

RESEARCH

Open Access



Associations between burnout symptoms and social behaviour: exploring the role of acute stress and vagal function

Magdalena K. Wekenborg^{1,2*}, LaBarron K. Hill³, Pia Grabbe⁴, Julian F. Thayer⁵, Clemens Kirschbaum¹, Susan Lindenlaub¹, Ralf Arne Wittling⁶ and Bernadette von Dawans⁷

Abstract

Background: The study aimed to investigate the link between burnout symptoms and prosocial behaviour, as well as the role of acute stress and vagally-mediated heart rate variability (vmHRV) on this association.

Methods: Seventy men were randomly assigned to either the stress or the control condition of the Trier Social Stress Test for Groups (TSST-G). Prosocial behaviour was assessed via a social decision-making paradigm during the respective TSST-G condition.

Results: Correlation analyses revealed negative correlations between prosocial behaviour and burnout symptoms. Acute stress was also associated with reduced prosocial behaviour, whereas no interaction effects with burnout symptoms could be revealed. Exploratory analyses showed that vmHRV was negatively correlated with burnout symptoms during the social decision-making paradigm but did not mediate the link between burnout and prosocial behaviour.

Conclusion: In conclusion, we report first experimental evidence that burnout symptoms are negatively associated with prosocial behaviour. Further studies are needed to explore the causal relations.

Keywords: Burnout, Cynicism, Prosocial behaviour, Heart rate variability, Acute stress

Background

Epidemiological research indicates a high prevalence of burnout symptoms especially but not exclusively among healthcare providers and related professions [1, 2]. This high prevalence is especially concerning given the numerous severe negative consequences of burnout symptoms on an organizational (e.g., absenteeism [3]), societal (e.g., immense economic costs [4]), and individual level (e.g., cardiovascular diseases [5]).

Deterioration of social interactions take a key role in modern conceptualizations of burnout symptoms: On the one hand, interpersonal stressors have been

described as the primary cause of burnout emergence [6]. On the other hand, in addition to emotional exhaustion and reduced personal accomplishment, a cynical attitude towards co-workers and clients (i.e., cynicism) is a key burnout sub-dimension according to the 11th Revision of the International Classification of Diseases (World Health Organization, 2018). More precisely, it has been proposed that the burnout sub-dimension cynicism develops as an attempt to distance oneself from experiencing exhaustion, by keeping an emotional distance to other's problems and feelings [7].

Despite the central role of deteriorated social interactions within the theoretical burnout concept, surprisingly little research has explicitly examined potential negative associations between prosocial behaviour and burnout symptoms. Prosocial behaviour is thereby understood

*Correspondence: magdalena.wekenborg@tu-dresden.de

¹ Department of Psychology, Chair of Biopsychology, Dresden, TU, Germany
Full list of author information is available at the end of the article



© The Author(s) 2022. **Open Access** This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>. The Creative Commons Public Domain Dedication waiver (<http://creativecommons.org/publicdomain/zero/1.0/>) applies to the data made available in this article, unless otherwise stated in a credit line to the data.

as the usage of one's own resources for the gain of others [8]. There are indications of negative associations between burnout symptoms and the provision of social support [9–11], as well as empathic abilities and social skills [12–17]. Yet, other research failed to find significant associations between burnout symptoms and prosocial behaviour [18].

In summary, it must be said that the concept itself is of high complexity comprising several domains (like personal aspects, acute stress, chronic stress, social interaction, physiological adaptations etc.) as well as their constant interactions. Several reasons may account for these inconsistent findings. First, as argued by Dahman, Jonsdottir [19], it seems important to differentiate between studies that pursue burnout as a psychological concept within occupational settings (i.e., burnout symptoms) and studies that examined patients receiving professional treatment (i.e., burnout syndrome): Notably, patients may differ from non-patients with respect to the severity of burnout symptoms. Furthermore, since they are commonly on sick leave it can be assumed that they are less exposed to daily stressors which suggests the presence of further outcome relevant differences between these groups [19]. Given the lack of universally accepted diagnostic criteria for burnout, it seems advisable to focus on employed individuals which varied based on their burnout symptoms rather than on inconsistently diagnosed patients. Second, most of the previous studies were conducted within specific occupational groups, limiting their external validity. Third, as none of the previous studies used experimental paradigms which enable direct and objective observation of interactive behaviour, well-known shortcomings of self-reported data (e.g., social desirability response bias) might have influenced the results.

Forth, none of the previous studies examined potentially modulating factors of the plausible association between burnout symptoms and prosocial behaviour. Acute stress has been shown to modify prosocial behaviour (for review, see [8, 20]). The direction of this modulation is, however, ambiguous, strongly depending on characteristics of the individual [8, 20]. The level of burnout symptoms might be an individual characteristic especially relevant for the direction of this modulation. We and others have shown that burnout symptoms are associated with dysregulations in the core stress systems of the human body (autonomic nervous system [ANS] and hypothalamus–pituitary–adrenal [HPA] axis) under acute stress [21, 22]. Whether these burnout-associated modulations in the core stress systems of the body also influence prosocial behaviour under acute stress remains an open question.

Elucidating the underlying physiological mechanisms linking burnout symptoms and prosocial behaviour is relevant both in understanding the aetiology of burnout, as well as the interplay of stress and social behaviour within a broader framework. The autonomic nervous system, and particularly, measures of vagally-mediated heart rate variability (vmHRV) may be a valid candidate. HRV describes the variability in the interval length between consecutive heartbeats [23]. Due to differences in chemical signalling, the vagus as the most important nerve of the parasympathetic nervous system, has a much faster influence on the heart rate (HR) than the sympathetic nervous system, making high-frequency changes in HRV (vmHRV) a relatively pure measure of vagal activity [24]. The two most prominent theories of cardiac vagal control, namely the *polyvagal theory* [25, 26] and the *model of neurovisceral integration* [27, 28] suggest, that measures of vmHRV index the capacity for effective emotion recognition and regulation, important prerequisites of the ability to empathize and connect with others. Empirical studies have further revealed significant associations between prosocial behaviour and enhanced basal vagal tone [29–32], as well as task-related vmHRV as a state marker [33–35]. In addition, higher basal and task-related vmHRV were found to promote similar constructs including social connectedness and social sensitivity [36–38]. Lastly, we and others have consistently shown that burnout symptoms are associated with reduced vmHRV cross-sectionally [39, 40] and longitudinal [41] for overview see [42]. Thus, it is plausible that burnout-associated reductions in vmHRV reflect similar reductions in prosocial behaviour.

Given these considerations, the present study sought to determine whether burnout symptoms would be associated with observable modulations in prosocial behaviour in an age- and occupationally- heterogeneous, yet relatively small male sample. Secondly, we investigated the potential modulatory role of acute stress and vagal function on the association between burnout and prosocial behaviour.

We used a validated paradigm from behavioural economics to investigate different prosocial behavioural facets as well as a non-social control condition [43]. We hypothesized 1) that burnout symptoms would be negatively related to prosocial behaviour, and 2) that an acute psychosocial stress provocation (i.e., the Trier Social Stress Test for Groups [TSST-G] [43]) would modulate this association. Lastly, we explored whether basal and/or vmHRV during social interaction would mediate the association between burnout symptoms and prosocial behaviour.

Methods

Participants

Participants for the present study were recruited either through their participation in the Dresden Burnout Study [44], or via public media. Due to influences of female menstrual cycle and oral contraceptives on the psychological stress response [45, 46] as well as the potential effects of gender in social interaction paradigms [47, 48] we choose an exclusively male sample without self-reported mental or physical illness.

Exclusion criteria were previous participation in a study involving any version of the Trier Social Stress Test (TSST [43, 49]), and current unemployment (to ensure a certain level of functioning).¹

Participants who met the inclusion criteria were allowed to participate in full the study (i.e., target participants). Participants who did not meet the inclusion criteria were included as social interaction partners for the target participants (i.e., interaction partners). This second group did not complete the stress or control condition of the TSST-G or other measures and was involved only in the social decision-making paradigm. Target participants received an initial 15€; whereas interaction partners received 5€ for participation. Both, target participants and interaction partners could earn additional money in the social decision-making paradigm (mean of additional gain [SD]: 16.58 [7.44] €). All participants gave written informed consent. The study protocol was approved by the ethics committee of the TU Dresden and conducted in accordance with the Declaration of Helsinki.

The social and non-social decision paradigms

Prosocial behaviour was assessed using a social decision making paradigm from behavioural economics already previously tested in men and women [50, 51], which is described in detail elsewhere [51]. In the present study, target participants interacted anonymously with randomly assigned real interaction partners who were not part of a TSST-G condition.

Shortly summarized, the social decision-making paradigm included decisions on trust and trustworthiness, on sharing (with four decisions each), as well as a non-social risk lottery.² Each decision reflected a binary choice (e.g., trust vs. no trust). The social decision-making paradigm consisted of two sets, which were randomized, whereas

each set comprised two decisions on trust game, two decisions on trustworthiness, two decisions on sharing, and four rounds of the non-social risk lottery.

Both, the trust game and trustworthiness game were sequential two-player games. The starting player decides whether to trust (gain depends on the decision of the other player) or not to trust (both players receive the same number of MU = monetary units). If the player with the first move chooses trust, overall more MU could be scored, provided that the second player was trustworthy. Participants played four variants of the game as the starting player (trust) and four variants of this game as player with the second move (trustworthiness).

In the sharing game, players had to choose between keeping all MU for themselves or to share with an interaction partner, giving the interaction partner no opportunity to influence the outcome.

In the non-social risk game, the target participant played on his own. Players had to gamble, choosing either a high risk or a low risk option. The results were determined by virtual dice throwing: rolling a 1, 2, or 3 resulted in the higher outcome, whereas rolling a 4, 5, or 6 resulted in the lower outcome.

For the analyses, results of the respective games were summed-up in the following behavioural scores: (1) *trust*, (2) *trustworthiness*, (3) *sharing*, and a (4) *non-social risk score*. In addition, we calculated the (5) *prosocial index* (ranging from 0 to 12), which comprises decisions reflecting trust, trustworthiness and sharing (sum score; each ranging between 0 to 4). For all social behavioural scores (trust, trustworthiness, sharing), higher values indicate higher prosocial behaviour.

For the non-social risk game, 1 point was given for each decision in favour of the risky game, which resulted in a minimum of 0 and a maximum of 8 (*non-social risk score*), with higher scores indicating more non-social risk behaviour.

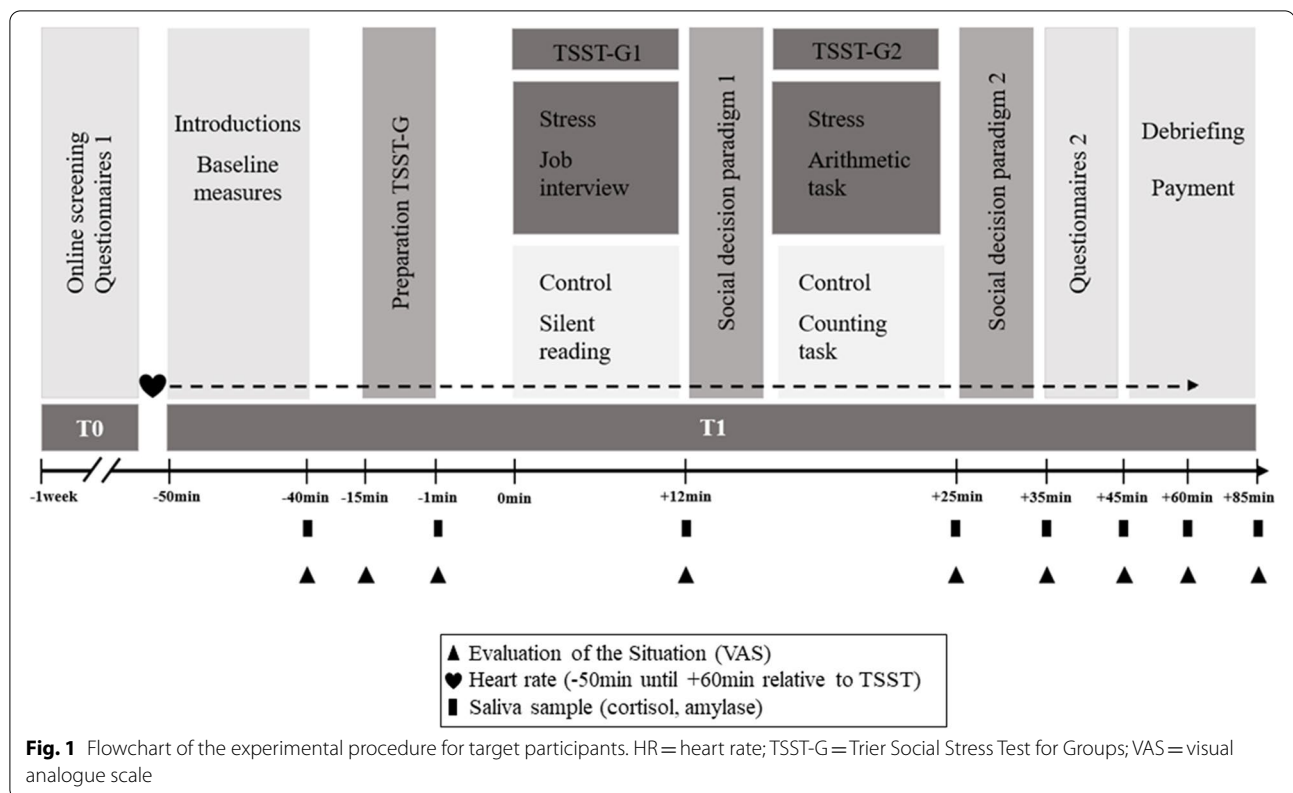
MU earned from all decisions were disbursed after the experiment according to the following exchange ratio: 100 MU = 0.95€, based on von Dawans, Ditzen [50]. The experiment was programmed and conducted with z-Tree software [52].

Procedure

The procedure for target participants followed the recommendations of von Dawans, Fischbacher [51] and is illustrated in Fig. 1. Participants were randomly assigned to either the stress ($n = 35$) or control condition ($n = 35$) of the TSST-G [43] and were invited to the lab in groups of four to six people. One week before the experiment,

¹ We are aware of the fact that the latter criterion limit the range of burnout symptom severity of participants included in the study, as very high levels of burnout symptoms are associated with an inability to work. However, as mentioned before, it has been suggested that studies should choose whether they examine burnout symptoms in a more or less healthy sample or in patients which have been seeking medical as results are not comparable due to difference in exposure to stressor resulting from sick leave/hospitalization. As no empirically validated burnout diagnoses has been established yet, we decided to focus on the former.

² Ensures that possible changes in behaviour are specific to prosocial behaviour and cannot merely be explained by changes in risk behaviour.



participants answered an online questionnaire on burnout symptomatology, sociodemographic characteristics and health-related factors (T0). One day before the experiment, participants were reminded via email to not take any medication and to abstain from alcohol, caffeine, sports, and smoking 24 h prior to the experiment. Moreover, they were told to eat standard meals and to abstain from food two hours prior to the experimental session. Experimental sessions started at 2 pm and lasted 2.5-h (T1). Upon arrival at the computer laboratory, participants were seated and were not allowed to communicate with each other. After reading and signing informed-consent forms, participants were introduced to the saliva-sampling method and were provided with a heart rate device (Polar RS800TM, Polar Electro, OY, Kempele, Finland) and baseline measures of salivary cortisol, HRV and psychometric variables were taken (additional measurements of acute stress were taken throughout the experiment as depicted in Fig. 1). After baseline measurement, participants received written instructions for the social decision making paradigm and were asked to complete control tasks to ensure the participants' understanding of the paradigms. In the following, target participants were provided with the instructions for either the TSST-G stress or control condition and had 6 min to prepare for the mock job interview/group reading. Afterwards, they

were guided to the test room. On their way, they were passed by the group of the interaction partners in order to guarantee the credibility of the existence of the human interaction partners. After arriving at the test room, target participants received a summary of the procedure.

As previously mentioned, target participants participated either in the stress condition of the TSST-G or a specific control condition, containing all factors of the stress condition except for the psychosocially stressful component, allowing the examination of the specificity of the stress effects [43]. In both conditions, participants stood next to one another, separated by partition walls, in front of a two-person committee that was evaluative only in the stress condition in order to induce socio-evaluative stress.

The exact sequence of tasks in the test room was: 12 min public-speaking task (stress condition TSST-G) or reading in a low voice (control condition TSST-G), followed by the first part of the social decision-making paradigm in a paper pencil version (5 min), then 8 min mental arithmetic task (stress condition TSST-G) or enumerating a series of numbers in a low voice (control condition TSST-G), followed by the second part of the social decision making paradigm (5 min; see also Fig. 1). After finishing the second part of the social decision making paradigm, target participants were guided back to the

computer laboratory, where their previously made decisions had been matched with the interaction group's decisions. At the end of the study participants were debriefed and received their compensation individually.

Self-report measures

MBI-GS

Burnout symptoms were assessed with the German version (MBI-GS-D [53]) of the Maslach Burnout Inventory-General-Survey (MBI-GS [54]), the most frequently used burnout measure in the field. The inventory comprises 16 items forming three sub-dimensions (emotional exhaustion, cynicism, reduced personal efficacy). All items are scored on a 7-point frequency-rating scale (0 = never; 6 = daily). The weighted MBI total score ($0.4 \times$ emotional exhaustion + $0.3 \times$ cynicism + $0.3 \times$ reduced personal accomplishment), introduced by Kalimo, Pahkin [55], and the three MBI sub-dimensions were considered as continuous variables and analysed separately. High scores on these scales indicate high burnout symptomatology.

PHQ-9

Depressive symptoms were measured with the German version (PHQ-D [56]) of the Patient Health Questionnaire (PHQ-9 [57]), which comprises the nine diagnostic criteria for depressive disorder of the Diagnostic and Statistical Manual of Mental Disorders [58]. The items are scored on a 4-point ranking scale (0 = not at all, 3 = nearly every day) and added up to a sum score. High scores on these scales indicate high depressive symptomatology.

Assessment of biological measures

Autonomic measures

HR of target participants was recorded continuously via a chest belt throughout the whole experimental procedure (Polar RS800TM, Polar Electro, Oy, Kempele, Finland), and transferred to the Polar Precision Performance Software (Polar Electro OY, Kempele, Finland). Researchers at the Center for Neuroscience Research (ZNF gGmbH, Trier, Germany) analysed the raw peak-to-peak intervals to calculate the HRV parameters according to the guidelines of the Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology [23] and their specific implementation in the "NEUROCOR[®] precisionHRV-Algorithm Pat". In the further process the HRV parameters of the intervals were only considered in the course of the evaluation if the artefact rate of the respective segment was below a given threshold in all valid neighbouring IBIs. Thus first, occurring artefacts were corrected by a smoothed spline interpolation and the artefact rate was calculated per interval. Second, in order to assess autonomic stress levels, mean HR (mHR) was calculated for each period of

90 s of continuous data collected throughout the experiment. Third, in order operationalize vagal function, the root mean square of successive differences of R-R-intervals (RMSSD) was calculated for 5 min of continuous data during each of the two sets of the social decision-making paradigm (vmHRV task). RMSSD was used as it has been shown to be less affected by breathing patterns and therefore more robust than high-frequency HRV [59, 60]. As previous research has been inconclusive regarding its influence on behavioural variables, basal as well as task-related vmHRV were considered within the present study. Basal vmHRV was operationalized as data collected during a 5 min seated resting condition before the introduction of the respective TSST-G condition. The two 5 min segments recorded during the two sets of the social decision making paradigm were averaged and are henceforth referenced as vmHRV task.³ As basal vmHRV and vmHRV task were not normally distributed, log transformation was applied to reduce skewness.

Statistical analyses

As the behavioural scores (*trust, trustworthiness, sharing, non-social risk score*) were not normally distributed, all analyses involving these scores were conducted using non-parametric statistics.

In order to test our first hypothesis regarding associations between burnout symptoms and prosocial behaviour, partial correlation analyses between the four MBI scores, the behavioural scores, as well as the *prosocial index* were conducted, adjusting for age and depressive symptoms. To minimize multiple testing, only those MBI scores exhibiting a significant relation to the *prosocial index*⁴ were considered for the subsequent moderation and mediation analyses.

Next, we examined direct effects of acute stress on prosocial behaviour using a non-parametrical MANCOVA, with the behavioural scores and the *prosocial index* as the dependent variables, TSST-G condition (stress vs. control) as the independent variable and age as a covariate.

The second hypothesis regarding potential interaction effects between acute stress and burnout symptoms on the *prosocial index* were tested by conducting moderator analyses using the PROCESS macro [61], with the respective MBI score as the independent variable (X), the TSST-G condition (stress vs. control) as the moderator

³ In two cases HR was only recorded during one set of the social decision making paradigm due to technical problems. For these cases the missing values were replaced by the mean values of the respective other set of social decision making paradigm. Including them in analyses did not change the results.

⁴ We focussed on the *prosocial index* as in contrast to the behaviour subscores as, following the central limit theorem, the distribution of a sample variable approximates a normal distribution.

Table 1 Demographic and health characteristics ($N = 70$)

Characteristics	Control ($N = 35$)	TSST-G ($N = 35$)	Group comparison
Demographics, M (SD)	40.34 (10.76)	36.63 (11.85)	$t(68) = 1.37$
Age, y			
BMI, kg/m^2	24.64 (3.84)	24.63 (4.08)	$t(68) = 0.02$
Health-related factors, n (%)			
Smokers	7 (20.0)	5 (14.3)	$\chi^2(1) = 0.53$
Daily alcohol consumption	9 (25.7)	6 (17.1)	$\chi^2(1) = 0.38$
MBI total score, M (SD)	2.32 (1.00)	2.12 (0.96)	$t(68) = 0.90$
Emotional exhaustion	2.71 (1.23)	2.68 (1.47)	$t(68) = 0.09$
Cynicism	2.19 (1.26)	1.73 (1.13)	$t(68) = 1.64$
Reduced personal accomplishment	1.94 (1.15)	1.76 (1.07)	$t(68) = 0.70$
PHQ-9, M (SD)	7.09 (4.18)	7.11 (4.54)	$t(68) = -0.28$
Salivary cortisol (baseline)	4.89 (3.20)	6.22 (7.89)	$t(68) = -0.48$
Mean VAS (baseline)	2.09 (1.01)	2.54 (1.50)	$t(68) = -1.47$

MBI total score Maslach Burnout Inventory—General Survey total score, mHR mean heart rate, PHQ-9 Patient Health Questionnaire, depression sum-score, Mean VAS mean value of six visual analogue scales. None of the group comparisons were significant

(M), and the prosocial index as the dependent variable (Y), adjusting for age and depressive symptoms.

Finally, in order to evaluate the role of vagal function, in a first step, we examined associations between the MBI scores, basal $vmHRV$ and $vmHRV$ task using partial correlation analyses, adjusting for age and depressive symptoms. To minimize multiple testing, only the $vmHRV$ exhibiting a significant relation to any of the MBI scores was considered in further analysis. In a second step, the potential indirect effect of burnout symptoms on prosocial behaviour through $vmHRV$ was evaluated, using the PROCESS macro [61]. Specifically, we estimated the conditional indirect effects of burnout symptoms (X) on social behaviour (Y) through $vmHRV$ (M). A confidence interval including zero means that no evidence for mediation is given [61]. All statistical analyses were conducted using IBM SPSS Statistics v. 22 (SPSS Inc., Chicago, IL, USA), significance was set at $p < 0.05$, all tests were two-sided. Overlap between burnout and depressive symptoms remains a debated topic (for review see [62]), thus all analyses including burnout symptoms adjusted for depressive symptoms.⁵ As age has been shown to be associated with alterations in $vmHRV$ [63] and burnout symptoms [64], it was considered as an additional covariate in these analyses,⁶ too.

Results

Descriptive statistics

The final sample ($N = 70$; mean [SD] age = 38.49 [11.39] years) included 35 participants in the stress condition

and 35 participants in the control condition of the TSST-G.⁷ The stress and the control condition of the TSST-G did not significantly differ in relevant demographic and health related characteristics (Table 1). The severity of the burnout symptoms of the participants varied between a 0.26 and 4.23 (mean [SD] MBI total score = 2.22 [0.97]) indicating a wide range of burnout symptoms, which was following the cut-off values proposed by Kalimo, Pahkin [55], subclinical on average.

TSST-manipulation check

We have previously demonstrated that the stress manipulation through the TSST-G was successful with respect to psychological (visual analogue scale) and biological (mean heart rate, salivary cortisol, $vmHRV$) markers of acute stress [21]. In contrast, the present paper focusses on burnout-associated changes in prosocial behaviour.

Within the scope of the first publication, we demonstrated that the stress manipulation through the TSST-G was successful with respect to psychological (visual analogue scale) and biological (mean heart rate, salivary cortisol, $vmHRV$) markers of acute stress [21].

Associations between burnout symptoms and prosocial behaviour

Testing our first hypothesis regarding associations between burnout symptoms and behavioral scores

⁵ PHQ-9 was significantly associated with all MBI scores (MBI-total: $r = .66$, $p < .01$; cynicism: $r = .53$, $p < .01$; emotional exhaustion: $r = .67$, $p < .01$; reduced personal accomplishment: $r = .53$, $p < .01$).

⁶ All statistical analyses were conducted without elimination of outliers (values ± 2 SD of group means), as reported findings were the same regardless of whether outliers were excluded or not.

⁷ One participant was excluded from analyses because he was erroneously included, although unemployed.

Table 2 Partial correlations between burnout symptoms, prosocial behaviour data, and vagally-mediated HRV at baseline and during the social decision making paradigm adjusted for age and depressive symptoms (N = 70)

	MBI total score		MBI EE		MBI CY		MBI PEr	
	r	p	r	p	r	p	r	p
MBI total score								
MBI EE	0.77**	<.001						
MBI CY	0.75**	<.001	0.44**	<.001				
MBI PEr	0.64**	<.001	0.22	0.07	0.34*	<0.01		
Basal vmHRV	-0.14	0.25	-0.06	0.64	-0.18	0.14	-0.08	0.52
VmHRV task	-0.24	0.05	-0.09	0.49	-0.30*	0.01	-0.15	0.22
Prosocial index	-0.19	0.13	-0.06	0.62	-0.26*	0.03	-0.15	0.23
Trust	-0.02	0.90	0.03	0.80	-0.11	0.39	-0.02	0.85
Trustworthiness	-0.18	0.14	-0.11	0.40	-0.19	0.12	-0.12	0.34
Sharing	-0.30*	0.01	-0.16	0.19	-0.36*	<0.01	-0.21	0.09
Non-social risk score	0.17	0.16	0.15	0.24	0.16	0.18	0.14	0.25

MBI total score = Maslach Burnout Inventory—General Survey total score; MBI EE = emotional exhaustion sub-dimension; MBI CY = Maslach Burnout Inventory-General Survey cynicism sub-dimension; MBI PEr = reduced professional efficacy sub-dimension; Basal vmHRV = root mean square of successive difference between heart beats at seated baseline; vmHRV task = root mean square of successive difference between heart beats during the social decision making paradigm. * for $p < .05$; ** for $p < .001$

using non-parametric partial correlation (adjusting for age and the PHQ-9) revealed significant negative associations between the MBI total score and the behavioral sub-score *sharing* ($r = -0.30$; $p = 0.014$). The cynicism sub-score was negatively associated with the behavioral sub-score *sharing* ($r = -0.36$; $p = 0.003$), as well as with the *prosocial index* ($r = -0.26$; $p = 0.03$). No further significant associations were observed between the additional MBI sub-scores and behavioural scores (see Table 2).

Effects of acute stress on prosocial behaviour and its interaction with burnout symptoms

The non-parametrical MANCOVA revealed reduced prosocial behaviour following acute stress, compared to the control condition with respect to *trust* ($F(1,67) = 6.92$, $p = 0.01$; $\eta^2 = 0.09$) and the *prosocial index* ($F(1,67) = 6.05$, $p = 0.02$; $\eta^2 = 0.08$). No significant associations were found with *trustworthiness* ($F(1,67) = 2.63$, $p = 0.11$), *sharing* ($F(1,67) = 1.22$, $p = 0.27$) and the *non-social risk score* ($F(1,67) = 0.43$, $p = 0.52$).

Next, a moderation analysis was conducted to test our second hypothesis of potential interaction effects of burnout symptoms and acute stress on prosocial behaviour. Only cynicism was considered, as previous analyses revealed that only this burnout sub-dimension depicted significant associations with the *prosocial index*. As depicted in Table 3, the moderation analysis did not provide confirmation of an interaction effect of the TSST-G condition on the association between cynicism and the *prosocial index* (Model $R^2 = 0.16$, $p < 0.05/\Delta R^2$ due to interaction = 0.002, $p = 0.73$).

Exploratory analyses on relations with vagal function

Exploratory analyses were conducted to examine if burnout symptom-related changes in prosocial behaviour are linked to modulations in vmHRV. Partial correlational analyses revealed that cynicism was significantly negative associated with vmHRV during the social decision making paradigm ($r = -0.30$; $p = 0.01$), whereas no significant associations were observed between baseline vmHRV and any of the MBI sub-scores (see Table 2). As depicted in Fig. 2, the relationship between cynicism and the *prosocial index* was not mediated by vmHRV during the social decision-making paradigm.

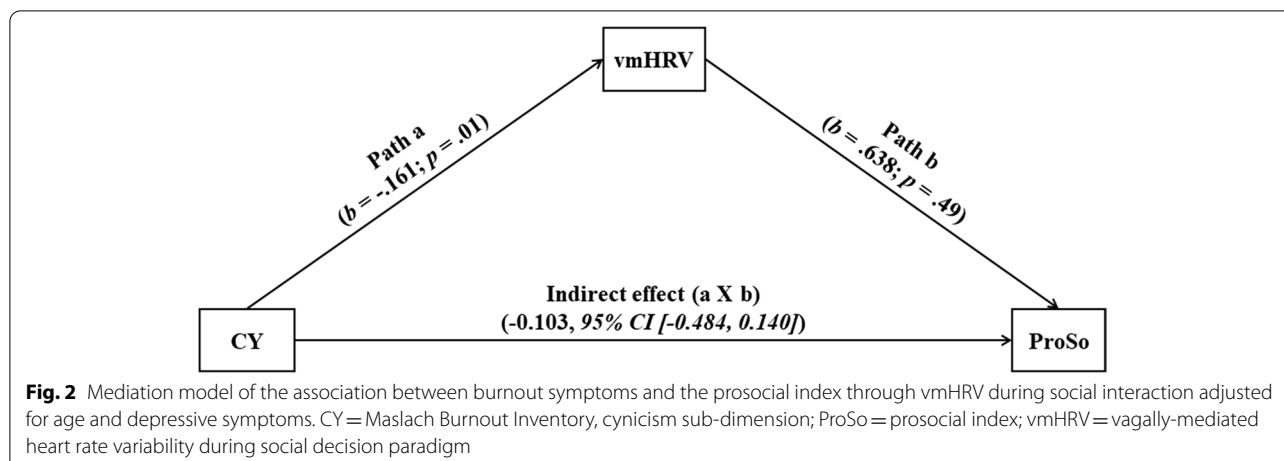
Discussion

The present study experimentally examined burnout-associated modulations in prosocial behaviour in an age and occupationally heterogeneous sample. Beyond this, we explored potentially modulating effects of acute stress, as well as underlying physiological mechanisms

Table 3 Moderation model of cynicism and acute stress predicting the prosocial index (N = 70)

	Estimates	SE	95% CI lower bound	95% CI upper bound	p
Age	-0.03	0.04	-0.12	0.05	.42
MBI CY	-1.24	0.57	-2.39	-0.09	.04*
Acute stress	-3.14	1.75	-6.63	0.35	.08
MBI CY x acute stress	0.27	0.77	-1.27	1.81	.73

MBI CY Maslach Burnout Inventory- General Survey cynicism sub-score, CI confidence interval. * for $p < .05$; ** for $p < .001$



of this association. We found that burnout symptoms were negatively associated with *sharing* and a sum-score of the three behavioural scores *sharing*, *trust*, and *trustworthiness* (*prosocial index*) during a social decision-making paradigm. In addition, even though acute stress was associated with reduced prosocial behaviour, there was no additional interaction effect with burnout symptoms. Explorative analyses revealed that burnout-associated reductions in vmHRV paralleled burnout-associated reductions in prosocial behaviour. However, we did not find direct mediation effects of vmHRV on the association between burnout symptoms and prosocial behaviour.

With respect to our first hypothesis, significant negative correlations were found with respect to *sharing* and the *prosocial index* with the burnout sub-dimension cynicism. In addition, *sharing* was negatively associated with the MBI total score, indicating that higher burnout symptoms were associated with a reduced tendency for prosocial behaviour.

Importantly, there was no significant relation between any of the four MBI scores and non-social risk behaviour, suggesting that the effects are specific to social interactions. To the author's knowledge our study is the first to indicate burnout-associated reductions in directly observable prosocial behaviour within a laboratory setting using a standardized social decision making paradigm. These findings are in line with previous questionnaire-based research revealing associations between burnout symptoms and reduced prosocial behaviour [18], enhanced hostile and impatient behaviour [65, 66], less prosocial organizational behaviour [67], more social conflicts [68, 69], and lower emotional intelligence [12, 14]. The finding of cynicism being the only burnout sub-dimension which showed significant negative associations with prosocial behaviour is in line with previous

findings [70] and supports prior assertions that cynicisms reflects the interpersonal sub-score of burnout [71].

Our findings are highly relevant, given the well-known clinical consequences of reduced prosocial behaviour. For instance, from a stress-buffering perspective [72], positive social interactions have been repeatedly shown to reduce acute stress load [73] and to prevent mental diseases [74]. Burnout-associated reductions in prosocial behaviour may signal the beginning of a vicious circle of increasing burnout symptoms progressively reducing potentially stress buffering positive social interactions.

With respect to possible explanations for burnout-associated reductions in prosocial behaviour, by drawing on the conservation of resources theory (COR [75]) it has been proposed that burnout symptoms reflect a drain of resources and that the expression of negative social behaviour serves as a coping strategy in order to deal with these reduced cognitive and emotional resources [65, 76]. Following a similar line of reasoning, it has been proposed that individuals with higher burnout symptoms lack the resources to regulate self-centred motives in order to engage themselves in prosocial interactions with others [77, 78]. Our finding that emotional exhaustion was not significantly associated with reduced prosocial behaviour contradicts these theoretically derived assumptions in a way. However, for an actual verification of these theories, longitudinal studies are indispensable.

In addition, we were interested in potentially modulating effects of acute stress on the association between burnout symptoms and prosocial behaviour. Previous research showed that, depending on so far insufficiently explored individual characteristics, acute stress can modulate prosocial behaviour (for review see [8]). As burnout symptoms have been associated with modulations in acute stress reactivity [21, 22], it appears likely that burnout symptoms are one of these individual characteristics

which influence the effects of acute stress on prosocial behaviour.

However, in contrast to our second hypothesis, we did not find any interaction effects between stress condition and burnout symptoms on prosocial behaviour. Interestingly, acute stress itself had a main effect on prosocial behaviour, in that subjects in the stress condition generally showed less prosocial behaviour compared to individuals in the control condition of the TSST-G. This finding is in line with a recently published review of 19 studies that induced acute stress in a laboratory setting and measured prosocial behaviour [8]. More precisely, Faber [8] reported that seven studies found a reduction of prosocial behaviour under acute stress, whereas only four studies found increases, three did not find any difference and five studies showed mixed results depending on moderating factors. The authors attribute this heterogeneity in study results to a complex interaction between acute stress, characteristics of the individuals, as well as the specific situation, which causes the individual to focus either on individual resources (gaining money through reduced prosocial behaviour; COR [79]) or social resources (gaining affiliation to social group through enhanced prosocial behaviour [8, 80]). One important difference between our and previous studies which found enhanced prosocial behaviour under stress [50, 51, 81] might be differences in the similarity with the social interaction partners. Previous research indicates more prosocial behaviour towards close members of the in-group but not to out-group others especially under acute stress [82]. In contrast to the age and occupationally heterogeneous sample of the present study, previous studies relied almost exclusively on rather homogenous samples of university students. Future studies are needed which examine the effect of conformity with regard to central demographic characteristic between interaction partners on prosocial behaviour under acute stress.

Finally, the finding of negative main effects of burnout symptoms and acute stress on prosocial behaviour with a simultaneous absence of a significant interaction between the two might suggest that burnout symptoms and acute stress contribute independently to prosocial behaviour.

As a more exploratory research question, based on the fact that vmHRV has been linked to both, enhanced prosocial behaviour [33], and reduced burnout symptoms [40, 41], this study investigated whether autonomic balance, as indexed by vmHRV during the social interaction paradigm mediated the link between burnout-related cynicism and prosocial behaviour. And in fact, we did find that reduced task-related vmHRV was associated with greater cynicism. However, there was no evidence for task-related vmHRV as a mediator between burnout-related cynicism and prosocial

behaviour. In sum, the present finding of associations between reduced vmHRV and the interpersonal sub-dimension of burnout (i.e., cynicism) supports the important role of autonomic imbalance for social functioning. However, the fact that vmHRV was not directly linked to social behaviour indicates that the role of vagal function for observable social behaviour might be selective for specific kinds of prosocial social behaviour. Nevertheless, future studies investigating the effects of vagal-excitatory interventions on social behaviour in burnout (e.g., physical activity; breathing techniques, vagus nerve massage, and nicotine-free programs) may further elucidate this possible interaction.

There are also some limitations to be considered. First, in order to minimize potential confounders, the study included only employed individuals, which led to a restriction in severity of burnout symptoms. Second, considering that the development of a cynical attitude has been associated with male gender-role socialization [83], and that a meta-analysis has also revealed slightly higher cynicism scores in males [84], the inclusion of males only, taken together with the relatively small sample size, limit the generalizability of the results. Third, considering the cross-sectional study design, no assertions about the causal relationship between burnout symptoms and changes in social behaviour can be made. Fourth, even though the central limit theorem suggests a normal distribution of a sample variable with sample sizes > 30 [85], results from parametric statistical test including the *prosocial index* (i.e., moderation and mediation analyses) should be interpreted with caution.

In sum, our study is the first to indicate negative associations between burnout symptoms and prosocial behaviour using a standardized social decision paradigm in a laboratory setting. In addition, we could show that the effects of acute stress on prosocial behaviour mirrored the results observed for burnout symptoms. The absence of interaction effects indicates a rather parallel influences of acute stress and chronic stress sequels (i.e., burnout symptoms) on prosocial behaviour. Finally, our finding of burnout-symptoms-associated reductions in vmHRV during the social decision making paradigm with a simultaneous absence of significant mediating effects of autonomic imbalance on the relation between burnout symptoms and prosocial behaviour, indicates that autonomic imbalance might play an important, yet more indirect role in burnout-associated modulations in prosocial behaviour.

Due to our small sample size, our findings should be interpreted with caution and should rather be seen as a starting point for longitudinal studies examining possible causal relationships between burnout symptoms and

changes in social behaviour as well as their physiological underpinnings.

Moreover, future studies need to further disentangle the various interconnections of the highly complex construct of burnout. Besides longitudinal designs, and bigger sample sizes, future studies need to try to disentangle the role of various aspects like personal characteristics, chronic or acute stress and their interrelations. This may also lead to subgroups and a dimensional rather than a categorical approach to diagnostics in subclinical and clinical populations. It would be necessary to use multi-method and multi-center approaches, including psychological as well as physiological variables and investigate social interactive behaviours with high external validity in real person interactions. This may include open science practices in sharing designs and procedures as well as datasets. In addition, such approaches with the respective high sample sizes would also allow for including men, women and diverse participants over different age groups what would in turn allow for generalizability. Results of such studies would allow for better interpretation and conclusions.

Based on these studies, new therapy approaches may be developed focusing on the enhancement of positive social interactions as a powerful protective factor, which potentially compromised along the pathogenesis and course of burnout symptomatology.

Abbreviations

ANS: Autonomic Nervous System; CY: Maslach Burnout Inventory, cynicism sub-dimension; HPA: Hypothalamus-Pituitary-Adrenal; HR: Heart rate; MBI-GS: Maslach Burnout Inventory-General-Survey; MBI-GS-D: German version of the Maslach Burnout Inventory-General-Survey; mHR: Mean heart rate; MU: Monetary units; TSST: Trier Social Stress Test; TSST-G: Trier Social Stress Test for Groups; vmHRV: Vagally-mediated heart rate variability; PHQ-9: Patient Health Questionnaire 9; PHQ-D: German version of the Patient Health Questionnaire 9; VAS: Visual analogue scale.

Acknowledgements

We thank Markus Fuhrmann and Adrianna Lipska-Dieck for assistance during the preparation of the manuscript.

Data available statement

The data that support the findings of this study are available from the corresponding author, [M.K.W.], upon reasonable request.

Authors' contributions

M.K.W. & S.L. performed the measurements. B.v.D. and M.K.W. designed the experiment. M.K.W., B.v.D., P.G., and L.K.H. designed the computational framework and analysed the data. B.v.D., L.K.H., C.K., and L.K.H. supervised the project. M.K.W. took the lead in writing the manuscript. All authors discussed the results and contributed to the final version of the manuscript. All authors read and approved the final manuscript.

Funding

Open Access funding enabled and organized by Projekt DEAL. M.K.W. was supported by the Else Kröner-Fresenius Center for Digital Health (EKFZ), Technische Universität Dresden (TU Dresden), Dresden, Germany.

Availability of data and materials

The datasets generated and/or analysed during the current study are not publicly available due to agreements among the authors but are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

All participants gave written informed consent. The study protocol was approved by the ethics committee of the TU Dresden and conducted in accordance with the Declaration of Helsinki.

Consent for publication

Not applicable.

Competing interests

The authors report there are no competing interests to declare.

Author details

¹Department of Psychology, Chair of Biopsychology, Dresden, TU, Germany.

²Else Kröner Fresenius Center for Digital Health, University Hospital and Medical Faculty Carl Gustav Carus, Dresden, TU, Germany.

³Department of Psychiatry and Behavioral Sciences, Duke University Medical Center, Durham, NC, USA.

⁴Department of General Internal Medicine and Psychosomatics, Center for Psychosocial Medicine, Heidelberg University Hospital, Heidelberg, Germany.

⁵Department of Psychological Science, School of Social Ecology, University of California, Irvine, CA, USA.

⁶ZNF - Center for Neuroscience Research NPO, Trier, Germany.

⁷Department of Biological and Clinical Psychology, University of Trier, Trier, Germany.

Received: 8 December 2021 Accepted: 15 April 2022

Published online: 05 May 2022

References

1. Rotenstein LS, Torre M, Ramos MA, Rosales RC, Guille C, Sen S, et al. Prevalence of burnout among physicians: a systematic review. *JAMA*. 2018;320(11):1131–50.
2. Woo T, Ho R, Tang A, Tam W. Global prevalence of burnout symptoms among nurses: A systematic review and meta-analysis. *J Psychiatr Res*. 2020;123:9–20.
3. Schaufeli WB, Bakker AB, Van Rhenen W. How changes in job demands and resources predict burnout, work engagement, and sickness absenteeism. *J Organ Behav*. 2009;30(7):893–917.
4. Han S, Shanafelt TD, Sinsky CA, Awad KM, Dyrbye LN, Fiscus LC, et al. Estimating the attributable cost of physician burnout in the United States. *Ann Intern Med*. 2019;170(11):784–90.
5. Melamed S, Shirom A, Toker S, Berliner S, Shapira I. Burnout and risk of cardiovascular disease: Evidence, possible causal paths, and promising research directions. *Psychol Bull*. 2006;132(3):327–53.
6. Maslach C, Jackson SE. The measurement of experienced burnout. *J Organ Behav*. 1981;2(2):99–113.
7. Leiter MP, Maslach C. Latent burnout profiles: A new approach to understanding the burnout experience. *Burn Res*. 2016;3(4):89–100.
8. Faber NS, Häusser JA. Why stress and hunger both increase and decrease prosocial behaviour. *Curr Opin Psychol*. 2021;44:49–57.
9. Halbesleben JR. Sources of social support and burnout: a meta-analytic test of the conservation of resources model. *J Appl Psychol*. 2006;91(5):1134.
10. Etzion D. Moderating effect of social support on the stress–burnout relationship. *J Appl Psychol*. 1984;69(4):615.
11. Kim B, Jee S, Lee J, An S, Lee SM. Relationships between social support and student burnout: A meta-analytic approach. *Stress Health*. 2018;34(1):127–34.
12. Mikolajczak M, Menil C, Luminet O. Explaining the protective effect of trait emotional intelligence regarding occupational stress: Exploration of emotional labour processes. *J Res Pers*. 2007;41(5):1107–17.
13. Pereira-Lima K, Loureiro S. Burnout, anxiety, depression, and social skills in medical residents. *Psychol Health Med*. 2015;20(3):353–62.

14. Platsidou M, Salman L. The role of emotional intelligence in predicting burnout and job satisfaction of Greek lawyers. *IJLPHL*. 2012;1(1):13–22.
15. Santos A, Mustafa MJ, Gwi TC. Trait emotional intelligence, emotional labour, and burnout among Malaysian HR professionals. *Manag*. 2015;38(1):67–88.
16. Andreychik MR. Feeling your joy helps me to bear feeling your pain: Examining associations between empathy for others' positive versus negative emotions and burnout. *Pers Individ Dif*. 2019;137:147–56.
17. Altmann T, Roth M. The risk of empathy: longitudinal associations between empathy and burnout. *Psychol Health*. 2020;36(12):1441–60.
18. Bang H, Reio TG Jr. Examining the role of cynicism in the relationships between burnout and employee behavior. *Rev Psicol Trab las Organ*. 2017;33(3):217–27.
19. Dahlman AS, Jonsdottir IH, Hansson C. The hypothalamo–pituitary–adrenal axis and the autonomic nervous system in burnout. In: Swaab DF, Buijs RM, Kreier F, Lucassen PJ, Salehi A, editors. *Handbook of clinical neurology*, 182. Amsterdam: Elsevier; 2021. p. 83–94.
20. von Dawans B, Strojny J, Domes G. The effects of acute stress and stress hormones on social cognition and behavior: current state of research and future directions. *Neurosci Biobehav Rev*. 2021;121:75–88.
21. Wekenborg MK, von Dawans B, Hill LK, Thayer JF, Penz M, Kirschbaum C. Examining reactivity patterns in burnout and other indicators of chronic stress. *Psychoneuroendocrinology*. 2019;106:195–205.
22. Jönsson P, Österberg K, Wallergård M, Hansen ÅM, Garde AH, Johansson G, et al. Exhaustion-related changes in cardiovascular and cortisol reactivity to acute psychosocial stress. *Physiol Behav*. 2015;151:327–37.
23. Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology. Heart rate variability. Standards of measurement, physiological interpretation, and clinical use. *Circulation*. 1996;93:1043–65.
24. Appelhans BM, Luecken LJ. Heart rate variability as an index of regulated emotional responding. *Rev Gen Psychol*. 2006;10(3):229–40.
25. Porges SW. The polyvagal perspective. *Biol Psychol*. 2007;74(2):116–43.
26. Porges SW. The polyvagal theory: phylogenetic substrates of a social nervous system. *Int J Psychophysiol*. 2001;42(2):123–46.
27. Thayer JF, Lane RD. A model of neurovisceral integration in emotion regulation and dysregulation. *J Affect Disord*. 2000;61(3):201–16.
28. Thayer JF, Lane RD. Claude Bernard and the heart–brain connection: Further elaboration of a model of neurovisceral integration. *Neurosci Biobehav Rev*. 2009;33(2):81–8.
29. Miller JG, Kahle S, Hastings PD. Moderate baseline vagal tone predicts greater prosociality in children. *Dev Psychol*. 2017;53(2):274.
30. Kogan A, Oveis C, Carr EW, Gruber J, Mauss IB, Shallcross A, et al. Vagal activity is quadratically related to prosocial traits, prosocial emotions, and observer perceptions of prosociality. *J Pers Soc Psychol*. 2014;107(6):1051.
31. Geisler FC, Kubiak T, Siewert K, Weber H. Cardiac vagal tone is associated with social engagement and self-regulation. *Biol Psychol*. 2013;93(2):279–86.
32. Shahrestani S, Stewart EM, Quintana DS, Hickie IB, Guastella AJ. Heart rate variability during adolescent and adult social interactions: A meta-analysis. *Biol Psychol*. 2015;105:43–50.
33. Bornemann B, Kok BE, Böckler A, Singer T. Helping from the heart: Voluntary upregulation of heart rate variability predicts altruistic behavior. *Biol Psychol*. 2016;119:54–63.
34. Barraza JA, Alexander V, Beavin LE, Terris ET, Zak PJ. The heart of the story: Peripheral physiology during narrative exposure predicts charitable giving. *Biol Psychol*. 2015;105:138–43.
35. Stellar JE, Cohen A, Oveis C, Keltner D. Affective and physiological responses to the suffering of others: compassion and vagal activity. *J Pers Soc Psychol*. 2015;108(4):572.
36. Kok BE, Coffey KA, Cohn MA, Catalano LI, Vacharkulksemsuk T, Algoe SB, et al. How positive emotions build physical health: Perceived positive social connections account for the upward spiral between positive emotions and vagal tone. *Psychol Sci*. 2013;24(7):1123–32.
37. Kok BE, Fredrickson BL. Upward spirals of the heart: Autonomic flexibility, as indexed by vagal tone, reciprocally and prospectively predicts positive emotions and social connectedness. *Biol Psychol*. 2010;85(3):432–6.
38. Muhtadie L, Koslov K, Akinola M, Mendes WB. Vagal flexibility: A physiological predictor of social sensitivity. *J Pers Soc Psychol*. 2015;109(1):106.
39. Kanthak MK, Stalder T, Hill LK, Thayer JF, Penz M, Kirschbaum C. Autonomic dysregulation in burnout and depression: evidence for the central role of exhaustion. *Scand J Work Environ Health*. 2017;43(5):475–84.
40. de Vente W, van Amsterdam JG, Olff M, Kamphuis JH, Emmelkamp PM. Burnout is associated with reduced parasympathetic activity and reduced HPA axis responsiveness, predominantly in males. *Biomed Res Int*. 2015. <https://doi.org/10.1155/2015/431725>.
41. Wekenborg MK, Hill LK, Thayer JF, Penz M, Wittling RA, Kirschbaum C. The longitudinal association of reduced vagal tone with burnout. *Psychosom Med*. 2019;81(9):791–8.
42. Jarczok MN, Jarczok M, Thayer JF. Work stress and autonomic nervous system activity. In: Theorell T, editor. *Handbook of Socioeconomic Determinants of Occupational Health: From Macro-level to Micro-level Evidence*. Basel: Springer Nature Switzerland AG; 2020. p. 1–33.
43. von Dawans B, Kirschbaum C, Heinrichs M. The Trier Social Stress Test for Groups (TSST-G): a new research tool for controlled simultaneous social stress exposure in a group format. *Psychoneuroendocrinology*. 2011;36(4):514–22.
44. Penz M, Wekenborg MK, Pieper L, Beesdo-Baum K, Walther A, Miller R, et al. The Dresden Burnout Study: Protocol of a prospective cohort study for the bio-psychological investigation of burnout. *Int J Methods Psychiatr Res*. 2018;27(2): e1613.
45. Kirschbaum C, Kudielka BM, Gaab J, Schommer NC, Hellhammer DH. Impact of gender, menstrual cycle phase, and oral contraceptives on the activity of the hypothalamus–pituitary–adrenal axis. *Psychosom Med*. 1999;61(2):154–62.
46. Strojny J, Domes G, Fischbacher U, von Dawans B. The modulation of social behavior and empathy via oral contraceptives and female sex hormones. *Psychoneuroendocrinology*. 2021;131:105250.
47. Eckel CC, Grossman PJ. Are women less selfish than men?: Evidence from dictator experiments. *Econ J*. 1998;108(448):726–35.
48. Eckel CC, Grossman PJ. The relative price of fairness: Gender differences in a punishment game. *J Econ Behav Organ*. 1996;30(2):143–58.
49. Kirschbaum C, Pirke K-M, Hellhammer DH. The 'Trier Social Stress Test'—a tool for investigating psychobiological stress responses in a laboratory setting. *Neuropsychobiology*. 1993;28(1–2):76–81.
50. von Dawans B, Ditzen B, Trueg A, Fischbacher U, Heinrichs M. Effects of acute stress on social behavior in women. *Psychoneuroendocrinology*. 2019;99:137–44.
51. von Dawans B, Fischbacher U, Kirschbaum C, Fehr E, Heinrichs M. The social dimension of stress reactivity acute stress increases prosocial behavior in humans. *Psychol Sci*. 2012;23(6):651–60.
52. Fischbacher U. z-Tree: Zurich toolbox for ready-made economic experiments. *Exp Econ*. 2007;10(2):171–8.
53. Büssing A, Glaser J. Deutsche Fassung des Maslach burnout inventory—General survey (MBI-GS-D). Munich: München, Technische Universität, Lehrstuhl für Psychologie; 1999.
54. Schaufeli WB, Leiter MP, Maslach C, Jackson SE. The Maslach burnout inventory-general survey. In: Maslach C, Jackson SE, Leiter MP, editors. *MBI manual*. 3rd ed. Palo Alto: Consulting Psychologists Press; 1996. p. 19–26.
55. Kalimo R, Pahkin K, Mutanen P, Topipinen-Tanner S. Staying well or burning out at work: work characteristics and personal resources as long-term predictors. *Work Stress*. 2003;17(2):109–22.
56. Löwe BP, Spitzer RL. Gesundheitsfragebogen für Patienten PHQ-D: Manual; Kompletversion und Kurzform: Pfizer GmbH; 2001.
57. Kroenke K, Spitzer RL, Williams JBW. The PHQ-9: Validity of a Brief Depression Severity Measure. *J Gen Intern Med*. 2001;16(9):606–13.
58. American Psychiatric Association. *Diagnostic and statistical manual of mental disorders*. 4th ed. Washington: APA; 2000.
59. Penttilä J, Helminen A, Jartti T, Kuusela T, Huikuri HV, Tulppo MP, et al. Time domain, geometrical and frequency domain analysis of cardiac vagal outflow: effects of various respiratory patterns. *Clin Physiol*. 2001;21(3):365–76.
60. Hill L, Siebenbrock A, Sollers J, Thayer JF. Are all measures created equal? Heart rate variability and respiration. *Biomed Sci Instrum*. 2009;45:71–6.
61. Hayes AF. *Introduction to mediation, moderation, and conditional process analysis: a regression-based approach*. New York: Guilford Press; 2017.
62. Schonfeld IS, Bianchi R. Burnout and depression: two entities or one? *J Clin Psychol*. 2016;72(1):22–37.

63. Zhang J. Effect of age and sex on heart rate variability in healthy subjects. *JMPT*. 2007;30(5):374–9.
64. Ahola K, Honkonen T, Isometsä E, Kalimo R, Nykyri E, Koskinen S, et al. Burnout in the general population. *Soc Psychiatry Psychiatr Epidemiol*. 2006;41(1):11–7.
65. Anwar A, Kee DMH, Ahmed A. Workplace cyberbullying and interpersonal deviance: understanding the mediating effect of silence and emotional exhaustion. *Cyberpsychology, Cyberpsychol Behav Soc Netw*. 2020;23(5):290–6.
66. Hallberg UE, Johansson G, Schaufeli WB. Type A behavior and work situation: Associations with burnout and work engagement. *Scand J Psychol*. 2007;48(2):135–42.
67. Emmerik IHV, Jawahar I, Stone TH. Associations among altruism, burnout dimensions, and organizational citizenship behaviour. *Work Stress*. 2005;19(1):93–100.
68. Salmela-Aro K, Savolainen H, Holopainen L. Depressive symptoms and school burnout during adolescence: evidence from two cross-lagged longitudinal studies. *J Youth Adolesc*. 2009;38(10):1316–27.
69. Tims M, Bakker AB, Derks D. Examining job crafting from an interpersonal perspective: Is employee job crafting related to the well-being of colleagues? *Appl Psychol*. 2015;64(4):727–53.
70. Billings ME, Lazarus ME, Wenrich M, Curtis JR, Engelberg RA. The effect of the hidden curriculum on resident burnout and cynicism. *J Grad Med Educ*. 2011;3(4):503–10.
71. Maslach C, Schaufeli WB, Leiter MP. Job burnout. *Annu Rev Psychol*. 2001;52(1):397–422.
72. Cohen S, Wills TA. Stress, social support, and the buffering hypothesis. *Psychol Bull*. 1985;98(2):310.
73. Raposa EB, Laws HB, Ansell EB. Prosocial behavior mitigates the negative effects of stress in everyday life. *Clin Psychol Sci*. 2016;4(4):691–8.
74. Turner RJ, Brown RL. Social support and mental health. In: Scheid TL, Brown TN, editors. *A handbook for the study of mental health: Social contexts, theories, and systems*. New York: Cambridge University Press; 2010. p. 200–12.
75. Hobfoll SE, Shirom A, Golembiewski R. Conservation of resources theory. In: Golembiewski RT, editor. *Handbook of Organizational Behavior*. New York: Scientific Research; 2000. p. 57–80.
76. Jahanzeb S, Fatima T. How workplace ostracism influences interpersonal deviance: The mediating role of defensive silence and emotional exhaustion. *J Bus Psychol*. 2018;33(6):779–91.
77. DeWall CN, Baumeister RF, Gailliot MT, Maner JK. Depletion makes the heart grow less helpful: Helping as a function of self-regulatory energy and genetic relatedness. *Pers Soc Psychol Bull*. 2008;34(12):1653–62.
78. Xu H, Bègue L, Bushman BJ. Too fatigued to care: Ego depletion, guilt, and prosocial behavior. *J Exp Soc Psychol*. 2012;48(5):1183–6.
79. Hobfoll S. *The psychology and philosophy of stress, culture, and community*. New York: Plenum; 1998.
80. Barclay P. Strategies for cooperation in biological markets, especially for humans. *Evol Hum Behav*. 2013;34:164–75.
81. Buchanan TW, Preston SD. Stress leads to prosocial action in immediate need situations. *Front Behav Neurosci*. 2014;8:5.
82. Margittai Z, Strombach T, van Wingerden M, Joëls M, Schwabe L, Kalenscher T. A friend in need: time-dependent effects of stress on social discounting in men. *Horm Behav*. 2015;73:75–82.
83. Schaufeli WB, Van Dierendonck D. A cautionary note about the cross-national and clinical validity of cut-off points for the Maslach Burnout Inventory. *Psychol Rep*. 1995;76(3):1083–90.
84. Purvanova RK, Muros JP. Gender differences in burnout: A meta-analysis. *J Vocat Behav*. 2010;77(2):168–85.
85. Fischer H. *A history of the central limit theorem: from classical to modern probability theory*. Berlin: Springer Science & Business Media; 2010.

Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Ready to submit your research? Choose BMC and benefit from:

- fast, convenient online submission
- thorough peer review by experienced researchers in your field
- rapid publication on acceptance
- support for research data, including large and complex data types
- gold Open Access which fosters wider collaboration and increased citations
- maximum visibility for your research: over 100M website views per year

At BMC, research is always in progress.

Learn more biomedcentral.com/submissions

