Health Psychology
2008, Vol. 27, No. 3, 358–368


0278-6133/08/$12.00 DOI: 10.1037/0278-6133.27.3.358

# Self-Efficacy As a Health-Protective Resource in Teachers? A Biopsychological Approach

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***Objective***: To examine the psychobiological correlates of self-efficacy in teachers. ***Design***: Study 1 examined associations between teacher self-efficacy and cardiac activation on a working day and Study 2 assessed the cortisol morning response in teachers with varying levels of teacher self-efficacy. ***Main outcome measures***: Teacher self-efficacy was assessed by questionnaire. In Study 1 heart rate, heart rate variability, and locomotor activity were recorded by 22 hours ambulatory monitoring and subjective measures of stress and strain were obtained. Study 2 assessed the cortisol response to awakening to obtain a measure of HPA-axis activation and teachers filled in a questionnaire on physical complaints. ***Results and Conclusion***: Study 1 found that self-efficacy proved protective for psychological well-being. Moreover, after controlling for locomotor activity, demographic, and lifestyle variables, self-efficacy was associated with elevated heart rate and attenuated heart rate variability during school and leisure time, respectively, but not during the night, thus questioning the health-implications of self-efficacy. Study 2 found that teachers high in self-efficacy exhibited an attenuated cortisol response to awakening and fewer cardiac complaints. The results of both studies are compatible with the view that teacher self-efficacy might act as a physiological toughening agent with possibly favorable health outcomes.

*Keywords:* ambulatory monitoring, burnout, cortisol response to awakening, cardiac activation, teacher self-efficacy



School teachers are faced with a variety of stressors during their everyday work (e.g., noise in the classroom, difficulties with pupils and their parents, additional administrative work, etc.) leading to substantial chronic stress (e.g., Guglielmi & Tatrow, 1998). Correspondingly, research has identified high rates of psychological (e.g., depression, burnout) and physical symptoms (e.g., cardiovascular diseases) among school teachers, thus affecting the learning environment and interfering with the achievement of educational goals (Bandura, 1997; Guglielmi & Tatrow, 1998).

Accordingly, there is a strong interest to identify factors that could prevent stress and health problems in teachers. Among them, self-efficacy (*SE*) has been discussed as a powerful resource in teachers protecting them from psychological strain (e.g., Bandura, 1997; Schmitz & Schwarzer, 2000). The construct of *SE* was introduced by Albert Bandura (1977, 1997) and refers to expectations of competence and control over the execution of behavioral tasks. When *SE* for a particular behavioral task is high, the individual is more likely to engage successfully in it. It has to be emphasized that *SE* cannot be considered as a cross-situational stable characteristic (i.e., trait) of an individual. Instead, it should be assessed specifically for the domain of interest. Hence, the job-related *SE* in teachers should be assessed as the subjective confidence to master the demands typically made on teachers. Accordingly, a teacher with high teacher *SE* should be less prone to stress and strain on the job because he/she is confident to perform successfully.

The stress-protective role of *SE* should result in attenuated physiological stress responses. Correspondingly, Bandura proposed that *SE* might exert a dampening effect on physiological arousal because of attenuated threat-appraisals (Bandura, 1997). Subsequent research, however, has revealed a far more complex picture of the physiological consequences of *SE* (e.g., Gerin, Litt, Deich, & Pickering, 1995, 1996; Hilmert, Christenfeld, & Kulik, 2002; Sanz & Villamarín, 2001; Sanz, Villamarín, & Alvarez, 2006). Associations depend on the type of physiological variable (heart rate, systolic or diastolic blood pressure, pulse pressure, skin temperature), the type of challenge (whether the outcome is fixed or unfixed, amount of control), the incentives applied during the task, and the status of the audience in front of whom the task should be performed (experts or novices).

Although research generally favors the view that—at least under specific experimental conditions—high *SE* is related to reduced physiological responsiveness, there are also studies reporting higher cardiovascular reactivity in individuals high in *SE*. Gerin et al. (1996), for example, found that *SE* was associated with increased blood pressure in a video game task where effort was left unconstrained. The authors argue that *SE* appears to decrease cardiovascular response when effort of responding is held constant, but it increases response when effort covaries. In line with this reasoning, for a task or challenge in which control is possible, individuals with higher *SE* will make more of an effort than those with a lesser degree of *SE*, with correspondingly greater increases in physiological reactivity. Indeed, psychophysiological research

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has consistently shown that effort allocation and task-engagement are associated with elevated levels of cardiovascular reactivity (e.g., Fowles, 1988; Gendolla & Richter, 2005; Lovallo et al., 1985; Schwerdtfeger, 2004; Wright & Kriby, 2001). Thus, when effort is left unconstrained, *SE* might lead to higher cardiovascular responses because of enhanced effort allocation or elevated levels of motivational approach.

While the physiological concomitants of *SE* have been studied predominantly in the laboratory, there is a lack of knowledge about how physiological functioning is related to *SE* in everyday life. Therefore we conducted two studies. In the first study we aimed at demonstrating associations between *SE* and cardiac functioning among school teachers throughout a working day. Probably most of the situations individuals face in their daily lives are unfixed, that is, the effort of responding is left uncontrolled. Hence, we would predict that *SE* on the job should be associated with higher cardiac activation. Moreover, due to its presumed protective role in psychological strain, *SE* should be negatively associated with burnout and negative affect, respectively, and positively associated with positive affect during work. To test these assumptions, a 22 hours ambulatory monitoring study was conducted with school teachers during a typical school day. We focused on the recording of heart rate (HR) and heart rate variability (HRV; by means of the root mean square of successive inter-beat-interval differences, RMSSD) as these variables can reliably be obtained in ambulatory settings and constitute a rather unobtrusive approach for the assessment of autonomic nervous system activity in daily life. Specifically, HRV can be regarded as an index of parasympathetic control of the heart with higher values indicating attenuated risk for CVD (Goldberger, Challapalli, Tung, Parker, & Kadish, 2000; Task Force Guidelines, 1996). Additionally, we recorded locomotor activity by means of accelerosensors, because physical activity is closely related to cardiac activation due to metabolic demands of the body.

# Study 1

## *Method*

### *Participants*

Fifty-eight school teachers (8 males) volunteered to participate in the study. They taught at 7 elementary schools and 2 elementary plus secondary schools; their mean age was 43.21 years ($SD$ = 11.44, range: 26–60) and the mean year of employment (seniority) was 17.15 years ($SD$ = 12.95). Age and seniority were highly correlated within this sample ($r$ = .91, $p$ < .01). The mean body mass index (BMI) was 24.03 kg/m$^2$ ($SD$ = 3.81), 67% reported regular exercise and 13% of the sample were smokers. Mean consumption of caffeine was 2.48 beverages per day ($SD$ = 2.02). Teachers did not receive monetary compensation for participating in this study.

### *General Procedure*

Prior to participation, teachers were contacted through their principals and received information on the procedure and the technical equipment. They were told that a 22-hr ambulatory monitoring study about stress and strain in daily life would be performed. After obtaining informed consent, an appointment was made with each teacher for ambulatory monitoring on a "typical school day". Upon the participants' arrival at the school, the transducers were attached and the participants were given instructions on the general procedure. Specifically, they were requested to fill in the state questionnaires of stress and affect after school and leisure time, respectively, as well as the teacher *SE* scale and the Maslach Burnout Inventory (MBI). They were also instructed to detach the electrodes the next morning after awakening and to return the equipment to their schools. On account of the sensitive technical equipment participants were not allowed to engage in intense aerobic training, bathing or showering during recording time.

### *Questionnaire Measures*

*Teacher SE.* For assessing teacher *SE* the German teacher self-efficacy scale by Schmitz and Schwarzer (2000) was applied. The scale comprises 10 items assessing teacher *SE* in four domains that appear to be of vital importance for successful teaching: (a) job accomplishment (i.e., "When I try really hard, I am able to reach even the most difficult students"), (b) skill development on the job (i.e., "I am convinced that, as time goes by, I will continue to become more and more capable of helping to address my students' needs"), (c) social interaction with students, parents, and colleagues (i.e., "I know that I can maintain a positive relationship with parents even when tensions arise"), and (d) coping with job stress (i.e., "I am convinced that I can develop creative ways to cope with system constraints (such as budget cuts and other administrative problems) and continue to teach well"). Items are rated on a 4-point Likert scale (1 = not at all true, 4 = exactly true). The scale has proven valid and reliable in previous research projects (Schmitz & Schwarzer, 2000). The reliability for the present sample proved satisfactory and in accordance with other findings (Cronbach's alpha = .78).

*Burnout.* The slightly modified German version of the MBI by Enzman and Kleiber (1989) was applied. Instead of a 7-point scale, the current version had a 4-point response option format (1 = not at all true, 4 = exactly true) as suggested by Schwarzer and Jerusalem (1999). Internal consistency of this scale was good (Cronbach's alpha for the total scale: .88). Internal consistencies of the subscales were lower (.83 for EE, .76 for LA, and .61 for DP) and in accordance with former studies (Maslach, Jackson, & Leiter, 1996). For reasons of parsimony we focus on the total burnout score in this paper.

*Affect and perceived stress.* For assessing positive affect (PA) and negative affect (NA) during both school and leisure time, the German version of the positive and negative affect schedule (PANAS; Krohne, Egloff, Kohlmann, & Tausch, 1996) was applied. The reliability of this scale was good. For school time, Cronbach's alpha was .88 for PA and .77 for NA, and for leisure time it was .87 for PA and .85 for NA. Moreover, a visual analog scale for assessing perceived stress during school and leisure time was applied (0 = no stress at all, 100 = extremely stressful).

In addition, demographic (age, seniority, BMI) and lifestyle variables (smoking status, caffeine consumption, exercise frequency) were obtained via a self-constructed questionnaire, since these variables have been found to influence cardiac function (Kuch et al., 2001; Tsuji et al., 1996).

### Physiological Measures

*HR and RMSSD.* The VARIOPORT-b (Becker Meditec, Karlsruhe, Germany) was used for physiological data recording. HR was recorded by means of an electrocardiogram (ECG) by applying a chest lead and participants were grounded on the right collar bone. The ECG signal was scanned with 512 Hz and sampled with 256 Hz on a memory card.

*Locomotor activity.* Locomotor activity was recorded by means of a three-dimensional accelerosensor (Becker Meditec, Karlsruhe, Germany). The sensor is sensitive in three dimensions and has a sensitivity of 0.2 milli Gs. It was attached on the left thigh (above the knee) and the signal was sampled at 32 Hz and stored on a memory card for further offline-processing.

### Data Reduction and Analysis

The ECG was analyzed by means of a semiautomatic peak detection software (written with LABVIEW 6.0i). The ECG of each participant was visually inspected on a minute-by-minute basis and low-pass filtered with 30 Hz to overcome gross movement artifacts. Interbeat intervals (IBIs) were calculated in milliseconds for each minute. Extraordinarily strong successive IBI variations were corrected when necessary by a moving average procedure if they differed by more than a multiplier of 1.5 or 0.7 from the preceding IBI. Minutes with more than 5 erroneous IBIs were discarded. HR for each minute was calculated by dividing 60,000 through the respective interbeat-intervals (IBI). Additionally, HRV was calculated as the square root of the mean of the sum of the squares of differences between successive IBIs (RMSSD) to obtain a time-domain measure of parasympathetic control of the heart (Goldberger et al., 2000; Penttilä et al., 2001; Task Force Guidelines, 1996). Higher RMSSD values indicate stronger parasympathetic outflow to the heart. Due to the skewed distribution of this variable it was log-transformed prior to analysis (ln ms). Locomotor activity was quantified by integrating each of the three axes of the accelerosensor and calculating the mean across axes. Prior to integration the signal was detrended by subtracting the DC-component from the AC-component. Integrals were subsequently square root transformed.

The general rationale of this study was to calculate associations between teacher *SE* and psychophysiological measures of stress and strain during three distinct phases of the day: School time, leisure time, and the night. Therefore, we decided to use three comparable time intervals of four hours each. School time was the time between 8:30 a.m. and 12:30 p.m. Leisure time was defined as the time between 5.00 p.m. and 9:00 p.m. and night time by our definition was between 1:00 a.m. and 5:00 a.m. We are aware that our definition of leisure time with a specific time frame is arbitrary, since the activities of our participants might have included work-related activities like preparing for the next school day. Indeed, 52% of the sample reported preparatory activities during this time interval. Nonetheless, this time frame seemed to represent the best choice, since some of the participants taught at all-day schools with teaching activities until 4:00 p.m. HR, RMSSD, and physical activity data were aggregated throughout these time intervals to reveal averages for school, leisure time, and the night.

Unfortunately, not all of the 58 participants could be included in data analyses. Six individuals were excluded, because they had not been involved in lecturing for at least three hours in the time interval between 8:30 a.m. and 12.30 p.m. Furthermore, 4 individuals showed marked recording artifacts in their ECG, making it impossible to analyze these data with sufficient accuracy. Another four participants had to be excluded because they received heart medication as revealed by a questionnaire. Thus, a total of 44 individuals (6 men) could be entered in data analyses.

We applied several *t* tests to examine differences in stress and strain between school and leisure time. Moreover, Pearson-correlations were calculated to examine associations between psychological and physiological variables. Finally, a number of hierarchical linear regression models was computed to test whether teacher *SE* was a significant predictor of physiological activation for school, leisure time, and the night. The alpha-level for all comparisons was fixed at $p < .05$ (two-tailed).

## Results

### Participants Characteristics

With regard to a number of psychological, demographic, and lifestyle measures, the sample of the 44 individuals meeting the requirement for this study was compared with the 14 individuals who had to be excluded. The latter were of higher seniority [$M$ = 28.86, $SD$ = 8.92 versus $M$ = 13.34, $SD$ = 11.76; $t(56) = 4.52$, $p < .01$] and had a higher BMI [$M$ = 27.59, $SD$ = 4.12 versus $M$ = 22.91, $SD$ = 2.97; $t(56) = 3.90$; $p < .01$] than the study participants. However, both groups did not differ with respect to smoking status ($\chi^2 = .00$, *ns*), regular exercise ($\chi^2 = .07$, *ns*), and caffeine consumption [$t(56) = .04$, *ns*]. There were also no group differences in teacher *SE*, burnout, PA, NA, and stress rating (all $p$s $> .09$).

### Preliminary Analyses

Descriptive statistics were computed to evaluate the plausibility of the data. The mean score on the MBI was rather low ($M$ = 1.67, $SD$ = .37, $Min$ = 1.19, $Max$ = 2.67) and the mean score on the teacher *SE* scale was 3.00 ($SD$ = .43, $Min$ = 1.90, $Max$ = 3.90), indicating that our sample of teachers exhibited rather low scores on burnout (a maximum of 2.67 on a 4-point scale) and rather intermediate scores on *SE*.

We calculated several *t* tests for dependent measures to examine mean differences in psychological and physiological variables of stress and strain between school and leisure time. These analyses generally suggested higher activation during school as compared to leisure time. In short, perceived stress [$t(43) = 4.00$, $p < .01$] and PA [$t(43) = 3.71$, $p < .01$] was higher during school as compared to leisure time (school time perceived stress: $M$ = 43.41, $SD$ = 24.21; leisure time perceived stress: $M$ = 27.05, $SD$ = 22.80; school time PA: $M$ = 3.26, $SD$ = 0.60; leisure time PA: $M$ = 2.84, $SD$ = 0.66). The same applied for both HR [$t(43)$ = 2.41, $p < .05$] and locomotor activity [$t(43) = 4.88$, $p < .01$] (school time HR: $M$ = 85.93, $SD$ = 8.97; leisure time HR: $M$ = 82.47, $SD$ = 9.86; school time locomotor activity: $M$ = 608.22, $SD$ = 111.19; leisure time locomotor activity: $M$ = 493.29, $SD$ = 135.55). However, there were no significant differences in RMSSD and in NA between school and leisure time, respectively [RMSSD: $t(43) = .55$, $p = .58$; NA: $t(43) = 1.61$, $p = .12$] (school time RMSSD: $M = 3.42$, $SD = 0.43$; leisure time RMSSD: $M = 3.40$, $SD = 0.49$; school time NA: $M = 1.48$, $SD = 0.39$; leisure time NA: $M = 1.59$, $SD = 0.44$). Finally, PA was more pronounced than NA during school [$t(43) = 14.03$, $p < .01$] and leisure time [$t(43) = 10.19$, $p < .01$], respectively.

### *Correlations Among Psychological Measures of Stress and Strain*

Next, correlations were calculated among the psychological variables. Teacher *SE* and burnout were strongly negatively interrelated ($r = -.77$, $p < .001$). Moreover, although teacher *SE* was not significantly related to perceived stress during both school ($r = -.23$, $p = .14$) and leisure time ($r = -.17$, $p = .27$), it was significantly positively related to PA during school ($r = .61$, $p < .001$) and negatively related to NA during school ($r = -.38$, $p < .05$). The correlation between burnout and perceived stress during school approached statistical significance ($r = .29$, $p = .059$) and there was no significant association for leisure time ($r = .10$, $p = .51$). However, burnout was negatively associated with PA during both school ($r = -.56$, $p < .01$) and leisure time ($r = -.35$, $p < .05$), and positively associated with NA during school ($r = .35$, $p < .05$). The correlation between burnout and NA during leisure time was not significant ($r = .14$, $p = .37$).

### *Associations Between SE and Physiological Measures of Stress and Strain*

Pearson correlations between teacher *SE* and physiological variables (HR, RMSSD, and locomotor activity) were calculated separately for school time and leisure time. For school time teacher *SE* was significantly positively associated with HR ($r = .37$, $p < .05$) and negatively with RMSSD ($r = -.34$ $p < .05$). There was no significant association between *SE* and locomotor activity ($r = -.07$, $p = .67$). For leisure time there were no significant associations with teacher *SE* [$r = .18$ ($p = .26$) for HR; $r = -.09$ ($p = .55$) for RMSSD; $r = -.16$ ($p = .29$) for locomotor activity]. Additionally, we calculated the correlation between teacher *SE* and cardiac activation for night time. *SE* was not significantly associated with HR ($r = -.01$, $p = .93$), RMSSD ($r = .03$, $p = .83$), and locomotor activity ($r = -.22$, $p = .16$).

### *Stepwise Hierarchical Regression Models to Predict HR and RMSSD*

Next, we were interested to examine associations between teacher *SE* and HR and RMSSD, respectively, while controlling for locomotor activity and other relevant demographic and lifestyle variables. Therefore, we calculated three stepwise hierarchical regression models (for school, leisure time, and the night) for each physiological outcome variable (a total of 6 regressions). Locomotor activity was entered on step 1, demographic variables (gender, seniority, and BMI) were entered on step 2, lifestyle variables (smoking status, caffeine intake, and frequency of regular exercise) were entered on step 3, and finally teacher *SE* was entered on step 4. The results of these analyses are presented in Tables 1 and 2.

*HR.* The regression model for the prediction of HR during school was marginally significant [$F(8, 34) = 2.16$, $p = .056$, $R^2 = .33$]. Teacher *SE* was the only significant predictor ($\beta = .46$, $p < .01$), accounting for 18% of the variance. For leisure time, the regression model was significant [$F(8, 34) = 3.65$, $p < .01$, $R^2 = .47$]. Locomotor activity was positively associated with HR ($\beta = .48$, $p < .01$), accounting for 23% of the variance. Moreover, exercise frequency tended to be negatively associated with HR and, again, teacher *SE* was a positive predictor of HR ($\beta = .35$, $p < .05$), accounting for 11% of the variance. For the night, the regression model failed to reach statistical significance [$F(8, 34) = 1.40$, $p = .23$, $R^2 = .25$]. The only significant predictor was exercise frequency which was negatively associated with HR ($\beta = -.33$, $p < .05$).

*RMSSD.* The regression model for the prediction of RMSSD during school was significant [$F(8, 34) = 2.27$, $p < .05$, $R^2 = .35$]. Seniority was negatively associated with RMSSD ($\beta = -.32$, $p < .05$) and teacher *SE* was a highly significant negative predictor of RMSSD ($\beta = -.44$, $p < .01$), accounting for 17% of the variance. The regression model for the prediction of RMSSD during leisure time was significant, too [$F(8, 34) = 3.60$, $p < .01$; $R^2 = .46$]. Again, higher seniority was associated with attenuated RMSSD ($\beta = -.38$, $p < .01$). Moreover, BMI was negatively associated with RMSSD ($\beta = -.30$, $p < .05$), exercise frequency tended to be positively related to RMSSD ($\beta = .29$, $p < .10$), and teacher *SE* was a significant negative predictor ($\beta = -.29$, $p < .05$). The regression model for the prediction of RMSSD during the night was also significant [$F(8, 34) = 4.36$, $p < .01$], accounting for 51% of the variance. The only significant predictors were seniority ($\beta = -.59$, $p < .01$) and exercise frequency ($\beta = .33$, $p < .05$). There was no significant association between RMSSD and teacher *SE* for night time.

Table 1
*Results of Three Stepwise Hierarchical Regressions of HR on Physical Activity, Demographic Variables, Lifestyle Variables and Teacher Self-Efficacy (SE) During School Time, Leisure Time and the Night*

| | $\beta$ | | |
|---|---|---|---|
| Predictor/HR (BPM) | School time[a] | Leisure time[b] | Night[c] |
| Step 1: Locomotor activity | .04 | .48** | −.17 |
| Step 2: Demographic variables | | | |
| Gender (0 = female, 1 = male) | −.08 | −.18 | −.24 |
| Seniority | −.25 | −.12 | .07 |
| BMI | −.17 | .06 | −.03 |
| Step 3: Lifestyle variables | | | |
| Smoking status (0 = non-smoker, 1 = smoker) | .00 | .07 | .15 |
| Caffeine intake (beverages/day) | −.15 | −.10 | −.21 |
| exercise frequency | −.18 | −.29† | −.33* |
| Step 4: Teacher *SE* | .46** | .35* | .00 |

*Note.* $n = 44$.
[a] $R^2 = .00$, n.s. for Step 1; $\Delta R^2 = .11$, n.s. for Step 2; $\Delta R^2 = .04$, n.s. for Step 3; $\Delta R^2 = .18$, p < .01 for Step 4.
[b] $R^2 = .23$, p < .01 for Step 1; $\Delta R^2 = .04$, n.s. for Step 2; $\Delta R^2 = .09$, n.s. for Step 3; $\Delta R^2 = .11$, p < .05 for Step 4.
[c] $R^2 = .03$, n.s. for Step 1; $\Delta R^2 = .06$, n.s. for Step 2; $\Delta R^2 = .16$, p < .10 for Step 3 $\Delta R^2 = .00$, n.s. for Step 4.
† $p < .1$. * $p < .05$. ** $p < .01$.

Table 2
*Results of Three Stepwise Hierarchical Regressions of RMSSD on Physical Activity, Demographic Variables, Lifestyle Variables and Teacher Self-Efficacy (SE) During School Time, Leisure Time and the Night*

| | β | | |
|---|---|---|---|
| Predictor/RMSSD (In ms) | School time[a] | Leisure time[b] | Night[c] |
| Step 1: Locomotor activity | .09 | −.14 | .17 |
| Step 2: Demographic variables | | | |
| Gender (0 = female, 1 = male) | .13 | .15 | .01 |
| Seniority | −.32* | −.38** | −.59** |
| BMI | −.16 | −.30* | −.07 |
| Step 3: Lifestyle variables | | | |
| Smoking status (0 = non-smoker, 1 = smoker) | −.04 | −.04 | −.10 |
| Caffeine intake (beverages/day) | .12 | .13 | .09 |
| exercise frequency | .09 | .29† | .33* |
| Step 4: Teacher *SE* | −.44** | −.29* | −.07 |

*Note.* $n = 44$.
[a] $R^2 = .01$, n.s. for Step 1; $\Delta R^2 = .15$, $p < .10$ for Step 2; $\Delta R^2 = .02$, n.s. for Step 3; $\Delta R^2 = .17$, $p < .05$ for Step 4.
[b] $R^2 = .02$, n.s. for Step 1; $\Delta R^2 = .28$, $p < .01$ for Step 2; $\Delta R^2 = .09$, n.s. for Step 3; $\Delta R^2 = .07$, $p < .05$ for Step 4.
[c] $R^2 = .03$, n.s. for Step 1; $\Delta R^2 = .35$, $p < .01$ for Step 2; $\Delta R^2 = .12$, $p < .05$ for Step 3 $\Delta R^2 = .00$, n.s. for Step 4.
†$p < .1$. *$p < .05$. **$p < .01$.

### Additional Analyses

We were further interested to examine whether teachers who reported work-related activities during leisure time exhibited higher HR and attenuated RMSSD during this time frame when compared with teachers who did not report work-related activities. *T* test revealed no significant differences between the groups [for HR: $t(42) = .89$, $p = .38$; for RMSSD: $t(42) = .17$, $p = .87$]. Moreover, there was no group difference with respect to teacher SE ($t(42) = 1.13$, $p = .26$], PA during leisure time [$t(42) = 1.67$, $p = .10$], NA during leisure time [$t(42) = .23$, $p = .82$], and burnout [$t(42) = 1.06$, $p = .30$]. However, there was a significant difference in stress rating. Teachers with work-related activities during leisure time showed higher stress rating ($M = 33.57$, $SD = 22.30$) than teachers without such activities [$M = 19.90$, $SD = 21.65$; $t(42) = 2.06$, $p < .05$].

## Discussion of Study 1

The aim of this study was to examine the relationship between teacher *SE* and ambulatory cardiac activation during school time, leisure time, and the night in a sample of primary school teachers. Laboratory studies suggest that *SE* is accompanied by elevated levels of cardiovascular activation when effort is left unconstrained. In accordance with this assumption, we found that teacher *SE* was positively associated with cardiac activation and a reduction in vagal tone (higher HR and attenuated RMSSD) during school time. There was no significant association for the night. However, *SE* was weakly positively related to elevated cardiac activation during leisure time. The result for leisure time was unexpected, since we did not assume higher effort allocation in high *SE* teachers during this time interval. As our additional analyses revealed, there was no significant difference in *SE* for teachers who did engage in school-related preparatory activities during leisure time and teachers who did not, suggesting that differential involvement in job-related activities might not have accounted for the cardiac activation difference. It should be noted that the association between *SE* and cardiac activation for leisure time was only significant after controlling for demographic and lifestyle-variables. Obviously, replication studies are needed to verify the elevated level of cardiac activation during leisure time in high *SE* teachers.

Some other findings are worth mentioning. First, with respect to *SE* we found positive associations with PA and rather strong negative associations with both burnout and NA, thus supporting the construct validity of the *SE* scale. Second, PA was higher during school time as compared to leisure time. Although this result seems puzzling at first, it becomes quite plausible when considering the item contents of the PANAS. PA is represented by states like activation, interest, strength, determination, alertness, attentiveness (see, Egloff, Schmukle, Burns, Kohlmann, & Hock, 2003), all of which are likely to be elevated during work-related activities. Third, exercise frequency was significantly associated with both HR and RMSSD during the night and—albeit weaker—during leisure time. Individuals with higher exercise frequency exhibited lower HR and elevated RMSSD. These results are in accordance with studies showing a dampening effect of aerobic training on cardiovascular activation due to increased vagal tone (Forcier et al., 2006; Galetta et al., 2005; Sandercock, Bromley, & Brodie, 2005). Finally, seniority was a robust negative predictor of RMSSD throughout the day which corresponds with the often reported negative relationship between age and heart rate variability (Tsuji et al., 1996), as seniority was highly correlated with age in this sample. Both these results support the validity of our HR and RMSSD measure.

According to this study, teacher *SE* was positively associated with both psychological well-being and cardiac activation. Thus, our findings raise the question of health-related consequences of *SE* in teachers. While the benefits of *SE* in lifestyle modification programs have been documented extensively (e.g., Bandura, 1997; Luszczynska & Schwarzer, 2005; O'Leary, 1992), there is a lack of studies examining longterm-consequences of biopsychological activation in high and low *SE* individuals. Regarding the classical reactivity hypothesis, frequent elevations in cardiovascular activation due to stressors represent a risk factor for the development of cardiovascular diseases (CVD) (Palatini & Julius, 1997; Schwartz et al., 2003; Sharpley, 1998). Moreover, delayed cardiovascular recovery—as was possibly indicated by higher cardiac activation during leisure time in high *SE* teachers—has been discussed as a CVD risk (Brosschot, Gerin, & Thayer, 2006; Linden, Earle, Gerin, & Christenfeld, 1997; Steptoe, Donald, O'Donnell, Marmot, & Deanfield, 2006). Correspondingly, the high *SE* teachers in this study could be at increased risk of developing CVD due to enhanced allostatic load (McEwen, 1998).

However, more recent studies suggest that vascular reactivity might be more closely related to CVD risk than cardiac reactivity which even proved rather protective for health. For example, Heponiemi et al. (2007) could recently show that HR reactivity to a mental arithmetic task was inversely related to carotid intima-media thickness (IMT), suggesting lower risk for atherosclerosis in high HR-reactive individuals. Similarly, Barnett, Spence, Manuck, and Jennings (1997) found negative associations between IMT and the cardiac stress response, whereas there were positive associations between IMT progression and vascular stress reactivity. Although the role of cardiac activation in the development of preclinical atherosclerosis is not entirely clear by now and some studies seem not to support the findings of Heponiemi et al. (e.g., Gianaros et al., 2005; Jennings, Kamarck, Everson-Rose, Kaplan, Manuck, & Salonen, 2004), it seems that elevated levels of cardiac activation are not necessarily indicative of higher stress and increased CVD risk. Following Dienstbier's (1989) work on physiological toughening, it might even be hypothesized that enhanced cardiac activation to a stressor reflects an adequate response of a healthy system to a challenge which is accompanied by positive emotions, motivational approach, and challenge appraisals, leading to rather favorable health outcomes in the long run (e.g., Tomaka, Blascovich, Kelsey, & Leitten, 1993). Following this line of reasoning, it could be speculated whether the elevated cardiac activation in high *SE* teachers reflects successful coping and less strain.

Summing up, it seems premature to evaluate the health impact of the elevated cardiac activation in high *SE* teachers in this study. In particular, this study was not able to clarify whether the elevated levels of cardiac activation indicate higher allostatic load and, consequently, might put high *SE* teachers at a health risk or whether it reflects a physiological toughening response with rather favorable health outcomes. We therefore aimed to record alternative biopsychological indicators of stress and health in Study 2 to further evaluate health implications for high *SE* teachers.

## Study 2

In Study 2 we assessed the activity of the hypothalamus-pituitary-adrenal (HPA) axis as a prominent biological indicator of stress and health. The HPA axis is known to respond sensitively to acute and chronic stressors through the secretion of the stress hormone cortisol, which has blunting effects on proinflammatory cytokines and is thus assumed to act as an immunosuppressant with corresponding adverse health consequences (e.g., Glaser & Kiecolt-Glaser, 2005). Moreover, with respect to CVD recent research suggests that elevated cortisol levels might predispose individuals to higher systolic blood pressure (Ahmed, de la Torre, & Wahlgren, 2004) and animal research found that free cortisol might facilitate coronary vasoconstricting responses (Hizume et al., 2006). Hence, elevated cortisol levels could indicate a state of increased allostatic load adversely affecting health (McEwen, 1998), whereas low cortisol response to a challenge has been discussed to indicate physiological toughness (Dienstbier, 1989).

Moreover, there are several studies indicating increased HPA axis activation in individuals suffering from depression or chronic stress (e.g., Bhagwagar, Hafizi, & Cowen, 2005; Melamed et al., 1999; Pruessner, Hellhammer, Pruessner, & Lupien, 2003; Van Eck, Berkhof, Nicolson, & Sulon, 1996). Hence, we expected that if teacher *SE* is a protective resource for psychological strain associated with physiological toughness, then it should be accompanied by attenuated activity of the HPA axis. To quantify HPA axis activation the cortisol response to awakening (CRA) was recorded using saliva samples. The CRA has been found to constitute a reliable biological marker for the individual's adrenocortical capacity to produce cortisol (Clow, Thorn, Evans, & Hucklebridge, 2003; Edwards, Clow, Evans, & Hucklebridge, 2001; Pruessner et al., 1997; Schmidt-Reinwald et al., 1999) and appears to be sensitive to subtle changes in HPA axis activity associated with extended periods of psychosocial stress (De Vente, Olff, van Amsterdam, Kamphuis, & Emmelkamp, 2003; Grossi et al., 2005; Eller, Netterstrøm, & Hansen, 2006; Portella, Harmer, Flint, Cowen, & Goodwin, 2005; Pruessner, Hellhammer, & Kirschbaum, 1999; Steptoe, Cropley, Griffith, & Kirschbaum, 2000). We expected that SE as a psychological buffer against stress should be associated with attenuated morning cortisol levels.

Additionally, we assessed physical complaints by questionnaire. We predicted that if *SE* has positive health effects, high *SE* teachers should experience fewer physical symptoms than low *SE* teachers. We were particularly interested to examine the association between teacher *SE* and cardiac complaints, since Study 1 found that *SE* was related to higher cardiac activation during school time. In sum, we hypothesized that teacher *SE* would be accompanied by attenuated morning cortisol levels and attenuated reports of physical complaints.

### *Method*

#### *Participants*

Fifty voluntarily participating high school teachers (23 males) could be recruited for the study. The mean age of the sample was 43.82 years ($SD$ = 9.35, range: 28–58) and the mean body mass index (BMI) was 24.98 kg/m$^2$ ($SD$ = 3.17). The mean year of employment (seniority) was 15.03 years ($SD$ = 10.36) and 12% of the sample were smokers. About 84% of the teachers reported regular exercise. Hence, the sample was quite comparable to that of Study 1, except for the higher number of men in this study. 57% of the teachers worked full-time, the remaining 43% had a teaching load of 0.75 full-time equivalents (FTE) or less. Twelve teachers reported being on medication. Teachers did not receive monetary compensation for participating in this study.

#### *General Procedure*

Teachers were contacted individually for participation in the study. They were told that a study about stress and strain in daily life would be performed. After obtaining informed consent, an appointment was made for study participation. Teachers were requested to choose a "typical school day" for participation and were asked to fill in questionnaires at home and to sample early morning saliva. Special care was taken that data collection was limited to a working day and that there was at least one week between holidays and study participation.

#### *Cortisol Response to Awakening*

Cortisol was assessed via saliva samples (Sarstedt Salivettes, Nümbrecht, Germany) with strict reference to the time of awakening. Teachers were instructed to sample saliva at the time of awakening and 15, 30, and 45 minutes thereafter. Awakening time varied between 5:07 a.m. and 8:25 a.m. with a median of 6:25 a.m.. Participants were requested to strictly follow the time schedule for saliva sampling to obtain valuable data. They were asked to complete sampling before breakfast and to not brush their teeth before completion of saliva sampling in order to avoid contamination of saliva with blood. Teachers were requested to store the samples in the freezer until the return of the samples to the laboratory.

### Questionnaire Measures

*Teacher SE.* The teacher *SE* scale from Study 1 was applied. The mean score on this scale was quite comparable to that of Study 1 ($M = 2.80$, $SD = .37$, $Min = 2.00$, $Max = 3.50$) and the reliability of this scale proved acceptable (Cronbach's alpha = .73).

*Physical Complaints.* Physical complaints were assessed with the Giessen Subjective Complaints List [Giessener Beschwerdebogen (GBB-24); Brähler & Scheer, 1995] which is standardized and validated for Germany (Brähler, Schumacher, & Brähler, 2000). It assesses physical complaints attributable to psychosomatic reasons in four domains: cardiac complaints, gastric complaints, limb pain, and fatigue tendency. Participants are asked to rate their complaints on a five-point scale (0 = no complaints, 4 = strong complaints). Moreover, a total score (overall subjective complaints) was calculated as the sum of these four domains. The reliability of this scale was satisfactory and in accordance with other findings (Cronbach's alpha for fatigue tendency .90; for cardiac complaints .74; for limb pain .79; for gastric complaints .71; for the overall subjective complaints .92). Because physical complaints are strongly influenced by gender and age (e.g., Brähler & Scheer, 1995), we additionally calculated normative values (quartiles) for each participant by comparing the individual scores to the scores of a representative sample of 2182 inhabitants of Germany. We applied the Kolmogorov–Smirnov goodness-of-fit test to test for a uniform distribution. Our sample evidenced overall attenuated reports of somatic complaints as compared to the norm ($K\text{-}S\text{-}Z = 2.31$, $p < .001$ for overall somatic complaints; $K\text{-}S\text{-}Z = 3.75$, $p < .001$ for gastric complaints; $K\text{-}S\text{-}Z = 2.31$, $p < .001$ for limb pain; $K\text{-}S\text{-}Z = 3.18$, $p < .001$ for cardiac complaints), except for the scale fatigue tendency on which our sample scored higher than the norm ($K\text{-}S\text{-}Z = 2.60$, $p < .001$).

### Data Reduction and Analysis

Saliva samples were analyzed with a commercial luminescenceimmunoassay (IBL Hamburg) especially designed for saliva samples and approved by the Food and Drug Administration (FDA). Pipetting standards, samples, and reagents were performed by a fully automated system (Labotech, Freiburg, Germany). Luminescence units were read by use of an automatic luminometer (Beckmann, Germany). All samples were measured in duplicates with sufficient intraassay precision (coefficient of variance, CV ≤6%) and analyzed with assays obtained from the same charge to reduce interassay variation, which was lower than 10%. Saliva analyses were conducted at the lab of Prof. J. Hennig at the Department of Psychology, Justus-Liebig-University Giessen, Germany. Cortisol concentration was quantified in nmol/L.

With respect to cortisol, only 42 teachers with complete samples could be analyzed (8 individuals had to be excluded due to forgetting to use one or more salivettes as revealed by empty probes). For calculating differences between high and low *SE* teachers in the CRA a 4 (time) x 2 (*SE* high vs. low) x 2 (gender) MANOVA was applied. Furthermore, correlations were calculated between *SE* and physical complaints. Because the subscales of the GBB-24 were mostly skewed, Spearman rank correlations were calculated. For all comparisons the level of significance was fixed at $p < .05$ (two-tailed). Additionally, effect sizes [partial Eta$^2$ ($\eta_p{}^2$)] were calculated.

## Results

### CRA and SE

A median split on the teacher *SE* scale was applied to designate teachers as high ($n = 21$) or low in *SE* ($n = 21$). *SE* groups did not differ in respect to age [$t(40) = .90$, $p = .37$), time of awakening ($M = 6{:}28$ for the high *SE* group and $M = 6{:}22$ for the low *SE* group), or gender ($\chi^2 = .01$, $p = .91$). A 4 (time after awakening) x 2 (high vs. low *SE*) x 2 (gender) MANOVA was calculated to examine associations with the CRA. Analyses revealed a significant main effect for time [Wilks $\Lambda = .48$, $F(3, 36) = 12.90$, $p < .01$, $\eta_p^2 = .52$]. Cortisol increased significantly from the time of awakening to 30 minutes after awakening and decreased from 30 to 45 minutes after awakening. Moreover, we found a significant main effect for teacher *SE* [$F(1, 38) = 5.96$, $p < .05$, $\eta_p{}^2 = .14$], indicating that high teacher *SE* was associated with attenuated cortisol levels in the morning (see Figure 1, left side). As post hoc tests revealed, between-groups differences were significant from Minute 15 on. There were no significant two-way or three-way interactions with respect to *SE*, gender, and time.

To control for potentially confounding variables we reran the 4 × 2 × 2 MANOVA with seniority, smoking status, and drug intake (yes vs. no) as covariates. Including these variables in the model did not substantially alter our previous findings. Again, there was a significant main effect for *SE* [$F(1, 35) = 6.08$, $p < .05$; $\eta_p{}^2 = .15$] documenting that the high *SE* group showed lower cortisol levels than the low *SE* group.

### CRA and Physical Complaints

We were also interested to examine the relationship between overall somatic complaints and the CRA, since some studies suggest associations between morning cortisol and health status (e.g., Clow et al., 2004; Kudielka & Kirschbaum, 2003). Therefore, a 4 (time after awakening) x 2 (overall subjective complaints high vs. low) x 2 (gender) MANOVA was conducted. Participants were classified as high versus low on the GBB-24 according to the overall somatic complaints scores relative to the age- and gender-matched population norm (Brähler & Scheer, 1995). Individuals scoring in the upper 50% of the norm ($n = 20$) were designated as high somatic complainers and individuals scoring in the lower 50% ($n = 21$) were designated as low somatic complainers. Groups did not differ with regard to age [$t(39) = 1.21$, $p = .23$), time of awakening ($M = 6{:}21$ for the high somatic complaints group and $M = 6{:}25$ for the low somatic complaints group), or gender ($\chi^2 = .69$, $p = .41$). Figure 1 (right side) depicts the response curves. We found a significant main effect for time [Wilks $\Lambda = .49$, $F(3, 35) = 12.13$, $p < .001$, $\eta_p{}^2 = .51$], indicating increasing cortisol levels from the time of awakening to 30 minutes after awakening and a slight decrease from 30 to 45 minutes after awakening.

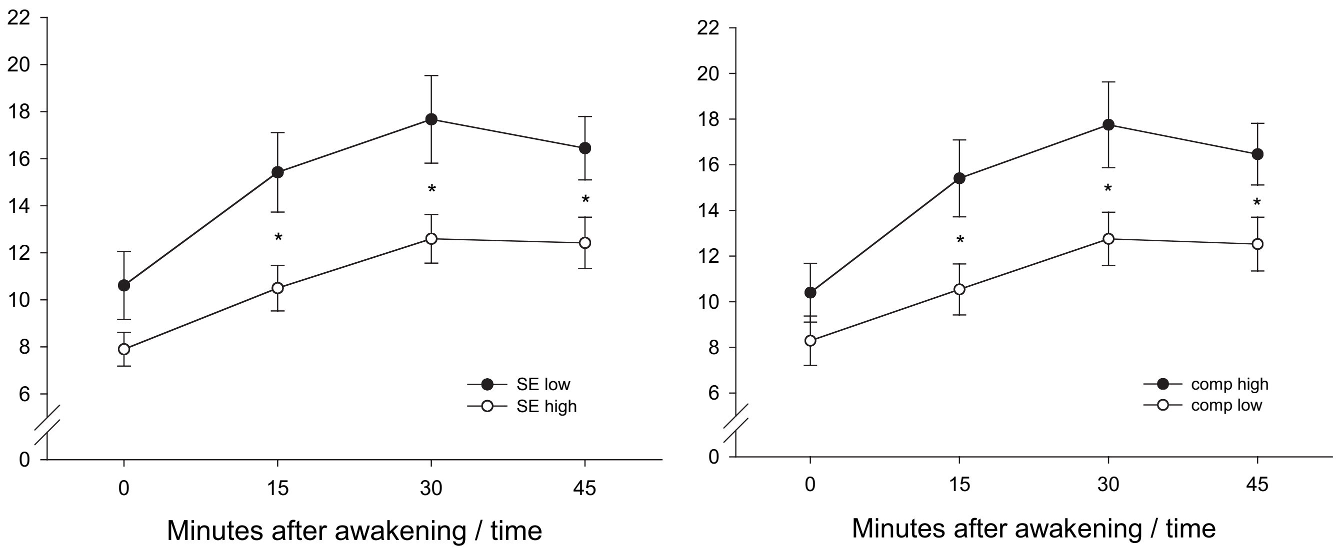


*Figure 1.* Left side: The cortisol response to awakening in high self-efficacy (light circles) and low self-efficacy teachers (dark circles). Right side: The cortisol response to awakening in teachers with high overall somatic complaints (dark circles) and teachers with low overall somatic complaints (light circles). Whiskers indicate ±1 standard error. Asterisks indicate significant between-groups differences ($p < .05$).



Furthermore, there was a significant main effect for somatic complaints [$F(1, 37) = 5.27$, $p < .05$, $\eta_p^2 = .13$], suggesting significant differences between groups. Compared to teachers with low somatic complaints, teachers with high somatic complaints evidenced overall increased cortisol levels. Post hoc *t* tests showed that groups did not differ significantly immediately after awakening but thereafter. However, there was no significant interaction between somatic complaints and time. Controlling for potentially confounding variables (seniority, smoking status, drug intake) did not alter the results substantially. Again, there was a significant main effect for somatic complaints [$F(1, 34) = 5.57$, $p < .05$, $\eta_p^2 = .14$].

When both *SE* and overall somatic complaints were entered as between-subjects factors in the CRA-MANOVA there were significant main effects for both variables [$F(1, 37) = 6.08$, $p < .05$, $\eta_p^2 = .14$ for *SE* and $F(1, 37) = 4.89$, $p < .05$, $\eta_p^2 = .12$ for somatic complaints] and no significant interaction, documenting that both variables were independently related to early morning salivary cortisol.

### *SE* and Physical Complaints

Finally, we calculated Spearman rank correlations between *SE* and physical complaints. There was a significant negative association between *SE* and cardiac complaints ($r = -.29$, $p < .05$). With respect to other complaints there were also negative—however not significant—relations [for gastric complaints: $r = -.18$ ($p = .23$); for limb pain: $r = -.14$ ($p = .35$); for fatigue tendency: $r = -.21$ ($p = .16$), for overall subjective complaints: $r = -.22$ ($p = .14$)].

## *Discussion of Study 2*

Study 2 aimed to assess HPA axis activation and physical complaints in teachers with varying levels of teacher *SE* on a typical working day. Research suggests that the repeated measurement of morning cortisol with strict reference to the time of awakening is sensitive to chronic stress and strain (Schmidt-Reinwald et al., 1999) and could indicate allostatic load. In accordance with expectations we found that teacher *SE* was associated with attenuated cortisol levels in the morning and attenuated reports of cardiac complaints. The lower cortisol levels of high *SE* teachers proved independent of gender, smoking status, and regular medication. According to psychoneuroimmunological studies, attenuated cortisol secretion might indicate lower levels of stress and strain with rather beneficial health outcomes (e.g., Glaser & Kiecolt-Glaser, 2005). Moreover, this result could also indicate a lower risk of developing stress-related disorders like hypertension or cardiac vasoconstriction as suggested by Ahmed et al. (2004) or Hizume et al. (2006).

In addition, our data demonstrate that somatic complaints were accompanied by increased cortisol levels. Importantly, this effect was independent of the relationship between teacher *SE* and CRA. This finding is compatible with studies showing HPA axis hyperactivity in individuals who are in rather poor health (see Clow et al., 2004). Nonetheless, we are aware of the fact that research is far from being homogenous in this respect. There are also studies reporting that a poor health status is accompanied by blunted early morning cortisol levels (e.g., Kudielka & Kirschbaum, 2003). Obviously further studies are needed to explore the tendency to exhibit increased or attenuated cortisol secretion with respect to stress, strain, and health to elucidate possible HPA axis dysregulation mechanisms (see also Miller, Chen, & Zhou, 2007).

Finally, we were able to demonstrate a significant negative correlation between teacher *SE* and cardiac complaints, suggesting that—at least on a subjective level—high *SE* teachers evidenced better cardiac health than low *SE* teachers. Of course, this association might partially have emerged because of the shared method variance of both variables, since both assess the willingness to complain. However, it should be noted that only cardiac complaints were significantly associated with *SE* and not the other subscales. All in all, Study 2 favors the view that *SE* is a health-protective variable associated with blunted cortisol levels in the morning and attenuated reports of cardiac complaints.

## General Discussion

Two studies were conducted to evaluate the psychobiological correlates of teacher *SE* in a natural setting. Whereas Study 1 found elevated levels of cardiac activation, more PA, and less burnout in high *SE* teachers, Study 2 found attenuated morning cortisol levels and attenuated reports of cardiac complaints. In combination, these results could be integrated in terms of Dienstbier's theory of physiological toughness (Dienstbier, 1989). According to this theory, low baseline sympathetic nervous system activation together with rather strong stressor-induced beta-adrenergic activation and cortisol suppression defines a response pattern called physiological toughness. This response pattern corresponds with positive performance in a variety of tasks, with emotional stability, and even with immune system enhancement due to attenuated cortisol responses.

In line with this reasoning, our studies revealed elevated cardiac responses to the challenge of teaching, elevated levels of positive affect in school, less burnout, fewer reports of cardiac complaints, and attenuated cortisol responses to awakening in high *SE* teachers. Hence, the data are compatible with the view that high *SE* in teachers could constitute an adaptive (toughening) resource with a variety of positive health consequences. Nonetheless, we have to emphasize that not all of our findings are entirely consistent with this interpretation. In particular, we are yet unsure about the meaning of the increased cardiac activation found in high *SE* teachers during leisure time. Although it may be possible that this finding reflects elevated levels of behavioral approach or engagement throughout the day, it might also indicate slower cardiac recovery after the challenge of teaching. Slower recovery, though, has been associated with ruminative thoughts and increased cardiovascular risk (e.g., Brosschot et al., 2006). Obviously, further studies are needed to elucidate the functional meaning of the increased cardiac activation in high *SE* individuals throughout the day.

### *Limitations*

Although our results appear quite promising and in line with the proposition that *SE* might constitute a psychobiological buffer against adverse health outcomes, there are some methodological limitations that have to be considered. First, the sample size in both studies was rather moderate because several individuals had to be excluded as they did not meet the criteria for this study (Study 1) or did not comply with the study protocol (e.g., cortisol assessment in Study 2). In order to test the robustness and generalizability of our findings, replication studies with larger sample sizes are indicated.

Second, although field studies offer the main advantage of higher ecological validity than laboratory stress research, its usability is also restricted by highly selective samples (only voluntarily participating individuals). That is, teachers with better health and rather high levels of engagement or motivation are more likely to participate in this kind of study. Consequently, our sample of teachers in Study 1 showed comparatively low levels of burnout and NA but rather high levels of PA during both school and leisure time. Given this restriction of range we are confident that associations with *SE* might grow stronger when more participants with less positive beliefs are included in a study. Additionally, our study participants were generally in good health, as became evident by the high percentage of individuals who reported regular exercise, the low rate of smokers, and the relatively low reports of physical complaints in comparison with the norm. Thus, the results of both studies cannot be generalized to teachers who are generally in poorer health.

Third, participants were allowed to choose a typical school day for participation. Although this might have reassured participation in the study, this procedure certainly has side effects; that is, we cannot rule out the possibility that high *SE* teachers in Study 1 might have chosen a more challenging day than low *SE* teachers, leading to higher cardiac activation. Future studies should control for this bias by randomly assigning participants to different days, although this might result in less willingness to participate in the study.

Fourth, with respect to cortisol measurement, we have to admit that we did not rigorously control the time saliva samples were obtained. There is now accumulating evidence that participants often do not report the true time of sampling early morning saliva (Kudielka, Broderick, & Kirschbaum, 2003; Wilmers, Schwerdtfeger, Wark, Berger, & Bohus, 1995), thus challenging the validity of the data. The lack of compliance might be especially problematic if high *SE* teachers were more compliant with the study protocol than low *SE* teachers, thus questioning the comparability of the cortisol response curves. Thus, we would recommend controlling for compliance in future studies, for example, by using electronic monitoring devices.

Fifth, although our study proposes that *SE* might constitute a meaningful variable related to biopsychological health in teachers, we do not know whether other, related psychosocial variables (e.g., optimism, job satisfaction, hardiness, social support) might—at least partially—have accounted for the relationships found here. For example, other research found negative relationships between positive affect and cortisol secretion throughout the day (Steptoe, Wardle, & Marmot, 2005), proposing that positive affect is also a powerful candidate for the prediction of psychobiological health indicators. Given the strong association between *SE* and positive affect in Study 1, we cannot rule out the possibility that positive affect or other psychosocial resource variables might have dominated the associations found here. It would be necessary to examine the relative impact of these variables with respect to the relationship of *SE* and biopsychological markers of health in future studies. Moreover, we want to emphasize that we used a correlational design, hence we are not able to provide clear evidence for a causal influence of *SE* on health.

Relatedly, unless the long-term consequences of cardiac activation and attenuated cortisol secretion in high *SE* teachers have been examined prospectively, our conclusion of protective health effects should be accepted with reservation. We also need more data on cardiovascular (blood pressure, hemodynamic activation, IMT) and immunological parameters of stress and strain to gain a broader view of health with respect to *SE*.

## Conclusions

Despite these limitations we found evidence for the hypothesis that teacher *SE* might constitute a health-protective resource in teachers. The results are compatible with the view that *SE* might act as a physiological toughening agent associated with elevated beta-adrenergic activation to challenge, more positive affect, attenuated cortisol secretion, reduced burnout, and attenuated cardiac complaints. Future studies should now explore the prognostic implications of teacher *SE* to verify this assumption.

## References

Ahmed, N., de la Torre, B., & Wahlgren, N. G. (2004). Salivary cortisol, a biological marker of stress, is positively associated with 24-hour systolic blood pressure in patients with acute ischaemic stroke. *Cerebrovascular Diseases, 18,* 206–213.

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review, 84,* 191–215.

Bandura, A. (1997). *Self-efficacy: The exercise of control.* New York: Freeman.

Barnett, P. A., Spence, J. D., Manuck, S. B., & Jennings, J. R. (1997). Psychological stress and the progression of carotid artery disease. *Journal of Hypertension, 15,* 49–55.

Bhagwagar, Z., Hafizi, S., & Cowen, P. J. (2005). Increased salivary cortisol after waking in depression. *Psychopharmacology, 182,* 54–57.

Brähler, E., & Scheer, J. W. (1995). Der Gieβener Beschwerdebogen (GBB) [The Giessen Complaints Questionnaire GBB-24], 2nd and Rev. ed. Hans Huber: Bern.

Brähler, E., Schumacher, J., & Brähler, C. (2000). Erste gesamtdeutsche Normierung der Kurzform des Gieβener Beschwerdebogens GBB-24 [First standardization of the short version of the Giessen-Subjective Complaints List GBB-24 in re-unified Germany]. *Psychotherapie, Psychosomatik, Medizinische Psychologie, 50,* 14–21.

Brosschot, J. F., Gerin, W., & Thayer, J. F. (2006). The perseverative cognition hypothesis: A review of worry, prolonged stress-related physiological activation, and health. *Journal of Psychosomatic Research, 60,* 113–124.

Clow, A., Thorn, L., Evans, P., & Hucklebridge, F. (2004). The awakening cortisol response: Methodological issues and significance. *Stress, 7,* 29–37.

De Vente, W., Olff, M., van Amsterdam, J. G. C., Kamphuis, J. H., & Emmelkamp, P. M. G. (2003). Physiological differences between burnout patients and healthy controls: Blood pressure, heart rate, and cortisol responses. *Occupational and Environmental Medicine, 60* (*Suppl I*), i54–i61.

Dienstbier, R. A. (1989). Arousal and physiological toughness: Implications for mental and physical health. *Psychological Review, 96,* 84–100.

Edwards, S., Clow, A., Evans, P., & Hucklebridge, F. (2001). Exploration of the awakening cortisol response in relation to diurnal cortisol secretory activity. *Life Sciences, 68,* 2093–2103.

Egloff, B., Schmukle, S. C., Burns, L. R., Kohlmann, C-W., & Hock, M. (2003). Facets of dynamic positive affect: Differentiating joy, interest, and activation in the Positive and Negative Affect Schedule (PANAS). *Journal of Personality and Social Psychology, 85,* 528–540.

Eller, N. H., Netterstrøm, B., & Hansen, Å. M. (2006). Psychosocial factors at home and at work and levels of salivary cortisol. *Biological Psychology, 73,* 280–287.

Enzmann, D., & Kleiber, D. (1989). *Helfer-Leiden: Stress und Burnout in psychosozialen Berufen* [Helper's suffering: Stress and burnout in psychosocial professions]. Heidelberg: Asanger.

Forcier, K., Stroud, L. R., Papandonatos, G. D., Hitsman, B., Reiches, M., Krishnamoorthy, J., & Niaura, R. (2006). Links between physical fitness and cardiovascular reactivity and recovery to psychological stressors: A meta-analysis. *Health Psychology, 25,* 723–739.

Fowles, D. C. (1988). Psychophysiology and psychopathology: A motivational approach. *Psychophysiology, 25,* 373–391.

Galetta, F., Franzoni, F., Femia, F. R., Roccella, N., Pentimone, F., & Santoro, G. (2005). Lifelong physical training prevents the age-related impairment of heart rate variability and exercise capacity in elderly people. *Journal of Sports Medicine and Physical Fitness, 45,* 217–221.

Gendolla, G. H. E., & Richter, M. (2005). Ego involvement and effort: Cardiovascular, electrodermal, and performance effects. *Psychophysiology, 42,* 595–603.

Gerin, W., Litt, M. D., Deich, J., Pickering, T. G. (1995). Self-efficacy as a moderator of perceived control effects on cardiovascular reactivity: Is enhanced control always beneficial? *Psychosomatic Medicine, 57,* 390–397.

Gerin, W., Litt, M. D., Deich, J., Pickering, T. G. (1996). Self-efficacy as a component of active coping: Effects on cardiovascular reactivity. *Journal of Psychosomatic Research, 40,* 485–493.

Gianaros, P. J., Salomon, K., Zhou, F., Owens, J. F., Edmundowicz, D., Kuller, L. H., & Matthews, K. A. (2005). A greater reduction in high-frequency heart rate variability to a psychological stressor is associated with subclinical coronary and aortic calcification in postmenopausal women. *Psychosomatic Medicine, 67,* 553–560.

Glaser, R., & Kiecolt-Glaser, J. K. (2005). Stress-induced immune dysfunction: Implications for health. *Nature Reviews Immunology, 5,* 243–251.

Goldberger, J. J., Challapalli, S., Tung, R., Parker, M. A., & Kadish, A. H. (2000). Relationship of heart rate variability to parasympathetic effect. *Circulation, 103,* 1977–1983.

Grossi, G., Perski, A., Ekstedt, M., Johansson, T., Lindström, M., & Holm, K. (2005). The morning salivary cortisol response in burnout. *Journal of Psychosomatic Research, 59,* 103–111.

Guglielmi, R. S., & Tatrow, K. (1998). Occupational stress, burnout, and health in teachers: A methodological and theoretical analysis. *Review of Educational Research, 68,* 61–99.

Heponiemi, T., Elovainio, M., Pulkki, L., Puttonen, S., Raitakari, O., & Keltikangas-Järvinen, L. (2007). Cardiac autonomic reactivity and recovery in predicting carotid atherosclerosis: The Cardiovascular Risk in Young Finns Study. *Health Psychology, 26,* 13–21.

Hilmert, C. J., Christenfeld, N., & Kulik, J. A. (2002). Audience status moderates the effects of social support and self-efficacy on cardiovascular reactivity during public speaking. *Annals of Behavioral Medicine, 24,* 122–131.

Hizume, T., Morikawa, K., Takaki, A., Abe, K., Sunagawa, K., Amano, M., Kaibuchi, K., Kubo, C., & Shimokawa, H. (2006). Sustained elevation of serum cortisol level causes sensitization of coronary vasoconstricting responses in pigs in vivo. *Circulation Research, 99,* 767–775.

Jennings, J. R., Kamarck, T. W., Everson-Rose, S. A., Kaplan, G. A., Manuck, S. B., & Salonen, J. T. (2004). Exaggerated blood pressure responses during mental stress are prospectively related to enhanced carotid atherosclerosis in middle-aged Finnish men. *Circulation, 110,* 2198–2203.

Krohne, H. W., Egloff, B., Kohlmann, C. W., & Tausch, A. (1996). Untersuchung mit einer deutschen Version der „Positive and Negative Affect Schedule" (PANAS) [Investigations with a German version of the Positive and Negative Affect Schedule (PANAS)]. *Diagnostica, 42,* 139–156.

Kuch, B., Hense, H. W., Sinnreich, R., Kark, J. D., von Eckardstein, A., Sapoznikov, D., & Bolte, H.-D. (2001). Determinants of short-period heart rate variability in the general population. *Cardiology, 95,* 131–138.

Kudielka, B. M., Broderick, J. E., & Kirschbaum, C. (2003). Compliance with saliva sampling protocols: Electronic monitoring reveals invalid cortisol daytime profiles in noncompliant subjects. *Psychosomatic Medicine, 65,* 313–319.

Kudielka, B. M., & Kirschbaum, C. (2003). Awakening cortisol responses are influenced by health status and awakening time but not by menstrual cycle phase. *Psychoneuroendocrinology, 28,* 35–47.

Linden, W., Earle, T. L., Gerin, W., & Christenfeld, N. (1997). Physiological stress reactivity and recovery: Conceptual siblings separated at birth? *Journal of Psychosomatic Research, 42,* 117–135.

Lovallo, W. R., Wilson, M. F., Pincomb, G. A., Edwards, G. L., Tompkins, P., & Brackett, D. J. (1985). Activation patterns to aversive stimulation in man: Passive exposure versus effort to control. *Psychophysiology, 22,* 283–291.

Luszczynska, A., & Schwarzer, R. (2005). The role of self-efficacy in health self-regulation. In W. Greve, K. Rothermund, & D. Wentura (Eds.), *The adaptive self: Personal continuity and intentional self development* (pp. 137–152). Göttingen, Germany: Hogrefe.

Maslach, C., Jackson, S. E., & Leiter, M. P. (1996). *Maslach Burnout Inventory (3rd ed.).* Palo Alto, CA: Consulting Psychologists Press.

McEwen, B. S. (1998). Protective and damaging effects of stress mediators. *New England Journal of Medicine, 338,* 171–179.

Melamed, S., Ugarten, U., Shirom, A., Kahana, L., Lerman, Y., & Froom, P. (1999). Chronic burnout, somatic arousal and elevated salivary cortisol levels. *Journal of Psychosomatic Research, 46,* 591–598.

Miller, G. E., Chen, E., & Zhou, E. S. (2007). If it goes up, must it come down? Chronic stress and the hypothalamic-pituitary-adrenocortical axis in humans. *Psychological Bulletin, 133,* 25–45.

O'Leary, A. (1992). Self-efficacy and health: Behavioral and stress-physiological mediation. *Cognitive Therapy and Research, 16,* 229–245.

Palatini, P., & Julius, S. (1997). Heart rate and the cardiovascular risk. *Journal of Hypertension, 15,* 3–17.

Penttilä, J., Helminen, A., Jartti, T., Kuusela, T., Huikuri, H. V., Tulppo, M. P., Coffeng, R., & Scheinin, H. (2001). Time domain, geometrical and frequency domain analysis of cardiac vagal outflow: Effects of various respiratory patterns. *Clinical Physiology, 21,* 365–376.

Portella, M. J., Harmer, C. J., Flint, J., Cowen, P., & Goodwin, G. M. (2005). Enhanced early morning salivary cortisol in neuroticism. *American Journal of Psychiatry, 162,* 807–809.

Pruessner, J. C., Hellhammer, D. H., & Kirschbaum, C. (1999). Burnout, perceived stress, and cortisol responses to awakening. *Psychosomatic Medicine, 61,* 197–204.

Pruessner, J. C., Wolf, D. H., Hellhammer, D. H., Buske-Kirschbaum, A., von Auer, K., Jobst, S., Kaspers, F., & Kirschbaum, C. (1997). Free cortisol levels after awakening: A reliable biological marker for the assessment of adrenocortical activity. *Life Sciences, 61,* 2539–2549.

Pruessner, M., Hellhammer, D. H., Pruessner, J. C., & Lupien, S. J. (2003). Self-reported depressive symptoms and stress levels in healthy young men: Associations with the cortisol response to awakening. *Psychosomatic Medicine, 65,* 92–99.

Sandercock, G. R., Bromley, P. D., & Brodie, D. A. (2005). Effects of exercise on heart rate variability: Inferences from meta-analyses. *Medicine and Science in Sports and Exercise, 37,* 433–439.

Sanz, A., & Villamarín, F. (2001). The role of perceived control in physiological reactivity: Self-efficacy and incentive value as regulators of cardiovascular adjustment. *Biological Psychology, 56,* 219–246.

Sanz, A., Villamarín, F., & Álvarez, M. (2006). Effects of specific and non-specific perceived control on blood pressure response in a stressful mental task. *Biological Psychology, 71,* 20–28.

Schmidt-Reinwald, A., Pruessner, J. C., Hellhammer, D. H., Federenko, I., Rohleder, N., Schürmeyer, T. H., & Kirschbaum, C. (1999). The cortisol response to awakening in relation to different challenge tests and a 12-hour cortisol rhythm. *Life Sciences, 64,* 1653–1660.

Schmitz, G. S., & Schwarzer, R. (2000). Selbstwirksamkeitserwartung von Lehrern: Längsschnittbefunde mit einem neuen Instrument. [Self-efficacy of teachers: Longitudinal data using a new questionnaire]. *Zeitschrift für Pädagogische Psychologie, 14,* 12–25.

Schwartz, A. R., Gerin, W., Davidson, K. W., Pickering, T. G., Brosschot, J. F., Thayer, J. F., Christenfeld, N., & Linden, W. (2003). Toward a causal model of cardiovascular responses to stress and the development of cardiovascular disease. *Psychosomatic Medicine, 65,* 22–35.

Schwarzer, R., & Jerusalem, M. (1999). *Skalen zur Erfassung von Lehrer- und Schülermerkmalen. Dokumentation der psychometrischen Verfahren im Rahmen der Wissenschaftlichen Begleitung des Modellversuchs Selbstwirksame Schulen* [Scales for the assessment of teacher and pupil-related variables], Berlin, Germany: Freie Universität Berlin.

Schwerdtfeger, A. (2004). Predicting autonomic reactivity to public speaking: Don't get fixed on self-report data! *International Journal of Psychophysiology, 52,* 217–224.

Sharpley, C.-F. (1998). Psychosocial stress-induced heart rate reactivity and atherogenesis: Cause or correlation? *Journal of Behavioral Medicine, 21,* 411–432.

Steptoe, A., Cropley, M., Griffith, J., & Kirschbaum, C. (2000). Job strain and anger predict early morning elevations in salivary cortisol. *Psychosomatic Medicine, 62,* 286–292.

Steptoe, A., Donald, A. E., O'Donnell, K., Marmot, M., & Deanfield, J. E. (2006). Delayed blood pressure recovery after psychological stress is associated with carotid intima-media thickness: Whitehall Psychobiology Study. *Arteriosclerosis, Thrombosis, and Vascular Biology, 26,* 2547–2551.

Steptoe, A., Wardle, J., & Marmot, M. (2005). Positive affect and health-related neuroendocrine, cardiovascular, and inflammatory processes. *PNAS, 102,* 6508–6512.

Task Force of the European Society for Cardiology and the North American Society of Pacing and Electrophysiology. (1996). Heart rate variability: Standards of measurement, physiological interpretation and clinical use. *Circulation, 93,* 1043–1065.

Tomaka, J., Blascovich, J., Kelsey, R. M., & Leitten, C. L. (1993). Subjective, physiological, and behavioral effects of threat and challenge appraisal. *Journal of Personality and Social Psychology, 65,* 248–260.

Tsuji, H., Venditti, F. J., Manders, E. S., Evans, J. C., Larson, M. G., Feldman, C. L., & Levy, D. (1996). Determinants of heart rate variability. *Journal of the American College of Cardiology, 28,* 1539–1546.

Van Eck, M., Berkhof, H., Nicolson, N., & Sulon, J. (1996). The effects of perceived stress, traits, mood states, and stressful daily events on salivary cortisol. *Psychosomatic Medicine, 58,* 447–458.

Wilmers, F. E., Schwerdtfeger, A., Wark, H-J., Berger, M., & Bohus, M. (1995). Do subjects report the true time of sampling early morning saliva? *Journal of Psychophysiology, 9,* 382–383.

Wright, R. A., & Kirby, L. D. (2001). Effort determination of cardiovascular response: An integrative analysis with applications in social psychology. In M. P. Zanna (Ed.), *Advances in experimental social psychology* (Vol. 33, pp. 255–307). New York: Academic Press.