Hormones and Affect at Early Adolescence

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We assessed the relationship between hormones and mood states within the individual across time. Forty-five children (24 9-10 year old females; 21 11-12 year old males) and their parents participated. The children provided first morning voids of urine and a sample of saliva three days a week for 4 consecutive weeks. Both children and parents provided daily reports of the children's moods, affective states, and related behaviors the evening of each day preceding a hormone sample collection. (Other psychosocial measures were also collected.) We assayed testosterone and progesterone in the saliva samples and estradiol, FSH, and LH in the urine samples. Today we will present our initial analyses of these data. The presentation will focus on the following issues:

1. Importance of measuring both hormones and moods across time.

2. Between subject analyses of the relationships between hormones and moods for boys and girls as a group and for boys and girls within each of the first three pubertal stages.

3. Within subject analyses of the relationships between hormones and moods.

4. Possible reasons for individual differences in the strength of the relationships between hormones and moods.

Importance of measuring hormones and moods across time.

Many studies of hormones and moods collect measures of both types of variables at one point in time and then do between subject analyses to assess the strength of association between hormones and moods or behaviors. This strategy provides some insights into the role hormone levels might play in explaining individual differences in moods or behaviors; for example, whether sex differences in aggression are associated with sex differences in androgen concentrations. It does not, however, allow us to assess whether varying levels of hormones are associated with varying levels of either moods or behaviors at the individual level. It also provides relatively little insight into the degree of variability of hormones and moods across time during the adolescent period even though it is this variability that is assumed to characterize this developmental period. Finally, because it provides no index of variability of either hormones or moods and behaviors, it provides no information on the association between the impact of hormone variability on moods and behaviors. Our study was designed to overcome these problems: We have collected both hormones and mood and behavior ratings at multiple time points.

Before presenting evidence of the association between hormones and moods, we'd like to present some summary information about the variability of hormones and moods during the early adolescent period.

STABILITY AND VARIABILITY OF MOODS.

First, I'll discuss hormones. To simplify this presentation, we created within subject means and variances across time; that is, we averaged each subjects multiple measures into two summary measures: a mean and a variance. Table 1 shows the mean of the indivdual subject mean levels, the minimum and maximum levels for the individual subject means and the standard deviations of these individual subject monthly means for the five hormones we have assessed to date for boys and girls separately. As one would expect, there is considerable between subject variance in the mean levels of hormones.

With the exception of LH and progesterone, boys and girls have approximately the same mean levels and the same range of mean levels.

But more to the point, Table 2 shows the mean variances, the maximum and minimum variances and the the standard deviations in the variances of our five hormones for boys and girls separately. As you can see the range of individual subject's variance scores is quite large, suggesting that hormone levels are stable for some children and unstable for other children in this age range. Given the potential importance of variation itself as well as the importance of obtaining "reliable" indices of hormone concentration levels when one is doing longitudinal within or between subject analyses, these data call into question the use of single indicators of hormonal concentrations.

This point is even more graphic when you look at the range of patterns in hormone fluctuation across the month in this sample. The next set of graphs illustrate individual patterns for androgen in boys and progesterone in girls. Figure One illustrates an unstable pattern for a boy in the early stage of puberty; Figure Two illustrates a more stable pattern for a more developed boy. Figures Three and Four illustrate two fairly stable patterns of progesterone in early pubertal girls; Figures Five and Six illustrate more unstable patterns of progesterone in both an early and a mid pubertal girl. Finally, Figure Seven illustrates an unstable but regular pattern of progesterone in a mid pubertal girl. This last figure illustrates an additional advantage of multiple measures. By having four weeks of data, we were able to identify a silent cycle in several of our girls even though none of them was menstruating yet. Unfortunately, by sampling only 12-14 points during the month, we may have missed evidence of the beginning of silent cycles in other girls.

STABILITY AND VARIABILITY OF MOODS.

As with our hormone measures, we created within subject means and variances across time for our mood and behavior composites; that is, we averaged each subjects multiple mood measures into two summary measures: a mean and a variance. I am going to focus today on four mood/behaviors that show some consistent relationships to our hormone indicators. Table 3 presents these measures. Children rated their moods and behaviors on the items listed three times each week on the evening before they collected their urine and saliva samples. Composites were created using cluster analysis; alpha coefficents range from .72 to .88.

Table 4 shows the mean levels, the minimum and maximum levels and the standard deviations for four of the mood/behavior indicators for boys and girls separately. In inspecting this table note that the scores for anger/impatience and aggression were transformed using a log transformation due to the skewness in the distributions of the actual scores; consequently, the absolute values of these descriptive statistics can not be compared across all four indicators. As one would expect, there is considerable between subject variance in the mean levels for each of these measures. By and large, boys and girls have similar mean levels and similar ranges for their mean levels.

But more to the point, Table 5 shows the mean variances, the maximum and minimum variances and the the standard deviations in the variances of these four variables for boys and girls separately. As you can see the range of individual subject's variance scores if quite large, suggesting that mood/behavior levels are more or less stable across individual children in this age range. This degree of within subject variability provides us with the necessary condition for assessing the relationships between hormone variation and mood/behavior variations at the level of the individual subject.

Hormone and Mood Associations

Overview of our methods

Hormones. We assessed three hormones in boys (LH, FSH, and Androgen) and five hormones in girls (LH, FSH, Androgen, Estradiol, and Progesterone). Androgens and progesterone were assessed in saliva; LH, FSH, and estradiols in urine. Saliva and urine samples were collected each morning in the home by the subjects and stored in their refrigerators until the end of each week of testing when the samples were picked up and delivered immediately to our freezers at the Reproductive Endocrinology Program at the University of Michigan. Our assays were done by technicians at the Reproductive Endocrinology Laboratory at the University of Michigan.

Moods. Our subjects provided us with self-ratings of their moods each of the three evenings preceding the saliva and urine collection; i.e. Sunday night preceding the Monday morning collection of saliva and urine; Monday night preceding the Tuesday morning collection; and Tuesday night preceding the Wednesday morning collection.

If subjects missed a day of collecting either their moods or their saliva and urine samples, they were asked to record this fact and then collect both types of data on Wednesday evening/Thursday morning or as soon as possible. They were asked to record the exact day on which the make-up data were collected.

Perceived Pubertal Status. We used Petersen et al.'s (1985) Scale of Pubertal Development to assess the children's perception of their own pubertal development. We created pubertal development composites using the formula developed by Petersen to simulate Tanner stages. Not surprisingly, given the age of our children, our sample fell into the first three stages only.

Overview of analyses.

We are reporting on two types of analyses: Between subject analyses and within subject analyses. I will say more about each of these as I get to that section. We are also reporting on two types of lags. Since we use both types of lags for both between and within subject analyses, I will go over these lags now. As I explained, we have hormones assays in both urine and saliva. These were gathered in the morning. We are assuming that the assays in saliva (androgen and progesterone) reflect the concentrations of that hormone in the blood at the moment of collection. These hormones presumedly have not yet had their affect on behavior. In contrast, LH, FSH, and estradiol were assayed from the urine samples. These assays reflect the metabolites of these hormones; consequently they represent active concentrations of the hormones during the preceding day or nighttime period. Moods and behaviors ratings were collected the evening before urine and saliva were collected. This regimen is illustrated on Figure 8. We can test various hypotheses about the causal direction of the associations between hormones and moods/behaviors by looking at various lagged analyses. For purposes of this discussion, I am assuming fairly short causal lag time between changes in mood states and changes in hormone concentrations.

For example, Figure 8 illustrates the use of night mood ratings to morning salivary hormones. This association is best interpreted as a predominantly behavior to hormone link in the absence of data indicating that the hormone levels are stable across time. Contrast this figure with Figure 9 which illustrates the use of a morning salivary hormone to night mood ratings. This association is best interpreted as a predominantly

hormone to behavior link in the absence of data indicating that the behaviors and moods are stable between day 1 and day 2.

Interpreting various lagged relationships between the urinary hormones and behavior ratings is more difficult because the time between hormone metabolism and the appearance of the metabolites in first morning urine is not firmly established. Since it is likely that the metabolites from yesterday's hormones are present in first morning urine, we have no logical justification for interpreting any associations between night time mood ratings and next morning urinary hormones as reflecting either a hormone to behavior link or a behavior/mood to hormone link. This is illustrated in Figures 10 and 11. Interpretations of significant associations between morning hormone concentrations and same day evening behavior/mood ratings are a bit easier to justify; these probably represent hormone to mood/behavior links. This is illustrated in Figure 12. Given limited time today, I am going to focus on the hormone to mood/behavior link and will draw your attention to the evidence supportive of this interpretation.

Between subject analyses

We have used several techniques to look at the association of between subject concentrations of hormones and mood/behavior ratings. At the grossest level, we used hormone concentrations to predict mood ratings taking each entry as a data point ignoring the fact that subjects are represented more than once in the data set.
Very few significant results emerge and the relationships are quite small.

Salivary Hormones:

Progesterone in females: See Table 6.
Night to Morning Patterns
Get no findings significant at <.05 for population as a whole or at any of the three pubertal levels. Weak **positive association between progesterone and both energy level and aggression in mid-pubertal girls.**

Morning to Night Patterns:
Significant **positive association between progesterone and aggression in total sample** and especially in **early pubertal girls.** Comparing the results of these two lags suggests a hormone to behavior link for progesterone to aggression in girls.

Androgen in females: See Table 7.
Night to Morning Patterns
Consistent and strong **negative relationship between androgen and anger/impatience** at all three pubertal levels.

Morning to Night Patterns:
Significant negative association between **androgen levels and anger/impatience in total sample** and in **mid-pubertal girls.** Comparing the results of the these two lags suggests a feedback loop involving causal effects in both directions.

Androgen in males: See Table 8.
Night to Morning Patterns
Strong relationship between **androgen and both anger/impatience and aggression among pre-pubertal boys**; and between androgen and anger/impatience for the **population as a whole.** The direction of these effects, however, differs for the two dependent variables: **negative for anger/impatience and positive for aggression.** We also get a weak **positive** relationship between **androgen and energy level in early pubertal boys and in the population as a whole.**

Morning to Night Patterns:
Significant **negative** associations between **androgen levels and positive mood** in total sample and in **early pubertal boys.** Significant **negative** association between **androgen levels and anger/impatience in mid pubertal boys.** Comparing the results of the two lags suggests that bi-directional causal relationship between androgens and anger/impatience in boys and a hormone to affect causal link between androgen and mood in boys.

Urinary Hormones:
Estradiol in females: See Table 9.
Night to Morning Patterns
Significant **negative** association between **estradiol and anger/impatience** in whole sample and in **mid pubertal girls.** Significant positive association between **estradiol and positive mood** in whole sample.

Morning to Night Patterns:
Weak **negative** relationship between **estradiol and anger/impatience and a weak positive association with mood** in **mid pubertal** and total sample. Comparing the two lags provides some support for a hormone to mood causal link between estradiol and both anger/impatience and positive moods.

LH in females: See Table 10.
Night to Morning Patterns
Significant **positive** association between **LH and anger/impatience and positive mood, and a negative** association to **aggression in early pubertal girls only.**

Morning to Night Patterns:
Again relations are weak and limited to sub populations. **Negative** relationship between **LH and energy in mid pubertal girls** and a **positve** relationship between **LH and aggression in early pubertal girls.** Comparing the two lags provides some support for a feedback loop between LH and hormone but only in early pubertal girls.

LH in males: See Table 11.
Night to Morning Patterns
Significant **negative** relationship between **LH and mood** only in **pre-pubertal boys.**

Morning to Night Patterns:
LH has **positive** associations with **anger/impatience** and a **negative** association with **mood.** However, since these relationships, as is true for the FSH results in boys, are substantially weakened when days with extreme LH scores are removed, these associations probably reflect the powerful influence a few extreme cases. Nonetheless, comparing the two lags provides some weak support for an LH to anger/impatience link in boys.

FSH in females: See Table 12.
Night to Morning Patterns
No significant relationships

Morning to Night Patterns:
No consistent effects

FSH in males: See Table 13.
Night to Morning Patterns
Consistent and strong **negative** associations between **FSH and both energy level and moods** in all boys except pre-pubertal boys. These effects, however, like the effects for LH, probably represent the impact of a few extreme scores because these effects are substantially weakened when days with extreme FSH scores are removed from the sample.

Morning to Night Patterns:
No consistent pattern, especially when outliers are removed.

Summary.
In summary, we have fairly consistent evidence in support of the following hormone to mood/behavior links.

1. **Progesterone to relatively high levels of aggression in females.**

2. **Androgen to low levels of anger/impatience** in both males and females.

3. **Estradiol to both low levels of anger/impatience and positive moods** in females.

4. LH to aggression in early pubertal girls only.

5. LH to negative mood in pre-pubertal boys.

6. Maybe a relationship of LH to relatively high levels of **anger/impatience in pre and early pubertal boys.**

7. Patterns of association vary by pubertal group but the pattern is quite mixed. The most consistent pubertal group effects, however, suggest that slightly more consistent relationships may hold during the pre and early pubertal periods than during the mid pubertal periods.

Between subject analyses controlling for repeated measurement.

The next set of analyses take advantage of our repeated measures to test between subject effects. Assuming that you need multiple measures of both hormones and moods to establish reliable indicators of children's average hormone concentrations and moods; and of the variability in children's hormone concentrations, we calculated mean levels and variances for each of these measures and then related these indices to each other. We made two types of predictions.

1. Children with higher mean concentrations on the hormone would evidence higher mean levels of the mood/behavior in question.

2. Children with more variable hormone concentrations would evidence higher mean levels of the mood/hormone in question.

We have just begun the analyses testing these hypotheses. Mary Lou Tucker is doing the anger/impatience and aggression analyses for her dissertation. Christy Miller is doing the energy and mood analyses on females only for her dissertation. Their initial findings are summarized briefly here. Rather than remove outliers in these analyses, we used log transformation where appropriate before analyzing our data.

Several interesting effects emerged from Mary Lou Tucker's analyses of anger/impatience and aggression. In general, in predicting anger/impatience and aggression, variance indicators were more often significant in the predicted direction than mean concentration levels.

a. Using the hormone standard deviation to predict mean levels of anger/impatience and aggression, **high standard deviation in androgen concentrations** was associated with high mean levels of **reported anger/impatience** (R-squared = .11) and **aggression** (R-squared = .16). ANCOVA analyses indicate that these effects do not vary by sex of child even though the coefficients are different (the females' coefficient is larger in each case).

b. Again using the hormone standard deviation to predict mean levels of anger/impatience and aggression, there is a **positive** association between **high variance in progesterone** and reported mean levels of **aggression** in girls (R-squared = .17).

c. Using the **mean hormone concentration** to predict mean levels of anger/impatience and aggression yielded a counter-intuitive result: Higher mean concentrations of **androgen** predicted lower **mean levels of anger/impatience** in both males and females (Coefficents = -.16 and -.18 respectively).

d. Again using the mean hormone concentration to predict mean levels of anger/impatience and aggression yielded a weak positive association between **progesterone concentrations** and reported mean levels of **aggression in girls** (R-coefficient = 27).

Equally interesting results have emerged in Christy Miller's analyses. She is using a different measure of mood. Instead of using the item asking whether they were in a positive or negative mood, Christy has looked at the individual moods themselves and grouped these moods into two multivariate clusters: a positive mood and a negative mood cluster. She has calculated two scores for each of these two clusters: an mean intensity score which reflects the monthly average of the child's daily deviation from the population modal response; and a mean variability score which is the variance across the month for each child's daily intensity scores.

A slightly different pattern emerges in Christy's data. When pubertal stage is not controlled, it is the concentration level, not the variability of the hormone that is a significant predictor. Relatively **high concentrations of FSH only** are associated with **relatively high intensity of negative moods (especially nervousness and shame). Average concentration of FSH only** is also positively related to both **positive and negative mood variability** across the month but more so for negative mood variability. Finally, **average concentrations of FSH only** is positively related to reported **variability in energy levels**. Consistent with Mary Lou's findings, Christy also finds a **negative** association between **mean androgen concentrations and impatience.**

Within Subject Analyses

Within subject regression analyses were to used to measure the strength of the relationship between daily variations in these hormones and fluctuations in composite indicators of our four mood/behaviors. Consistent with the analyses already reported, we used both types of lags in these analyses and will focus on those that provide the most consistent support of a hormone to mood/behavior link.

Given that the individual subject is the sample in these analyses, the number of observations in each regression is quite small (between 9 and 14). Consequently, one would need a very large R-squared for each analyses to be significant. However, it is unlikely that hormones account for a large proportion of the variance in moods and behaviors if they account for any at all. Ideally, then to test for a significant association at the individual level one would need many more observations than one could reasonably expect to get from a volunteer sample. How then do we assess the significance of our results? We counted the proportion of individuals that produced an R-squared value of greater .10. These proportions are reported on Tables 14 and 15. We looked for proportions higher than 60%.

Females: Salivary Hormones

Consistent with the hypothesis of greater hormone to mood/behavior links, a higher proportion of females show a relationship between hormones and the mood/behavior indices on the morning to night analyses than on the night to morning analyses. But more importantly, only two sets of regressions yield proportions higher than 60%: **Progesterone and energy level; and progesterone and aggression.** But the direction of the relationship was not consistent across individuals: It was positive for some and negative for others, suggesting a complex relationship between progesterone and both energy and aggression.

Males: Salivary Hormones

Again consistent with the hypothesis of greater hormone to mood/behavior links, a higher proportion of males show a relationship between androgens and the mood/behavior indices on the morning to night analyses than on the night to morning analyses. Furthermore, these proportions are quite high, especially for anger/impatience, suggesting that the association between **androgens and anger/impatience** is characteristic of most boys. But, as was true for progesterone, the direction of the relationship varied across individuals.

Females: Urinary Hormones

The bulk of the evidence for urinary hormones supports a hormone to mood/behavior link. This link is most reliably demonstrated for association between **FSH and anger/impatience** and between **LH and mood.** As was true for the between subject analyses, there is also evidence of an association between **estradiol and both anger/impatience and mood.** Again, the direction of all of these relationships varied across individuals.

Males: Urinary Hormones

Once again the bulk of the evidence supports a hormone to mood/behavior link. This link is most reliably demonstrated for the positive association between **LH and aggression.** There is also evidence of an association between **FSH and anger/impatience, mood, and aggression** in the morning hormone to evening mood/behavior ratings, but the direction of these relationships varied across individuals.

Summary and Discussion

The different types of analyses presented here have yielded some consistent and some inconsistent patterns of results. The link between **androgens and anger/impatience** yielded the most consistent pattern especially for the **hormone variance** indicators. Having high mean concentrations of androgens is not associated with high mean levels of anger/impatience or aggression. Instead it is the people who have the most variable concentrations of androgens who have the highest mean levels of anger/impatience, and the within subject analyses suggest that they are the angriest when their concentrations are relatively low.

The link between **progesterone and aggression** in girls also yielded a fairly consistent pattern even though the associations were quite weak in some analyses. This positive association is evident for both the mean concentration levels and the variability of progesterone suggesting that both high levels and highly fluctuating levels of progesterone are associated with relatively higher levels of aggression in females. Individual analyses complicate this pattern, however. In these analyses the association is positive in some children and negative in others, suggesting that although there is a trend in the aggregated data toward a positive association between progesterone and aggression, this trend is not characteristic of all of the girls who appear to be sensitive to the effects progesterone.

LH seemed to have an effect on **boys only** and only in the within subject analyses: **LH was positively associated with aggression** in these analyses.

In contrast, **FSH** had effects on both males and females but the consistency in the pattern of these associations varied across sex. Evidence of an association between **FSH and anger/impatience** emerged for males but only in the within subject analyses, and the direction of the association in these analyses varied across individuals. Evidence of a positive association between FSH and anger/impatience in some females emerged in both the within and between subject analyses. However, the association of FSH and both mood and anger/impatience was negative for at least some of the girls, suggesting again that not girls who are sensitive to the effects of particular hormones respond in the same way. Evidence of a positive association between **FSH concentrations and other negative moods such as shame and impatience** also emerged in the between subject analyses of Christy Miller.

Finally, we found some consistent evidence of a relationship between **estradiol and both low levels of anger/impatience and moods** in girls.

Between Subject Variation in Within Subject Patterns of Association between Hormones and Mood/Behaviors

What isn't evident in the analyses I presented thus far is the range of individual variation in the strength of the association between hormones and mood/behaviors. For each set of analyses, individual subject R-squareds ranged from .000 to as high as .90 and the direction of association ranged from positive to negative. These variations

certainly make an already complex story more complex and may explain why it is so difficult to document consistent hormone - mood/behavior links across studies and across populations.

We have just begun to investigate whether there is any systematic explanation for these individual differences. One obvious explanation of course is pubertal stage. One might predict, for example, that hormone variations will have their strongest impact on mood/behaviors early in pubertal development before the body has a chance to adapt to increasing levels of hormones and before the hormonal system stabilizes. We have found very little evidence of systematic variation in these relationships associated with pubertal stage. This may reflect the pubertal measure we are using: it is a perceived, self-report measure, and as Christy will report later in this conference, is only moderately related to doctors' ratings of the children's pubertal stage especially for boys. The inconsistent associations with pubertal stage may also reflect the age range of our sample. We have a limited age range. Pubertal stage might emerge as a stronger predictor if a wider age range was used.

Alternatively, the variation may reflect non-monotonic relationships between hormones and moods. Some evidence from the animal literature suggests, for example, that estradiol may alter the sensitivity of an individual. How they feel would then depend on the type of person they are or on the social experiences they have while their sensitivity is altered. The mixed relationships with mood provide an example of this process. The low end of this scale is negative mood; the high end is positive mood. Some girls may experience negative moods in association with heightened levels of estradiol; others might experience positive moods depending on such factors as their temperament and their social experiences. The same process could be going on with anger/impatience. The very low ends of this scale might reflect depressed states whereas the relatively high ends might reflect highly activated states. Hormones changes could facilitate either state depending on the situation and the person. We are just beginning to explore these possible explanations.

What else might account for these individual differences. Given the undoubtedly strong impact of social experiences on moods and behaviors, it seems likely that the strength of the association between hormones and moods will vary depending on daily fluctuations in the social experiences of the child. Hormonal influences may be easily overridden or intensified by social experience. At this young age, we may see the associations between hormones and moods primarily in children with stable, benign social environments in which normal variations in social experience can interact with hormone states in influencing moods. We have gathered the type of information that will allow us to explore this hypothesis and will report on our analyses in the future.

Table 1

Means, Standard Deviations, and Ranges for Hormone Concentrations at Wave 1 - Girls

Hormone	N	Minimum	Maximum	Mean	Standard Deviation
Progesterone	24	31.17	97.25	58.00	16.90
Androgen	24	44.55	737.83	256.91	174.11
Estradiol	25	70.18	294.82	141.04	42.82
LH	25	0.83	3.06	1.67	0.60
FSH	25	1.71	5.73	3.09	0.96

UNITS: Progesterone and androgens measured in pg / ml.
Estradiol measured in pg / mg.
LH and FSH measured in mIU / mg.

Means, Standard Deviations, and Ranges for Hormone Concentrations at Wave 1 - Boys

Hormone	N	Minimum	Maximum	Mean	Standard Deviation
Androgen	21	86.67	835.45	263.25	189.19
LH	21	2.30	9.28	5.15	1.92
FSH	21	1.13	5.25	2.94	1.14

UNITS: Progesterone and androgens measured in pg / ml.
LH and FSH measured in mIU / mg.

Table 2

Means, Standard Deviations, and Ranges for Hormone Variance at Wave 1 - Girls

Hormone	N	Minimum	Maximum	Mean	Standard Deviation
Progesterone	24	93.54	3620.70	732.44	866.53
Androgen	24	743.06	177530.00	31837.00	51141.00
Estradiol	25	397.61	30073.00	2952.70	6815.90
LH	25	0.03	32.10	1.86	6.50
FSH	25	0.58	65.10	5.08	13.04

UNITS: Progesterone and androgens measured in pg / ml.
Estradiol measured in pg / mg.
LH and FSH measured in mIU / mg.

Means, Standard Deviations, and Ranges for Hormone Variance at Wave 1 - Boys

Hormone	N	Minimum	Maximum	Mean	Standard Deviation
Androgen	21	805.19	251190.00	32625.00	63914.00
LH	21	0.85	20.08	6.09	5.58
FSH	21	0.19	9.57	1.83	2.09

UNITS: Progesterone and androgens measured in pg / ml.
LH and FSH measured in mIU / mg.

Table 4

Table 3

Line Item Questions Comprising Mood and Behavior Composites

I. ENERGY COMPOSITE:

A. Today I was mostly:
1 = Tired
5 = Full of energy

B. Today, I felt mostly like doing something:
1 = Very quiet or relaxing
5 = Very active

C. Today I had:
1 = Less energy than usual
5 = More energy

II. ANGER COMPOSITE:

A. How often did you feel frustrated today?
1 = Not at all
5 = Very often

B. Today I felt (Angry):
1 = Not at all angry
5 = Very angry

C. Today I felt (Impatient)
1 = Not at all impatient
5 = Very impatient

III. MOOD COMPOSITE:

A. This morning I was in a:
1 = Very bad mood
5 = Very good mood

B. This afternoon I was in a:
1 = Very bad mood
5 = Very good mood

C. This evening I was in a:
1 = Very bad mood
5 = Very good mood

IV. AGGRESSION COMPOSITE:

How often did you do each of the following?

A. Yell, at a friend, brother or sister?
1 = Never
2 = Once or twice
3 = Three or more times

B. Yell at your mother or father?
1 = Never
2 = Once or twice
3 = Three or more times

C. Throw something because you were angry?
1 = Never
2 = Once or twice
3 = Three or more times

D. Hit or push someone?
1 = Never
2 = Once or twice
3 = Three or more times

Means, Standard Deviations, and Ranges for Mood Composites at Wave 1

Hormone	N	Minimum	Maximum	Mean
Energy	25	1.00	4.57	3.46
Anger	25	.00	.99	.43
Mood	25	2.74	5.00	4.12
Aggression	25	.03	.67	.30

Note. Log transformations were performed for anger and aggression compo

Means, Standard Deviations, and Ranges for Mood Composites at Wave 1

Hormone	N	Minimum	Maximum	Mean
Energy	21	2.72	4.33	3.54
Anger	21	.09	1.13	.49
Mood	21	2.98	4.95	3.88
Aggression	21	.12	.69	.32

Note. Log transformations were performed for anger and aggression comp

Table 5

Means, Standard Deviations, and Ranges for Mood Composite Variance at Wave 1 - Girls

Hormone	N	Minimum	Maximum	Mean	Standard Deviation
Energy	25	.00	3.48	1.14	1.01
Anger	25	.00	.29	.10	.07
Mood	25	.00	2.29	.50	.48
Aggression	25	.002	.15	.04	.04

Note. Log transformations were performed for anger and aggression composites.

Means, Standard Deviations, and Ranges for Mood Composite Variance at Wave 1 - Boys

Hormone	N	Minimum	Maximum	Mean	Standard Deviation
Energy	21	.03	2.42	88	68
Anger	21	.02	.21	.08	.06
Mood	21	.01	1.06	30	.25
Aggression	21	.01	.10	.04	.03

Note. Log transformations were performed for anger and aggression composites.

Table 6

Results of regression analyses using progesterone to predict moods (night to morning) for girls

Hormones

		Energy		Anger		Mood		Aggression	
Pubertal Status	N	R^2	F	R^2	F	R^2	F	R^2	F
Pre-pubertal	30	.01	.44	.02	.56	.003	.96	.02	.70
Early pubertal	121	.00	84	.00	.17	.00	.13	.01	1 74
Mid pubertal	102	.04	3.69*	.00	.23	.02	1.81	.03	3.27*
All Girls	253	.002	.58	.00	.08	.002	.55	.01	2.34

*p≤.10

Results of regression analyses using progesterone to predict moods (morning to night) for girls

Hormones

		Energy		Anger		Mood		Aggression	
Pubertal Status	N	R2	F	R2	F	R2	F	R2	F
Pre-pubertal	30	.04	.98	.01	.13	.12	3 90*	00	67
Early pubertal	121	.003	.39	.001	.99	.001	.64	04	4 47**
Mid pubertal	102	.003	35	003	28	01	62	01	65
All Girls	253	.00	.004	.00	03	00	10	.02	3 97**

*p ≤ .10 **p≤.05

Table 7

Results of regression analyses using androgens to predict moods (night to morning) for girls

Hormones

		Energy		Anger		Mood		Aggression	
Pubertal Status	N	R^2	F	R^2	F	R^2	F	R^2	F
Pre-pubertal	30	.01	.32	.09	2.97*	.00	.18	.08	2.85*
Early pubertal	121	.01	.92	.04	5.15**	.00	.28	.00	.70
Mid pubertal	102	.04	4.04*	.05	5.37**	.01	.92	.00	.12
All Girls	253	.00	.25	.05	12.22****	.001	.26	.002	.53

*p≤.10 **p≤.05 ****p≤.001

Results of regression analyses using androgens to predict moods (morning to night) for girls

Hormones

		Energy		Anger		Mood		Aggression	
Pubertal Status	N	R2	F	R2	F	R2	F	R2	F
Pre-pubertal	30	.03	.90	.03	.77	.01	.18	.12	3.89*
Early pubertal	121	.003	.31	.02	1.89	.001	.14	.02	2.60
Mid pubertal	102	.01	.78	.06	6.16***	.01	.47	.00	.17
All Girls	253	.003	.71	.03	7.76***	.00	.003	.002	.51

*p ≤ .10 ***p≤.01

Table 8

Results of regression analyses using androgens to predict moods (night to morning) for boys

Hormones

		Energy		Anger		Mood		Aggression	
Pubertal Status	N	R^2	F	R^2	F	R^2	F	R^2	F
Pre-pubertal	55	.01	.54	.25	18.47****	.002	.13	.26	18.63****
Early pubertal	156	.03	5.43**	.01	2.03	.00	.77	.00	43
Mid pubertal	12	.10	1.00	.00	.17	.13	1.34	.10	1.01
All Boys	223	.01	2.71*	.04	18.91***	.001	.26	.01	1.38

*p≤.10 **p≤.05 ***p≤.01 ****p≤.001

Results of regression analyses using androgens to predict moods (morning to night) for boys

Hormones

		Energy		Anger		Mood		Aggression	
Pubertal Status	N	R2	F	R2	F	R2	F	R2	F
Pre-pubertal	55	.03	1.70	.003	.18	.02	1.29	.01	.77
Early pubertal	156	.01	1.98	.001	.95	.03	4.75**	.003	.45
Mid pubertal	12	.15	1.71	.39	6.50**	.002	.24	.08	.91
All Boys	223	.002	.53	.00	.17	.03	6.91***	.00	.05

**p ≤ .05 ***p≤.01

Table 9

Results of regression analyses using estradiol to predict moods (night to morning) for girls

Hormones

		Energy		Anger		Mood		Aggression	
Pubertal Status	N	R^2	F	R^2	F	R^2	F	R^2	F
Pre-pubertal	30	.003	.84	.00	.59	.02	.59	.01	.32
Early pubertal	121	.00	.31	.002	.28	.02	2.86*	.01	1.16
Mid pubertal	102	.01	1.48	.08	9.07***	.03	3.11*	.01	.89
All Girls	253	.002	.54	.03	7.03***	.02	4.35**	.01	2.79*

*p≤.10 **p≤.05 ***p≤.01

Results of regression analyses using estradiol to predict moods (morning to night) for girls

Hormones

		Energy		Anger		Mood		Aggression	
Pubertal Status	N	R2	F	R2	F	R2	F	R2	F
Pre-pubertal	30	.01	.42	.08	2.72	.03	1.12	.001	.30
Early pubertal	121	.001	.11	.00	.18	.02	2.39	.001	.10
Mid pubertal	102	.03	3.15*	.04	3.95**	.03	3.17*	.002	.15
All Girls	253	.01	2.14	.01	3.62*	.02	4.60**	.002	.46

*p ≤ .10 **p≤.05

Table 10

Results of regression analyses using LH to predict moods (night to morning) for girls

Hormones

		Energy		Anger		Mood		Aggression	
Pubertal Status	N	R^2	F	R^2	F	R^2	F	R^2	F
Pre-pubertal	30	.01	.27	.05	1.68	.05	1.43	.004	.12
Early pubertal	121	.02	2.15	.06	7.82***	.03	4.08**	.11	14.43****
Mid pubertal	102	.04	4.14	.002	.22	.00	.65	.00	.84
All Girls	253	.00	.002	00	.01	.00	01	.01	1.28

**p≤.05 ***p≤.01 ****p≤.001

Results of regression analyses using LH to predict moods (morning to night) for girls

Hormones

		Energy		Anger		Mood		Aggression	
Pubertal Status	N	R2	F	R2	F	R2	F	R2	F
Pre-pubertal	30	.001	.33	.01	.26	003	.10	.04	1.29
Early pubertal	121	.02	2.39	.01	.92	01	1.09*	.04	4.75**
Mid pubertal	102	.05	5.25**	00	.22	002	.23	003	.30
All Girls	253	.00	.09	00	04	.00	.20	.004	.97

*p ≤ .10 **p≤.05

Table 11

Results of regression analyses using LH to predict moods (night to morning) for boys

Hormones

		Energy		Anger		Mood		Aggression	
Pubertal Status	N	R^2	F	R^2	F	R^2	F	R^2	F
Pre-pubertal	55	.01	.27	.05	2.54	.14	8.66***	.00	.21
Early pubertal	156	.002	.33	.01	1.53	.001	.19	.01	1.20
Mid pubertal	12	.13	1.08	.21	1.89	.08	.57	.003	.22
All Boys	223	.00	.01	.001	.25	.003	.72	.003	.70

***p≤.01

Results of regression analyses using LH to predict moods (morning to night) for boys

Hormones

		Energy		Anger		Mood		Aggression	
Pubertal Status	N	R2	F	R2	F	R2	F	R2	F
Pre-pubertal	55	.000	.59	.16	9.24***	.16	9.31***	.07	3.66*
Early pubertal	156	.002	.43	.02	2.95*	.02	2.35	.01	1.38
Mid pubertal	12	.28	3.16	.46	6.84**	.29	3.19	.01	.53
All Boys	223	.004	.76	.03	6.92***	.02	5.09**	.003	.54

*p≤.10 **p ≤ .05 ***p≤.01

Table 12

Results of regression analyses using FSH to predict moods (night to morning) for girls

Hormones

		Energy		Anger		Mood		Aggression	
Pubertal Status	N	R^2	F	R^2	F	R^2	F	R^2	F
Pre-pubertal	30	.06	1.79	.01	.44	.01	.31	.004	.11
Early pubertal	121	.003	.37	.01	1.19	.02	2.04	.01	.72
Mid pubertal	102	.02	1.84	.00	.12	.001	.16	.00	.17
All Girls	253	.00	.58	.00	.67	.01	1.81	.00	.73

Results of regression analyses using FSH to predict moods (morning to night) for girls

Hormones

		Energy		Anger		Mood		Aggression	
Pubertal Status	N	R2	F	R2	F	R2	F	R2	F
Pre-pubertal	30	.01	.29	.01	46	.01	.43	.002	62
Early pubertal	121	.001	.14	.001	.14	.01	.90	.01	1.45
Mid pubertal	102	.05	4.85**	.001	48	.01	.90	.01	1.25
All Girls	253	.01	1.40	.00	04	.01	2.12	.00	.19

**p≤.05

Table 13

Results of regression analyses using FSH to predict moods (night to morning) for boys

Hormones

		Energy		Anger		Mood		Aggression	
Pubertal Status	N	R^2	F	R^2	F	R^2	F	R^2	F
Pre-pubertal	55	.01	.34	.001	.91	.04	2.32	.05	2.99*
Early pubertal	156	.06	9.33***	.01	1.23	.03	5.24**	.001	.92
Mid pubertal	12	.45	7.24**	.04	.40	.58	12.45***	.01	.71
All Boys	223	.03	7.97***	.01	2.77*	.05	11.71****	.002	.38

*p≤.10 **p≤.05 ***p≤.01 ****p≤.001

Results of regression analyses using FSH to predict moods (morning to night) for boys

Hormones

		Energy		Anger		Mood		Aggression	
Pubertal Status	N	R2	F	R2	F	R2	F	R2	F
Pre-pubertal	55	.00	.13	.14	7.71***	.01	.30	.02	1.10
Early pubertal	156	.01	.94	.003	.41	.001	.15	.001	.10
Mid pubertal	12	.00	.34	.01	.46	.001	.58	.05	.49
All Boys	223	.01	1.64	.00	.18	.004	.97	.003	.61

***p≤.01

Table 14

Proportion of R^2 between .10 and .90 for Various Hormone-Behavior Relationships for Girls (night to morning).

Hormones

	$Androgens_{sal}$		$Estradiol_{urine}$		FSH_{urine}		LH_{urine}		$Progesterone_{sal}$	
Moods/Behaviors	%	N	%	N	%	N	%	N	%	N
Energy	.30	7/23	.38	9/24	.38	9/24	33	8/24	.26	6/23
Anger	.49	11/23	.35	8/23	57	13/23	39	9/23	43	10/23
Mood	.30	7/23	35	8/23	35	8/23	52	12/23	43	10/23
Aggression	.39	9/23	33	8/24	33	8/24	33	8/24	43	10/23

Proportion of R^2 between .10 and .90 for Various Hormone-Behavior Relationships for Girls (morning to night - no outliers)

Hormones

	$Androgens_{sal}$		$Estradiol_{urine}$		FSH_{urine}		LH_{urine}		$Progesterone_{sal}$	
Moods/Behaviors	%	N	%	N	%	N	%	N	%	N
Energy	.59	10/17	.50	10/20	52	11/21	56	10/18	67	10/15
Anger	.57	8/14	.63	10/16	75	12/16	.63	10/16	55	6/11
Mood	.47	7/15	.72	13/18	59	10/17	71	12/17	54	7/13
Aggression	.53	9/17	.50	9/18	.60	12/20	.56	9/16	77	10/13

Table 15

Proportion of R^2 between .10 and .90 for Various Hormone-Behavior Relationships for Boys (night to morning).

Hormones

	Androgens$_{cal}$		FSH$_{urine}$		LH$_{urine}$	
Moods/Behaviors	%	N	%	N	%	N
Energy	.29	6/21	.48	10/21	.48	10/21
Anger	.24	5/21	.29	6/21	.43	9/21
Mood	.43	9/21	.29	6/21	.52	11/21
Aggression	.38	8/21	.29	6/21	.57	12/21

Proportion of R^2 between .10 and .90 for Various Hormone-Behavior Relationships for Boys (morning to night-no outliers)

Hormones

	Androgens$_{cal}$		FSH$_{urine}$		LH$_{urine}$	
Moods/ Behaviors	%	N	%	N	%	N
Energy	.75	15/20	.42	8/19	.36	5/14
Anger	.80	16/20	.61	11/18	.47	7/15
Mood	.70	14/20	.67	12/18	.38	6/16
Aggression	.63	12/19	.65	11/17	.63	10/16

Figure 1

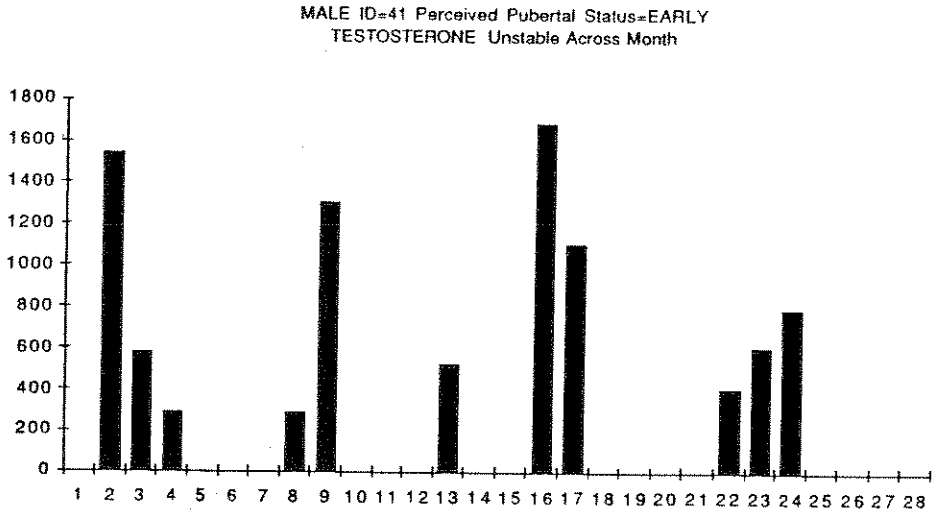

Figure 2

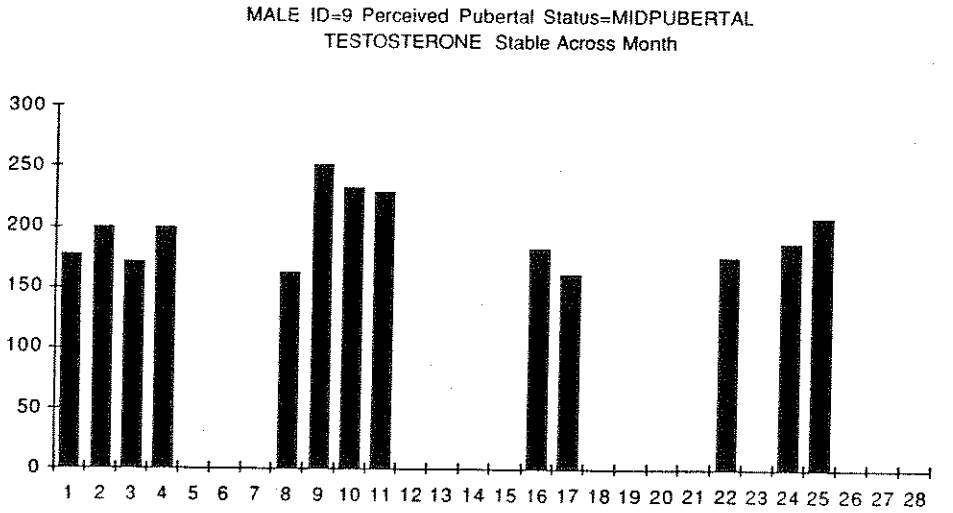

Figure 3

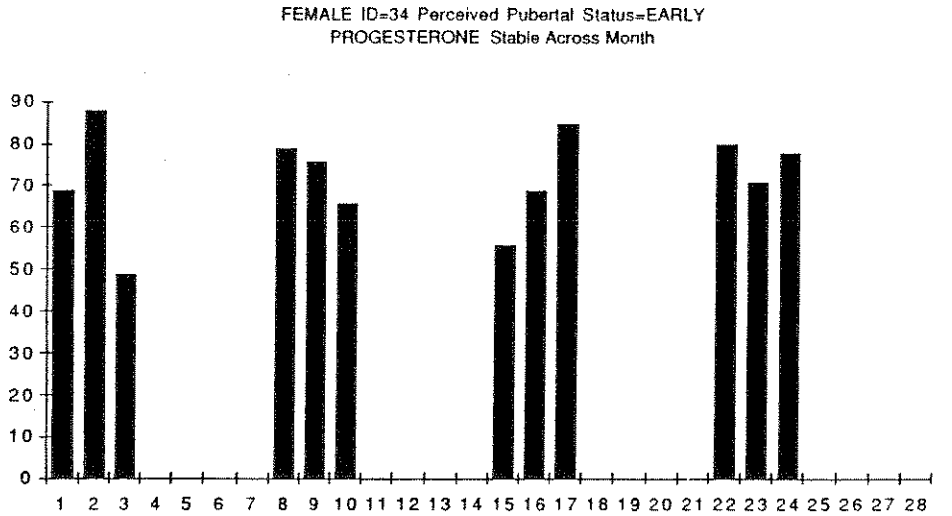

Figure 4

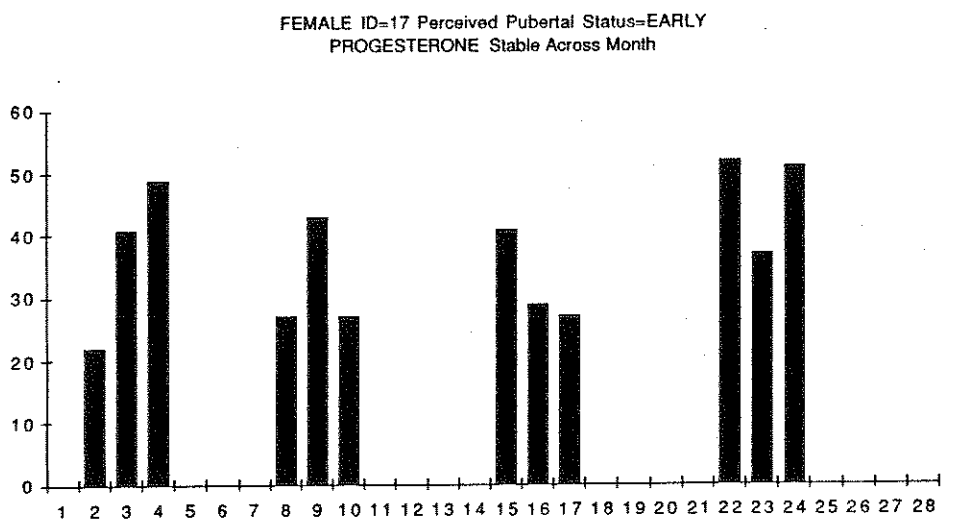

Figure 5

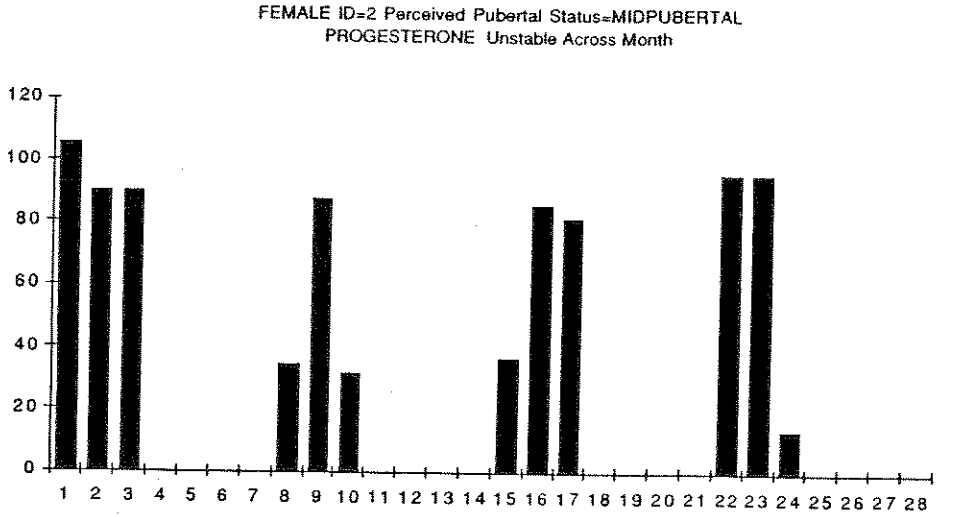

Figure 6

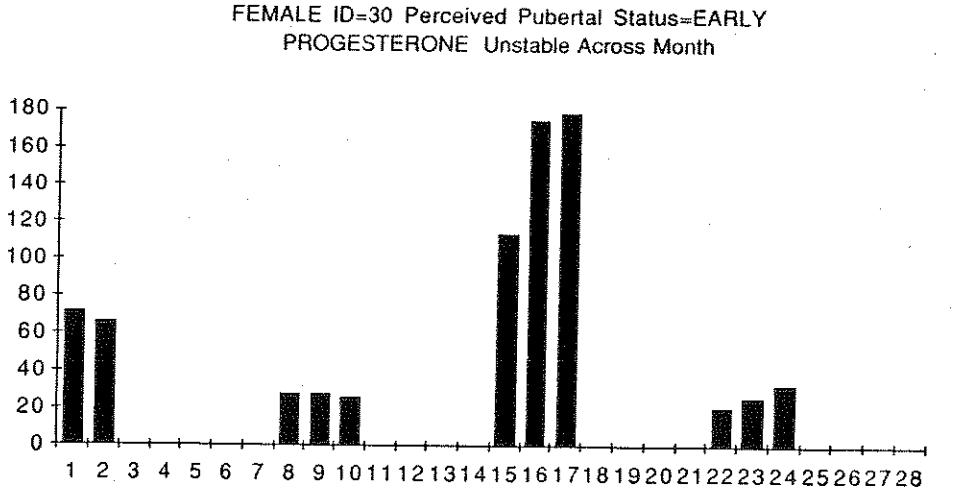

Figure 7

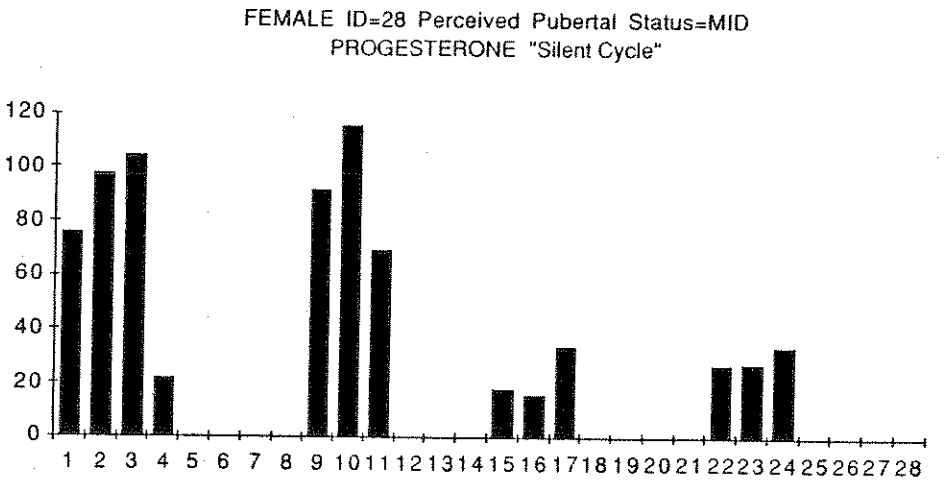

Figure 8

Schematic representation of possible causal lags w/n wave 1 subjects w/n a week

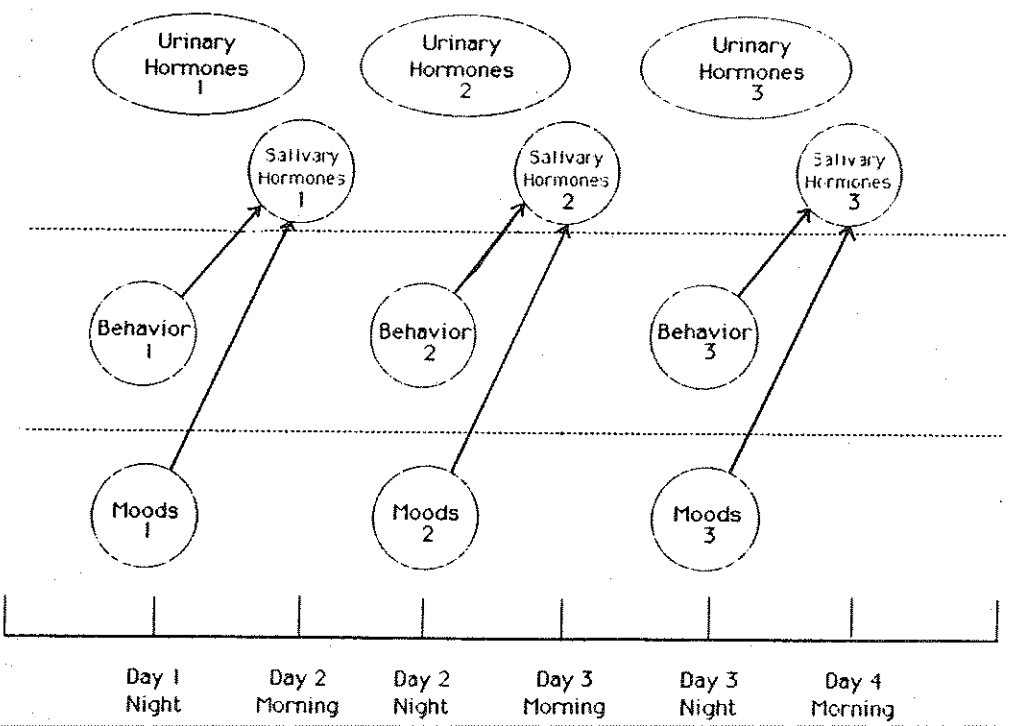

Figure 9

Schematic representation of possible causal lags w/n wave 1 subjects w/n a week

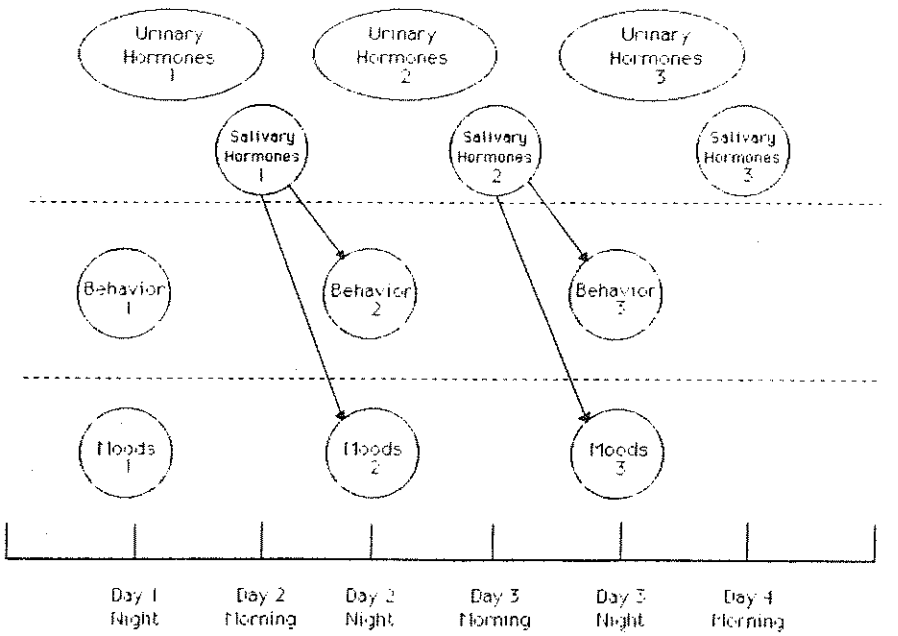

Figure 10

Schematic representation of possible causal lags w/n wave 1 subjects w/n a week

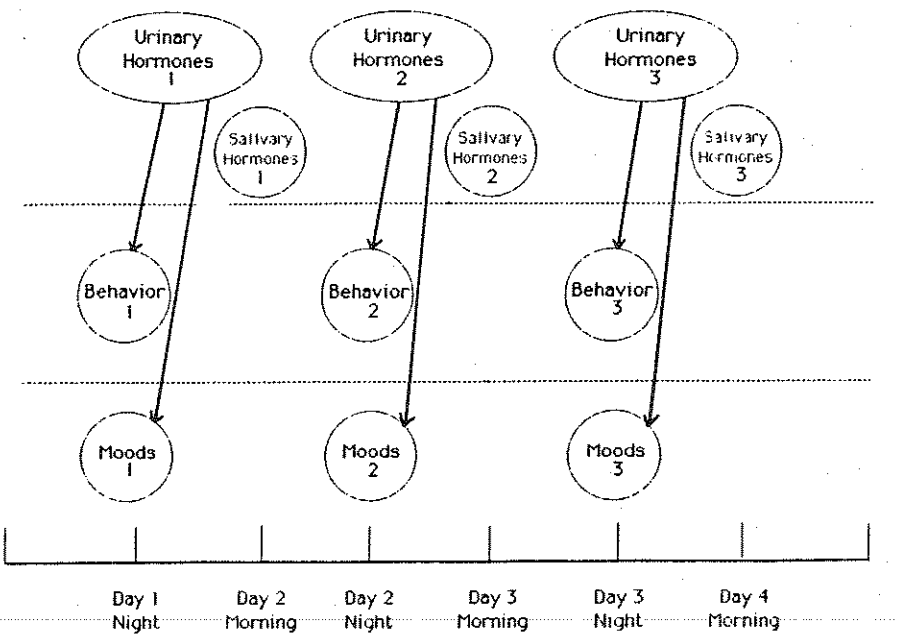

Figure 11

Schematic representation of possible causal lags w/n wave 1 subjects w/n a week

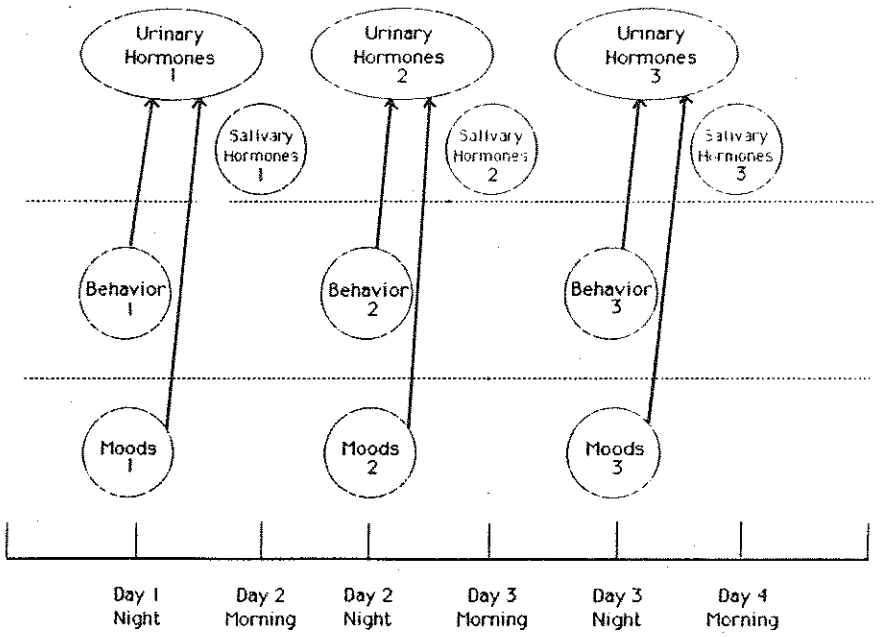

Figure 12

Schematic representation of possible causal lags w/n wave 1 subjects w/n a week