and Peterson, 1979).

Jensen (1982) examined the effects of the menstrual cycle on task performance using signal frequency, task load, and psychomotor performance. She tested 18 subjects with highly regular cycles while in the intermenstrual (eight to 12 days after flow onset), premenstrual (one to four days before anticipated onset of flow), or menstrual (within 24 hours after flow onset) phase of their cycle. Results suggested that subjects performed better both during the menstrual and intermenstrual phases. Overall, performance capacity appeared to be lowest at the premenstrual phase indicating menstrual cycle effects on performance.

Cognitive test performance across the menstrual cycle was studied by several investigators with opposing results. Hutt (1980) tested subjects over four phases of the menstrual cycle (second day of flow, four days after cessation of flow, 12 days after flow and three days before flow). He found no differences in perceptual-motor performance on a choice reaction time study utilizing a numerals-keys serial response task. Curtis (1981) tested females' and males' success and failure on a task dependent upon prior testing. A word analogies task in which the level of difficulty was either high or low such that subjects would succeed or fail was given first. Then a word analogies test of average difficulty was given. She suggested that there was no sex difference or difference between women in different phases of their menstrual cycles.

Golub (1976) looked at a representative of intellectual functions from a set of cognitive measures including sensory-perceptual factors, memory, problem solving and concept formation. She did find significant changes in performance across the menstrual cycle with poorest performance on all tests occuring during the premenstrual period (one to four days before onset of flow). Ruggieri and Vareri (1981) examined four phases of the menstrual cycle and found perceptions of right and left halves of the body varied across the stages tested. Changes in performance on mirror tracking across the menstrual cycle was found by Wells and Payne (1979). Finally, Broverman et al. (1981) found a relationship between menstrual cycle related changes in estrogen and various cognitive tasks.

These studies show differences across the menstrual cycle. However, each study has divided the cycle into different phases. There appears to be so many diverse classification schemes that it is difficult to ascribe to any one set of labels for groups of days across the cycle.

CFF and the Menstrual Cycle

One of the first groups of investigators to examine hormonal influences in CFF was Simonson, Kearnes and Enzer (1941). They found that administering testosterone (male sex hormone) to subjects (eunuchoids and castrates), who normally did not have this hormone present, resulted in significantly increased CFF.

Table 1 shows results from five studies which examined sensitivity to intermittent light across the menstrual cycle. Becker et al. (1982) used multiple flashes; the other four studies used two flash.

Kopell et al. (1969) found that thresholds were lowest during the menstrual phase and rose during the rest of the cycle, but no differences were significant. In the DeMarchi and Tong (1972) study thresholds were lowest on day seven; however, their results indicated that changes in thresholds were due to criterion placement rather than sensory sensitivity. Subjects were found to adopt a stricter

Table 1. Studies examining sensitivity changes across the menstrual cycle.

Authors	Number of Subjects	Period Threshold Lowest (greatest sensitivity)	Days Tested
Becker et al. (1982)	14	+ menstrual (1-5)* + follicular (7-15)	Every other day except Sunday
Braier and Asso (1981)	36	intermenstrually * (10-18)	premenstrually (23-27) intermenstrually (10-18)
DeMarchi and Tong (1972)	20	postmenstrual (7)	premenstrual (25) menstrual (1) postmenstrual (7)
Friedman and Meares (1978)	21	follicular * (6-14)	1-5, 6-10, 11-14 15-19, 20-24, 25-28
Kopell et al. (1969)	8	menstrual (3)	3, 14, 24, 26, 28

* significant   + converted to a 28 day cycle, not original division

criterion premenstrually.

Friedman and Meares (1978) made use of vaginal basal body temperature and urine samples to eliminate subjects who did not show ovulation in the two cycles tested. They reported that subjects tested from day six to 14 had significantly lower thresholds than those tested during the rest of the cycle. According to Braier and Asso (1981), subjects tested during the middle third of the cycle had thresholds that were significantly lower than those tested during the pre-menstrual period.

Becker et al. (1982) studied CFF over the complete menstrual cycle as part of a larger investigation involving changes in physiological and psychological parameters during the spontaneous cycle and cycles during which oral contraceptives were taken. In order to time the cycle days more accurately and relate changes to hormonal levels, they did hormone analyses of serum levels of LH, FSH, prolactin and progesterone measured by radioimmunoassays. Their findings for CFF are presented in Figure 1. Note that downward deflection indicates higher CFF, as in the original figure in Becker et al. (1982). No scale for the ordinate is given, since none was given in the original figure. Becker et al. (1982) reported that CFF during the menstrual phase was significantly higher than during the luteal phase. During the follicular phase, also, CFF was higher than that of the luteal phase, but not significantly.

DeMarchi and Tong (1972) in their literature review have indicated that measures of CFF have been indications of arousal. Also, arousal has been found to change during

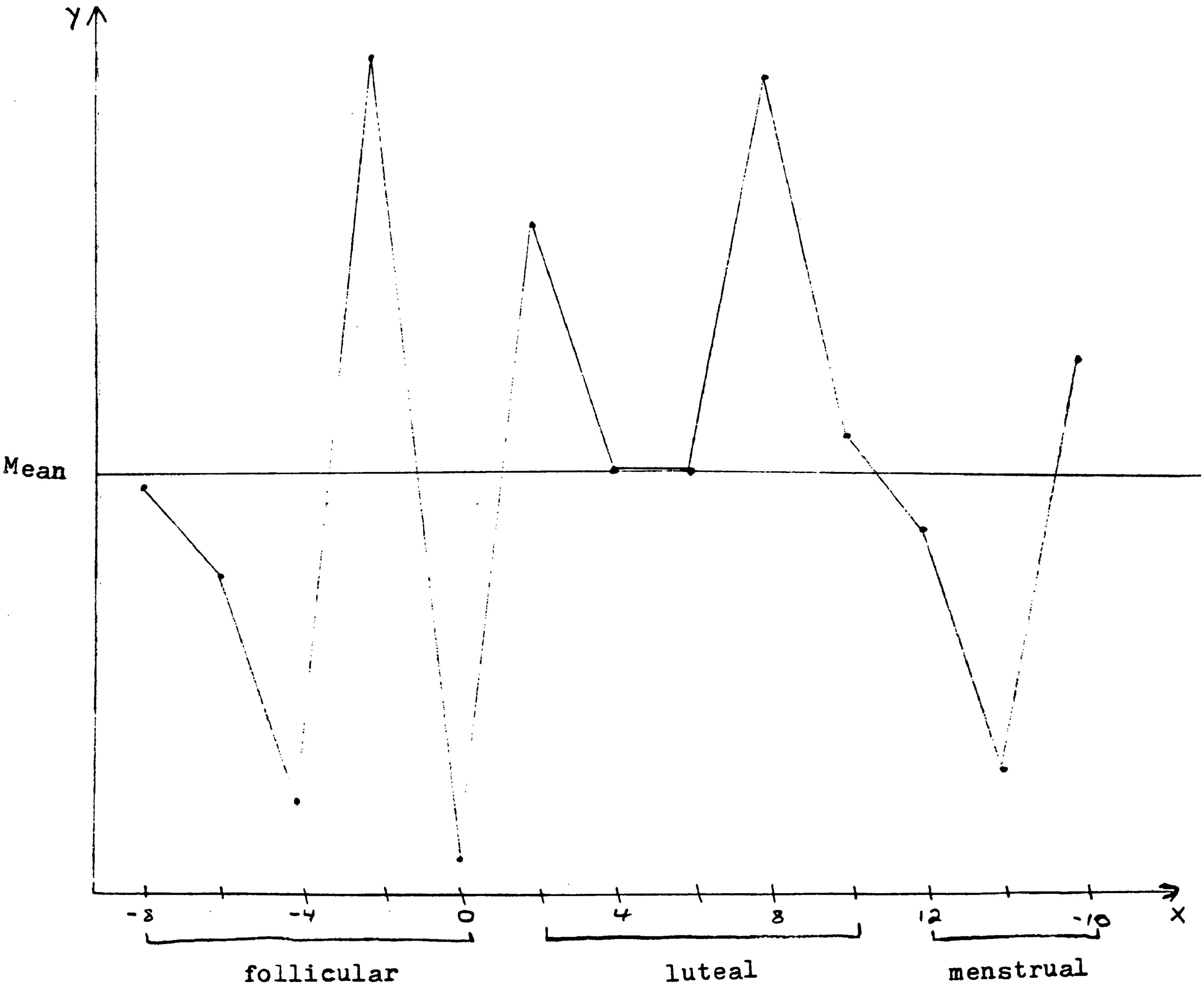


Figure 1. Cycle stage-dependent changes in CFF. Downward deflection during the day of preovulatory LH release (day 0) indicates improved performance. The upward deflection during the premenstrual time (days 8 and 10) indicates impaired performance. From Becker et al. (1982) p. 84.

the menstrual cycle. Therefore, these changes in arousal across the cycle could contribute to changes in CFF. Kopell et al. (1969) report similar variations in arousal across the menstrual cycle. They suggest that hormonal fluctuations over the cycle may be related to arousal changes. Consequently, the arousal of the nervous system may vary with the cycle. Such changes in the arousal of the nervous system may cause fluctuations in CFF. Calloway and Alexander (1960) theorized that CFF is processed through the CNS.

CFF and Sex-Roles

While investigators have found sex differences in CFF the possibility that this difference reflects psychosexual rather than biological factors has not been studied. Recently, considerable evidence has been obtained showing that masculine or feminine sex roles are important determinants of behavior. Bem (1974) devised a sex-role inventory which measured self-perceptions of masculinity and femininity. It was her belief that sex-role perceptions could be an important variable in areas where sex differences had previously been found.

If this is the case, than sex-role perception could influence the criterion for deciding when intermittent light is fused or flickering.

Deaux's (1984) analysis of gender research suggested that the Bem Sex Role Inventory (BSRI) and the Personal Attributes Questionnaire (PAQ) are the best known scales used to assess masculinity and femininity. From the original BSRI, the concept of androgeny was also incorporated. However, as Deaux suggested, the concept of androgeny is based on the masculinity and femininity roles and actually adds littlee information.

The BSRI has been used extensively to assess masculinity and femininity. However, it has rarely been used in studies of perception. Ho (1981) studied the relation between sex, sex-role typing behavior, and children's problem solving ability. Subjects were categorized into sex role orientations based on Bem's scale and were tested on a concept identification task. Ho concluded that problem solving bahavior was differentially related to sex-role typing behavior.

Milton (1957) studied the effects of sex-role identification upon problem solving skills with adult subjects. A group of 63 males and 66 females were given a variety of problem solving tasks including mathematical tests, verbal tests, and behavioral tests. Milton speculated that sex differences in problem solving may be partially accounted for by differences in sex-role identification. The results indicated that there was a positive relationship between masculine sex-role identification and problem solving skills both across sexes and within a sex. When allowances were made for this relationship, the difference between men and women in problem-solving performance diminished.

Sex-role identification as a variable in studies of sex differences in perception has not been explored to date. Since sex-roles have been found to be related to sex differences in some areas of cognitive research, such as problem solving, it would be useful to investigate how measures of CFF may be related to sex roles.

The present study is designed to investigate sex differences in CFF. Sensitivity across the menstrual cycle will be explored by testing CFF across the complete menstrual cycle. In addition, the influence of sex-role perception on CFF will be examined.

Experiment I

Method

Subjects. Three female volunteers aged 21, 22 and 23 acted as subjects. These subjects met the criteria of menstrual regularity, normal visual acuity and were free of medication. At the time of selection, each girl was required to provide information concerning the dates of menstruation for her previous two periods, the expected dates for the next two periods and the usual length of menstruation.

Apparatus. A Lafayette Flickometer, Model No. 1202A was used to activate a glow modulator tube (Sylvania R1166) which produced a luminance of 30.3 ft.-L. The pulse to cycle value used was .5. An optical system was devised which projected the target stimulus onto a diffusing glass 2.5 cm. in diameter masked with white cardboard. The subject viewed the target luminance through the glass binocularly from a distance of 100 cm. The rate of intermittence was continually changed by a 9-rpm motor attached to the flickometer knob. The motor was activated by the experimenter by throwing a switch and was stopped by the subject pressing a button. The subject pressed the button when the target first appeared to either flicker or remain steady depending upon the trial.

Procedure. During two minutes of adaptation to the illumination of the room, subjects were instructed to watch the light which would appear through the aperture in front of them. Subjects were asked to blink as infrequently as possible. They were instructed to press a button located on the table in front of them when the light appeared to be steady or flickering, depending upon the trial. Subjects were told prior to each trial whether to respond to the light if flickering or steady. After a couple of test trials the subject was given 10 test trials using the method of limits with half of the trials ascending and half descending. The ascending and descending values were averaged to yield the subject's mean CFF score for each session.

The subjects repeated the 10 trials three times a week for a period of approximately two months or sufficent time to cover two complete menstrual cycles. Subjects gave a brief record of menstrual cycles occurring during the experimental period.

Results.

Three female subjects were tested over two complete menstrual cycles. Their CFF values were computed by taking the mean of the 10 trials for each day, combining both ascending and descending values. The mean CFF value for each day of the cycle tested for each subject are found in Appendix C. Their CFF values for the various days of each cycle are plotted in Figures 2, 3, and 4. Mean CFF values are represented along the y-axis and days of the cycle along the x-axis beginning with the first day tested.

In order to reveal any possible patterns of sensitivity changes over the cycle time, and to facilitate comparison among subjects, the data for the two months for each subject were combined in the following manner. (see Appendix H). (1) Days of testing were indicated in tabular form. (2) For each day in month one, a corresponding day in month two was found so that they formed a pair with either exactly a cycle between them, or a cycle plus or minus one day. All such paired days are indicated in Appendix H by ellipses. (3) Average values for all pairs are shown in Figures 5, 6, and 7.

For each subject by herself, the question can be raised as to whether or not her pattern in month one resembles her pattern in month two. To investigate this, correlations were computed for each subject between the

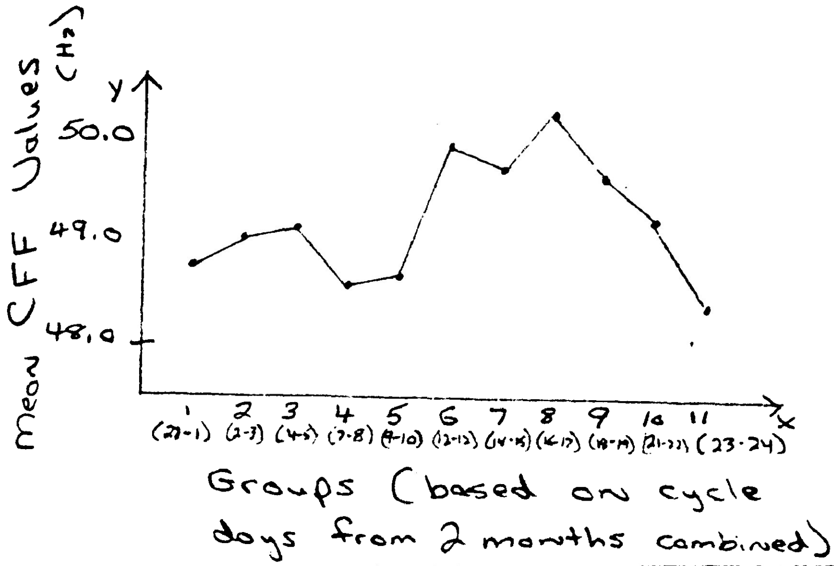


Figure 5. CFF values for various days averaged across two complete menstrual cycles for subject one.

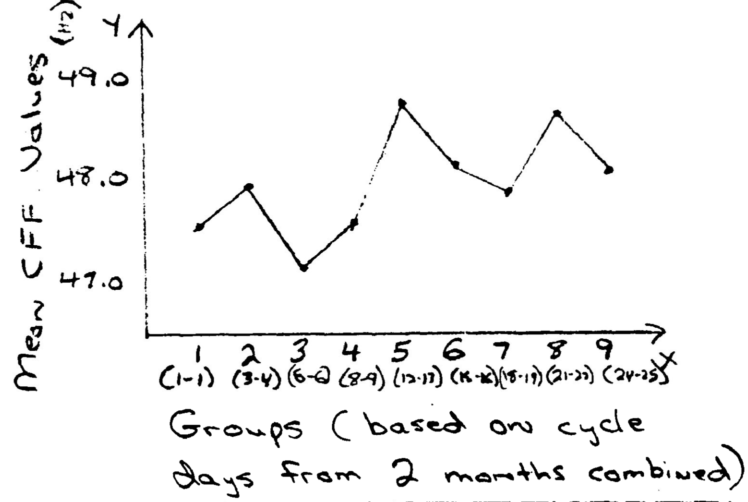


Figure 6. CFF values for various days averaged across two complete menstrual cycles for subject two.

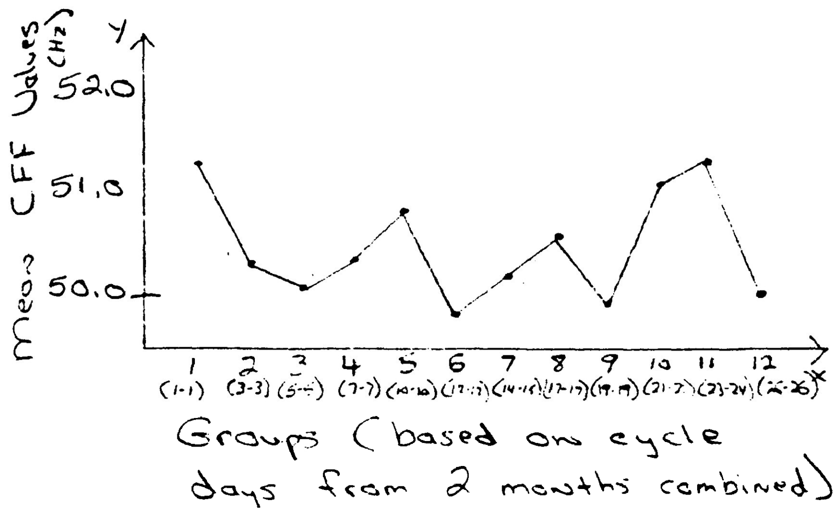


Figure 7. CFF values for various days averaged across two complete menstrual cycles for subject three.

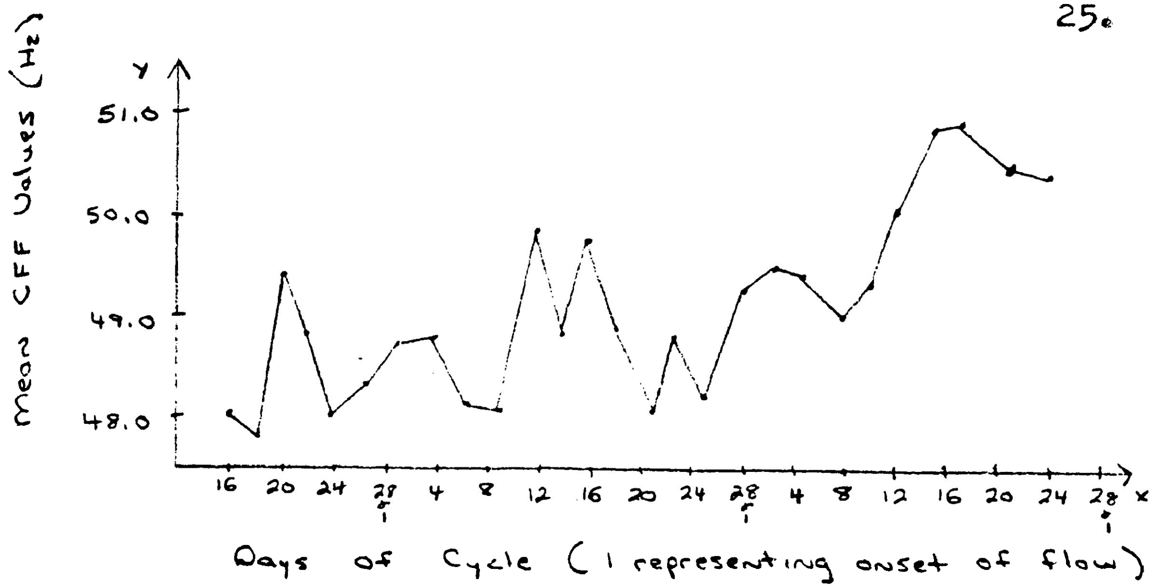


Figure 2 . Subject one's CFF values for various days across two complete menstrual cycles.

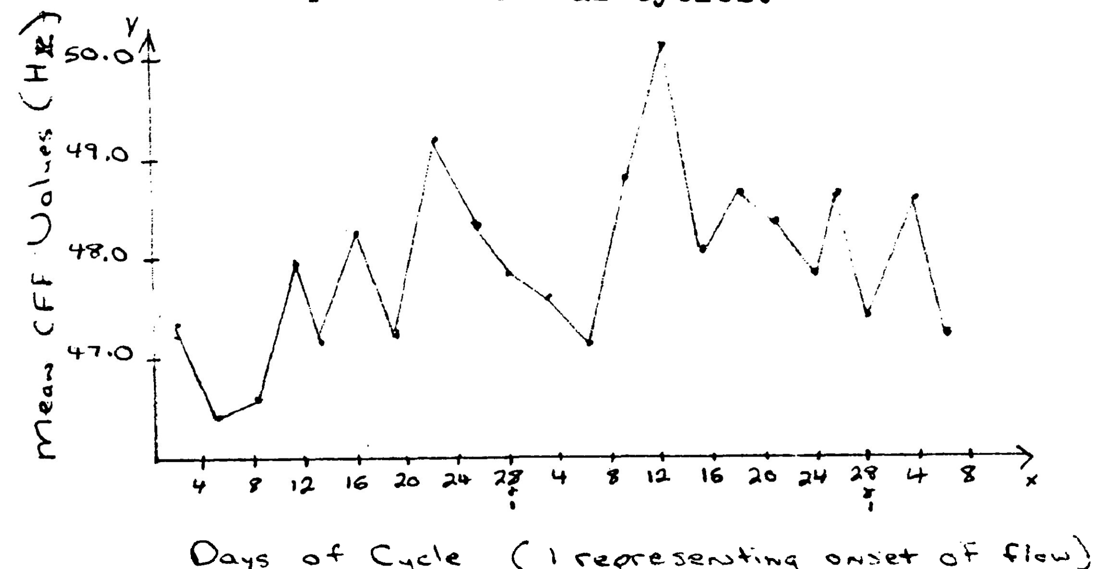


Figure 3 . Subject two's CFF values for various days across two complete menstrual cycles.

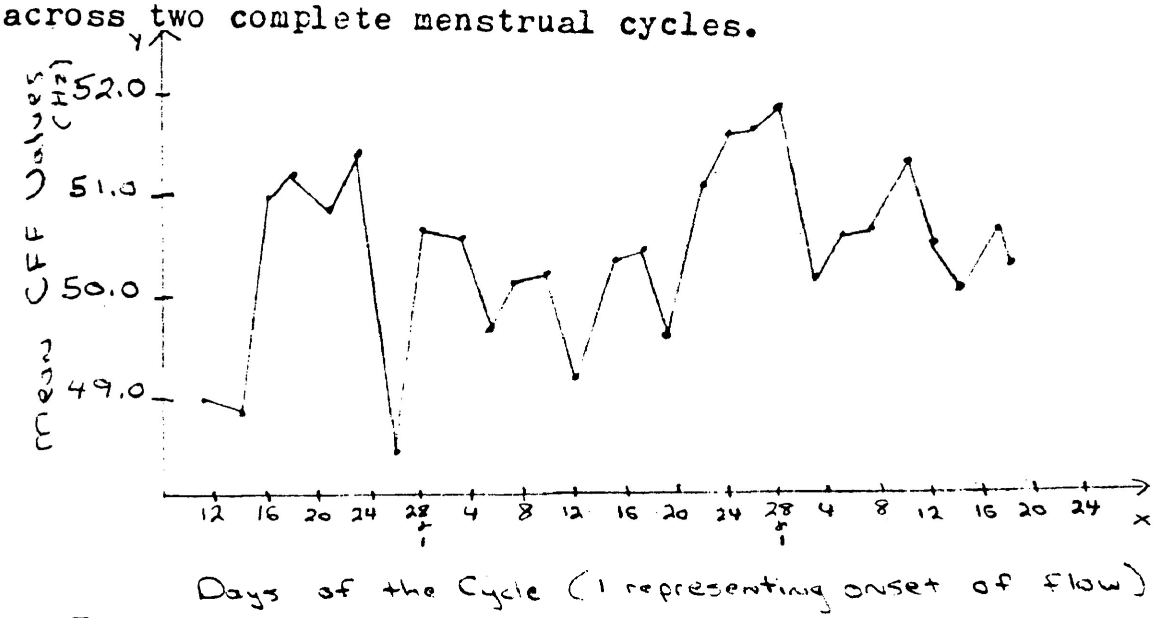


Figure 4 . Subject three's CFF values for various days across two complete menstrual cycles

paired days in appendix H. These correlations are as follows: .58 for subject one, .27 for subject 2, and .12 for subject 3.

A practice effect is evident from Figures 2, 3, and 4. All three subjects' CFF values increased during the second cycle tested. With all three subjects, the mean CFF value for the first month tested was lower than the mean CFF value for the second month tested. This is seen in Table 2.

Table 2. Mean CFF Values for each Month.

	Mean CFF Values	
Subject Number	First month tested	Second month tested
1	48.65	49.55
2	47.62	48.27
3	50.09	50.73

Experiment II

Method.

Subjects. One hundred and five subject volunteers with 50 males and 55 females in the group ranging in age from 18 to 39 years were tested. The mean age for both males and females was 22 years of age. Female subjects had to be free of medication and preference was given to those with menstrual regularity. Five female subjects were separated from the group because they were taking oral contraceptives. All subjects participated as part of the course requirement for the introductory psychology program at Lakehead University, Thunder Bay, Ontario.

Apparatus. A Layfayette Flickometer and optical system, described in Experiment I was used. Bem's Sex Role Inventory (1974) consisting of 60 items to be rated on a seven point scale was administered (in Appendix A). The females were given an additional questionnaire pertaining to their menstrual cycles (in Appendix B).

Procedure. Subjects were given the 10 trials, as outlined for Experiment I, only once. After the trials, subjects were required to complete Bem's Sex Role Inventory. This was labelled as a personality inventory. Female subjects from this group were given an additional questionnaire and were told it was a questionnaire on the menstrual cycle to see if bio-rhythms had an effect on personality traits.

Results.

Fifty males with a mean age of 22 obtained a mean CFF score based on five ascending and five descending trials. As well, each subject obtained a mean masculinity and a mean femininity score based on a seven point rating scale of 20 masculine and 20 feminine items derived from Bem's Sex Role Inventory. These results are in Appendix D. A list of the 20 masculine and 20 feminine items utilized is in Appendix F.

Fifty-five females with a mean age of 22 obtained mean scores for CFF, masculinity and femininity as outlined above for males. In addition, the day of the menstrual cycle each girl was at when tested and the length of their typical cycle was recorded. This information is available in Appendix E. Although girls were screened prior to testing to eliminate those on any medication which might alter or regulate their cycles, such as oral contraceptives, five subjects did participate who were taking such medication and consequently, these five were dropped from any subsequent data analysis. Their results are in Appendix E. This cut the female sample in this study down to 50.

The CFF score for the males ($\bar{x}$ = 46.82, S.D. = 2.52) and for females ($\bar{x}$ = 45.16, S.D. = 2.09) were compared using a t-test of the difference between means for independent groups. They differed significantly, $t(98) = 3.53$, $p < .001$. The five pill users tested had CFF scores similar to the female group and significantly different from the male group, $t(53) = 1.82$, $p < .05$ (one tailed).

Analysis of the Bem scores for males show the mean masculinity score to be 5.29 while the femininity score is 4.63. For females, the mean masculinity score is 4.78 while the mean femininity score is 5.05. The Bem scores were compared with mean CFF values for males and females separately and these correlations are found in Table 3.

Table 3. Correlations between Bem scores and the mean CFF values for males and females.

Sex	Items Correlated	r
Male	CFF and masculinity	.22
	CFF and femininity	.37*
	CFF and masculinity/femininity difference	.02
	CFF and masculinity/femininity sum	.34*
Female	CFF and masculinity	-.10
	CFF and femininity	-.07
	CFF and femininity/masculinity difference	.03
	CFF and femininity/masculinity sum	-.12

*$p < .02$

For the 50 females, their CFF scores were looked at across the menstrual cycle. Of the 50 subjects, 43 had a regular menstrual cycle (approximately 28 days). The other seven subjects had irregular cycles and the cycle day they were on when tested could not be derived with any degree of accuracy. Cycle days for the other subjects were predicted by counting the number of days that had passed since the onset of flow of their last period. CFF values for the 43 regular subjects were plotted in Figure 8 based on the day of their cycle on which they were tested.

The points of figure 8 show no obvious patterns across the cycle. To reveal any possible trends in the data, the following operations were carried out. The number of subjects tested on each cycle day were grouped in a table (see Appendix G). With the exception of the three subjects tested on days 24, 26, and 27 it is possible to divide the other 40 subjects into four groups according to time of testing. The scores of these groups were examined for trends in both CFF and sex role values. These data are found in Table 4 and Figure 9 for CFF and in Table 5 and Figures 10,11 and 12 for sex roles.

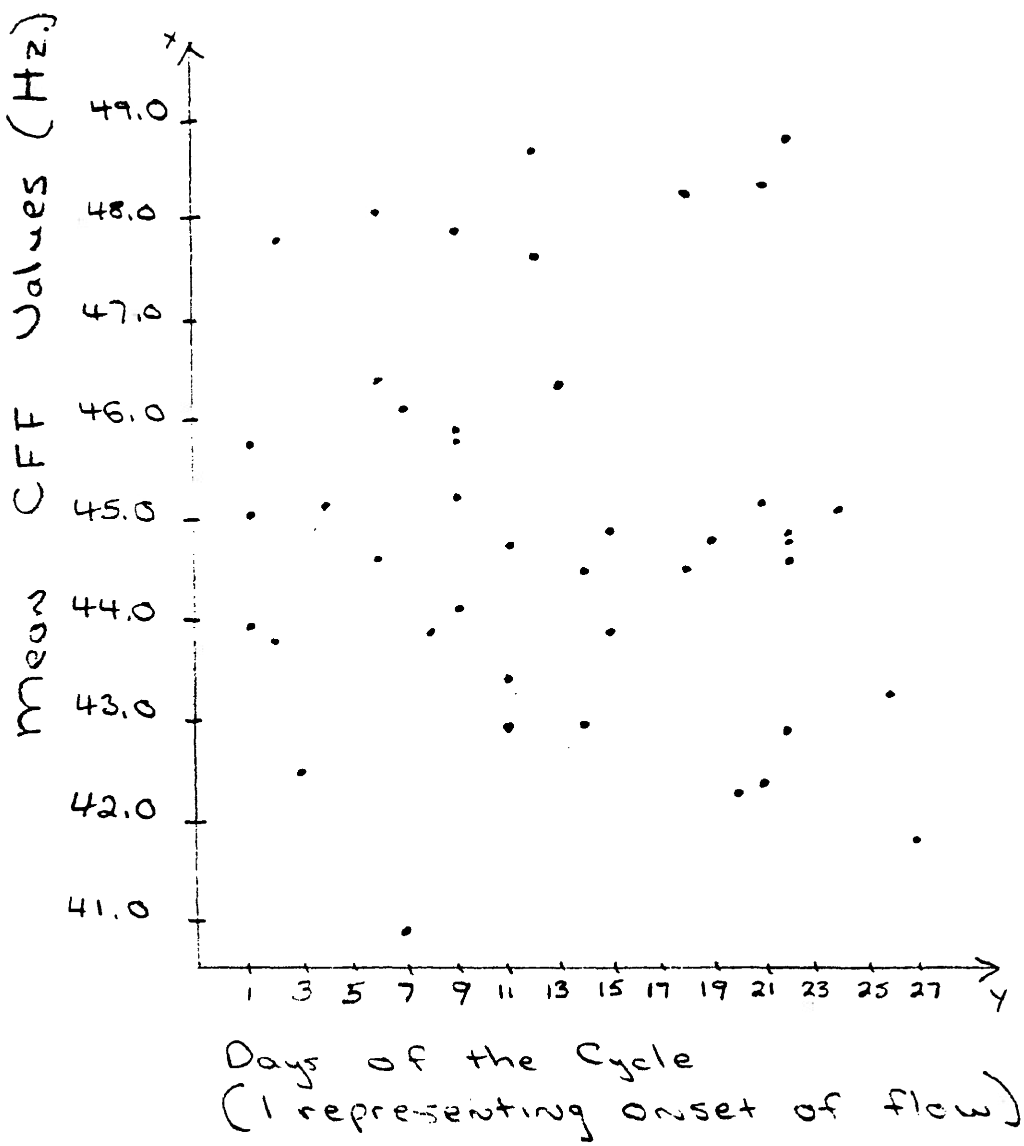


Figure 8 . CFF Values for Various Days across the Menstrual Cycle.

Table 4. Median and Mean CFF scores for four groups of subjects tested during various cycle days.

Group	Cycle Days	Number of Subjects Tested	Median CFF Values	Mean CFF Values
1	1 to 4	7	45.06	44.86
2	6 to 9	11	45.78	45.40
3	11 to 15	10	44.65	45.00
4	18 to 22	12	44.80	45.19

Table 5. Median femininity, masculinity and femininity/ masculinity difference scores for four groups of subjects tested during various cycle days.

Group	Cycle Days	Number of Subjects Tested	Median Femininity Score	Median Masculinity Score	Median Femininity/ Masculinity difference Score
1	1 to 4	7	5.10	4.90	.20
2	6 to 9	11	4.90	4.90	.00
3	11 to 15	10	5.30	4.70	.60
4	18 to 22	12	5.05	4.75	.30

Figure 9. Median CFF values for various days across the menstrual cycle collapsed into four groups

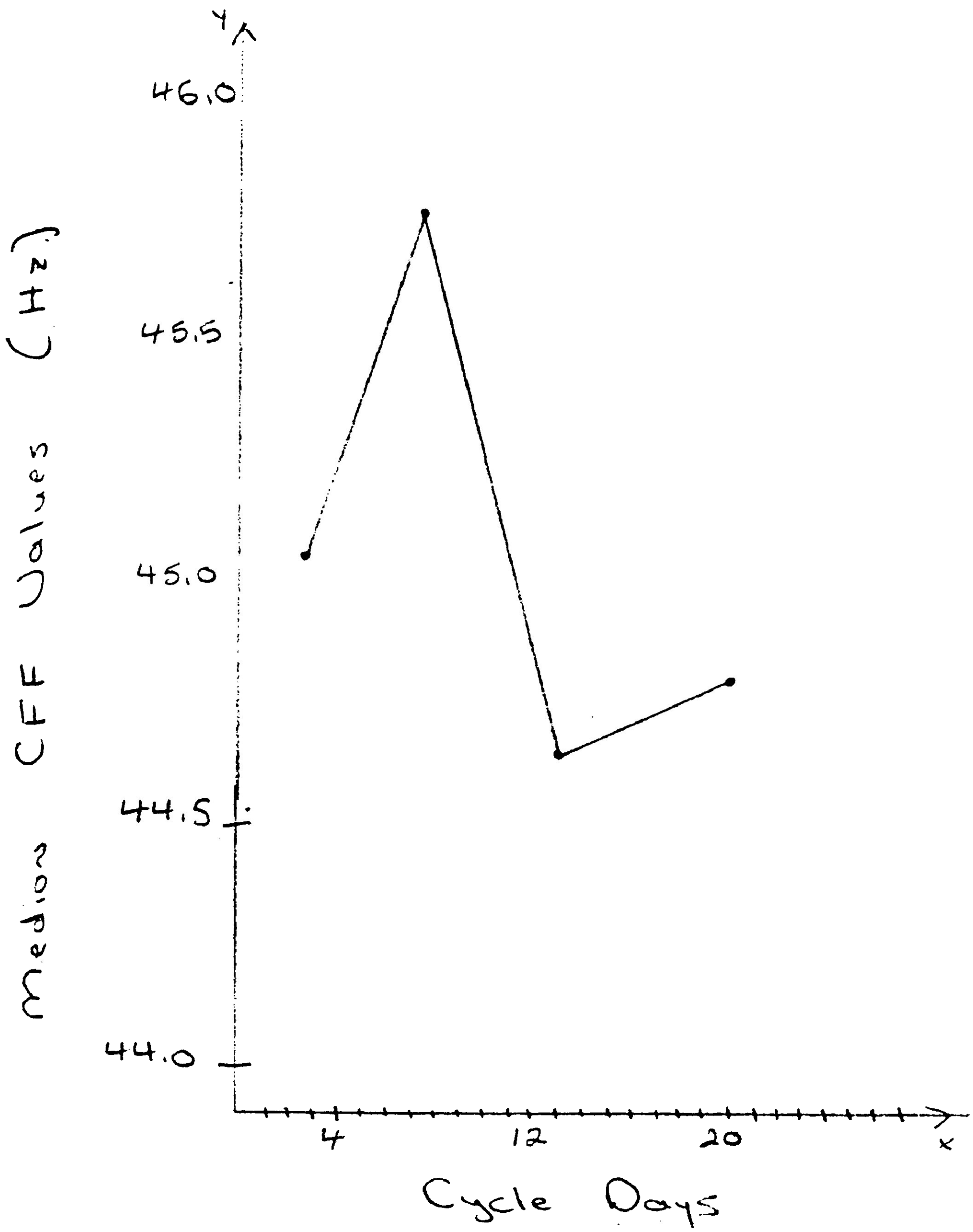


Figure 10. Femininity scores for four groups of cycle days

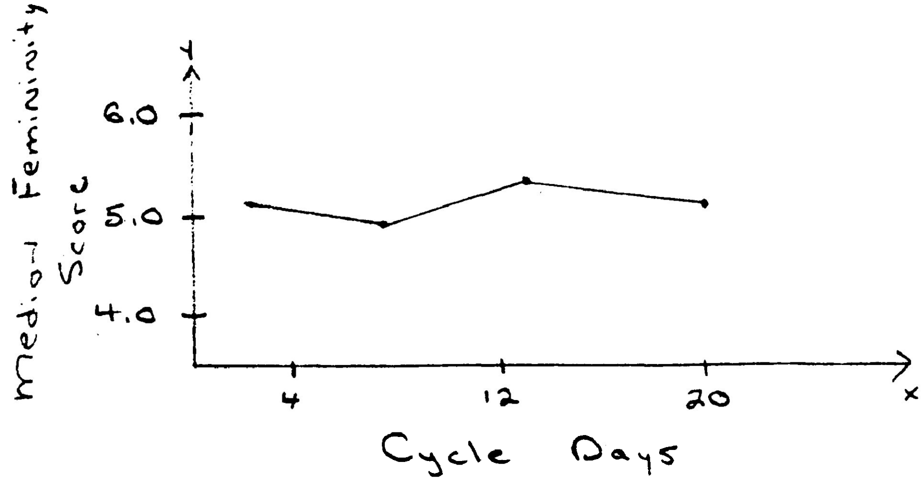


Figure 11. Masculinity scores for four groups of cycle days

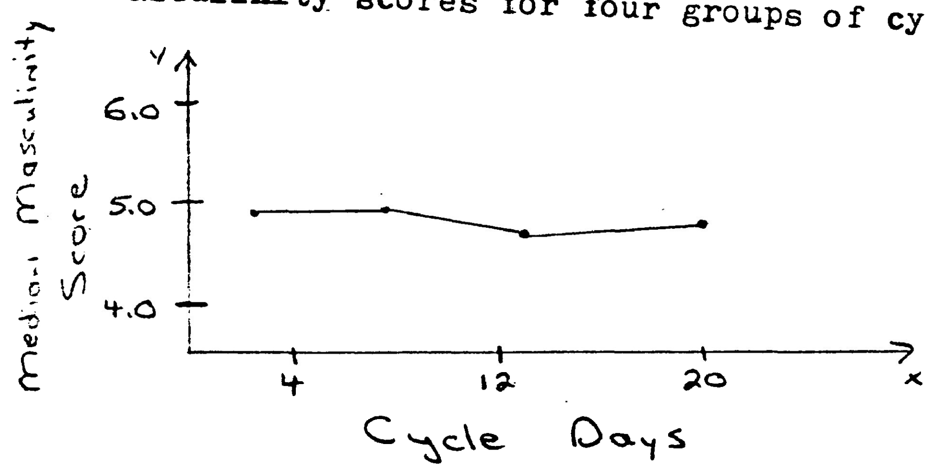
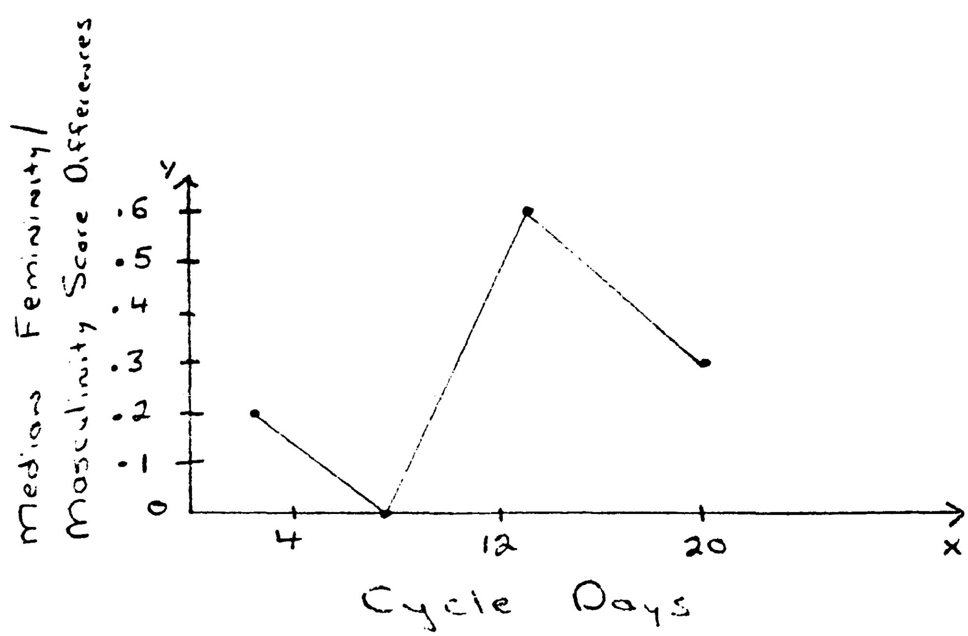


Figure 12. Femininity/Masculinity difference scores for four groups of cycle days.



A one way analysis of variance was done for the four groups of subjects mentioned in Table 5. These results are found in Table 6.

Table 6. A one way analysis of variance for four groups of subjects at four different cycle stages.

Source	ss	df	MS	F	p
Total	151.84	39	-	-	-
Between groups	1.469	3	.49	.12	-
Within groups	150.371	36	4.18	-	-

Discussion.

The present study examined sex differences in sensitivity to intermittent light. Males were found to be significantly more sensitive than females. Two interpretations to account for this sex difference were explored. One interpretation attributes it to differences between the sexes in internal biochemical environment. Any differences found across the menstrual cycle would tend to support such an interpretation. However, the present study found no evidence for differences in CFF across the cycle. The other interpretation suggested that the difference was due to psychosexual factors which could be related to sex role perception. This was partially supported. Males CFF scores tended to be correlated with their sex role perception. Particularly their femininity and masculinity/femininity sum scores. No relationship between CFF and sex roles was found for females.

The average difference in CFF between males and females was 1.66 Hz. Ginsburg et al. (1982) found a similar difference (1.69 Hz) in a similar CFF task. Misiak (1947) found a 1.83 Hz. difference with males scoring higher (for his young sample). All three studies show a sex difference in the same direction and of the same order of magnitude. This difference was also found by Hartmann (1934). In Experiment I the average CFF scores were higher than those of either of the groups in Experiment II. However, the CFF values are not unusually high and similar values were found by Hecht and Shlaer (1942).

Investigators who have found a sex difference in CFF (Ginsburg et al., 1982) have speculated that these differences may be due to hormonal influences. Gandelman (1982) stated that hormones modulate the expression of various behaviors and may alter sensory-perceptual mechanisms. He suggested, in a review of this area, that one approach to studying the effects of hormones is by observing events across the menstrual cycle.

There are at least two ways in which data from thresholds across the cycle could lend support to a hormonal interpretation of the sex difference. The simplest arguement is as follows. Let us suppose that females have roughly the same sensitivity as males except for one critical period during the cycle. Presumably this period would be during the menstrual flow itself, when it would be expected that sensitivity is appreciably lowered. In any group of female subjects randomly tested as to time of their cycle, about one fifth would be expected to be at this critical period. If the sensitivity of this subgroup were sufficiently depressed, that could conceivably lower the average score for the whole female group.

The data of the present study failed to support such an argument. Of the 50 female subjects, 40 had CFF scores lower than the median for males (46.95). If we examine the subgroup of seven females who were tested during the first four days of the cycle, their median was 45.06, compared with the median score of 44.8 for all females.

Another argument suggests that there may be a systematic relationship between sensitivity and the menstrual cycle. The second way in which cyclic fluctuation might support an hormonal interpretation is more complex. Males produce testosterone; females produce progesterone, prolacytin, LH and FSH. Conceptually, the most straight-forward way of studying hormone effects would be to administer hormones to subjects who lack them. But, practically, this is rarely possible. In the only such study of which we are aware, Simonson et al. (1941) gave methyltestosterone (male sex hormone) to males who had very little of it and found their sensitivity was increased.

In lieu of the difficulty of direct manipulation, we can make use of nature's manipulations. Hormone levels change greatly during the menstrual cycle. If we find changes in sensitivity related to the time in the cycle, this supports an hormonal interpretation of sensitivity differences.

Investigators who have studied the relationship between visual sensitivity and the menstrual cycle have used either CFF tasks or two-flash tasks. Results from these studies are found in Table 1. Becker et al. (1982), Braier and Asso (1981), and Friedman and Meares (1978) did find a significant relationship between sensitivity and the menstrual cycle. However, any generalization from these three studies is difficult to draw. It could be said that the period of approximately one week, ending shortly after ovulation, appears to be one of greater sensitivity. Becker et al. (1982), however, found that the time of menstruation was also one of greater sensitivity.

One of the problems in generalizing is that each study used a different way of dividing the cycle. As noted in Table 1, Braier and Asso (1981) used two periods, Becker et al. (1982) three, Kopell et al. (1969) five, and Friedman and Meares (1978) six. This contrasts with the seven divisions recommended by Dalton (1977). It would be helpful to future research if the divisions could be standardized.

An additional difference should be noted among the investigations. Two of the three studies which reported a significant relationship between sensitivity and cycle time made use of physiological measures to determine cycle time. Friedman and Meares (1978) dropped nine subjects from their original sample of thirty since they failed to show evidence of ovulation. It is possible that any study (like the present one) which is limited to subject's verbal report for evidence of cycle time might therefore fail to find a relationship with sensitivity.

Kopell et al. (1969) looked at two-flash threshold and found subjects performed best menstrually (day 3) and poorest premenstrually (days 26 to 28) although their results did not reach significance. DeMarchi and Tong (1972) reported no relationship between sensory sensitivity and the menstrual cycle based on a two-flash task. They did find subjects performed best postmenstrually (day 7) but this was not significant. The present study found no relationship between CFF and the menstrual cycle.

In Experiment I, no pattern of sensitivity fluctuations in accordance with the days of the menstrual cycle is evident. Subject one's results seem to indicate that performance was poorest premenstrually (days 24 to 28) and immediately following the menstrual period (days 6 to 9). Mid-cycle (days 12 to 20) reflect the best performance. Results from subject two are not as clear but they do reflect a similar sequence. However, subject three's performance is opposite to this with best performance levels occuring at the beginning and the end of the cycle. The poorest performance was recorded during the mid-cycle period. These results do not support Becker et al. (1982) who also tested CFF across the cycle.

In Experiment II, grouping points in Figure 9 showed that the subject's sensitivity was greatest postmenstrually (day 7). A one way analysis of variance revealed that this trend was not significant. These findings are very similar to those found by DeMarchi and Tong (1972). They noted lower thresholds postmenstrually (day 7).

The present study observed no systematic differences in sensitivity across the menstrual cycle. Neither did DeMarchi and Tong (1972). Becker et al. (1982), Braier and Asso (1981) and Friedman and Meares (1978) have found a relationship between sensitivity and the menstrual cycle. With these conflicting results further research is needed before any one can draw conclusions about the influence of hormones on sensitivity. Whether hormones account for sex differences in CFF is still an area of controversy. The present study would suggest that hormonal influences on CFF are not a major variable and perhaps other explanations for the sex difference found should be entertained.

The very nature of research on the menstrual cycle makes conclusive remarks difficult. Many studies on the menstrual cycle have used a different scheme to divide the cycle into days. Becker et al. (1982), for example have labelled the day of ovulation day zero and the first day of menstruation, day 10. However, the typical cycle length is 28 days with ovulation occuring around day 14. Therefore, the classification used by Becker et al. (1982) appears to be somewhat arbitrary. Perhaps future research could standardize the cycle day groupings.

A second interpretation to account for sex differences found in studies of CFF suggests that these differences
found in studies of CFF suggests that these differences
might be due to sex role perception. The present study examined this interpretation. The incorporation of masculinity and femininity personality factors showed some significant results. A significant relationship was found between femininity and the femininity/masculinity sum and CFF for males. Also, the masculinity and CFF correlation approached significance for the male group. No relationship was found between sex role perception and CFF for females.

A problem and oversight in drawing any conclusions from these experiments is that in this study only one level of luminance and one PCF value were used. Perhaps

... two or more levels of each of these would have produced different results. It is possible that the different luminance levels could have an effect on the arousal level of the nervous system. Perhaps the level of luminance and the PCF choosen were not influenced by the hormonal changes occuring over the menstrual cycle while other values might be. This is definitely an area worth further consideration in the future.

No other studies, to the best of our knowledge, have examined the influence of sex role perception on CFF. With the significant correlations we found for the male group, this area of research looks promising. Ho (1981) and Milton (1957) believed that sex role perception partially accounted for sex differences in problem solving. The present study suggests that sex role perception may be a variable in CFF sex differences. These results tend to support Bem's (1974) suggestion that sex role perception is a variable in sex differences. The criterion for deciding the point at which CFF occurs may be based on the subjects perceived masculinity or femininity.

One third possible interpretation of the sex differences found in CFF, not investigated here, is genetic. Perhaps the sex difference in sensitivity has a genetic basis.

The possibility of a hormonal basis is unclear and the influence of sex role perception, although promising, may only partially account for the sex differences found. A genetic basis may be another direction for future research. Maybe the genetic differences between males and females influence sensitivity.

Bock and Kolakowski (1973) explored the possibility of a sex-linked major-gene influence on human spatial visualizing ability. Their study found sex differences in human subjects ability to visualize spatial relations and mentally manipulate visual images was influenced by a sex-linked recessive gene. Exploring a genetic basis for sex differences along the lines of Bock and Kolakowski (1973), may show the influence of a recessive gene on visual sensitivity. This suggests the necessity for a large sample size study including parents and siblings to test this genetic theory.

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Appendix A.

Bem's Sex-Role Inventory

On [redacted] this sheet, you will find listed a number of personality characteristics. We would like you to use those characteristics to describe yourself, that is, we would like you to indicate, on a scale from 1 to 7, how true of you each of these characteristics is. Please do not leave any characteristic unmarked.

1	2	3	4	5	6	7
Never or almost never true	Usually not true	Sometimes but infrequently true	Occasionally true	Often true	Usually true	Always or almost always true

Defend my own beliefs		Adaptable		Flatterable	
Affectionate		Dominant		Theatrical	
Conscientious		Tender		Self-sufficient	
Independent		Conceited		Loyal	
Sympathetic		Willing to take a stand		Happy	
Moody		Love children		Individualistic	
Assertive		Tactful		Soft-spoken	
Sensitive to needs of others		Aggressive		Unpredictable	
Reliable		Gentle		Masculine	
Strong personality		Conventional		Gullible	
Understanding		Self-reliant		Solemn	
Jealous		Yielding		Competitive	
Forceful		Helpful		Childlike	
Compassionate		Athletic		Likable	
Truthful		Cheerful		Ambitious	
Have leadership abilities		Unsystematic		Do not use harsh language	
Eager to soothe hurt feelings		Analytical		Sincere	
Secretive		Shy		Act as a leader	
Willing to take risks		Inefficient		Feminine	
Warm		Make decisions easily		Friendly	

Sex: ______

Age: ______

	a	b	Class	
R.S.				
S.S.				

*

Appendix B.

General Questionnaire

Please answer all the questions here as quickly as possible. Some questions are of a personnal nature however all the information requested will be kept strictly confidential. The calendar at the bottom of the page may be helpful in recalling certain dates.

Age: ________

1. What are the dates of the onset of your last two menstrual cycles? (onset of flow) ______________________________

____

2. When do you estimate your next cycle to begin? ________

____

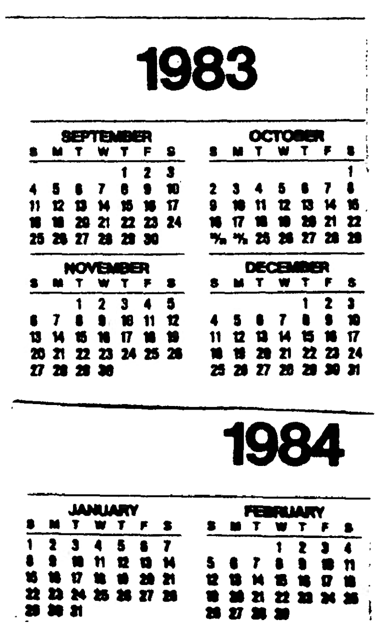
3. How many days does your cycle usually last? __________

4. Do You have a regular or irregular cycle? ___________

____

5. Are you presently on any medication which will regulate your cycle or which may alter it? ie. oral contraceptives, hormones, prescription drugs. Yes ___ No ___

Thank You!



Appendix C.

CFF in Hz. For Subjects one, two and three.

Subject One		Subject Two		Subject Three	
Cycle Days	Mean CFF	Cycle Days	Mean CFF	Cycle Days	Mean CFF
16	48.01	2	47.38	11	48.96
18	47.82	5	46.49	14	48.88
20	49.45	8	46.52	16	50.96
22	48.83	11	47.95	18	51.15
24	48.0	13	47.26	21	50.96
27	48.28	16	48.24	23	51.43
2	48.77	19	47.17	26	48.42
4	48.81	22	49.11	28&1	50.73
7	48.1	25	48.38	3	50.52
9	48.06	28&1	47.82	5	49.66
12	49.80	3	47.52	7	50.06
14	48.82	6	47.15	10	50.12
16	49.7	9	48 78	12	49.12
18	48.88	12	50.33	15	50.29
21	48.08	15	48.08	17	50.43
23	48.87	18	48.69	19	49.57
25	48.22	21	48.34	22	51.17
28&1	49.36	24	47.83	24	51.53
3	49.51	26	48.63	26	51.54
5	49.49	28&1	47.43	28&1	51.81
8	49.01	4	48.59	3	50.07
10	49.41	6	47 16	5	50.58
12	50.11			7	50.63
15	50.84			10	51.38
17	50.94			12	50.48
19	50.49			14	50.04
22	50.46			17	50.71
				19	50.27

Appendix D.

CFF in Hz. for the 50 male subjects of Experiment II.

Age	CFF Mean	Bem Scores Masculinity	Bem Scores Femininity
20	53.61	4.9	5.9
26	50.97	5.5	4.85
21	50.33	6.35	5.7
20	49.51	4.1	4.3
21	49.03	5.85	4.1
19	48.98	5.85	4.5
23	48.77	5.75	4.65
30	48.76	5.65	4.9
25	48.7	4.75	5.6
19	48.7	5.05	5.05
22	48.33	4.8	4.5
23	48.16	6.4	4.75
22	48.16	5.25	4.2
19	48.09	3.7	4.45
24	48.07	6.7	4.9
24	48.01	5.9	4.55
23	47.78	6.0	4.3
20	47.52	6.35	5.0
24	47.48	5.2	5.3
24	47.43	6.5	5.65
22	47.42	5.35	4.6
26	47.34	5.5	4.45
20	47.18	4.95	3.9
20	47.17	4.9	4.75
26	46.99	5.05	4.25
24	46.92	5.55	5.25
20	46.78	5.25	4.85
27	46.6	6.4	4.65
22	46.59	5.25	5.15
22	46.59	4.2	4.5
19	46.45	4.45	4.0
19	46.23	5.7	5.0
21	46.04	5.45	4.85
27	45.99	5.6	5.05
24	45.98	5.6	4.35
24	45.89	6.7	4.2
19	45.82	5.65	4.05
19	45.72	6.3	4.1
19	45.48	4.2	5.45
22	45.32	4.9	3.4
21	45.13	4.2	4.05
20	45.03	4.35	3.85
25	44.44	5.25	4.35
20	44.36	3.95	4.0

19	44.3	4.0	4.1
20	43.88	4.7	4.25
19	43.7	5.95	4.05
19	42.92	5.85	4.35
24	41.82	4.3	5.0
21	40.41	4.9	5.25

Appendix E.

CFF in Hz. for the 55 female subjects in Experiment II.

Age	CFF mean	Bem Scores Mas.	Bem Scores Fem.	Menstrual Cycle Day tested	Menstrual Cycle Usual cycle length
20	50.75	3.95	4.5	11	irregular
19	48.95	4.8	5.03	22	30
19	48.7	4.7	4.95	12	31
19	48.56	4.00	5.05	21	30
19	48.28	5.2	5.05	18	26
23	48.1	5.65	4.9	6	28
20.	48.08	4.4	4.95	16	irregular
19	47.87	5.05	4.45	9	28
26	47.79	4.9	4.75	2	28
18	47.66	4.8	5.05	12	28
21	46.43	4.7	5.1	6	33
20	46.4	4.35	5.9	13	28
23	46.18	4.75	4.1	7	29
23	46.16	4.2	5.45	11	irregular
21	45.88	5.7	5.45	9	28
28	45.78	5.35	4.8	9	28
19	45.71	3.7	4.8	1	30
20	45.49	5.3	4.95	39	irregular
22	45.28	4.7	5.4	9	32
23	45.22	4.45	6.3	4	29
23	45.2	4.65	4.3	21	28
19	45.10	4.1	5.5	24	28
27	45.06	4.65	5.25	1	28
19	44.87	5.2	5.75	15	28
20	44.81	5.15	5.25	19	32
22	44.81	4.15	4.65	22	28
19	44.78	3.35	5.65	22	27
20	44.77	4.7	5.5	11	28
18	44.77	5.25	4.9	44	irregular
20	44.7	6.6	5.35	11	irregular
39	44.67	5.05	5.05	22	26
27	44.64	4.6	4.9	6	30
18	44.53	4.75	5.15	14	28
20	44.51	4.36	4.8	18	32
19	44.14	4.9	5.7	9	29
29	43.96	5.5	4.2	1	30
36	43.86	4.6	4.9	8	30
21	43.84	5.5	5.15	15	30
21	43.82	5.45	5.1	2	28
32	43.37	4.4	5.45	11	32
24	43.28	4.25	4.65	26	28
19	42.94	4.1	5.5	14	30
21	42.93	4.3	4.05	11	29
19	42.92	4.45	5.3	15	irregular
19	42.91	4.55	4.1	22	30
22.	42.51	5.25	5.5	3	31
19	42.44	5.8	4.9	21	28
20	42.32	5.25	5.25	20	34
26	41.63	4.0	4.25	*32	33
20	40.91	5.3	5.45	7	28

These participants were omitted because they were taking oral contraceptives.

20	46.21	4.25	4.25
19	45.35	4.75	5.4
19	44.04	4.75	5.1
24	44.61	4.75	4.75
37	43.45	4.55	4.95

These last five are not in order of testing due to their extraction from the above sample.

* Day 32 was plotted in figure seven as day 27 based on Dalton's cycle conversion.

Appendix F.

Critical Items on Bem Sex-Role Inventory

Masculine Items	Feminine Items
Defend my own beliefs	Affectionate
Independent	Sympathetic
Assertive	Sensitive to needs of others
Strong Personality	Understanding
Forceful	Compassionate
Have Leadership Abilities	Eager to sooth hurt feelings
Willing to take risks	Warm
Dominant	Tender
Willing to take a stand	Love Children
Aggressive	Gentle
Self-reliant	Yielding
Athletic	Cheerful
Analytical	Shy
Makes Decisions Easily	Flatterable
Self-sufficient	Loyal
Individualistic	Soft-spoken
Masculine	Gullible
Competitive	Childlike
Ambitious	Do not use harsh language
Act as a leader	Feminine

Appendix G.

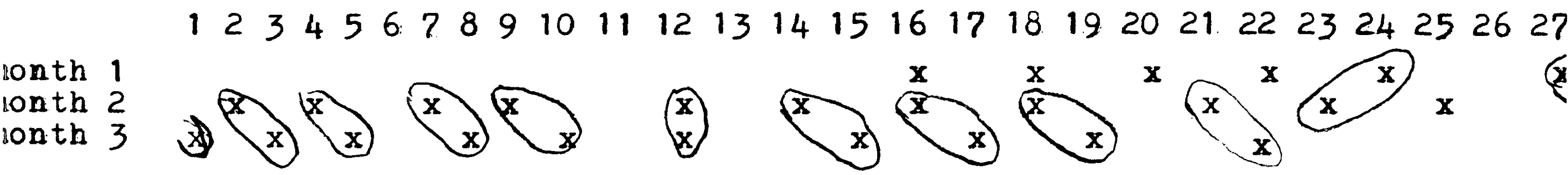
Number of female subjects with a regular cycle tested on the various cycle days. These results are plotted in figure seven and are the basis for groupings for figures nine, 10 and 11.

Days	Number of Subjects Tested
1	3
2	2
3	1
4	1
5	-
6	3
7	2
8	1
9	5
10	-
11	3
12	2
13	1
14	2
15	2
16	-
17	-
18	2
19	1
20	1
21	3
22	5
23	-
24	1
25	-
26	1
27	1

Combining of days across two cycles for figures 4, 5, and 6.

Subject 1.

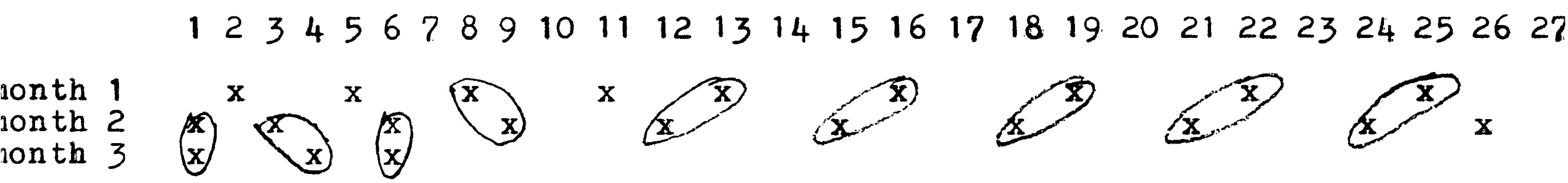
Cycle Days;



x represents day tested ⬭ represents groupings.

Subject 2.

Cycle Days;



Subject 3.

Cycle Days;