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Peer Rejection and HPA Activity in Middle Childhood: Friendship Makes a Difference

Ellen Peters, J. Marianne Riksen-Walraven, Antonius H. N. Cillessen, and Carolina de Weerth

Radboud University Nijmegen

Exclusion and victimization by classmates were related to levels and diurnal change in cortisol in 97 fourth graders (53% boys, M = 9.3 years). Number and quality of friendships were considered as moderators. Salivary cortisol was collected 5 times daily on 2 school days. Excluded children had elevated cortisol levels at school and a flattened diurnal cortisol curve, suggesting hypothalamic–pituitary–adrenocortical (HPA) axis dysregulation. This effect was weaker for children with more friends or better friendships. Victimization was not associated with cortisol level or change. The results demonstrate the role of HPA activity in peer group processes and indicate that group and dyadic factors interact in predicting stress in the peer group.

The hypothalamic–pituitary–adrenocortical (HPA) system, responsible for cortisol release in humans, can be activated by psychological distress. This is particularly the case when stressors have a social-evaluative component and are seen as a threat to the self (Dickerson & Kemeny, 2004). Consequently, potential or explicit social rejection can seriously influence the human stress system. Indeed, social rejection has been related to increased cortisol levels in preschoolers (Gunnar, Sebanc, Tout, Donzella, & Van Dulmen, 2003; Gunnar, Tout, de Haan, Pierce, & Stansbury, 1997), adolescents (Vaillancourt et al., 2007), and adults (Blackhart, Eckel, & Tice, 2007; Stroud, Salovey, & Epel, 2002).

However, little is known about the association between rejection and cortisol in middle childhood. This is a developmental period when the significance of children's position in the peer group is large and peer rejection is particularly stressful (see Rubin, Bukowski, & Parker, 1998). In addition, friendships are also quite important at this age (see, e.g., Bagwell, Newcomb, & Bukowski, 1998). An example of this importance is the fact that friendships can function as a buffer against the negative effects of peer rejection on children's well-being and adjustment (e.g., Hodges, Boivin, Vitaro, & Bukowski, 1999; Hodges, Malone, & Perry, 1997). The current study examined whether rejection in the peer group, specifically victimization and exclusion, are related to increased levels of cortisol in a middle childhood sample, and whether friendships and friendship quality can mitigate this association.

Stress and the HPA System

The HPA system is a neuroendocrine system that produces the human stress hormone cortisol. In response to psychological stress, cortisol is elevated beyond normal levels to mobilize energy and facilitate responses to a potential threat (Gunnar & Quevedo, 2007; Sapolsky, 1994). Cortisol responses to stress help an individual to cope with the stressor and adapt to the increased demands of stressful situations (e.g., Gunnar et al., 1997). Increased cortisol levels are adaptive, but chronically high levels of cortisol have negative effects on various areas of functioning, such as the immune system (Coe, Rosenberg, & Levine, 1988), learning and memory performance (Heffelfinger & Newcomer, 2001), socioemotional adjustment (Smider et al., 2002), and in the long run the functioning of the HPA system itself.

Cortisol and Rejection by Peers

Peer rejection is the collective disliking of group members of an individual in the group (Buhs & Ladd, 2001). Such disliking expresses itself in explicit behavioral manifestations of rejection such as

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Correspondence concerning this article should be addressed to Marianne Riksen-Walraven, Behavioural Science Institute, Radboud University Nijmegen, PO Box 9104, 6500 HE, Nijmegen, the Netherlands. Electronic mail may be sent to m.riksen@psych.ru.nl.

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exclusion and victimization (Boivin & Hymel, 1997; Ladd, 2009). A growing body of research has identified several concurrent and long-term consequences of victimization and exclusion, such as increased school avoidance, externalizing problems, loneliness, social anxiety, depression and negative health outcomes (e.g., Baumeister & Leary, 1995; Boivin, Hymel, & Bukowski, 1995; Buhs & Ladd, 2001; Buhs, Ladd, & Herald, 2006; Crick & Grotpeter, 1996; Hawker & Boulton, 2000; Kochenderfer & Ladd, 1996; MacDonald, Kingsbury, & Shaw, 2005; Twenge, Baumeister, Tice, & Stucke, 2001; Williams, Chambers, Logan, & Robinson, 1996).

One of the mechanisms that may account for the link between peer rejection and concurrent and long-term adjustment problems may be stress that is caused by peer rejection. It is known that victimization and exclusion are both associated with considerable subjective distress (Newman, Holden, & Deville, 2005). Children, for example, spontaneously report being teased or isolated by the peer group as examples of stressful daily experiences (e.g., Spirito, Stark, Grace, & Stamoulis, 1991). However, little is known about how victimization and exclusion by peers are associated with more objective measures of stress, such as cortisol levels. In adult and adolescents samples, exclusion is associated with increased cortisol levels. For example, studies that experimentally manipulated social exclusion or isolation reported increased cortisol levels in excluded adults (Stroud, Tanofsky-Kraff, Wilfley, & Salovey, 2000; Stroud et al., 2009; Zwolinski, 2008). The only study that has examined victimization in relation to cortisol reported lower instead of higher cortisol among bullied adolescents (Vaillancourt et al., 2007). According to the researchers, this may have been the result of chronic exposure to high levels of stress, which may lead to dysregulation of the stress system and lower cortisol levels in the long run. This mechanism will be explained in more detail below.

The goal of the current study was to assess the contribution of two forms of peer rejection, victimization and exclusion, to cortisol levels in middle childhood. It was expected that children who are victimized and excluded by classmates have higher cortisol levels at school than children who are not subjected to these forms of negative treatment by peers.

The Role of Friendship

That children are rejected by classmates does not by definition imply that they have no friends in class. Peer rejection is defined and measured at the group level and refers to the behavior of the peer group in general toward a child, while friendship is defined and measured at the dyad level and refers to an intimate relationship between two children. Those two levels are related but not identical (see, e.g., Asher, Parker, & Walker, 1996). Children who do not have the social skills to function effectively in the larger peer group may still be able to maintain harmonious dyadic relationships. Children who are rejected by the peer group as a whole are not necessarily friendless.

Several studies have shown that a few good friends may protect children from the negative outcomes of being rejected by peers (Hodges & Perry, 1999; Hodges et al. 1997; Hodges et al., 1999; Laursen, Bukowski, Aunola, & Nurmi, 2007). Parker and Asher (1993) showed that loneliness among rejected children is reduced if they have at least one high-quality friendship. Friends may have these positive and buffering effects because they provide a sense of security in a stressful environment (Berndt & Keefe, 1995; Goldstein, Field, & Healy, 1989; Ladd, 1990). A close friend can provide the social support that is known to reduce stress (Gunnar & Donzella, 2002; Uchino, Cacioppo, & Kiecolt-Glaser, 1996).

According to Cohen and Wills (1985), social support buffers stress in two ways. First, threatening conditions are seen as less stressful when support is available. Second, support enhances the regulation of actual stressful experiences, thereby leading to a reduced physiological stress response. Heinrichs, Baumgartner, Kirschbaum, and Ehlert (2003) suggested that the neuropeptide oxytocin may play a role in this mechanism, because it is involved in positive social interactions and able to inhibit HPA activity.

The current study also examined the moderating role of friendship in the association between rejection and cortisol. Two measures of friendship were used: number of friends and friendship quality (Hartup, 1996). Higher levels of cortisol were expected in victimized or excluded children with fewer friends and/or a lower quality friendship.

The Diurnal Cortisol Curve

The available studies on the associations between rejection and cortisol have focused primarily on cortisol at school rather than on the patterning of cortisol over the day (see, e.g., Gunnar et al., 1997; Gunnar et al., 2003). Normally, cortisol production follows a circadian rhythm with the highest level shortly after wake-up followed by a progressive

decline during the day (Kirschbaum & Hellhammer, 1989). In case of adequate regulation of the HPA system, exposure to high levels of cortisol is minimized via a ''negative feedback'' mechanism, whereby cortisol shuts down its own release. But in case of chronically high levels of cortisol, the elasticity of the system may become overstrained, leading to flattened or even increased (in young children) cortisol curves over the day (Gunnar & Donzella, 2002; Gunnar & Vazquez, 2001; Hart, Gunnar, & Cicchetti, 1996; Miller, Chen, & Zhou, 2007). This can be interpreted as a sign of HPA dysregulation (Caplan, Cobb, & French, 1979). For example, flattened cortisol curves have been found in clinical populations of maltreated or depressed children (Hart et al., 1996; Kaufman, 1991).

Thus, the diurnal cortisol curve reflects children's long-term adjustment to chronic stress (see also Granger, Stansbury, & Henker, 1994; Pérez-Edgar, Schmidt, Henderson, Schulkin, & Fox, 2008; Stansbury & Gunnar, 1994). Rejection by peers is a source of chronic stress that can negatively influence the HPA system. Therefore, in addition to the level of cortisol, we also examined the decline of the diurnal cortisol curve. Excluded and victimized children were expected to show a relatively small diurnal decline in cortisol, particularly when they had few friends or low quality friendships.

Control Variables

Gender and behavior problems were included as two variables that might influence the association between rejection and HPA activity. Studies have shown gender differences in cortisol responses to psychological stress (e.g., Kirschbaum, Wust, & Hellhammer, 1992), and gender differences in peer rejection have also been reported in numerous studies. For example, boys typically receive higher scores for victimization than girls (e.g., Solberg & Olweus, 2003).

With regard to behavior problems, both externalizing and internalizing problems have been related to victimization and exclusion, and also to cortisol secretion. For example, externalizing behavior has been found associated with both basal cortisol and cortisol reactivity (Alink et al., 2008), and externalizing behavior is also related to peer rejection (e.g., Hodges & Perry, 1999; Hodges et al., 1997). Internalizing problems, particularly depression, have also been found related to both HPA functioning (Gunnar & Quevedo, 2007) and measures of peer rejection (e.g., Boivin, Hymel, et al., 1995; Hawker & Boulton, 2000).

Summary of Research Questions

This study examined the extent to which peer victimization and exclusion in middle childhood are related to HPA activity. It was hypothesized that both would predict higher levels of cortisol at school, particularly for children with fewer friends and/or a lower quality friendship. It was also expected that victimization and exclusion would predict smaller declines in cortisol over the day, resulting in flatter diurnal curves. This effect was also expected to be stronger for children with fewer friends and/or a lower quality friendship.

Method

Participants

Participants were part of the Nijmegen Longitudinal Study on Infant and Child Development, which started in 1998 with a community sample of one hundred and twenty-nine 15-month-old children (Van Bakel & Riksen-Walraven, 2002a). The families were recruited via local health care centers in the city of Nijmegen in the Netherlands. Families with a 15-month-old baby were sent an invitation to participate in the study that aimed to ''gain more insight into children's development in the first years of life.'' If they met the two eligibility criteria (i.e., sufficient fluency in Dutch and child without serious health problems) and were interested in participation, they could return a response card. Of the 639 families approached, 174 replied and 129 families were then randomly selected for the study. As indicated by the distribution of parental and child measures at 15 months, the initial sample was representative of the Dutch population of families with young children (Van Bakel & Riksen-Walraven, 2002a, 2002b).

Attrition was low throughout the longitudinal study; see Smeekens, Riksen-Walraven, and Van Bakel (2007a, 2007b) for the 5-year wave, for example. In the present measurement wave, at age 9, 118 of the one hundred and twenty-nine children in the original sample participated (53.4% boys, M = 9.27 years, SD = 0.20). The primary caregivers were between 30 and 55 years old and had a mean level of education of 5.03 (SD = 1.72) on a scale of 1 (*elementary school*) to 7 (*college degree or more*), which was not significantly different from that of the primary caregivers in the 11 families that had dropped out of the study. The 118 children attended 83 classrooms in 53 elementary schools. These schools served lower-middle to middle-class families. The

majority of the participants were Caucasian (83.4%); the ethnic minority children in the sample were Turkish (3.0%), Moroccan (2.0%), Surinamese (1.1%), from the Antilles (1.0%), or of other background (9.5%). Ninety-five percent of the children were from two-parent families.

Consent was obtained from parents and teachers following school policies. Of all approached teachers, one decided not to participate. The participation rate in the sociometric assessment was high, exceeding 85% in all classrooms. Only eight children in the 83 classrooms (from eight different classrooms) did not receive parental permission. In some classrooms one or two children were absent because of illness on the day of testing.

All involved parents agreed to the saliva collection procedure; 97 of the 118 children (53% boys, M = 9.3 years) successfully completed the salivary samples at home and school. The children without successful salivary samples were excluded because they used potentially interfering medication (against attention deficit hyperactivity disorder, allergies, or asthma), felt ill during sampling, or returned sampling packages that were potentially thawed too long. Seven parents refrained from cortisol sampling because of a lack of time. The children who dropped out did not differ statistically from the included children on any relevant study variable. All 97 children with cortisol data participated in the measures of rejection, friendship, and behavior problems.

Overview of Data Collection

Data collection occurred in stages, within a 4-week period for each child. First, parents received a questionnaire to assess child behavior problems, which they returned by mail. Next, the children were visited at school two times. During the first visit, sociometric data were collected in the classrooms of the 118 target children to identify their friendships and assess victimization and exclusion. During the second school visit, within 2 weeks after the first, the target children completed a questionnaire assessing the quality of their best friendship. Finally, within 2 weeks after the second school visit, saliva was collected from the target children on 2 consecutive school days.

Measures and Procedures

Peer rejection experiences. Sociometric data with unlimited nominations were collected during a 30-min classroom session. To help children complete the nominations, the names of all eligible classroom peers were written on the blackboard. There were two measures of children's peer rejection experiences. *Victimization* was measured by asking children to name peers in their classroom ''who are often bullied or picked on by other children.'' *Exclusion* was measured by asking children to name peers ''who are often excluded from peer activities.'' For both questions, nominations received were counted and standardized to z scores within classrooms to control for differences in classroom size as is customary in sociometric research (cf. Cillessen, 2009). The validity of peer nominations for victimization and exclusion has been demonstrated repeatedly (e.g., Gazelle & Druhen, 2009; Perry, Kusel, & Perry, 1988).

Friendship measures. There were two measures of friendship. First, *number of friends* was assessed as part of the classroom peer nominations. Children were asked ''Who of your classmates are your friends?'' (Bukowski, Hoza, & Boivin, 1994). They could nominate as many or as few friends as they wished, starting with their first best friend, second best friend, and so on. From these data, the number of reciprocal friendships in the classroom was computed.

Second, *friendship quality* was assessed with the Friendship Quality Questionnaire (FQQ; Parker & Asher, 1993). The FQQ consists of 40 friendship qualities. Children rate how true each is of their best friendship on a 5-point scale (0 = *not at all true*, 4 = *really true*). Children were asked to complete the FQQ with reference to their very best friend as determined by the sociometric procedure. A child's best friend was the classmate whom the child nominated as highest ranked among her or his top three best friends and who also nominated the child in her or his top three in return. If there was no top three reciprocal friend, priority was given to the target child's next ranked friend who also nominated the target child as a friend (irrespective of rank order). If there was no reciprocal friend—which happened on only one occasion—the best friend was defined as the highest ranked nonreciprocal friend of the target child.

Personalized versions of the FQQ were created with the name of the identified best friend embedded in each item to prevent that children would complete the questionnaire for an idealized friendship, or for a combination of different friendships (see Parker & Asher, 1993). Examples items are: ''Susan and I loan each other things all the time'' and ''Susan and I tell each other secrets.'' The FQQ yields six subscales: companionship and recreation

(α = .77), validation and caring (α = .80), help and guidance (α = .86), intimate exchange (α = .89), conflict and betrayal (reversed, α = .50), and conflict resolution (α = .70). A child's score on each subscale is the average of her or his ratings for the relevant items. Consistent with previous research (Parker & Asher, 1993), a total FQQ score was computed by averaging the subscale scores. Higher scores indicate higher friendship quality.

Behavior problems. Parents (primary caregivers) completed the 113-item Dutch version of the Child Behavior Checklist for Ages 6–18 (CBCL/6-18; Achenbach & Rescorla, 2000). The items include several problem behaviors rated on a 3-point scale (0 = *not true*, 1 = *somewhat or sometimes true*, 2 = *often true*), in eight behavioral domains: Anxious/Depressed, Withdrawn, Somatic Complaints, Social Problems, Thought Problems, Attention Problems, Rule Breaking Behavior, and Aggressive Behavior. In the present study the CBCL total problem score was used, which is obtained by summing scores across domains.

Salivary cortisol. Saliva samples were obtained on 2 consecutive school days (Monday and Tuesday). Five samples were taken on each day: two at home in the morning (directly after awakening and 30 min later), two at school (at noon before lunch and in the afternoon before going home), and one at home in the evening before bedtime.

The equipment needed for the salivary collection was sent in a postal package to the children's homes, a few days before the sample period. The package consisted of a sampling booklet, digital watch, short parental questionnaire, and a ''salivary kit,'' containing two plastic bags marked ''Day 1'' and ''Day 2.'' Each bag enclosed five plastic devices with sterile absorbent cotton dental roles without any oral stimulants held inside (Salivettes; Sarstedt, Nuembrecht, Germany). All Salivettes were separately marked with the desired sampling times. Children were trained to chew on the cotton rolls for at least 1 min, until they were saturated with saliva. They were asked not to eat or brush their teeth during a 2-hr period before sampling. Children were instructed to always directly record the exact times of sampling, determined by the provided digital watch. Children and their parents were instructed to store the saliva samples in their home refrigerator. The sampling booklet contained information on how to collect the saliva, questions about quality of sleep, and potential stressors or problems around sampling. Parents completed the short questionnaire about children's leisure activities, use of medication, illness, or other noteworthy details during the sampling period.

Salivary samples were sent to the Biochemisches Labor at the University of Trier, Germany, to be analyzed in duplicate using time-resolved fluorescence immunoassay (DELFIA; Dressendorfer, Kirschbaum, Rohde, Stahl, & Strasburger, 1992). The samples of each child were analyzed in the same assay batch to minimize variability. If control samples showed cortisol values outside a defined range (± 2 *SD*) the whole batch was reanalyzed. Cortisol was measured as nmol/L. Samples with higher values than the highest standard (100 nmol/L) were diluted and reanalyzed. The intra-assay coefficient of variation ranged from 4.0% to 6.7%; the inter-assay coefficients of variation ranged from 7.1% to 9.0%. All values > 50 nmol/L were considered outliers (Nicolson, 2008) and reassigned a value of *2 SD* above the mean, as suggested by Kertes and Gunnar (2004).

Cortisol Parameters

To estimate school levels of cortisol and the diurnal change in cortisol levels, data from both days of data collection were combined. Combining aggregated cortisol data across days is recommended when examining individual characteristics in relation to cortisol levels (Adam & Gunnar, 2001; Nicolson, 2008). This was justified by the individual stability in cortisol levels. Children's daily cortisol averages (mean of four saliva samples) across the 2 days were positively correlated ($r = .54$, $p < .001$). Consistency of cortisol levels from Day 1 to Day 2 was indicated by significant correlations between each time point, rs = .57, .32, .32, and .44, all ps < .001, for morning, noon, afternoon, and bedtime, respectively.

To examine the effects of exclusion and victimization on the level of cortisol at school, the area under the curve (AUC_{school}) was calculated as a measure of children's cortisol secretion during school hours. AUC_{school} was calculated with the formula for AUC with respect to ground (see Pruessner, Kirschbaum, Meinlschmid, & Hellhammer, 2003). This measures the total amount of cortisol secretion during a specific time period, in this case, for the period from noon before lunch until going home in the afternoon. Because this time period varied between children, cortisol secretion at school was divided by the time (in minutes) between the two samples. AUC_{school} was computed for the majority of children who had data at both school times; 11 children missed one of both times

and therefore did not have an AUC_{school} score. The correlation of AUC_{school} between Day 1 and Day 2 was .34 ($p < .001$).

The effects of exclusion and victimization on the diurnal decline in cortisol were examined with linear mixed models in SPSS 15. Mixed models can estimate individual differences in the cortisol intercept (morning level) and slope (decline across the day) and allows for the inclusion of participants with incomplete data. Mixed modeling of repeated cortisol assessments is recommended to estimate a typical pattern in a homogeneous population (see Van Ryzin, Chatham, Kryzer, Kertes, & Gunnar, 2009). Time was measured in hours and centered at 7:00 a.m. Therefore, effects on the cortisol intercept (not of primary interest here) indicate effects on the early morning cortisol level. Slope effects (of primary interest in these analyses) indicate effects on the hourly change of cortisol across the entire school day.

Results

Preliminary Analyses

Descriptive statistics. Because the distribution of raw cortisol values was somewhat skewed, they were log transformed. All analyses were conducted with the log-transformed scores. Table 1 shows the descriptives and correlations of the study variables. Gender (dummy coded; girls = 1, boys = 0) was negatively related to problem behavior. Boys scored higher on the CBCL than girls. The positive correlation between gender and friendship quality indicates that girls rated their friendships higher in quality. Victimization and exclusion were moderately correlated. Neither was related to gender or behavior problems. Victimization and exclusion were uncorrelated with friendship quality. Exclusion was negatively associated with number of friends, and positively with AUC_{school}. Because both gender and CBCL were not correlated with cortisol level, there was no need to control for these variables in further analyses.

Predicting School Cortisol Levels

To examine the effects of exclusion and victimization on AUC_{school}, and the moderating effects of friendship, two hierarchical regressions were run. In the first analysis, exclusion was entered in Step 1, the two friendship measures (number of friends and friendship quality) in Step 2, and the interactions of exclusion with the two friendship measures in Step 3. In the second analysis, victimization went into Step 1, the two friendship measures in Step 2, and the interactions of victimization with both friendship measures in Step 3. Table 2 shows the results.

The analysis of exclusion explained 19% of the variance in school cortisol level, $F(5, 85) = 5.37$, $p < .01$. Significant incremental variance was added in Step 1 and Step 3. In Step 1, a significant positive effect of exclusion was found. Children who scored higher on exclusion also had higher cortisol levels at school. In Step 3, a significant interaction was found between number of friends and exclusion. That is, the association between exclusion and AUC_{school} was moderated by number of friendships. To examine the nature of this moderating effect, the association between exclusion and AUC_{school} was plotted at 0, 1, 2, and 6 friendships. Zero, 1, and 2 friendships were chosen because they are the lowest numbers possible and often considered important substantively in friendship research (see Hartup, 1996). Six was chosen because it represented the upper end of the distribution of classroom friendships (range = 0–9) and slightly more than 1 *SD* above the mean (5.6

Table 1
Intercorrelations and Descriptive Statistics of Study Variables

	1	2	3	4	5	6	*M*	*SD*	Range
1. Gender							0.47	0.50	0–1
2. CBCL	−.23*						23.96	15.33	2–85
3. Victimization	−.03	.00					0.02	1.02	−1.31–4.77
4. Exclusion	−.17	.19	.41*				0.02	1.04	−1.18–4.64
5. No. friends	.03	−.16	−.17	−.36*			3.75	1.84	0–9
6. Friend quality	.31*	−.14	.09	−.13	.23*		3.90	0.60	2.13–4.98
7. AUC_{school}	−.15	.15	−.11	.28*	−.13	−.12	1.61	0.51	0.57–3.30

Note. $82 \leq N \leq 97$.
*$p < .05$.

Table 2
Results of Hierarchical Regressions Predicting AUC_{school} From Exclusion and Victimization

Predictors	β	ΔR^2	Predictors	β	ΔR^2
Step 1		.07*	Step 1		.01
Exclusion	.40*		Victimization	−.12	
Step 2		.01	Step 2		.03
No. friends	−.05		No. friends	−.10	
Friend quality	.07		Friend quality	−.12	
Step 3		.11*	Step 3		.01
Exclusion × No. Friends	.36*		Victim. × No. Friends	.10	
Exclusion × Friend Quality	.16		Victim. × Friend Quality	−.03	
Total R^2		.19*	Total R^2		.04

Note. $N = 86$.
*$p < .05$.

friends). Exclusion was already a *z* score. Therefore, −1 and +1 were chosen as low and high values representing the mean minus and plus 1 *SD* consistent with Aiken and West (1991). Figure 1 shows the resulting graph. The slopes of the regression lines in Figure 1 indicate that the association between exclusion and cortisol was stronger as the number of friends increased (*b*s = .23, .35, .47, and .94, for 0, 1, 2, and 6 friends, respectively).

The analysis of victimization explained 4% of the variance in school cortisol level and was not significant, $F(5, 85) = .74$, $p = .61$. None of the steps added significant incremental variance. There were no significant main effects of victimization or interactions with friendship.

Predicting Diurnal Decline of Cortisol

For both exclusion and victimization, a linear mixed model was run following the logic and framework of the multilevel model of change (Singer & Willett, 2003). A person–period data file was created in which all available time points were nested within each child. Cortisol, measured at the maximum of the five time points during the school day, was the dependent variable in this analysis. Both the intercept of cortisol, in this case centered at the first measurement point as is customary in cortisol studies, and the slope of cortisol during the school day, were estimated. The main focus of this analysis is on the estimated change in cortisol across the entire school day. Two mixed models were run, one for exclusion and one for victimization. In the model for exclusion, exclusion and the two friendship variables were time-invariant predictors. Their effects on the cortisol intercept and slope were estimated. To test moderation, the interactive effects of exclusion with both friendship variables on the intercept and slope were estimated as well. In the model for victimization, victimization and the two friendship variables were the

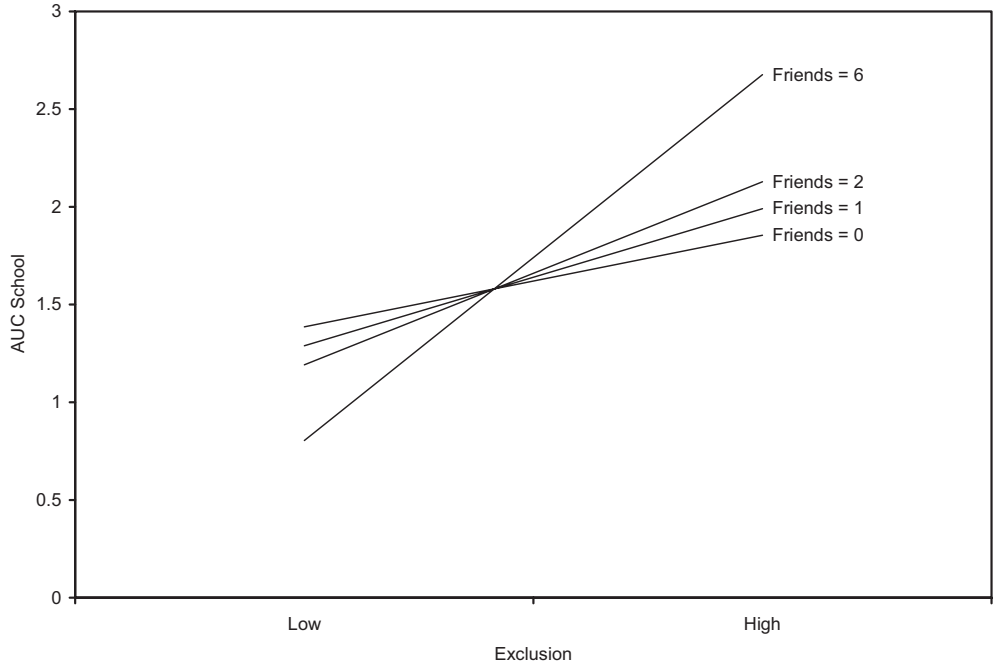

Figure 1. Interaction between peer exclusion and number of friends in the prediction of school cortisol level (AUC_{school}).

time-invariant predictors, predicting both intercept and slope. Again, the interactive effects of victimization with both friendship variables on the intercept and slope were also estimated. The results are summarized in Table 3.

As can be seen in Table 3, exclusion had a significant negative effect on the intercept. Higher levels of exclusion were associated with lower levels of morning cortisol than normal. This effect of exclusion on the intercept was moderated by both friendship variables. Having more friends or a higher quality friendship counteracted the reduction of morning cortisol that is associated with exclusion.

The rate of change was significant and negative, indicating the normal reduction of cortisol across the school day. Exclusion had a positive effect on the rate of change, indicating that excluded children had a less negative rate of change of cortisol across the day, or a flatter curve. Combined with the intercept results, this indicates that excluded children started lower in the morning but also had a flatter curve across the day.

Importantly, the interaction of exclusion with both friendship variables on the rate of change was significant. Prototypical plots were again created to understand both interactions. Figure 2 displays the prototypical plot for the interaction between exclusion and number of friends. Figure 3 displays the interaction between exclusion and friendship quality. In both cases, low and high values of the predictor (exclusion) and moderators (number of friends and friendship quality) were set at $M \pm 1$ *SD* (Aiken & West, 1991; Singer & Willett, 2003). For number of friends, this corresponded with 1.9 friends ($M - 1$ *SD*) and 5.6 friends ($M + 1$ *SD*).

As shown in Figure 2, the interaction between exclusion and number of friends on the rate of change was caused by a different slope for excluded children with few friends. Children who were excluded and had few friends had a flatter cortisol curve across the day than children who were excluded and had more friends or children who were not excluded.

Figure 3 shows that the interaction between exclusion and friendship quality on cortisol change was also caused by a different slope for excluded children with low-quality friendships. This effect was even more pronounced than for the number of friends. Children who were excluded and had a low-quality friendship had a much flatter cortisol curve across the school day than children who had higher quality friendships or were not excluded.

The analysis for victimization yielded a significant rate of change, representing the normal decline in cortisol during the day. No other effects were significant in this analysis.

Discussion

This study examined whether exclusion and victimization in the peer group predicted HPA activity in children, and whether these effects were moderated by friendships. As expected, exclusion predicted HPA activity. Children who were excluded by peers exhibited higher levels of cortisol at school. In addition, excluded children had a flatter diurnal

Table 3
Results of Linear Mixed Models Predicting Diurnal Cortisol From Exclusion and Victimization

Effects of exclusion	*B*	*SE*	Effects of victimization	*B*	*SE*
On initial status	15.82	1.09	On initial status	16.13	1.16
Exclusion	−5.01*	1.04	Victimization	−1.56	0.96
No. friends	0.00	0.26	No. friends	−0.31	0.26
Friend quality	0.10	0.78	Friend quality	0.18	0.81
Exclusion × No. Friends	1.34*	0.30	Victim. × No. Friends	0.10	0.22
Exclusion × Friend Quality	3.21*	1.00	Victim. × Friend Quality	0.75	0.91
On rate of change	−1.28*	0.13	On rate of change	−1.30*	0.14
Exclusion	0.43*	0.12	Victimization	0.13	0.12
No. friends	0.00	0.03	No. friends	0.03	0.03
Friend quality	−0.03	0.09	Friend quality	−0.04	0.10
Exclusion × No. Friends	−0.11*	0.04	Victim. × No. Friends	−0.01	0.03
Exclusion × Friend Quality	−0.29*	0.12	Victim. × Friend Quality	−0.07	0.11

*$p < .05$.

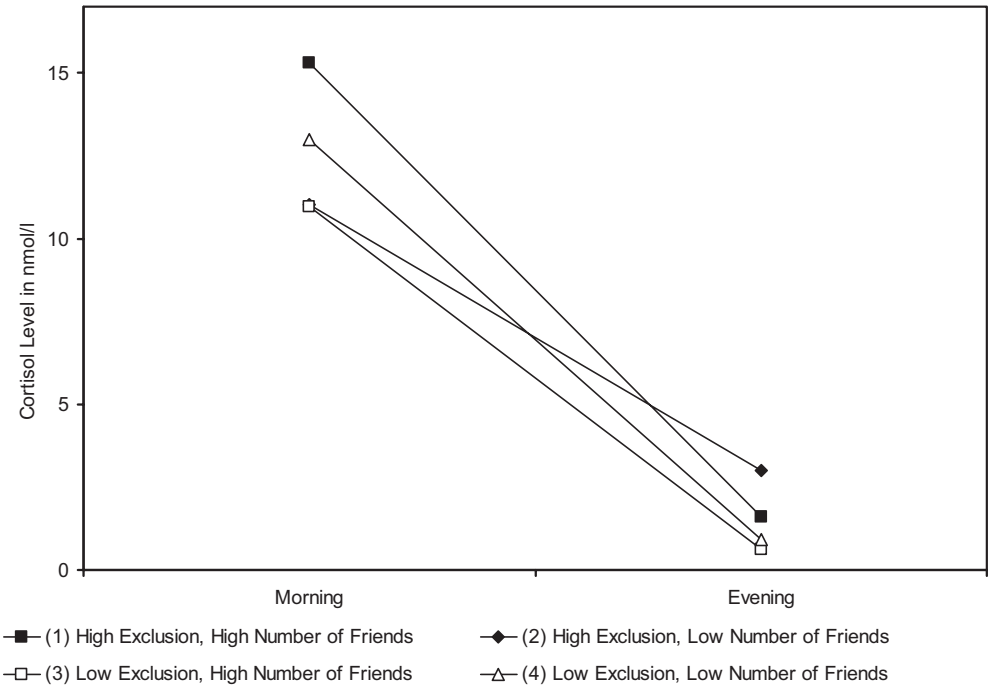

Figure 2. Interaction between peer exclusion and number of friends in the prediction of diurnal cortisol decline.

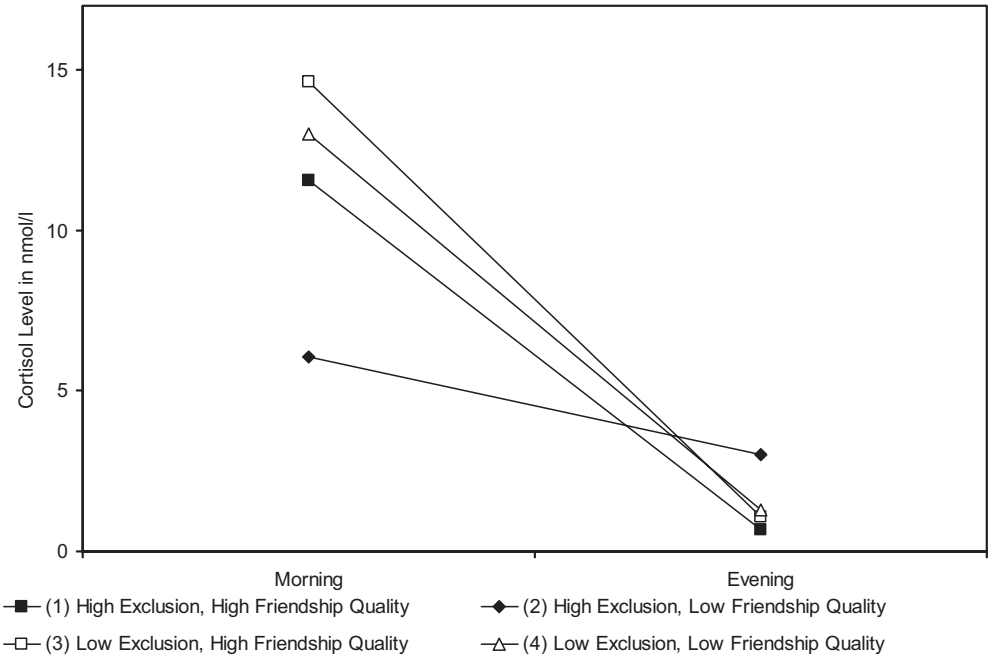

Figure 3. Interaction between peer exclusion and friendship quality in the prediction of diurnal cortisol decline.

cortisol curve, that is, a smaller decline in cortisol over the day. This was even more pronounced for excluded children with few friends or low-quality friendships. Peer victimization was not directly associated with HPA activity. Together, the results demonstrate that although friends cannot completely eliminate the stress of exclusion at school, they do reduce the stress of exclusion.

The elevated level of cortisol at school and flattened diurnal curve of excluded children could

indicate that exclusion is stressful. The fact that the same effects were not found for victimization may suggest that exclusion is more stressful than victimization. Why would this be the case? An answer may lie in the evolutionary function of social contact. Social contact has clear benefits for survival and social success. In a classic series of studies on the psychology of affiliation, Schachter (1959) demonstrated already half a century ago that people affiliate with others in order to decrease anxiety. Evolutionary selection has favored the formation and maintenance of social bonds and the experience of distress when they are missing (Baumeister & Leary, 1995). This is in line with our finding that flattened cortisol curves were particularly evident in excluded children with few friends. Such curves point to HPA axis dysregulation as a result of chronic stress. Excluded children with few friends have less social contact than most of their peers—probably also after school. This may lead to levels of distress that are too high to cope with, eventually resulting in dysregulation of the HPA system.

Peer victimization, in contrast, does not per definition include deprivation of social contact and may therefore be less stressful than social exclusion by peers. In the only earlier study that examined peer victimization in relation to cortisol (Vaillancourt et al., 2007), lower levels of cortisol were found in bullied adolescents, which the authors interpreted as an indication of dysregulation of the stress system as a result of chronic stress. The fact that we did not find a relation between victimization and flattened diurnal cortisol curves is not at odds with the findings of Vaillancourt et al. (2007), given the younger age of our participants. It is possible that flattened diurnal curves emerge at a later age, after longer exposure to victimization. A longitudinal follow-up of the present sample could clarify this issue.

Another explanation for the difference in results between exclusion and victimization may have to do with their measurement by peer nominations. Nominations may better capture exclusion than children's victimization experiences. Who is excluded by the peer group can be observed easily by all group members, but victimization may often occur in dyads or small groups, and therefore be less easy to see for the rest of the peer group. Indeed, Perry et al. (1988) found that some children who report to be victims of bullying are not recognized as victims by their peers. Our results for victimization might have been stronger if the data had been supplemented with a self-report measure of victimization, and if we would have examined cortisol levels of children who are not only seen as victims by their peers, but also reported high levels of peer victimization themselves.

It should also be noted that our models were run for victimization and exclusion separately, without controlling for the overlap between the two. While exclusion does not necessarily imply victimization, victimization is expected to include a certain degree of exclusion, especially in the case of relational victimization, which is defined by behaviors such as excluding others. However, in our data set the association between victimization and exclusion was modest (r = .41), pointing to about 16% of shared variance between both constructs. Thus, results for victimization while controlling for exclusion might not have looked very different. In fact, they might have looked worse, given that controlling for a part of the variance of a construct usually weakens its effects. Most importantly, the effects of victimization were examined without controlling for exclusion to do full justice to the experience of victimization and recognizing that it can include a certain degree of exclusion. It is possible that in a future study the effects of victimization might be stronger if the experience of exclusion would be taken into account, but this would require separate measures of relational and nonrelational forms of victimization, as well as self-report measures of exclusion experiences that were not present in the current study.

The results showed that excluded children with more friendships had higher cortisol levels at school. This may seem counterintuitive, especially considering that these friendships did protect them from dysregulation of the HPA axis in general, as reflected in their diurnal cortisol curve. However, this finding may be explained by the characteristics of excluded children's friends. Friends are often similar (Haselager, Hartup, Van Lieshout, & Riksen-Walraven, 1998; Peters, Cillessen, Riksen-Walraven, & Haselager, 2010). Excluded children's friends may also be excluded. This may take away the protective effect that they might have. A rejected friend may not protect against victimization or exclusion but in fact enhance one's vulnerability. Two rejected children spending time together may be more inviting to bullies than one (Rubin, Wojslawowicz, Rose-Krasnor, Booth-LaForce, & Burgess, 2006). It is also possible that excluded friends coruminate about their problems, increasingly focus on their negative school experiences, and thereby exacerbate the stress they experience

rather than alleviate it (see Oh et al., 2008; Rose, 2002; Rubin et al., 2006).

Another possible explanation for the finding that excluded children with more friends had higher cortisol levels at school is that excluded children's friends are (among) the ones excluding them, resulting in higher cortisol levels than in the case of exclusion by nonfriends. We could not examine this possibility because our exclusion measure was aimed at identifying children who are excluded, but not by whom they are excluded. Future studies with such a measure may shed light on this issue.

It is remarkable that friendships had a positive effect on the decline of excluded children's cortisol curve over the full day, while they did not protect against increased cortisol levels during school hours. A possible explanation lies in the effect of excluded children's contacts with friends *after* school. Children who have friends are also likely to interact with them after school, and this may reduce excluded children's elevated school cortisol levels, resulting in a steeper decline of the cortisol curve across the day. That is, it may be more difficult for friends to counteract the effects of exclusion within the immediate school context (when bullies and other peers doing the exclusion are present), but their supportive effect may be beneficial in the course of the entire day (outside of the presence of excluding peers).

Limitations and Directions for Future Research

Although this study assumed that peer rejection causes stress that can be measured by cortisol in saliva, the causal direction of the relation between peer rejection and cortisol cannot be proven in this cross-sectional study. The possibility remains that elevated cortisol at school or dysregulated HPA activity precede peer exclusion. Such a causal direction has been suggested for the association between aggression and low cortisol. Underarousal of the physiological stress system is thought to urge children to stimulation seeking behavior (such as aggression) in order to elevate their arousal to comfortable levels (Susman, 2006). For excluded children, this would imply that high cortisol would cause them to act in ways that lead to rejection. Longitudinal cortisol data over longer time periods would be necessary to disentangle these possibilities.

Furthermore, the identification of friendships was limited to the classroom. Other important friendships may have been missed as a result. For example, friendships from the neighborhood or leisure activities may also be important sources of social and emotional support, especially for children who experience difficulties in their peer group at school. Future studies should therefore also include children's friendships outside the classroom. It would be valuable to collect data on the frequency and nature of contacts with friends after school. Such reports were not available in the present study, but we highly recommend them for future research. They would make it possible to examine the relative supportive effects of friends within school versus outside of school. This could be assessed by comparing, for example, the diurnal stress curves during school days of children who have supportive friendship interactions in school and after school, in school only or after school only, or neither in school nor after school.

Most target children came from different classrooms. There were too few from the same classroom to analyze possible classroom effects on the association between peer victimization and HPA activity. However, the issue of classroom-level effects merits attention in future studies. Previous research in the peer relationships field has indeed shown that classrooms can differ in various aspects, such as norms of aggression, and that such aspects of the classroom context can serve as important moderators of other associations (see, e.g., Boivin, Dodge, & Coie, 1995; Stormshak, Bierman, Bruschi, Dodge, & Coie, 1999; Wright, Giammarino, & Parad, 1986). Similarly, classroom contextual factors may also influence the degree of stress associated with peer group experiences such as exclusion. For example, in highly cooperative and prosocial classrooms in which rejection almost never occurs, an incident of exclusion may trigger a stronger stress response than the same event in a classroom where exclusion occurs daily. Because such effects are unknown, future studies should consider the role of classroom context as a potential moderator of children's physiological responses to peer experiences.

The current study measured cortisol on two regular school days. Future research may benefit from examining the association between peer rejection and HPA activity on other days, such as during weekends and holidays. This may yield additional insights into the associations among peer rejection, friendships, and stress responses. For example, if high cortisol in excluded children is the result of hostilities with peers at school, cortisol should be more normal at home.

The cortisol data were collected up to 4 weeks after the assessment of rejection and friendships. Despite this lag, we found meaningful correlations

of rejection and friendship with cortisol. This suggests that the time lag was not a problem in our study. This also makes sense given the relative stability of rejection and friendships over several months in school at this age (e.g., Berndt & Hoyle, 1985; Bukowski & Newcomb, 1984; Sandstrom & Coie, 1999). Because of the time lag, our estimates of the association between rejection/friendship and cortisol may be conservative. Future studies with shorter time lags may yield stronger results.

Implications

This study showed that excluded children have enhanced levels of cortisol at school and relatively flat cortisol curves over the day. Previous studies have clearly shown that chronically high cortisol has negative effects on child development (Coe et al., 1988; Heffelfinger & Newcomer, 2001; Smider et al., 2002). Exclusion by itself also has numerous negative consequences (e.g., Baumeister & Leary, 1995; Buhs & Ladd, 2001; Buhs et al., 2006; Crick & Grotpeter, 1996; MacDonald et al., 2005; Twenge et al., 2001; Williams et al., 1996). The fact that high cortisol and exclusion are related may point to an important mechanism through which exclusion contributes to negative outcomes. Buhs et al. (2006) found that excluded children achieve poorly in elementary school. They suggested that exclusion may impair a child's ability to participate in classroom activities, which leads to low school achievement in the long term. The current study points to another mechanism that may be involved. Chronically high cortisol is related to decreased memory and learning performance (Heffelfinger & Newcomer, 2001). Therefore, low academic achievement of excluded children may be caused by increased cortisol levels associated with peer exclusion at school.

The current study shows that the stress of peer exclusion is reflected in children's physiological responses. Yet, friendships offer children provisions that are unique relative to general peer group influences (Ladd, Kochenderfer, & Coleman, 1997). Importantly, the current study evidences a psychobiological mechanism that can explain how peer relations at the group level and the dyadic level can interact in their contribution to children's functioning.

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