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Student–teacher relationships and classroom climate in first grade: how do they relate to students' stress regulation?

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The present study involved 105 German students at the end of their first semester in elementary school in order to explore the stress that students may experience within the school environment, and how the relationship with the teacher buffers or exacerbates the stress. Student–teacher relationships were explored on both classroom and individual interaction levels. Classrooms were described by external observers in terms of teachers' support and classroom organization. Teachers reported on the relationships with their students regarding closeness, conflict, and dependency, which determined four specific patterns of student–teacher relationships. Furthermore, saliva samples were taken on a Monday and a Friday of the same week (four times each day) to display diurnal cortisol profiles. These profiles were later evaluated by means of slopes and intercepts, reflecting students' daily stress regulation. Comparisons between Monday and Friday profiles of the same student served as an estimate for the stress regulation throughout the week. Finally, associations between the profiles and the specific relationship patterns provided information on significant environmental conditions for students' stress. Students in non-supportive, as compared to supportive, classrooms had flatter cortisol profiles, suggesting that classrooms of low quality hindered sufficient down-regulation of cortisol levels at both the beginning and the end of the week. Moreover, students with conflict-loaded relationships with their teachers were less able to appropriately down-regulate stress (especially on Fridays) than students with proximal-balanced relationships, showing the most optimal cortisol profiles.

Keywords: relationship patterns; diurnal cortisol profiles; slopes; intercepts; interaction levels

Introduction

Over the past two decades, considerable research has been carried out about the importance of relationships between students and teachers in shaping the quality of students' classroom learning experiences including many new challenges, especially after school entry. It became clear that students' relationships with teachers most importantly reflect the interpersonal culture of classrooms and the abilities of students and teachers to begin connecting with each other. In early research, teachers were portrayed as determining the quality of their relationships with students through their attempts to create a supportive climate in the classroom and their allocation of attention to students' individual needs (e.g., Minuchin & Shapiro,

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1983). However, surprisingly little is known about these first classroom experiences and how irksome and stressful school experiences might also detract students from academic performance and motivation to achieve. Thus, the present paper explores individual teacher–student and teachers' class-level interaction including teaching styles as two central aspects of teacher–student relationship quality, in order to link them to the stress that students may experience within the school environment.

Although school settings constrain the intensity and frequency of experience with teachers, students inevitably form individual relationships with them. Over the past decade, Pianta and his colleagues (e.g., Hamre & Pianta, 2001, 2005; Pianta, 1992, 2001; Pianta, Steinberg, & Rollins, 1995) evidenced three distinct dimensions of student–teacher relationships, i.e. closeness, dependency, and conflict, relating to various aspects of school adjustment. Dependency and conflict emerged as a correlate of school adjustment difficulties, causing negative school attitudes and less school engagement, whereas students' closeness with the teachers is linked to better school attitudes and more self-directedness (e.g., Birch & Ladd, 1998). Researchers have long assumed that these associations reflect teachers' secure base function which is similar to the key mechanism of relationships known from the *Bowlby-Ainsworth attachment theory* (Bowlby, 1969; Bretherton & Munholland, 2008; Waters & Waters, 2006). Regarding student–teacher relationships, students might form close relationships when they begin to acquire event-based information of their teachers' tendencies to be available and sensitive to their needs. In this way, teachers might function as a secure base from which children can engage in exploration and their intellectual activities in the classroom can be scaffolded. If student–teacher relationships were organized according to the closeness dimension, having been assisted by the other two dimensions, dependency and conflict, the relationships could reflect varying facets of the secure base function. The present paper therefore aims to cluster the three relationship dimensions in order to exploit the full potential of the relevant characteristics of teacher–child relationships and to determine complex relationship patterns similar to children's attachments towards their parents and other significant adults (e.g., Ahnert, 2005).

Socio-cultural theories which include views from the Bowlby-Ainsworth attachment theory progress beyond the evaluation of individualized reciprocal effects of teacher–student interactions, and consider relationships as embedded within classrooms. Socio-cultural researchers do not appreciate simply the structural characteristics but the overall interpersonal culture of the classroom that contributes to teacher–student interactions (e.g., Turner & Meyer, 2000). Teachers are not only able to demonstrate caring through their use of scaffolding techniques in the classroom, and the instrumental support of students' abilities so as to support their performance, they are also capable of demonstrating care due to their ability to attain intersubjectivity (see Goldstein, 1999). While creating a shared intellectual space, teachers might build the relationships with their students upon empathetic stimulation. A meta-analysis on relationships in preschools, for example, revealed that empathetic group-oriented behaviors of the teachers predicted closeness of the teacher–child relationship better than teachers' sensitivity towards individual children did (Ahnert, Pinquart, & Lamb, 2006). Not surprisingly, a positive emotional climate during school lessons plays a role in the path towards a positive adaptation to school and thus became the corner stone in measuring quality in school contexts (e.g., NICHD Early Child Care Network, 2002; Rimm-Kaufman, Curby, Grimm, Nathanson, & Brock, 2009). For example, if offered strong instructional and emotional support in first-grade classrooms, students obtained higher achievement scores than when placed in less supportive classrooms, which was especially prominent in at-risk students (Hamre & Pianta, 2005). In contrast, impersonal teaching styles can leave students feeling vulnerable and limited in terms of their achievements. For example, strategies emphasizing the power differential between students and teachers can have a negative impact on relationships, particularly when students do not understand the process of evaluation of their performance (Thomas & Oldfather, 1997).

Surprisingly little is known about how critical student–teacher relationships and classroom climates are for helping first-graders to adjust to school contexts, specifically with regard to stress management. Clearly, poor quality relationships with teachers and non-supportive classroom climates can be seen as sources of chronic stress, affecting the hypo-thalamic-pituitary-adrenal (HPA) system. Stress results when contexts are actually or potentially threatening *and* they are experienced as overwhelming and people are inhibited in their capacity to manage the situation (e.g., Lazarus & Folkman, 1984). Thus, stress can be demonstrated by the inability to effectively regulate irksome situations even though close relationships inside and outside of children's families appear to buffer children's HPA activity to challenges (e.g., Ahnert, Gunnar, Lamb, & Barthel, 2004; Nachmias, Gunnar, Mangelsdorf, Parritz, & Buss, 1996). In general, children's successful adaptation to stressful school contexts requires appropriate actions and responses by teachers who are able to regulate children's stress through the mechanism within close relationships. We therefore assume that the student–teacher relationship may thus serve an important support function, especially for first graders in their attempts to adjust to the challenges at school. Therefore, student–teacher relationships which are salient in closeness may provide external coping resources and perceived safety, buffering the potential stress in the classroom.

Stress has been traditionally evaluated on the basis of HPA axis activities which release the glucocorticosteroid cortisol in the form of diurnal patterns. Under basal conditions, the HPA axis maintains a circadian rhythm, which provides high levels of cortisol in the morning to prepare the organism for the upcoming challenges and continuously reduces cortisol levels over the course of the day. Thus, diurnal cortisol profiles regularly display high *intercepts* as displayed in morning levels and large negative *slopes* representing cortisol decreases down to evening levels. On the following day, high cortisol levels are the consequence of the resetting of the cortisol production by the HPA axis overnight. In sum, elevated morning cortisol levels play a role in the metabolism of stored energy, in facilitating the mobilization of the resources necessary to manage the challenges for the day (Schmidt-Reinwald, Pruessner, Hellhammer, Federenko, Rohleder, Schürmeyer, et al., 1999). In contrast, chronic stress and the activation of the HPA system are believed to lead to distorted down-regulation of the system and blunted cortisol levels throughout the diurnal profiles (Fries, Hesse, Hellhammer, & Hellhammer, 2005; Gunnar & Quevedo, 2007; Gunnar & Vazquez, 2001; Heim, Ehlert, & Hellhammer, 2000). Studies of clinical groups report low morning levels and less inclined slopes in diurnal cortisol profiles of patients suffering from stress-related physical disorders (e.g., Heim et al., 2000). Morning cortisol levels that were lower than expected have also been recorded for teachers who experience high degrees of job stress and burnout symptoms (Pruessner, Hellhammer, & Kirschbaum, 1999). Flat diurnal cortisol profiles were also observed in white-collar workers who experienced chronic stress, both self-reported and verified by diaries (Caplan, Cobb, & French, 1979). Kudielka, Buchtal, Uhde, and Wuest (2007) have demonstrated that an implementation of night work in former day workers lead to physical exhaustion, reduced sleep quality, and flattened cortisol profiles. Interestingly, similar physical reactions have been observed in the Adam and Gunnar (2001) study on mothers of toddlers, whose cortisol production appeared to be linked with the number of hours that they worked outside of the home.

In children, deviations from typical diurnal profiles have been detected specifically in low-quality child care, where the children were only able to down-regulate cortisol levels in a limited manner, displaying high cortisol levels when they were expected to be low (e.g., Geoffroy, MCôté, Parent, & Séguin, 2006; Vermeer & van IJzendoorn, 2006). Because it remained unclear as to which aspects of quality interact with neurobiological processes (c.f., Lisonbee, Mize, Payne, & Granger, 2008), the present study aims to investigate students' cortisol profiles in response to the student–teacher relationships on classroom and individual interaction levels. For that reason, the study was designed to measure students' stress regulation near to the end of the first semester after school entry, when students are still novices, focusing on the beginning and the end of a normal week during that time. We aimed to investigate: (1) whether stress is more pronounced on Fridays than Mondays of the same week, (2) whether students in non-supportive classrooms display cortisol profiles of heightened stress and vice versa for students of supportive classrooms, and (3) whether poorer quality of an individual relationship with the teacher elevates students' stress profiles and vice versa for better quality relationships. In more detail, we expected cortisol profiles to decrease more saliently from mornings to evenings in better than in poor relationships in which profiles might flatten. That is, better student–teacher relationships should be reflected in larger slopes and intercepts of the diurnal profiles, and should be similar on Mondays and Fridays. In contrast, we expected poorer student-teacher relationships to relate to less inclined slopes and smaller intercepts of the diurnal profiles, which even should exacerbate on Fridays. We finally explored: (4) whether a combination of the three environmental conditions (day of the week, classroom climate, and individual student–teacher relationship) would advance or compensate their effects.

Method

Sample

Students

The present study involves 105 healthy children (58 girls; 62 firstborns; 31 single children) as part of a longitudinal study on the transition from kindergarten to elementary school. We recruited the children through listings in child care centers, where they also passed health checks provided by state-controlled services, and followed up on them at the end of the first semester in German elementary schools. By then, target students reached 7.3 years ($SD = 6$ months) of age on average.

Families

The families were representative of middle-class families in Germany with respect to parental age, education, occupation, and income. Mothers were 37.3 years ($SD = 4.10$) and fathers 39.8 years ($SD = 5.8$) old on average, with mothers vs. fathers having accomplished vocational trainings (52.2% vs. 50.1%), college (33.4% vs. 31.9%), or university (14.5% vs. 17.9%). Families with single-mother status constituted 22% of the sample which is common in Germany. In two-parent families, 19.2% were single-earner families, i.e., 16.2% of the mothers and 3% of the fathers stayed at home.

Schools

The study took place in 42 elementary schools in two German towns, a middle-sized city in Saxony-Anhalt (Stendal) and a large-sized city in North Rhine-Westphalia (Cologne), involving 72 teachers (70 females). Teachers averaged 43.4 years of age ($SD = 9.11$) and had experienced 18.2 years ($SD = 11.6$) of teaching. They all were head teachers of classes consisting of 23 students on average ($SD = 3.8$). Initially, all of the recruited children were observed individually in different groups in kindergarten. Later on, however, the sample became semi-nested when the children entered school. Most of the children ($n = 46$; 63.9%) were enrolled in different classrooms at elementary schools. Classes with two target children constituted 27.8% ($n = 40$) of the sample. Five classes admitted three target students each ($n = 15$; 6.9%) and the rest ($n = 4$; 1.4%) were all from the same class. Overall, 72 classrooms revealed an average size of 1.46 target children.

Procedures and measures

Overview

Towards the end of the first semester, i.e. 22.7 weeks ($SD = 4.4$) after school entry, we first gathered observational data while the teachers were teaching in classrooms during three lessons lasting 45 minutes each. Furthermore, we collected saliva from each student on a Monday and the subsequent Friday of the same week (four times each day) in order to determine diurnal cortisol profiles for each day. Teachers who were observed in the classrooms were also asked to report on their relationship with the respective target student.

Saliva collection

Saliva samples were collected four times on two days, a Monday and a subsequent Friday, of the same week, which was also when the observations took place. The saliva collections followed a strict time schedule, and were carried out at least 30 minutes after students had consumed some food or drinks. After the students arrived at school, research assistants collected saliva at 8:00 AM, during a break between two lessons at 11.00 AM, and between 2:00 and 3:00 PM during the afternoon activities. Parents were also instructed to collect saliva in the evening between 6:00 and 7:00 PM. Although there was more time given for the saliva collections in the afternoons and evenings as opposed to earlier in the day, when only breaks between lessons were used, collections varied equally lasting one to three minutes. Students were told to suck on eye spears which were put into a 3oz plastic cup. All samples were immediately frozen to $0°F/-18°C$ and stored in a freezer until assayed.

Cortisol quantification

The samples were analyzed by Professor Clemens Kirschbaum of the Biopsychological Department at the Technical University in Dresden/Germany using Enzyme Immuno Assay (EIA) "Synelisa Sensitive" which has a reported sensitivity of

.02 μg/dl in concentrations of 0 to 10 μg/dl. Using 10 μl saliva samples, intra- and interassay variability ranged from 7 to 10% for concentrations of .4 to .7 μg/dl. In the present study, all samples were analyzed in a single batch to minimize variability. To further ensure reliability, duplicate assays were performed. Cortisol levels were then log transformed to base 10 in order to ensure normal distribution. To create the diurnal cortisol profiles for all target students on two days, we calculated *slopes* and *intercepts* using linear approximation for the four cortisol levels based on the timeline of the data collection according to Adam and Gunnar (2001; see also alternative measures by Pruessner, Kirschbaum, Meinlschmid, & Hellhammer, 2003). The majority of the cortisol profiles were based on four cortisol levels (as planned), 6.7% of the profiles were estimated using only three cortisol levels, and missing data were not imputed. For better interpretation of the intercepts (see Gelman & Hill, 2007), collection times were centered at the grand mean of all collection times and assigned to the cortisol levels for that time. Thus, intercepts in this study reflect the linearly approximated cortisol levels at 1:00 PM of the diurnal cortisol profiles, named *midday-intercept*. Whereas *midday-intercept* provides an indication of the profile's overall elevation and is highly correlated with the morning cortisol, the *slope* reflects the decrease of the cortisol curve describing the degree of down-regulation of the HPA axis' activity over the course of a day. Based on all cortisol data of the sample, Figure 1 displays the averaged diurnal cortisol profiles for Mondays and Fridays consisting of slopes and midday-intercepts.

Classroom climate

We made use of the First Grade Classroom Observation System (COS-1) to evaluate classroom climates (CASTL Center for Advanced Study of Teaching and Learning, 2002) after translating COS-1 into German and adjusting it to the German elementary school context. We maintained the 11 original seven-likert items representing three dimensions: (1) *Emotional support* (i.e., the teacher's sensitivity, his or her consideration of the students' perspective and his or her ability to encourage a favorable classroom atmosphere); (2) *Instructional support* (i.e., the teacher's capability to provide knowledge, to develop concepts and provide feedback and guidance); and (3) *Classroom organization* (i.e., the teacher's dexterous ability to introduce rules and expectations that

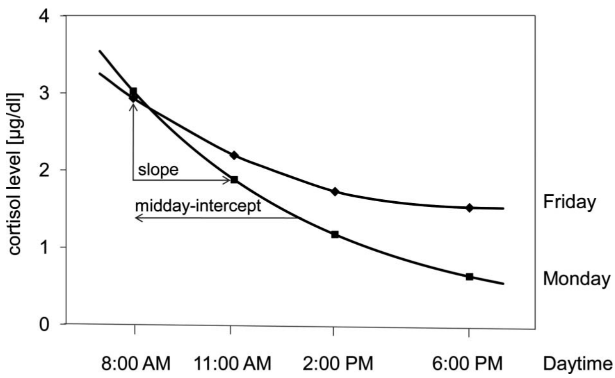

Figure 1. Mean cortisol levels over the course of a Monday and a Friday of the same week (N = 105).

encourage students to be productive). Cronbach's alpha of the three scales ranged between .88 and .93. Interrater reliability based on 25% of all observations and 11 raters who observed the same classroom at the same time, ranged between $r = .72$ to .78. Classrooms were observed for approximately three hours starting at the beginning of the school day which included academic instruction, particularly in German and mathematics lessons. We then subjected the three scales to a cluster analysis. A subsequent discriminant analyses confirmed two clusters (Wilks Lambda = .27; $p < .001$) dividing all three scales along the same line into a supportive and non-supportive part. Thus, supportive as opposed to non-supportive classroom climates received scores with $M = 6.1$ ($SD = 0.7$) vs. $M = 3.4$ ($SD = 0.8$) on emotional support, with $M = 5.8$ ($SD = 0.7$) vs. $M = 3.7$ ($SD = 1.1$) on instructional support, and with $M = 6.0$ ($SD = 0.8$) vs. $M = 3.5$ ($SD = 1.0$) on classroom organization. The majority of students (77.1%) experienced supportive classroom climates with teachers who were emotionally supportive and inspiring, whereas 22.9% of the students were exposed to non-supportive classroom climates.

Student–teacher relationships

In order to describe the relationship that the target student experienced with the teacher, teachers filled out the Student–Teacher Relationship Scale (Pianta, 2001) which provides three subscales. (1) *Closeness* measures the degree to which a teacher experiences affection, warmth, and open communication with a student. A teacher endorsing higher closeness scores senses that the student views the teacher as supportive and appreciates him or her as a resource. (2) *Dependency* describes the degree to which a teacher perceives a student as overly dependent and demonstrating overreliance on him or her, often requesting help when unnecessary. (3) *Conflict* measures the degree to which a teacher perceives a student as angry or unpredictable. In such cases, a teacher perceives the relationship as negative and conflictual, and consequently feels emotionally drained. After translation into German and administering them in German elementary schools, the subscales reached alphas similar to those of the original scales with *Closeness* and *Conflict* between .75 and .85. In contrast, *Dependency* appeared low with .51 confirming concerns from previous studies (e.g., Doumen, Verschueren, Buyse, De Munter, Max, & Moens, 2009). However, as Cortina (1993) noted, the number of items, and item inter-correlations need to be taken into account in order to understand alpha. As follows, if the five items on *Dependency* are inter-correlated with $r = .30$ to .50 (as it is the case here) an alpha of up to .45 should be expected. Furthermore, we examined the validity for the *Dependency* scale and revealed a negative correlation to students' overall motivation and self-motivation, $r = -.32$; which were measured using different methods by external observers while testing the student on school competencies, as well as by the teachers in obligatory final reports at the end of the semester (for more details for the entire STRS validation see Milatz, Harwardt, Schneiderwind, & Ahnert, 2010). For these reasons regarding reliability and validity, we did not exclude *Dependency* from further analyses.

Results

Patterns of student–teacher relationships

In order to describe complex patterns of relationships, we subjected all STRS data to a cluster analysis with a *k*-means algorithm based on squared Euclidean distance.

Four clusters emerged, differing significantly from each other as shown by a discriminant function, with Wilks Lambda ranging between .05 and .67 ($p < .001$). These clusters are seen as complex patterns of student–teacher relationships with or without secure base functions that are best described according the extent to which they incorporate the single scales closeness, dependency, and conflict. *Conflict* appeared as the leading scale describing *Conflict-Loaded* [CL] relationships between the students and their teachers. Low *dependency* portrayed *Distant-Independent* [DI] relationship patterns, and closeness was most prominent for *Proximal-Dependent* [PD] relationships. Finally, *Proximal-Balanced* [PB] student–teacher relationships displayed a balanced pattern of medium *Closeness* and *Dependency*, combined with low *Conflict* (see Table 1).

When associating the clusters with gender and classroom climate, *Proximal-Balanced* [PB] and *Proximal-Dependent* [PD] relationships were more prevalent in girls. Whereas *Distant-Independent* [DI] patterns were equally distributed with regard to gender, *Conflict-Loaded* [CL] patterns were most often observed in relationships of male students and their teachers, $Chi^2(3) = 11.14$, $p < .01$. Although relatively more *Proximal-Dependent* [PD] patterns seemed to be observed in non-supportive classrooms, the four types of patterns were found equally as often in supportive and non-supportive classrooms, $Chi^2(3) = 6.64$, *n.s.* (see Table 2). We then explored students' experiences in the classrooms in further detail and analyzed the underlying dimensions *Emotional support, Instructional support*, and *Classroom organization* separately (see Table 3). *Emotional support* appeared as the only characteristic which

Table 1. Means and standard deviations of the basic scales determining the patterns of student–teacher relationships ($N = 105$).

	Proximal-Balanced [PB] M (*SD*)	Proximal-Dependent [PD] M (*SD*)	Conflict-Loaded [CL] M (*SD*)	Distant-Independent [DI] M (*SD*)	Effects $F(3,104)$
Conflict	1.23 (.18)[a]	1.39 (.31)[a]	2.14 (.48)[b]	1.32 (.32)[a]	41.02***
Closeness	3.75 (.29)[c]	4.47 (.16)[d]	3.51 (.38)[c]	3.53 (.44)[c]	44.75***
Dependency	2.35 (.33)[e]	2.76 (.56)[f]	2.71 (.40)[f]	1.60 (.22)[g]	36.92***

Note: Means with the same subscripts did not differ. Means with different subscripts differed significantly with regards to *Conflict* or *Closeness* at $p < .001$; *t*s ranging between 6.51 and 11.54. For *Dependency, t-values* were significant with $p < .001$, except PB vs. PD/CL differed at $p < .01$; *t*s of 3.06 and 3.65.

Table 2. Patterns of student–teacher relationships ($N = 105$) in relation to gender and classroom climate.

	Proximal-Balanced [PB]	Proximal-Dependent [PD]	Conflict-Loaded [CL]	Distant-Independent [DI]	Overall
Gender [*n* (% of the sample)]					
Boys	7 (6.6%)	6 (5.7%)	25 (23.8%)	9 (8.6%)	47 (44.7%)
Girls	15 (14.3%)	19 (18.1%)	15 (14.3%)	9 (8.6%)	58 (55.3%)
Classroom climate [*n* (% of the sample)]					
Supportive	19 (18.1%)	15 (14.3%)	31 (29.5%)	16 (15.2%)	81 (77.1%)
Non-supportive	3 (2.9%)	10 (9.5%)	9 (8.6%)	2 (1.9%)	24 (22.9%)

Table 3. Means and standard deviations of classroom climate scales divided by relationship patterns.

	Proximal-Balanced [PB] M (*SD*)	Proximal-Dependent [PD] M (*SD*)	Conflict-Loaded [CL] M (*SD*)	Distant-Independent [DI] M (*SD*)	Effects F(3,104)
Emotional support	5.65 (1.20)	4.93 (1.56)[a]	5.43 (1.26)	6.06 (1.10)[b]	2.78*
Instructional support	5.42 (1.03)	4.94 (1.41)	5.34 (1.10)	5.90 (1.04)	2.43
Classroom organization	5.55 (1.19)	5.07 (1.58)	5.28 (1.39)	5.93 (0.88)	1.65

Note: $^*p < .05$. Means with different subscripts significantly differed at $p < .05$; $t(1,41) = 2.62$.

differentiated experiences of the classroom climate among the relationship patterns. Specifically, as compared to students in *Distant-Independent* [DI] relationships, students in *Proximal-Dependent* [PD] relationships experienced lower levels of emotional support in the classroom. Hence, more clingy students were more likely to be in classrooms characterized by less emotional (but not instructional) support.

Preliminary test on the semi-nested design structure

Due to the semi-nested structure of the sample with a common cluster size of 1.46, we computed intra-class correlations to evaluate design effects based on the four independent variables (slopes and intercepts for Mondays and Fridays) to be used for further statistical analyses. We followed Muthén and Satorra's (1995) advice that large intra-class correlations might point to a large deviation from the assumption of independence between observations which in turn leads to distortions of conventional statistical procedures. Even though some of the intra-class correlations appeared large ($ICC_{\text{Monday-slope}} = .05$; $ICC_{\text{Friday-slope}} = .29$; $ICC_{\text{Monday-intercept}} = .47$; $ICC_{\text{Friday-intercept}} = .002$), design effects only varied between 1.0 and 1.2 allowing for conventional inference statistics.

Day of week and classroom climate

To answer the question as to what extent classroom climates impact on students' stress regulation, all *slopes* and *intercepts* of the individual cortisol profiles were submitted to a Repeated Measurement ANOVA (factor: supportive/non-supportive classrooms). There was a repetition effect on the *slopes* with $F(1,103) = 3.68$; $p < .05$, but not on the *intercepts*. Thus, cortisol profiles from Fridays appeared flatter than on Mondays (see Table 4; for better understanding of the meaning of slope and intercept see Figure 1). Furthermore, classroom climates clearly had significant effects on the slopes, $F(1,103) = 8.15$, $p < .01$ (but not on the intercepts). That is, in students' response to non-supportive classrooms the cortisol profiles displayed smaller slopes, so that the decrease in their cortisol levels over a day was slower than cortisol decrease for students in supportive classrooms. In other words, students in non-supportive as compared to supportive classrooms had flatter cortisol profiles, suggesting that classrooms of low quality hindered sufficient down-regulation of morning cortisol levels at both the beginning and the end of a week in school.

Table 4. Slopes and midday-intercepts of the diurnal cortisol profiles on Monday and Friday as a function of classroom climate.

	Classroom Climate						
	supportive ($n = 81$)		non-supportive ($n = 24$)				
	Monday	Friday	Monday	Friday	Effects; $F(1,103)$		
	M (*SD*)	M (*SD*)	M (*SD*)	M (*SD*)	Days	Quality	Days × Quality
Slope	−.08 (.36)	−.07 (.27)	−.06 (.38)	−.05 (.31)	3.68*	8.15**	.03
Midday-intercept	.63 (.18)	.61 (.15)	.66 (.15)	.67 (.20)	.02	1.77	.57

Note: *$p < .05$; **$p < .01$.

The impact of individual student–teacher relationships: advances and compensatory effects

To test whether different relationships that students and teachers had formed by the end of the first semester affect students' cortisol regulation, we carried out separate Repeated Measurement ANOVAs using *slopes* and *intercepts* of the individual cortisol profiles as dependent variables (factor: relationships; i.e. *Proximal-Balanced* [PB], *Proximal-Dependent* [PD], *Conflict-Loaded* [CL], and *Distant-Independent* [DI] patterns). We first confirmed the repetition effect for the days, revealing that *slopes* varied significantly from Monday to Friday; $F(1,101) = 4.75$; $p < .05$, with smaller slopes for the cortisol profiles on Fridays. Most interestingly, as shown in Figure 2, there was a main effect of relationship patterns on *slopes*, suggesting greater slopes for *Proximal-Balanced* [PB] patterns in comparison to *Proximal-Dependent* [PD] or *Conflict-Loaded* [CL] relationship patterns; $F(3,101) = 3.70$; $p < .01$. Students experiencing proximal-balanced relationships [PB] with their teacher were thus overall more capable of lowering cortisol levels over the course of a day than the rest of the students. The interaction effect, $F(3,101) = 5.10$; $p < .001$, furthermore revealed that the [PB] group did not even differ in the slopes between Monday and Friday, whereas all other groups did. Students exposed to conflict relationships with their teachers [CL] especially failed to significantly down-regulate cortisol levels on Friday as compared to Monday. That is, post-hoc univariate analyses testing differences in slopes between Mondays and Fridays showed significant differences only for the *Conflict-Loaded* [CL] patterns; $t(1,78) = 1.83$; $p < .05$.

To explore how *intercepts* of the cortisol profiles are affected by relationship patterns, a Repeated Measurement ANOVA revealed no main effects, only an interaction effect between Day × Relationship Patterns; $F(3,101) = 3.01$; $p < .05$. Post-hoc univariate analyses yielded one significant change from Monday to Friday within the *Proximal-Balanced* [PB] patterns; $t(1,42) = 1.95$; $p < .05$ (see Figure 2). In detail, students who had proximal-balanced relationships with their teachers had lower cortisol levels on Friday than on Monday mornings. This suggests that the [PB] group had lost its high morning cortisol levels on Monday, which, on Friday, appeared to be at a similar level to those of the other students.

Based on the assumption that supportive classrooms might compensate the impact of low quality student–teacher relationships on students' stress regulation, we repeated the entire statistical analyses with classroom climate as an additional factor.

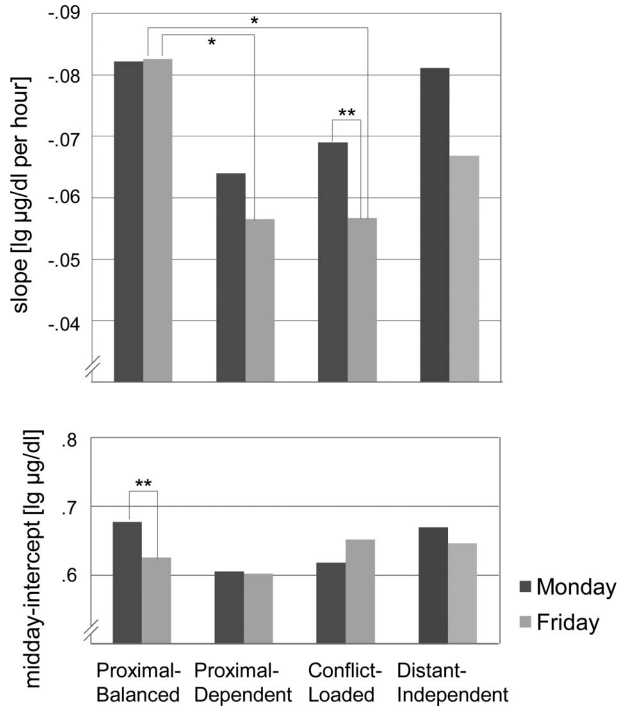

Figure 2. Slopes and intercepts of students' cortisol profiles on Mondays and Fridays in relation to patterns of student–teacher relationships.
Note: *$p < .05$; ** $p < .01$.

However, we did not find any further explanations for the variance. For example, no interaction effect was found to justify assumed compensation or exacerbating effects. Instead, we confirmed the impact of classroom climate, $F(1,97) = 3.52$, $p < .10$, as well as that of relationship patterns, $F(3,97) = 3.10$; $p < .05$), on students' diurnal cortisol profiles, as two main effects on students' stress regulation.

Discussion

To provide greater insight into the adaptation to school and the potential which lies in the emerging student–teacher relationships in elementary school, the present paper links students' stress neurobiology to student–teacher relationships on both the classroom and individual interaction levels. Thereby, evaluation of salivary cortisol has especially provided a great deal of information on individual adjustment and stress management. Whereas changes in cortisol levels sometimes make it difficult to evaluate the HPA axis activities, the present paper dealt with diurnal cortisol profiles, analyzing slopes and intercepts of the curves. We relied on previous studies which have argued that truncated down-regulation of the HPA axis over the day might reflect chronic activation pointing to imbalanced stress regulation. Low early morning levels (low intercepts) often remain low throughout the day, causing flat cortisol profiles (low slopes) and attentional, behavioral, and health-related problems (Adam & Gunnar, 2001; Caplan et al., 1979; Fries et al., 2005; Gunnar & Quevedo, 2007; Gunnar & Vazquez, 2001; Heim et al., 2000; Kudielka et al., 2007; Pruessner et al., 1999).

The present study related the diurnal cortisol profiles of the students to the quality of relationships with their head teachers, and based the relationship measures on classroom and individual interaction levels. We hypothesized that poor student–teacher relationships, bad classroom climates, and cortisol obtained at the end of a week in school (on Fridays) would be associated with students' stress management, and tested whether the three environmental conditions would exacerbate or compensate the effects of each other, depending on their combinations. In clustering the singular relationship dimensions closeness, conflict, and dependency (from STRS; Pianta, 2001) we described four patterns of student–teacher relationships, i.e. *Proximal-Balanced* [PB], *Proximal-Dependent* [PD], *Conflict-Loaded* [CL], and *Distant-Independent* [DI]. Interestingly, these patterns revealed similarities with children's attachments described by Ainsworth, Blehar, Waters, and Wall (1978) and Main and Solomon (1990). From this perspective, only the [PB] pattern could be interpreted as a type of "secure" relationship with closeness as a salient characteristic, whereas the rest reflect rather "insecure" relationships, either ambivalent [PD], distant [DI], or conflictual [CL] in nature. The [PD] group showed similarities to the insecure-ambivalent children in the Ainsworth-Attachment System who seek closeness with their parents but in a clingy-angry manner. In contrast, [DI] students were characterized by low closeness and dependency but also by low conflict, as if these students did not want to be involved in the classrooms in any way at all. In the [CL] group, however, high conflict was associated with high dependency bearing the potential to lead to continued struggles within these relationships. Not surprisingly, the [CL] as well as the [PD] groups appeared to be most under stress.

In general, 77% of the classrooms appeared "supportive" due to teachers' effort in shaping the interpersonal climate. Moreover, classroom interactions were related to individual student–teacher relationships. Specifically, students with *proximal-dependent* relationships were more likely to be in classrooms characterized by less emotional (but not instructional) support, compared to students with *distant-independent* relationships. Additionally, the *conflict-loaded* relationships were over-represented among boys compared to girls. This is in line with previous research showing higher levels of conflict for boys than for girls (e.g., Pianta, 2001).

Results were quite straightforward when students' diurnal cortisol profiles were analyzed. In comparing students' profiles on a Monday and a Friday of the same week, the Friday profile had generally changed into a flattened curve (a smaller slope) indicating the typical transformation from regular stress management to a strained one. Moreover, students in non-supportive classrooms showed flatter cortisol profiles during the day, suggesting that classrooms of low quality hindered sufficient down-regulation of cortisol levels. These results confirm findings from NICHD Early Childcare Network (2002) demonstrating that students' engagement in negative behaviors with teachers and peers was higher when classrooms provided less instructional and emotional support. Together, these behavioral as well as the neurobiological findings contribute to our understanding of students' early classroom experiences and how important it is to provide positive climates.

Individual student–teacher relationships are also of importance. In principal, students in *proximal-balanced* relationships exceeded all other students, due to stable large slopes of the Monday as well as Friday profiles. The superior high intercepts on Mondays, however, dropped down on Friday, yet equally to the stress regulation of the companions. On Friday, students from the [PD], [CL], and [DI] groups mostly showed smaller slopes than the *proximal-balanced* group. Especially students in the *conflict-loaded* group reflected lower stress regulation over the course of the week by their flattened profiles from Monday to Friday. These results are in line with earlier behavioral research, demonstrating that dependency and conflict in student–teacher relationships hinder successful school adjustment, whereas closeness enhances it (Birch & Ladd, 1997; Hamre & Pianta, 2001, 2005; Lisonbee at al., 2008). However, through the analyses of the present cortisol profiles it became obvious that closeness in combination with dependency negatively influences the students, at least with regard to stress regulation. This might explain why past research dealing with closeness as a single dimension resulted in weak or controversial associations between closeness and children's positive outcomes (see for example Pianta & Stuhlman, 2004).

However, there are also limitations of the present study. (1) The study took place in high quality schools with professional teachers and involved students from middle-class and advantaged family backgrounds. Thus, it remains unclear as to how strong the impact of classroom climate and student–teacher relationships would be if there was an additional risk sample. (2) For reasons of parsimony, cortisol profiles were only available for Monday and Friday to reflect the course of a whole week. It would have been more reliable to have collected saliva samples on further occasions during the week. (3) Classroom climate also needed to take into consideration students' peers, especially when peer interactions became more and more established through the school experiences of the consecutive semesters. (4) Finally, to shed more light onto the consequences of student–teacher relationship patterns, more information needs to be gathered about students' school engagement, motivation to achieve, and enjoyment from learning.

Despite having room for further improvements, however, the present study demonstrated how critical students' relationships with their teachers can be with regard to their stress management. We are of the opinion that in this paper, which focuses on daily cortisol profiles rather than on single cortisol levels, clustering different dimensions for student–teacher relationships was certainly beneficial. Because activities of HPA axes are part of and related to a very complex organism it was advantageous to systematically link the stress regulation to complex behavioral units as seen in the different types of student–teacher relationship patterns. To the best of our knowledge, this paper provides first evidence linking stress patterns to first grade experiences, thereby contributing to research on relationship-environment interactions in school contexts from a neurobiological perspective.

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