Received 3 March 1999; accepted 7 April 1999

ABSTRACT: Noon and evening salivary cortisol levels were examined in 70 elementary school children during the 1st week of a new school year. Samples were obtained on the 1st and 5th days of school and on weekend days. Delta cortisol scores were created to measure the change in children’s levels on initial school days relative to weekend days. Temperament was assessed using Rothbart’s Child Behavior Questionnaire, a parent report instrument. The three dimensions of surgency or extroversion, negative affectivity, and effortful control were examined. Positive correlations were obtained with Day 1 delta cortisol for negative affectivity and Day 5 delta cortisol for surgency. Contrary to the expectation that internalizing aspects of temperament (shyness, fearfulness) would be associated with larger increases in cortisol to the novelty and challenge of a new school year, these data indicate that larger increases in cortisol were observed in more extroverted children.

Keywords: temperament; children; cortisol

Children respond differently to the social challenges in their life. Their ability to cope with social challenge depends on many factors, including temperament and experience. These factors are related to children’s behavioral and physiological responses to social challenges (Stansbury & Gunnar, 1994). Cortisol, a measure of the activity of the hypothalamic–pituitary–adrenocortical (HPA) system, has been a focus of many physiological studies of stress and challenge (Hennessy & Levine, 1979; Mason, 1975; Rose, 1980). The start of a new school year is a challenging event that almost every child must face. Entry into a novel social group is related increased activity of the HPA axis in studies with animals (Goo & Sassenrath, 1980; Lyons, Mendoza, & Mason, 1994; Saltzman, Mendoza, & Mason, 1991). In the following study, we examined whether the beginning of a new school year would stimulate increases in cortisol in human children.

Studies of both adults and children have shown that cortisol rises in response to threatening or challenging

© 1999 John Wiley & Sons, Inc.
events, particularly if these events are novel and ego involving (Kirschbaum & Hellhammer, 1989, 1994). Activation of this system leads to mobilization of central and peripheral resources to manage threat or challenge (de Kloet, 1991). While survival is related to the capacity to mount a response of this system, much of the research on the HPA axis is focused on the negative consequences of elevated cortisol levels (Coe, Rosenberg, & Levine, 1988; Lapen et al., 1994; McEwen et al., 1992). Theories of individual differences in HPA axis activity also emphasize potentially problematic aspects of personality or temperament. Shy, anxious, or fearful individuals are expected to be particularly likely to produce elevations in cortisol in novel social situations (Kagan, Reznick, & Snidman, 1987; Rosen & Schulkin, 1998). Indeed, elevations in cortisol in such individuals are believed to form part of the diathesis for the development of anxiety and other affective disorders (Rosen & Schulkin, 1998; Schulkin, McEwen, & Gold, 1994). In addition, elevations in cortisol are expected to reflect failures in coping (Levine & Wiener, 1988), and thus individuals showing the largest elevations in cortisol to stressful, challenging events are expected to be those with the poorest coping capacities (Spangler & Scheubeck, 1993).

Based on these arguments about the dynamics of the HPA system, beginning a new school year should produce elevations in cortisol, particularly for the most shy/anxious children. Although these predictions follow fairly directly from research and theory on the HPA system (Kirschbaum & Hellhammer, 1989; Rosen & Schulkin, 1998; Sapolsky, 1990), attempts to verify them in children have led to mixed results. Shy/ anxious children do exhibit many behavioral signs of anxiety when meeting new peers (Asendorf, 1993; Ruhn, Coplan, Fox, & Calkins, 1995). However, shy/ anxious children do not always exhibit the most marked increases in cortisol in response to novel social settings. There is some evidence that children with clinically significant behavior problems may produce higher cortisol levels during group entry if their problems involve both externalizing (e.g., conduct disorder) and anxiety problems, but not if they only involve anxiety disorders (Granger, Stansbury, & Henker, 1994; McBurnett et al., 1991). Among nonclinic samples, it has been found that while extremely shy children have higher home baseline cortisol (Kagan et al., 1987; Schulkin, 1991), they do not produce larger increases in cortisol over home levels in response to novel, social challenges (Kagan et al., 1987). In fact, the results of a number of studies with preschool children contradict the hypothesis that shyness is related to larger increases in cortisol in new social situations. These studies have shown that, in response to the challenge of entering a new social group, children who are high in surgency/extroversion and assertive, aggressive behavior have higher cortisol levels and larger increases in cortisol over baseline levels (de Haan, Gunnar, Tout, Hart, & Stansbury, 1998; Granger, Stansbury, Lopez, & Kannekis, 1992; Gunnar, Tout, de Haan, Pierce, & Stansbury, 1997; Legende & Tru-del, 1994).

All of the studies showing that surgent/extroverted children had the largest elevations in cortisol in new social settings were conducted with preschool-aged children. It was possible, therefore, that this unexpected pattern of association might be peculiar to this age group. Preschoolers have fairly immature social skills (Rubin et al., 1985). Perhaps extroverted preschool children rush into new social situations and find themselves in over their heads, making the situation more stressful (Gunnar, 1994). With development and improved self-regulatory skills, these children may become better able to control their entry into new groups and to cope with challenges and cease to produce elevations in cortisol. At the same time, with development of cognitive abilities that allow children to think or worry about future events, shy/anxious children might become more responsive to the challenge of entering a new social group, and thus more likely to produce elevations in cortisol.

The purpose of this study was to investigate the relations between shy/anxious temperament and elevations in cortisol at the beginning of a new school year in elementary school children. Samples of saliva were obtained for cortisol determination during the 1st week of school (Days 1 and 5) and were compared to baseline levels (mean of 2 weekend days). The children were drawn from a sample that had taken part in a previous cross-sectional study of age changes in cognitive functioning (Luciana & Nelson, 1998). They thus reflected a broad age range of elementary school children entering first through fifth grade. Temperament was assessed using Rothbart’s Child Behavior Questionnaire (Ahadi, Rothbart, & Ye, 1993). Parent report rather than teacher report was used because at the beginning of the school year teachers were expected to be unfamiliar with the children. Based on factor analysis, the Child Behavior Questionnaire (CBQ) has been shown to reflect three factors or dimensions of temperament: surgency/extroversion, negative affectivity, and effortful control (Ahadi et al., 1993). Shyness, a scale on the CBQ, loads negatively on the dimension of surgency/extroversion. Fearfulness, another scale on the CBQ, loads positively on the dimension of negative affectivity. Therefore, we expected larger increases in cortisol
from baseline for children scoring lower on surgency or extraversion (and thus higher on shyness) and higher on negative affectivity. In addition, because Rothbart and colleagues (Rothbart, Derryberry, & Posner, 1994) have argued that poor attentional control should increase a child’s vulnerability to negative emotionality, we expected that these associations between temperament and cortisol increases would be the most pronounced for the children scoring lower on effortful or attentional control.

METHODS

Subjects

Seventy (37 boys, 33 girls) subjects age 7 to 12 years (\(M = 8\) years) were retained from a sample of 168 children who had taken part in a previous study (Luciana & Nelson, 1998). Children were excluded for the following reasons: They did not attend either public or private school (\(n = 11\)), were taking medication (e.g., asthma inhalers) (\(n = 7\)), were not starting at least the first grade (\(n = 15\)), experienced a major life challenge within 2 months of the start of the school year (e.g., parent divorce, death in the family, or hospitalization) (\(n = 7\)), or had been diagnosed with a clinical disorder (\(n = 2\)). Of the 126 selected recruits, 12 could not be contacted, 9 did not agree to participate, and 35 agreed to participate but did not complete the sampling procedure.

Saliva Collection

Families agreeing to participate were mailed saliva collection kits. To collect each sample, the child was given less than one eighth of a teaspoon of Kool-Aid crystals to stimulate salivation. The child then mouthed a cotton dental role. After the cotton was saturated, it was placed into a needleless syringe and saliva was squeezed into a small plastic vial. On 4 sampling days, parents were asked to collect samples in the morning (15 to 30 min after the child woke up, but before breakfast), at noon (before lunch), and in the evening (within 30 min of bedtime). Collection days were designated as the 1st and 5th day of school and on a weekend a month or more after the start of school. Parents then mailed the samples to the laboratory where they were stored in a freezer at \(-20^\circ\text{C}\) until assayed: Mailing should not affect the cortisol concentrations (Kirshbaum & Hellhammer, 1994). Samples were assayed in 50 \(\mu\)l aliquots using a modification of the Ciba Corning Magic Cortisol assay kit (Kirshbaum, Strasburger, Jammers, & Hellhammer, 1989). The use of one eighth teaspoon of Kool-Aid to stimulate salivation has been shown to have little effect on cortisol levels using this CIBA assay (Schwartz, Granger, Susman, & Gunnar, 1998). All samples from each subject were included in the same assay batch to eliminate within subject interassay variance. Samples were assayed in duplicate and averaged. Duplicates varying by more than 20% were reassayed. The interassay and intraassay coefficients of variation were 13.30 and 7.35, respectively.\(^1\)

Cortisol levels follow a circadian rhythm and are affected by food intake and sleep patterns (de Kloet, 1991; Stansbury & Gunnar, 1994). To ensure that these factors did not differ systematically on school and baseline days, for each sampling day parents completed a diary noting the time of each sample, when the child woke up and went to bed, time of meals, use of medication, and general health. These data were examined to determine that sampling times were listed viewed as reflecting the children’s typical or baseline, nonschool cortisol values.

We recognized that it might have been difficult for families to collect noon samples on school days. However, 54 of the participants provided noon school samples on at least 1 of the 2 school days. Families collected these noon samples by sending collection materials to school along with the child’s lunch. Children sampled themselves before eating. Because collection procedures were simple, children in this age range were able to do this on their own. We were concerned that the school noon samples might be less reliable or might reflect data from a group of older or more mature children. Thus the data were analyzed separately for the evening and noon samples. In addition, results were examined for the sample as a whole and for only the children with school noon samples. The pattern of results appeared similar, although the reduction in sample size limited statistical significance. Therefore, only the results for the total sample of children are presented here.

Collected samples were stored in the family’s refrigerator until all sampling was completed for that child. Parents then mailed the samples to the laboratory where they were stored in a freezer at \(-20^\circ\text{C}\) until assayed: Mailing should not affect the cortisol concentrations (Kirshbaum & Hellhammer, 1994). Samples were assayed in 50 \(\mu\)l aliquots using a modification of the Ciba Corning Magic Cortisol assay kit (Kirshbaum, Strasburger, Jammers, & Hellhammer, 1989). The use of one eighth teaspoon of Kool-Aid to stimulate salivation has been shown to have little effect on cortisol levels using this CIBA assay (Schwartz, Granger, Susman, & Gunnar, 1998). All samples from each subject were included in the same assay batch to eliminate within subject interassay variance. Samples were assayed in duplicate and averaged. Duplicates varying by more than 20% were reassayed. The interassay and intraassay coefficients of variation were 13.30 and 7.35, respectively.\(^1\)

Cortisol levels follow a circadian rhythm and are affected by food intake and sleep patterns (de Kloet, 1991; Stansbury & Gunnar, 1994). To ensure that these factors did not differ systematically on school and baseline days, for each sampling day parents completed a diary noting the time of each sample, when the child woke up and went to bed, time of meals, use of medication, and general health. These data were examined to determine that sampling times were listed

\(^1\)Kindergartners were excluded from analyses for several reasons. First, the goal of this study was to examine the relation between cortisol reactivity and temperament in older children and second, data from these children would have been confounded by the fact that some children went to morning kindergarten and some to afternoon kindergarten.

\(^2\)Cortisol levels that were more than 3 standard deviations above the mean were removed from analyses. This led to the removal of 1 subject’s school Day-1 evening sample and another subject’s home evening sample. Other samples from those 2 subjects remained in analyses.
as occurring before breakfast and before lunch and that the child did not have a fever on sampling days. In addition, differences in sampling times between school and baseline days were examined. Not surprisingly, there was a large difference in the timing of wake-up samples. On school days, wake-up samples were collected almost 1 hr earlier than on baseline days; school days: $M = 7:21$ a.m., $SD = 34$ min; baseline days: $M = 8:14$ a.m., $SD = 40$ min. Because of the marked and rapid decrease in cortisol over the early morning hours (Kirschbaum & Hellhammer, 1989), the difference in wake-up sampling times was of concern. If morning samples on school days were found to be higher than on weekend days, we would not be able to determine whether this difference reflected normal circadian variation or a response to starting school. For this reason, we decided to only analyze the noon and evening samples (see Table 1). The stability of cortisol levels within sampling context was analyzed using Pearson correlation coefficients. Modest, but statistically significant, stability was noted with correlations ranging from .26 to .29, $p’s < .05$. Notably, school cortisol levels were not significantly correlated with weekend values either at noon or in the evening, $r’s$ ranged from $- .12$ to $.18$. Thus, while there was stability within context, school versus weekend baseline, there was no evidence of stable individual variations in cortisol across contexts. The fact that the within context sampling was closer in time to one another, however, may explain this pattern. Because the weekend samples were modestly correlated across day, they were averaged within time contexts. Because the weekend samples were modestly correlated across day, they were averaged within time contexts.

### Table 1. Mean Time of Measurement for Saliva Samples

<table>
<thead>
<tr>
<th>Sampling Context</th>
<th>Noon</th>
<th>Evening</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$M$</td>
<td>$SD$</td>
</tr>
<tr>
<td>Baseline</td>
<td>12:42</td>
<td>46 min</td>
</tr>
<tr>
<td>School Day 1</td>
<td>11:58</td>
<td>31 min</td>
</tr>
<tr>
<td>School Day 5</td>
<td>11:51</td>
<td>30 min</td>
</tr>
</tbody>
</table>

### RESULTS

#### Cortisol Data: Effects of Day, Time of Day, Sex, and Age

Descriptive data for the cortisol measures are shown in Table 2. For children with complete data (e.g., noon and evening samples on school and baseline days, $n = 45$), a $2 \times 2 \times 3$ (Sex $\times $ Noon/Evening $\times $ School Day 1/School Day 5 Baseline) ANOVA was computed with repeated measures on the last two factors and using Greenhouse-Geisser adjustments as required. Neither the main effect of sex, $F(1, 43) = .01$ nor day, $F(2, 86) = .25$ was significant. The effect of time of day was highly significant, $F(1, 43) = 256.39$, $p < .01$. In addition, there was a significant Time $\times$ Day interaction, $F(2, 67) = 4.41, p < .05$. Examination of the means suggested that cortisol concentrations were slightly higher at noon, but not in the evening, on school days as compared to baseline days. Newman-Keuls post hoc tests, however, were not significant, $p’s > .10$. Thus, as a group there was little evidence that school-age children produce significant elevations in cortisol during the 1st week of a new school year.

To examine whether individual children showed elevations in cortisol on school response days as compared to baseline days, we computed the difference scores between morning and evening samples on school days. Since scores are expected to be skewed, the difference scores were log transformed. A one-way ANOVA with repeated measures on the last factor was computed. There was a significant effect of time of day, $F(1, 43) = 19.00$, $p < .01$. Neither the main effect of sex, $F(1, 43) = .55$, nor day, $F(1, 43) = 4.41$, was significant. These results suggest that cortisol levels were higher at noon than in the evening on school days.

### Table 2. Cortisol Values Across the Different Sampling Contexts in µg/dl

<table>
<thead>
<tr>
<th>Sampling Context</th>
<th>Noon</th>
<th>Evening</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$M$</td>
<td>$SD$</td>
</tr>
<tr>
<td>Baseline</td>
<td>22</td>
<td>.10</td>
</tr>
<tr>
<td>School Day 1</td>
<td>24</td>
<td>.08</td>
</tr>
<tr>
<td>School Day 5</td>
<td>25</td>
<td>.10</td>
</tr>
</tbody>
</table>
pared to baseline days, we computed delta cortisol scores by subtracting children’s baseline levels from levels on the 2 school response days. We then counted the number of children whose noon values on school days were more than one-half standard deviation above their baseline levels at noon. An increase of over half a standard deviation was defined as a cortisol response. On the 1st day of school 42% and on the 5th day 39% of the children had cortisol levels that were one-half standard deviation higher than baseline levels. Of these children, 26% on Day 1 and 22% on Day 5 had levels that were over 1 standard deviation above their baseline noon levels. A similar analysis for the evening values yielded 14% and 13% of children for Days 1 and 5, respectively, who had evening levels that were over one-half standard deviation above their baseline levels. Thus for a number of children, the noon data in particular suggested a cortisol response to the 1st days of school, although this did not characterize the group of children as a whole.

Familiarity with starting school might influence the likelihood of showing a cortisol response to the start of each year. Indeed, age was negatively correlated with both noon delta cortisol scores. Coefficients were $r(50) = -0.30, p < .05$ for Day 1 and $r(49) = -0.42, p < .01$, for Day 5. Even evening delta scores were not correlated with age ($r$s ranged from $-0.15$ to $-0.07$) whether the total sample or only the children with school noon cortisol data were examined.

### Temperament Data: Effects of Sex and Age

The descriptive data on the higher order factors is shown in Table 3. A multivariate analysis of covariance was computed to examine gender differences and associations with age for these temperament factors. Age was not a significant covariate, Hotelings $F(3, 63) = 0.81$, n.s. There was a nonsignificant trend for an effect of gender, Hotelings $F(3, 63) = 2.44, p = .07$. Follow-up univariate tests indicated a significant gender difference for effortful control, with girls scoring higher than boys (see Table 3), $F(1, 65) = 5.4, p < .05$.

### Temperament Associations With Delta Cortisol

To examine the prediction that surgency or extroversion would be negatively correlated and negative affectivity positively correlated with delta cortisol, correlations were computed using surgency and its subscales. Because age was not correlated with any of the temperament measures even though it was correlated with the cortisol measures, partial correlations were not used in these analyses. As can be seen in Table 4, Surgency was positively, not negatively correlated with delta cortisol both at noon and in the evening on the 5th day of school. On the 1st day of school there was a similar positive association with evening cortisol that did not reach traditional levels of significance. Shyness was not positively correlated with any of the four measures of delta cortisol; indeed,

---

**Table 3. Descriptive Data on Temperament Dimensions**

<table>
<thead>
<tr>
<th>Temperament Factors</th>
<th>Girls $n = 31$</th>
<th>Boys $n = 37$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surgency</td>
<td>Mean</td>
<td>Mean</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>SD</td>
</tr>
<tr>
<td>Negative Affectivity</td>
<td>0.11</td>
<td>0.69</td>
</tr>
<tr>
<td>Effortful Control</td>
<td>0.16</td>
<td>0.69</td>
</tr>
</tbody>
</table>

*Note. Temperament dimensions were computed as the mean of the standardized scales.*

**Table 4. Correlations Between Surgency and Noon and Evening Delta Cortisol Scores**

<table>
<thead>
<tr>
<th>Subscales of Surgency</th>
<th>Surgency</th>
<th>High Pleasure</th>
<th>Impulsivity</th>
<th>Shyness</th>
<th>Activity Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Δ Noon</td>
<td>Day 1</td>
<td>.08</td>
<td>.10</td>
<td>.11</td>
<td>.07</td>
</tr>
<tr>
<td>Day 5</td>
<td>.32*</td>
<td>.40**</td>
<td>.27*</td>
<td>-.22</td>
<td>.25+</td>
</tr>
<tr>
<td>Δ Evening</td>
<td>Day 1</td>
<td>.20</td>
<td>.15</td>
<td>.17</td>
<td>-.12</td>
</tr>
<tr>
<td>Day 5</td>
<td>.27*</td>
<td>.24*</td>
<td>.20+</td>
<td>-.24*</td>
<td>22+</td>
</tr>
</tbody>
</table>

*Note. Noon Day 1 $df = 50$, Day 5 $df = 49$ and evening Day 1 $df = 64$, Day 5 $df = 68$.

*p < .01, **p < .05, *p < .10.*
it was negatively correlated with one of the delta measures. To be certain that we had not missed an association between more extreme shyness and elevations in cortisol, we examined the children who scored above 5 on the 7-point shyness scale. This reflected the top 10% of the children, the group sometimes labeled extremely inhibited (Kagan et al., 1987). Of the 4 who had school noon cortisol data, only 1 exhibited a cortisol response (delta noon > ±SD over baseline noon) on Day 1 of school, and none did on Day 5. Thus, it did not appear that the association with surgency or extroversion obscured a significant rise in cortisol for those children who were extremely shy according to their parents.

Next we examined associations with negative affectivity. Again the prediction was that negative affectivity would be positively correlated with delta cortisol. Negative affectivity was positively correlated with delta cortisol at noon on Day 1 of school, \( r(50) = 0.32, p < .05 \). The correlation for Day 5 noon delta cortisol was in the same direction, \( r(49) = .21 \), but was no longer significant. Of the scales contributing to the negative affectivity summary score, only anger/frustration reached traditional levels of significance. This was true for Day 1, \( r(50) = .38, p < .05 \), and Day 5, \( r(49) = .40, p < .05 \). However, anger/frustration, was negatively correlated with baseline noon cortisol, \( r(67) = -.26, p < .05 \). After we computed partial correlations controlling for the baseline value, the association between Day 1 noon delta cortisol and anger/frustration was no longer significant.

Finally, we examined associations with effortful control. Effortful control was not significantly associated with any of the four delta cortisol measures, \( r \) ranging from \(-.14 \) to \(+.14 \). However, our prediction for effortful control was not that it would be directly related to delta cortisol, but that it would have moderate associations with shyness and/or negative affectivity. The lack of associations between shyness and the internalizing aspects of negative affectivity tended to render this prediction moot. However, we did examine whether effortful control might moderate the associations between extroverted, externalizing aspects of temperament, and cortisol elevation. For this analysis we chose the temperament scale most correlated with delta cortisol, high pleasure. For Day 2 noon delta cortisol we computed a hierarchical regression equation entering high pleasure first, followed by effortful control, followed by the interaction between effortful control and high pleasure. The interaction step was not significant (interaction beta \( .03, \) n.s.). Thus, there was no evidence in these data that effortful control was either linearly related to delta cortisol on the 1st days of school or that it moderated associations between elements of extroverted, externalizing aspects of temperament and cortisol reactivity.

**DISCUSSION**

The beginning of a new school year is a challenge that every child must face. This challenge appears to produce elevations in cortisol for some children. Cortisol increases were more likely to be seen for the noon sample taken while the children were still at school than the samples taken in the evening on these initial school days. Around 40% of the children with noon samples had cortisol concentrations on either Day 1 or 5 of school that exceeded one-half standard deviation of their baseline levels a month later, while around 25% had concentrations that exceeded 1 standard deviation of baseline levels. The likelihood of showing a cortisol response on one or the other day was related to age. Children who did not respond according to these criteria on either day tended to be older (\( M = 8.4 \) years) than children who responded on one or the other day (\( M = 7.5 \) years). While we believe that the children were responding to the challenge of starting the new academic year, it should be noted that we do not have data on school-day cortisol concentrations later in the year. Thus, we cannot know whether these responses habituate or change. Indeed, it may be that what we were detecting were cortisol responses to school days, per se, rather than to the initiation of the school year.

Regardless, the data relating temperament to delta cortisol were quite clear. In marked contrast to our predictions, there was no evidence that shy/anxious children showed larger increases in cortisol on the 1st days of school than other children. In fact, there was some evidence that shyness was negatively associated with delta. Counter to our predictions, but highly consistent with the data on preschool children, delta cortisol during this 1st week of school was positively associated with more exuberant, extroverted temperament. Surgency or extroversion was positively correlated with the Day 5 delta cortisol measure. Furthermore, the association was due to responses on school days, as surgency was not significantly correlated with the baseline cortisol data. High pleasure or the love of intense play (e.g., going down high slides, riding bicycles really fast), impulsivity, activity level, and low shyness constitute the core scales in the surgency dimension of temperament. Of these scales, high pleasure appeared to be the most strongly related to delta cortisol. High pleasure reflects risk-taking aspects of temperament and is strongly related to both Impulsivity and activity level (Ahadi et al., 1993).
However, it is not necessarily reflective of poor self-regulation. In work with preschoolers, especially for boys, high pleasures scores are associated with popularity with peers (Kramer & Sebanc, 1999). Instead of viewing surgency and particularly high pleasure as reflective of some deficit that predisposes a child to adrenocortical stress responses in new social situations, this dimension of temperament is probably more accurately viewed as reflecting zest, exuberance, and a lively engagement of life’s challenges. Rothbart describes surgency as similar to extroversion and positive affectivity (Rothbart et al., 1984). Thus, to repeatedly find surgency associated with larger cortisol responses in new situations suggests that elevations in cortisol to social challenge may be stimulated by approach as opposed to withdrawal aspects of emotionality (for this distinction see Davidson, Baron, Semliner, Ekman, & Friesen, 1990).

Negative affectivity was positively correlated with delta cortisol as predicted. However, counter to predictions, it was the anger/frustration and not the fearfulness scale of this temperament dimension that was most closely associated with delta cortisol measures during the 1st week of school. Anger/frustration is also another approach affect in some schemes of emotionality (e.g., Davidson et al., 1990). Children who score high in anger/frustration as measured by the Child Behavior Questionnaire tend to react with anger and frustration when they are blocked from attaining goals. Making controllable events suddenly uncontrollable may provide an analogue of frustration, and has been shown in animal studies to produce elevations in cortisol (Hanson, Larson, & Snowdon, 1976). Anger/frustration has been found to correlate with larger increases in cortisol from home levels during periods of group formation in preschoolers (de Haan et al., 1998). However, in the present study, after controlling for its correlation with home baseline cortisol, the associations with school levels were no longer significant. Thus, there was no clear evidence in the present study for an association between anger/frustration and activation of the HPA axis at the beginning of the school year.

If cortisol elevation, at least at the beginning of the new school year, is associated with more extroverted, approach-oriented behavioral or emotional styles, and is not related to anxious, internalizing characteristics, what does this imply about our theories of the psychobiology of HPA axis activity? Most discussions of HPA axis activity are couched in terms of risk. While cortisol production is necessary for survival, activation of the system is typically described as reflecting a failure in coping (Levine & Wiener, 1988; Spangler & Scheubeck, 1993). Elevations are discussed as part of a potential diathesis for the development of anxiety disorders (Rosen & Schulkin, 1998). In social contexts, greater cortisol elevation is characterized as typical of subordinate individuals who lack control over their lives and are at risk for stress-related disorders and depression (Sapolsky, 1990). None of these descriptions or predictions would lead one to expect greater cortisol elevation among children who are extrovert, outgoing extroverts.

The model of cortisol elevations as reflective of anxiety and failure to cope also does not fit with the results of several studies of adults. In one recent study, Hellhammer and colleagues (Hellhammer, Buchwald, Gutherlet, & Kirschbaum, 1997) examined army recruits during boot camp. In nine groups of men housed together, they identified those individuals who became the leaders compared to those who became the most subordinate. In response to two challenges, one social (a speech task) and one physical (running), they expected the subordinates to show greater cortisol elevation. In fact, it was the dominant men who showed the largest cortisol responses. In studies of nonhuman primates, high cortisol responses have also been associated with assertive or dominant behavior, particularly during periods of group formation (Manogue, Leshner, & Candland, 1975). This evidence suggests that elevations in cortisol should not necessarily be viewed as indexing a failure to cope. Instead, especially when the challenge is new or just initiated, increases in cortisol may reflect personality and temperament characteristics that lead individuals to choose active engagement as a mode of coping or adjustment.

Under such conditions, should we still expect increases in cortisol to pose a risk to health and well being? As in the present study, the increases in cortisol in response to normative challenges tend to be small (van Eck, Berkhof, Nicolson, & Sulon, 1996). There is increasing evidence that small to moderate increases in cortisol may tend to enhance behavioral and cognitive functioning, and that in many instances there is an inverted U-shaped relationship between increasing cortisol concentrations and adaptive functioning (Sapolsky, 1997). Indeed, most of the work that has demonstrated deleterious impacts of elevated glucocorticoids has involved quite high, albeit often physiologic, levels of corticoids and/or intensely threatening stressors (McEwen et al., 1992). As these and other data on children seem to indicate, in order to develop a more complete understanding of the role of the HPA axis in adaptation, we may need to focus more attention on the factors regulating small increases in cortisol and their role in human functioning.

Finally, there are several limitations in these data that should be discussed. First, as noted, the results...
may not be particular to group formation or the start of the new school year. Without data on cortisol levels on school days later in the year, we cannot determine whether the beginning of the year or merely being in school influenced our results. Second, the results are based on parental report. There is much debate over parent report measures of temperament. While some researchers view them as relatively meaningless, others argue that parents, because they have a long history with the child, are important sources of information on temperament (Rothbart & Bates, 1998). We cannot determine whether teachers or direct observations might have been better at predicting cortisol elevation in the present study. We can only note that the data obtained here are consistent with other studies that used teacher report and observational measures (Gunnar, 1994; Gunnar et al., 1997; Granger et al., 1994). Finally, although we did not find associations with anxious, shy, fearful behavior, few of the children in this study were extreme in these characteristics. Thus, we cannot rule out the possibility that extremely anxious, shy, or inhibited children would have shown evidence of high cortisol elevation on these first days of the new year.

NOTES
This research was supported by a grant from the National Institute of Mental Health (MH59586) and a National Institute of Mental Health Research Science Award (MH00946) to Meghan R. Gunner. The authors wish to thank the parents and children who helped with this research. Thanks are also expressed to Pat Larson and Mary Fowler of the Endocrine Laboratory at the University of Minnesota for their careful analysis of the salivary cortisol data.

REFERENCES


of the Society for Research in Child Development, Albuque-
re, NM.
stress and coping behavior of young children confronted
with a group of unfamiliar peers. Poster presented at the
9th International Conference on Infant Studies, Paris.
of mother-infant relationships in nonhuman primates.
gence of prefrontally guided working memory systems in
4- to 8-year-old children. Neuropsychologia, 36, 273–
293.
Lupien, S., LeCours, A. R., Lussier, I., Schwartz, G., Nair,
N. P. V., & Meaney, M. (1994). Basal cortisol levels and
cognitive deficits in human aging. The Journal of Neu-
roscience, 14, 2893–2903.
Psychosocial and hormonal aspects of hierarchy forma-
tion in groups of male squirrel monkeys. American Jour-
nal of Primatology, 32, 109–122.
Dominance status and adrenocortical reactivity to stress
in squirrel monkeys (Saimiri sciureus). Primates, 16, 457–
463.
Mason, J. W. (1975). Emotion as reflected in patterns of
endocrine integration. In L. Levi (Ed.), Emotions, their
parameters and measurement (pp. 143–181). New York:
Raven Press.
McBurnett, K., Lahey, B. B., Frick, P. J., Rich, C., Loeber,
Anxiety, inhibition, and conduct disorder in children: II.
Relation to salivary cortisol. Journal of the American
Academy of Child and Adolescent Psychiatry, 30, 192–
196.
McEwen, B. S., Angulo, J., Cameron, H., Chao, H. M., Dan-
iel, D., Gannon, M. N., Gould, E., Mendelson, S., Sakai,
of adrenal steroids on the brain: Protection versus degen-
Rose, R. M. (1980). Endocrine response to stressful psy-
chological events. Psychiatric Clinics of North America, 3,
251–275.
pathological anxiety. Psychological Review, 105, 325–
350.
Damon (Series Ed.) & N. Eisenberg (Vol. Ed.), Handbook
of child psychology. Vol. 3. Social, emotional, and per-
sonality development (5th ed., pp. 105–176). New York:
Wiley.
psychobiological approach to the development of temper-
ament. In J. Bates, & T. Wachs (Eds.), Temperament: In-
dividual differences at the interface of biology and be-
havior (pp. 83–115). New York: American Psychological
Association Press.
Rubin, K. H., Coplan, R. J., Fox, N. A., & Calkins, S. D.
(1995). Emotionality, emotional regulation, and pre-
schoolers’ social adaptation. Development and Psycho-
pathology, 7, 49–62.
Sociophysiology of relationships in squirrel monkeys. I.
Formation of female dyads. Physiology & Behavior, 50,
271–280.
Sapolsky, R. M. (1990). Stress in the wild. Scientific Amer-
ican, 262, 116–123.
Sapolsky, R. M. (1997). McEwen-induced modulation of
endocrine history: A partial review. Stress, 2, 1–12.
Schmidt, L. A., Fox, N. A., Rubin, K. H., Sternberg, E. M.,
Gold, P. W., Smith, C. C., & Shulkin, J. (1997). Behav-
ioral and neuroendocrine responses in shy children. De-
velopmental Psychobiology, 30, 127–140.
Schwartz, E. B., Gianger, D. A., Susan, E. I., & Gunnar,
amygdala, and anticipatory angst. Neuroscience and Biob-
ehavioral Reviews, 18, 385–396.
Spangler, G., & Scheibeck, R. (1993). Behavioral organi-
zation in newborns and its relation to adrenocortical and
and emotion regulation. In N. Fox (Ed.), Monographs of
the Society for Research in Child Development: Vol. 59:
The development of emotion regulation: Biological and
behavioral consequences (pp. 108–134). Chicago: Soci-
ety for Research in Child Development.
The effects of perceived stress, traits, mood states, and
stressful daily events on salivary cortisol. Psychosomatic
Medicine, 58, 447–458.