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Prolonged performance-related neuroendocrine activation and perseverative cognition in low- and high-anxious university music students

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Highlights

- We measured music students' sC, sAA and perseverative cognition (PC) for 7 days.
- SC and sAA output were largest on concert day; post-concert recovery was only partial.
- Music performance anxiety (MPA) was associated with higher concert-related PC.
- MPA was related to lower sC output and delayed sAA output recovery.
- Concert-related PC was related to day-to-day changes in sC and sAA output.

Abstract

Music performances are social-evaluative situations that can elicit marked short-term neuroendocrine activation and anxious thoughts especially in musicians suffering from music performance anxiety (MPA). The temporal patterns of neuroendocrine activity and concert-related worry and rumination (perseverative cognition, PC) days before and after a concert in low- and high-anxious musicians are unknown. The first goal of the present study was to investigate the prolonged effects of a solo music performance and the effects of trait MPA on salivary cortisol (sC), alpha-amylase (sAA), and concert-related PC. The second goal was to investigate whether concert-related PC is associated with neuroendocrine activity and mediates the effects of measurement day and trait MPA on neuroendocrine responses. Seventy-two university music students collected saliva samples and reported their PC for seven consecutive days. On the fifth day, they performed solo. Measurement day and trait MPA were tested as main predictors of the diurnal area under the curve with respect to ground (sC AUCg, sAA AUCg), awakening responses, and PC. SC AUCg, sAA AUCg, and concert-related PC were highest on concert day. SC AUCg decreased only partially on post-concert days. SAA AUCg remained elevated on the first post-concert day among students with moderate to very high trait MPA. Throughout the assessment period, trait MPA was associated with smaller sC AUCg and higher concert-related PC. Concert-related PC showed significant positive associations with sC AUCg and sAA AUCg but did not mediate the effects of measurement day and trait MPA on these measures. These findings suggest that solo music performances have prolonged neuroendocrine effects and that trait MPA is an important factor having specific effects on university music students' hypothalamic-pituitary-adrenal axis, autonomic nervous system, and cognitive activity.

Keywords: ambulatory assessment; music performance anxiety; perseverative cognition; salivary cortisol; salivary alpha-amylase; university music students

1. Introduction

Music performance anxiety (MPA) has been defined as "the experience of marked and persistent anxious apprehension related to musical performance […] which is manifested through combinations of affective, cognitive, somatic and behavioral symptoms." (Kenny, 2010, p. 433). MPA is a major issue for musicians, especially music students (Kaspersen and Gotestam, 2002; Patston, 2014). For instance, one third of students of Swiss music universities considered MPA to be a problem, and two thirds expressed the need to receive more support in order to cope better with MPA (Studer et al., 2011).

Music performance situations can be conceived as social-evaluative stressors within the social self-preservation theory. This theory posits that preservation of the social self (i.e., individual's worth and status within a social group) is a fundamental human motivation (Kemeny, 2009). Music performance situations can be perceived as threatening to the social self because of the combination of several elements (Rohleder et al., 2007): a) A high level of performance is an important goal to the musicians' self-identity; b) The music performance requires the display of high-level cognitive and sensorimotor skills coupled with aesthetic and interpretative abilities; c) The musicians' performance is evaluated by others; d) There are factors that are uncontrollable and unpredictable (e.g., size, composition, and behavior of the audience).

In response to social-evaluative tasks, most people acutely display increased activity of the autonomic nervous system (ANS) and the hypothalamic-pituitary-adrenal (HPA) axis (Dickerson and Kemeny, 2004; Goldstein and Kopin, 2008). Some evidence suggests that, under certain circumstances, these responses are prolonged for hours before and/or after actual exposure to social-evaluative stressors (Rohleder et al., 2007; Wetherell et al., 2015). According to theoretical accounts (Brosschot et al., 2010; McEwen, 1998; Ursin and Eriksen, 2004) and supported by empirical evidence (e.g., Heponiemi et al., 2007), prolonged stress-related neuroendocrine activation, i.e., neuroendocrine responses that occur before and after actual exposure to a stressor, contributes to the bodily wear and tear that can ultimately cause or codetermine disease. Perseverative cognition (PC), defined as "repetitive or sustained activation of cognitive representations of past stressful events or feared events in the future" (Brosschot

et al., 2010, p. 407) has been put forward as a mechanism through which appraisal of stressful situations can lead to poor health by prolonging neuroendocrine activation (Brosschot et al., 2010). There is emerging evidence that PC can affect ANS and HPA axis activity and lead to prolonged stress-related neuroendocrine activation (Brosschot et al., 2010; Ottaviani et al., 2016). Prototypical forms of PC are future-oriented worry and past-oriented rumination (Ottaviani et al., 2016).

Compared to practice, rehearsal, or rest, performing publicly elicits in most musicians short-term changes in endocrine and ANS parameters, that, as a whole, can be interpreted as signs of increased physiological arousal (e.g., Aufegger and Wasley, 2017; Fredrikson and Gunnarsson, 1992; Studer et al., 2012). The limited research on short-term MPA-related neuroendocrine differences has provided divergent results, indicating, for instance, increased (Fredrikson and Gunnarsson, 1992) or similar heart rate reactivity (Studer et al., 2012) in high- compared to low-anxious musicians. Worry, often in the form of catastrophic thoughts, is a central cognitive process just prior to or while performing, in particular in high-anxious musicians (Lehrer et al. 1990; Liston et al., 2003; Oudejans et al., 2017; Steptoe and Fidler, 1987).

Very few studies have taken a broader time perspective in investigating psychobiological aspects of performing in musicians. There is some evidence that musicians can experience increased anxiety days, weeks, and even months before performing (Kenny, 2010; Tartalone, 1992; van Kemenade et al., 1995). However, knowledge about the neuroendocrine activity and PC patterns in low- and high-anxious musicians on the days preceding and following a concert is lacking.

The first aim of the present study was to investigate the 7-day temporal pattern of salivary cortisol (sC), alpha-amylase (sAA), and PC in university music students during four pre-concert days, a concert day, and two post-concert days and the influence of trait MPA on these responses. The second aim was to investigate whether PC is significantly associated with the neuroendocrine responses and mediates the effects of measurement day and trait MPA on these responses.

With regard to the first aim, we predicted a significant main effect of day on sC, sAA, and concert-related PC but not on concert-unrelated PC. Specifically, we expected sC, sAA, and concert-related PC to be highest on concert day. Due to limited empirical research, we treated as exploratory issue the

question whether the neuroendocrine activity and concert-related PC significantly increase across the pre-concert days, suggesting a steadily increasing anticipation stress response, and return completely or only partially to initial levels during the post-concert days. A second hypothesis was that trait MPA is positively associated with sC and sAA activity as well as concert-related PC but not concert-unrelated PC. We also tested whether the effect of trait MPA depends on the day (i.e., significant interaction between day and trait MPA) but no specific hypotheses were made given the novelty of this question. With regard to the second aim, we hypothesized that both concert-related and concert-unrelated PC show a significant positive association with sC and sAA activity. Finally, we predicted that concert-related PC is a significant mediator of the predicted measurement day and MPA effects on the neuroendocrine responses.

2. Material and methods

2.1. Participants

We recruited music students via advertising at five Swiss music universities. Prospective volunteers were administered a first questionnaire and excluded if they had any of the following: any known endocrine or cardiovascular disease; use of psychoactive drugs or any medication affecting the biological systems under study; being pregnant; lactating; wearing a pacemaker; working night shifts; major depression syndrome, bulimia, binge eating disorder, and alcohol abuse as assessed using the Patient Health Questionnaire (Spitzer et al., 2000). We excluded 18 students based on these criteria leaving a final sample of 72 participants. Their characteristics are given in Table 1.

The data collection took place between January 2014 and May 2015. The study was approved by the ethics committee of the canton of Vaud, Switzerland. All participants gave their written informed consent to participate in the study and were remunerated 500 Swiss Francs.

2.2. Baseline Questionnaires

Before the ambulatory assessment, participants completed questionnaires assessing the following variables.

2.2.1. Music performance anxiety (MPA)

We conceptualize trait MPA as the person's general tendency to react to music performance situations on a continuum ranging from no anxiety to extreme anxiety. We measured trait MPA with the 20-item State-Trait Anxiety Inventory (state form, STAI; Spielberger, 1983). For the purpose of the study, we adapted the instructions to music performance situations and asked the participants to answer each item by referring to how they generally feel during solo performances. The STAI has been often adapted in this way and used to assess trait MPA[1] (e.g., Studer et al., 2012). The score can vary between 20 (no anxiety) and 80 (extreme anxiety). Cronbach's alpha in the present study was .93.

2.2.2. Social Anxiety (SA)

Some music performance-anxious individuals fear a broad range of social and performance situations, whereas others solely fear music performance situations (Kenny, 2010). We measured SA, conceptualized as the person's general tendency to react to social and performance situations in general, with the self-report version of the 24-item Liebowitz Social Anxiety Scale (LSAS-SR; Fresco et al., 2001). The score can range from 0 (no SA) to 144 (extreme SA). Cronbach's alpha in the present study was .94.

2.2.3. Depressive symptoms

Depression is associated with psychobiological alterations (Gold, 2015). We assessed depressive symptoms with the 21-item Beck Depression Inventory (Beck et al., 1996). The score can range from 0 (no depression) to 63 (extreme depression). Cronbach's alpha in the present study was .78.

2.2.4. Perseverative thinking

As daily PC was a main variable and trait PC can affect neuroendocrine responses to stressors (e.g., Zoccola et al., 2010), we assessed the general tendency toward perseverative thinking with the 15-item Perseverative Thinking Questionnaire (Ehring et al., 2011). The score can range from 0 (no

perseverative thinking) to 60 (extreme perseverative thinking). Cronbach's alpha in the present study was .92.

2.3. Protocol of the ambulatory assessment

Participants were examined during a 7-day period that was composed by 4 pre-concert days (Day-4, Day-3, Day-2, Day-1), one concert day and two post-concert days (Day+1, Day+2). On concert day, students performed solo one or more musical pieces (5-10 min in total) in front of an audience of 10-15 persons (M = 12.6, SD = 1.4) who were unfamiliar to the students and were introduced to them as music connoisseurs[2]. Students selected pieces from their repertoire that they were currently studying with their teacher. Thirteen concerts with four to six students per concert were organized. The concerts started between 3 pm and 6 pm[3]. Students performed once and had no other solo performances during the assessment period.

There were six sampling occasions on each day (immediately after awakening, 30 min after awakening, 11 am, 2 pm, 6 pm, 9 pm). Participants collected saliva samples on each occasion and filled in questionnaires on each occasion except at the first time point (see chapter 2.5). Students were trained in collecting saliva and filling in the questionnaires handling a pre-programmed iPod® touch 5 (iDialog Pad, Gerhard Mutz, Cologne University, Germany). Sampling times were automatically registered on the iPod. Additionally, participants reported collection times on a paper form.

2.4. Salivary cortisol (sC) and alpha-amylase (sAA)

Saliva samples were obtained via a passive drooling method using SaliCaps® (IBL, Hamburg, Germany). Students were instructed to rinse their mouth with water whenever possible and swallow or spit the saliva currently in their mouth before collecting their saliva. Afterwards, they were asked to accumulate saliva for 2 min in their mouth (using a timer within iDialog Pad) and transfer all saliva into the tubes. The first sample was collected immediately after awakening when still lying in bed. Participants were required to avoid eating, smoking, brushing their teeth, drinking, and performing intense physical activity between the first and second sample, and to avoid eating, smoking, brushing

their teeth, and drinking caffeinated and alcoholic beverages and fruit juices for at least 30 min prior to collection of the other four samples. Participants were asked to report whenever they did not follow these instructions.

Samples were stored during the assessment period in the participants' fridges and then kept in a freezer at -20°C before being sent on dry ice to the Biochemical Laboratory of the Department of Clinical Biopsychology, University of Marburg, Germany, where they were again stored at -20°C until biochemical analyses. Free sC concentrations were measured using a commercially available enzyme-linked immunosorbent assay (IBL, Hamburg, Germany). SAA activity was measured using an in-house kinetic colorimetric test with reagents obtained from Roche Diagnostics (Mannheim, Germany). Intra- and inter-assay coefficients of variation were 8.4 and 10.3 (sC) and 5.4 and 14.3 (sAA), respectively.

For both sC and sAA, we analyzed the diurnal area under the curve with respect to the ground (sC AUCg, sAA AUCg) and the awakening response (CAR, AAR). SC AUCg and sAA AUCg were calculated via a trapezoidal function using all available samples. CAR and AAR were defined as difference between first and second sample. Moreover, we analyzed sC and sAA immediately after awakening (sC S1, sAA S1) as recommended for interpreting awakening responses (Stalder et al., 2016).

2.5. Daily diary

On each sampling occasion except immediately after awakening, students answered the following question to assess perseverative cognition (PC): "Since the last assessment time, have you had any negative thoughts or images related to problems, preoccupations, or any negative events, experiences or situations from the past, the present or the future?" (Verkuil et al., 2012). If they answered "yes", they further indicated the duration of these thoughts/images in minutes and estimated how many minutes were related to the concert. We computed daily concert-related and concert-unrelated PC. Moreover, participants reported their wake-up time and at each sampling occasion except immediately after awakening, how many caffeinated and alcoholic beverages they had

drunk, how many cigarettes they had smoked, and how many stressful events they had experienced since the last entry (Verkuil et al., 2012).

2.6. Data processing and statistical analyses

Participants did not collect 157 of the 3024 maximum possible samples. One sC value and 107 sAA values could not be determined because the specimen volume was insufficient or the levels were undetectable. Twenty-five sC values and 25 sAA values were dropped from further analyses because of non-compliance with saliva collection instructions. Thus, 2841 sC values and 2735 sAA values were available for computation of sC and sAA parameters.

For computation of all parameters, we required the first sample to be collected within 10 min of the self-reported wake-up time. For AUCg parameters and awakening responses, we further required the 30-min post-wake sample to be collected within 15 min of the expected time. For calculation of AUCg parameters, we additionally required the first, second, and sixth sample to be available (Out et al., 2013) and the sixth sample to be collected between 8 pm and 10 pm. When values were available for other time points, they were also included in the computation (Out et al., 2013). AUCg and S1 scores were log transformed to better approximate normal distribution.

All statistical analyses were performed using STATA version 14.0 for Windows (Stata Statistical Software; StataCorp LP, College Station, TX). The alpha level was set at 0.05.

To answer the questions of the first study goal, we fitted two-level linear mixed models with restricted maximum likelihood estimation for analyses of salivary variables as outcomes (see Appendix A for intraclass correlation coefficients and model specifications). The PC scores were zero-inflated so that no purely quantitative outcome models would be adequate. Thus, for analyses with PC variables as outcomes, we divided PC scores into four categories (i.e., 0 min, 1-5 min, 6-20 min, more than 20 min; Brosschot et al., 2007) and fitted two-level mixed ordered logistic regression with odd ratios (OR). Predictors of main interest were measurement day and MPA. Following Adam and Kumari (2009), we also included in the models age, sex, hormonal contraception, body mass index, day of the week, and daily wake-up time for all outcomes, and daily consumption of caffeine, alcohol, tobacco, and daily

stressful events for AUCg and PC parameters (models identified by "A"). Participants performed the concert on different days of the week, and therefore day of the week was an intrinsic design-related confounder of measurement day. In a second step, we refined our models by adding SA, depressive symptoms, perseverative thinking and season of the year (identified by "B"). Continuous predictors were mean centered. For each outcome variable, we tested a model with main effects (identified by "1") and a model additionally including the interaction between measurement day and MPA (identified by "2").

Significant effects of measurement day were followed-up by the following analyses. First, we compared response of Day-4 to responses of Day-3, Day-2, and Day-1 to determine whether there were significant changes in the outcomes as the concert day approached. Second, we compared response of the concert day to responses of Day-4, Day-3, Day-2, and Day-1 to evaluate whether the concert day was characterized by significant changes in the outcomes as compared to the preceding days. Finally, if there were significant changes in the outcomes during the concert day in comparison to one or more pre-concert days, we evaluated recovery from the concert day by comparing each post-concert day to the concert day and to the pre-concert days that were significantly different from the concert day. With reference to the daily outcome, we defined a) "full recovery" if the post-concert day was significantly lower than the concert day and not significantly different from the pre-concert days, b) "no recovery" if the post-concert day was significantly higher than the concert day or not significantly different from the concert day and significantly higher than the pre-concert days, and c) "partial recovery" if the post-concert day was not significantly different from the concert day and the pre-concert days or if the post-concert day was significantly lower than the concert day and significantly higher than the pre-concert days. All contrasts were Bonferroni adjusted.

To answer the questions of the second study goal, we used two-level linear mixed models to test within- and between-person associations between PC measures and sC AUCg and sAA AUCg. PC measures were first decomposed into their within-person component (i.e., within-person centered PC representing deviations from an individual's average PC across the 7-day period) and between-person component (i.e., grand-mean centered PC representing deviations from an individual's average score relative to the

sample average). In a first step, we entered these components as predictors of sC AUCg and sAA AUCg together with the variables found to be confounders in the analyses of the first study goal. In a second step, we evaluated whether the within- and between-person PC components served as mediators of the predicted measurement day and MPA effects, respectively, on sC AUCg and sAA AUCg.

Model diagnostics (West et al., 2015) showed that distributional assumptions were met for all final models implying satisfactory model specification. Diagnostic plots can be obtained from the first author.

3. Results

Table S.1. in Appendix A summarizes sampling times, sC levels, and sAA activity for the six daily samples. Table 2 and Table 3 give models for sC AUCg/sAA AUCg and PC, respectively. Table S.2. and Table S.3. in Appendix A show models for CAR/AAR and sC S1/sAA S1, respectively.

3.1 Salivary cortisol

3.1.1. SC AUCg

The main effect of measurement day was significant (see Figure 1 for estimated marginal means and Figure S.1. in Appendix A for means). SC AUCg of Day-4 was not significantly different from sC AUCg of Day-3, Day-2, and Day-1 (estimates between -11.6% and 3.6%, *SE*s between 5.4% and 6.0%, $\chi^2(1) < 4.49$, *p*s > .10). SC AUCg of concert day was significantly larger than sC AUCg of Day-4, Day-3, and Day-2 (estimates between 16.1% and 31.3%, *SE*s between 5.2% and 5.8%, $\chi^2(1) > 7.02$, *p*s < .032) but not sC AUCg of Day-1 (estimate = 12.1%, *SE* = 5.7%, $\chi^2(1) = 4.28$, $p = .15$). SC AUCg of concert day was 22.2% (*SE* = 4.4%) larger than sC AUCg of the first three days taken together. This contrast was significant for the samples collected at 2 pm, 6 pm, and 9 pm ($\chi^2(1) > 3.95$, *p*s < .047). SC AUCg of Day+1 and Day+2 were smaller than sC AUCg of concert day; yet, the contrasts did not reach statistical significance after applying Bonferroni correction (both estimates = -10.2%, *SE* = 5.8% and 5.3%, $\chi^2(1) = 3.61$ and 4.45, *p*s = .11 and .070, respectively). SC AUCg of Day+1 and Day+2 were larger than sC AUCg of Day-4, Day-3, and Day-2 taken together, but the contrasts were not significant after applying

Bonferroni adjustment (estimates = 9.7% and 9.6%, both *SE*s = 4.6%, $\chi^2(1) = 4.20$ and 4.15, *p*s = .080 and .083, respectively).

MPA was related to smaller sC AUCg. SA was related to larger sC AUCg. Figure 1 illustrates estimated marginal means of sC AUCg of participants with five combinations of MPA and SA scores. Because MPA and SA had opposite relationships with sC AUCg, students reporting relatively low MPA and high SA exhibited the largest sC AUCg, whereas students reporting relatively high MPA and low SA exhibited the smallest sC AUCg. Compared to participants with relatively low MPA (i.e., 1 *SD* lower than the mean = 37.5 on STAI), participants with relatively high MPA (i.e., 1 *SD* higher than the mean = 61.1 on STAI) had a 25% smaller sC AUCg (assuming equal SA). Compared to participants with relatively low SA (i.e., 1 *SD* lower than the mean = 13.0 on LSAS-SR), participants with relatively high SA (i.e., 1 *SD* higher than the mean = 55.6 on LSAS-SR) had a 25% larger sC AUCg (assuming equal MPA). Earlier wake-up time, higher caffeine consumption, and more stressful events were significantly associated with larger sC AUCg. The interaction between measurement day and MPA was not significant ($\chi^2(6) = 3.99$, $p = .67$).

3.1.2. CAR

There were no significant effects of measurement day, MPA, and their interaction ($\chi^2(6) = 1.65$, $p = .95$). SA and earlier wake-up time were significantly related to larger CAR. Day of the week was a significant predictor with the highest CAR on Sunday. Women taking hormonal contraceptives exhibited significantly lower CAR than naturally cycling women.

3.2. Salivary alpha-amylase

3.2.1. sAA AUCg

The main effect of measurement day was significant (see Figure 2 for estimated marginal means and Figure S.2. in Appendix A for means). The contrasts between Day-4 and Day-3, Day-2, and Day-1 were all nonsignificant (estimates between -4.8% and 2.5%, *SE*s between 11.1% and 12.2%, $\chi^2(1) < 0.17$, *p*s > 0.99). SAA AUCg of concert day was significantly larger than sAA AUCg of all pre-concert days,

with an average increase of 38.7% (*SE* = 8.9%; estimates between 35.3% and 45.7%, *SE*s between 10.6% and 12.0%, $\chi^2(1) > 7.61$, *p*s < .023). The contrast between concert day and all pre-concert days taken together was significant for the samples collected at 11 am, 2 pm, and 6 pm ($\chi^2(1) > 4.05$, *p*s < .044). SAA AUCg of Day+1 was not significantly smaller than sAA AUCg of concert day (estimate = -14.6%, *SE* = 11.8%, $\chi^2(1) = 1.98$, $p = .31$) and tended to be higher than sAA AUCg of the four pre-concert days taken together (estimate = 18.4%, *SE* = 8.9%, $\chi^2(1) = 3.98$, $p = .092$). SAA AUCg of Day+2 was significantly smaller than sAA AUCg of concert day (estimate = -22.2%, *SE* = 10.5%, $\chi^2(1) = 6.30$, $p = .024$) and was not significantly different from sAA AUCg of the four pre-concert days taken together (estimate = 7.9%, *SE* = 8.8%, $\chi^2(1) = 0.83$, $p = .72$).

Whereas the main effect of MPA was not significant, the interaction between measurement day and MPA was significant. MPA did not significantly modulate the differences between Day-4 and Day-3, Day-2, and Day-1 (estimates between 0.003 and 0.004, all *SE*s = 0.009, $\chi^2(1) < 0.21$, *p*s > 0.99) and between concert day and Day-4, Day-3, Day-2, and Day-1 (estimates between -0.012 and -0.008, *SE*s between 0.009 and 0.010, $\chi^2(1) < 1.85$, *p*s > .69). The effect of MPA on the difference between Day+1 and concert day was not significant (estimate = -0.014, *SE* = 0.010, $\chi^2(1) = 1.86$, $p = .34$), whereas it was significant on the difference between Day+1 and the four pre-concert days taken together (estimate = 0.024, *SE* = 0.008, $\chi^2(1) = 9.56$, $p = .004$). Figure 2 depicts estimated marginal means for students with levels of MPA ranging from 30 to 70 on STAI. At MPA = 30, sAA AUCg tended to be lower on Day+1 in comparison to the four pre-concert days (estimate = -25.2%, *SE* = 18.5%, $\chi^2(1) = 2.93$, $p = .087$). As MPA level increased, the difference in sAA AUCg between Day+1 and the four pre-concert days taken together became progressively more positive, and at MPA levels between 50 and 70, the difference was significant (MPA = 40, estimate = -4.7%, *SE* = 11.6%, $\chi^2(1) = 0.19$, $p = .66$; MPA = 50, estimate = 21.5%, *SE* = 9.1%, $\chi^2(1) = 4.97$, $p = .025$; MPA = 60, estimate = 54.8%, *SE* = 13.3%, $\chi^2(1) = 12.34$, $p < .001$; MPA = 70, estimate = 97.3%, *SE* = 20.8%, $\chi^2(1) = 12.96$, $p < .001$). MPA did not significantly modulate the difference between Day+2 and concert day (estimate = -0.004, SE = 0.010,

$\chi^2(1) = 0.21$, $p > 0.99$) and between Day+2 and the four pre-concert days taken together after applying Bonferroni correction (estimate = 0.015, SE = 0.007, $\chi^2(1) = 4.38$, $p = .072$).

3.2.2. AAR

There were no significant predictors of AAR, except season. Participants tested in fall had significantly lower AAR than participants tested in winter.

3.3. Perseverative cognition (PC)

For concert-related PC, the effects of measurement day and MPA were significant. Their interaction was not significant ($\chi^2(6) = 6.39$, $p = .38$). As shown in Figure 3 (see Table S.3. in Appendix A for descriptive statistics), concert-related PC on Day-3, Day-2, and Day-1 was on average slightly higher than on Day-4 (ORs between 2.56 and 3.15, $\chi^2(6)$ between 4.17 and 5.59, *p*s between .054 and .12). Participants reported significantly more concert-related PC on concert day than on all pre-concert and post-concert days (ORs between 4.21 and 23.43, $\chi^2(1) > 10.59$, *p*s < .005). There were no significant differences between Day-4 and both post-concert days ($\chi^2(1) < 0.95$, *p*s > .33). Higher MPA was associated with more concert-related PC.

For concert-unrelated PC, there were no significant effects of measurement day, MPA, and their interaction ($\chi^2(6) = 0.80$, $p = .99$). Number of stressful events showed a significant positive association with both PC measures. Higher alcohol consumption was significantly associated with less concert-unrelated PC.

3.4. Associations between PC and sC AUCg

The within-person component of both PC measures showed a significant positive association with sC AUCg ($\chi^2(1) > 5.90$, *p*s < .015). The between-person component of both PC measures were not significantly associated with sC AUCg ($\chi^2(1) < 2.16$, *p*s > .14).

Given these results and those reported in 3.1.1. and 3.3., we evaluated whether the within-person component of concert-related PC served as mediator of the relationship between measurement day and sC AUCg and found that it was not a significant predictor of sC AUCg when entered into the model including measurement day ($\chi^2(1) = 0.06$, $p = .81$).

3.5. Associations between PC and sAA AUCg

The within-person component of concert-related PC showed a positive association with sAA AUCg ($\chi^2(1) = 7.02$, $p = .008$). There were no other significant associations ($\chi^2(1) < 1.57$, ps $> .21$).

Given these results and those reported in 3.2.1. and 3.3., we evaluated whether the within-person component of concert-related PC served as mediator of the relationship between measurement day and sAA AUCg and found that it was not a significant predictor of sAA AUCg when entered into the model including measurement day ($\chi^2(1) = 2.66$, $p = .10$).

4. Discussion

SC AUCg was about 22% larger on concert day than on the first three pre-concert days taken together, mainly due to higher sC levels on concert day between 2 pm and 9 pm. This finding is in line with studies investigating sC responses to music performances (e.g., Aufegger and Wasley, 2017; Halleland et al., 2009; Pilger et al., 2014) and other social-evaluative situations (e.g., Jezova et al., 2016; Rohleder et al., 2007; Wetherell et al., 2015), The heightened sC AUCg observed on concert day in the present study cannot be explained by physical demands of performing for 5-10 min because the duration and intensity of physical exertion associated with the concert were below the thresholds required to stimulate cortisol release (Aufegger and Wasley, 2017; Strahler et al., 2017). SC AUCg on concert day and on the last pre-concert day were not significantly different from each other. This finding would be in line with an anticipatory HPA axis activation on the last pre-concert day. We qualify this anticipatory activation as relatively small considering that sC AUCg on the last pre-concert day was not significantly different from sC AUCg of the first pre-concert day. SC AUCg did not significantly decrease from concert day

to post-concert days. Moreover, sC AUCg on both post-concert days was almost 10% larger than on the first three pre-concert days, and this difference approached statistical significance. These findings suggest that in terms of HPA axis activity, the recovery process was not fully completed and support the hypothesis of prolonged post-performance HPA activation.

Contrary to our predictions, MPA was significantly associated with smaller and not larger sC AUCg. Moreover, SA was significantly associated with larger sC AUCg. Considering that the 7-day assessment period represents well a typical week in a student's academic life, the observed relationships between sC AUCg, MPA, and SA may reflect an enduring rather than a transient hormonal state associated with the concert. Assessing sC levels during different periods of the year could confirm this hypothesis.

To the best of our knowledge, the present study is the first to reveal these relationships between sC secretion, MPA, and SA. Research on SA and short-term HPA axis reactivity to psychosocial stressors has produced conflicting results (e.g., Condren et al., 2002; Crisan et al., 2016; Klumbies et al., 2014). In subjects with high trait anxiety, short-term cortisol responses to a public speech task were blunted (Duncko et al., 2006; Jezova et al., 2004). Studies assessing diurnal cortisol levels did not find significant differences between socially anxious individuals and controls (Laufer et al., 2005; Van Veen et al., 2008; Vreeburg et al., 2010). In these studies, cortisol was assessed on a single day, which is insufficient to reliably identify between-person differences in cortisol parameters (Hellhammer et al., 2007; Segerstrom et al., 2014). The specifier "performance only" has been introduced in the DSM-5 based on the evidence that performance-anxious-only individuals may differ on a number of factors including their physiological arousal from individuals fearing a broader range of social and performance situations (American Psychiatric Association, 2013a,b; Blöte et al., 2009). The present findings support the notion that SA subtyping might be important to understanding the neuroendocrinology of SA.

Duration of exposure to stress has been suggested to be a critical element in the link between chronic stress and HPA function. Evidence suggests that HPA activity is initially hyperactivated under stress exposure but progressively turns into reduced activity as exposure duration increases (Elzinga et al., 2008; Fries et al., 2005; Miller et al., 2007). The opposite relationships observed between sC and MPA and sC and SA might be related to the frequency and duration of exposure to the feared situations.

(Debilitating) performance anxiety differs from (generalized) SA in a number of qualities including commitment to the feared situation (Kenny, 2010; Powell, 2004). Individuals who suffer from performance anxiety remain committed to the feared performance situation and are more likely to stay in the threatening performance situation than people with SA who want to avoid interactions with others if they can. We speculate that the students with relatively high MPA, although still young, may have already shifted to a state of blunted sC secretion as a consequence of an already long history of frequent exposures to feared performance situations. On the contrary, the students with relatively high SA may have comparatively been exposed so far to fewer feared social situations, possibly because of more avoidance behavior, and thus, at this stage of their life, show heightened sC secretion.

SAA AUCg did not significantly change across the four pre-concert days and increased on concert day by an estimated 38.7%, mainly due to higher sAA levels on concert day between 11 am and 6 pm. Thus, at the day level, sAA activity did not show an anticipatory response but increased only on concert day. The increase in sAA AUCg on concert day is in line with our predictions and with studies reporting that stressors with a social-evaluative component acutely elicit increased sAA activity (e.g., Bosch et al., 1996; Filaire et al., 2010; Thoma et al., 2012). Given that sAA has been shown to increase in response to exercise lasting at least 20 min (Strahler et al., 2017), it seems unlikely that the physical effort associated with 5-10-min music performances can explain these effects, although this remains to be tested.

SAA AUCg on the first post-concert day did not decrease significantly from concert day and was still 18.4% higher than on the pre-concert days, and this difference approached significance. Importantly, MPA modulated this effect. Students with a STAI score over 50 exhibited sAA AUCg significantly larger than on the pre-concert days and comparable to those on concert day. They started to show a decline in sAA AUCg only on the second post-concert day. These findings suggest prolonged post-performance sAA activity in music students reporting moderate to very high MPA. Bosch et al. (1996) found that a measure of the tendency to worry about failure during exams was significantly related to increases in sAA prior to an examination. Arch et al. (2016) reported that trait rumination was associated with higher sAA 10 minutes after a laboratory social-evaluative stressor. We are not aware of any study

investigating anxiety-related differences in sAA recovery during the days following a social-evaluative task.

Taken together, the present findings suggest that neuroendocrine effects of a solo performance go beyond concert day. Specifically, HPA axis and ANS recovery from a solo performance appear to require days, in particular for the most music performance-anxious students. Considering that university music students perform regularly and plan to perform at the professional level, the prolonged post-performance neuroendocrine activation in this population could represent a relevant factor with well-being, health, and career-related implications. Particularly critical could be periods with several performances close to each other. Insufficient recovery associated with sustained psychobiological stress responses may lead to a generalized pathogenic state and may ultimately lead to a number of disorders. A methodological implication of these findings is that experimental conditions of studies on the psychobiology of music performances should preferably be separated by several days to avoid carry-over effects. An important future step would be to determine to what extent the observed neuroendocrine day-to-day patterns relate to adaptive/maladaptive coping and performance outcomes.

As predicted, concert-related PC but not concert-unrelated PC varied as a function of measurement day. Compared to the first day, concert-related PC was slightly increased on the three days before the concert and substantially higher on concert day. Already on the first post-concert day, concert-related PC had returned to initial levels. The concert-related PC pattern thus showed similarities but also noteworthy differences compared to the neuroendocrine pattern. Both concert-related PC and neuroendocrine activity were highest on concert day. On the contrary, whereas neuroendocrine activity remained partially elevated on post-concert days, concert-related PC went quickly back to initial levels. Despite this difference, analyses of the associations between PC and neuroendocrine measures showed the expected relationships. In agreement with the perseverative cognition hypothesis (Brosschot et al., 2010) and with emerging evidence suggesting a link between PC and neuroendocrine activation (Ottaviani et al., 2016), within-person changes in concert-related and concert-unrelated PC were positively associated with sC AUCg. Within-person fluctuations in concert-related PC were also positively associated with

sAA AUCg. To the best of our knowledge, this is the first ambulatory study to show an association between state measures of PC and sAA activity.

Confirming our expectations, higher levels of trait MPA were significantly associated with more concert-related but not concert-unrelated PC across the 7-day period. Previous survey results suggested that anxious musicians worry more than non-anxious musicians just before or during a performance (Lehrer et al. 1990; Liston et al., 2003; Steptoe and Fidler, 1987). Our findings extend this work by showing that this MPA-related difference in cognitive activity extends well beyond the performance situation.

Finally, we hypothesized that between-person and within-person components of concert-related PC would mediate the effects of MPA and measurement day, respectively, on sC AUCg and sAA AUCg. The between-person component of concert-related PC was not significantly associated with either sC AUCg or sAA AUCg and therefore could not be a significant mediator. The within-person fluctuations in concert-related PC were significantly associated with sC AUCg and sAA AUCg, yet, they did not mediate the effect of measurement day on these neuroendocrine outcomes. The mechanisms responsible for the observed neuroendocrine temporal patterns and MPA-related differences remain to be determined.

Future research may use polysomnography or actigraphy to verify awakening time, control for factors such as menstrual cycle phase and chronotypes and assess neuroendocrine activity over more post-concert days and in different performance situations (e.g., competitions). A detailed characterization of PC (e.g., repetitiveness, intrusiveness, difficulty with disengagement) may refine the picture about prolonged music performance-related cognitive processes. Prospective studies are required to investigate developmental aspects of MPA and its psychobiological concomitants. Such studies could include a broader range of biomarkers and more heterogeneous populations and would allow causal relationships and implications of the observed effects on well-being, health, and performance to be established.

In conclusion, we found that a short solo music performance is a real-life stimulus eliciting heightened diurnal sC and sAA output and concert-related PC on concert day in university music students. The

neuroendocrine effects are partially prolonged onto the post-concert days, especially for sAA among students reporting moderate to very high MPA. MPA is associated with reduced diurnal sC output and higher concert-related PC. MPA appears to be an important determinant of psychobiological functioning in music students with unique effects on HPA axis, ANS, and cognitive activity. The mechanisms underpinning these findings and their implications for students' life and career need further investigation.

Author contributors

PG conceived the concepts and methods of the study, performed the data analyses, interpreted the results, wrote a first version of the present manuscript and finalized its final version after critical review by the other authors. CN was involved in the conception of the study, led the data collection, performed the statistical analyses and contributed to the present manuscript. RKS participated in the data preparation and critically reviewed the present manuscript. HH participated in the conception and selection of the methods, recruitment of the participants, interpretation of the results, and review of earlier drafts of the manuscript. PLK was involved in the conception of the study, the selection of the measures, the interpretation of the results, and reviewed earlier drafts of the manuscript. PW participated in defining and implementing the statistical data analysis methods and critically reviewed the manuscript. UMN was involved in the design of the study, assessment and analysis of biological parameters, interpretation of the results, and providing edits on earlier drafts of the manuscript. BD supervised and participated in the conception of the study, supervised the data collection and data analyses, and critically reviewed the manuscript. All authors approved the final version of the manuscript.

Conflicts of interest

None.

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Footnotes

[1] In the remainder of the paper, we use the term MPA to refer to trait MPA.

[2] The audience size did not significantly differ as a function of MPA (p = .95) as determined with negative binomial regression analyses.

[3] The time of the concert did not significantly vary as a function of MPA (p = .96) as determined with linear regression analyses.

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Figure captions

Figure 1

Model-predicted estimated marginal means (*SE*s) of sC AUCg (log) for five combinations of MPA and SA and all participants. Low and high MPA are 1 *SD* below and above the MPA mean on the STAI and correspond to a score of 37.5 and 61.1, respectively. Low and high SA are 1 *SD* below and above the SA mean on the LSAS-SR and correspond to a score of 13.0 and 55.6, respectively. Moderate MPA and moderate SA correspond to the MPA mean (STAI score = 49.3) and SA mean (LSAS-SR score = 34.3), respectively. SC AUCg for low MPA & low SA, moderate MPA & moderate SA, high MPA & high SA, and for all participants are very similar, and thus the lines overlap almost completely. See Table 2 for predictors' estimates.

Figure 2

Model-predicted estimated marginal means (*SE*s) of sAA AUCg (log) for five levels of MPA and for all participants. The five levels of MPA correspond to the following scores on the STAI: very low MPA = 30; low MPA = 40; moderate MPA = 50; high MPA = 60; very high MPA = 70. See Table 2 for predictors' estimates.

Figure 3

Upper graph: Model-predicted estimated marginal means (*SE*s) of the four categories of concert-related PC (0 min, 1-5 min, 6-20 min, more than 20 min) for all participants. *Lower graph*: Model-predicted estimated marginal means of concert-related PC (categories 1-5 min, 6-20 min, and more than 20 min summed together) for three levels of MPA. Low, moderate, and high MPA correspond to scores 37.5 (mean – 1 *SD*), 49.3 (mean), and 61.1 (mean + 1 *SD*) on STAI, respectively.

Figure 1

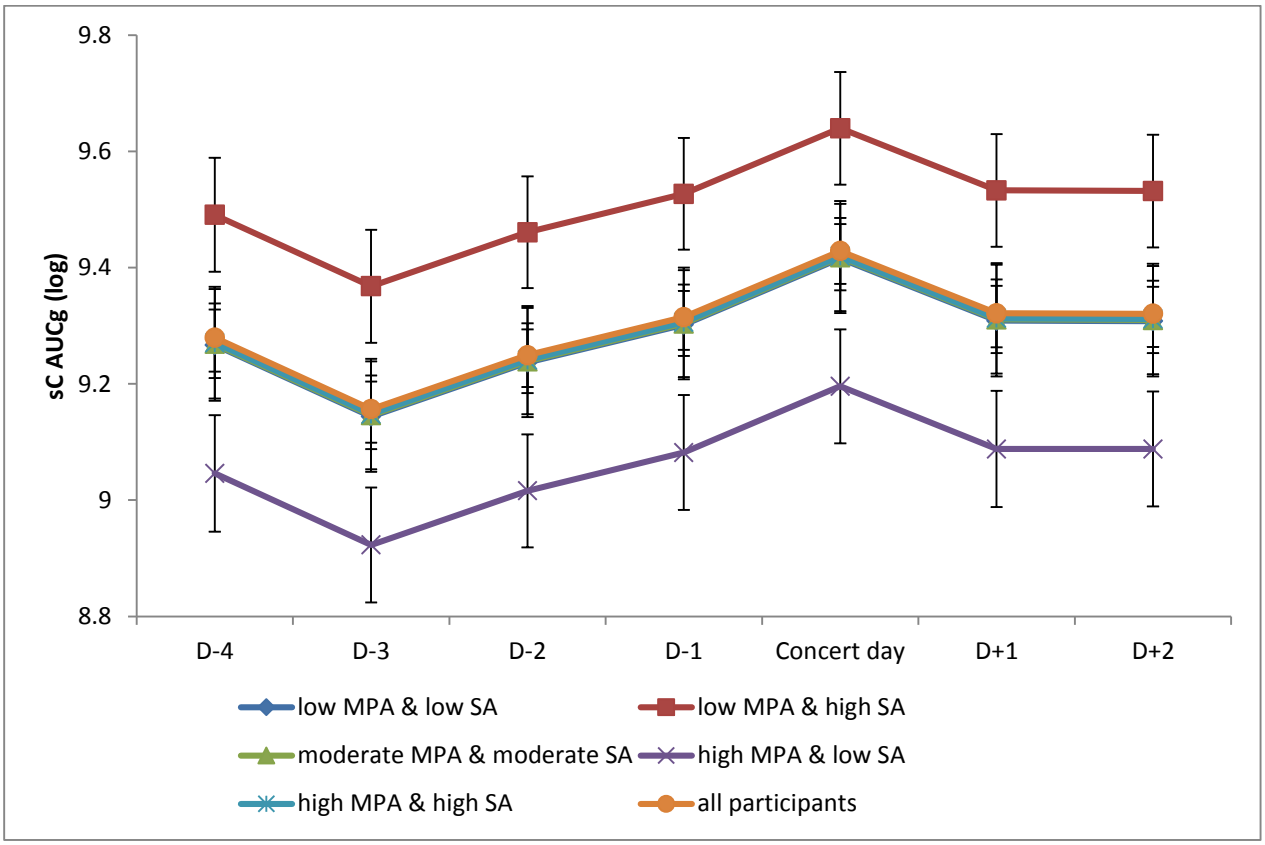


Figure 2

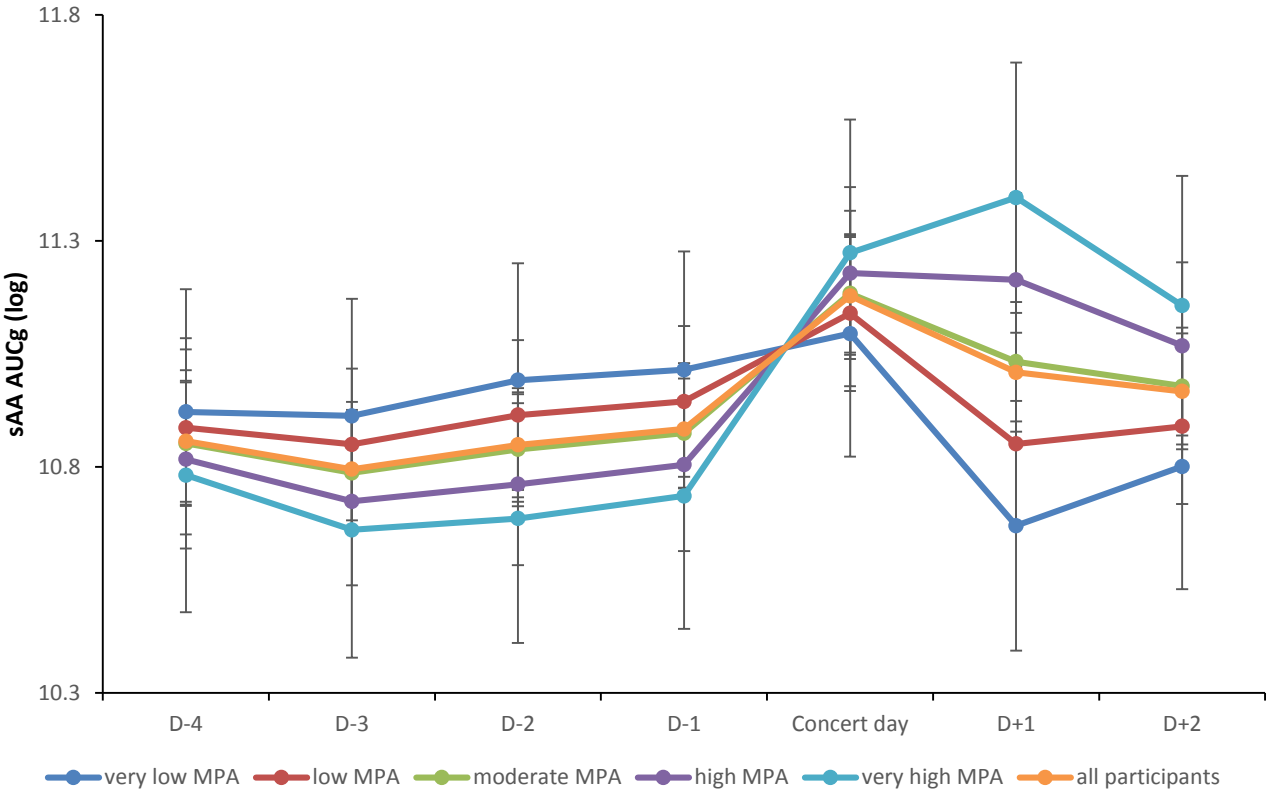
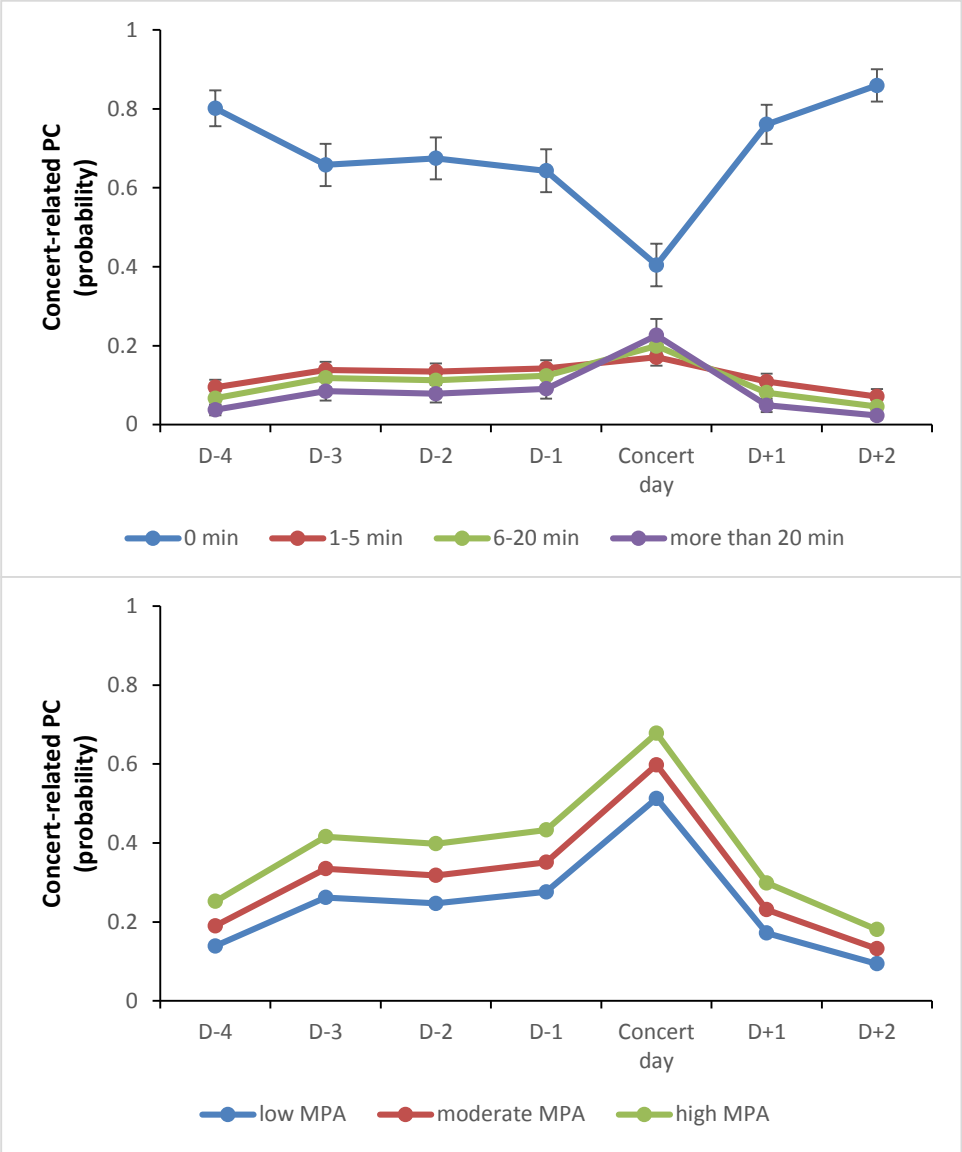


Figure 3



Tables

Table 1. Participants' characteristics

	N	%	*M* (*SD*)	Range
Sex				
Men	25	35		
Women	47	65		
Hormonal contraception				
Yes	24	51		
No	23	49		
Age (years)			22.7 (3.0)	18 – 30
BMI (kg/m^2)			20.9 (2.3)	14.6 – 26.6
Music performance anxiety (MPA)			49.6 (11.7)	27 – 73
Social Anxiety (SA)			34.2 (21.3)	4 – 98
Depressive symptoms (DS)			6.2 (5.0)	0 – 21
Perseverative thinking (PT)			27.3 (11.0)	4 – 51
Academic year				
First	23	32		
Second	15	21		
Third	12	17		
Fourth	9	12		
Fifth	3	4		
Sixth	6	8		
Seventh	4	6		

Table 1 continued

	N	%	*M* (*SD*)	Range
Instrument group				
Strings	23	32		
Woodwind	20	28		
Voice	12	17		
Piano	8	11		
Brass	7	10		
Miscellaneous	2	3		
Instrumental practice (years)			12.9 (4.2)	2 - 25
Instrumental practice (hours/day)			4.9 (1.6)	2 - 12
Number of solo performances			8.6 (5.7)	3 - 23
Number of ensemble performances			12.3 (12.2)	0 - 33

Notes for Table 1

Instrumental practice (years) refers to the number of years the students have been studying their main instrument. Instrumental practice (hours/day) refers to the number of hours per day spent practicing any instrument including all sorts of activities such as individual practice, classes, and rehearsals. The number of performances are over the last 12 months. Pearson correlations between MPA, SA, DS, and PT were as follows: MPA-SA, ρ = .30; MPA-DS, ρ = .40; MPA-PT, ρ = .45; SA-DS, ρ = .43; SA-PT, ρ = .40, DS-PT, ρ = .62.

Table 2. Estimated linear mixed models for sC AUCg and sAA AUCg

	sC AUCg Model A1			**sC AUCg Model B1**			**sAA AUCg Model A2**			**sAA AUCg Model B2**		
	Coeff.	*SE*	χ^2	Coeff.	*SE*	χ^2	Coeff.	*SE*	χ^2	Coeff.	*SE*	χ^2
Intercept	9.14	0.10	**8112*** **	9.13	0.11	**6546*** **	10.93	0.24	**2159*** **	10.97	0.27	**1610*** **
Music performance anxiety	-0.9%	0.4%	**4.37***	-0.9%	0.5%	**4.20***	0.0%	1.2%	0.00	-0.3%	1.3%	0.08
Social anxiety				0.5%	0.3%	**4.00***				0.4%	0.6%	0.40
Depressive symptoms				1.8%	1.2%	2.13				4.1%	3.0%	1.77
Perseverative thinking				-0.8%	0.6%	1.99				-1.2%	1.4%	0.69
Age	1.3%	1.6%	0.66	0.2%	1.6%	0.02	-1.3%	3.9%	0.11	-3.0%	4.4%	0.50
Sex	23.5%	12.5%	3.20	9.6%	12.6%	0.59	-2.4%	31.1%	0.01	-17.8%	34.0%	0.45
Hormonal contraception	-5.6%	12.3%	0.25	1.9%	12.0%	0.03	-33.2%	29.2%	2.50	-25.7%	31.0%	1.21
Body mass index	-4.1%	2.3%	3.53	-3.3%	2.2%	2.40	2.1%	5.7%	0.14	3.8%	6.0%	0.40
Measurement day			**29.00*** **			**30.02*** **			**18.85** **			**19.18** **
Day-3	-11.5%	6.0%		-11.6%	6.0%		-6.2%	12.8%		-6.2%	12.8%	
Day-2	-3.2%	5.4%		-3.0%	5.4%		-0.7%	11.5%		-1.2%	11.6%	
Day-1	3.3%	5.6%		3.6%	5.6%		2.2%	12.1%		2.4%	12.1%	
Concert day	15.5%	5.8%		16.1%	5.8%		38.3%	12.4%		38.9%	12.4%	
Day+1	4.2%	5.9%		4.3%	5.9%		19.1%	12.4%		18.7%	12.5%	
Day+2	4.0%	6.0%		4.2%	6.0%		13.3%	12.5%		12.9%	12.5%	
Day of the week			5.83			5.93			6.70			6.93
Monday	-1.5%	6.1%		-1.4%	6.1%		14.8%	13.5%		15.3%	13.5%	
Tuesday	5.8%	5.9%		6.2%	6.0%		29.2%	12.7%		29.8%	12.8%	
Wednesday	8.1%	5.7%		8.3%	5.8%		6.3%	12.2%		6.6%	12.3%	
Thursday	0.1%	6.0%		0.2%	6.0%		4.1%	12.6%		4.2%	12.6%	
Friday	0.5%	5.7%		0.9%	5.7%		5.4%	12.2%		5.4%	12.2%	
Saturday	-0.7%	5.8%		-0.6%	5.8%		14.2%	12.4%		14.7%	12.4%	

Table 2 continued

	sC AUCg Model A1			**sC AUCg Model B1**			**sAA AUCg Model A2**			**sAA AUCg Model B2**		
	Coeff.	*SE*	χ^2	Coeff.	*SE*	χ^2	Coeff.	*SE*	χ^2	Coeff.	*SE*	χ^2
Season						5.68						2.26
Summer				-20.9%	20.3%					-24.9%	60.1%	
Fall				16.7%	12.9%					40.5%	35.7%	
Winter				16.6%	12.0%					-6.8%	30.4%	
Wake-up time	-11.3%	1.8%	**44.22*** **	-11.2%	1.8%	**44.62*** **	-3.7%	3.1%	1.51	-3.8%	3.1%	1.59
Caffeine	5.0%	2.1%	**5.90***	5.1%	2.0%	**6.15***	-4.1%	4.4%	0.94	-4.3%	4.4%	1.06
Alcohol	3.5%	2.9%	1.44	3.7%	2.9%	1.64	3.2%	6.0%	0.29	3.2%	6.0%	0.29
Tobacco	-0.4%	2.0%	0.04	-0.4%	2.1%	0.04	3.5%	4.2%	0.71	2.5%	4.4%	0.34
Stressful events	2.7%	0.9%	**8.12****	2.4%	0.9%	**6.55***	0.2%	2.0%	0.01	-0.2%	2.0%	0.01
Measurement day x MPA									**13.70***			**13.49***
Day-3							-0.3%	0.9%		-0.3%	0.9%	
Day-2							-0.4%	0.9%		-0.4%	0.9%	
Day-1							-0.3%	0.9%		-0.3%	0.9%	
Concert day							0.8%	1.0%		0.8%	1.0%	
Day+1							2.2%	1.0%		2.2%	1.0%	
Day+2							1.3%	0.9%		1.2%	0.9%	

Notes for Table 2

Model A1 tested main effects of the predictors music performance anxiety, age, sex, hormonal contraception, body mass index, measurement day, day of the week, wake-up time, caffeine, alcohol, tobacco and stressful events. Model B1 is like Model A1 with social anxiety, depressive symptoms, perseverative thinking and season as additional predictors. Models A2 and B2 are like A1 and B1, respectively, with the addition of measurement day x MPA. Reference categories for categorical predictors were as follows: sex: men; hormonal contraception: naturally cycling women; season: spring; measurement day: Day-4; day of the week: Sunday. For continuous predictors, coefficients express the change in the outcome measure per unit of the corresponding scale. Units are as follows: music performance anxiety, social anxiety, depressive symptoms, perseverative thinking: 1 point on the corresponding scales; age: 1 year; body mass index: 1 kg/m^2; wake-up time: 1 hour; caffeine: 1 caffeinated beverage; alcohol: 1 alcoholic beverage; tobacco: 1 cigarette; stressful events: 1 event. Coeff. = estimated coefficient; *SE* = standard error; MPA = music performance anxiety. Coefficients and *SE*s are in % change. Degrees of freedom for χ^2 are six for measurement day, day of the week, and measurement day x MPA, three for season, and one for all other predictors. Statistically significant results are marked in bold. ***p <.001, ** p < .01, *p < .05

Table 3. Estimated mixed ordered logistic regression for concert-related PC and concert-unrelated PC

	Concert-related PC Model A1			**Concert-related PC Model B1**			**Concert-unrelated PC Model A1**			**Concert-unrelated PC Model B1**		
	OR	95% CI	χ^2	OR	95% CI	χ^2	OR	95% CI	χ^2	OR	95% CI	χ^2
Music performance anxiety	1.04	1.00-1.08	**4.71***	1.04	1.00-1.08	**4.20***	1.03	1.00-1.06	3.10	1.02	0.98-1.06	1.28
Social anxiety				1.00	0.98-1.02	0.00				1.01	0.99-1.03	1.96
Depressive symptoms				1.02	0.92-1.13	0.17				1.00	0.90-1.10	0.01
Perseverative thinking				1.01	0.96-1.06	0.07				1.00	0.96-1.05	0.04
Age	1.03	0.90-1.19	0.22	1.03	0.90-1.18	0.20	1.07	0.95-1.22	1.28	1.07	0.94-1.22	1.10
Sex	1.39	0.50-3.84	0.41	1.22	0.44-3.40	0.15	1.25	0.51-3.09	0.24	1.14	0.44-2.95	0.08
Hormonal contraception	1.64	0.61-4.38	0.96	1.93	0.73-5.07	1.77	1.27	0.52-3.10	0.28	1.28	0.52-3.18	0.29
Body mass index	1.05	0.87-1.26	0.22	1.06	0.89-1.26	0.38	1.12	0.95-1.33	1.77	1.15	0.97-1.36	2.62
Measurement day			**52.17*****			**52.14*****			4.58			4.58
Day-3	2.86	1.07-7.63		2.87	1.08-7.62		1.67	0.72-3.86		1.69	0.73-3.91	
Day-2	2.50	1.01-6.18		2.57	1.04-6.36		1.58	0.71-3.51		1.61	0.72-3.58	
Day-1	3.15	1.21-8.18		3.15	1.22-8.17		1.07	0.47-2.45		1.09	0.48-2.48	
Concert day	13.22	5.06-34.53		13.28	5.11-34.55		1.06	0.47-2.37		1.06	0.47-2.39	
Day+1	1.38	0.52-3.66		1.39	0.53-3.68		0.87	0.38-1.97		0.88	0.39-2.00	
Day+2	0.55	0.17-1.72		0.57	0.18-1.78		1.05	0.44-2.55		1.07	0.44-2.60	
Day of the week			2.68			2.20			1.38			1.38
Monday	1.58	0.59-4.27		1.53	0.57-4.12		1.23	0.51-2.98		1.21	0.50-2.93	
Tuesday	0.88	0.34-2.24		0.92	0.36-2.35		1.38	0.60-3.19		1.38	0.60-3.18	
Wednesday	1.35	0.50-3.69		1.37	0.50-3.71		1.39	0.58-3.36		1.37	0.57-3.30	
Thursday	1.00	0.36-2.86		1.03	0.37-2.87		1.19	0.48-2.90		1.17	0.48-2.85	
Friday	1.09	0.42-2.90		1.12	0.43-2.90		1.60	0.69-3.70		1.58	0.68-3.65	
Saturday	0.85	0.31-2.32		0.87	0.32-2.36		1.27	0.53-3.03		1.25	0.52-2.97	

Table 3 continued

	Concert-related PC Model A1			**Concert-related PC Model B1**			**Concert-unrelated PC Model A1**			**Concert-unrelated PC Model B1**		
	OR	95% CI	χ^2	OR	95% CI	χ^2	OR	95% CI	χ^2	OR	95% CI	χ^2
Season						6.19						1.92
Summer				0.25	0.05-1.12					0.70	0.17-2.85	
Fall				0.66	0.23-1.86					0.51	0.19-1.35	
Winter				1.67	0.64-4.35					0.83	0.34-2.03	
Wake-up time	0.94	0.74-1.18	0.30	0.93	0.74-1.17	0.38	1.08	0.88-1.32	0.55	1.08	0.88-1.32	0.55
Caffeine	1.07	0.80-1.43	0.19	1.07	0.81-1.43	0.24	1.29	1.00-1.65	**3.88***	1.27	0.99-1.62	3.46
Alcohol	0.69	0.42-1.13	2.22	0.70	0.43-1.15	2.02	0.59	0.39-0.90	**6.00***	0.59	0.39-0.91	**5.81***
Tobacco	1.06	0.86-1.31	0.27	1.04	0.84-1.28	0.12	1.28	0.97-1.43	2.69	1.22	1.00-1.49	3.69
Stressful events	1.29	1.15-1.46	**17.39*****	1.32	1.17-1.49	**19.89*****	1.49	1.31-1.69	**37.82*****	1.50	1.31-1.70	**37.45*****

Notes for Table 3

Model A1 tested main effects of the predictors music performance anxiety, age, sex, hormonal contraception, body mass index, measurement day, day of the week, wake-up time, caffeine, alcohol, tobacco and stressful events. Model B1 is like Model A1 with social anxiety, depressive symptoms, perseverative thinking and season as additional predictors. Reference categories for categorical predictors were as follows: sex: men; hormonal contraception: naturally cycling women; season: spring; measurement day: Day-4; day of the week: Sunday. OR = odd ratio; CI = confidence interval. Degrees of freedom for χ^2 are six for measurement day and day of the week, three for season, and one for all other predictors. Statistically significant results are marked in bold. ***p <.001, *p < .05