EFFECTS OF MENSTRUAL CYCLE ON VERBAL AND SPATIAL ABILITY

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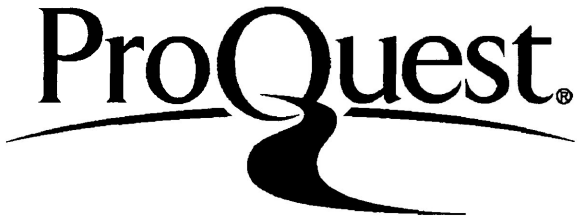

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Abstract

The effects of the various phases of the menstrual cycle upon spatial and verbal ability were investigated. Three groups, males, females on oral contraceptive (OC) and females not on oral contraceptive (NOC), served as subjects. All females had 28 day regular menstrual cycles. Each group had thirty subjects. On days 3, 14 and 24 of the regular 28 day cycle, representing three menstrual cycle phases (menstrual phase , ovulatory phase, premenstrual phase) each subject was administered both the Vocabulary subtest of the Wechsler Adult Intelligence Scale and the Spatial subtest of the General Aptitude Test Battery. Males were randomly assigned cycles similar to females being tested.

Males scored significantly higher on the spatial task than either of the female groups, and in the verbal task males scored significantly lower than either of the female groups. The present findings indicate that the two female groups (NOC and OC) did not differ significantly from each other on either the verbal task or the spatial task. However, over the three phases of the menstrual cycle the two female groups showed different levels of fluctuation on verbal ability.

Both spatial and verbal abilities of the OC female group and male group showed stability over a 28 day menstrual cycle. Whereas, the NOC female group showed stability for spatial ability over the 28 day menstrual cycle but not for verbal ability. For the NOC female group the verbal scores on day 14 were significantly higher than

the scores on either day 3 or day 24. On the verbal scores, the two female groups did not differ significantly from each other at any specific phase of menstrual cycle.

The fluctuation in NOC group's verbal ability as reported in the present study could be attributed to the effects of menstrual cycle. Although menstrual cycle had significant effect on the NOC female group's verbal ability, the overall effect it had on sex differences was minimal.

INTRODUCTION

The female menstrual cycle is characterized by a number of physiological changes which are maintained by a reciprocal relationship between the pituitary gonadotropins and ovarian steriods (Laws, 1977). As a part of the normal activity of the menstrual cycle, fluctuations in the amount of estrogen and progesterone are observed at different phases of the cycle, (see Figure 1). In the present study, subjects were tested at three different phases of the menstrual cycle (menstrual phase, ovulatory phase, premenstrual phase). Once phase of menstrual cycle was determined, inferences about hormonal activity were postulated. It is known that the pituitary ovarian relationship can be altered through the use of oral contraceptives. For this reason, a group of females taking oral contraceptives were used in this study as a control group. A group of males were also used as a control group to study sex differences.

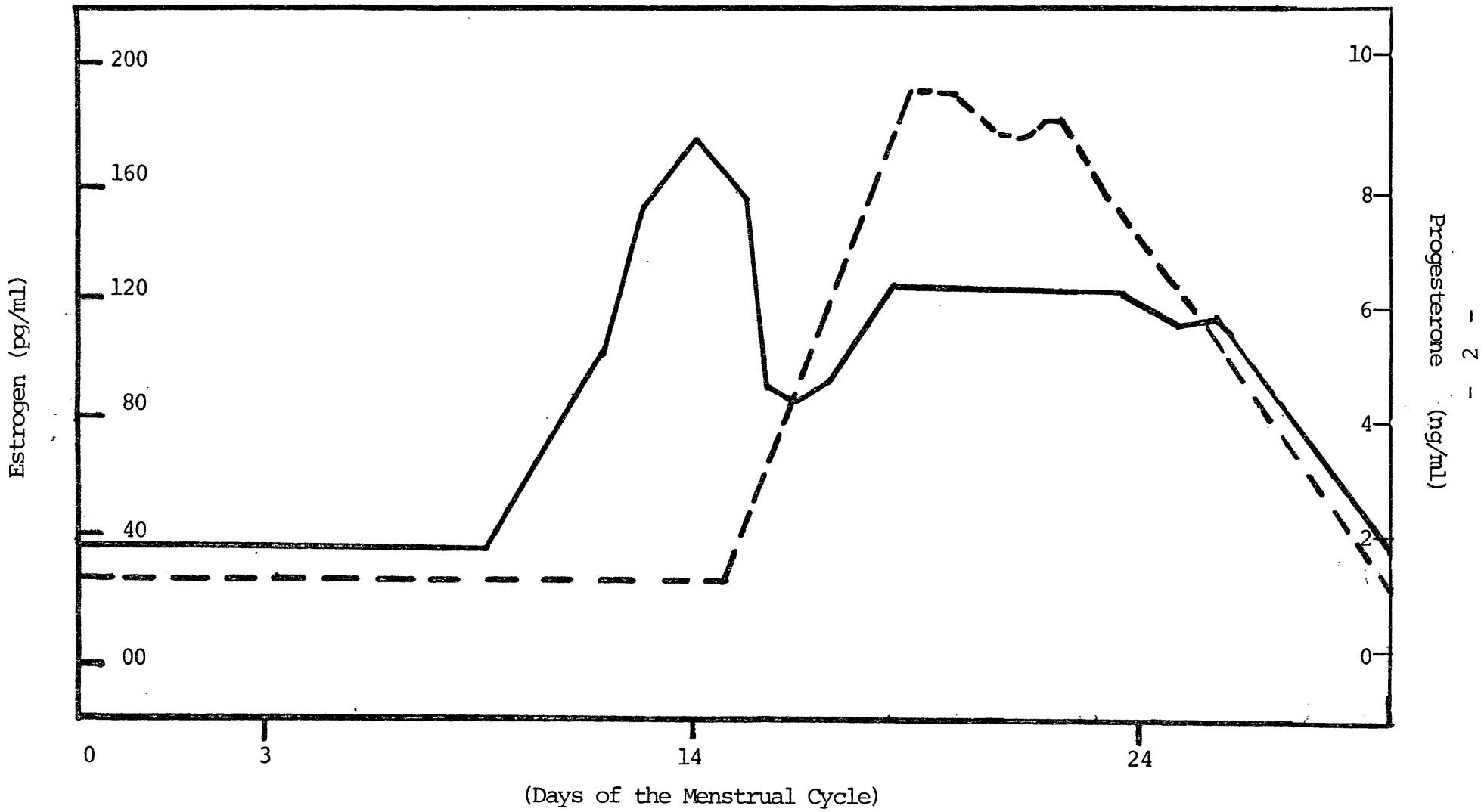

Figure 1. Relative changes in estrogen and progesterone levels throughout the Menstrual Cycle; Day 0 refers to onset of menstrual flow. Level of progesterone is indicated by a dotted line. Level of estrogen is indicated by a solid line (Mogenson, 1977).

Sex Differences in Spatial Tasks

Spatial ability refers to the extent to which one can internalize reflection and construction of space in thought (Hart and Moore, 1973). Spatial ability could refer to audio-spatial perception, tactual-spatial perception or visual-spatial perception. Since nearly all theory and data concern only visual-spatial perception, this research focused itself on visual-spatial perception.

There is a general agreement that more than one spatial factor exists and that the factors are highly related. There is not, however, an agreement on how many spatial factors there are, their names and how they differ from each other. One factor, Spatial relations and orientation, is considered to involve comprehending the arrangement within a visual stimulus pattern with the subject's body as a frame of reference, eg., tests such as Flags or Cards (Michael, Guilford, Fruchter and Zimmerman, 1957). In contrast, the visualization factor requires mental manipulation of an object or parts of the configuration such as with the Space Relations test (Bennet, Seashore and Wesman, 1966). A third factor involves right-left discrimination (Michael et al., 1957) A fourth factor has been called Gestalt Flexibility in the space perception literature (Thurstone, 1944) and also field dependence versus field independence (Witkin, Lewis, Herzman, Machover, Meissner and Wapner, 1954) or global versus analytical cognitive style (Witkin, Dyk, Patterson, Goodenough and Karp, 1962). This skill involves retaining a configuration so as to be able to pick it out in spite of perceptual distractions of an organized nature (Coates,

1974). It has also been called visual disembedding, field articulation and figure-ground discrimination. It has been measured by a laboratory test, the Rod and Frame Test.

Maccoby and Jacklin (1974) concluded that sex differences in spatial tasks involving disembedding and those in visual-spatial tasks not involving disembedding emerge in early adolescence and are maintained in adulthood for both kinds of tasks.

By far the greatest amount of research concerning sex-related spatial differences has been focused on field articulation. Field-dependence versus field-independence and global versus analytical cognitive approach are considered as crucial dimensions of human development upon which the two sexes differ (Witkin et al., 1954; Witkin et al., 1962). Females are generally found to be field-dependent and males are generally found to be field-independent.

Differences between the sexes in the 1955 standardization sample of the Block Design subtest of the Wechsler Adult Intelligence Scale (Matarazzo, 1972) were also found. The Block Design subtest is a highly respected test of spatial visualization which has also been used as a measure of field articulation. The sample consisted of 1700 persons between sixteen to sixty-four years of age. Males scored significantly higher than females.

It has generally been thought that males are superior to females in visual spatial perception. This opinion is expressed by various authors (Anatasis, 1958; Burstein, Bank and Jarvik, 1980; Cohen, Schaie and Gribbin, 1977; Droege, 1967; Eichhorn, 1973;

Fruchter, 1954; Guilford, 1959; Maccoby, 1966; Maccoby and Jacklin, 1974; Oetzel, 1966; Schaie and Strother, 1968; Shipman, 1971; Smith, 1964; Stanford Research Institute, 1972; and Tyler, 1965).

Sex Differences in Verbal Tasks

Unlike spatial ability, females are usually conceded to have well-developed verbal ability. Females are generally thought to be superior in verbal skills as compared to males (Burstein et al., 1980; Davies, 1965; Droege, 1967; Flanegan, Darley, Shaycoft, Gorhow, Orr, Goldberg, and Neyman, 1961; Hall, 1978; Harris, 1977; Maccoby and Jacklin, 1974; McGuinness, 1976; Oetzel, 1966; and Very, 1967).

Maccoby and Jacklin (1974) state there are distinct phases in the development of verbal skills in the growth cycles of both the sexes. The females' advantage in language development is short lived. At about three years the boys catch up and in most populations the two sexes perform very similarly until adolescence, when again females exhibit superiority over males. Maccoby and Jacklin (1974) described the usual female advantage in the verbal area as about 0.25 SD. They pointed out that the female advantage includes "higher-level skills, such as comprehension on complex written test, quick understanding of logical relations expressed in verbal terms, and in some instances verbal creativity", (page 84). These data indicate that the slight verbal advantage that females retain in adulthood applies to verbal skill in general.

The results of the vocabulary subtest from the 1955 standardization of the Wechsler Adult Intelligence Scale (Matarazzo, 1972)

shows that females scored significantly higher than males.

However, when rigid control of variables related to sex role are introduced, the size of the differences between the sexes decreases for both spatial and verbal abilities (Fennema and Sherman, 1977; Johnson, 1976; Sherman, 1974).

Behavioral Changes During Menstrual Cycle

It is well known that many women show fluctuations in various aspects of their behavior which occur in conjunction with the phases of the menstrual cycle (Burstein et al., 1980; Schwank, 1971, b; Silbergeld, Brast and Noble, 1971; Sommer, 1973, b; and Southam and Ganzaga, 1965). These behaviors will be considered under the following subsections: physical symptoms, behavioral symptoms, and behavioral and physiological changes:

Physical Symptoms Many women report variations in negative affect over the menstrual cycle. Paulson (1956) found that over seventy percent of women tested complained of premenstrual irritability, tension, fatigue, abdominal bloating, or back pain, and Vingilis (1978) found that there was a significant tendency for irritability, and back pain during the last premenstrual day and the first two menstrual days. Sutherland and Stewart (1965) found that only seventeen percent of one-hundred and fifty women were free from pain during the menstrual cycle. Sixty-eight percent among one thousand teenage Finnish girls reported some form of negative premenstrual symptomology (Widholm and Kantero, 1971). Several studies have reported similar findings (Beaumont, Richardi,

and Gelder, 1975; Gruba and Rohrbaugh, 1975; Moos and Leiderman, 1978; Reeves, Garvin and McElen, 1971; Samspon and Jenner, 1977; and Takayama, 1971).

Behavioral Symptoms Many studies have reported both positive and negative behavioral symptoms to vary significantly across the menstrual cycle. Negative behavioral symptoms include accident proneness (Dalton, 1960; Liskey, 1972), emergency hospital admissions (Dalton, 1959; Dalton, 1960; Glass, Meninger, Lansky and Talan, 1971; Janowsky, 1969; and MacKinnon, MacKinnon and Thomspon, 1959; Mandell and Mandell, 1967; Tonks, Rack and Ross, 1967; Wetzel and McClure, 1972; and Wetzel, Reich and McClure, 1971), neurotic and psychotic depression (Beaumont et al., 1975; Dalton, 1959; Gregory, 1957; and Jacobs and Charles, 1970), crimes of violence (Dalton, 1961; Morton, Addition, Addisom, Hunt and Sullivan, 1953), aggressiveness (Luschen and Pierce, 1972; Moos, 1969; Schonberg, Costanzo and Carpenter, 1976) mood fluctuations (Altman, Knowles and Bull, 1941; Gottschalk, Kaplan, Gleser, and Winget, 1968; Herlihy, 1977; Ivey and Bardwick, 1968; Luschen and Pierce, 1972; Parker, 1960; Rossi and Rossi, 1977; and Sommer, 1973, a). Positive behavioral symptoms include willingness to volunteer (Doty and Silverthorne, 1975; Parlee, 1975), and sexual arousal (Hart, 1960; Luschen and Pierce, 1972).

Behavioral symptoms which could be categorized as negative occurred most frequently during either the menstrual phase and/or premenstrual phase. Behavioral symptoms which could be categorized as positive occurred most frequently during ovulation.

Sexual desire was also reported to occur during menstrual phase (Hart, 1960).

Behavioral and Physiological Changes Studies have reported female behavioral performance to show non-significant variation on various tasks associated with menstrual cycle (Kopell, Lunde, Clayton, Moos, Hamburg, 1969; Pierson and Lockhart, 1963; Sommer, 1971; Smith, 1950). While other studies, have reported behavioral and physiological changes, as summarized in the following paragraphs, to vary significantly across the menstrual cycle.

Although not all of the following studies relate directly to the present research, their documentation is of importance to show trend of menstrual cycle effect.

The relationship between gonadal hormones and cognitive performance were studied in females with ovulatory menstrual cycles, females on oral contraceptives and males (Dickey and Stone, 1978). For the females with the ovulatory menstrual cycle the highest performance on simple repetitive tasks and the lowest performance on tasks requiring inhibition occured in the ovulatory phase.

As reported by Sommer (1973, b), "self-report" studies indicated that a small percentage of women feel that their judgement or mental faculties were impaired to some extent particularly in the premenstrual phase of the menstrual cycle (Moos, 1968; Morton et al., 1953).

Sex differences in auditory figural after-effects (FAE) were examined with and without associating the differences in FAE to

the various phases of the females' menstrual cycle (Satinder and Mastronardi, 1974); The magnitude of the FAE varied significantly in relation to the phase of the menstrual cycle in the female group. No significant sex differences were found when the phases of the menstrual cycle were not taken into account.

A number of experiments have demonstrated changes in various measures of visual perception related to the menstrual cycle (Baisden and Gibson, 1975; Demarchi and Tong, 1972; Diamond, Diamond and Mast, 1972; Kopell et al., 1969).

For vibrotacticle learning, in which electronic pulses were transmitted to the subject's left wrist, (27 NOC female subjects aged 17-27) premenstrual group showed significantly greater number of errors particularly relative to pressure sensitivity (Diespecker and Kolokotronis, 1971).

Sensory sensitivity changes in female NOC subjects was reported to closely parallel the changes in estrogen and progesterone secretion accompanying the menstrual cycle (Wong and Tong, 1974).

Schwank (1971, a) tested ten NOC female college subjects between the ages of nineteen and twenty-eight years. The primary task was a self paced key press in response to a light flash. A second task involved the sorting of regular playing cards with the subject estimating the time required after the deck was sorted. A trend toward lower performance in the menstrual and premenstrual phases was noted although the differences were not statistically significant.

Wineman (1971) reviewed studies of autonomic balance changes in normal women during and through the menstrual cycle and found significant phase differences in the measures of the autonomic nervous system activity (salivary output, sub-lingual temperature, palmar and volar skin conductance, diastolic blood pressure, log conductance change) with high scores reported during menses, follicular and ovulatory phases. During the luteal phase, these scores were the lowest. It was concluded that high estrogen levels are accompanied by decreased sympathetic nervous system (SNS) function.

In summary, there is a consistent strong trend for negative reports to occur more frequently in the premenstrual and menstrual phases and positive reports to occur more frequently in the ovulatory phase in relation to physical and behavioral symptoms. However, findings in relation to the behavioral and physiological changes were not as consistent.

Some studies reported lower scores during premenstrual and menstrual phases (Diespecker and Kolokotronis, 1971; Schwank, 1971, a), some reported higher scores to occur during ovulation (Dickey and Stone, 1978; Wineman, 1971), some reported lower scores to occur during ovulation (Dickey and Stone, 1978), some reported higher scores to occur during menstrual phase (Wineman, 1971), while some reported scores not to change (Kopell et al., 1969; Pierson and Lockhart, 1963; Sommer, 1971; Sommer, 1972; Smith, 1950).

Various theories have attempted to explain the behavioral changes which are reported to occur during the menstrual cycle.

Several studies attribute the changes to variations in the general state of arousal during the menstrual cycle. It is speculated that change from a state of either lowered arousal to a state of heightened arousal or change from a state of heightened arousal to a state of lowered arousal may have profound psychological effects. This period of disequilibrium could be experienced by some as pleasant or unpleasant depending on individual characteristics. This state of disequilibrium has been speculated to be related to symptoms such as the increased irritability associated with premenstrual tension syndrome and improved functioning at midcycle.

The mechanisms responsible for the change in arousal during menstrual cycle (NOC) has been explained using a hormonal model attributing changes before ovulation to estrogen and changes occurring in the luteal phase to progesterone or the combination of estrogens and progesterone. This scheme is consistant with reports that estrogens have a CNS-activating effect, whereas, progesterone or the combination of estrogens and progesterone have a depressant effect (Vogel, Broverman, and Klaiber, 1971).

Other studies have suggested that gonadal hormones may not in themselves be the most important factors. Other possibilities include the reninangiotensin-aldosterone system which could be fluctuating in parallel with phases of the menstrual cycle and having an effect on central neurotransmitters.

The adrenergic system has also been used to explain changes in activity levels, since plasma monamine oxidase (MAO) activity has been found to be significantly higher in the postovulatory compared

to preovulatory phase of the NOC menstrual cycle (Klaiber, Kobayashi, Broverman, Hall, 1971). It has been suggested that elevated levels in the second half of the cycle could result in a deficiency of catecholamine activity and this could account for lowered arousal.

Other studies have attributed such specific behavioral changes as physical and behavioral symptoms to be a combination of learned behavior, as well as, due to change in the general state of arousal of the nervous system. Such studies base their position on evidence indicating that females tend to report suffering severity of behavioral and physical symptoms similar to symptoms reported by their mothers.

Effects of Gonadal Hormones on Female Performance

If hormones do indeed affect female behavior, what are the properties and characteristics of estrogen and progesterone which cause them to affect cognitive functioning and how does this relate to verbal and spatial ability?

Some studies have investigated the effects of gonadal hormones on female performance. According to Broverman, Klaiber, Kobayashi, Vogel (1968), sex hormones, by inhibiting the enzyme monamine oxidase (MAO) raise the level of central norepinephrine and are therefore associated with activation or arousal. Activation is hypothesized to facilitate performance on simple repetitive tasks and to impede performance on tasks requiring inhibition (Broverman et al., 1968).

As summarized by Burstein et al., (1980), "In essence,

Broverman et al., (1968) have postulated that the perceptual restructuring required for spatial tasks is facilitated by cholinergic inhibitory neural processing mechanisms of the parasympathetic nervous system as opposed to the adrenergic activating processing mechanisms of the sympathetic nervous system. Large amounts of estrogens or androgens are postulated to tip the neural balance in the direction of activation, but estrogens are thought to be more powerful than androgens so that females are more likely to have the balance of their nervous system tipped in the direction of activation, and have more difficulty with tasks requiring inhibition. The theory of Broverman et al. (1968) has been criticized on physiological (Parlee, 1972) and methodological (Singer and Montgomery, 1968) grounds...", page 300.

Briggs and Briggs (1972) and Klaiber et al. (1971) found that plasma MAO activity varied systematically over the course of the menstrual cycle in women, the lowest levels of MAO activity occurring when estradiol levels were highest (ovulatory phase).

Therefore, according to Broverman et al. (1968) one would expect highest activation and arousal during the ovulatory phase of the menstrual cycle. This would be consistent with previous research findings indicating a trend for positive reports, in regards to symptoms, mood, behavior, and some performance tasks to occur in conjunction with the ovulatory phase.

Also, according to Broverman et al. (1968), performance tasks requiring inhibition are affected negatively by high activation and arousal. Dickey and Stone (1978) are in agreement with Brover-

man et al. (1968) reporting spatial performance to be lowest during ovulatory phase.

Biochemical, neurophysiological and behavioral evidence has been reported to show that progesterone enters the brain and affects brain function (Hamburg, 1966). Among the reported effects of progesterone on brain function are the following: (i) general anesthesia in large doses (ii) sedation in moderate doses (iii) elevation of threshold for convulsive seizures and (iv) facilitation of various aspects of reproductive behavior.

McAdoo, Doering, Kraemer, Dessert, Brodie and Hamburg (1978) reported that several hours following the administration of gonadotropin-releasing hormone, there was a decrease in anxiety and fatigue and an increased alertness and speed of performance in human subjects. The increased alertness in the first half of the cycle found in this study was attributed to the presence of lutenising hormone (LH) and follicle-stimulating hormone (FSH) which are released by gonadotropin-releasing hormone. The LH peak especially coincides with the change in arousal.

Lamb, Ulet, Masters and Robinson (1953) and Vogel et al. (1971) found that the EEG "driving responses" to photic stimulation of regularly menstruating women varied over the menstrual cycle. Their research also indicated that estrogen had an inhibitory effect of the "driving response" while an estrogen plus a progestin enhanced the response.

In summary, findings of studies investigating gonadal hormones

to determine how they affect performance have found that neither estrogen nor progesterone always affect cognitive abilities in the same manner. Some cognitive abilites would appear to be facilitated by estrogen and hindered by progesterone, whereas, for other cognitive abilities the reverse would appear to be the case.

This suggests that in determining how a specific cognitive task will be affected by fluctuating hormones one must not only understand the properties of the hormones being studied but one must also understand the properties of the specific cognitive task being studied.

Effects of Oral Contraceptive on Hormonal Fluctuation

Hormonally mature females who are not using oral contraceptives or who are not pregnant, undergo continual cyclic fluctuations in their amount of estrogen and progesterone, (see Figure 1). Whereas, those females who are using oral contraceptives show little or no hormonal fluctuation. Therefore, if the behavior is dependent upon and is in part the result of hormonal activity, one would expect menstruating females, who are not using oral contraceptives to have behavior more variant than that of males and females using oral contraceptives.

Study of the psychological aspects of oral contraceptives showed that females using oral contraceptives were more stable on a number of menstrual cycle symptoms, i.e., negative affect, pain, concentration etc., than the female group not using oral contraceptives. Paige's (1971) study of the effects of oral contracep-

tives on affective fluctuations associated with the menstrual cycle indicated that while women with natural menstrual cycles produced a U-shaped pattern of negative affect, women using oral contraceptives showed no cyclic affective changes. Negative affect was measured at various phases of the menstrual cycle by an instrument that is not distorted by self-report or social expectations about menstruation. Their results are presented in Figure 2 (Paige, 1971).

Other studies have also reported that women on oral contraceptives experience significantly less severity of symptoms such as pain, water retention, concentration and negative affect than women not taking oral contraceptives (Englander-Golden, Wellis, and Dienstbier, 1977; Friedman and Meares, 1979; Grant and Pryse-Davies, 1968; Herzberg and Coppen, 1970; Marinar, Leshner and Doyle, 1976; Paige, 1971; and Wong and Tong, 1974).

The Rationale of Present Research Several studies have reported male superiority in spatial ability and female superiority in verbal ability to emerge at adolescence (Maccoby and Jacklin, 1974). For example, in the age range from 6-11 years, there appear to be no consistent sex differences in verbal abilites (Burstein, et al., 1980), although after adolescence females generally appear to out perform males in tests of verbal skill (Droege, 1967; Eichhorn, 1973; Gallagher, 1964; Maccoby and Jacklin, 1974). No distinct sex differences were found in spatial skill until adolescence, in a review of over thirty studies involving some component of spatial ability (Maccoby and Jacklin, 1974).

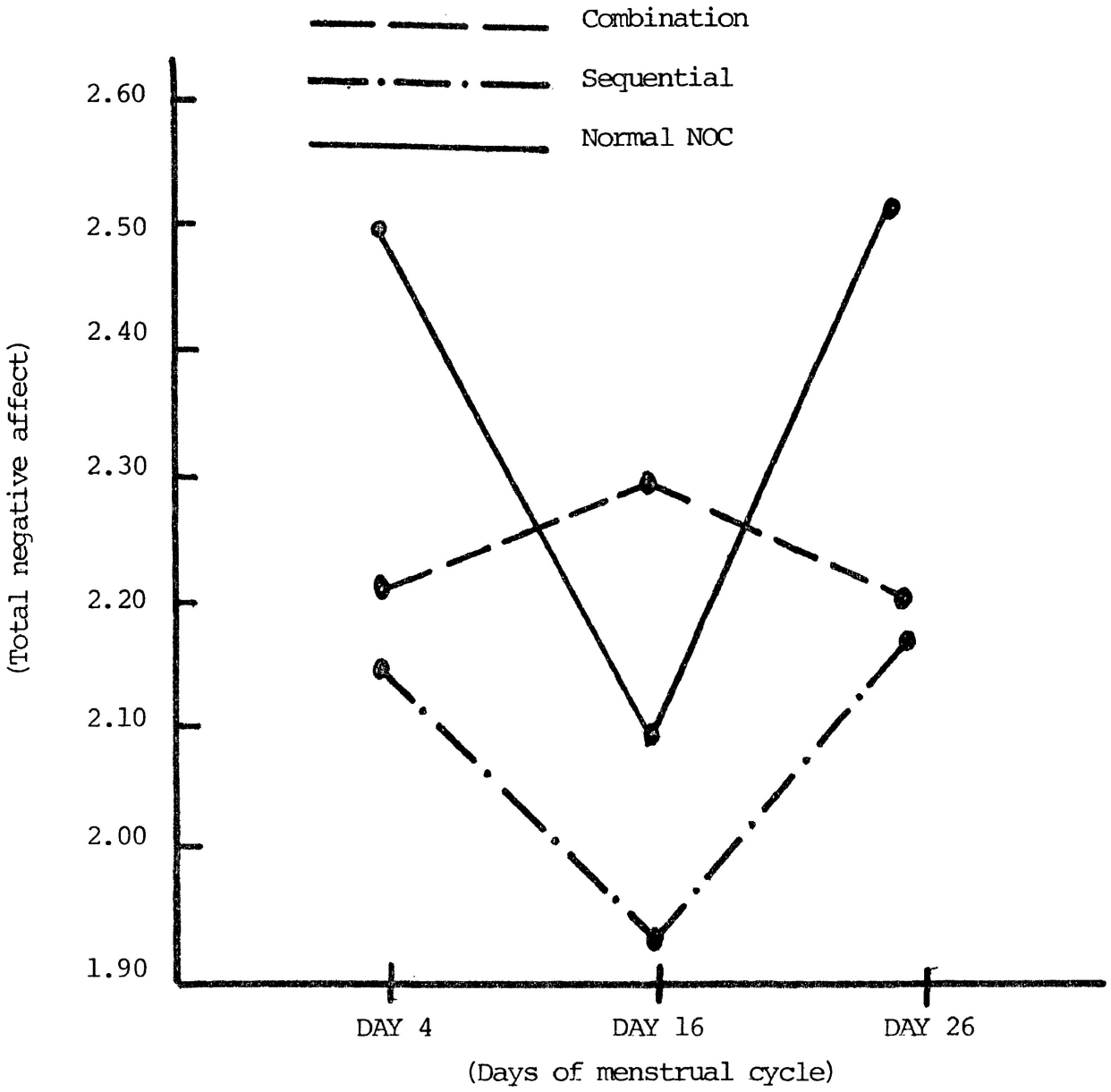

Figure 2. Total negative affect experienced by three groups of females (using combination oral contraceptives, using sequential oral contraceptives, not using oral contraceptives) during one menstrual cycle, (Paige, 1971). (Note: only information pretaining to the present research is illustrated).

One distinct change which takes place in both sexes at adolescence is that of sexual maturation. The manifestation of sexual maturity is distinctly different in the two sexes.

One sex difference at puberty which has varying effect upon male and female behavior concerns the anterior pituitary, which contains cells that secrete growth hormone and prolactin; this organ grows considerably at puberty in girls but barely, if at all, in boys.

The pituitary is greatly involved in the events of puberty. Two of it's products, FSH and LH are present at low levels during childhood but increase during puberty until a point is reached where FSH stimulates either the tubules of the testes or the ovarian follicles to develop.

When FSH stimulates the tubules of the testes males have not been know to undergo much physical stress. However, unlike males, when FSH stimulates the ovarian follicles to develop, females have been known to undergo stress due to the ensuance of the menstrual cycle. As a result, in addition to the secondary sex characteristics which both sexes must adjust to at puberty, females are additionally hampered with adjusting to the physical, physiological, psychological and social stresses which accompany menstruation.

Following this line of thought Englander Golden, Wellis, Dienstbier (1976) hypothesized that some apparent performance differences between the sexes might be artifacts because after adolescence, it is possible that an unstressed male group could be compared with

a female group containing a variable number of women under menstrual stress.

With this in mind, sex-related cognitive differences in the specific areas of spatial and verbal abilities were investigated as a function of the menstrual cycle.

Method

Subjects

Ninety university students, involving equal numbers of males, females taking oral contraceptives and females with a regular 28 day menstrual cycle who were not using oral contraceptives served as subjects. Subjects who fit this requirement were chosen from those who were registered in the first year psychology course. The personal information needed about the subjects was obtained through a general questionnaire (see Appendix A). The subjects ranged in age from 19 to 25 years. Subjects, prior to testing, filled out a questionnaire where they were required to list names and grade levels of courses previously completed (see Appendix A). This was a requirement to ensure subjects chosen would be of relatively equal educational background.

Materials and Apparatus

General information inventory The general information inventory asked the subjects for such personal data as age and sex (see Appendix A). Subjects were also asked to check from a list of courses they had taken and at what level. These courses, such as drafting, physics, mathematics etc., were courses which according to social conditioning theory are thought to facilitate spatial ability. In collecting such information a control for socialization was built into the research design by ensuring the involvement of subjects who all had relatively equal training in the above mentioned fields. Specific questions were asked pertaining to the

regularity of each female's menstrual cycle.

Verbal ability task The vocabulary subtest of the Wechsler Adult Intelligence Scale (WAIS) was used because it is a standardized validated test of verbal ability (Wechsler, 1955). The WAIS assesses intellectual ability in adults. The WAIS is generally used for two kinds of comparisons: how the individual compares with his or her age group and how he or she compares with those who are at the peak of mental development.

Spatial ability task The spatial subtest of the General Aptitude Test Battery (GATB) was used. The GATB is recognized as a validated multiple aptitude test battery for use in vocational guidance because of its extensive research base (United State Employment Service, 1947). The GATB was developed by the United States Employment Service and has been used since 1947 by state employment service offices and by Canada Manpower. Since that time the GATB has been included in a continuing program of research to validate the tests against success in many different occupations.

Experimental Design

Only women with regular 28 day menstrual cycles were recruited as subjects, assuming ovulation for each subject to occur around the fourteenth day following the onset of menstrual flow. The hormonal status of each subject was determined on the basis of menstrual cycle information given to the experimenter before the testing began (see Appendix A).

Hormonal status was not concluded by specific measure of

hormonal levels. Rather, phase of menstrual cycle was determined and inferences about hormonal activity were postulated.

Females using oral contraceptives were used as a control group. This allowed a comparison to be made between females experiencing fluctuating hormonal levels and females who's hormonal levels were controlled. Males were used as a second control group. This allowed comparison to be made between the sexes.

Because each test was intended to be used three times per subject, a control for possible effect of repeated use of tests was built into the design. Each group of thirty subjects was subdivided into three groups of ten, each subgroup thereby started on either day 3, 14, or 24 of the menstrual cycle. This procedure ensured the account of the possible learning effects due to repeated exposure to tests.

At each of the three testings for each individual subject, the Vocabulary subtest of the Wechsler Adult Intelligence Scale (Wechsler, 1955) was administered first followed by the Spatial subtest of the General Aptitude Test Battery (United States Employment Service, 1947). This order of tests administered was decided by random selection.

Procedure

After each subject was comfortably seated in the test room, the Vocabulary subtest of the Wechsler Adult Intelligence Scale (Wechsler, 1955) was administered according to the instructions in the Test Manual.

Following the completion of the Vocabulary subtest (Wechsler, 1955), the Spatial subtest of the General Aptitude Test Battery (United States Employment Services, 1947) was administered according to the instructions given in Section 1 of Administration and Scoring Test Manual.

The test administration order, i.e., verbal test followed by spatial test, was always the same for all the subjects.

This same procedure was repeated for each subject on days 3, 14, and 24 of the menstrual cycle representing menstrual phase, ovulatory phase and premenstrual phase.

Scoring The standard procedures for the Vocabulary subtest of the WAIS (Wechsler, 1955) were followed as laid out in the Test Manual. Due to the scoring procedure being somewhat subjective for the Vocabulary subtest (Wechsler, 1955), the subjects were scored blind. Subjects were given numbers instead of names to ensure that group indentity of the subjects was not known.

The standard scoring procedures for the Spatial subtest of the General Aptitude Test Battery (United States Employment Services, 1947) were followed according to the instructions given in Section 1 of Administration and Scoring Test Manual.

Results and Discussion

The results were evaluated by repeated measures analysis of variance using the scores for the two tasks (spatial and verbal) of the groups (male, female OC, female NOC), with each subject being tested three times during the menstrual cycle (day 3, 14, 24). Two analysis were done, one for cycle effect (the scores of the two tasks were arranged according to the three menstrual cycle phases; menstrual phase, ovulatory phase, premenstrual phase), and the other for order effect (the scores of the two tasks were arranged according to test order; test 1, test 2, test 3).

The males scored significantly higher on the spatial task than the female OC group, $F(1,58)=6.0$, $p < .02$ and the female NOC group, ($p < .02$) and in the verbal task males scored significantly lower than the female OC group, ($p < .03$) and the female NOC group, ($p < .02$).

The present findings support previous studies (Anastasis, 1958; Burstein et al., 1980; Cohen et al., 1977; Droege, 1967; Eichhorn, 1973; Fruchter, 1954; Guilford, 1959; Maccoby, 1966; Maccoby and Jacklin, 1974; Oetzel, 1966; Schaie and Strother, 1968; Shipman, 1971; Smith, 1964; Stanford Research Institute, 1972; Tyler, 1965), showing higher scores for males than females in visual spatial perception and higher scores for females than males on the verbal task (Burstein et al., 1980; Davies, 1965; Droege, 1967; Flanegan et al., 1961; Hall, 1978; Harris, 1977; Maccoby, 1966; Maccoby and Jacklin, 1974; Matarazzo, 1972; McGuinnes, 1976; Oetzel, 1966; Tyler,

1965).

Although the present findings support previous studies, one cannot assume that the reported sex differences are unequivocal. In a recent study, Hyde (1981) reanalyzed the findings on cognitive sex differences, considered to be well-established by Maccoby and Jacklin (1974), to determine the magnitude of these gender differences. Maccoby and Jacklin's (1974) "well-established" sex differences in verbal and spatial abilities were found to be small by Hyde (1981). To better understand the practical implication of the present findings it is important to note that studies such as Hyde (1981) and Sherman (1978), have continually pointed out that although many studies have reported sex differences in spatial and verbal abilities the magnitude of these differences is small.

Menstrual Cycle effect

Analysis of the data for verbal task (Figure 3), by phase of the cycle (days 3, 14, 24), showed no significant differences within the male group ($p > .8$) and female OC group ($p > .3$) but for the female NOC group significant cycle phase differences were found, $F(2,58) = 40.2$, $p < .0001$. On cycle day 14 (ovulatory phase) of the NOC female group, verbal scores were significantly higher than day 3 (menstrual phase), $F(1,29) = 65.8$, $p < .0001$ and day 24 (premenstrual phase), $p < .0001$. Day 3 and day 24 were not significantly different from one another.

When the entire menstrual cycle was considered the two female groups did not differ significantly from one another on either

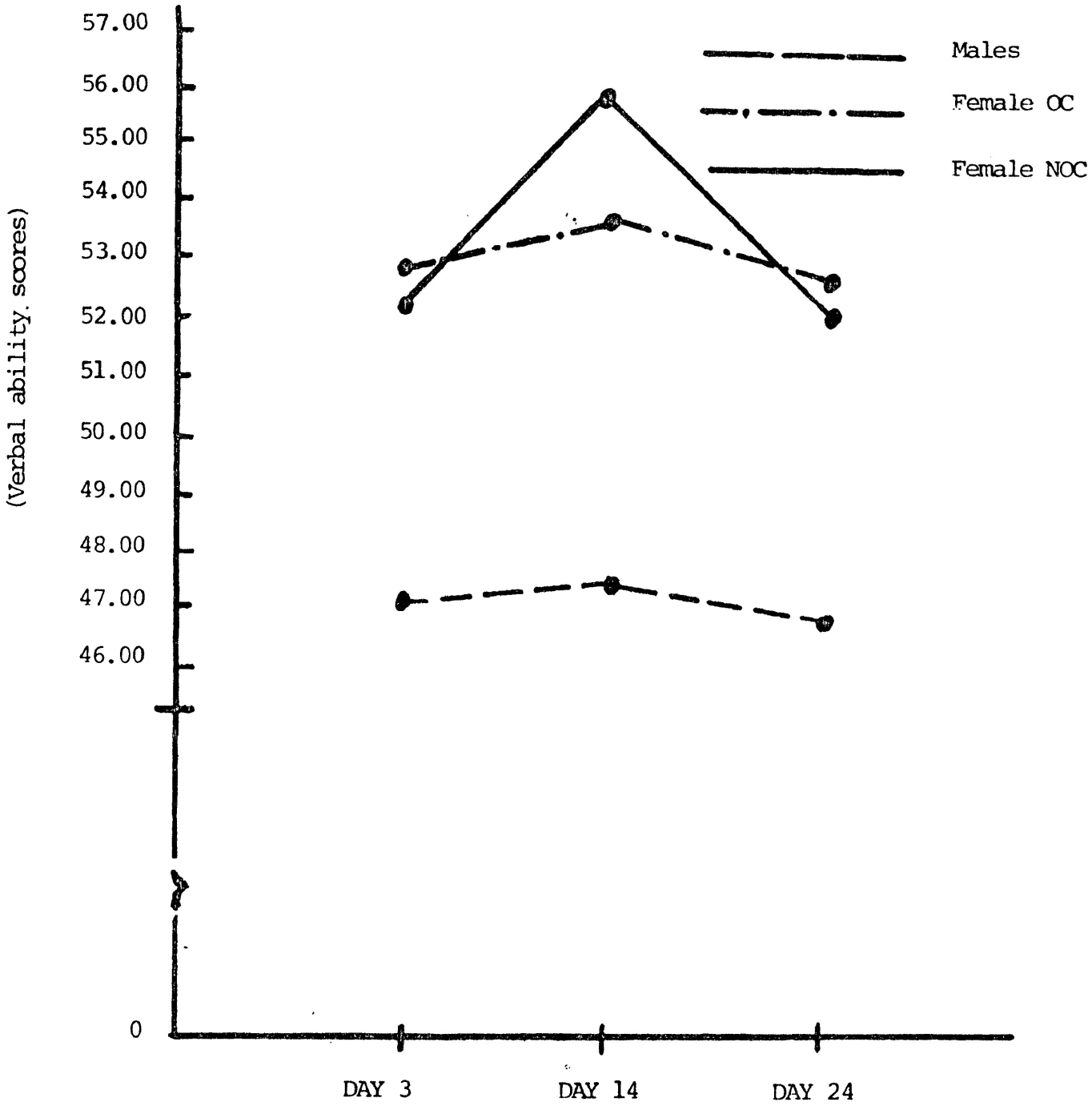

Figure 3. Mean scores of the three groups (females NOC, females OC, males) for the verbal task by three phases of the menstrual cycle; menstrual phase (day 3), ovulatory phase (day 14), premenstrual phase (day 24).

spatial ($p > .73$) or verbal ($p > .85$) task. However, over the three phases of the menstrual cycle, the two female groups showed different levels of fluctuation on verbal ability scores, $F(4, 116) = 7.54$, $p < .00083$.

Verbal scores of the two female groups did not differ from each other at any specific phase of menstrual cycle.

Differences in spatial scores among these phases were (Figure 4) not significant within any of the groups indicating that the scores for all three groups were very stable for the three phases of the menstrual cycle.

Test Order effect

The verbal scores (Figure 5) of all three groups were relatively straight lines across test 1, test 2 and test 3, showing no statistically significant change in any of the three groups.

The spatial task scores (Figure 6) of all the three groups showed steady increase from test 1 to test 2 to test 3, which was confirmed by statistical analysis showing significant improvement for the male group, $F(1,58) = 85.6$, $p < .0001$, female OC group, $p < .0001$, female NOC group, $p < .0001$. These findings clearly indicate that repeated exposure to the same spatial task did result in considerable improvement in performance.

No significant differences were found among the subgroups in any of the experimental groups in either of the tasks, thus indicating that the order of the cycle phases in which an individual was tested had no effect on the scores of both the tasks.

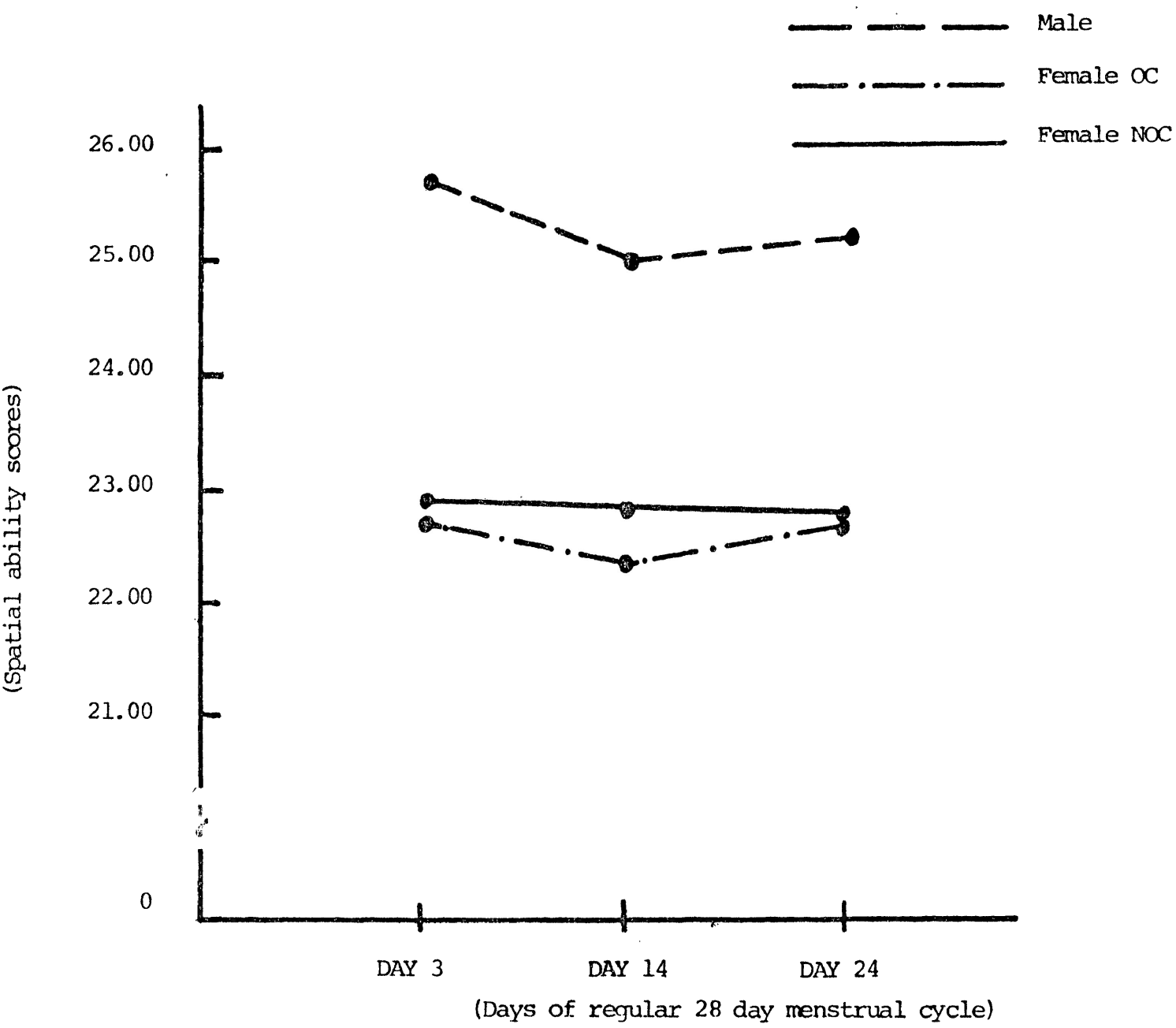

Figure 4. Mean scores of the three groups (females NOC, females OC, males) for the spatial task by three phases of the menstrual cycle; menstrual phase (day 3), ovulatory phase (day 14), premenstrual phase (day 24).

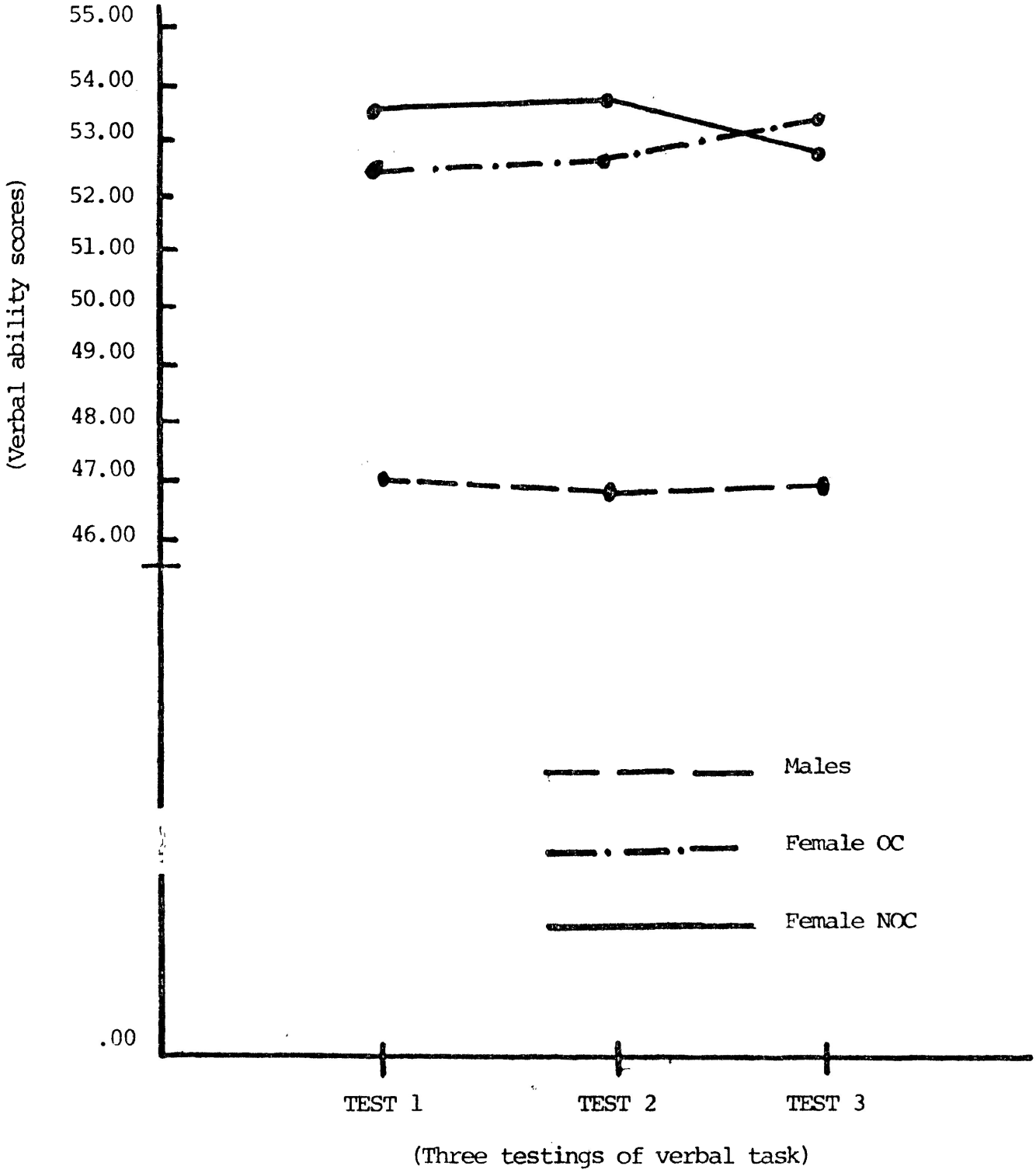

Figure 5. Mean scores of the three groups (females NOC, females OC, males) for verbal task by test order.

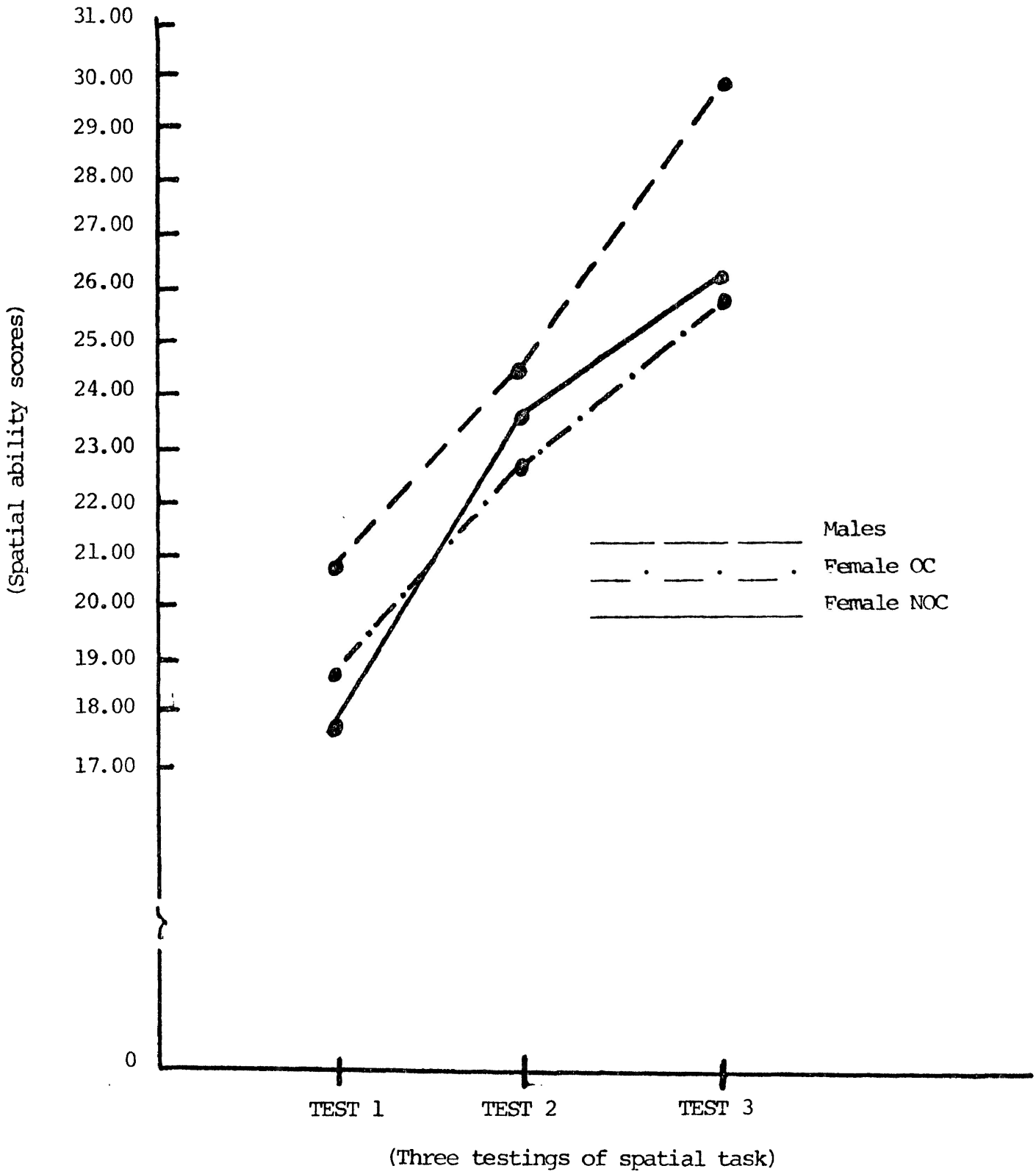

Figure 6. Mean scores of the three groups (females NOC, females OC, males) for the spatial task by test order.

To examine whether the effects in spatial task were masked, latin square analysis for order effect was conducted. When the order effect was removed from the error term, F ratios for phase of menstrual cycle were still less than one for each of the three groups indicating that the effects in the spatial group were not masked.

The remaining discussion will attempt to provide possible explanations for the present findings.

One possible explanation for the present findings is that performance changes were due to the changes in the general state of arousal of the nervous system during the menstrual cycle. As previously stated, it is speculated that change from a state of either lowered arousal to a state of heightened arousal or change from a state of heightened arousal to a state of lowered arousal may have profound psychological effects. This period of disequilibrium has been speculated to be related to symptoms such as the increased irritability associated with premenstrual tension syndrome and improved functioning at midcycle. The fact that NOC female group's verbal ability was significantly higher at midcycle (ovulatory phase) than at premenstrual phase and menstrual phase is in agreement with this interpretation.

The mechanisms responsible for the change in arousal during the menstrual cycle of the NOC female group could be explained using a hormonal model attributing changes before ovulation to estrogen and changes occurring in the luteal phase to progesterone

or the combination of estrogens and progesterone. This scheme is consistent with reports that estrogens have a CNS-activating effect, whereas, progesterone or the combination of estrogens and progesterone have a depressant effect (Vogel et al., 1971) which may have reciprocal and/or varied affect upon various types of cognitive functioning.

This line of thought may assist in the understanding of why NOC female group's scores were significantly effected by menstrual cycle fluctuation for one cognitive task (verbal) but not for another (spatial).

As discussed in the introduction, studies investigating behavioral and physiological changes throughout the menstrual cycle reported both high and low performance scores to occur during all phases of the menstrual cycle for various cognitive tasks. One could explain these findings by postulating that different CNS activity levels are required to produce optimal performance in different cognitive tasks.

Therefore, neither estrogen nor progesterone can hinder or facilitate performance on cognitive tasks specifically but, as indicated by the present findings, it depends upon the activity level at which the cognitive task is best performed at.

A second possible explanation for the present findings is that gonadal hormones may not in themselves be the most important factors. Other possibilities include the reninangiotensin-aldosterone system which could be fluctuating in parallel with phases of the menstrual

cycle and having an effect on central neurotransmitters. The adrenergic system has been used to explain changes in activity levels, since plasma monamine oxidase (MAO) activity has been found to be significantly higher in the postovulatory compared to preovulatory phase of the NOC menstrual cycle (Klaiber, Kobayashi, Broverman and Hall, 1971). It has been suggested that elevated levels in the second half of the cycle could result in a deficiency of catecholamine activity and this could account for lowered arousal. Studies by Briggs and Briggs (1972) and Klaiber et al. (1971) have shown that plasma MAO activity varies systematically over the course of the menstrual cycle in women, the lowest levels of MAO activity occurring when estradiol levels were highest (ovulatory phase).

Therefore, according to the functioning of the reninangiotensin-aldosterone system which could be fluctuating in parallel with the phases of the menstrual cycle and having an effect on central neurotransmitters, one would expect highest activation and arousal during the ovulatory phase of the menstrual cycle.

This second explanation may indicate that the improved verbal ability scores at ovulation as reported in the present research may in part be attributable to an increased activity level.

In summary, the present study investigated the effects of menstrual cycle on verbal and spatial ability, reporting findings supporting previous studies showing higher scores for males than females in visual-spatial perception and higher scores for females than males on verbal task. The importance of the present study

is that, in addition to investigating cognitive sex differences in the specific area of verbal ability and spatial ability, the present study controlled for the effect of menstrual cycle fluctuation.

The present study reported NOC female group to have significant fluctuation in verbal ability. Whereas, the OC female group whose menstrual cycle fluctuation is controlled by oral contraceptives, did not differ significantly from the NOC female group in general as well as at any specific phase of menstrual cycle for either spatial or verbal ability. Thus indicating that although menstrual cycle had significant effect on the NOC female group's verbal ability, the overall effect it had on sex differences was minimal. The effect of menstrual cycle fluctuation could not account for the reported sex differences in either verbal ability or spatial ability.

As stated, when the variable of menstrual cycle fluctuation was accounted for, cognitive sex differences in spatial and verbal ability were reported to still exist. Therefore, the present study indicates that further research is required to investigate what variables, other than menstrual cycle fluctuation could be attributing to the reported sex differences in spatial and verbal ability.

The present study indicates also that further research is required to investigate why cognitve tasks are affected differently by menstrual cycle fluctuation. If different CNS activity levels are required to produce optimal performance in different cognitive tasks, menstrual cycle fluctuation may very well be attributing

strongly to some of the reported sex differences in cognitive tasks other than those of spatial and verbal ability.

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APPENDIX A

Date: _____

GENERAL INFORMATION QUESTIONNAIRE

Surname _____ Given Names _____

Sex _____ Telephone Number _____

Birthdate _____

Address _____

1. Would you volunteer to take part in an experiment? Yes ___ No ___
2. Check which courses you have taken previously and at what grade level.

	YES	NO	LEVEL
Mathematics	___	___	_____
(specifically)			
Calculus	___	___	_____
Algebra	___	___	_____
Geometry	___	___	_____
Art	___	___	_____
Drafting	___	___	_____
Architecture	___	___	_____
Carpentry	___	___	_____
Engineering	___	___	_____
Mechanics	___	___	_____
Physics	___	___	_____

THE REMAINING QUESTIONS ARE DIRECTED SOLELY TO FEMALES!

1. Do you have a regular menstrual cycle? Yes ___ No ___
2. Does your cycle consist of 28 days? Yes ___ No ___
3. Are you presently using oral contraceptives? Yes ___ No ___
4. What was the date when your last cycle began? (The day you started menstruating) _____