

# Hormonal and Experiential Correlates of Maternal Responsiveness during Pregnancy and the Puerperium in Human Mothers

Alison S. Fleming

*Department of Psychology, University of Toronto, Erindale Campus,  
Mississauga, Ontario L5L 1C6, Canada*

Diane Ruble

*Department of Psychology, New York University, New York, New York 10012*

and

Howard Krieger and P. Y. Wong

*Toronto General Hospital, Toronto, Ontario M5G 2C4, Canada*

Two studies were undertaken (1) to determine whether human mothers undergo a change in maternal responsiveness during pregnancy before the birth of the baby, as shown for other mammalian species, and (2) to establish whether a relation exists between changes in maternal feelings and attitudes and changes in hormones. In both studies prospective first-time mothers completed an extensive set of questionnaires, covering a broad range of issues, including a set of 76- to 100-item likert scales concerning attitudes toward infants, childbirth, pregnancy, caretaking, and other interpersonal relationships. In the first cross-sectional study, mothers completed the questionnaires at one of seven time points, ranging from prior to pregnancy to 3 months postpartum. In the longitudinal study, questionnaires were completed repeatedly throughout this same time period. In addition, blood was taken at these same time points and assayed by RIA for plasma concentrations of the steroids, estradiol, progesterone, testosterone, and cortisol. The primary findings are (1) feelings of nurturance grow during pregnancy and from pregnancy to postpartum; in the cross-sectional study, for most of the factors relating to infants or mothering, pregnancy and postpartum responses were more positive than prepregnancy responses; in the longitudinal study, many of these factors also showed elevations across pregnancy itself, as well as further elevations with the birth of the infant. (2) Pregnancy hormones were not related to the growth of at-

tachment to the infant across pregnancy. (3) However, the pattern of change in the ratio of estradiol to progesterone from early to late pregnancy was related to postpartum attachment feelings. (4) Finally, hormonal correlates of attachment feelings may reflect effects both on feelings of nurturance directly and, indirectly, on mothers' feelings of well-being. © 1997 Academic Press

How new mothers care for their young is influenced by a variety of social and situational factors—including their past experiences as infants (Suomi, 1990; Kraemer, 1992; Main, Kaplan, and Cassidy, 1985; Fairbanks, 1989) and with infants (Pryce, 1993; Ruppenthal, Arling, Harlow, Sackett, and Suomi, 1976; Fleming, Ruble, Flett, and Shaul, 1988; see Corter and Fleming, 1995), their life histories and stresses, and their present social and physical contexts (see Corter and Fleming, 1995). Less obvious is the role of biological factors in mothering and the process of becoming attached to one's infant. However, biological factors clearly contribute to mothering behavior in most other mammals that have been studied, including a number of primates (Pryce, 1993, 1995) and there is no reason to assume that humans are immune from these effects.

Among many mammals, mothers show heightened

responsivity to offspring during the latter part of pregnancy, before the young are born, culminating in a complete integrated response at parturition (see Corter and Fleming, 1991; Maestriepi and Wallen, 1995; Gibber, 1986). Although we do not yet know which precise hormones mediate responsiveness during gestation, we know that the changes in hormones that occur between mid- and late pregnancy or that accompany parturition contribute to the rapid onset of nurturant behavior that occurs with the birth of the young; in general, the relevant pattern of hormonal changes includes a period with high levels of progesterone during pregnancy followed by the decline of progesterone and the associated rise in estrogen, prolactin, and oxytocin (Rosenblatt, 1990; Bridges, 1990; Insel, 1990; Pryce, 1993; Pryce, Doebli, and Martin, 1993; see Pryce, Martin, and Skuse, 1995).

However, hormonal influences are expressed only if the social and situational factors are favorable. Thus, among some primates (e.g., marmosets) mothers will often not care for their offspring if they have not had prior juvenile experience allomothering—that is, caring for someone else's offspring (Pryce, 1993; Pryce, Doebli, and Martin, 1993; see Pryce, Martin, and Skuse, 1995). In another New World monkey (the red-bellied tamarin) the effects of exogenous hormone replacement are also apparent only in previously experienced, multiparous animals (Pryce, Abbott, Hodges, and Martin, 1988). Among pigtail macaques social dominance status determines the amount of interest shown during pregnancy in "foster" infants (Maestriepieri and Wallen, 1995). Even in rats in which hormonal effects are clear and distinct, they cannot override or inhibit the effects of a prior experience cannibalizing young or the effects of stress and overcrowding, etc. (see Fleming, Morgan, and Walsh, 1996).

Not surprisingly, few studies have explored the role of hormones in the regulation of human parenting, and those that have report the counterintuitive results that associate the adrenal hormones rather than the ovarian or placental steroids with parental responsiveness (see Corter and Fleming, 1995; Fleming, Steiner, and Anderson, 1987). We found there was a strong linear correlation between circulating postpartum concentrations of the adrenal steroid, cortisol, and the intensity of mothers' close contact approach behaviors while interacting with their infants on Day 3 postpartum. This relation was further enhanced if mothers were also positively motivated toward infants, as expressed in their pregnancy attitudes (Fleming, Steiner, and Anderson, 1987). These hormonal correlates do

not, however, occur in a vacuum. The mothers' background experiences and experiences interacting with the infant, in particular, also correlate with her feelings and attitudes and these may well accentuate, mask, or interact with the hormonal correlates (Fleming, Ruble, Flett, and Shaul, 1988).

The present set of studies is an extension of this approach to the analysis of hormone–environment interactions in the regulation of maternal responsiveness in new mothers. In the present paper we report results which reflect our interest in hormonal factors during pregnancy and across the parturitional period and their relation to mothers' maternal attitudes. In another paper (Fleming, Steiner, and Corter, in preparation), we evaluate hormonal changes during the postpartum period and their relation to mothers' maternal behaviors. Here we describe only a selected portion of two studies, one cross-sectional, the other longitudinal, each with its own extensive data set and both analyzed previously to address different questions (see Ruble, Brooks-Gunn, Fleming, Fitzmaurice, Stangor, and Deutsch, 1990; Ruble, Fleming, Hackel, and Stangor, 1988). And in each study we ask what is the evidence that reproductive state or hormones are related to maternal feelings and attitudes during pregnancy and the puerperium in new mothers. A second goal of these studies is to simultaneously assess the relation to mothering of mother's prior experiences with infants; hence, we use hierarchical multiple regression analyses to determine the variance in mothering explained by hormones and by previous parity or infant experience.

## GENERAL METHODS

The primary measure of maternal responsiveness in the present experiments was based on responses on questionnaires. In addition, in the second, longitudinal experiment, hormone concentrations were measured in blood plasma.

### Measures: Questionnaires (Experiments 1 and 2)

Women in both the cross-sectional and the longitudinal experiments completed questionnaires. The questionnaire was quite large, requiring 1–1½ hr to complete. It consisted of almost 1000 items addressing a broad range of issues including physical symptoms and moods, eating behavior and alcohol consumption, baby

temperament, demographics, and background, in addition to the maternal attitude items that represent the present focus.

One measure, the Childbearing Attitudes Questionnaire (CAQ), consisted of a 76-item scale concerning attitudes toward the pregnancy and birth, self-esteem, and other interpersonal relationships. The set of items involved 19 different issues important to infants and childbirth, consisting of 3–6 items each, counterbalanced for direction to minimize response bias. Participants completed this measure by responding to each item on a 7-point scale ranging from disagree strongly (1) to agree strongly (7).

The attitude factors used in the present report were derived from the set of attitude items by factor analysis (Ruble, Brooks-Gunn, Fleming, Fitzmaurice, Stangor, and Deutsch, 1990; see also Ruble, Fleming, Hackel, and Stangor, 1988). In one analysis, based on responses of all 667 subjects, 14 factors were extracted through iterated principal axis factor analysis, followed by a promax oblique rotation (see Ruble *et al.*, 1990). Of these, four will be discussed in the present report. The other analysis was based on a smaller Toronto sample of 246 women (see Fleming, Ruble, Flett, and Shaul, 1988) who completed a 104-item questionnaire (including the original 76). In this analysis, the same basic factors were derived as in the larger analysis. However, in addition, 4 new clusters or factors (based on the additional items included in the questionnaire) were derived and the item intercorrelations were subjected to a principal-components factor analysis. Attitude clusters used in the present set of studies assessed mothers' feelings of attachment or nurturance toward the growing fetus (fetus), attitudes toward preparing for the infant's arrival (preparation), feelings of identification with the pregnancy (pregnancy id), feelings of nurturance toward own infant postpartum (attachment), feelings of nurturance toward infants in general (other infants), feelings about caretaking activities (caretake), feelings of adequacy in the maternal role (maternal adequacy), feelings toward the partner or spouse (relationship with partner), and feelings toward their own mothers (relationship with mother). The factors fetus and preparation were assessed only during the pregnancy. The other attitude clusters were assessed at all time points.

To determine mood state, mood factors derived from the current experience scale (CES) were used. These included factors that reflect feelings of anxiety, depression, well-being, fatigue, and physical discomfort. These mood factors have been found to be reliable and valid for the postpartum population and show consis-

tency across time, (see Fleming, Ruble, Flett, and Shaul, 1988; Fleming, Ruble, Flett, and Van Wagner, 1990). Correlations between the CES and standardized mood scales (e.g., the MAACL (Zuckerman and Lubin, 1965) and BDI (Beck, Ward, Mendelson, Mock, and Erbaugh, 1961) are highly significant, ranging from 0.55 to 0.80 in different studies (Fleming *et al.*, 1988, 1990).

## EXPERIMENT 1: MATERNAL ATTITUDES AT DIFFERENT STAGES OF PREGNANCY AND POSTPARTUM: A CROSS-SECTIONAL ANALYSIS

### Methods

#### Subjects

Subjects were recruited in a number of ways, including parent preparation, birthing, and exercise classes; newspaper and radio advertisements; and responses to displays in the offices of obstetricians. Classes of various types were the most frequent source of subjects, and to provide some measure of comparability across phases, pregnant women were randomly assigned to pregnant or postpartum (i.e., arrangements were made to contact them at 1 or 3 months postpartum). Because of the nature of the recruitment procedure, return rate was difficult to calculate precisely. Approximately 60% of the questionnaires sent to homes or left in doctors' offices or classes were returned. Clearly, a self-selection factor was operating and, unfortunately, it was not possible to determine on what dimensions responders and nonresponders differed.

The cross-sectional sample was recruited from three locations: Toronto, Seattle, and the greater New York area. The samples were recruited during the same time period, which involved a term of approximately 2 years from 1981 to 1983. Approximately equal numbers of subjects in each childbearing phase participated at each location. The two basic requirements for eligibility were that the woman was married (or cohabitating) and living with her husband (partner) at the time of the study and that the child was the woman's first.

The cross-sectional sample consisted of 667 women in 7 groups: (a) 113 women at 0 weeks who were planning to conceive within 2 years (prepregnant); (b) 91 women 1–17 weeks in their first trimester; (c) 91 women 18–27 weeks in their second trimester; (d) 73 women 28–36 weeks in their third trimester; (e) 40 women at 37 weeks to the end of pregnancy; (f) 129

women in their first month postpartum; and (g) 129 women in their third postpartum month. The mean age for participants was 29, with a range of 18 to 42. The sample was 98% Caucasian and predominantly middle income, in social classes III, IV, and V (Hollingshead, 1965). Over 70% of the women were college graduates.

## Procedures

Participants took the questionnaires home with them from class or from a physician's office or they received them by mail. They were asked to complete them at home and return them by mail within 2 weeks.

The wording of items for the different childbearing groups or stages varied slightly in order to be appropriate to each phase (e.g., "I expect to enjoy looking pregnant"; "I enjoy looking pregnant"; and "I enjoyed looking pregnant"). Since not all women filled out the entire questionnaire at each time point and only a subset of women gave blood for the radioimmunoassays different numbers of women are involved in different analyses.

## Results

The first question we addressed was the extent to which feelings of nurturance and related feelings about infants and self as mother change across pregnancy. A related issue was how specific are these changes? Do they apply only to infants or do they apply to all social stimuli?

Separate one-way ANOVAs (with seven stages, groups) were undertaken on attitudes that reflect maternal feelings. The first set of ANOVAs compared all seven groups in their feelings about infants, pregnancy, caretaking activities, and their own maternal adequacy. The second compared only the four pregnant groups in their feelings toward the fetus and in preparations being made for the baby. In addition, other social attitudes were assessed by comparing the seven groups in their attitudes toward their spouses and their mothers.

There were significant main effects of stage on all factors that related to own infants, infant care, or mothering. In contrast, attitudes toward one's own spouse, toward mothers, or toward other (nonown) infants showed only marginal changes.

As shown in Figs. 1A and 1B, a significant stage effect was found for fetus ( $F(3, 290) = 10.4, P < 0.001$ ), pregnancy identification ( $F(4, 381) = 2.6, P < 0.036$ ), preparation for the baby ( $F(3, 290) = 29, P < 0.000$ ), maternal adequacy feelings ( $F(6, 464) = 7.6, P < 0.001$ ), and caretaking feelings ( $F(6, 464) = 4.3, P < 0.001$ ). As can be seen in Figs. 1A and 1B, for most of the mothering factors the nonpregnant group gave the lowest ratings and the postpartum groups gave the highest ratings with the pregnant groups between the two (differences between nonpregnant and 12 weeks postpartum significant for maternal adequacy, caretaking, and pregnancy id). When one compares the pregnant groups, an interesting pattern emerges. For the factor, fetus, there occurred a precipitous increase in positive feelings between the first and the second trimesters ( $P < 0.05$ ) and a slight decline once again at the very end of pregnancy ( $P < 0.05$ ). For the factors, feelings about other children and caretaking, ratings across the three trimesters did not change appreciably, but there also occurred a slight (albeit nonsignificant) decline in ratings in the 2 to 4 weeks prior to the infant's birth. In contrast, preparations for the infant (preparation) increased linearly across all the time points (comparisons between each successive period,  $P < 0.05$ ) and maternal adequacy feelings (maternal adequacy) increased only with the birth of the infant (12 weeks postpartum > most other time points).

In contrast to the mothering factors, no systematic pattern of change was seen in mothers' relation with their mothers. However, there was a significant change in mothers' feelings about their spouses (relationship with partner;  $F(6, 464) = 3.45, P < 0.002$ ) with the most positive feelings occurring during the second and third trimesters and relatively more negative feelings prior to pregnancy and at 12 weeks postpartum (different from midpregnancy,  $P < 0.05$ ).

## Discussion

These results indicate large differences between nonpregnant and postpartum women in attitudes toward caretaking and own maternal adequacy, with little change across pregnancy. These differences probably reflect the differences between the groups in their actual experiences interacting with their infants and hence in their competence caring for infants (Ruble *et al.*, 1990). Where there seemed to occur a real growth in responsiveness across pregnancy itself was in the attitude factors relating to mothers' feelings about the fetus and

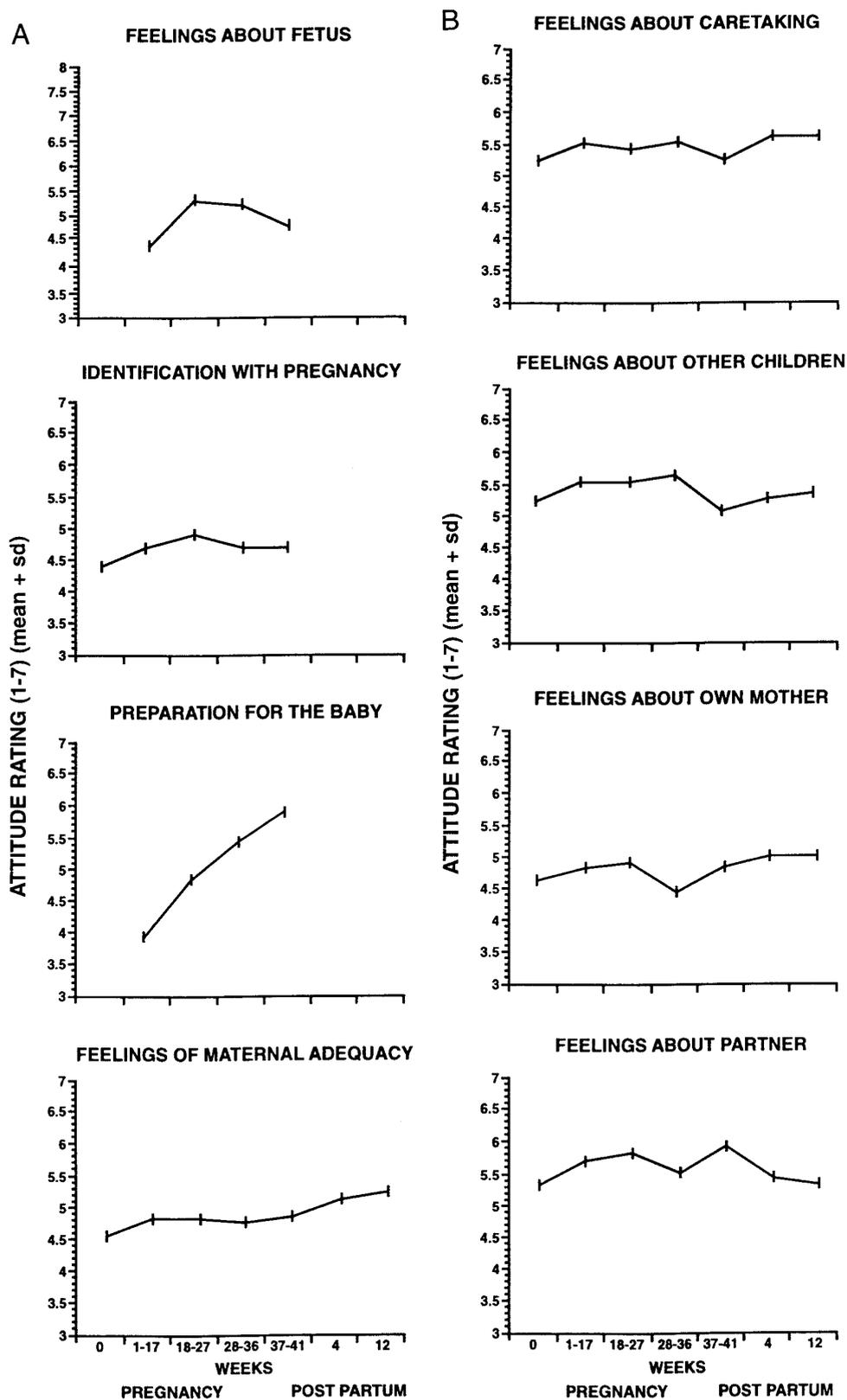


FIG. 1. Changes in maternal attitudes across pregnancy and the postpartum period in seven cross-sectional samples of first-time mothers. Scores reflect rating on a 7-point likert scales, ranging from negative (1) to positive (7).

preparation for the baby. Positive feelings about the fetus increased primarily between the first and the second trimesters, whereas preparation for the infant continued to intensity across the entire pregnancy. The slight decline in positive feelings about the fetus as well as that in feelings about other infants immediately prior to the birth is interesting in light of a similar prepartum dip in responsiveness in monkeys (Maestriepieri and Wallen, 1995). Again, these effects seem not to be due to inhibitory effects of hormones. More likely, they reflect physical discomfort associated with the impending birth or with a heightened anxiety toward pregnancy termination.

These attitude changes are explored in greater detail in the next longitudinal experiment, where the contributions to attitude change of both hormones and experience are also considered.

## STUDY 2: RELATION BETWEEN HORMONAL AND ATTITUDINAL CHANGES ACROSS PREGNANCY AND THE PUERPERIUM: A LONGITUDINAL ANALYSIS

### Methods

#### Subjects

The longitudinal sample came from Toronto only and participants were recruited by general practitioners or obstetricians who monitored them throughout the pregnancy and postpartum period. As with the cross-sectional sample, the two basic requirements for eligibility were that the woman was married (or cohabitating) and living with her husband (partner) at the time of the study and that the child was the woman's first.

Women were recruited into, and remained throughout, the longitudinal study, which involved questionnaires ( $n = 38$ ) and hormonal assessments ( $n = 29$ ) at five to six time points from gestational weeks 0–16 (first trimester), 20–27 (second trimester), 28–35 (third trimester), and (in some women) 36–42 (end) as well as on Day 4 postpartum and Week 6 postpartum. Since not all women filled out the entire questionnaire at each time point and only a subset of women gave blood for RIA, different numbers of women are involved in different analyses. The participants in sample had a mean age of 29, with a range of 18 to 36, and were over 80% Caucasian. They were predominantly middle

income, in social classes III, IV, and V (Hollingshead, 1965) and 55% were college graduates.

There were no significant differences (by *t* test) on any of the dependent measures (e.g., age, education, income, attitudes) between women who completed all the questionnaires and those completing only some. There were also no significant demographic differences between those who gave blood and those who did not; in general, time constraints determined whether women did or did not give blood at any particular time point. Moreover, a number of assays were eliminated because of breakdown of a refrigeration unit in which the plasmas were stored.

### Questionnaires

The same questionnaires were given to the longitudinal sample as to the cross-sectional sample. In addition, the longitudinal sample also completed a childbirth questionnaire on the first postpartum day. This childbirth questionnaire contained questions relating to demographics and background factors, birth events and experiences (e.g., length of labor, use of anesthetic), latency to first nurse or hold the infant, time spent nursing, time spent in the presence of the infant during the first postpartum hours and days, as well as the maternal factor, feelings of attachment to the infant. Other attitude factors were not included in the childbirth questionnaire.

### Hormonal Assays

Blood was drawn at each stage of pregnancy and postpartum by the general practitioner/obstetrician in the doctor's office (during pregnancy) or in the hospital (Day 1 postpartum). Blood was drawn from the antecubital vein using a 5-ml syringe. Bloods were centrifuged, aliquoted into cryovials, and stored at  $-80^{\circ}\text{C}$ , until assayed for cortisol, estradiol, testosterone, progesterone, and sex-hormone-binding globulin (SHBG). All hormones were assayed by radioimmunoassay. Estradiol, testosterone, and SHBG kits were supplied by DPC Corp. (Los Angeles, CA); progesterone kit was supplied by Johnson/Johanson (Toronto, Canada); and cortisol was assayed by an in-house method (P. Y. Wong, A. V. Mee, and F. Ho, *Clin. Chem.* **25**, 914–917, 1979). The sensitivities of the hormone assays for cortisol, estradiol, testosterone, and progesterone were 20 (nmol/L), 10 (pmol/L), 0.2 (nmol/L) and 0.1 (nmol/L), respectively. Between-assay precisions for cortisol, estradiol, testosterone, and progesterone were as fol-

lows: cortisol, 5.9% at 70 nmol/L and 7.1% at 580 nmol/L; estradiol, 4.9% at 270 pmol/L and 5.5% at 1600 pmol/L; testosterone, 9.8% at 3.9 nmol/L and 5.4% at 22.4 nmol/L; and progesterone, 4.8% at 7.9 nmol/L and 3.7% at 40 nmol/L. Recovery for cortisol, estradiol, testosterone, and progesterone was 92–103, 90–110, 93–103, and 78–92%, respectively.

## Results

### Pregnancy

#### **Changes in maternal attitudes across pregnancy.**

Within-group ANOVAs (including five or six time points; three or four points during pregnancy, (in some cases, 4 days postpartum) and 6 weeks postpartum) were undertaken on the same set of mothering and social factors as described for the cross-sectional sample.

For this small sample, there were a number of significant changes across pregnancy that were consistent with the cross-sectional comparisons. A series of one-way ANOVAs, with repeated measures, were performed comparing women's attitudes across the first three trimesters of pregnancy. These comparisons were recomputed including the 6-week time point. As shown in Figs. 2A–2C, there was a significant growth across pregnancy in mother's feelings of attachment to the fetus/baby ( $F(2, 36) = 6.23, P < 0.005$ ), feelings about caretaking activities ( $F(2, 38) = 5.72, P < 0.007$ ), and preparations for the baby ( $F(2, 18) = 6.89, P < 0.006$ ). Worries about the infant also subsided over this same period ( $F(2, 34) = 4.69, P < 0.016$ ). In contrast, there were no changes in women's feelings about their partners, their mothers, or other children.

**Changes in hormones across pregnancy.** Values of the hormone concentrations were expressed both as total concentrations of the different sex steroids (estradiol, progesterone, and testosterone) and cortisol and as free (e.g., biologically active) values (the ratio of the total sex steroids to the sex hormone-binding globulin (SHBG)). Since, in other animals (Rosenblatt, 1990; Insel, 1990; Bridges, 1990; Poindron and Levy, 1990), the steroids estradiol and progesterone, and, especially, the ratio of these two hormones at the end of pregnancy, are known to be important for maternal behavior, in the present paper analyses were also done on the estradiol/progesterone ratio.

As shown in Figs. 3A and 3B there were very large and highly significant changes in all the hormones

across the gestational period. Correlations computed between concentrations of the different hormones at two consecutive pregnancy periods were all highly significant ( $P < 0.05$  to  $P < 0.001$ ). In contrast, there were no meaningful correlations between hormone levels at points during pregnancy and hormone levels either 4 days or 6 weeks postpartum. Moreover, there were no significant relations between levels of any of the hormones during pregnancy or postpartum and any of the birth events (type of delivery, duration of labor, type of delivery, etc.). Analyses of circulating hormones during pregnancy as a function of the gender of the child showed a marginal difference between women giving birth to male and female offspring in the ratio of testosterone to sex-hormone binding globulin (T/SHBG) at the end of pregnancy. Mothers of males had marginally higher levels of circulating biologically active testosterone ( $P = 0.08$ ).

#### **Hormonal correlates: Correlations between hormones and maternal attitudes.**

In order to determine whether there is a significant relation between the different hormones and maternal feelings, Pearson correlation coefficients were computed relating for each time point separately, levels of hormones (both total and free) and the different maternal factors. To determine whether the hormones are related to other characteristics of the mother, correlations were also computed relating the hormones to mothers' anxiety, depression, and well-being and to both past experience with infants and postpartum experience. Only consistent (two or more time points) relations are reported.

There were no significant correlations between any hormone (either total or free fractions) or hormone ratios and any of the maternal attitudes within any pregnancy period. Of particular interest was the observation that none of the hormones correlated with feelings of attachment to the infant or fetus within the same pregnancy time point or between hormones at one time and attachment feelings at the next time point. Moreover, when change scores were computed for the different hormones between successive pregnancy time points, they showed no correlation with maternal attitudes at the later (i.e., the second of two consecutive) pregnancy time points.

Reinforcing these results, when women were divided by median split on different maternal attitudes at each of the pregnancy time points, indicating low versus high feelings of attachment to the fetus, etc. there were no significant group differences in their different hormone concentrations either at the same or at previous time points.

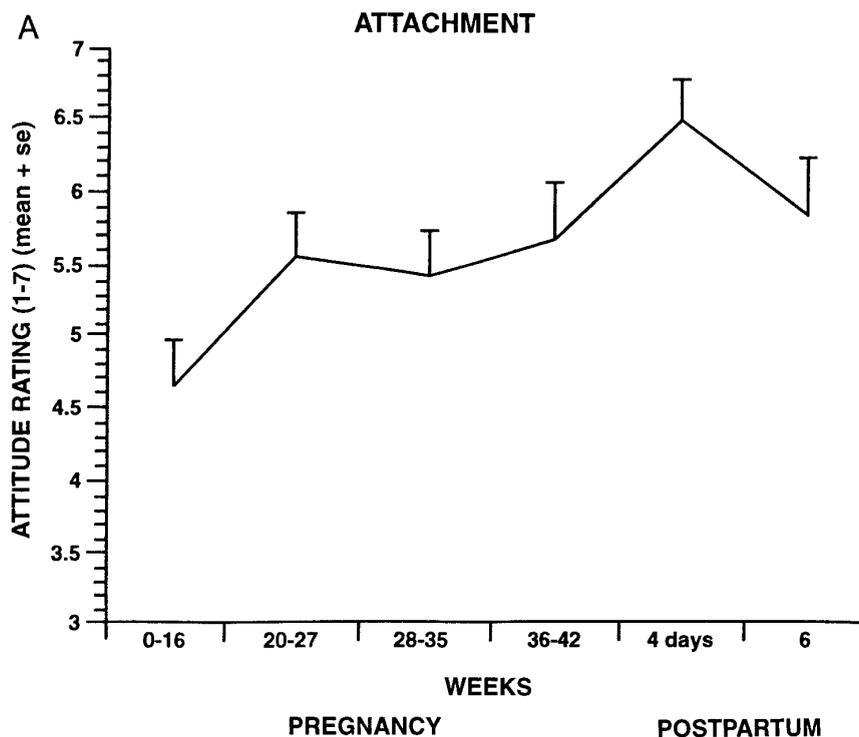


FIG. 2. Changes in maternal attitudes across pregnancy in a longitudinal sample of first-time mothers. Scores reflect ratings on a 7-point likert scales, ranging from 1 (negative) to 7 (positive).

**Hormonal correlates: Correlations between hormones and mood.** In contrast, hormones were related to mothers' mood state. During the second trimester and at the end of pregnancy, mothers with either high free estradiol or high estradiol to progesterone ratios experienced more negative mood (depression and anxiety) (second:  $r = 0.72$ ,  $n = 10$ ,  $P < 0.001$ ;  $r = 0.55$ ,  $n = 19$ ,  $P < 0.014$ ; third:  $r = 0.40$ ,  $n = 17$ ,  $P = 0.05$ , 1 T and  $r = 0.52$ ,  $n = 16$ ,  $P < 0.039$ ) and reduced well-being (second:  $r = -0.55$ ,  $n = 19$ ,  $P < 0.01$ ).

**Prior experience correlates.** In contrast, when mother's prior experience with infants (assessed at 5 months of pregnancy) was correlated with maternal attitudes during pregnancy, a number of interesting relations were found. Mothers who had had more prior childcare experience (with siblings or infants of friends or within the babysitting context) felt more positively during the second or third trimester of the pregnancy periods about caretaking ( $r = 0.43$ ,  $P < 0.04$ ), about children, in general ( $r = 0.75$ ,  $n = 23$ ,  $P < 0.001$ ) and about their own fetus ( $r = 0.41$ ,  $P < 0.05$ ). Already at the beginning of pregnancy (first trimester), they also felt more adequate in the mothering role ( $r = 0.39$ ,  $P$

$< 0.05$ ). However, prior experience with infants did not relate to their relationship with their partners or mothers.

### Postpartum

**Hormonal correlates of attachment.** When mothers' immediate postpartum, as opposed to pregnancy, feelings of attachment to the infant were considered, a different pattern of results was found. As indicated under Methods, the attachment factor is based on responses to questionnaires and includes such items as "I am amazed and thrilled when I look (think of) at my baby," and "I do not feel as close to my baby as I expected." Although there were no significant relations between postpartum feelings of attachment to the infant and concentrations of postpartum hormones, postpartum attachment feelings were related to pregnancy hormones. Mothers with high feelings of attachment during the early postpartum period had a low ratio of estrogen to progesterone concentrations at the first two pregnancy time points, generating correlations between postpartum attachment and E/P hormone ratios at 5

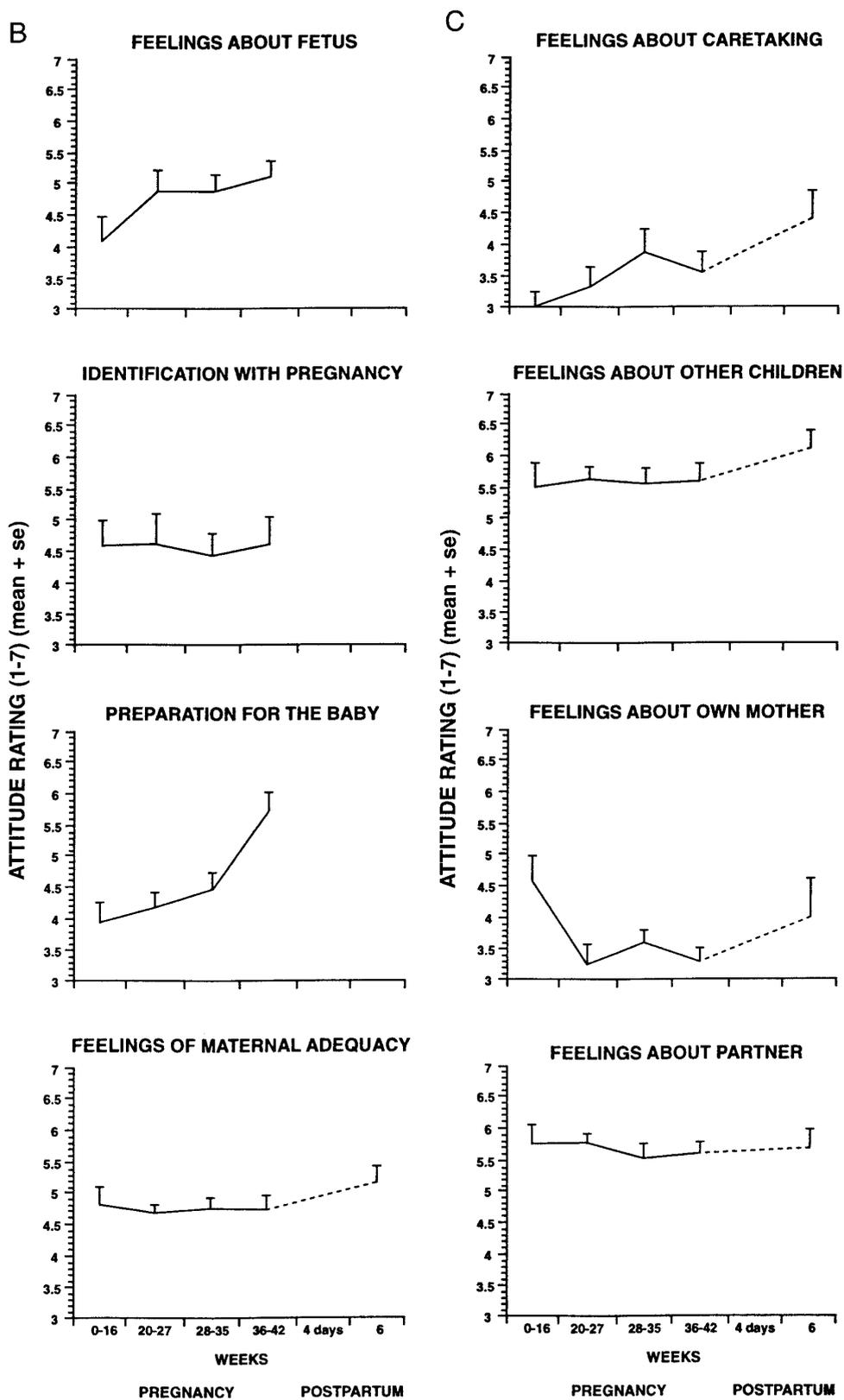


FIG. 2—Continued

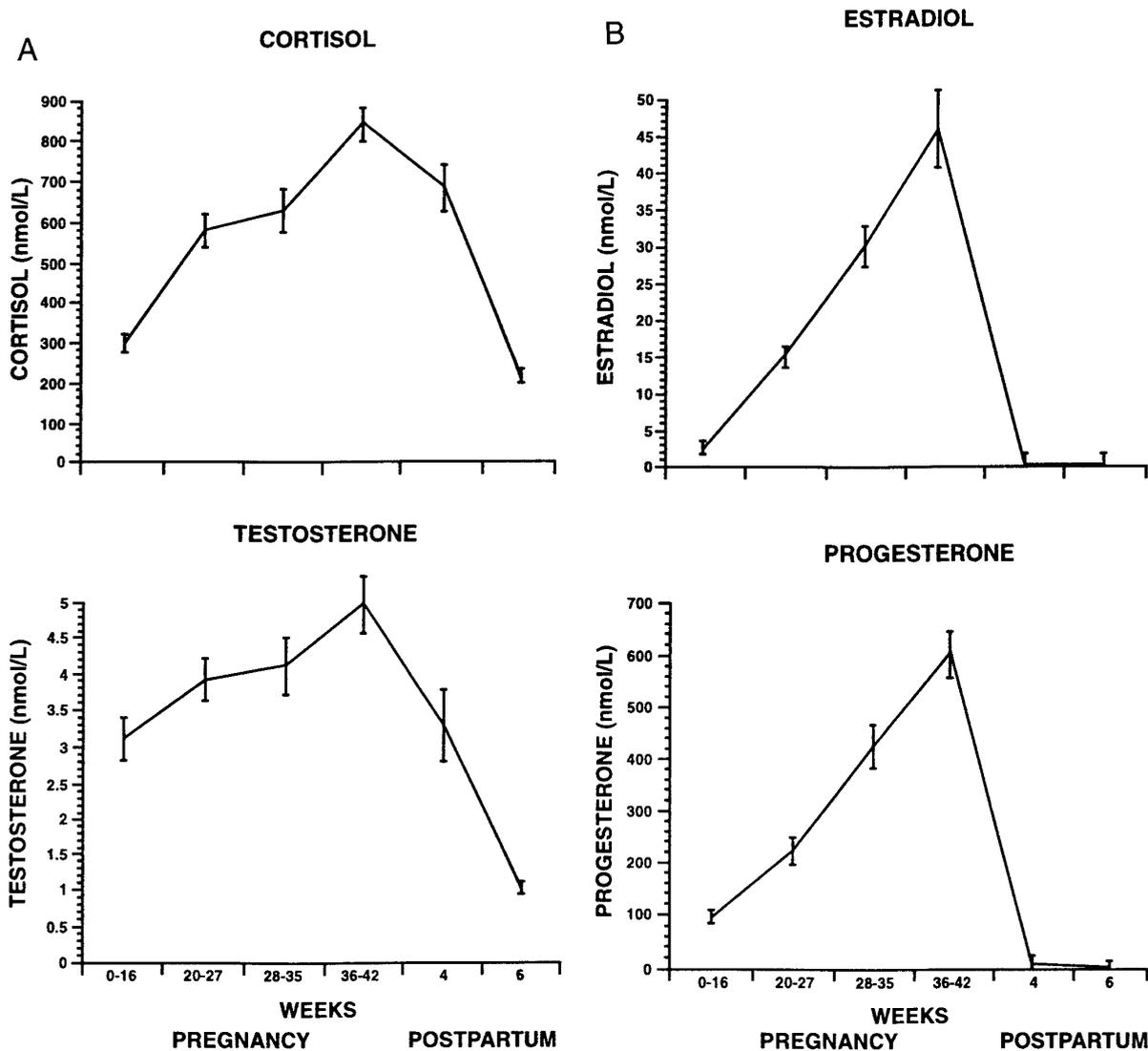


FIG. 3. Changes in plasma concentration of steroids across pregnancy and the postpartum period in a longitudinal sample of first-time mothers.

and 7 months of  $r = -0.45$  ( $n = 21$ ,  $P < 0.04$ ) and  $r = -0.50$  ( $n = 20$ ,  $P < 0.02$ ), respectively. These relations seem to be due primarily to concentrations of estradiol during pregnancy (both total and unbound), which showed essentially the same inverse relation with postpartum attachment (for each of the pregnancy time points hormones correlated with postpartum attachment; e.g., total:  $r_s = -0.48$  to  $-0.52$ ,  $n = 18-20$ ,  $P < 0.018$ ; unbound,  $r = -0.34$  to  $-0.56$ ,  $n = 18-20$ ,  $P < 0.05-0.02$ )).

Moreover, consistent with the literature, mothers who experienced a smaller decrease in the E/P ratio from early pregnancy to day 4 postpartum had higher

postpartum feelings of attachment to their infants (5 months, 7 months, and 9 months, to 4 days postpartum,  $r = -0.60$ ,  $n = 17$ ,  $P < 0.01$ ;  $r = -0.35$ ,  $n = 16$ ,  $P = 0.18$ ; and  $r = -0.35$ ,  $n = 17$ ,  $P = 0.16$ , respectively). Put another way, mothers who maintained a higher E/P ratio over this time period (from pregnancy to postpartum) tended to have higher attachment feelings postpartum. Again, these relations to the E/P ratio were due primarily to changes in estrogen levels. Mothers who maintained relatively higher levels of estradiol over the parturitional period (less of a decline) experienced marginally higher attachment feelings postpartum (5 months:  $r = -0.44$ ,  $n = 17$ ,  $P = 0.075$ ; 7 months:

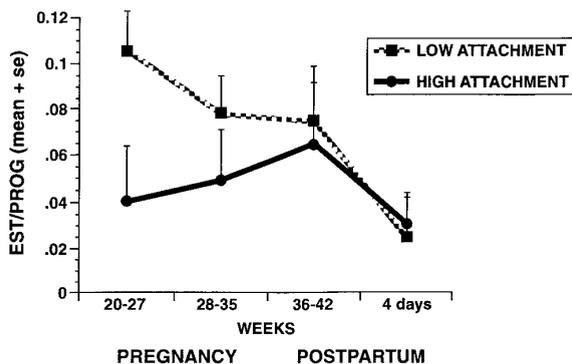


FIG. 4. Plasma estradiol/progesterone ratios during different phases of pregnancy in women expressing high and low levels of attachment (by median split) to their infants during the first few postpartum days.

$r = -0.45$ ,  $P = 0.075$ ; 9 months:  $r = -0.32$ ,  $n = 18$ ,  $P = 0.11$ ). Progesterone concentrations per se appeared unrelated to these effects.

The relation between postpartum attachment and changes in the E/P ratio *between* pregnancy time points, as opposed to across the parturitional period, were analyzed. Mother's postpartum attachment scores were divided by median split into high versus low postpartum attachment scores, and ANOVAs were performed on the change in the E/P ratio from the fifth to the ninth months of pregnancy. This analysis showed a significant interaction between postpartum attachment status (high vs low)  $\times$  E/P ratio change ( $F(1, 17) = 6.1$ ,  $P < .04$ ). As shown in Fig. 4 mothers expressing high attachment underwent an increase from the early to late pregnancy in the E/P ratio whereas those with low attachment experienced a decrease in the E/P ratio over this same time period.

**Mood correlates of attachment.** Attachment postpartum was also related to mood postpartum. Mothers who felt more elated and happier postpartum also felt more attached to their infants ( $r = 0.57$ ,  $n = 17$ ,  $P < 0.01$ ). Finally, the E/P ratios and E from pregnancy (5, 7, and 9 months) also correlated with mood postpartum (E/P: 5 months,  $r = -0.37$ ,  $n = 20$ ,  $P = 0.05$ , 1 t; 7 months,  $r = -0.44$ ,  $n = 19$ ,  $P = 0.03$ , 1 t; 9 months:  $r = -0.43$ ,  $n = 20$ ,  $P < 0.05$ ; E: 5 months:  $r = -0.28$ ,  $n = 20$ , ns; 7 months:  $r = -0.41$ ,  $n = 19$ ,  $P = 0.04$ , 1 t; 9 months:  $r = -0.44$ ,  $n = 21$ ,  $P < 0.05$ ).

**Multiple regression analyses.** Given these relations between hormones and postpartum mood we tested the hypothesis that mother's mood state postpartum in fact accounts for much of the variance in attachment

accounted for by hormones. Hierarchical regression analyses were undertaken on attachment postpartum in which first postpartum mood and then the change in the E/P ratio or E from pregnancy to postpartum were entered. Separate analyses were done in which we entered, as predictors, change in hormones from 5, 7, and 9 months of pregnancy to the postpartum period. Considering the change from 9 months of pregnancy to the postpartum, analyses showed that well-being postpartum accounted for 32% of the variance in attachment ( $F(1, 16) = 7.8$ ,  $P < 0.01$ ;  $R^2 = 0.327$ ) but that change in the E/P ratio or in E levels made no significant additional contributions (E/P:  $F(2, 14) = 3.3$ ,  $P = 0.06$ ;  $R^2 = 0.37$ ; E:  $F(2, 15) = 4.4$ ,  $P < 0.03$ ,  $R^2 = 0.37$ ). Using hormonal change from earlier pregnancy time-points in the equation produced somewhat different results. For both the 5- and 7-month time periods changes in the E/P ratio or in E alone made a significant additional contribution to attachment postpartum, after the entry of postpartum well-being. Thus, the change in E levels from 5 or 7 months of pregnancy to postpartum accounted for an additional 12 and 28% of the variance in postpartum attachment, respectively. The overall variance accounted for by both well-being and estradiol change from the 5- and 7-month time periods is 43% ( $F(2, 14) = 5.2$ ,  $P < 0.02$ ) and 48% ( $F(2, 13) = 6.2$ ,  $P < 0.02$ ), respectively.

**Prior experience effects.** The relation of prior experience to postpartum attachment was also evaluated. Surprisingly, prior experience caring for infants did not correlate with attachment to own infant postpartum ( $r = 0.30$ ,  $n = 19$ ,  $P = 0.20$ ). Other attitudes during pregnancy were, however, predictive of postpartum feelings of attachment. Interestingly, attitudes during the early pregnancy period were better predictors of Day 3 postpartum attachment than attitudes expressed at 7 or 9 months of pregnancy. For instance, mothers who felt more attached to their infants postpartum felt more attached to the fetus, had more positive feelings toward other infants and liked caretaking activities more during the first trimester of the pregnancy ( $r_s = 0.47-0.51$ ,  $n = 18-20$ ,  $P < 0.03-0.05$ ). Moreover, these mothers tended to have a better overall sense of well-being early in the pregnancy ( $r = 0.46$ ,  $n = 18$ ,  $P < 0.05$ ). Finally, there was no relation between either pre- or postpartum hormones and the amount of reported prior experience caring for infants.

**Hormone  $\times$  experience correlates.** Although prior experience with infants did not correlate with postpartum attachment feelings, the possibility still exists that hormonal effects would enhance the effects of experi-

ence on mothering. To test this, we undertook a series of multiple regression analyses in which we first entered prior childcare experience, then hormones (either pregnancy E/P ratios based on total concentrations and total or unbound E levels during the different pregnancy stages or change in hormone levels from the different pregnancy time points to postpartum). The last term entered into the equations was the hormone  $\times$  experience interaction term. Experience per se did not predict attachment on Postpartum Day 4, whereas for a number of the analyses the hormones accounted for a significant proportion of the variance; for example, prior experience with infants accounted for 13% of the variance in postpartum attachment feelings (not a significant effect) and the E/P ratio change from early pregnancy to postpartum accounted for an additional 26% of the variance (a significant change) bringing the total variance accounted for to 39% ( $F(2, 13) = 4.1, P < 0.03$ ). However, in none of the analyses did the interaction term make an additional contribution.

## DISCUSSION

The primary findings of these studies are (1) feelings of nurturance grow during pregnancy and from pregnancy to postpartum and (2) although hormones play no role in the growth of attachment feelings across pregnancy, they may well contribute to postpartum nurturant feelings; mothers showing less of a decline in the ratio of estradiol to progesterone or of estradiol levels from pregnancy to the early postpartum period reported the highest attachment feelings. Moreover, mothers with higher postpartum attachment feelings showed an increase in the E/P ratio from the fifth and from the seventh month, to the ninth month of pregnancy, whereas those with lower postpartum attachment scores showed no change or a decrease in the ratio over this same time period. Finally, (3) hormonal effects may act on feelings of nurturance directly and by influencing mothers' feelings of well-being.

Although there occurs across pregnancy a change in a number of maternal factors, different factors show different patterns of change. In the cross-sectional study, for most of the factors relating to infants or mothering, pregnancy and postpartum responses were more positive than prepregnancy responses; in the longitudinal study, many of these factors also showed elevations across the pregnancy itself as well as further elevations with the birth of the infant. For the factor related to the partner or spouse, the opposite pattern was found, with

more positive feelings during pregnancy and relatively less positive feelings pre- and postpregnancy.

The results of these studies suggest that the pattern of change in maternal attitude factors across the pregnancy period can best be explained, not by hormonal changes, but rather by changes in the women's cognitions and expectations. For instance although in other species, the growth in responsiveness across pregnancy seems to be dependent on hormones (see Fleming and Corter, 1988; Corter and Fleming, 1995), in women we find no relation between any of the hormones at any pregnancy time point and any of the maternal attitudes. We interpret the pregnancy-related elevation in positive feelings on a number of the maternal factors to be due instead to the cognitive changes associated with the knowledge of being pregnant and the associated demand characteristics (Fleming and Corter, 1988; Corter and Fleming, 1995).

Also, the change in mothers' positive feelings toward the fetus during the second trimester in both the cross-sectional and the longitudinal samples is consistent with descriptive results reported by Leifer (1977, 1980) that positive feelings at or around 20 weeks of gestation coincides with the "quickenings" or time of first perception by mothers of the movement of the fetus. Leifer describes this as a time when the fetus is first perceived as a distinct and unique individual, separate from the mother. Unfortunately, since we did not specifically ask mothers when they first felt fetal movement, we cannot correlate time of onset of fetal movement and elevated attachment to the fetus.

Although mother's postpartum feelings about the newborn were not related to the amount of time she had spent with infants prior to the pregnancy, they were positively related to her earlier feelings about infants and infant-related issues and overall well-being during earlier stages of pregnancy. Whether these early pregnancy attitudes actually reflect prepregnancy attitudes, we cannot tell from our longitudinal sample. However, the fact that there tends to be a high positive correlation between attitude factors across different stages of pregnancy suggests that they may in part. In contrast, our cross-sectional samples clearly show that first trimester mothers express more positive maternal attitudes than do non pregnant mothers, suggesting that something does indeed happen attitudinally with pregnancy onset. Consistent with the decline in positive maternal feelings toward the end of pregnancy, the relation between pregnancy attitudes and postpartum attachment drops out when attitudes later in pregnancy are correlated with postpartum feelings.

In contrast to the absence of a strong hormonal correlate of maternal feelings during pregnancy, the early postpartum feelings of nurturance or attachment to the infant seem to be related to the change in estrogen or the estrogen/progesterone ratio from early pregnancy to late pregnancy and to the early postpartum period. Mothers who undergo less of a decline in the E/P ratio or in E from pregnancy to postpartum or who in fact experienced an increase in the E/P ratio across pregnancy were more positively disposed toward their infants immediately after the birth. In contrast, the absolute levels or ratios of these hormones either during pregnancy or during the postpartum period were not related to postpartum responsiveness. There are, unfortunately, no animal studies that explore the relation between hormonal profiles during the early stages of pregnancy and postpartum maternal behavior with which to compare these results. In fact, there are remarkably few studies that undertake correlational analyses in animals at all.

Although we cannot comment on the temporal parameters of the relevant hormonal change, the present results are consistent with findings for other mammalian mothers in showing a relation between the change or dynamics of the steroids estradiol and progesterone during pregnancy and over parturition and maternal responsiveness in human mothers (Rosenblatt, 1990; Keverne, 1990; Bridges, 1990; Insel, 1990).

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