Stress on the Dance Floor: The Cortisol Stress Response to Social-Evaluative Threat in Competitive Ballroom Dancers

Nicolas Rohleder
Dresden University of Technology and University of British Columbia
Silke E. Beulen
University of Wuppertal
Edith Chen
University of British Columbia
Jutta M. Wolf
Dresden University of Technology and University of British Columbia
Clemens Kirschbaum
Dresden University of Technology

The social self-preservation theory states that humans have a fundamental motivation to preserve the social self and that threats to the social self perturb biological markers such as cortisol. Five studies were designed to examine the cortisol response to competitive ballroom dancing as a paradigm for real-life social-evaluative threat. Competitive dancing produced substantial increases in cortisol compared to a control day. These increases were not due to the physical strain of dancing and were greater than those found during social-evaluative laboratory stressors. Responses did not habituate across competitions and were mostly elevated under highly focused conditions of threat (couple vs. group competition). These findings support the notion of a social self-preservation system that is physiologically responsive to threats to the social self.

Keywords: *ballroom dancing; psychosocial stress; social self-preservation; cortisol; social-evaluative threat; social evaluation*

INTRODUCTION

The social self refers to how an individual perceives his or her social status and value and is shaped by how others evaluate that individual's worth. Individuals who have higher social status are typically ones who possess attributes that are highly valued by the social group. Researchers have argued that the need to belong to a social group is a fundamental human motivation and that humans are driven to behave in ways that further their belongingness to groups (Baumeister & Leary, 1995). This could include behaviors such as presenting one's valued attributes to a social group. If so, it suggests that humans are dependent on others to evaluate certain attributes and that these evaluations from others can contribute to their sense of self, including self-esteem and self-identity (Crocker & Park, 2004; Leary & Kowalski, 1990).

Some researchers have argued that similar to a motivation to preserve the physical self, humans also have a fundamental motivation to preserve the social self (Dickerson & Kemeny, 2004; Kemeny, Gruenewald, & Dickerson, 2006). This theory argues that there is a social self-preservation system that monitors the environment for threats to one's social status and responds accordingly when such threats are perceived. Responses

PSPB, Vol. 33 No. 1, January 2007 69-84
DOI: 10.1177/0146167206293986

to social threats include a set of both psychological and physiological responses, similar to responses to threats to the physical self.

Perceptions of and responses to social-evaluative threat appear to more likely occur under certain conditions that we summarize as the following: (a) A central goal must be involved, (b) the situation requires the display of an attribute or skill that the individual values, (c) the attribute or skill is evaluated by others, (d) the goal may be threatened in the situation in that a negative evaluation could lead to a loss of social status, and (e) achieving the goal may be impeded by factors that are uncontrollable. The first two conditions highlight the importance of an individual's performance in a domain that is significant to their self-identity. The third and fourth conditions refer to the importance of social ties for this theory—that is, goals and performances that are not evaluated by others will not evoke a social-evaluative threat response. Lastly, elements of uncontrollability may increase social-evaluative threat because individuals perceive that their performance and its evaluation are not completely under their own control.

Psychologically, threats to the social self in important domains can lead to loss of self-esteem and negative emotional states such as shame and are characteristic of psychiatric disorders such as anxiety and depression (Crocker & Wolfe, 2001; Dickerson, Gruenewalk, & Kemeny, in press; Ingram & Price, 2001; Leary, Tambor, Terdal, & Downs, 1995). Physiologically, the biological system that may be most sensitive to social-evaluative threat is the hypothalamic-pituitary-adrenal (HPA) axis.

HPA Axis and Its Relationship to Stress

The HPA axis is responsible for the secretion of the stress hormone cortisol. The secretion of cortisol is initiated at the paraventricular nucleus of the hypothalamus, where corticotropin releasing factor (CRF) is produced. After being carried to the anterior pituitary, CRF cleaves the protein proopiomelanocortin into adrenocorticotropic hormone (ACTH) and betaendorphin, which both are released into the systemic circulation afterward. Each pulse of ACTH that reaches the adrenal cortex results in an increased synthesis of cortisol, which finally is released into the bloodstream. Because it is bound rapidly to carriers such as corticosteroid-binding globulin, albumin, and erythrocytes, only a small fraction of 2% to 15% of released cortisol remains unbound (Kirschbaum & Hellhammer, 2000). Only this "free" hormone fraction is biologically active (Mendel, 1989; Robbins & Rall, 1957). Although blood contains both bound and unbound cortisol, only the free hormone fraction is able to get into saliva through passive diffusion. Correlations between salivary cortisol and unbound blood cortisol levels are high (r ~ .90); hence, salivary cortisol provides an index of the biologically active fraction of this steroid hormone (Kirschbaum & Hellhammer, 2000). Thus, the measurement of cortisol in saliva is the method of choice in psychoendocrinology studies (Kirschbaum & Hellhammer, 1989).

Numerous studies have indicated that both physical and psychological stress lead to a significant activation of the HPA axis. Stressors can override the negative feedback loop at the pituitary and hypothalamus, leading to increased frequency and amplitude of cortisol pulses. For example, marathon runs (Cook, Read, Walker, Harris, & Riad-Fahmy, 1986) and exercising on a bicycle ergometer (Mason et al., 1973; O'Connor & Corrigan, 1987) are among the physical strains that are capable of activating the HPA axis. Psychological loads can activate the HPA axis as much or more than physical stimuli do. In early work, Mason (1968) reported that psychological influences are among the most potent natural stimuli known to affect HPA activity; his work emphasized the importance of situational characteristics as novelty, unpredictability, uncontrollability, anticipation of negative consequences, and personal involvement in activating the HPA axis. In addition, academic examinations (Kahn et al., 1992), public speaking (Bassett, Marshall, & Spillane, 1987), parachute jumping (Cook et al., 1992; Deinzer, Kirschbaum, Gresele, & Hellhammer, 1997), hostage imprisonment (Rahe, Karson, Howard, Rubin, & Poland, 1990), and psychosocial stress tasks in laboratory research all have been found to stimulate the HPA axis. One tool for investigating moderate psychological stress in a laboratory setting is the Trier Social Stress Test (Kirschbaum, Pirke, & Hellhammer, 1993), which consists of an anticipation period followed by a test period in which the participants have to perform a free speech and mental arithmetic in front of an audience. Participation in this stress task induced considerable changes in the concentration of ACTH and cortisol. Whereas psychological stressors of short duration (i.e., 15 minutes; Kirschbaum et al., 1993) are capable of activating the HPA axis, a physical strain will have to exceed certain thresholds to stimulate cortisol release. When exercising with 55% of maximal oxygen uptake (55% VO_2max), an exercise duration of 80 minutes is not sufficient to activate the HPA axis (Tremblay, Copeland, & Van Helder, 2005). Even when exercising with a high intensity of 75% VO_2max, the HPA axis is not activated when exercise duration is shorter than 30 minutes (O'Connor & Corrigan, 1987).

Cortisol plays a particular role in maintaining the organism's efficiency (McEwen, 1998). For example, enhanced cortisol levels due to acute stress lead to mobilization of energy-producing mechanisms on the one hand and to inhibition of less relevant organic functions on the other hand. This is thought to prepare the organism for fight or flight. Although originally developed to deal with physical stressors, this system may have evolved over time to respond to psychological threats as well, thus resulting in the associations found between psychological (nonphysical) stressors and cortisol.

Cortisol and Social-Evaluative Threat

Some researchers have argued that not all psychological stressors activate the HPA axis. Rather, the HPA axis may be specifically activated under conditions of social-evaluative threat. That is, psychological situations that involve performances related to an important goal, under conditions of social evaluation, and with elements of uncontrollability may be most likely to evoke a cortisol response. Some researchers have argued that the HPA axis is activated when central goals are threatened (Blascovich & Tomaka, 1996). In addition, in a meta-analysis, Dickerson and Kemeny (2004) found that only certain types of acute laboratory stress tasks elicited a cortisol response. Evaluative tasks, such as ones that involved public speaking, produced greater cortisol responses than nonevaluative tasks (e.g., watching an emotion-eliciting video). Uncontrollable tasks produced greater cortisol responses than tasks that were controllable. The largest effects sizes were found for motivated performance tasks (tasks that required active responses) that combined social-evaluative threat with uncontrollability. Finally, the meta-analysis found that tasks in which the evaluator was present (e.g., audience members for the speech task) produced greater cortisol responses than tasks where the evaluator was less salient (speech task that was videotaped for later evaluation). Overall, these findings suggest that in a laboratory context, motivated performance tasks that involve salient social-evaluative threat and uncontrollability result in the greatest activation of the HPA axis.

The meta-analysis investigated studies that contained components of social-evaluative threat, although many of these studies were not designed specifically to manipulate social-evaluative threat. Laboratory studies that have focused on social-evaluative threat have found that the social evaluation component is critical to the cortisol response; a stressor task performed in front of an audience produced an increase in cortisol, whereas the same stressor task performed alone did not (see Dickerson et al., in press, for a review of this group's laboratory studies in this domain).

Previous research on social-evaluative threat and cortisol has focused on laboratory studies of stressors. However, if the first two components of social self-preservation theory (a central goal and the display of skill that the individual values) are important for the elicitation of social-evaluative threat responses, this suggests the importance of identifying real-life stressors that are more central to an individual's identity than the stressors that are typically used in laboratory studies. For example, sport competitions, in which athletes are expected to show high levels of performance in front of judges and an audience, may be exemplary real-life situations that evoke social-evaluative threat. In contrast, although laboratory stressors such as giving a speech in front of an audience is a form of social-evaluative threat, the artificiality and anonymity of the laboratory environment may result in participants being less likely to value their performance or the evaluation of others during this task. In the present set of studies, we investigated competitive ballroom dancing as a real-life paradigm of social-evaluative threat.

The Ballroom Dancing Competition

During competitions, each couple has to perform five dances in front of a panel of five judges and audience members. In modern dancing, the performance includes slow waltz, tango, Viennese waltz, slow foxtrot, and quickstep. In Latin dancing, the cha-cha-cha, samba, rumba, paso doble, and jive are performed. Each dance is performed for 1 minute or 90 seconds, with minimal breaks in between. The quality of each couple's dancing is evaluated in relation to the other participating couples. Couples compete in rounds and advance to subsequent rounds if their ratings are high enough. Each round of five dances takes between 6 and 8 minutes, with breaks of 15 minutes between rounds for calculation of results. Rules and regulations follow the "TSO" of the German Dancesport Federation (Deutscher Tanzsportverband e.V., 2003) and are identical across competitions.

We expected that ballroom dancing competitions would contain many of the characteristics important to evoking social-evaluative threat in real life. First, this situation involves a central goal in that all participants were competitive ballroom dancers, and thus a high level of performance is an important goal to all these athletes' self-identity. Second, the situation requires the display of a skill that the individual values in that dancers engage in multiple dance performances throughout the competition. Third, their skill is evaluated by others, in this case the judges. Fourth, their goal may be threatened by a negative evaluation in that a poor rating from the judges may hinder their goal of being a top ballroom dancer. Fifth, aspects of the situation may feel uncontrollable to the athletes.

With respect to uncontrollability, the other competitors' performances are out of the athlete's control, and yet their ranking is determined relative to the other competitors. The judges may change from competition to competition and may have their own biases in judging performance that is out of the control of the athletes. The audience members also change from competition to competition and may vary in their support of the athletes versus their competitors, adding another element of uncontrollability to the competition. Finally, the condition of the dance floor and other environmental characteristics may vary from competition site to competition site and are also out of the control of the athlete.

The present article reports on five studies that address the question of whether competitive ballroom dancing represents a real-life motivated performance task that serves as a powerful stimulus of the HPA axis because of its social-evaluative threat and uncontrollability. We expected that competitive ballroom dancing would elicit a significant cortisol response that would be greater than what has been observed in the laboratory. In addition, we sought to determine what the specific parameters of real-life stressors are that most strongly predict the cortisol response, including dimensions of physical demands, repeatability, and the extent of focus on an individual.

STUDY 1

In Study 1, we examined whether real-life social-evaluative situations (competitive ballroom dancing) elicit stress-induced cortisol responses.

Study 1 Method

Participants

We recruited 44 competitive modern and Latin dancers, 22 men and 22 women, from different clubs located in the region of Nordrhein-Westfalen in Germany. Their age ranged from 17 to 62 years. All of the participating couples were quite experienced in ballroom dancing tournaments, having participated in 137.52 (24 to 400) competitions in the past 10.5 years on average. All participants were amateurs (i.e., there were no monetary consequences of winning or losing a tournament). Participation in this study was voluntary, and each participating athlete received 10 Euros as well as his or her personal cortisol profile.

Materials

Cortisol measures. Salivary cortisol samples were obtained using “Salivettes“ (Sarstedt; Nümbrecht, Germany) and were kept cool in the refrigerator until analysis. To monitor compliance with the salivary cortisol collection protocol (described in detail in the following), we removed the sampling swabs from their original plastic tubes and put them in an electronic drug exposure monitor (eDEM™; Aardex Ltd., Switzerland). By use of a special interface and the software program PowerView, the data were transferred from the electronic monitoring device to a computer, which revealed actual sampling times. Employment of this device strengthens compliance of informed participants and prevents invalid cortisol profiles in noncompliant participants (Kudielka, Broderick, & Kirschbaum, 2003). If any saliva collection occurred more than 20 minutes before or after the specified time, participants were asked to repeat the entire saliva collection protocol on another control or competition day. Thus, all data analyzed in this study are based on samples with 100% compliance with the study protocol.

Salivary cortisol samples were prepared for biochemical analysis by centrifuging at 3,000 rpm for 5 minutes, which resulted in a clear supernatant of low viscosity. Salivary-free cortisol concentrations were determined employing a chemi-luminescence-assay (CLIA) with high sensitivity of 0.16 ng/ml (IBL; Hamburg, Germany). This technique was used in all studies reported in this article.

Psychological Measures of the Competition

Perceived stress. Participants were asked to rate how stressed they currently felt on a 0 to 10 scale. This measure was taken simultaneously with each cortisol sample.

Stress factors. Participants were asked to indicate how many of a list of 14 factors related to the competition they found stressful. Factors included ones directly related to social-evaluative threat (judges, competitors, audience members) and other factors (e.g., physical environment, partner's behavior). The total number of competition factors participants found stressful was totaled.

Performance satisfaction. Participants were asked to rate how satisfied they were with their performance during the competition on a 0 to 10 scale.

Procedure

Participants were asked to collect salivary samples throughout one competition day and during one noncompetition control day (no competition or training). During the competition day, there were 14 measuring times altogether. The first 2 samples were obtained immediately after awakening and 30 minutes later; afterward, sampling was continued in intervals of 2 hours until the start of the tournament. For logistical reasons, the next measuring times were after the first round, after the second round, and at the very end of the contest. After the

TABLE 1: Number of Participants Collecting Salivary Samples at the Different Measuring Times in Study 1

Measuring Time	*N Competition Day*	*N Control Day*
Awakening	43	44
+30 minutes	43	42
–6 hours	24	24
–4 hours	30	30
–2 hours	44	44
Beginning	44	44
Ending Round 1	44	—
Ending Round 2	32	—
Very end	44	—
+2 hours	44	44
+4 hours	44	44
+6 hours	43	40
+8 hours	19	19
+10 hours	13	12

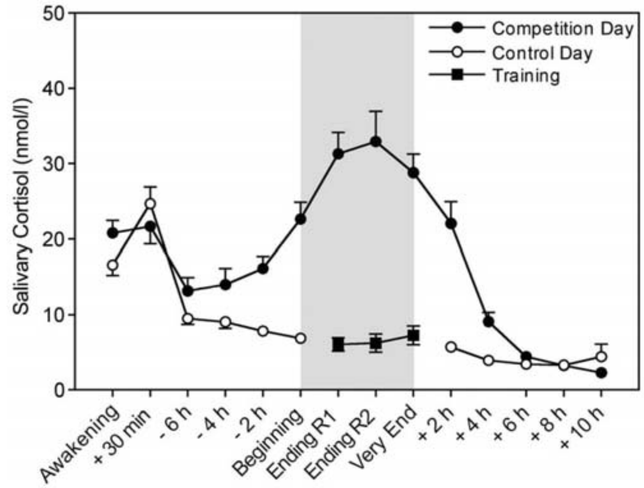

Figure 1 Mean salivary cortisol profile of ballroom dancers on a competition day in comparison to a control day in Study 1, and salivary cortisol during training in Study 2 at the beginning of Training Round 1, at the end of Training Round 1, and at the end of Training Round 2.

tournament ended (approximately 1 to 1.5 hours in total), a sample was taken 2 hours after the time of the beginning of the tournament and continued at 2-hour intervals until participants went to bed that evening. During the control day, participants collected salivary samples at identical times: after awakening, 30 minutes later, and then every 2 hours until bedtime. Because there was no tournament, samples could not be collected at the end of each round. To help remind the athletes of their times for obtaining salivary samples, each of them received a written plan tailored to the starting time of their tournament. Due to the fact that competition start times were distributed between 11 a.m. and 6 p.m., some of the measurements could not be completed by all of the participants. For example, if the tournament began at 11 a.m., then participants typically did not collect a sample 6 hours prior to competition (at 5 a.m.) because they were still asleep. The total number of salivary samples collected at the specific measuring times are listed in Table 1.

Study 1 Results and Discussion

Cortisol data were averaged separately for each measuring time. Figure 1 reveals differences in the mean cortisol profile on the competition day in comparison to the course of the control day. Whereas the control day is characterized by a typical awakening response and constantly decreasing values throughout the day with a small increase in the late evening, the competition day reveals a completely different picture. For example, 6 hours prior to competition, the mean cortisol level already exceeds the concentration measured at the same time on the control day. Furthermore, a large increase can be observed that peaks after the second round of competition. After finishing the competition, cortisol concentrations decrease and return to baseline 6 hours later.

Due to the fact that there were no corresponding times on the control day, the three maximum cortisol values after Round 1, after Round 2, and at the end of competition are not suited for analysis of variance (ANOVA). Thus, we compared the values closest to competition time from the competition day versus the control day (–2 hours, beginning, +2 hours). We conducted a 3 (time: –2 hours vs. beginning vs. +2 hours) × 2 (day: competition day vs. control day) ANOVA. For all of the following analyses, we first employed the Mauchly test of sphericity. If this test was significant, we used the Greenhouse-Geisser correction, thus resulting in some cases in which degrees of freedom are not whole numbers. The ANOVA revealed the presence of a main effect of day, $F(1, 43) = 54.58$; $p < .001$; effect size $\omega^2 = 0.17$. Although there was no main effect of time, $F(1.62, 69.78) = 2.28$; $p > .10$, the interaction of day × time was significant, $F(1.51, 65.05) = 6.00$; $p < .01$; $\omega^2 = 0.04$. These analyses indicate that cortisol levels were higher on the competition day compared to the control day and that patterns for cortisol across the three time points increased over time on the competition day but slightly decreased over time on the control day.

Psychologically during the competition, dancers' peak perceived stress rating was positively correlated with their peak cortisol levels, $r(42) = .32$, $p < .05$. In addition, the more factors a dancer endorsed as stressful during the competition, the higher his or her peak cortisol, $r(42) = .36$, $p < .05$. In particular, the stress factor most relevant to social-evaluative threat—the judges in the competition—related to peak cortisol response in the dancers. Dancers who endorsed the judges as stressful had higher peak cortisol levels than dancers who did not find the judges to be stressful, $t(42) = 2.04$, $p < .05$. Lastly, the more satisfied dancers were with their performance, the lower their peak cortisol levels, $r(43) = -0.34$, $p < .05$.

To investigate the possible impact of subjective and objective performance during the competition on cortisol recovery, we calculated correlations between rank and points during competition (objective performance) and satisfaction with performance and the cortisol levels at 2, 4, 6, and 8 hours after the end of the tournament. There were no significant correlations (all $r < .20$). We further constructed a variable in which we coded whether participants' cortisol levels had returned to baseline after 2, 4, 6, or 8 hours. There were no associations of this variable with performance parameters (all $r < .20$), indicating that subjective and objective performance and satisfaction did not influence the recovery of the HPA axis.

The findings of Study 1 support our hypothesis that the competitive situation of ballroom dancing serves as powerful real-life stimulus affecting the HPA axis and resulting in a significant stress-induced cortisol response. The day of saliva collection (competition vs. control) accounted for 17% of the variance in cortisol levels. Our results are consistent with the meta-analysis of Dickerson and Kemeny (2004), which found that laboratory stress tasks characterized by social-evaluative threat and uncontrollability elicit elevated cortisol secretion. The present study extended these findings to real-life social-evaluative threat situations and provides an example of a threat that likely reflects an important aspect of these participants' self-identity (competition performance for a competitive ballroom dancer).

Our psychological data also provide general support for social self-preservation theory. Having a central goal threatened in an important performance situation—as indicated by perceiving a greater number of factors during the dancing competition as stressful—was associated with higher peak cortisol levels. Lower satisfaction with performance was also associated with higher peak cortisol levels. We hypothesize that this association reflects that dancers who performed better subjectively or objectively felt the situation as less stressful and the judges less threatening and consequently showed a lower HPA axis activation. Finally, perceiving social-evaluative threat—finding the judges to be stressful—was associated with higher peak cortisol levels. These findings provide suggestive evidence for the hypothesis that threatening a central goal through social evaluation activates the physiological stress system involving the HPA axis.

The fact that 6 hours prior to competition salivary cortisol levels already began to increase is also interesting. Even before the competition began, anticipated negative evaluations from judges, the other competitors, and/or audience members may have posed a meaningful social-evaluative threat. Thus, the increase may reflect heightened anticipatory anxiety about the upcoming competition. Alternatively, it may reflect preparations that relate to the competition and serve as reminders about the competition, such as preparing one's makeup, hair, and driving to the competition site. This anticipation of the competition may have increased the dancers' preparatory response, which then was expressed in elevated hormone secretion (Hellhammer, Kirschbaum, & Lehnert, 1988; Rose, 1984). It would have been interesting to assess whether the performance in a previous tournament impacted the height of this anticipatory cortisol increase. Unfortunately, these data were not available in the present study.

Overall, Study 1 demonstrated the activation of a biological stress response under real-life conditions of social-evaluative threat. In Studies 2 through 5, we identify specific characteristics that are related to this biological social-evaluative threat response.

STUDY 2

In Study 2, we tested an alternative hypothesis that the cortisol elevation on competition days is due to the physical strain of ballroom dancing. We did this by comparing cortisol levels during a training day with levels during a control day.

Study 2 Method

Participants

In this study, 16 competitive ballroom dancers from Germany, 8 men and 8 women, all amateurs, participated. The 21- to 55-year-old participants were recruited by one of the authors (S.B.) and did not receive payment for their cooperation.

Materials

All samples were collected into Salivettes (Sarstedt; Nümbrecht, Germany) and kept cool in the refrigerator until analysis. Electronic monitors were not used in this study as the number of samples was small compared to Study 1, and the collection of training samples was observed by one of the authors (S.B.), so compliance is known. Salivary cortisol samples were analyzed biochemically using CLIA in the same manner as described in Study 1.

Procedure

Participants took part in a modern simulated competition carried out at 7 p.m. in the regular training hall, well known by all athletes. Each of the five dances was performed for 1.5 to 2 minutes, with a break of the same

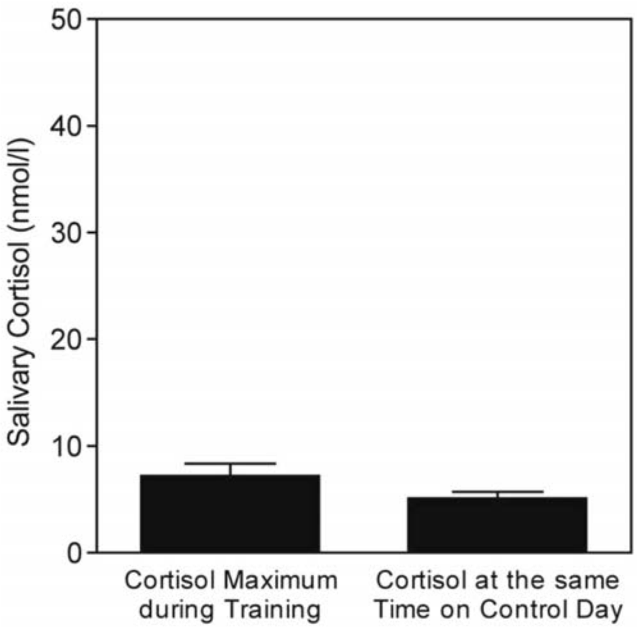

Figure 2 Salivary cortisol maximum during training and at the same time on a control day in Study 2.

length in between. After this first round, the same procedure was repeated once more as a second round to mirror competition circumstances. Consequently, the athletes were placed in the same physical state as during real contests. During this training period, participants collected three salivary samples at similar intervals to Study 1; immediately before starting the first round, right after the first round, and at the very end of the second round. Participants were also asked to collect a fourth saliva sample at 7 p.m. on a control day without training.

Study 2 Results and Discussion

Salivary cortisol levels measured by each of the participants during training in a simulated competition were averaged. As depicted in Figure 1, these mean values are quite low from the beginning of the first round up to the end of the second round and represent normal values typically observed in a healthy population (Kirschbaum & Hellhammer, 2000). The cortisol values during a training session are also significantly lower than the values during a competition day from Study 1. The 3 (time: beginning Round 1 vs. ending Round 1 vs. ending Round 2) × 2 (day: competition day vs. training day) ANOVA revealed the presence of a main effect of day, $F(1, 11) = 13.49$, $p < .01$; $\omega^2 = 0.15$, and a main effect of time, $F(1.19, 13.11) = 4.54$, $p < .05$; $\omega^2 = 0.09$. The interaction of Day × Time was not significant, $F(1.28, 14.05) = 4.13$, *n.s.*

We also compared the training cortisol values to values measured at the same time on the control day. To do this, we selected each participant's salivary cortisol maximum during training to compare to the control day value. A paired-samples t test revealed no statistically significant difference between the cortisol maximum during training and the cortisol level at the same time on the control day $t(15) = 2.10$, *n.s.* See Figure 2.

The results of Study 2 demonstrate that the physical strain of ballroom dancing does not account for the activation of the HPA axis and the increased salivary cortisol levels seen during dancing competitions. Competitive dancers undergoing the same number of dances did not show elevations in cortisol on a training day compared to a nontraining day, and cortisol levels were lower than on the competition day. These findings are in accordance with the literature, which suggests that only physical exercise above a threshold of 75% of maximal oxygen uptake and of at least 30 minutes duration successfully stimulates the HPA axis (O'Connor & Corrigan, 1987; Tremblay et al., 2005). Due to the short duration of each round (6 to 7 minutes) and the breaks between rounds, it is highly unlikely that ballroom dancing produced physical exertion of this level. We cannot exclude the possibility that dancers put more effort into their performance during a real-life competition as compared to a training session, even if the participants were willing to fulfill our instruction to dance with the same effort during our simulated tournament of Study 2. It may therefore be argued that the higher cortisol output during competition is caused by a potentially higher physical effort in the real-life conditions. Apart from the fact that the physical activity is below the threshold for HPA axis activation (O'Connor & Corrigan, 1987; Tremblay et al., 2005), it is highly improbable that a slightly higher physical effort can account for the huge difference observed in our study. Instead, these results provide suggestive evidence that the psychological (rather than physical) characteristics of competitive dancing, such as the social-evaluative threat involved, may better account for the physiological profiles observed during competition.

STUDY 3

The goal of Study 3 was to determine whether cortisol responses to social-evaluative threat conditions habituate over time. Because it was not possible to assess dancers during the first tournament in their lives, we chose to test this by assessing dancers' cortisol responses over the course of three subsequent competitions and also by comparing cortisol responses of dancers with different experience levels.

Study 3 Method

Participants

In the first part of the study, 16 competitive ballroom dancers, ages 20 to 62 years, were asked to participate. All participants were amateurs, and 8 were women and 8 men. Their experience averaged 131.25 ballroom competitions over the past 8.2 years on an average. Participants were not paid for this study. In addition, data of the 44 participants of Study 1 were reanalyzed here.

Materials

All samples were collected into Salivettes (Sarstedt; Nümbrecht, Germany) and kept cool in the refrigerator until analysis. Electronic monitors were not used in this study as samples were only taken during competitions, and thus the number of samples was many fewer than in Study 1. Salivary cortisol samples were analyzed biochemically using CLIA in the same manner as described in Study 1.

Procedure

Athletes obtained salivary samples at three different tournament competitions with intervals of about 2 weeks in between. Only competitions of the same rank (in terms of importance) were used in this study so that the three competitions would be of equivalent types. Samples were collected at three times, shortly before the beginning, after the first round, and at the very end of each competition.

Study 3 Results and Discussion

Salivary cortisol concentrations were averaged separately for each of the three measuring times during each of the three competitions. Figure 3 (A) reveals few differences in the extent of cortisol peaks after the first round at a first (T1), second (T2), and a third tournament (T3).

To test statistically whether there was a significant difference between the stress-induced cortisol responses at repeated measurements, we submitted the data to a 3 (tournament: T1 vs. T2 vs. T3) × 3 (time: beginning vs. ending Round 1 vs. very end) ANOVA. First we employed the Mauchly test of sphericity. If this test was significant, we used the Greenhouse-Geisser correction. Analysis revealed only the presence of a main effect of time, $F(2, 18) = 4.11$; $p < .05$; $\omega^2 = 0.06$, whereas there was no main effect of tournament, $F(2, 18) = 0.85$; $p > .4$. The interaction of tournament by time also was not significant, $F(1.46, 13.11) = 0.88$; $p > .4$. These results indicate that the cortisol response is highest at the beginning of the competition compared to the middle or end of competition but that cortisol responses do not change across repeated competitions.

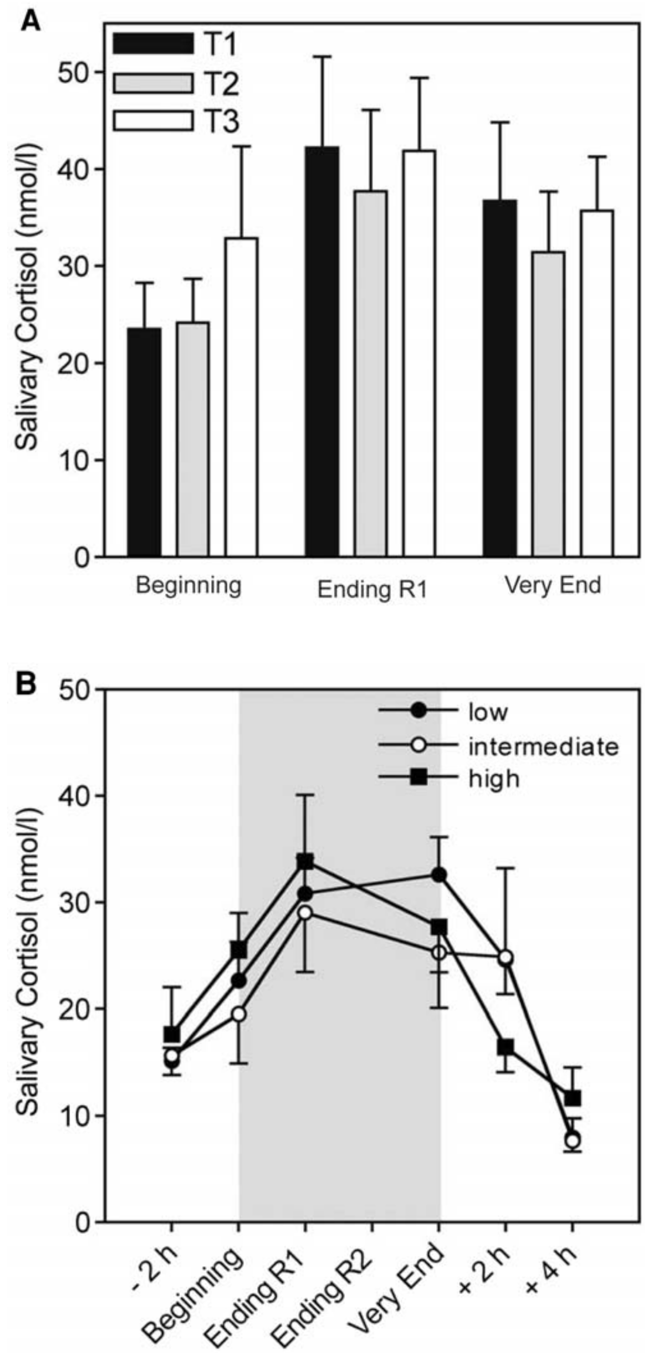

Figure 3 (A) Salivary cortisol repeatedly measured at three competitions (T1, T2, T3) at the beginning of the competition, at the end of Round 1, and at the end of the competition in Study 3. (B) Salivary cortisol responses of participants of Study 1 divided into three groups with different experience levels (low: < 80 competitions; medium: 80 to 173 competitions; high: > 173 competitions).

Because habituation of HPA axis responses may have occurred much earlier than in the three tournaments tested here, we reanalyzed the data of Study 1 participants with a focus on different experience levels. If habituation would have occurred, cortisol responses of less experienced dancers would be expected to be higher than those of more experienced dancers. We therefore split the participants into three equal groups with low (< 80 competitions), medium (80 to 173 competitions), and high (> 173 competitions) experience (see Figure 3B). We conducted a 3 (experience: low vs. medium vs. high) × 3 (time: beginning vs. ending Round 1 vs. very end) ANOVA. Analysis revealed a main effect of time, $F(2, 80) = 6.53$; $p < .05$, but no main effect of experience, $F(2, 40) = 0.42$; $p > .6$, and no interaction of experience by time $F(2, 80) = 0.62$; $p > .6$. To control for the possibility that more experienced dancers could be older, we added age as a covariate to the same analysis. There was no significant main effect of age, $F(1,40) = 1.68$; $p > .2$, and no interaction of age with time $F(2, 80) = 1.58$; $p > .2$. The main effect of experience $F(1, 40) = 0.26$; $p > .7$, and the interaction of experience and time $F(2, 80) = 0.36$; $p > .8$, remained insignificant after adding age as a covariate.

These results provide evidence for a lack of habituation of the psychophysiological stress response to the competitive situation of ballroom dancing. That is, each competition produced a similar pattern of increase in cortisol; patterns did not diminish in subsequent competitions and did not differ between dancers with different experience levels.

The human goal of social self-preservation may be a central enough goal that the social-evaluative threat response does not habituate but instead remains responsive to repeated threats over time. For a competitive ballroom dancer, any time a tournament takes place, there is the potential to be negatively evaluated and to lose social status in a domain that is important to a competitive dancer, and thus the HPA axis may be repeatedly activated each time this situation arises. This interpretation is limited by the fact that the analyses conducted here do not allow to assess the psychophysiological response to the first ever tournament as the least experienced couple in our study had absolved 24 tournaments before participating in our experiment. We can therefore not exclude the possibility that a first ever cortisol response would have been higher than the levels seen here. On the other hand, we were able to document that psychophysiological responses have at least reached a plateau level without further changes in either direction. A successful habituation of physiological responses would imply a steady decrease of responses that should have led to a total abolishment of responses at least in highly experienced dancers.

STUDY 4

In Study 4, we tested whether the cortisol response to a social-evaluative threat varied depending on the focus on the individual. Specifically, we investigated whether decreasing the individual focus in social evaluation conditions would reduce the cortisol response. We tested this question by comparing the cortisol responses of dancers competing in group (formation dancing) competitions versus individual couple competitions.

Study 4 Method

Participants

A modern dancing formation group from the region of Nordrhein-Westfalen in Germany was requested to join in this study. Because 1 of the dancers declined to participate, a total of 15 dancers, 8 men and 7 women aged between 22 and 42 years, participated. The athletes' experience in formation contests ranged widely from 3 months to 20 years and from 1 to 76 tournaments. On an average, they had participated in 25.47 competitions in the past 7.3 years. All participants were amateurs. Each participant received 10 Euros and his or her personal cortisol profile for participating.

Materials

Salivary cortisol samples were obtained using Salivettes (Sarstedt; Nümbrecht, Germany) and were kept cool in the refrigerator until analysis. To monitor compliance with the salivary cortisol collection protocol, we used the electronic drug exposure monitors described in Study 1. If any saliva collection occurred more than 20 minutes before or after the specified time, participants were asked to repeat the entire saliva collection protocol on another control or competition day. Thus, all data analyzed in this study are based on samples with 100% compliance with the study protocol. Salivary cortisol samples were analyzed biochemically using CLIA in the same manner as previous studies.

Procedure

Similar to Study 1, participants had to obtain salivary samples throughout a competition day and a control day without any dancing. In contrast to the single couples of Study 2, whose tournaments were at different days and times, all formation dancers as part of the same group logically have to perform at the same days and times. Therefore, measuring times were exactly the same for all of the athletes. Participants were asked to collect a total of 23 samples, 13 during the competition day and 10 during the control day (at identical times, except no saliva collection at the end of Round 1, end of Round 2, or end of competition).

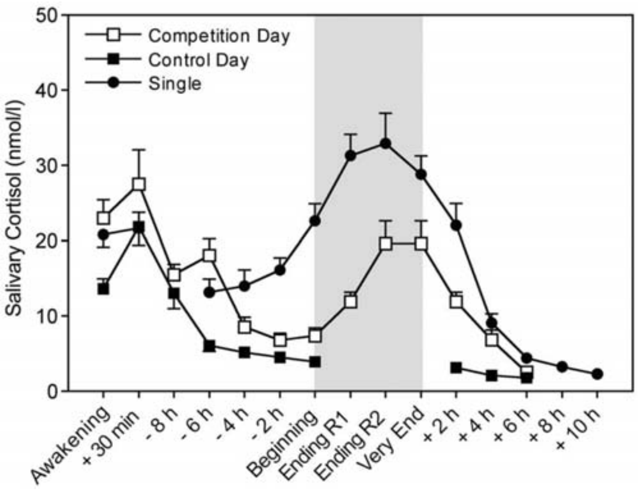

Figure 4 Mean salivary cortisol profile on the group competition day in comparison to the control day in Study 4 and in comparison to cortisol responses of dancers in a single competition.

Formation dancing contests. Single and formation dancing contests follow identical main principles. In formation contests, a team consists of eight couples. Similar to single contests, all of these couples perform five dances for a total duration of 5 to 6 minutes. Each team's program consists of an individually arranged mixture of the five modern or Latin dances. As each program represents an individually composed performance, there are no breaks between the dances. One major difference in formation contests is that before the tournament actually starts, each of the participating teams has to perform its program in front of the judges, who check if the program meets set rules regarding duration of music, number of certain figures, and so on. This test run also allows the team to become familiar with the dance floor.

Study 4 Results and Discussion

As depicted in Figure 4, the control day is characterized by a typical mean salivary cortisol profile with awakening response and constantly decreasing values throughout the day, whereas on the competition day, two additional cortisol peaks can be observed, one coinciding with the competition and one with the test run in front of the judges. In addition, 6 hours after the competition, cortisol concentrations return to the same levels as on the control day.

To test the significance of these differences in mean salivary cortisol values on the competition day and on the control day, we conducted a 3 (time: –2 hours vs. beginning vs. +2 hours) × 2 (day: competition day vs. control day) ANOVA, identical to our approach in Study 1. We first employed the Mauchly test of sphericity. If this test was significant, we used the Greenhouse-Geisser correction. There was a main effect of day, $F(1, 14) = 35.92$; $p < .001$; $\omega^2 = 0.28$; a main effect of time, $F(2, 28) = 6.41$; $p < .01$; $\omega^2 = 0.11$; and a significant interaction of Day × Time, $F(2, 28) = 11.30$; $p < .001$; $\omega^2 = 0.19$. These findings indicate that cortisol levels were higher during group competition compared to a control day and that, overall, cortisol levels increased over time but that this increase occurred specifically on competition day (the interaction of Day × Time).

The next step was to compare the mean salivary cortisol profile of the formation dancers found in this study with those of the single couple dancers investigated in Study 1. As shown in Figure 4, both groups of participants show considerable cortisol responses to the competitive situation, but much more striking was the single couple dancers' cortisol maximum of 35.2 nmol/l compared to the formation dancers' maximum of 19.6 nmol/l measured at the same time. A 6 (time: –2 hours vs. beginning vs. ending Round 1 vs. ending Round 2 vs. very end vs. +2 hours) × 2 (dancers: single vs. formation) ANOVA was conducted. Analysis revealed the presence of a main effect of dancers, $F(1, 57) = 10.88$; $p < .01$; $\omega^2 = 0.03$; and a main effect of time, $F(2.66, 151.52) = 9.37$; $p < .001$; $\omega^2 = 0.10$. The interaction of Dancers × Time was not significant, $F(2.66, 151.52) = 1.75$; $p > .15$. These findings indicated that individual couple dancers had higher cortisol levels than group formation dancers and that cortisol levels rose and then fell over time.

These data support our assertion that the same kind of stressor, namely, social-evaluative threat in ballroom dancing competitions, is more powerful in eliciting psychophysiological stress responses when the athletes are faced with it as part of a 2-person couple than as a team of 16 people. The day of saliva collection (competition vs. control) accounted for 28% of the variance in cortisol responses; in addition, the type of dancer (couple vs. group) accounted for 3% of the variance in cortisol responses. Although not a large effect, the results of Study 4 suggest that the more a social-evaluative threat is focused on an individual, the greater the cortisol response will be. It may also be the case that the group formation dancing provides a means of social support and that this social support mitigates the effects of social-evaluative threat on the HPA axis.

STUDY 5

In Study 5, we compared the cortisol response to social-evaluative threat in a real-life situation versus a laboratory situation. We did this by comparing the cortisol response during competitive ballroom dancing to the response to a standardized social-evaluative laboratory stressor (the Trier Social Stress Test, TSST; Kirschbaum et al., 1993). Given the premise that the centrality of a goal is important to the magnitude of the physiological social-evaluative threat response, we hypothesized that competitive ballroom dancing would elicit a larger cortisol response than a laboratory social evaluative stress task. To control for the possibility that the social evaluation during the TSST is a threat to a less important goal in ballroom dancers, we compared their responses to a group of university students' TSST responses. For the latter, the TSST is of relatively high importance due to its similarity to oral academic examinations.

Study 5 Method

Participants

We recruited 17 competitive modern dancers, 8 men and 9 women, all amateurs, from different clubs located in the region of Sachsen in Germany. They were between 14 and 24 years of age and received 30 Euros for their participation. As a control group, we recruited 20 university students, 10 men and 10 women (age ranging from 19 to 29 years), who received 15 Euros for participation.

Materials

Cortisol measures. All samples were collected into Salivettes (Sarstedt; Nümbrecht, Germany) and kept cool in the refrigerator until analysis. Because the collection of all salivary samples was observed by one of the authors (so compliance is known), there was no need for using electronic monitors. Salivary cortisol samples were analyzed biochemically using CLIA in the same manner as described in Study 1.

Trier Social Stress Test. This tool for investigating moderate psychological stress in a laboratory setting consists of an anticipation period and a test period in which the participants have to perform a free speech and mental arithmetic in front of an audience. Participants are told that the two panel members and independent experts will evaluate their performance with a focus on nonverbal indicators of stress. Participation in this stress task leads to considerable changes in multiple subjective and biological response systems, including ACTH and cortisol (Kirschbaum et al., 1993).

Procedure

Dancers were asked to obtain three saliva samples on a competition day: before the first round, after the first round, and at the very end of the tournament. All competitions took place in the morning or in the afternoon. In the following week, these same participants were invited to the laboratory to participate in the TSST. They collected three salivary samples at corresponding times, specifically, before the TSST, 10 minutes after the TSST, and 20 minutes after the TSST. The control group of university students underwent the same TSST protocol as the dancers.

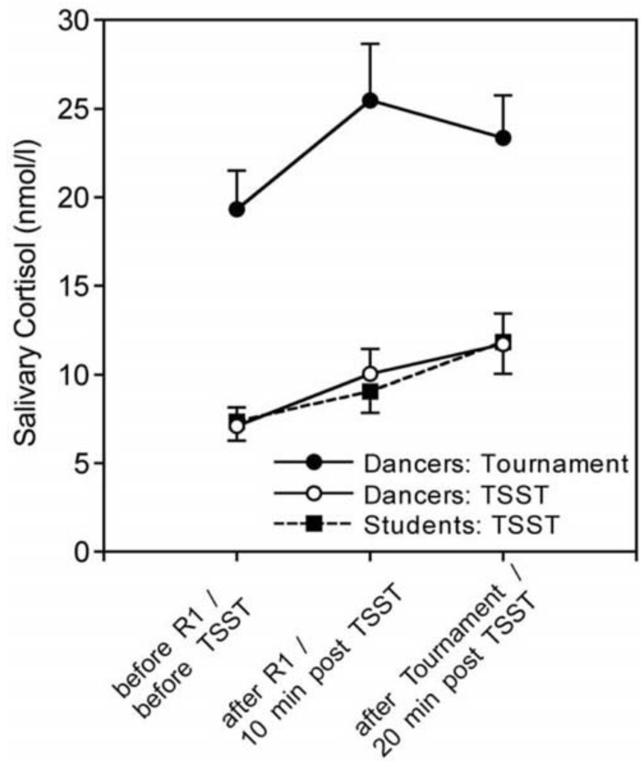

Figure 5 Salivary cortisol of ballroom dancers measured at three times during the competition and during the Trier Social Stress Test and cortisol responses to the Trier Social Stress Test in university students in Study 5.

Study 5 Results and Discussion

Salivary cortisol levels were averaged separately for each of the three measuring times during the tournament and during the TSST for dancers and for each of the times for university students. As depicted in Figure 5, cortisol concentrations measured before, during, and after the tournament are all larger than those measured before and after the TSST.

Because it is not possible to assess cortisol responses of university students in a ballroom dancing tournament, the experimental design is incomplete. We therefore decided for a two-step analysis. In a first step, we tested whether ballroom dancers' cortisol responses to the TSST differed from those of university students.

A 3 (time: before Round 1/before TSST vs. after Round 1/10 minutes after TSST vs. after tournament/20 minutes after TSST) × 2 (group: ballroom dancers vs. university students) ANOVA revealed a significant main effect of time, $F(1.19, 41.66) = 13.2$; $p < .001$; $\omega^2 = 0.18$; but no main effect of group, $F(1, 35) = 0.02$; $p = .89$; and no Group × Time interaction, $F(1.19, 41.66) = 0.30$; $p = .62$. This first analysis shows that there is no difference in cortisol responses to the TSST between ballroom dancers and university students, underscoring that this laboratory stress protocol is an appropriate method to induce social evaluative stress in ballroom dancers.

To test whether cortisol responses to TSST differed between responses to a real-life stress of a tournament in ballroom dancers, a 3 (time: before Round 1/before TSST vs. after Round 1/10 minutes after TSST vs. after tournament/20 minutes after TSST) × 2 (type of stressor: tournament vs. TSST) ANOVA revealed the presence of a main effect of kind of stressor, $F(1, 16) = 35.17$; $p < .001$; $\omega^2 = 0.25$; and a main effect of time, $F(2, 32) = 7.70$; $p < .01$; $\omega^2 = 0.12$. The interaction of kind of Stressor × Time was not significant, $F(2, 32) = 2.06$; $p > .10$. These findings indicate that a real-life social evaluative stressor elicits larger cortisol responses than a laboratory social evaluative stress task when compared within the same individual. This supports the theory that threatening a goal that is more central to an individual (an evaluative tournament for a competitive ballroom dancer) will evoke a larger cortisol response than a laboratory stressor that is evaluative but that may not be tapping a central goal (public speaking stressor for a competitive ballroom dancer).

GENERAL DISCUSSION

Overall, this set of studies provided support for the theory of a social self-preservation system. Our studies demonstrated that a real-life social-evaluative performance stressor of competitive ballroom dancing elicits a large psychophysiological threat response as indicated by elevated cortisol levels. We documented that this biological stress response is not due to the physical strain of dancing, does not habituate across competitions, is dependent on the extent to which the individual is focused on during the evaluation, and is greater in magnitude than the response documented during laboratory stressors. In the following sections, these findings are discussed in greater detail.

Competitive Ballroom Dancing: A Paradigm for Social-Evaluative Threat

The data of the present work clearly show that ballroom dancing tournaments serve as powerful stimuli affecting the HPA axis and leading to large cortisol releases. The presence or absence of a competition tournament accounted for 17% to 28% of the variance in cortisol responses in Studies 1 and 4. These cortisol increases are similar to the fight-or-flight response to physical stress (Cannon, 1915). However, in the competitive ballroom dancing situation, the cortisol responses are not due to physical stress (see Physical Versus Psychological Stressors section in the following). Rather, the magnitude of the response appears to be driven more strongly by psychological factors. In our first study, overall perceived stress level, perceiving more aspects of the competition to be stressful, and performance satisfaction were all correlated with peak cortisol level during the competition.

These findings suggest support for the notion of a social self-preservation system (Dickerson et al., in press; Dickerson & Kemeny, 2004; Kemeny et al., 2006). These competitions meet the criteria for a social-evaluative threat in that there is a central goal (being an elite dancer) that could be threatened by a poor performance on the part of the dancer and negative social evaluations of others (judges, other competitors, audience members). According to social self-preservation theory, the detection of a salient social-evaluative threat results in physiological (as well as psychological) responses such as activation of the HPA axis.

The centrality of the goal of being an elite dancer and the relevance of dancing skills to their self-identity is evident in the fact that these athletes spend most of their time and financial resources on their dancing career. As with other competitive athletes, these dancers organize their lives around training and competing in dance tournaments. The threat to this goal is evident in that lower performance satisfaction and perceiving the judges (the primary social evaluative force) to be stressful were both associated with higher cortisol levels.

Overall, these results are consistent with laboratory studies that have demonstrated the necessity of social evaluation for evoking a cortisol response on a motivated performance task (Dickerson & Kemeny, 2004). However, the results extend this literature to real-life social-evaluative threats and, in so doing, allowed us to determine the characteristics of real-life social-evaluative threats that are important in evoking a physiological threat response.

Physical Versus Psychological Stressors

The results of Study 2 demonstrated that competitive ballroom dancing does not rank with those sports that are accompanied by HPA axis activation due to physical strain. Although we cannot exclude that participants danced with a slightly higher physical effort during a real-life compared to a simulated competition, and although we were not able to objectively assess physical strain, the literature suggests that only a small, if any, part of the huge cortisol difference between training and competition is attributable to the physical part of the exercise.

This suggests that in the case of competitive ballroom dancing, the elements responsible for the heightened cortisol profile are the psychological rather than the physical characteristics of the competition.

Habituation of the Stress Response

In Study 3, we were able to demonstrate that competitive ballroom dancers do not show signs of habituation of the physiological response to social-evaluative threat. Although we could not assess the cortisol response to a first ever competitions, we showed that across multiple competitions, dancers' cortisol profiles were similar, that the cortisol response did not diminish during subsequent competition, and that experience level did not influence the height of the cortisol response. Previous research has demonstrated that physical stressors also produce this type of pattern of repeated cortisol increases over time (Cook et al., 1986; Mason et al., 1973). In contrast, psychological social-evaluative stressors in the laboratory produce a pattern of habituation of the cortisol response as they are repeated over time (Kirschbaum et al., 1995), perhaps because laboratory stressors tap less central goals. In addition, other types of psychological stressors have responses that habituate over time with repeated exposure (e.g., treatment for specific phobias), and physiological responses to situations that may be feared have been found to habituate over time (Antony & Swinson, 2000; Barlow, 2002; Deinzer et al., 1997). In this case, an extreme fear response (phobia) to stimuli such as heights may be maladaptive, and exposure therapy may help create a more realistic appraisal and response to fearful situations. In contrast, to the extent that responses to social-evaluative threats represent a fundamental drive to preserve the social self, this response system may not be mitigated over time for real-life threats. In this regard, the response to social-evaluative threat may be more similar to the response to physical stress (activating the fundamental drive to preserve the physical self) that also does not habituate over time.

Individual Focus During Social-Evaluative Threats

The results of Study 4 revealed that the amount of focus on an individual under conditions of social-evaluative threat affects the physiological stress response. Cortisol response during group formation dance competition was lower than the cortisol response of dancers who competed in individual couple dance competitions. This suggests that humans are sensitive to the attention they receive during social-evaluative threats and that more focused evaluative attention results in greater activation of one's threat response systems, including the HPA axis. The larger the group of people sharing the total responsibility for their dancing performance, the smaller the threat of losing social esteem and status in each team member. This finding has parallels to previous research demonstrating that laboratory stressors involving multiple social-evaluative components (more intense evaluation focused on the individual) produce a greater cortisol response than stressors that involve a single social-evaluative component (Dickerson & Kemeny, 2004). Overall, these findings suggest that the physiological threat response system is not an all-or-none system; rather, responses can occur along a continuum, depending on the extent of focus on the individual during a social-evaluative threat.

An alternative explanation for these findings is that group formation dancing provides a form of social support to dancers during competition. Thus, these patterns might indicate a stress-buffering effect of social support. Social support in a number of previous studies has been found to reduce physiological responses to stress and to be beneficial for health (Berkman & Syme, 1979; House, Landis, & Umberson, 1988; Isacsson & Janzon, 1986; Kamarck, Manuck, & Jennings, 1990; Lepore, Allen, & Evans, 1993).

These findings may also be discussed with respect to the phenomenon of social loafing. When individuals work alone they tend to put out greater effort than when working with others (Latane, Williams, & Harkins, 1979). According to Williams, Harkins, and Latane (1981), the phenomenon of social loafing is most prominent when individuals feel that their performance is not individually evaluated. It could therefore be argued that dancers during a group competition tend to put out less (physical) effort and that this may be the cause of lower cortisol responses. This is, however, rather improbable. First, the duration of physical output is below the threshold for HPA axis activation in group and single competitions, as well as during training, so that subtle differences in physical strain, which may indeed occur, cannot be expected to account for the huge differences between the conditions seen here. Second, the group competition in ballroom dancing is not totally comparable to the experiments by, for example, Williams et al. as the single dancer's performance is not less intensely evaluated in a group compared to a single competition. Evaluation comes from the judges, the partner and the other participants in the group, and additional people in the audience, such as other competitors and coaches. It may therefore be questioned to which extent social loafing occurs during group competition. Unfortunately, we have no data to statistically compare the extent and impact of social loafing here.

The results of Study 4 also revealed two peaks in the group formation dancers' salivary cortisol profile on the competition day. These peaks revealed that both the competition as well as the test run in front of the judges increased cortisol levels. Although the extent to which the dancing program meets fixed rules of performance is the only aspect judged during the test run, this situation still involves a form of social evaluation. The threat of social evaluation may be less given that only the presence or absence of objective characteristics of the dance program are evaluated and not the quality of the performance. Thus, the cortisol peak may be indicative of a social-evaluative threat but smaller during the test run than during competition, indicating social-evaluative threat of a lower magnitude. Again, this pattern suggests that the social-evaluative threat system operates along a continuum, depending on the extent of the threat.

Real-Life Versus Laboratory Stressors

Study 5 demonstrated that the cortisol response to social-evaluative threat is markedly stronger during real-life stressors compared to laboratory stressors. Although both are considered psychological stressors that evoke social-evaluative threat, cortisol responses to real-life stressors are approximately twice as high as that found during acute laboratory stressors. The magnitude of response to laboratory stressors in this study is similar to that reported in earlier studies (Kirschbaum et al., 1993). It may be that real-life stressors tap goals that are more central to a participant's self-identity. For example, a dancing competition to a competitive ballroom dancer has the potential to threaten a central goal of being an elite dancer and takes place in a public forum where loss of status may be very salient. In contrast, a laboratory public speaking task, although evaluative, may not be perceived as tapping a central life goal for many research participants; in addition, loss of social status may not feel as publicly salient given the confidentiality surrounding research participation.

Health Consequences of Social-Evaluative Threat

What are the health consequences of repeatedly experiencing a physiological response to social-evaluative threat? Allostasis, the ability to maintain physiological stability in response to changing environmental states, is critical to the survival of the organism (McEwen, 2000). Internal and external challenges must be responded to by turning on allostatic systems (e.g., HPA axis) to grant optimal adaptation to existing conditions. When the threat is passed, the stress responses have to be shut off. Excessive demands on the allostatic system over weeks, months, or even years result in allostatic load with pathophysiological consequences (McEwen, 2000). According to the allostasis model (McEwen, 1998), the competitive ballroom dancers examined in the present work may suffer from a mixture of two types of allostatic load, namely, "repeated hits" and "lack of adaptation." The athletes show stress-induced cortisol increases whenever a tournament takes place, which is quite frequently, and do not habituate to this stressor. These allostatic load patterns over time are thought to increase the risk for negative health outcomes, such as diabetes, hypertension, and cardiovascular disease (McEwen, 1998).

In our sample of competitive dancers, there was a large increase in cortisol on the competition day. However, the values rapidly returned to baseline so that the entire interval of time in which stress effects occurred covered 6 to 8 hours (single dancers) and 10 to 12 hours (formation dancers), respectively. Because the cortisol profiles of the athletes on the control day did not differ from those of healthy adults, the competitive situation may be a time-limited form of repeated episodic stress. In addition, because these dancers seek out this type of social-evaluative situation (they choose to compete in ballroom dancing), there may be a number of positive consequences of training and competing. Thus, the long-term effects of repeatedly experiencing this type of social-evaluative situation are unclear and are an important topic for future research.

Given that this competitive situation is sought out by the dancers, there may be parallels to the concept of "sensation seeking" (Zuckerman, 1979). Participants high on sensation seeking often engage in physically risky activities; seek to enlarge their life experiences through traveling, music, art, or drug use; and strive for social stimulation. Although competitive athletes do not show all of the aforementioned characteristics, they may nonetheless possess a high need for seeking and mastering new challenges relative to the average population. Perhaps dancers with these drives who seek out competitive situations are promoting their physical and mental health by fulfilling these drives.

Limitations and Future Directions

Limitations to our study include the general questions regarding psychological states among the dancers. Given the real-life competitive environment, we could only include a very brief set of psychological questions to have a protocol that would be logistically feasible for the dancers. Although we could have asked more lengthy questions at the end of the day (once the competition was over), research has shown that recall of specific psychological states does not correspond well to responses obtained on a momentary basis (Stone, Broderick, Shiffman, & Schwartz, 2004; Stone et al., 1998). We preferred more immediate reactions to the competition and thus were limited to a few brief questions. As a result, our psychological battery contained several simple perceived stress questions. Future studies that are able to conduct more elaborate assessments of goals, perceived social-evaluative threat, and emotional responses to social-evaluative threat (i.e., shame) will allow for a stronger test of social self-preservation theory.

Another limitation is the fact that we were not able to objectively assess the physical strain during competitions versus training sessions. Although it is highly improbable that physical activity of such short duration as in the tournaments investigated induce a cortisol response of such a magnitude reported here, without an objective assessment, this cannot be finally excluded. It will therefore be an important task for future studies to find ways to objectively measure physical effort in real-life situations without disturbing the natural setting. In the present study, the assessment of oxygen consumption or the sampling of blood for lactate determinations would have been impossible. None of the dancers had agreed to blood sampling, as most of them feared a too strong influence on their performance.

Furthermore, our finding of a missing habituation of the cortisol response has to be interpreted with caution. Although our data clearly show that there is no change in psychophysiological reactivity over repeated tournaments and that different experience levels are not associated with different responses, we were not able to assess the response to a first ever ballroom dancing competition. It cannot be excluded that cortisol responses were much higher during the first tournament in a dancer's life. On the other hand, as the responses observed in our studies seem to have reached a stable level that is much higher than responses to all known laboratory stress tasks (Dickerson & Kemeny, 2004), one can safely conclude that a sufficient habituation of the stress response has not taken place.

In addition, future studies that allow researchers to determine the conditions under which social-evaluative threat is adaptive and conditions under which it is detrimental would further our understanding of the role of the social self-preservation system in everyday life. For example, testing whether repeated physiological responses to social-evaluative threat have negative effects on long-term health outcomes would provide important information about the health implications of social-evaluative threat. In addition, determining whether negative health consequences occur for all social-evaluative situations or for only certain types (e.g., social-evaluative situations that are not sought out by the individual) would be an important future research question.

In sum, the present set of studies documented a robust physiological stress response to social-evaluative threat in a real-life context. The cortisol response to a competition day for ballroom dancing was greater than on a control day. This response to a social-evaluative stressor was not due to the physical strain of dancing, did not habituate across competitions, and was affected by the extent of focus on the individual during the evaluation period. Moreover, the physiological stress response was greater during ballroom dancing competition than during a laboratory stressor, highlighting the importance of conducting future studies in real-world settings to further test the notion of a social self-preservation system that is responsive to threats to the social self.

REFERENCES

Antony, M. M., & Swinson, R. P. (2000). *Phobic disorders and panic in adults: A guide to assessment and treatment*. Washington, DC: American Psychological Association.

Barlow, D. H. (2002). *Anxiety and its disorders: The nature and treatment of anxiety and panic* (2nd ed.). New York: Guilford.

Bassett, J. R., Marshall, P. M., & Spillane, R. (1987). The physiological measurement of acute stress (public speaking) in bank employees. *International Journal of Psychophysiology*, *5*, 265-273.

Baumeister, R. F., & Leary, M. R. (1995). The need to belong: Desire for interpersonal attachments as a fundamental human motivation. *Psychological Bulletin*, *117*, 497-529.

Berkman, L. F., & Syme, S. L. (1979). Social networks, host resistance, and mortality: A nine-year follow-up study of Alameda County residents. *American Journal of Epidemiology*, *109*, 186-204.

Blascovich, J., & Tomaka, J. (1996). The biopsychosocial model of arousal regulation. *Advances in Experimental Social Psychology*, *28*, 1-51.

Cannon, W. B. (1915). *Bodily changes in pain, hunger, fear and rage: An account of recent researches into the function of emotional excitement*. New York: Appleton.

Cook, N. J., Read, G. F., Walker, R. F., Harris, B., & Riad-Fahmy, D. (1986). Changes in adrenal and testicular activity monitored by salivary sampling in males throughout marathon runs. *European Journal of Applied Physiology*, *55*, 634-638.

Cook, N. J., Read, G. F., Walker, R. F., Harris, B., & Riad-Fahmy, D. (1992). Salivary cortisol and testosterone as markers of stress in normal subjects in abnormal situations. In C. Kirschbaum, G. F. Read, & D. H. Hellhammer (Eds.), *Assessment of hormones and drugs in saliva in behavioral research* (pp. 147-162). Seattle, WA: Hogrefe & Huber.

Crocker, J., & Park, L. E. (2004). The costly pursuit of self-esteem. *Psychological Bulletin*, *130*, 392-414.

Crocker, J., & Wolfe, C. T. (2001). Contingencies of self-worth. *Psychological Review*, *108*, 593-623.

Deinzer, R., Kirschbaum, C., Gresele, C., & Hellhammer, D. H. (1997). Adrenocortical responses to repeated parachute jumping and subsequent h-CRH challenge in inexperienced healthy subjects. *Physiology & Behavior*, *61*, 507-511.

Deutscher Tanzsportverband e.V. (Ed.). (2003). Turnier- und Sportordnung des Deutschen Tanzsportverbandes e.V. [Official regulations for dancesport and tournaments of the German Dancesport Federation]. Available from Deutscher Tanzsportverband e.V., Otto-Fleck-Schneise 12, 60528 Frankfurt am Main.

Dickerson, S. S., Gruenewald, T. L., & Kemeny, M. E. (in press). When the social self is threatened: Shame, physiology, and health. *Journal of Personality*.

Dickerson, S. S., & Kemeny, M. E. (2004). Acute stressors and cortisol responses: A theoretical integration and synthesis of laboratory research. *Psychological Bulletin*, *130*, 355-391.

Hellhammer, D. H., Kirschbaum, C., & Lehnert, H. (1988). Zur Rolle der Hypophysen-Nebennierenrinden-Achse in Belastungssituationen

[Role of the hypothalamus-pituitary-adrenal axis in situations of strain]. *Homo*, *39*, 16-26.
House, J. S., Landis, K. R., & Umberson, D. (1988). Social relationships and health. *Science*, *241*, 540-545.
Ingram, R. E., & Price, J. M. (Eds.). (2001). *Vulnerability to psychopathology: Risk across the lifespan*. New York: Guilford.
Isacsson, S. O., & Janzon, L. (1986). *Social support—Health and disease*. Stockholm: Almqvist and Wiksell.
Kahn, J. P., Michaud, C., de Talance, N., Laxenaire, M., Mejean, L., & Burlet, C. (1992). Applications of salivary cortisol determinations to psychiatric and stress research: Stress responses in students during academic examinations. In C. Kirschbaum, G. F. Read, & D. H. Hellhammer (Eds.), *Assessment of hormones and drugs in saliva in behavioral research* (pp. 111-127). Seattle, WA: Hogrefe & Huber.
Kamarck, T. W., Manuck, S. B., & Jennings, J. R. (1990). Social support reduces cardiovascular reactivity to psychological challenge—A laboratory model. *Psychosomatic Medicine*, *52*, 42-58.
Kemeny, M. E., Gruenewald, T. L., & Dickerson, S. S. (2006). *Social self preservation system: The interface of social threats, self-evaluation, and health*. Unpublished manuscript.
Kirschbaum, C., & Hellhammer, D. H. (1989). Salivary cortisol in psychobiological research: An overview. *Neuropsychobiology*, *22*, 150-169.
Kirschbaum, C., & Hellhammer, D. H. (2000). Salivary cortisol. In G. Fink (Ed.), *Encyclopedia of stress* (Vol. 3, pp. 379-383). San Diego, CA: Academic Press.
Kirschbaum, C., Pirke, K.-M., & Hellhammer, D. H. (1993). The Trier Social Stress Test—A tool for investigating psychobiological stress responses in a laboratory setting. *Neuropsychobiology*, *28*, 76-81.
Kirschbaum, C., Prüssner, J. C., Stone, A. A., Federenko, I., Gaab, J., Lintz, D., et al. (1995). Persistent high cortisol responses to repeated psychological stress in a subpopulation of healthy men. *Psychosomatic Medicine*, *57*, 468-474.
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.
Latane, B., Williams, K., & Harkins, S. (1979). Many hands make light the work: The causes and consequences of social loafing. *Journal of Personality and Social Psychology*, *37*, 823-832.
Leary, M. R., & Kowalski, R. M. (1990). Impression management: A literature review and two-component model. *Psychological Bulletin*, *107*, 34-47.
Leary, M. R., Tambor, E. S., Terdal, S. K., & Downs, D. L. (1995). Self-esteem as an interpersonal monitor: The sociometer hypothesis. *Journal of Personality and Social Psychology*, *68*, 518-530.
Lepore, S. J., Allen, K. A., & Evans, G. W. (1993). Social support lowers cardiovascular reactivity to an acute stressor. *Psychosomatic Medicine*, *55*, 518-524.
Mason, J. W. (1968). A review of psychoendocrine research on the pituitary-adrenal cortical system. *Psychosomatic Medicine*, *30*, 576-607.
Mason, J. W., Hartley, L. H., Kotchen, T. A., Mougey, E. H., Ricketts, P. T., & Jones, L. G. (1973). Plasma cortisol and norepinephrine responses in anticipation of muscular exercise. *Psychosomatic Medicine*, *35*, 406-414.
McEwen, B. S. (1998). Protective and damaging effects of stress mediators. *New England Journal of Medicine*, *338*, 171-179.
McEwen, B. S. (2000). Allostasis and allostatic load. In G. Fink (Ed.), *Encyclopedia of stress* (Vol. 1, pp. 145-150). San Diego, CA: Academic Press.
Mendel, C. M. (1989). The free hormone hypothesis: A physiologically based mathematical model. *Endocrine Reviews*, *10*, 232-274.
O'Connor, P. J., & Corrigan, D. L. (1987). Influence of short-term cycling on salivary cortisol levels. *Medicine and Science in Sports and Exercise*, *19*, 224-228.
Rahe, R. H., Karson, S., Howard, N. S., Jr., Rubin, R. T., & Poland, R. E. (1990). Psychological and physiological assessments on American hostages freed from captivity in Iran. *Psychosomatic Medicine*, *52*, 1-16.
Robbins, J., & Rall, J. E. (1957). The interaction of the thyroid hormones and protein in biological fluids. *Recent Progress in Hormone Research*, *13*, 161-208.
Rose, R. M. (1984). Overview of endocrinology of stress. In G. M. Brown (Ed.), Neuroendocrinology and psychiatric disorder (pp. 95-122). New York: Raven Press.
Stone, A. A., Broderick, J. E., Shiffman, S. S., & Schwartz, J. E. (2004). Understanding recall of weekly pain from a momentary assessment perspective: Absolute agreement, between- and within-person consistency, and judged change in weekly pain. *Pain*, *107*, 61-69.
Stone, A. A., Schwartz, J. E., Neale, J. M., Shiffman, S., Marco, C. A, Hickcox, M., et al. (1998). A comparison of coping assessed by ecological momentary assessment and retrospective recall. *Journal of Personality and Social Psychology*, *74*, 1670-1680.
Tremblay, M. S., Copeland, J. L., & Van Helder, W. (2005). Influence of exercise duration on post-exercise steroid hormone responses in trained males. *European Journal of Applied Physiology*, *94*, 505-513.
Williams, K., Harkins, S., & Latane, B. (1981). Identifiability as a deterrent to social loafing: Two cheering experiments. *Journal of Personality and Social Psychology*, *40*, 303-311.
Zuckerman, M. (1979). *Sensation seeking—Beyond the optimal level of arousal*. Hillsdale, NJ: Lawrence Erlbaum.

Received July 8, 2005
Revision accepted June 27, 2006