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Basic Psychological Need Satisfaction, Stress-Related Appraisals, and Dancers' Cortisol and Anxiety Responses

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Self-determination theory (Deci & Ryan, 2000) posits basic psychological need satisfaction (BPNS) as essential for optimal functioning and health. Grounded in this framework, the current study examined the role of BPNS in dancers' cognitive appraisals and hormonal and emotional responses to performance stress. Dancers reported their degree of BPNS 1 month before a solo performance. Threat and challenge appraisals of the solo were recorded 2 hr before the performance. Salivary cortisol and anxiety were measured 15 min before, and 15, 30, 45, and 60 min postperformance. Higher BPNS was associated with lower cortisol responses and anxiety intensity. Challenge appraisals mediated the association between BPNS and cortisol. Threat appraisals mediated the BPNS–anxiety intensity relationship. These findings point to the potential importance of performers' BPNS for optimal emotional and hormonal homeostasis in performance conditions.

Keywords: basic psychological needs, stress, threat, challenge, cortisol, anxiety

For elite athletes and performing artists, performances represent the culmination of many hours dedicated to training and practice. The anticipation and undertaking of athletic and artistic feats evokes an array of psychological and biological stress reactions. Indeed, psychosocial stress associated with evaluated performance is considered to be a primary catalyst of hormonal (Bosch et al., 2009; Dickerson & Kemeny, 2004) as well as emotional fluctuations (Jones, Meijen, McCarthy, & Sheffield, 2009). These responses may have implications for the quality of performance as well as be relevant to the long-term health of the performer (Burns, 2006; Gaab, Rohleder, Nater, & Ehlert, 2005; Swain & Jones, 1996). While the situational predictors of hormonal responses to performance stress have been well established (Dickerson & Kemeny, 2004; Michaud, Matheson, Kelly, & Anisman, 2008), less is known about psychological differences as determinants of hormonal fluctuations. This void in the literature seems amiss,

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given the importance of maintaining biological and emotional homeostasis for the performing athlete or artist.

The basic needs theory (Ryan & Deci, 2000), a mini-theory within the self-determination framework (Deci & Ryan, 1985, 2000), has become a popular approach to understanding antecedents of healthful, effective and optimal functioning in performance domains (Gagne & Blanchard, 2007). The theory advocates satisfaction of three basic psychological needs (i.e., autonomy, competence and relatedness) to be a primary determinant of cognitive, emotional, and behavioral responses.

Basic Psychological Needs

Basic needs theorists (Deci & Ryan, 2000; Ryan & Deci, 2000) define the need for autonomy as feeling that one's actions are self-directed, self-endorsed and derived from personal choices, as opposed to external controls or pressures. The extent to which one feels capable of meeting task demands effectively is inferred by the term *competence* (DeCharms, 1968). The need for relatedness is satisfied when one feels that there is a sense of mutual and meaningful care among those in the context at hand (Baumeister & Leary, 1995).

Numerous studies undertaken in the physical domain support the role of basic psychological need satisfaction (BPNS) as a central determinant of athletes' psychological health (Gagne & Blanchard, 2007). For example, recent evidence demonstrates that BPNS predicts variability in athletes' and dancers' experiences of positive affect (Adie, Duda, & Ntoumanis, 2008b; Quested & Duda, 2009a, 2010) subjective vitality (Adie et al., 2008b), burnout (Hodge, Lonsdale, & Ng, 2008), and negative affective states (Quested & Duda, 2010). Only a few studies have considered the role of basic needs as predictors of stress-related emotional responses (Baard, Deci, & Ryan, 2004; Black & Deci, 2000; Deci et al., 2001). These studies, undertaken in workplace and academic settings, found the basic needs to relate negatively to anxiety responses. The aforementioned investigations have typically relied upon self-reported indicators of optimal functioning. In a recent study, Bartholomew and colleagues (Bartholomew, Ntoumanis, Ryan, Bosch, & Thøgersen-Ntoumani, 2011) found psychological need thwarting (defined by these authors as when individuals perceived their needs to be actively undermined by others) to predict secretory immunoglobulin A (S-IgA), an immunological protein recognized to be a marker of psychobiological functioning. However, BPNS was unrelated to S-IgA (Bartholomew et al., 2011). Very little is known about how and to what extent BPNS covaries with biological stress responses that may be determinants of long-term health. Typically, previous work on the BPNS–health relationship has tended to consider perceived typical health status over a series of weeks as the outcome variable. The role of BPNS in shaping stress-related appraisals and subsequent biological responses is yet to be determined.

Psychophysiological Stress Reactions

Cortisol has been studied extensively as a putative biological mediator of the links between the social context, stress, and physical health (Miller, Chen, & Cole, 2009). Cortisol release regulates homeostatic control via the modulation of metabolic and

immunological processes. However, when cortisol secretion is excessive and/or sustained bodily systems may be adversely influenced (Miller, Chen, & Zhou, 2007). Consequently, repeated exposure to situations perceived as excessively stressful may have metabolic and immunological effects (Raison & Miller, 2003), as well as long-term physical (Burns, 2006) and psychological (Raedeke & Smith, 2004) health implications. Given that the health status of dancers is often recognized to be compromised (Laws, 2005), there is added relevance to examining the role of BPNS in determining differential responses to stress.

Athletic and artistic events are naturalistic stressors that have been recognized to elicit dramatic changes in cortisol secretion (Eubank, Collins, Lovell, Dorling, & Talbot, 1997; Filaire, Sagnol, Ferrand, Maso, & Lac, 2001; Rohleder, Beulen, Chen, Wolf, & Kirschbaum, 2007). For example, Rohleder and colleagues revealed that performing in a ballroom dancing competition explained 28% of the variance in cortisol secretion between control (inactive) and performance days; dancing alone (as opposed to in a group) explained a further 3% of the variance. These studies focused on manipulated situational features of the performance or competition (e.g., win/loss experiences, dancing alone or in a group). To date, variability in person-level determinants of cortisol responses has been neglected. Indeed, it has been argued that future models of stress and metabolic and immunological processes should consider such person-based variability in perceptions and appraisals as they may help explain inconsistencies in biological stress responses (Miller et al., 2007).

Predictors of Stress Responses

Cognitive appraisals can shape emotional, physiological and behavioral responses to stressful situations (Lazarus, 2000; Lazarus & Folkman, 1984). Threat appraisals represent the construal that the forthcoming event presents danger to the individual's well-being or self-esteem. On the contrary, when one appraises the forthcoming event with a focus on the opportunities for success, growth, learning and mastery, these reflect challenge-oriented appraisals (Lazarus & Folkman, 1984). Typically, though not universally, threat appraisals are associated with undesirable anxiety responses, whereas perceived challenges tend to augment anxiety symptoms in a more positive manner (Jones et al., 2009). Threat appraisals are also believed to exaggerate cortisol reactions (Gaab et al., 2005; Jones et al., 2009). For example, Gaab and colleagues revealed threat appraisals to predict 29% of the variance in cortisol responses during an evaluative protocol. A recent meta-analysis (Dickerson & Kemeny, 2004) indicates human cortisol responses are strongest in situations that pose an evaluative threat.

Despite the recognition that individuals do not appraise and respond to stressful circumstances in a uniform manner, predictors of this between-person variability remain underexplored. Basic psychological need satisfaction has been proposed to impact upon the appraisal process in psychologically demanding situations, by shaping "the apparent reality of objective events" (Skinner & Edge, 2002, p. 306). Recent theorizing implies that one's degree of BPNS may determine whether one is vulnerable to potentially damaging emotional and physiological responses in demanding scenarios (Ntoumanis, Edmunds, & Duda, 2009). It seems reasonable to expect that the extent to which an individual feels competent and able, and in control and supported (i.e., the degree of BPNS), should determine how he/she

appraises and responds to the demands presented in potentially stressful circumstances. High BPNS could determine whether one approaches a performance feeling in control and perceiving that they have the resources and capacity to tackle the demand in question. However, with low BPNS, it might be more likely that the demand is viewed as more daunting and considered a threat to the social or physical self. However, no evidence exists to support the hypothesized theoretical sequence linking BPNS, appraisal processes, and hormonal and emotional responses in stressful circumstances. In sum, a basic needs theory (Ryan & Deci, 2000) driven approach to examining appraisals of stressful events and predictors of emotional and hormonal stress responses is warranted. This is relevant to our understanding of healthy versus health compromising participation in performance domains, such as the particular case of vocational dance.

Study Objectives and Hypotheses

Firstly, it was hypothesized that the dancers' typical degree of BPNS experienced in their dance school context over several weeks would significantly predict the dancers' state perceptions of the solo performance as a threat and challenge (negatively and positively, respectively) on the day of performance. Given that BPNS has been proposed to shape adaptive responses in stressful circumstances (Skinner & Edge, 2002), we hypothesized that BPNS and challenge appraisals would negatively, and threat appraisals would positively, predict the dancers' salivary cortisol secretion before and after the solo performance. In line with recent theorizing (Jones et al., 2009; Ntoumanis et al., 2009), threat and challenge appraisals were expected to mediate the association between BPNS and the dancers' anxiety and cortisol responses.

Method

Participants and Procedure

Sixty-one (20 male, 41 female, $M_{age} = 19.30$ years, $SD = 1.74$) dancers undertaking full time training at a leading dance conservatory in London, UK, were recruited for the study. It was made clear that participants were free to withdraw at any stage without any implications for their ongoing training. Dancers agreeing to take part provided informed consent. The duration of the study period spanned 4 weeks. In Week 1, the dancers completed the control day protocol over two consecutive days. In Week 4, participants completed the performance day protocol, which included performing a ballet solo in front of an audience of peers and teachers. The study was approved by a departmental ethics board at a large UK University.

Control Day. A day before the control condition, dancers completed a questionnaire packet recording BPNS, demographic information (including age, weight, height, years of dance experience) and their health status and associated behaviors over the past 7 days. On the control day, dancers collected five envelopes, each containing a questionnaire and a saliva collection tube. Instructions specified that each envelope should be opened on, or as close as possible to, the hour between 13:00 and 17:00. Each time, dancers were asked to provide a saliva sample and to

respond to two questions assessing their state anxiety intensity. At this time dancers were also asked to provide details of health related behaviors in the preceding 24 hr (first envelope only) and the past hour (all envelopes). During the control day, dancers completed their usual activities, including practical dance classes. Dancers were asked to return the saliva samples to the researcher immediately or to refrigerate them until a convenient time for their return.

Performance Day. On the morning of their solo performance, dancers completed a questionnaire assessing their perceptions of threat and challenge associated with the upcoming performance. The performance day protocol for assessing health status and behaviors, saliva collection and anxiety measurements mimicked that of the control day, except that the sampling time points differed. Specifically, dancers were asked to provide saliva samples and complete the anxiety measures 15 min before their performance, and immediately, 15 min, 30 min, and 1 hr after their solo finished. Performances took place between 14:00 and 16:00 and lasted for approximately 2 min.

Measures

Cortisol. Unstimulated salivary cortisol samples were collected using Salivettes (Sarstedt, Nümbrecht, Germany). Dancers were asked to leave the cotton swab under their tongue for a timed period of 2 min. The chronological time that each sample was provided and the exact length of time the Salivette remained under the tongue was recorded. Once returned, Salivettes were refrigerated and subsequently frozen at –80 °C pending analysis. Following defrosting, saliva samples were centrifuged at 9400 rpm for 10 min. The samples were analyzed using a commercially available enzyme-linked immunosorbent assay (IBL International, Hamburg, Germany).

Basic Psychological Need Satisfaction. Three scales tapped need satisfaction and a composite BPNS score was calculated from the scale means, aligned with the approach adopted in previous research due to the interdependencies between the three needs (Standage, Duda, & Ntoumanis, 2005). This accounts for the tendency of the three needs to have shared variance, and precludes the possibility of determining the independent contribution of each need as a unique predictor of the outcome variables. The selected measures were specifically chosen because their scale reliability and factor structure had been supported in previous research involving dancers and/or athletes (Quested & Duda, 2009b; Reinboth & Duda, 2006). Satisfaction of the need for competence was measured using the five-item competence subscale of the Intrinsic Motivation Inventory (McAuley, Duncan, & Tammen, 1989). Dancers responded to items (e.g., "I am satisfied with my dancing") on a Likert scale of 1 (*strongly disagree*) to 7 (*strongly agree*). Six items (e.g., "I feel free to express my ideas and opinions") targeting the degree to which the dancer felt he/she had choice and could make decisions in terms of his/her dance engagement, assessed satisfaction of the need for autonomy (Deci et al., 2001). This scale employs a Likert scale ranging from *not at all true* (1) to *very tru*e (7). The dancers' need for relatedness was tapped via five items (e.g., "valued") from the acceptance subscale of the Need for Relatedness Scale (Richer & Vallerand, 1998) on a Likert series of *strongly disagree* (1) to *strongly agree* (5). All items followed the stem "In this dance school I feel." Internal consistency of the autonomy

($\alpha = .79$), competence ($\alpha = .86$), and relatedness ($\alpha = .91$) scales were acceptable. We were interested in the degree of BPNS afforded normally in the school during the academic year (i.e., when there is not an immediately imminent performance). Therefore the measure of BPNS was taken 1 month before performance in an effort to gauge what was "typical." Dancers were asked to respond to all items in relation to their experiences and feelings in their school "over the past few weeks."

Perceptions of Threat and Challenge. A six-item scale, based on a measure used in the academic domain (McGregor & Elliot, 2002) and employed in recent sport research (Nien, 2007), was slightly adapted to measure the dancers' challenge and threat appraisals with regard to the upcoming performance. Dancers were instructed to respond to the stem "When I think about this performance." Dancers responded to three threat (e.g., "I view this performance as a threat") and three challenge (e.g., "I look forward to being challenged") appraisal items on a scale of 1 (*not at all true for me*) to 7 (*very true for me*). The factorial validity and reliability of the long, 10-item (Adie, Duda, & Ntoumanis, 2008a) and shortened, 6-item (Nien, 2007) versions of this scale were supported in research involving athletes similar in age to the dancers in the current study. In the present work, internal consistency of the threat ($\alpha = .91$) and challenge ($\alpha = .72$) scales were acceptable.

Anxiety. Dancers responded to two items assessing state anxiety each time a saliva sample was provided during the performance day. Items were adapted from a short form self-report assessment previously designed to tap athletes' state anxiety (Thomas, Hanton, & Jones, 2002) and all anxiety items were assessed on a 7-point scale ranging from *not at all* to *extremely*. Dancers were asked to indicate their "thoughts right now" regarding their level of cognitive anxiety ("I feel concerned/ worried/ anxious") and somatic anxiety ("I feel physically nervous (e.g., tense, fast heart rate, 'butterflies')"), as an indicator of anxiety intensity.

Data Analysis

Performance day cortisol responses at –15 min, +15 min and +1 hr were time matched with the three closest time corresponding control day samples. Version 17 of SPSS was the statistical package used in all non-multilevel analyses. Before the main analysis, multivariate analysis of variance (MANOVA) determined the potential influence upon cortisol levels of smoking status, caffeine intake, gender and dance experience. Differences in cortisol response patterns between the performance day and control day were also examined using repeated-measures ANOVA. Least squares regression analyses determined whether the dancers' BPNS predicted their threat and challenge appraisals on the day of performance. Cortisol was also represented as area under the curve relative to ground (AUC_G) which gives a measure of total cortisol release. This can be calculated using cortisol concentrations and time with the baseline as zero (Fekedulegn et al., 2007). The AUC_G representation was used to determine an overall effect size in the analyses related to cortisol.

Multilevel modeling (MLM) techniques using MLwiN version 2.11 (Rasbash, Charlton, Browne, Healy, & Cameron, 2009) were used to examine whether BPNS, threat, and challenge appraisals (Level 2 variables) predicted the level and between-person variability of cortisol and anxiety reactions (Level 1 variables) during the performance day. Individual cortisol levels at each time point were

used in the multilevel analyses. Cortisol data were centered at +15 min, as this was found to be the peak in the cortisol when the data were represented graphically. Anxiety data were centered at –15 min, which was when the data peaked. Centering is an approach used in multilevel modeling to facilitate the interpretation of the intercept (Singer & Willet, 2003). First, an unconditional growth model was tested, specifying random effects for the intercept (at both levels), as well as for the linear and quadratic terms at Level 2 only (Singer & Willet, 2003). This model examined (a) whether there were significant changes in cortisol responses over time and (b) whether there was between-person variability in the mean levels of cortisol at the point of centering (i.e., +15 min), as well as in the rates of change. A two-level MLM was employed. Individual changes in the dependent variable over time were modeled at Level 1. Variability in response patterns between participants was represented at Level 2 (Singer & Willet, 2003). When the pattern of change of the dependent variables was curvilinear, both a linear and a quadratic term for time were included as predictors in the equations, in addition to BPNS and/or appraisals (Dickerson, Mycek, & Zaldivar, 2008; Singer & Willet, 2003). The predictors were initially treated as random at the between-person level (i.e., Level 2), but when the variance of a predictor at this level was nonsignificant, analysis proceeded with the predictors fixed at that level. A series of conditional growth models were run to examine (a) the direct effects of the dancers' BPNS on cortisol responses; (b) the direct effects of the dancers' threat and challenge appraisals on cortisol levels; and (c) whether threat and challenge appraisals mediated the association between BPNS and cortisol levels. The same approach was adopted to analyze the cognitive and somatic anxiety data.

A set of multilevel models were tested to evaluate mediation with respect to each of the three dependent variables (Krull & MacKinnon, 2001). The change in the magnitude of the direct X to Y path (c) with the inclusion of the mediators (i.e., path c') provides information regarding the total mediation effect (see Figure 1). The magnitude and significance of each mediating effect (B_aB_b) was also determined (Krull & MacKinnon, 1999).

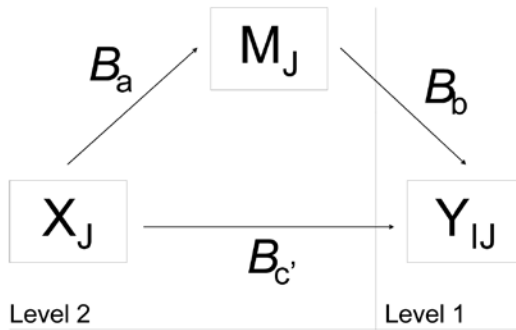

Figure 1 — Mediation paths tested in MLM analyses (adapted from Krull & MacKinnon, 2001). The predictor X denotes BPNS. The mediators (M) were threat and challenge. The dependent variable Y represents cortisol, somatic anxiety intensity, cognitive anxiety intensity, which were separately analyzed.

Data Preparation and Screening

Data were examined for distribution (skewness and kurtosis), Mahalanobis distances, multicollinearity and violations of standard univariate and multivariate analysis assumptions (Tabachnick & Fidell, 2001). No severe deviations from normality were observed, except in the case of the cortisol data distribution. Log transformations (log 10 x + 1) were performed to improve the distribution of the positively skewed cortisol data, and one univariate outlier was removed. Actual physiological cortisol levels are provided in the Tables and in Figure 2. Logged data were used in all multilevel analyses to avoid violating statistical assumptions.

Results

Preliminary Analysis

MANOVA analyses revealed that there were no differences in cortisol responses on account of smoking status (ps > .23), caffeine consumption (ps > .43), or gender (ps > .22). Therefore these variables were not included in the models tested. There were significant differences between dancers in their first and second year of dance training in cortisol responses at all time points in the performance day and the time-matched –15 min control day data point (ps < .05), as well as in challenge appraisals (p = .02). Therefore, dance experience was controlled in all analyses when challenge or cortisol were the dependent variables.

Cortisol Responses: Control Day vs. Performance Day

Figure 2 reveals differences in the patterning of cortisol between the two conditions. Specifically, cortisol responses in the control day maintained a flat profile. On the contrary, the performance day showed a marked increase, peaking 15 min postperformance and then gradually decreasing. Repeated-measures ANOVA revealed a main effect for time, $F(2, 31) = 4.01$, $p = .02$, $\eta^2 = .11$; a main effect for condition that approached statistical significance, $F(2, 31) = 3.27$, $p = .08$, $\eta^2 = .09$; and a significant condition × time interaction, $F(2, 31) = 4.17$, $p = .02$, $\eta^2 = .12$, indicating that cortisol secretion during the performance day increased at a greater rate than in the control day.

Descriptive Statistics and Correlations

Table 1 presents the descriptive statistics for the study variables. Overall, dancers reported modest BPNS and were more likely to appraise their upcoming performance as a challenge than as a threat. Mean anxiety scores averaged across time indicating that the dancers experienced modest cognitive and somatic anxiety symptoms. It is noteworthy that standard deviations of all self-reported data were small. Basic psychological need satisfaction was significantly related to threat, cognitive anxiety and somatic anxiety in the hypothesized directions. Figure 2 presents the cortisol patterning of dancers with low and high BPNS. Threat appraisals positively related to the intensity of the cognitive anxiety symptoms reported.

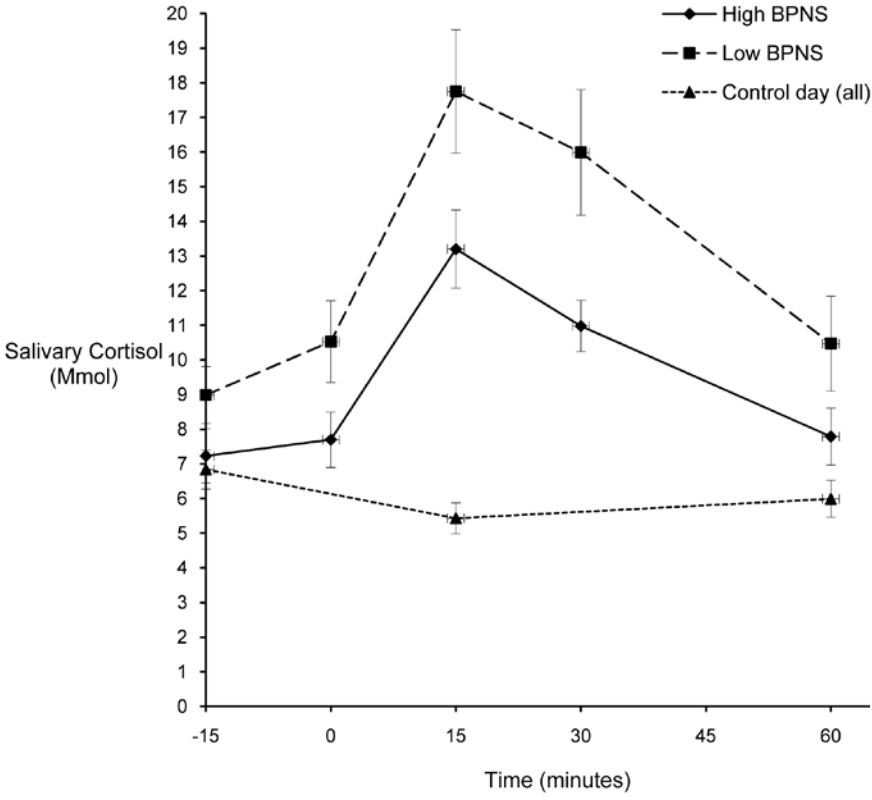

Figure 2 — Mean cortisol values during the control day (all) and performance day conditions (median spilt by high and low BPNS).

Regression Analyses: Predicting Threat and Challenge Appraisals (B_a Path)

Basic psychological need satisfaction negatively predicted the dancers' threat appraisals ($B = -.80$, $p < .001$, $R^2 = .09$) and positively predicted the dancers' challenge appraisals ($B = .29$, $p < .01$, $R^2 = .04$).

Multilevel Regression Analyses: Predicting Cortisol Responses

The dancers' cortisol response peaked 15 min after the end of their performance (see Figure 2). As this peak was of interest in our study, time was centered at +15 min when predicting cortisol responses. The results showed significant linear ($B = 0.03$, $p < .001$) and quadratic ($B = -0.01$, $p < .001$) changes in cortisol responses over time. The between-person variability associated with the linear and quadratic slopes was negligible and not significant. This finding was reinforced via a visual inspection of the data. This suggests there to be no between-person variability in

Table 1 Descriptive Statistics and Bivariate Correlations Among the Study Variables

	Variable	*M*	*SD*	Min	Max	1	2	3	4	5	6
1	BPNS Mean	3.96	.68	2.28	5.28	—					
2	Challenge	5.52	1.05	2.67	7.00	.16	—				
3	Threat	2.51	1.69	1.00	7.00	–.35*	–.13	—			
4	CA (Level)	3.10	1.33	1.00	7.00	–.44**	–.16	.43**	—		
5	SA (Level)	3.22	1.19	1.00	7.00	–.33*	.01	.18	.73**	—	
6	Cortisol AUC_G	841.01	384.33	305.81	2242.42	–.31[a]	–.17	.22	.16	.04	—

Note. AUC_G = area under the curve relative to ground. CA = cognitive anxiety; SA = somatic anxiety (means are averaged across time points).

[a] $p < .06$, *$p < .05$, **$p < .01$.

the patterns of cortisol secretion over time. Further, the difference in the deviance statistic when the linear and quadratic components of time were fixed (iterative generalized least squares (IGLS) deviance = –243.25) versus random (IGLS deviance = –234.99) was nonsignificant (difference = 8.26, $df = 5$, $p = .14$). Therefore, analysis proceeded with the two terms for time fixed at Level 2.

In the conditional model, and supporting the main study hypotheses, BPNS ($B = –0.07$, $p < .05$) significantly predicted cortisol responses. In a separate model, the association between challenge and cortisol was significant ($B = –0.04$, $p < .05$) but cortisol was not significantly predicted by threat ($B = 0.01$, $p = .52$). Accordingly, threat was no longer included in the mediation analysis. Table 2 presents the results of the mediation analysis. When BPNS and challenge were simultaneously included as predictors, the BPNS coefficient (B_c) was reduced and became nonsignificant (B_c'), suggesting evidence of a mediating effect. However, the indirect effect (B_aB_b) via challenge was not significant.

Table 2 Multilevel Estimates of the B_b, B_c, and B_c' Coefficients for the Tests of Mediation

Y	B_c (SE)	B_c' (SE)	B_b (SE)	Mediated effect (B_aB_b)
Cortisol	–0.07* (0.03)	–0.05 (0.03)	–0.05* (0.02)	–0.01
Somatic Anxiety	–0.59* (0.25)	–0.35 (0.26)	0.21* (0.09)	–0.16*
Cognitive Anxiety	–0.70** (0.24)	–0.37 (0.23)	0.38** (0.08)	–0.30**

Note. B_c denotes the direct path between the independent variable and the dependent variable, without (B_c) and with (B_c') the mediator included in the model. In the case of cortisol, the mediator was challenge. For somatic and cognitive anxiety, the mediator was threat. B_b represents the path between the mediator and the dependent variable. The multilevel analyses were undertaken on the logged cortisol data collected from each dancer on multiple occasions during the performance day.

*$p < .05$, **$p < .01$, ***$p < .001$.

Basic psychological need satisfaction accounted for 11%, and threat and challenge contributed a further 5% to the variance in cortisol AUC_G. A threat × linear time interaction term significantly predicted cortisol responses ($B = 0.004$, $p < .05$), indicating that the cortisol responses of those with higher threat appraisals increased at a greater rate than those with lower threat appraisals. No other interaction terms were significant.

Multilevel Regression Analyses: Predicting Anxiety Responses

The dancers' somatic and cognitive anxiety intensities peaked 15 min before performance, decreased immediately following performance and the curves reached a plateau 15 min after the performance finished. Therefore, time was centered at –15 min in the models predicting anxiety responses. Interactions between the independent variables and linear and quadratic times were examined as predictors of all anxiety variables. No interaction terms were significant.

Somatic Anxiety Intensity. In an unconditional growth model, both linear ($B = –1.06$, $p < .001$) and quadratic ($B = 0.09$, $p < .001$) changes in the intensity of somatic anxiety were found. The between-person variances associated with the linear and quadratic terms were nonsignificant ($p > .05$). In addition, there was no significant difference (difference = 6.14, $df = 5$, $p = .34$) between the deviance statistic when the linear and quadratic components of time were specified as random (IGLS deviance = 886.88), versus when they were treated as fixed (IGLS deviance = 892.58). Similarly, we found no between-person variability in BPNS, challenge and threat appraisals. Thus, all predictors were treated as fixed at Level 2.

Results indicated BPNS to significantly and negatively predict somatic anxiety intensity ($B = –0.59$, $p = .02$). In a separate model, when threat and challenge were entered as predictors, threat ($B = 0.21$, $p = .025$) significantly and positively predicted somatic anxiety intensity, but the relationship between somatic anxiety and challenge ($B = 0.07$, $p = .64$) was not significant. The multilevel estimates from the mediation analyses are presented in Table 2. When BPNS and threat were simultaneously included as predictors of somatic anxiety intensity, the BPNS coefficient reduced and became nonsignificant, indicative of a mediating effect via threat. The indirect effect via threat was significant ($B_aB_b = –0.16$, $p < .05$). BPNS accounted for 11% of the variance in mean somatic anxiety intensity, with threat and challenge appraisals contributing a further 1%.

Cognitive Anxiety Intensity. Both linear ($B = –1.00$, $p < .001$) and quadratic ($B = 0.09$, $p < .001$) changes in cognitive anxiety intensity were found. The difference in the deviance statistic between a model in which the linear and quadratic components of time were specified as random (IGLS deviance = 878.14), and a model where both were fixed (IGLS deviance = 908.23) was significant (difference = 30.10, $df = 5$, $p < .001$). This means that the trajectories were not the same for all dancers. Therefore the linear and quadratic components of the model were modeled as random. As there was no significant between-person variance in BPNS, challenge and threat appraisals these predictors were fixed.

BPNS significantly and negatively predicted cognitive anxiety intensity ($B = –0.70$, $p < .01$). When threat and challenge were entered as predictors, threat significantly and positively predicted cognitive anxiety intensity ($B = 0.38$, $p < .001$), but there was no significant relationship between cognitive anxiety and challenge ($B = 0.02$, $p = .88$). With the inclusion of threat, the BPNS coefficient reduced and became nonsignificant. A significant mediating effect via threat was evident ($B_aB_b = –0.30$, $p < .01$). BPNS predicted 19% of the variance in mean cognitive anxiety intensity and an additional 9% was contributed by threat and challenge appraisals.

Discussion

Basic psychological need satisfaction is considered to be a necessity for optimal functioning and the experience of well-being (Deci & Ryan, 2000; Ryan, 1995). This study demonstrated the relevance of BPNS and cognitive appraisals of a stressful event to dancers' state hormonal and emotional stress responses. Findings were largely supportive of the study hypotheses.

The results indicate BPNS experienced in dance school to be associated with the way in which dancers perceive an upcoming salient performance; that is, BPNS

predicted the dancers' threat and challenge appraisals. Previous authors have pointed to the potential for BPNS to enable individuals to appraise potentially stressful situations in a more positive light (Ntoumanis et al., 2009; Skinner & Edge, 2002). Our findings are largely supportive of this theorizing and consistent with the overarching tenets of basic needs theory (Deci & Ryan, 2000).

The cognitive appraisal process is understood to be largely driven by an appraisal of the demand, and an evaluation of the resources available to tackle the forthcoming demand (Blascovich, Mendes, Tomaka, Salomon, & Seery, 2003). The findings indicate that BPNS may foster valuable psychological resources that can be accessed and applied to promote facilitative pre-performance appraisals. For example, a dancer who typically perceives herself to possess high dance competence (i.e., high satisfaction of the basic need for competence) might be more likely to appraise that she has the physical and technical skills to perform the ballet solo. If the dancer also generally feels supported, a sense of volition and that she is in control with regard to her dance training, she would more likely feel in command, respected and cared for and capable when publicly executing dance skills. With these psychological resources available, the construal that an opportunity to perform in front of others is more of a challenge is perhaps unsurprising. On the contrary, when a dancer feels less competent, connected with others and autonomous in his/her behaviors, personal resources are more likely to be perceived as inadequate. In this case, it is understandable that performances are more likely to elicit a sense of pressure and apprehension, associated with threat appraisals. Our findings point to the importance of promoting BPNS in dance training if dancers are to feel equipped with the psychological resources to handle evaluative performance-related demands.

BPNS, Cognitive Appraisals and Cortisol Secretion

Salivary cortisol showed a sharp increase immediately following the solo performance. It is unlikely that this increase is due to the physical strains of the performance. Evidence suggests that exercise must be intense (> 70% VO_2max) *and* exceed 40 min in duration to result in significant increases in cortisol secretion (Jacks, Sowash, Anning, McGloughlin, & Andres, 2002). While it has been recognized that the aerobic demands of ballet can reach 80% VO_2max (Schantz & Åstrand, 1984), the dancers' solo performances were between 1 and 3 min in duration. Rohleder and colleagues (2007) established that the dancers' cortisol levels before and after a simulated nonpublic and noncompetitive dance performance were significantly lower than at equivalent times during an authentic public and competitive performance. In the former condition, cortisol profiles mimicked those of an inactive day (Rohleder et al., 2007). Collectively, these points provide evidence that the dancers' elevated cortisol profiles over the study time period were psychologically, rather than physiologically, stimulated.

Previous studies have failed to establish a relationship between person level variables and cortisol fluctuations induced by independent episodes of acute stress (Pruessner et al., 1997). The need for further theoretically driven hypotheses regarding the role of cognitive, behavioral and emotional mechanisms in this hormonal response has been emphasized (Miller et al., 2007). In line with the tenets of self-determination theory (Deci & Ryan, 2000), the current study indicates that BPNS may be a central psychological mechanism in this biological response. Characteristics of the stressor, such as perceived controllability, threats to self-esteem and

threats to the social self, have previously been linked with cortisol output (Dickerson & Kemeny, 2004). Thus, satisfaction of the needs for autonomy, competence, and relatedness could be psychological differences between individuals of relevance to the potential biological impact of stressful performance situations.

The present findings suggest that dancers with low BPNS may be particularly at risk for prolonged or repeated cortisol elevation and, consequently, physiological and psychological deregulation (Michaud et al., 2008). Indeed, cortisol is a catabolic hormone that has been associated with health risks of specific concern in the dance population, such as degradation of bone mass (Newman & Halmi, 1989), disturbed eating (McLean, Barr, & Prior, 2001), and impaired tissue repair (Bosch, Engeland, Cacioppo, & Marucha, 2007). Given that cortisol levels following dance performance can remain above baseline for 6 to 12 hr (Rohleder et al., 2007), longitudinal research is required to delineate the role of BPNS in safeguarding against compromised allostasis and health. For example, it would be valuable to examine whether BPNS predicts the extent to which cortisol responses to performance stress habituate or adapt over time.

Findings support our hypotheses regarding the role of challenge, but not threat, appraisals in the BPNS– cortisol relationship. Threat and challenge appraisals are considered to induce differential physiological mechanisms (Blascovich et al., 2003). Specifically, hypothalamic-pituitary-adrenal axis activity is understood to be triggered by perceptions of threat, but unstimulated in challenge states (Jones et al., 2009). In the current study, challenge appraisals were negatively associated with cortisol secretion. On the surface, this result may appear contradictory to previous work. In explicating the present findings, however, it is notable that only two dancers scored below the midpoint range in the scale assessing challenge appraisals. Therefore we are not in a position to argue that low challenge appraisals stimulated the release of cortisol. Rather, it could be the case that challenge appraisals have the propensity to suppress cortisol secretion (Dienstbier, 1989; Eubank et al., 1997). Findings from the mediation analysis partially support the hypothesis that BPNS may abate hormonal stress responses via the fostering of challenge appraisals as there was some evidence of a mediating effect. However, the indirect effect was not significant. Thus, these suggestions are tentative.

Contrary to our expectations, threat appraisals did not significantly relate to the dancers' cortisol secretion. An examination of the mean scores suggests that on the whole, the dancers did not consider the performance to be threatening (M = 2.51 SD = 1.69); only five of the dancers scored 5 or above on the 1 (low) to 7 (high) threat scale. Nevertheless, the direction of the beta coefficient supports the expected association between threat appraisals and cortisol secretion. In addition, the findings of the interaction analyses also indicate that cortisol was secreted at a higher rate when dancers perceived the performance as more threatening. The direct effect of BPNS upon cortisol secretion suggests other mechanisms besides stress-related appraisals may also mediate the BPNS–cortisol association.

BPNS, Cognitive Appraisals and Anxiety Responses

Our hypotheses were supported with regard to the association between BPNS and the intensity of the dancers' cognitive and somatic anxiety. Threat appraisals significantly predicted the intensity of the dancers' cognitive and somatic anxiety responses, and significantly mediated the impact of BPNS upon the intensity of

reported state cognitive and somatic anxiety. Collectively, these findings point to the relevance of BPNS for performers. Even in the midst of physically and psychologically demanding situations, BPNS may enhance resilience to maladaptive cognitive appraisals, and as a consequence, related emotional responses may be more adaptive.

The nonsignificant paths between challenge appraisals and the intensity of the dancers' somatic and cognitive anxiety did not support our hypothesis. It has been proposed that challenge states can elicit intense negative as well as positive emotions (Jones et al., 2009). Thus, when viewed as challenging, there might still be the potential for public dance performances to elicit unease and uncertainty. Even if the dancer felt competent, cared for and autonomous (i.e., high in BPNS), an important performance may nonetheless be unsettling and associated with worry, not necessarily through fear of failure, but perhaps reflecting the value and importance the dancer places on tackling this challenge. Positive emotions, such as excitement and exhilaration associated with challenge appraisals (Folkman, 2008), may also instigate undesirable somatic reactions. While some dancers may have the self-regulatory skills to manipulate their physiological arousal, for others, somatic responses may become disruptive to the ideal physical performance state. This complex association may explain the null finding between the dancers' challenge appraisals and the level of their somatic and cognitive anxiety symptoms. It is also possible that challenge appraisals are predominantly associated with positive emotions, which were not analyzed in the current study.

Conclusions and Future Directions

This study indicated that higher BPNS and high challenge appraisals, coupled with low threat appraisals, may result in a physiological and emotional state that can be advantageous for dancers' healthful functioning and performance. The exploration of the interrelationships between dancers' BPNS, cognitive appraisals and cortisol/anxiety responses in an ecologically valid setting was a notable strength of the current study. This enabled the examination of naturally occurring, rather than laboratory manipulated, emotional and hormonal responses. With respect to the latter, significant differences in cortisol secretion were noted between a typical school day for the vocational dancers (i.e., the control day) and the performance day. In future research, it could also be informative to examine the psychophysiological correlates of state BPNS immediately before, during, and perhaps right after performance. State BPNS could predict the dancers' response variables over and above the BPNS experienced during the normal teaching term and this possibility is worthy of research attention.

While challenge appraisals were more salient in the relationship between BPNS and cortisol reactions, threat was the principal mechanism in the BPNS–anxiety association. The expected association between threat and cortisol secretion may not have emerged on account of the dancers' low perceptions of threat in the current study. Nevertheless, the observed association between threat and state anxiety indicates that the threshold at which threat appraisals stimulate anxiety responses may be lower than that required to trigger cortisol secretion. The role of BPNS in the stimulation of other anticipatory physiological stress reactions (e.g., sympathetic adrenomedullary activity) considered to be differentially associated with performance stress (Jones et al., 2009) warrants research attention.

Recent studies in dance point to the important role of teachers in the nurturing or thwarting of BPNS (Quested & Duda, 2009a, 2009b, 2010). Perceptions of autonomy supportive teaching have previously been associated with decreases in students' anxiety throughout a semester (Black & Deci, 2000). In light of these and the present findings, it is reasonable to hypothesize that teachers may be able to help dancers become less susceptible to potentially debilitative performance stress reactions, via the fostering of BPNS.

In conclusion, findings support self-determination theory (Deci & Ryan, 1985, 2000) as a relevant framework within which to advance understanding of social-psychological factors that may contribute toward psychophysiological stress responses. However, this investigation is also limited by the assumptions of SDT regarding the relevance of the role of BPNS (at least as assessed as the more "typical experience" at the context level) which did not wholly account for the findings. Future studies should also consider alternative theoretical perspectives that may explain variability in hormonal and stress-related responses to performance via alternative psychological determinants. The social-psychological and motivational processes underpinning variability in performance appraisals, and ensuing emotional and biological responses, remains an intriguing and underexplored line of inquiry.

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