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Inhibition and Exuberance in Preschool Classrooms: Associations With Peer Social Experiences and Changes in Cortisol Across the Preschool Year

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Associations between behavioral inhibition and activity of the hypothalamic-pituitary-adrenocortical (HPA) system, a stress-sensitive neuroendocrine system indexed by salivary cortisol, have varied widely across studies. In the current study, we examined the role of peer social experiences in moderating patterns of association between inhibition/risk-aversion and cortisol reactivity. As expected based on previous research, preschool children (N = 165, 78 boys, 87 girls, 3.0–5.0 years) had significantly different social experiences in their preschool classrooms depending on temperament. Highly inhibited/risk-averse children were less socially integrated, less dominant, and less involved in aggressive encounters than both average and highly exuberant/risk-seeking children, but they were no more likely to be peer rejected. Highly exuberant children were more dominant, exhibited anger more often, and had friendships characterized by higher conflict. Cortisol levels fell from fall to spring for average and highly exuberant children but not for highly inhibited children. Unexpectedly, for highly inhibited children, having friends and being more dominant and popular than other highly inhibited children was associated with increasing cortisol levels over the school year. In contrast, highly exuberant children who were less socially integrated than other highly exuberant children maintained higher cortisol levels. Results indicate that the types of social experiences that affect stress-responsive biological systems may differ markedly for highly inhibited and highly exuberant children.

Keywords: behavioral inhibition, cortisol, peer relations, dominance, preschool children

Behavioral inhibition, characterized by inhibition of approach to unfamiliar people, objects, and situations (Kagan, Reznick, & Snidman, 1987), is a temperamental style that can be observed from early infancy, with highly inhibited infants showing high negative emotionality and motor reactivity when presented with novel stimuli. In highly exuberant infants, by contrast, novel stimuli elicit positive emotionality and motor reactivity. Membership in these extreme groups of inhibited and exuberant children is relatively stable through early childhood into adolescence and beyond (Caspi et al., 2003; Degnan, Hane, Henderson, Moas, Reeb-Sutherland, & Fox, 2010; Fox, Henderson, Rubin, Calkins, & Schmidt, 2001; Kagan, Reznick, & Snidman, 1988; however, see also Asendorpf, 1994; Davidson & Rickman, 1999; Degnan & Fox, 2007; Stifter, Putnam, & Jahromi, 2008). These temperamental extremes are also relatively stable across situations (Fox, Henderson, Marshall, Nichols, & Ghera, 2005). Exuberance may be more than simply a lack of behavioral inhibition: These two temperamental constructs may not be at opposite ends of a unitary continuum but rather may have distinct underlying neurobiological profiles (Pfeifer, Goldsmith, Davidson, & Rickman, 2002; Polak-Toste & Gunnar, 2006).

The early emergence, temporal continuity, and cross-contextual consistency of inhibition and exuberance suggest a biological basis for these temperamental dispositions. Indeed, the contrasting responses to novelty of highly inhibited and highly exuberant children have been attributed to differences in excitability of the amygdala and of neural circuitry linking the amygdala to cortical regions (Calkins, Fox, & Marshall, 1996) and to hypothalamic and brain stem systems regulating activity of the hypothalamic-pituitary-adrenocortical (HPA) system and the sympathetic nervous system (Kagan & Snidman, 1991). Physiological differences between extremely inhibited and exuberant children include heart rate (Kagan, Reznick, Snidman, Gibbons, & Johnson, 1988; Scarpa, Raine, Venables, & Mednick, 1997), frontal electroen-

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cephalogram (EEG) asymmetry (Calkins et al., 1996; Fox et al., 2001; McManis, Kagan, Snidman, & Woodward, 2002), and cardiac vagal tone (Fox et al., 2001; Hastings, Rubin, & Mielcarek, 2005). These physiological differences are presumed to reflect temperament-related differences in the amygdala's excitability and neural projections: In highly inhibited children, greater amygdala reactivity produces greater sympathetic nervous system activity (raising heart rate), greater inhibition of the parasympathetic nervous system (lowering vagal tone), and through projections to the frontal cortex produces increased right, relative to left, frontal EEG activity. EEG asymmetry has been conceptualized as reflecting underlying approach-withdrawal motivation (Davidson, 1992; Fox, 1994). Right frontal EEG asymmetry is associated with social withdrawal, whereas left frontal EEG asymmetry, which characterizes highly exuberant children, is associated with engaging in high levels of social interaction with unfamiliar peers (Degnan et al., 2010; Fox et al., 1995).

In contrast to temperamental differences in physiological indices of parasympathetic and sympathetic activity, the association of temperamental disposition and activity of the HPA system remains unclear. In the HPA stress response pathway, secretion of corticotropin-releasing hormone (CRH) from the medial parvocellular region of the paraventricular nucleus (mpPVN) of the hypothalamus initiates a cascade that leads to increased production of cortisol by the adrenal cortex. The amygdala is one of several excitatory inputs to the mpPVN, stimulating HPA axis activation (Gunnar & Davis, 2003; Herman & Cullinan, 1997). The HPA system has a protracted developmental course, and social experience plays a key role in both challenging and shaping immature HPA circuits (see for review, Tarullo, Quevedo, & Gunnar, 2008). In the preschool years, peers become increasingly important, yet the social skills necessary to manage peer interactions still are emergent. The preschool classroom context may challenge the developing regulatory capacities of the HPA system (Gunnar & Donzella, 2002). Indeed, among young children, those who are peer rejected, who have low social competence, or who exhibit emotion regulation difficulties—that is, those with the least developed social skills—are most likely to show cortisol elevations in childcare settings (Dettling, Gunnar, & Donzella, 1999; Dettling, Parker, Lane, Sebanc, & Gunnar, 2000; Gunnar, Sebanc, Tout, Donzella, & van Dulmen, 2003; Gunnar, Tout, de Haan, Pierce, & Stansbury, 1997). One of the goals of the current study is to characterize the social experiences of highly inhibited and highly exuberant children. To the extent that highly inhibited and highly exuberant children have differing social experiences, they might be expected to show differing cortisol levels in the preschool classroom.

It has been argued that inhibition should, in and of itself, result in elevated HPA activity (Kagan et al., 1987; Rosen & Schulkin, 1998). Specifically, Rosen and Schulkin (1998) contended that in highly inhibited children, hyperactivity of limbic-HPA circuits would increase CRH activity in the amygdala, sensitizing the amygdala to perceived threat and leading to increased frequency and duration of HPA stress responses. This theoretical pathway has been proposed as an explanatory mechanism for the increased risk of anxiety disorders in highly inhibited children (Rosen & Schulkin, 1998). However, empirical studies of HPA activity in relation to inhibition have yielded inconsistent and often contradictory findings (Gunnar, 2001). Behavioral inhibition has been found to be related to larger cortisol responses to novel and mildly threatening stimulation in toddlers, but only when the children are accompanied by a parent with whom they have an insecure attachment relationship (Nachmias, Gunnar, Mangelsdorf, Parritz, & Buss, 1996; Spangler & Schieche, 1998). In the preschool years, the association between cortisol and inhibition appears to depend on the setting in which cortisol is sampled. Highly inhibited preschool children show increases in cortisol across a laboratory session, whereas highly exuberant children show a drop in cortisol levels during the session (Blair, Peters, & Granger, 2004). Shy, inhibited toddlers and preschoolers have higher levels of cortisol when sampled at home (de Haan, Gunnar, Tout, Hart, & Stansbury, 1998; Kagan et al., 1987; Schmidt et al., 1997). Yet, in one study, these same highly inhibited children did not have higher cortisol when sampled in the preschool setting (de Haan et al., 1998). In peer group settings, cortisol levels sometimes have been reported to be higher in *exuberant* children. Higher cortisol levels at preschool were noted in dominant, aggressive toddlers and preschoolers (de Haan et al., 1998; Montagner et al., 1978), and exuberant elementary school children showed a greater increase in cortisol between home and school during the first weeks of the school year (Davis, Donzella, Krueger, & Gunnar, 1999).

Even within peer group settings, the direction of association between cortisol and inhibition may depend on other aspects of the child's social experience. For example, exuberant preschool children who were also aggressive and rejected by peers had elevated cortisol, but in the absence of aggression and peer rejection, exuberant children actually tended to produce *lower* cortisol levels than less exuberant children (Gunnar et al., 2003). The familiarity of the classroom setting plays a moderating role. Exuberant, extroverted children have higher cortisol reactivity during peer group formation, presumably as they are establishing their relationships and position in the peer group, but show a drop in cortisol levels over time as the group becomes familiar (Davis et al., 1999; de Haan et al., 1998; Gunnar et al., 1997). Sex also needs to be taken into account. In two studies of full day center based care, shyness in boys, but not girls, was associated with larger increases in cortisol over the child care day (Dettling et al., 1999; Tout, de Haan, Campbell, & Gunnar, 1998). The variable associations reported between cortisol levels and inhibition or exuberance when children are in peer group settings led us to posit that the relations between HPA activity and inhibition are not linear; rather, they depend on a number of contextual factors, of which the child's social experiences in the peer group may be critical (Gunnar et al., 1997). The current study examined the relations between cortisol levels in the fall and he spring of the preschool year and temperamental disposition as a function of children's social experiences in the classroom.

By the preschool years, highly inhibited and highly exuberant children are likely to have markedly different social experiences. Behavioral inhibition in the infant and toddler years is often an antecedent of social reticence with both unfamiliar and familiar peers in preschool (Fox et al., 2005; Fox et al., 2001; Gersten, 1989; Henderson, Marshall, Fox, & Rubin, 2004; Reznick et al., 1986; Rubin, Burgess, & Hastings, 2002) and of lower aggression in classroom settings (Rimm-Kaufman & Kagan, 2005). Social reticence, like laboratory measures of behavioral inhibition, correlates with right frontal EEG asymmetry, suggesting shared neural substrates (Fox et al., 1995; Henderson et al., 2004).

The social reticence of highly inhibited children may stem from a lack of social approach motivation. Alternately, children may be motivated toward social approach but may not engage in these behaviors due to a concurrent motive toward social avoidance to reduce social anxiety (Coplan, Prakash, O'Neil, & Armer, 2004; Rubin, Coplan, & Bowker, 2009). Highly inhibited children hovering at the edges of social interactions, watching other children play, are likely exhibiting these conflicting tendencies toward social approach and avoidance. Thus, although highly inhibited children tend to be less socially integrated than their peers due to their own avoidant behaviors, one would expect them to find this state of isolation stressful.

Although the social isolation of highly inhibited children may initially be self-imposed, over time peers may begin to reinforce this status. Rubin et al. (2009) differentiated between social withdrawal, in which the child isolates himself, and active isolation, in which the child is isolated due to peer rejection. In the transactional developmental model proposed by Rubin et al. (2009), inhibited toddlers become socially reticent preschoolers, and their avoidance of social interactions prevents them from developing age-appropriate social skills. When they do attempt to integrate with peers, they are ill prepared to negotiate social interactions, leading them to experience peer rejection and bullying. In a vicious cycle, these unsuccessful experiences reinforce their social avoidance behaviors. Peer rejected status is especially salient to shy, withdrawn children (Hymel, Bowker, & Woody, 1993), contributing to low self-esteem and the emergence of internalizing problems (Rubin et al., 2009). Highly inhibited children are at elevated risk of developing anxiety disorders and depression by adolescence (Biederman et al., 1990; Hayward, Killen, Kraemer, & Taylor, 1998; Muris, Merckelbach, Wessel, & van de Ven, 1999; Prior, Smart, Sanson, & Oberklaid, 2000; Rosenbaum et al., 1993; Schwartz, Snidman, & Kagan, 1999).

Highly exuberant children, with their strong tendency to social approach, are also at risk for peer difficulties and psychopathology. Highly exuberant children have more disruptive behaviors and externalizing behavior problems in the preschool years and beyond (Bruce, Davis, & Gunnar, 2002; Burgess, Marshall, Rubin, & Fox, 2003; Rimm-Kaufman & Kagan, 2005; Rubin, Coplan, Fox, & Calkins, 1995). This association may also reflect a transactional developmental model, in which highly exuberant children who fail to regulate their surgent impulses are more likely to engage in relationally or physically aggressive behaviors (Gunnar et al., 2003; Rubin et al., 1995). This aggression, in turn, leads to peer rejection and loneliness (Coie, Dodge, & Kupersmidt, 1990; Crick & Grotpeter, 1995). Social isolation may particularly frustrate those highly exuberant children who become actively isolated through this pathway, as they are repeatedly thwarted in their tendency to engage with their peers. Highly exuberant children who successfully regulate their impulses are not prone to externalizing problems (Rubin et al., 1995). Thus, when predicting child outcomes, temperament should be considered in the context of social experience.

In the current study, we aimed to characterize social experiences of highly inhibited and highly exuberant children in half-day preschool classrooms and to predict change across the school year in free-flowing salivary cortisol as a function of temperamental disposition and social experience. Although behavioral inhibition is typically assessed with laboratory measures, these measures by definition involve a novel setting and unfamiliar peers. As our primary interest was in children who appear highly inhibited or highly exuberant within a *familiar* peer setting, our measure of temperamental inhibition was based on teacher and researcher reports of the child's behavior within the classroom setting. Inhibition reflects not only shyness but also low approach to novelty, caution, and low risk taking, whereas exuberance reflects high approach to novelty and stimulus seeking (Fox et al., 2005; Kagan et al., 1987). The children we identified as fitting these behavioral profiles in a familiar peer setting likely overlap substantially, but perhaps not entirely, with those who would have been identified via laboratory-based measures.

Social experiences were assessed via classroom observations, sociometrics, and teacher-reported and behavioral measures of dominance rank in the classroom. We expected that the highly inhibited children would be less socially integrated, less dominant, and more likely to be rejected or neglected by peers than the children who were average with regard to inhibition. Highly exuberant children were expected to engage in more aggression, have friendships that were higher in conflict, be more dominant, and be more likely to be peer rejected than were average children. On the basis of prior findings (Gunnar et al., 1997), we predicted that average cortisol levels would fall over the course of the school year for highly exuberant and average children, while remaining unchanged or even increasing in the highly inhibited children. Given prior evidence associating peer rejection and lower social competence with cortisol elevations in childcare settings (Dettling et al., 1999; Dettling et al., 2000; Gunnar et al., 2003; Gunnar et al., 1997), we hypothesized that peer rejection and social isolation would predict increases in cortisol for children at both ends of the inhibition spectrum.

Method

Participants

Children who were present in the preschool for both fall and spring and were not classified by the school as students with special needs ($N = 24$) served as participants ($N = 165$, 78 boys, 87 girls). At the beginning of the fall semester, the children ranged from 3.01 years to 5.01 years of age ($Mdn = 3.8$ years). Approximately 60% were White, non-Hispanic; 7% were Hispanic/Latino; 14% were Asian; 8% were Black; and the remainders were of mixed race, or their race was not available in the school records. The study was conducted over 4 years in four classrooms each year. Data were collected on all the children in each classroom each year of the assessment period; data for the main analyses in this report were from the first year of collection on each child in all but 15 cases. Those 15 children were nonnative English speakers; for these children, data from their second year was used, as by then their English language skills allowed them to engage easily with other children. Data were collected from children attending both morning ($N = 85$) and afternoon ($N = 80$) classes. Each year, 40–44 children's data contributed to the data set analyzed in this report. There were 55 children (30 boys) on whom 2 years of data were available, and the longitudinal data for this subset of the children was used to assess rank-order stability of inhibition over time.

Procedures

A university laboratory half-day preschool program served as the study site. The classes were multiage, 3- and 4-year-old classrooms as defined by the children's age at the beginning of the fall semester. (Note that in rare instances, children were 5 years old at the beginning of the school year.) Each classroom had a lead teacher with an advanced degree in early childhood education (MA, MS, or M.Ed.) and between two and three student teachers each semester. Class size ranged from 16 to 20 children (median 18 children).

The same procedures were followed for each year of data collection. Parents who place their children in this preschool agree to have them take part in research that is approved by the school and the university's institutional review board. Prior to any research procedure that required more than classroom observations or teacher reports, a description of the task the child would be asked to perform was posted, and parents could request that their child not take part. The only procedure for which any parent requested that their child ($N = 2$) not participate was the dominance task (described below).

The lead researcher for all 4 years of this project had a BA in child development, preschool licensure, and a M.Ed. in early childhood education. She had done her student teaching in this preschool and had served for a time as an assistant teacher. She conducted all of the procedures that involved direct contact with the children and completed temperament questionnaires and dominance ratings (see below) on each child. A second researcher, a Ph.D. student in child development, recruited and trained undergraduate observers and maintained agreement as the criterial observer over all 4 years of the data collection.

Social observations and salivary cortisol sampling were conducted over weeks 3–8 in the fall and the spring semesters. Each semester, we waited 2–3 weeks before beginning data collection to give the children a chance to acclimatize. Peer sociometrics and teacher reports of dominance rankings were conducted near the end of each semester. The observational dominance task was performed in the first 2 months of the spring semester. Finally, at the end of the school year, temperament questionnaires and friendship quality questionnaires were completed on each child. Throughout each year, including summers, parents were invited to bring their children in for a laboratory session in another part of the university campus.

Instruments and Measures

Classroom inhibition and exuberance. The lead teacher and lead researcher completed a modified short form of the Children's Behavior Questionnaire (CBQ; Putnam & Rothbart, 2006) for each child at the end of the school year. Based on previous work by Rothbart (Rothbart, Ahadi, Hershey, & Fisher, 2001), the scales were combined into their higher order dimensions. The higher order dimension of Surgency was used to identify highly exuberant (very high surgency) and highly inhibited (very low surgency) children. Scales on the surgency dimensions were activity level, enjoyment of highly stimulating and risky activities (high pleasure), impulsivity, approach to novelty, and shyness (reversed). Based on work by Kagan and others (Fox et al., 2005; Kagan et al., 1987), inhibition reflects not only shyness but also low approach to novelty, caution, and low risk taking, all indexed on the higher order dimension of Surgency. Teacher and researcher ratings were highly correlated ($r = .92$) and thus were combined to yield one measure per child. The Surgency dimension was normally distributed ($M = .02$, $SD = .84$, skewness $= -.13$, kurtosis $= -.75$). These scores were divided to create groups of highly exuberant (HE) children (≥ 1 *SD* on the Surgency dimension, $N = 24$, 18 boys, 6 girls), highly inhibited (HI) children (≤ 1 *SD* below the mean, N = 24, 10 boys, 14 girls), and children who were average with regard to inhibition (average [AVE], $-.99$ to .99 *SD*s from the mean, $N = 117$, 50 boys, 67 girls). The HE and HI groups each reflected 15% of the children. There were no missing data for temperament.

To determine whether the classroom ratings reflected measures comparable to those from the laboratory assessments often used to assess inhibition (e.g., Fox et al., 2001), during the course of the year when the child contributed classroom data to the data set, the child's parents were contacted and invited to bring him or her into a laboratory assessment that involved the parent completing the CBQ scales for Surgency and the child being administered the Stranger Approach vignette from the Laboratory Assessment of Temperament (LabTAB; Goldsmith, Reilly, Lemery, Longley, & Prescott, 1999). Other procedures also were completed, and reports from this session have been published previously (Kertes et al., 2009; Talge, Donzella, & Gunnar, 2008). Coding of Stranger Approach was completed using the LabTAB instructions. Two variables were examined: hesitancy, or conversational nonresponsiveness to the stranger (0–2 scale), and activity decrease, or the extent to which the child displayed decreased gross motor activity (0–3 scale). Each was scored and averaged across 10–20 s intervals. These variables were chosen because they best captured behavioral freezing or stilling in response to the stranger, a profile that has been associated with reactivity of stress-sensitive neurobiological systems in both developing children and animals (Buss, Davidson, Kalin, & Goldsmith, 2004). Intraclass correlations for coder agreement, calculated on 10% of the sessions, were .96 and .97, respectively. These measures were standardized and combined to yield a measure of laboratory social inhibition (Cronbach's $\alpha = .66$). Fifty-three children were missing laboratory assessments of inhibition; this was independent of temperament group, $\chi^2(2, N = 165) = 3.21$, *ns*, and was due to the parents declining to schedule a laboratory visit.

Classroom social behavior. Children were observed for an hour in the fall semester and an hour in the spring semester, with observations spread out over 6 days across each semester for 10 min on each day of observation. Each child was observed four times in the classroom setting, once in the gym, and once on the playground per semester to capture behavior across a range of settings. All observations were made by observers at a discrete distance who were visible to the children. As this was not the only study being conducted in this preschool and children in the school are frequently observed for research, the presence of adults with clipboards was a common sight. A team of six observers, trained to agreement with Cohen's kappas of greater than .80 with a criterial observer, contributed observations each semester. Agreement was maintained by reliability coding on 20% of observations between each observer and the criterial observer. Cohen's kappas were computed on agreement for the 30-s epochs and were greater than .80 on all of the classroom observation measures described in this report.

Social behaviors were recorded using the Peer Relations Observation Inventory (Gunnar, Kryzer, Mliner, Tarullo, & Gustafson, 2004), which was developed from the modified Observational Ratings of the Caregiving Environment (M-ORCE; Kryzer, Kovan, Phillips, Domagall, & Gunnar, 2007) using the scales relevant to peer interaction in preschool settings. For 10 min, the observer alternated between 30 s observe and 5 s record frames. For each 30-s epoch, the behavior that accounted for the majority of the child's activity in the interval was scored. Solitary activity could be coded as watching/wandering, solitary play, or other nonsocial (putting on coat, washing hands; not analyzed in this report). If none of these applied, by default the child was engaged in some kind of social activity, in which case social behavior measures also were scored. Interacts only with teacher was a code describing intervals when the child's only social partner was one of the teachers. Positive integration (0–2) assessed the extent to which the child's role in peer interaction was central to the group. A score of 2 indicated that the child was a key player in positive interactions, directing the interactions or being looked to by others, whereas a score of 1 indicated positive engagement, but in a role where the child was a subordinate or peripheral actor in the activities or engaged in parallel play, and a score of 0 reflected an absence of positive engagement with peers. Rebuffed/ignored was scored in intervals in which the child made a social overture that was either ignored or actively rebuffed by other children. Received and directed negative actions (scored separately) were scored for intervals when any type of aggressive behavior was observed. Aggressive behavior comprised verbal acts, including verbal threats of physical harm; physical acts, including pushing and shoving as well as hitting and forcibly attempting to take things away from other children; and relational aggression involving threats or actions directed at harming relationships with peers (e.g., "If you don't give me that, I won't be your friend"; see Crick, Casas, & Mosher, 1997). At the conclusion of each 10-min observation period, several global codes were assigned. Belonging was a qualitative code reflecting the extent to which the child acted relaxed, confident, and assured (scored 4) as opposed to anxious, tentative, and cautious (scored 1); that is, the extent to which the child seemed to act as if they "belonged" in the setting as opposed to appearing like an outsider. Four mood variables were scored from 1 to 4 in each interval: Positive mood described the spectrum from neutral expression to high expressions of smiling and laughter; anxious/vigilant mood described the range from no evidence of anxiety to high expressions of such behaviors as flinching when other came near, moving quickly away from others, and continuously dividing attention between what the child was doing and scanning of the environment; Sad mood encompassed no evidence of sadness to high expression of sadness including facial and vocal expressions; and angry/hostile mood described the spectrum from no expression of anger/hostility to high expressions in face, voice and gesture. All measures were summed and divided by the total number of observation intervals. There were no missing data for the classroom observation measures.

Peer sociometrics. Sociometric interviews were completed with each English-speaking child at the end of the fall and the spring semesters. Procedures were adapted from Hartup and colleagues (Hartup, Laursen, Stewart, & Eastenson, 1988). Each child viewed an array of photographs of all of the children in their classroom. After reviewing the names of his or her classmates, the child was asked to nominate three children "who you like to play with" and three children "who you don't like to play with." They were then asked to nominate children who were their "special friends." One child (AVE) was missing peer sociometric data in the spring because he had left the classroom by the time the spring sociometrics were performed; this child was present for the rest of the data collection in the spring and was retained in the sample.

Following established procedures (Coie & Dodge, 1983), the number of positive and negative nominations was standardized within classroom and sex. Peer preference measures were calculated as the difference and peer impact was calculated as the sum of these standard scores. We also computed peer status groups (popular, rejected, neglected and other) for each semester using the following criteria based on the standardized scores: popular (preference > 1.0, like > 0, dislike < 0; fall $N = 48$, spring $N = 38$); rejected (preference < -1.0, like < 0, dislike > 0; fall $N = 34$, spring $N = 29$); and neglected (impact < -1.0, like < 0, dislike < 0; fall $N = 22$, spring $N = 24$). The remaining children were placed in the other category (fall $N = 53$, spring $N = 66$).

Both preference ($r = .44$, $N = 165$, $p < .001$) and impact ($r = .24$, $N = 165$, $p < .01$) were modestly stable from fall to spring. This was also the case for the peer status groups, $\chi^2(9, N = 157) = 22.32$, $p < .01$. Given this stability and to reduce the number of tests performed, we identified children who were in each of the peer status groups at least once during the school year (fall, spring, or both), yielding three dichotomous (yes/no) scores for whether each child ever had been a member of the popular ($N = 67$ yes), rejected ($N = 51$ yes), and neglected ($N = 44$ yes) classifications.

Dominance measures. The dominance measures consisted of both task and teacher ratings. Both were designed to assess dominance as a measure of the child's access to resources when other children also were attempting to obtain those resources.

Dominance task. The procedures developed by one of the coauthors, which have been described previously (Pellegrini et al., 2007), required children to line up on three occasions to obtain tickets to attend special events. Children in the first third of the line were able to go to the event immediately; the remainder had to wait until the next day. Those in the middle third of the line were able to attend on the first occasion on the next day, whereas those in the bottom third of the line were in the last group on the second day. The valued resource in this task was being able to attend the special events without delay.

To train the children about the task, in the beginning of the spring quarter, the children were read a story about animals lining up to attend a party. Mo, a toy monkey that was ambiguous as to sex, was always the host of these events. Mo held one event that served as a practice event, then three special events—a monkey hunt, a carnival, and a jungle party—in a room near the classroom. Following the practice event, children were assessed individually to determine whether they understood the ticket rules. The lead researcher, who was familiar to all the children, read the training story and asked the child a number of questions to determine comprehension. Children who failed the assessment were retrained on the story and assessed again. Children who could not pass the assessment upon retraining ($N = 5$) were not included in the data analysis, although they were allowed to attend the events. As noted, two families requested that their children not take part in this exercise; alternative activities were found for these children.

On each day when tickets were drawn, the lead researcher introduced the event and read a story about animals lining up and taking tickets for the event. The children then were told to line up for their tickets. Teachers were present but did not intervene except to prevent physical harm. Although children did push and shove, the level of physicality never rose to a level requiring intervention. The tickets were numbered consecutively and colored differently for the first, middle, and last third of the line. Once the child obtained a ticket, the child handed it to a researcher who recorded the number and color. Immediately following distribution of the tickets, a researcher collected the first group, who left to attend the event with Mo. The children were scored on each event by the number of their ticket, with the first child in line having the number 1. The three dominance events were correlated between .44 and .55 and thus were combined into one dominance task score per child (Cronbach's α = .70). Higher scores on this task reflected being further back in the line; thus on some analyses, the score was reversed so that higher scores would reflect higher dominance. Seven children were missing data on the ticket tasks: five because of failure to understand the task and two because of parent refusal of participation. Missing dominance task data were independent of temperament group, $\chi^2(2, N = 165) = 2.05$, *ns*.

Dominance ratings. At the end of each semester, teachers scored children on the likelihood that when paired with each other child in the classroom, each child would win (1), lose (−1) or draw (0) in any competition over a resource. Scores for each child were summed. As a check on the reliability of the teacher ratings, in the spring the lead researcher also completed these ratings. There were no missing data. Concurrent teacher and researcher ratings were highly correlated ($r = .76$, $N = 165$, $p < .001$). Teacher ratings were also highly correlated from fall to spring ($r = .82$, $N = 165$, $p < .001$). In addition, the teacher ratings and dominance task scores were significantly correlated for both fall and spring teacher ratings ($rs = .52$ and .47, $N = 158$, $p < .001$).

Friendship qualities. At the end of the school year, the teacher and lead researcher completed the Friendship Features Questionnaire (Sebanc, 2003), which was composed of age-appropriate items culled from the Friendship Quality Questionnaire (Parker & Asher, 1993), the Exclusivity scale of the Friendship Questionnaire (Furman & Adler, 1982), and the Relative Power scale of the Network of Relationships Inventory (Furman & Buhrmester, 1985). Two questionnaires were completed for each child, one each for two of their friendships. Only children who had friends, as determined by the peer sociometric interview in the spring, were included in these analyses. To be certain that the relationships being scored were actually friendships, teachers also noted whether the children identified as "special friends" were indeed friends of the child, based on their knowledge of the children's relationships. Seventeen children were missing friendship quality questionnaires because they were not identified as a special friend by anyone in the spring, and lack of a special friend was related to temperament group. No HE children were missing these data, whereas AVE ($N = 11$; 9%) and HI ($N = 6$; 25%) children were missing these data. However, as these measures were interpreted as descriptive of children who had special friends, this difference by group was considered acceptable. The questionnaire yielded seven scores: Help and Guidance, Validation and Caring, Companionship, Conflict, Conflict Resolution, Exclusivity, and Asymmetry. Scales for the two friendships scored by the two raters (teacher and researcher) were combined for each scale, with the Cronbach's alphas ranging from .66 (conflict resolution) to .95 (exclusivity), *Mdn* = .92. Principal factor analysis was used to reduce the scales. Two factors were identified. However, because Conflict Resolution cross-loaded on the two factors > .40, it was removed, and the analysis was repeated. The first factor with an eigenvalue of 3.48 accounted for 57.92% of the variance. After varimax rotation, the scales loading on this factor were Help and Guidance (.90), Validation and Caring (.90), Companionship (.90) and Exclusivity (.89). The second factor with an eigenvalue of 1.2 accounted for 20% of the variance. Only Conflict loaded on this factor (.97). Two scores were computed from the analysis by combining the standardized scores for the scales loading on each factor, using the weights from the factor analysis: Friendship Closeness, corresponding to Factor 1, and Friendship Conflict, corresponding to Factor 2.

Salivary cortisol. Samples were collected in the fall and spring of the year by having the children play a "tasting game." The game was played prior to snack period, which was approximately 1.5 hrs into each class session (around 10:00 am for morning classes, and 2:30 pm for afternoon classes), and was repeated over several weeks in the middle of the fall and spring semesters. Researchers distributed paper cups with a few grains (approximately 0.025 g) of cherry flavored Kool-Aid drink mix and a 1.5 in. (3.81 cm) piece of cotton dental roll. The children were trained to collect the grains by mouthing the cotton roll and then dipping the end into the cup, repeating the procedures until the grains were gone and the cotton roll was saturated. These procedures have been shown to have no impact on cortisol measurement (Talge, Donzella, Kryzer, Gierens, & Gunnar, 2005). The children then put the wetted roll back into the cup, which had been prelabeled with their name, and gave it back to the researchers. Researchers and teachers watched carefully to be sure that children did not trade cups. Once all of the samples were collected for each room, each cotton roll was placed in a needleless syringe, and the saliva was expressed into a 1.5 ml Eppendorf Safe-Lock microtube and sealed. The tube was labeled with the date and the child's identification number and frozen at -20^{0} centigrade until assay.

To provide a reliable measure of each child's cortisol level, we attempted to collect 5 samples on which to calculate cortisol mean levels each semester. There were 11 children who refused saliva sampling in the fall, and this tended to differ by temperament group, $\chi^2(2, N = 165) = 5.61$, $p = .06$. The difference was due to no HE children refusing saliva sampling, whereas those who refused were in the AVE ($N = 7$; 6%) and HI ($N = 4$; 16%) group. By spring semester, only six children refused sampling, and this did not differ by temperament group, $\chi^2(2, N = 165) = 1.06$, ns. One child was excluded from sampling because of use of corticosteroid topical cream on her face that appeared to get into her saliva. For the AVE and HI groups, we examined whether the children who refused saliva sampling in either the fall or the spring differed from others in their temperament group. There were no differences by refusal to provide cortisol samples on any of the measures. We therefore determined that data were missing at random, but because of the small number of children in the extreme (HI and HE) groups, we decided not to impute missing data.

For those who provided samples, we were able to calculate means based on five samples >93% of the time each semester, with an addition 4% providing at least four samples. Because we had so few children who provided only two or three samples, we included them in the analysis (accounting for <3% of cases). Cronbach's alphas based on five samples were .79 and .81 for fall and spring, respectively, with αs > .70 if calculated based on four samples. To obtain five samples per child, during each sampling period, sampling was conducted in each class for about 2 weeks in the morning classes, as these met 5 days per week, and 3 weeks in the afternoon classes, as these met 3 days per week. After this, those few who did not have five samples were approached individually. The first five samples with sufficient saliva for analysis for each child were retained for assaying. Assays were conducted in duplicate using a time-resolved fluorescence immunoassay (DELFIA). Intra- and interassay coefficients of variation were at or less than 6.7% and 9.0%, respectively, and duplicates correlated highly ($r = .997$, $p < .001$). There were no differences in cortisol values for the morning versus afternoon classes, so it was not necessary to correct for time of day.

Mean levels of cortisol were calculated for the fall and the spring sampling periods for each child. The distributions were positively skewed and were therefore log10 transformed prior to analysis. We also computed a change score by subtracting the fall from the spring untransformed values. The distribution of change scores was normal and thus was *not* transformed.

Data Analysis Plan

Preliminary analyses revealed that the temperament groups differed by sex, $\chi^2(2, N = 165) = 8.67$, $p < .05$. This was due to more boys in the HE group (75% boys), compared with the AVE and HI groups, which were more balanced by sex (47% and 41% boys, respectively). Preliminary analyses were conducted to examine all the measures for sex differences (ps < .05) using t tests. Boys had higher scores than girls for directing and receiving negative interactions, angry/irritable mood, conflict quality of friendships, dominance task, and dominance ratings. Girls had higher scores than boys for solitary play, interacting only with teacher, sad mood, number of special friend nominations, and closeness quality of friendships. Sex was covaried in all analyses involving these measures. Analyses were conducted using general linear models (GLM) within SPSS. When changes from fall to spring were examined, GLM for repeated measures (RM-GLM) were used with Greenhouse-Geisser corrections for sphericity, as needed. When significant Group × Trials interaction effects were noted, tests of simple effects were employed. Post hoc tests were Bonferroni or, when equality of variance was violated, Tamhane's T2.

Results

Cross Situational and Over Time Consistency of Inhibition

The first analyses were designed to determine whether the classroom measure of inhibition based on the combined teacher and lead researcher report on the CBQ captured an index of inhibition that exhibited rank-order stability across situations and over time. Situational stability was examined with GLM to relate membership in our temperament groups based on teacher and researcher CBQ to the inhibition measures from the laboratory assessment, whereas stability over time was examined with Pearson correlations for the children for whom we had a second year of teacher and researcher CBQ reports.

Cross situational stability. Parent reported inhibition and the measure of laboratory social inhibition were examined. There was a highly significant multivariate effect for group, Hotelling's $F(4, 202) = 8.77$, $p < .001$, partial $\eta^2 = .5$. Levine's test of equality of variance was not violated for either measure. Follow-up univariate tests were significant for both the parent reported inhibition and laboratory social inhibition measures, $F(2, 17.08) = 16.13$, $\eta^2 = .24$, and $F(2, 10.28) = 9.19$, $\eta^2 = .5$, ps <.001, respectively. Parent Reported Surgency was lowest for the classroom HI group ($M = -1.12$, $N = 14$, $SD = 0.63$) and highest for the HE group ($M = 0.50$, $N = 13$, $SD = 0.70$), with the AVE group in between ($M = -0.26$, $N = 79$, $SD = 0.77$), with post hoc tests indicating that all three groups differed significantly from one another. Laboratory social inhibition showed a similar pattern with all three groups differing significantly (HI, $M = 0.58$, $N = 14$, $SD = 0.80$; HE, $M = -0.65$, $N = 13$, $SD = 0.67$; AVE, $M = 0.04$, $N = 79$, $SD = 0.78$). The combined teacher/researcher classroom surgency was correlated significantly with parent reported surgency ($r = .66$, $N = 103$, $p < .001$) and laboratory social inhibition ($r = -.55$, $N = 103$, $p < .001$). Thus, the classroom groupings based on the combined lead researcher and teacher CBQ report were consistent with parent report and laboratory observational measures.

Rank-order stability over time. Of the 165 children in the Year 1 analysis, only the 3-year-olds ($N = 103$) could have Year 2 data because the 4-year-olds left for kindergarten; 55 3-year-olds did remain in the preschool for Year 2. We had Year 2 lead teacher and lead researcher reports of temperament on 30% ($N = 37$) of the Year 1 AVE group, 25% ($N = 6$) of the HE group, and 50% ($N = 12$) of the HI group. When they returned for Year 2, 75% had a different teacher than in Year 1. The spring-to-spring stability in temperament scores was $r = .75$, $N = 55$, $p < .001$. Year 2 temperament scores were grouped into HI, HE, and AVE groups using the same $+/-1$ SD cut points as used on the Year 1 scores. A cross-tabulation showed that children tended to remain in their temperament groups, $\chi^2(4, N = 55) = 55.03$, $p < .001$.

Detailed Descriptive Analyses of Classroom Behavior and Experiences

The next set of analyses provide a detailed description of the HI and HE children's experiences in the classroom relative to AVE children, with observational measures of social interaction; scores on observational and teacher reports of dominance; peer sociometrics of social preference, social impact, and special friend nominations; and teacher reports of the qualities of children's friendships.

Classroom observations. RM–GLM was used to assess whether there were changes from fall to spring in observational measures of social interaction as a function of temperament group. Table 1 shows the results for trials and temperament group effects.

Table 1
Means and Standard Deviations of Social Observation Measures

	Fall		Spring				Highly exuberant		Average		Highly inhibited			
Variable	*M*	*SD*	*M*	*SD*	*F* trials	Trials partial η^2	*M*	*SD*	*M*	*SD*	*M*	*SD*	*F* group	Group partial η^2
Watching/ Wandering	0.15	0.10	0.12	0.08	8.94^{**}	0.05	0.09_a	0.04	0.13_b	0.06	0.22_c	0.11	22.77^{**}	0.22
Solitary play	0.24	0.14	0.21	0.12	*ns*	NA	0.24	0.10	0.22	0.12	0.25	0.12	*ns*	NA
Interact only with teacher	0.07	0.07	0.06	0.06	*ns*	NA	0.05_a	0.04	0.06_a	0.05	0.11_b	0.07	1.80^{**}	0.04
Positive integration	1.36	0.16	1.40	0.14	8.49^{**}	0.05	1.40_a	0.11	1.40_a	0.12	1.25_b	0.11	16.29^{***}	0.17
Direct negative action	0.023	0.03	0.012	0.02	*ns*	NA	0.03_a	0.02	0.02_a	0.01	0.00_b	0.00	9.26^{***}	0.10
Receive negative action	0.014	0.02	0.010	0.02	*ns*	NA	0.02_a	0.02	0.01_a	0.01	0.00_b	0.01	5.83^{**}	0.07
Belonging	2.67	0.44	2.73	0.40	*ns*	NA	2.78_a	0.30	2.76_a	0.35	2.32_b	0.25	18.55^{***}	0.19
Positive mood	2.61	0.33	2.73	0.33	5.82^{*}	0.04	2.76_a	0.25	2.65_a	0.25	2.37_b	0.25	15.58^{***}	0.16
Anxious/vigilant mood	1.79	0.46	1.68	0.38	4.51^{*}	0.03	1.52_a	0.23	1.71_a	0.32	2.09_b	0.41	18.67^{***}	0.19
Sad mood	1.28	0.27	1.25	0.28	*ns*	NA	1.18_a	0	1.24_a	0	1.46_b	0	11.85^{***}	0.13
Angry mood	1.19	0.26	1.21	0.27	*ns*	NA	1.34_a	0.21	1.20_b	0.22	1.06_c	0.09	10.00^{***}	0.11

Note. $N = 165$. Highly exuberant $N = 24$; Average $N = 117$; Highly inhibited $N = 24$. Means with different subscripts differ significantly ($p < .05$ or more) with either Bonferroni or Tamhane's T2, as appropriate. NA = not applicable.
* $p < .05$. ** $p < .01$. *** $p < .001$.

For the percentage of intervals rebuffed or ignored, no significant effects were obtained; thus, this variable is not in the table.

From fall to spring, the children generally became more relaxed and positively involved in play in the classroom. From fall to spring, there was an overall decrease in watching and wandering and in anxious/vigilant mood and an increase in positive integration into play and positive mood. There were no significant interactions of temperament group and trials but there were main effects of temperament. Compared with children in the other two groups, HI children spent more time interacting only with the teacher, were less integrated into positive peer interactions, acted less confident in the classroom (belongingness), received and directed fewer negative actions, were less positive in mood, and were more anxious/vigilant and sad. All three groups differed on two measures, with the HE group scoring the lowest and the HI group scoring the highest for watching/wandering and the reverse for angry mood.

Dominance. Temperament group differences in dominance were examined with GLM for the observational *dominance task* and RM–GLM for the *dominance ratings* that were completed in the fall and the spring. The task and teacher ratings assessed dominance as the child's access to valued resources. On the *dominance task*, there was a highly significant effect of temperament group, $F(2, 159) = 16.31$, $p < .001$, partial $\eta^2 = .7$, with all three groups differing significantly from one another. Average rank in line was approximately sixth for HE children ($M = 6.16$, $SD = 2.6$), ninth for AVE children ($M = 8.72$, $SD = 3.4$), and 12th for HI children ($M = 11.64$, $SD = 3.2$). For HE children, 33% always got to attend the events in the first group, and none were always in the last group, whereas for HI children, 4% always were in the first group, whereas 25% were always in the last group. The RM–GLM analysis for *dominance ratings* yielded comparable results. The effect of temperament group was highly significant, $F(2, 161) = 49.91$, $p < .001$, partial $\eta^2 = .38$. All three groups differed significantly. HE children were scored as the most likely to win conflicts over resources ($M = 9.14$, $SD = 4.17$, $N = 24$), followed by AVE children ($M = -0.03$, $SD = 7.37$, $N = 117$) and HI children ($M = -10.54$, $SD = 4.37$, $N = 24$).

Peer sociometrics. For these analyses, we were interested in whether peer nominations differed by temperament group. Peer preference and impact were analyzed separately with GLM for the fall and the spring semesters because standardization with classroom and sex precluded examining changes over time. Chi-squares were used to assess whether peer status group membership varied by temperament group. Special friend nominations were not standardized within either classroom or sex because we were interested in the total number of nominations received by children in each temperament group, which was examined with RM–GLM with sex as a covariate.

For peer preference, there were no temperament group differences in either the fall, $F(2, 162) = 0.74$, *ns*, or the spring, $F(2, 162) = 1.41$, *ns*. Temperament group differences were, however, noted for peer impact in both the fall, $F(2, 162) = 6.85$, $p < .001$, $\eta^2 = .08$, and spring, $F(2, 162) = 10.08$, $p < .001$, $\eta^2 = .12$, with all three groups differing significantly. In both semesters, HI children scored lowest on impact ($M_{\text{fall}} = -0.42$, $M_{\text{spring}} = -0.52$; *SD*s = 0.84 and 1.11), followed by AVE children ($M_{\text{fall}} = -0.06$, $M_{\text{spring}} = -.01$; *SD*s = 1.09 and 1.11), followed by HE children ($M_{\text{fall}} = 0.67$, $M_{\text{spring}} = 0.93$; *SD*s = 1.14 and 1.21). We also examined whether a child was ever (fall or spring) in the popular, rejected, or neglected groups. Neither being popular at least once, $\chi^2(2, N = 153) = 4.20$, *ns*, nor being rejected at least once, $\chi^2(2, N = 153) = 4.77$, *ns*, differed by temperament group. A group difference was noted for being in the Neglected category at least once, $\chi^2(2, N = 153) = 9.16$, $p = .01$, with 42% of the HI children falling into this category at least once, compared with 5% of HE children.

For special friend nominations, no significant effects of fall/spring or Fall/Spring × Temperament group interactions were obtained. There was a significant main effect of temperament group, $F(2, 160) = 4.75$, $p < .01$, partial $\eta^2 = .06$. Averaged over fall/spring nominations, HI children received significantly fewer special friend nominations ($M = 1.79$, $SD = 0.94$) than did either AVE children ($M = 2.53$, $SD = 1.41$) or HE children ($M = 2.33$, $SD = 1.37$) who did not differ significantly.

Friendship quality. Friendship quality measures were obtained at the end of the school year, and their relation to temperament group was analyzed with multivariate GLM for those children who received nominations as a special friend from at least one child during the spring semester when the ratings were made (*N*s = 24 HE, 105 AVE, 18 HI). The multivariate effect of temperament group was significant, Hotelling's $F(4, 318) = 11.67$, $p < .001$, partial $\eta^2 = .13$. Univariate effects of group were significant for both closeness, $F(1, 161) = 3.2$, $p < .05$, partial $\eta^2 = .04$, and conflict, $F(1, 161) = 15.55$, partial $\eta^2 = .20$. Post hoc tests indicated that HI children scored lower on closeness ($M = -0.31$, $SD = 0.83$) than did AVE children ($M = 0.19$, $SD = 0.99$), with HE children ($M = -0.23$, $SD = 0.91$) not differing from either group. For conflict, all three groups differed significantly with HE children having friendships with the most conflict ($M = 0.99$, $SD = 0.80$), HI children having the least conflict ($M = -0.85$, $SD = 0.55$), and AVE children falling in the middle (M = -0.04, $SD = 0.91$).

Cortisol Levels: Temperament Group Differences and Change From Fall to Spring

This set of analyses concerned cortisol levels and change in cortisol over time as a function of temperament group. To analyze changes in cortisol levels from fall to spring as a function of temperament group, RM–GLM was conducted on logged cortisol values, whereas GLM assessed temperament group differences in cortisol levels within each semester. To examine whether any increases from fall to spring were above the child's typical day-to-day variability in cortisol, for each child we computed whether their fall to spring change in mean values exceeded the standard deviation of their fall samples.

The RM–GLM analysis on the logged cortisol values yielded a marginally significant effect of trials, $F(1, 150) = 3.77$, $p = .054$, qualified by a Temperament Group × Trials interaction, $F(2, 150) = 4.71$, $p < .05$, partial $\eta^2 = .06$. Tests of simple effects of trials within temperament group indicated a decrease in cortisol from fall to spring for both the HE, $F(1, 23) = 8.03$, $p < .01$, and AVE groups, $F(1, 108) = 17.39$, $p < .001$, but no significant change for the HI children, $F(1, 19) = 1.42$, *ns* (see Figure 1). The Temperament Group × Trials interaction was also significant when the RM–GLM analysis was limited to girls only, $F(2, 78) = 4.67$, $p < .05$, indicating that this effect is not due to the unequal sex distribution across temperament groups.

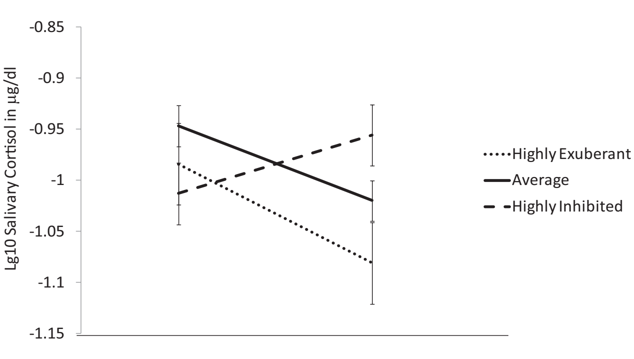

Figure 1. Log10 cortisol levels in μg/dl for the three temperament groups in the fall semester and the spring semester. Error bars reflect standard errors of the mean. *N*s were highly exuberant = 24, average = 109, and highly inhibited = 20.

The repeated measures analysis was conducted on children who provided saliva samples in both the fall and the spring. When we examined group differences within semesters, we included all of the children who provided samples, allowing us to pick up three HI children who had refused fall sampling. There were no group differences in the fall, but in the spring, the difference was significant, $F(2, 158) = 3.31$, $p < .05$, with post hoc tests indicating that the HI children had higher cortisol levels, log10 $M = -0.93$, $SD = 0.27$, $N = 23$, than the HE children, log10 $M = -1.08$, $SD = 0.16$, $N = 24$, who did not differ from the AVE children, log10 $M = -1.01$, $SD = 0.19$, $N = 112$. Of the HI children, 55% exhibited a mean increase from fall to spring (i.e., change score of +.01 or more), and for 35% ($N = 7$ of 20 children who had both fall and spring values), the increase was larger than their fall day-to-day variability. This was the case for only 12% of the AVE and 4% of the HE children, $\chi^2(2, N = 153) = 9.72$, $p < .01$. Thus, not only did the HI children as a group fail to exhibit the average decrease in cortisol levels from fall to spring that was observed in the HE and AVE groups, but a substantial percentage of them exhibited a clear increase in cortisol from fall to spring.

Cortisol Change Over the Year: Associations With Social Experiences Within Temperament Groups

This set of analyses was designed to examine social experience factors associated with changing cortisol production from fall to spring as a function of temperament group. We first looked at the role of special friend nominations and popular peer status. Because all of the HE children had at least one child nominate them as a friend, having or not having at least one friend could only be examined for the AVE and HI children. The results of a 2 Group (AVE/HI) × Friends (some/none) analysis on the change in cortisol (spring minus fall) yielded a significant interaction effect, $F(1, 125) = 6.16$, $p < .02$, partial $\eta^2 = .05$. Contrary to what might be expected, as shown in Figure 2, it was the HI children who had received one or more special friend nominations who showed increases in cortisol from fall to spring. We next examined whether the child was ever placed in the popular category on the peer nomination task. Because all three temperament groups had children who were classified as popular, all children with cortisol data could be included in this analysis. A Temperament Group × Popularity interaction was obtained, $F(2, 147) = 4.09$, $p < .05$, partial $\eta^2 = .05$. As shown in Figure 3, it was the HI but popular children who showed increases in cortisol production from fall to spring semester.

We also examined differences in the correlations between four social variables that had yielded significant temperament group differences—dominance, peer impact, positive integration and friendship closeness—and the change in cortisol from fall to spring. These associations and tests of significant differences between HE and HI groups are shown in Table 2. For dominance, we standardized the task (reverse scored) and teacher ratings and averaged them to yield one summary dominance measure for these analyses, Cronbach's $\alpha = .63$. As shown, the pattern of correlations was different for the HE and HI children, with peer impact

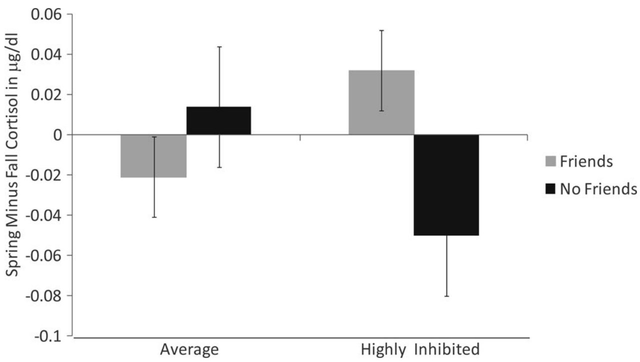

Figure 2. Change in cortisol from the fall to the spring within temperament groups, in relation to whether the child was nominated by at least one child as a special friend (yes, no). Only data for average (*N*s = 98 with and 10 without friends) and highly inhibited children (*N*s = 15 with and 5 without friends) were graphed because all highly exuberant children received at least one special friend nomination. Error bars are standard errors of the mean.

and dominance tending to be associated with less decrease/more increase in cortisol from fall to spring for HI children, whereas the reverse was true for the HE children. Even more clearly, HE children who were more integrated into the positive social activities of the classroom and those who had friendships characterized by greater closeness exhibited greater decreases in cortisol from fall to spring. In contrast, for the HI children, these measures, if anything, were associated with larger increases in cortisol over the school year, with the coefficients being significantly different between the HE and HI groups.

Discussion

In the present study, we examined social experiences and cortisol levels of highly inhibited and highly exuberant preschool children in a familiar peer group setting. The first aim was to obtain a comprehensive picture of the social experiences of these extreme temperament groups in the preschool classroom via classroom observations, peer sociometrics, a dominance task, and teacher ratings of dominance and friendship quality. As expected, there were substantial differences in the social experiences of HI and HE preschool children. Next, we assessed changes in cortisol levels across the preschool year by temperament group. Although cortisol decreased from fall to spring for HE and average children, many of the HI children appeared to be activating the HPA axis more rather than less as the year progressed. The third goal of the study was to determine whether the types of social experience that predicted change in cortisol over time differed for the HI and HE groups. Counter to expectations, for HI children, being less socially integrated, less dominant, and friendless was not associated with rising production of cortisol as the year progressed. Rather, among the HI children, those who were relatively *more* socially integrated were increasing cortisol production over time. The expected pattern of relations between less supportive social experiences and changing production of cortisol over time was, nonetheless, observed among the HE children: Those who were relatively less popular and less socially integrated showed less of a decrease in cortisol production as the year progressed. These findings have implications both for understanding the processes that sustain social inhibition and social exuberance and, perhaps, for supporting healthy emotional development for children in each of these extreme temperament groups. Each of the findings will be discussed in turn.

It should be noted that in the current study we were interested in identifying children who exhibited a HI (shy, wary, and risk averse) or a HE (outgoing, stimulus seeking) profile within a familiar peer context. Therefore, our temperament groups were based on teacher/researcher ratings obtained at the end of each year. These ratings were consistent with parent and laboratory observations of social inhibition, and they remained highly stable from one year to the next, despite advancing age and a change in classrooms and, thus, in the teachers providing the ratings. They likely overlapped substantially, though not entirely, with the children who would have been identified as inhibited or exuberant in a laboratory, which is necessarily a novel context. Indeed, we noted substantial overlap for the subset of children on whom we were able to obtain laboratory measures of inhibition to stranger approach.

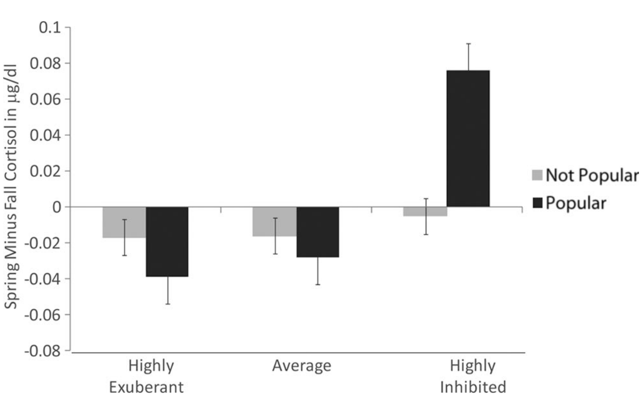

Figure 3. Change in cortisol from the fall to the spring within temperament groups, in relation to whether the child was ever classified as popular based on fall or spring sociometric data. *N*s for never popular versus ever popular by group were highly exuberant = 16 and 8, average = 66 and 43, and highly inhibited = 16 and 4. Error bars reflect standard errors of the mean.

Table 2
Pearson Correlation Coefficients of Social Experience Measures: Associations With Change in Cortisol Levels Spring Minus Fall Over the School Year

Measure	Highly exuberant	Average	Highly inhibited	Difference between HE and HI coefficients: *Z*
Peer impact	−.31	−.10	.47*	−2.55**
Dominance[a]	−.21	−.07	.53*	−2.37*
Social integration	−.42*	−.11	.43†	−2.74**
Friendship closeness	−.40†	.05	.43†	−2.71**

Highly exuberant $N = 24$; average $N = 109$; highly inhibited $N = 20$. HE = highly exuberant; HI = highly inhibited; AVE = average.
[a] Computed as a partial correlation to control for sex difference in dominance.
† $p < .10$. * $p < .05$. ** $p < .01$.

The social experiences of our HI and HE groups were markedly different. Compared with both HE and average inhibition children, HI children were less socially integrated in positive peer play, were less aggressive and less frequently involved in peer conflicts, and received fewer nominations as anyone's special friend. In contrast, HE children differed from average children on only a few of the social observation variables. They scored higher on peer impact, but not peer preference, had friendships that were more conflictual, and exhibited an angry mood more often than average and HI children. As expected, dominance, defined as access to valued resources, differed significantly by temperament group: Based both on the ratings and the behavioral task, the HE children were the most likely to succeed at obtaining contested resources, followed by the average children, with the HI children least likely to attain these resources.

We had predicted that HI children would be more likely to be peer rejected based on prior reports that HI children tend to be bullied and rejected by their peers (Deater-Deckard, 2001; Hanish & Guerra, 2004; Hart, Yang, Nelson, Robinson, & Olsen, 2000; Ladd, 2006; Newcomb, Bukowski, & Pattee, 1993). In the current study, however, HI children were no more likely to be rejected than the HE or average children and were *less* likely to be the recipients of negative or aggressive social actions. These children were more likely to be socially neglected, but they were not targets of peer relational or physical aggression. This finding should not be surprising once we consider the moderating role of classroom climate. Gazelle (Gazelle, 2006) reported that anxious and socially withdrawn first graders were disproportionately rejected and victimized by peers only if they were in classrooms with negative emotional climates and concluded that a warm, supportive classroom environment is beneficial for shy and anxious children. The laboratory preschool in the current study is exceptional with regard to teacher training and child–teacher ratio. Teachers regularly provide scaffolding to help children negotiate social encounters and to prevent or resolve negative interactions. This highly supportive preschool setting facilitated examination of the association between inhibition and cortisol as moderated by individual differences in social experiences without the further confound of variability in classroom climate. However, it is not certain whether this pattern of results would generalize across the full range of preschool environments that young children experience.

Rubin and colleagues (Rubin et al., 2009) proposed a transactional developmental model for shy children, in which social withdrawal leads to a dearth of social experiences, which in turn leads to less developed social skills. When these less socially skilled preschool children do attempt to meet social goals, it is suggested, they are prone to being bullied or rejected, further reinforcing social withdrawal and creating a vicious cycle (Rubin et al., 2009). Certainly, the association between social withdrawal and peer rejection, first emerging in early childhood, becomes increasingly pronounced as children get older (Ladd, 2006). In the context of this transactional model, what are the developmental implications if social withdrawal is *not* associated with peer rejection or bullying? The HI children in the current study, like their peers, became relatively more integrated and less anxious/vigilant over the course of the school year, though they maintained their rank within the classroom on these measures. In other words, their level of integration increased but was still less than that of their average and HE peers. They were just as likely to be popular as their peers, and many formed friendships. It may be that the warm, supportive classroom climate was a protective factor for these HI children, allowing them opportunities to develop social skills that will help them to avoid eliciting peer rejection in the future. On the other hand, underlying emotional disposition was not altered in these classrooms—teacher-rated inhibition was quite stable not only from fall to spring but also from one year of preschool to the next. It seems possible that whether the social skills that HI children developed in this preschool context will generalize to kindergarten may depend on whether continued scaffolding is provided by their kindergarten teachers. The transition to elementary school is particularly stressful for shy and withdrawn children (Coplan, Arbeau, & Armer, 2008). A future direction would be to assess how inhibited children from highly supportive preschools fare in the transition to kindergarten, not only with regard to their vulnerability to peer rejection and bullying but also in terms of effects on cortisol reactivity.

Having documented the pervasive temperament group differences in social experiences that were evident even within this exceptionally supportive preschool setting, we next aimed to examine how and whether HE and HI children responded to these experiences with differential activity of the HPA axis. There were no main effects of temperament within the fall semester, although in the spring semester, the HI children had higher cortisol levels. With regards to the lack of difference in the fall semester, it is important to recall that cortisol measures were not collected during the initial transition to the classroom setting but after the children had time to acclimate—several weeks into the fall semester. Prior studies indicate that during the transition to a new social group, cortisol levels are highest for exuberant, extroverted children (Davis et al., 1999; de Haan et al., 1998; Gunnar et al., 1997). One interpretation is that cortisol elevations are associated with rising to the challenge of social interaction in an unfamiliar environment. Cortisol reactivity declines for these HE children once the group becomes familiar. During the transition to school, HI children presumably are *not* doing much initiating of social interactions and thus may buffer themselves from social challenge, thus reducing activation of the HPA axis. Prior work (e.g., Gunnar et al., 1997) has shown that shyness actually was associated with *lower* cortisol activity during the first month in a new preschool class and was unassociated with cortisol activity once the children had become familiar with the classroom setting. These patterns illustrate why we were unlikely to find main effects of temperament on cortisol levels obtained during the fall semester, after the children had several weeks to acclimatize to the classroom.

As expected, cortisol levels changed over the school year as the children became more familiar with the context and more socially skilled. For HE and average temperament children, cortisol levels fell from fall to spring, but this was not the case for the HI children. Indeed, for at least 35% of the HI children, a clear increase in cortisol levels was noted from fall to spring. These children activated the HPA axis more, producing higher levels of cortisol, as the year progressed. The types of social experience that were positively associated with HPA activation depended on temperament group. Having friends, being popular, having higher peer impact, and being more dominant were associated with *rising* cortisol levels over time in HI children, whereas HE children who were more socially integrated and had closer friendships showed larger *decreases* in cortisol levels from fall to spring. Furthermore, the differences in patterns of correlation between the HE and HI children were significant. Thus for HI children, being more socially integrated and popular relative to other HI children was associated with more activation of the HPA axis, whereas for HE children, the more expected pattern was noted of more positive social integration and warmer friendships being associated with a lowering of cortisol as the school year progressed. Behavioral inhibition is associated with increased neural sensitivity both to threatening stimuli (Schwartz, Wright, Shin, Kagan, & Rauch, 2003; Williams, Mathews, & MacLeod, 1996) and to nonsocial reward stimuli (Guyer et al., 2006). The brain may also respond differently to the social rewards of friendship and popularity as a function of temperament.

Behavioral inhibition is characterized as a biologically based tendency toward social avoidance (Fox et al., 1995). For HI children, avoidant social behavior is expected to decrease anxiety in the short term, thereby reinforcing social withdrawal behavior, a cycle of avoidance that ultimately may increase the risk of anxiety disorders (Crozier & Alden, 2005; Rubin et al., 2009). We expected that due to conflicting motives to social approach and avoidance (Coplan et al., 2004) HI children would experience being less socially integrated into the classroom as stressful. However, the results of the current study suggest that for these children, hovering at the edge of a social group or playing alone may make less demand on stress-sensitive neurobiological systems such as the HPA axis than being socially integrated. The HI children who developed friendships and attained popular status in the classroom continued to be rated as HI by their teachers despite these social achievements—their underlying temperament had not changed. Attaining these social goals therefore may have required them to overcome their own tendency toward social avoidance. These children had increasing cortisol levels across the school year, which suggests that integration into their peer group may have been, for them, physically, cognitively, and/or emotionally challenging. This result is congruent with the notion that trait internalizing dispositions are associated with greater HPA reactivity in familiar everyday contexts, where individuals are attempting to manage repeated instances of similar stressors (Gunnar, 2001; van Eck, Berkhof, Nicolson, & Sulon, 1996).

In contrast, the HE and average temperament children had decreasing cortisol levels across the school year. Falling cortisol levels as a context becomes familiar is the expected pattern when children or adults have adapted to a generally supportive and positive context. For the HE children, more positive social integration and more intimate friendships were associated with greater decreases in cortisol over time. HE children are conceptualized as having a strong social approach motivation (Fox et al., 1995), so engaging with their peers is congruent with their temperamental disposition and did not appear to activate the HPA axis. Indeed, a less integrated social standing in the classroom appeared to diminish their ability to lower activity of the HPA axis as the year progressed. We might expect that for HE children, social isolation would be a particularly potent stressor and could activate the HPA axis. This hypothesis could not be examined in the current data set because none of the HE children were socially isolated; they all had at least one friend in the classroom. Social isolation may be uncommon in HE children, though it could occur via peer rejection, particularly for those children with behavior regulation difficulties (Coie, Dodge, & Kupersmidt, 1990; Crick & Grotpeter, 1995). And as noted earlier, in a previous study, exuberant children who were peer rejected did exhibit elevated cortisol levels relative to other children (Gunnar et al., 2003).

The notion that social closeness and peer integration are emotionally stressful for HI children is only one of several possible interpretations of the results. Although the increase in cortisol production among HI, socially integrated children is evidence of physiological stress, we cannot conclude for certain that it indicates emotional stress. Activation of the HPA axis could also be due to increased metabolic energy demands that do not involve emotions. The cortisol increase could simply reflect the cognitive and physical demands of HI, socially integrated children operating against their temperamental predisposition.

In the nonhuman primate and adult human literature on dominance hierarchies, the more dominant individuals tend to have high cortisol during the group formation phase and low cortisol during periods of group stability, when their dominance has been established (Hellhammer, Buchtal, Gutberlet, & Kirschbaum, 1997; Sapolsky, 2005). Low dominant individuals show the reverse pattern—blunted responding during group formation and higher cortisol in the familiar group (Hellhammer et al., 1997; Saltzman, Hogan, & Abbott, 2006; Sapolsky, 2005). In the current study, access to valued resources was assessed only in the familiar group phase, and the direction of correlation between dominance and cortisol change over time varied by temperament group: Access to valued resources tended to be associated with decreasing cortisol for the HE group and increasing cortisol for the HI group. This result was consistent with the general pattern that negotiating social interactions resulted in increased HPA activation for the HI group.

There are a number of limitations of this study, some of which have been noted. Medication history, which may have affected cortisol levels, was not available for the children in this study. The analyses relating peer group status to temperament group involved relatively small *N*s within each cell and will need to be replicated with a larger sample. The study was conducted in a laboratory preschool setting with highly trained teachers, a low child to teacher ratio, and many physical resources. The present findings may not generalize to other types of preschool settings. Although no data were available regarding the education and income of the children's parents, it seems likely, given that the preschool draws from the university community, that the families these children lived in were highly educated. Again, this limits generalization. Thus, in future studies, it will be important to examine a broader range of preschool settings and children who represent a variety of backgrounds, to obtain a more comprehensive picture of how associations between social experiences and changing cortisol levels over the school year vary as a function of whether children are high or low in behavioral inhibition. Finally, a larger longitudinal sample would be required to address critical questions about the interplay of cortisol, social behavior, and temperament across multiple school years. Despite these limitations, the present results suggest that it may be fruitful to consider whether differences among children in behavioral inhibition predict not only different social experiences with peers but also different relations between those experiences and activity of stress-sensitive physiological systems. Exploring this question should broaden our understanding of the processes through which behavioral inhibition is maintained or changed and the influences on physical and emotional health.

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