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Reduced self-regulation mirrors the distorting effects of burnout symptomatology on task difficulty perception during an inhibition task

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Abstract

Burnout, a pathological consequence of chronic work stress, shows an increasing incidence rate in industrialized countries. Previous findings indicate that burnout may be linked to a detachment of the negative association between subjectively appraised task demand and cognitive performance, which is typically seen in healthy individuals. The present study sought to confirm this relationship and to investigate whether this dissociation is mirrored in a biological marker of self-regulation, i.e., resting vagally mediated heart rate variability (HRV). A heterogeneous sample (*N* = 65) of working adults (*M* age = 43.3, SD = 10; 23.1 % male) with varying degrees of burnout symptomatology completed three cognitive tasks (2-back, number-letter, and go/nogo) to assess different domains of executive functioning (updating, set-shifting, and inhibition), and respective demand ratings. Additionally, vagally mediated HRV at rest, operationalized as the root-mean square differences of successive R-R intervals (RMSSD), was recorded. Burnout symptomatology moderated the association between subjective task difficulty and performance parameters of the go/nogo task, such that higher burnout scores were associated with reductions in the naturally occurring negative association between self-rated task demand and response inhibition. Intriguingly, this pattern was mirrored when replacing burnout with HRV. These findings suggest that burnout symptomatology, and individual differences in self-regulatory capacities (indexed by resting HRV), may alter one's capacity for accurate task evaluation, a mechanism which could potentially underlie the dissociation between self-rated cognitive function and actual performance among individuals experiencing burnout.

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Keywords

Burnout; heart rate variability; cognitive function; task difficulty; self-regulation

Introduction

Cognitive impairment is one of the most commonly selfreported symptoms of burnout (Feuerhahn, StamovRosznagel, Wolfram, Bellingrath, & Kudielka, 2013; Öhman, Nordin, Bergdahl, Birgander, & Neely, 2007; Österberg, Karlson, & Hansen, 2009; Weber & Jaekel-Reinhard, 2000), a consequence of long-term stress at work with growing incidence rates in western countries (Honkonen et al., 2006). It is important to note, however, that the question of whether burnout symptomatology is actually associated with detectable declines in cognitive functions has yet to be satisfactorily answered. While cognitive impairments (e.g. executive functioning or memory) at severe stages of burnout appear to be well-documented (for review, see Deligkaris, Panagopoulou, Montgomery, & Masoura, 2014), the early phase of this disease seems to be particularly characterized by a deficit in accurately evaluating one's own abilities, rather than an objective decline in cognitive function (Oosterholt, Linden, Maes, Verbraak, & Kompier, 2012; Oosterholt, Maes, Van der Linden, Verbraak, & Kompier, 2014; Österberg et al., 2009). Recent findings of a dissociation between subjective perception of task demands and task performance in individuals with high, yet not clinically relevant, burnout symptomatology (Oosterholt et al., 2014), suggest that this deficit might be the result of a pathological rigidity of environmental perception regardless of actual situational demands.

Following the concept of perseverative cognition, which theorizes that it is not the actual stressor per se, but rather its cognitive representation, which causes prolonged stress reactivity (Brosschot, Gerin, & Thayer, 2006; Brosschot, Verkuil, & Thayer, 2010), exhaustion and other psychological and physiological symptoms related to burnout may be at least partially reinforced by the detachment of the task and its subjective perception.

One potential explanation for this rigid evaluation of environmental stimuli is a deficit in self-regulation capacities, defined as the ability to select context appropriate responses in the support of long-term adaption (Baumeister, Vohs, & Tice, 2007; Thayer & Lane, 2000). Following this line of reasoning, the dissociation between demand perception and actual task difficulty could be a manifestation of a general lack in the capacity to adequately judge environmental challenges, consequently leading to an inability to adaptively modulate one's own behavior in order to meet the needs of demanding situations.

However, there is little empirical evidence to support the theoretical assumption that an increased rigidity in perception of environmental challenges associated with burnout symptomatology is related to deficits in self-regulatory abilities. Therefore, the primary goal of the present study was to assess whether burnout is actually associated with a reduced association between task demand ratings and objective performance. In addition, we wanted to investigate if this effect is mirrored in a well-established physiological marker of self-regulation, vagally mediated heart rate variability (HRV) at rest (Thayer & Lane, 2000, 2009). According to the neurovisceral integration model (Thayer & Lane, 2000), vagal functioning is directly linked to a set of cortical and subcortical structures comprising the central autonomic network (CAN), which controls a variety of self-regulatory activities. Therefore, self-regulatory abilities can be indexed by HRV, operationalized as fast beat-to-beat changes in heart rate which are known to result from the tonic, inhibitory influence of the parasympathetic nervous system on the heart via the vagus nerve, with reduced vagally mediated HRV reflecting an inability to flexibly respond to environmental challenges. A general deficit in self-regulatory abilities may promote maladaptive emotional, cognitive, and behavioral response selection, leading to cognitive inflexibility and a propensity toward activation of prepotent responses (i.e. “fight or flight”) to both threatening and non-threatening environmental challenges (Thayer & Lane, 2000). Over time, this maladaptive behavioral pattern may contribute to further reductions in self-regulatory capacity.

We thus hypothesized that those individuals with higher burnout symptomatology and those with lower resting HRV would display a less flexible demand perception, observable in a decrease of the naturally occurring negative association between demand perception and task performance. In a second step, we sought to compare the effects of burnout and HRV, which in turn provides valuable information about their combined and unique contributions by examining the joint marginal and conditional effects of both measures.

Methods

Study population

Participants (N = 79) were a subsample of the Dresden Burnout Study (DBS), a large-scale longitudinal study designed to investigate psychological, biological, and societal factors associated with burnout. The current sample was recruited via responses to an email sent to all DBS participants living in Dresden. Inclusion criteria were age between 18 and 68 and German language skills. During data analysis, 14 participants were excluded due to poor quality or artefactual heart rate recordings resulting in a final sample of 65 participants (for demographic and health characteristics of the sample see Table 1). The study protocol was approved by the ethics committee of the TU Dresden and conducted in accordance with the Declaration of Helsinki. All participants gave written informed consent. No financial compensation was paid.

Study design and procedure

The cognitive testing procedure lasted approximately 60 min and was conducted between 8:00 am and 5:00 pm. After arriving at the laboratory, participants signed the consent forms and were fitted with the heart rate monitoring device (Polar RS800TM, Polar Electro, Oy, Kempele, Finland). They were then seated in soundproof individual cabins. After an assessment of resting HRV for 335 s, the cognitive testing procedure was initiated with a number-letter task, followed by a go/nogo task, ending with a spatial 2-back task (detailed description provided below). After each of the three tasks, individuals were instructed to rate the subjective demand of the just completed task. At the end of the testing procedure, participants completed psychological and demographic questionnaires (see below).

Burnout

Burnout symptomatology was assessed using the German version (MBI-GS-D; Büssing & Glaser, 1999) of the Maslach Burnout Inventory-General Survey (MBI-GS; Schaufeli, Leiter, Maslach, & Jackson, 1996), the most frequently used burnout measure in the field. Sixteen items of the MBI-GS are rated on a 7-point Likert scale (0 = never, 6 = daily) to form three subscales (emotional exhaustion [EE], cynicism [CY], reduced personal efficacy [PEr]). As previous research has shown that the three burnout dimensions have different weights in the syndrome, burnout was operationalized drawing back on the only existing empirically derived weighted sum score of the MBI-GS, introduced by Kalimo, Pahkin, Mutanen, and Topipinen-Tanner (2003; [0.4*EE +0.3*CY +0.3*Per]).

Depressive symptomatology

Depressive symptomatology was measured with the German version (PHQ-9-D; Löwe, Spitzer, Zipfel, & Herzog, 2002) of the Patient Health Questionnaire (PHQ-9; Kroenke, Spitzer, & Williams, 2001). The PHQ-9 consists of nine items, which quantify the frequency, over the last 2 weeks, of each of the nine diagnostic criteria for a depressive disorder of the *Diagnostic and Statistical Manual of Mental Disorders* (4th ed., text rev.; DSM–IV–TR; American Psychiatric Association, 2000). The items are scored on a 4-point ranking scale (0 = not at all, 3 = nearly every day) and summed up to a continuous variable (PHQ-9 sum score), with higher scores representing more depressive symptoms.

Heart rate variability

Inter-beat intervals (IBI) were recorded with a Polar RS800CX heart rate monitoring system via the corresponding wrist unit and chest belt (Polar Electro OY, Kempele, Finland) during the entire testing procedure. Only the 335-s period of the seated resting condition, which was recorded prior to the initiation of the cognitive testing procedure, was analyzed in the present study. Data were then transferred to the Polar Precision Performance Software (Polar Electro OY, Kempele, Finland) and exported as raw IBI data for further analysis. Raw IBI data were artifact corrected by Neurocor Ltd. & Co. KG (Trier, Germany), according to the guidelines of the Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology (1996) using the NEUROCOR precisionHRV-Algorithm. During this analysis step, artifacts in EKG-recordings are marked and corrected without violation of the phasing of the overall time of the signal. Subsequently, HRV measures were calculated. Preliminary analyses revealed high positive correlations between RMSSD and other measures of vagally mediated HRV, which are also commonly used (correlation coefficients between 0.25 and 0.87, $ps < 0.05$ for SDNN, pNN50, HF-HRV, and nHF-HRV). In the following analysis, RMSSD was used to operationalize high-frequency variation in heart rate because of its status as an approved short-term measure of HRV reflecting vagal cardiac influence and its robustness against breathing patterns (Hill, Siebenbrock, Sollers, & Thayer, 2009; Penttilä et al. 2001; Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology, 1996). RMSSD values at rest were not normally distributed, thus log transformations were applied to reduce skewness.

Assessment of cognitive function

We focused on the assessment of complex, higher cognitive processes (i.e. executive functions) as these have been found to show particularly robust associations with burnout symptomatology (Deligkaris et al., 2014). A computer-based cognitive testing battery was based on the model of executive functioning by Miyake et al. (2000), which conceptualizes executive functions as three intercorrelated, but distinguishable basic functions, namely (1) shifting (describing the ability to switch attention between multiple operations or tasks), (2) updating (requiring monitoring of working memory representations), and (3) response inhibition (intentional inhibition of dominant, automatic, or prepotent operations). Therefore, the following tasks were chosen to tap these executive functions (for distributions of cognitive variables see Table 2).

Number-letter task: to assess shifting function, a modified version of the number–letter task, introduced by Rogers and Monsell (1995), was administered. In particular, a number–letter pair (1a, a1, 1b, b1, 2a, a2, 2b, b2) was presented above or below a horizontal line on the computer screen. Participants were required to indicate with one of two keys on a keypad whether the digit was “1” or “2” when the pair was presented above the horizontal line and to indicate whether the letter was “a” or “b” when the pair was presented below the line. Each trial started with the display of a horizontal line for 500 ms, after which the number–letter pair was presented for 2500 ms, followed by a blank screen for 250 ms. Participants were given one practice block with 37 trials, which was followed by one testing block consisting of 257 trials. Task performance was operationalized using the EZ-diffusion model for two-choice response time tasks, introduced by Wagenmakers, Van Der Maas, and Grasman (2007), as it allows an unambiguous quantification of performance via consideration of the speed-accuracy tradeoff (i.e. individually differing response strategies). The two parameters of the EZ-diffusion model used in the present study, namely drift rate (v; speed of information accumulation) and boundary separation (a; response conservativeness), were calculated separately for switch and no-switch conditions using mean response time, variance of response time, and response accuracy based on the calculation instruction introduced by Wagenmakers et al. (2007).

Go/nogo task: to assess the inhibition function, a modified version of the go/nogo task, introduced by Wolff et al. (2016) was administered. Two vertical circles (go targets) or two horizontal circles (nogo targets) were presented in the middle of the screen requiring the participants to respond as quickly and as accurately as possible. Contrary to the classical go/nogo tasks in which participants are instructed to respond only to the go stimulus by pressing a button and withhold at display of the nogo stimulus, in this modified version both, go and nogo stimuli, needed to be identified at display by pressing one of two keys. The probability of nogo stimulus presentation was 12.5 %. Each stimulus was preceded by a fixation cross for 750 ms while one trial lasted 2000 ms followed by a blank screen for 250 ms. Participants were administered one practice block with 24 trials, which was followed by one testing block consisting of 400 trials. To account for individually differing response strategies, the signal detection measures d′ and C were calculated following Stanislaw and Todorov (1999). Higher values of d′ indicate better ability to discriminate between the go and nogo stimuli, whereas lower values of C indicate that participants tended to report the presence of the go stimulus more frequently and therefore adapted a more liberal decision criterion.

Spatial 2-back task: to assess the updating function, a modified version of the spatial n-back task introduced by Friedman et al. (2008) was chosen. Thereby, eight smaller circles arranged to appear as a single large circle where presented to the participant. In each trial, the target (i.e. a cross) appeared randomly within one of the small circles for 2000 ms. The participants had to identify whether the target was shown in the same small circle as two trials before by pressing one of two keys on a keypad (target rate was 30%). Each (non-)target was followed by a picture showing the eight small circles empty for 500 ms. Hence, each trial lasted 2500 ms before the next target cross was presented. Participants were given two practice blocks with 10 trials each, which were followed by eight testing blocks consisting each of 20 trials. The updating function was also assessed using signal detection analyses, which allowed for differentiation between response bias (C; general tendency to report the presence of a target) and sensitivity (d′; ability to differentiate between targets and nontargets) (Stanislaw & Todorov, 1999).

Assessment of subjective demand of the tasks

Subjective demand ratings followed each cognitive task. Participants rated the perceived demand on a 10-point Likert scale (0 = “not at all”, 9 =”very much”), respectively.

Statistical analysis

Following data pre-processing, in order to determine the extent to which burnout symptomatology and RMSSD influence the association between demand rating and cognitive performance, separate moderator analyses were conducted with cognitive performance during the three tasks as the criterion, demand rating of the respective task as the predictor and the MBI total score, and RMSSD at rest as the moderator, respectively.

To examine the joint marginal and conditional effects of both measures, we further generated an additional model in which the MBI total score and RMSSD at rest were added simultaneously as moderators of the relationship between demand rating and cognitive performance. To control for Type-I-errors, additive moderation models were only applied for those cognitive tasks, for which significant moderation effects of either the MBI total score and/or RMSSD at rest were observed (cf. Dmitrienko, Tamhane, & Wiens, 2008).

We also sought to account for the potential confounding influence of factors which have been previously associated with burnout and cognitive function. In particular, given ongoing debate regarding the distinguishability of depressive and burnout symptomatology (for review see Bianchi, Schonfeld, & Laurent, 2015), the PHQ-9 was used as a control variable in all moderation analyses to examine the effects of burnout symptomatology independent from affective symptomology. Additionally, negative associations between age and executive function performance have been frequently reported in previous research (Craik & Salthouse, 2011; Rhodes, 2004); and while the directionality is less ambiguous, sex also has been shown to impact cognitive function/performance (Reilly, Neumann, & Andrews, 2016; Weiss, Kemmler, Deisenhammer, Fleischhacker, & Delazer, 2003). Thus, all moderation models also controlled for age and sex.

All continuous predictors and control variables of interest were mean centered to enhance interpretability. All statistical analyses were performed using IBM SPSS Statistics v. 22 (SPSS Inc., Chicago, IL). Moderation analyses were conducted using the SPSS add-on PROCESS version 2.15 (Hayes, 2013).

Results

As expected, results of correlation analyses revealed significant negative associations between subjective demand ratings and at least one indicator of cognitive performance during the completion of each task (Table 3). Also consistent with predictions, the MBI total score was positively associated with demand ratings for each task (*rs* between 0.32 and 0.34, $ps \leq 0.05$), but unrelated to cognitive performance on any of the three tasks (*rs* between −0.21 and 0.04, $ps > 0.10$). Resting HRV was not significantly associated with the MBI total score, demand ratings or performance parameters for any of the cognitive tasks.

Results for the moderation analyses are depicted in Table 4. In accordance with previous research, age was negatively associated with cognitive performance in all three cognitive tasks. Female sex was positively associated with cognitive performance only with respect to C in the 2-back task model with the MBI total score as the moderator. PHQ-9 was significantly associated with the MBI total score ($r = 0.83$; $p < 0.001$), but not with any cognitive parameter in any of the analysis.

Interaction effects of the MBI total score and demand ratings on predicting task performance

Table 4 depicts the independent moderating effects of the MBI total score and HRV on the relationship between demand rating and performance during the three cognitive tasks (number-letter task, go/nogo task, 2-back task). As predicted, the MBI total score moderated the association between demand rating and cognitive performance in the go/nogo task, with respect to both, d′ ($F(6,58) = 5.87$; $p < 0.001$; $R^2 = 0.38$; R^2 increase due to interaction [ΔR^2] = 0.11; $F(1,58) = 9.93$; $p < 0.01$) and C ($F(6,58) = 5.68$; $p < 0.001$; $R^2 = 0.37$; $\Delta R^2 = 0.10$; $F(1,58) = 9.46$; $p < 0.01$). Figure 1 displays the direction of the moderation effect for the three levels of the MBI total score, indicating that higher levels of burnout symptomatology (defined as M + 1SD) substantially attenuated the negative association between demand ratings and actual performance in the go/nogo task, both for (A) d′ and (B) C. Apart from the go/nogo task, however, the interaction effects between the MBI total score and the demand rating were negligible in the number-letter task (v switch condition: $\Delta R^2 < 0.01$; $F(1,58) = 0.31$; $p = 0.58$; a switch condition: $\Delta R^2 = 0.01$; $F(1,58) = 0.52$; $p = 0.47$; v no-switch condition: $\Delta R^2 < 0.01$; $F(1,58) = 0.05$; $p = 0.83$; a no-switch condition: $\Delta R^2 < 0.01$; $F(1,58) = 0.44$; $p = 0.51$), and in the 2-back task (d′: $\Delta R^2 < 0.01$; $F(1,56) = 0.01$; $p = 0.93$; C: $\Delta R^2 = 0.02$; $F(1,56) = 1.40$; $p = 0.24$).

Interaction effects of HRV and demand ratings on predicting task performance

Regression analysis using log RMSSD as a moderator mirrored the effects of the MBI total score (Table 4), with significant interactions between HRV and demand rating on cognitive performance during the go/nogo task, with respect to both, d′ ($F(6,58) = 5.03$; $p < 0.001$; R^2

= 0.34; ΔR^2= 0.06; $F(1,58) = 5.64$; $p = 0.02$) and C ($F(6,58) = 4.16$; $p < 0.01$; $R^2 = 0.30$; $\Delta R^2 = 0.06$; $F(1,58) = 5.20$; $p = 0.03$). Figure 1 displays the direction of the moderation effect, showing that lower levels of HRV (defined as M – 1 SD) substantially attenuated the negative association between demand ratings and performance in the go/nogo task with respect to both, (C) d′ and (D) C.Similar to the MBI total data, no significant interaction effects were found between HRV and the demand rating on both performance parameters of the number–letter task (v switch condition: $\Delta R^2 = 0.02$; $F(1,58) = 1.11$; $p = 0.30$; a switch condition $\Delta R^2 = 0.005$; $F(1,58) = 0.31$; $p = 0.58$; v no-switch condition: $\Delta R^2 = 0.02$; $F(1,58) = 1.28$; $p = 0.26$; a no-switch condition: $\Delta R^2 = 0.03$; $F(1,58) = 2.47$; $p = 0.12$), and the 2-back task (d′: $\Delta R^2 < 0.01$; $F(5,56) = 0.35$; $p = 0.55$; C: $\Delta R^2 = 0.05$; $F(5,56) = 3.63$; $p = 0.06$).

Multiple additive moderation analyses including HRV and the MBI total score

Based on the results of the independent contributions of the MBI total score and HRV, we conducted two multiple additive moderation analyses to assess the relative contributions of the two moderators for the prediction of the d′ and the C parameter of the go/nogo task. Results indicated that including both moderators explained substantially more variance (d′: $\Delta R^2 = 0.12$; $F(2,56) = 5.78$; $p < 0.01$; C: $\Delta R^2 = 0.13$; $F(2,56) = 6.08$; $p < 0.01$), compared to the conditional estimation of explained variance of the MBI total score when controlled for HRV (d′: $\Delta R^2 = 0.06$; $F(1,56) = 5.48$; $p = 0.02$; C: $\Delta R^2 = 0.06$; $F(1,56) = 5.99$; $p = 0.02$) or the conditional estimation of explained variance of HRV when controlled for the MBI total score (d′: $\Delta R^2 = 0.02$; $F(1,56) = 2.28$; $p = 0.14$; C: $\Delta R^2 = 0.02$; $F(1,56) = 2.22$; $p = 0.14$).

Discussion

The present study sought to investigate the role of burnout in the dissociation between subjective task demands and cognitive performance and to establish whether the inflexible and rigid perception of task demands is mirrored in a physiological marker of self-regulatory ability. To the authors knowledge, this is the first study to demonstrate that burnout symptomatology actually moderates the association between demand ratings and cognitive performance during a response inhibition task, in that higher levels of burnout symptomatology were associated with an attenuation of the naturally occurring association between demand ratings and task performance. This is in line with previous notions that individuals with burnout symptomatology display a dissociation between self-perception and actual performance (Oosterholt et al., 2014). Moreover, our findings for burnout were independent of depressive symptomatology; an observation which challenges previous notions that burnout and depression are conceptually and clinically indistinct (for review see Bianchi et al., 2015).

In addition, we also showed that resting-state HRV mirrored this effect, replicating previous findings that low levels of vagally mediated HRV are associated with a rigid appraisal of environmental demands (Friedman & Thayer, 1998; Melzig, Weike, Hamm, & Thayer, 2009; Ruiz-Padial, Sollers, Vila, & Thayer, 2003). Our findings indicate that a reduced flexibility, particularly with regard to perception of cognitive task demands among

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individuals with burnout symptomatology, is also reflected in a biological marker of adaptability to environmental demands (Thayer & Lane, 2000, 2009).

Interestingly, moderating effects of burnout symptomatology and vagally mediated HRV were found only with respect to a go/nogo task assessing response inhibition. Response inhibition is the only one of the three executive functions described by Miyake et al. (2000), which has been most consistently shown to be impaired in burnout pathology (Diestel, Cosmar, & Schmidt, 2013; Jonsdottir, Hagg, Glise, & Ekman, 2009; Sandström et al., 2011; Sandström, Rhodin, Lundberg, Olsson, & Nyberg, 2005; Van der Linden, Keijsers, Eling, & Van Schaijk, 2005). In contrast, updating has been more rarely examined (Diestel et al., 2013; Oosterholt et al., 2012) and shifting ability does not appear to be impaired in burnout (Castaneda et al., 2011; Oosterholt et al., 2012; Van Dam, Keijsers, Verbraak, Eling, & Becker, 2012). Our results support the idea that the ability to inhibit an inappropriate response might be of special relevance both in burnout symptomatology and self-regulation. Alterations in this particular cognitive function might be one of the mechanisms behind the inflexible and maladaptive pattern of behavior, observable both in individuals with high burnout symptomatology and low self-regulatory skills.

In the present study, burnout symptomatology was not per se associated with objectively measured impairments in executive functioning operationalized following the widespread concept of Miyake et al. (2000). Indeed, the regression coefficient for burnout symptomatology was significant with respect to the C parameter of the go/nogo task in the complex moderation model. However, due to the high inter-correlations between burnout symptomatology and the other variables entered, this coefficient cannot be interpreted as a simple main effect (Hayes, 2013). The absence of an association between burnout and impairments in cognitive function apparently contradicts conclusions drawn by Deligkaris et al. (2014), that the vast majority of studies found burnout to be associated with deficits in executive function. The evidence in this review was, however, based primarily on studies in samples with clinically relevant burnout symptomatology (Jonsdottir et al., 2013; Oosterholt et al., 2012; Sandström et al., 2011). Thus, it is plausible that the link between burnout and executive functioning might differ in nonclinical populations with relatively mild burnout symptoms, as was the case in the present study. Indeed, with the exception of one study (Diestel et al., 2013), evidence from other investigations of burnout in nonclinical populations has consistently shown that performance on executive function tasks can be sustained at varying levels of burnout (Castaneda et al., 2011; Oosterholt et al., 2014). These findings underscore the notion that impairments in executive functioning are more pronounced in later stages of burnout disease, whereas early stages of burnout seem to be particularly characterized by subjective rather than objective cognitive changes (Oosterholt et al., 2012, 2014; Österberg et al., 2009).

Interestingly, we did not find associations between resting vagally mediated HRV and burnout symptomatology. The results of the few existing previous studies investigating this association have been inconclusive with some evidence suggesting reductions in vagally mediated HRV associated with the MBI total score (de Vente, van Amsterdam, Olff, Kamphuis, & Emmelkamp, 2015), while others have reported no association (Jönsson et al., 2015; van Doornen et al., 2009; Zanstra, Schellekens, Schaap, & Kooistra, 2006) or only with respect to specific sub-dimensions of this measure (Kanthak et al., 2017). Based on this small number of studies it would be premature to draw conclusions on burnout-associated modulations in vagal function.

In addition to determining the independent contributions of burnout symptomatology and vagally mediated HRV, we also considered an alternative model in which both burnout and HRV might jointly influence the relationship between demand ratings and cognitive performance. To test this hypothesis, we entered both moderators in a model of multiple additive moderation. Our results of a significant additive effect of burnout symptomatology and vagally mediated HRV in explaining performance variance on a response inhibition task suggest that the detrimental impact of burnout symptomatology on the association between demand rating and actual cognitive performance might not be fully accounted for by diminished self-regulation, as indexed by HRV. The fact that HRV and burnout symptomatology explained more variance when combined than each alone suggests that problematic psychological outcomes are more likely to emerge for those individuals with a combination of high burnout symptomatology and low HRV. It remains to be determined whether the combination of burnout symptomatology and HRV is an important predictor of other psychological outcomes, as well. Notably, however, it should also be considered that the reported moderation effect may not necessarily be specifically attributable to burnout symptomatology (i.e. stress load that emerged from work-related strain), but could be due to chronic stress in general. Thus, assessing the relationships among chronic stress, perceived demands and executive functioning may be a worthwhile target for future research.

There are also some limitations to the present study which should be noted. First, our study focused solely on executive functioning, as this has been shown to be most strongly impaired in individuals with severe burnout symptomatology, while further cognitive domains have not been explicitly addressed. Therefore, the extent to which the moderating effects of burnout and HRV might generalize to additional cognitive processes remains to be investigated. Additionally, our study sample size was relatively small. Several other studies of the relationship between burnout and cognitive functioning also featured smaller (Oosterholt et al., 2012; Sandström et al., 2011) or comparably sized samples (Jonsdottir et al., 2013). As others have noted, it is possible that findings based on small samples may overestimate effect sizes or have limited reproducibility (Button et al., 2013). In supplemental sensitivity analysis, we did not observe any alterations in the effects of the MBI total score on cognitive functioning when including those 14 participants who were initially excluded due to deficient heart rate recordings. While this suggests that our findings, at least for the go/nogo task, are quite robust, results should be interpreted with caution, and replication studies are clearly needed. This is particularly necessary to determine the reliability of the joint moderating effects of HRV and burnout as well as the lack of significant effects of burnout with respect to updating/shifting.

Moreover, our assessment was cross-sectional in nature and does not allow any assertions about causality or directionality. Further, while our results clearly suggest that other mechanisms should be considered when examining dissociation between subjective task perception and actual task performance seen in individuals with burnout, self-regulation is not a homogenous construct, and vagally mediated HRV at rest, may not capture all facets of this phenomenon (Duckworth & Kern, 2011). Therefore, potential overlaps between burnout symptomatology and self-regulatory abilities cannot be completely ruled out based on the present design and future research should consider incorporating additional measures of self-regulation. Lastly, although we controlled for age and gender in our analysis, we cannot rule out other confounders (i.e. medication intake), which may have influenced our findings. Therefore, larger studies incorporating valid and comprehensive medical and psychosocial examinations are needed to disentangle the specific role of burnout symptoms on the revealed effects.

Conclusion

Our results support prior assertions that the early stages of burnout may be characterized by a dissociation between perception of task demands and actual task performance – particularly for tasks involving response inhibition. This effect was mirrored using a well-established biomarker of self-regulatory capacity; and the results of an additive model support the notion that higher levels of burnout and lower levels of HRV may be jointly associated with an inflexible and rigid perception of environmental demands. From a clinical perspective, our findings suggest that early intervention strategies in burnout pathology should focus more on the perception of environmental task load, rather than the enhancement of alleged cognitive impairments alone. Overall the research field would benefit from large-scale prospective studies, further examining the specific influence of burnout on environmental perception, as well as the potential effectiveness of psychotherapeutic approaches in improving burnout symptomatology.

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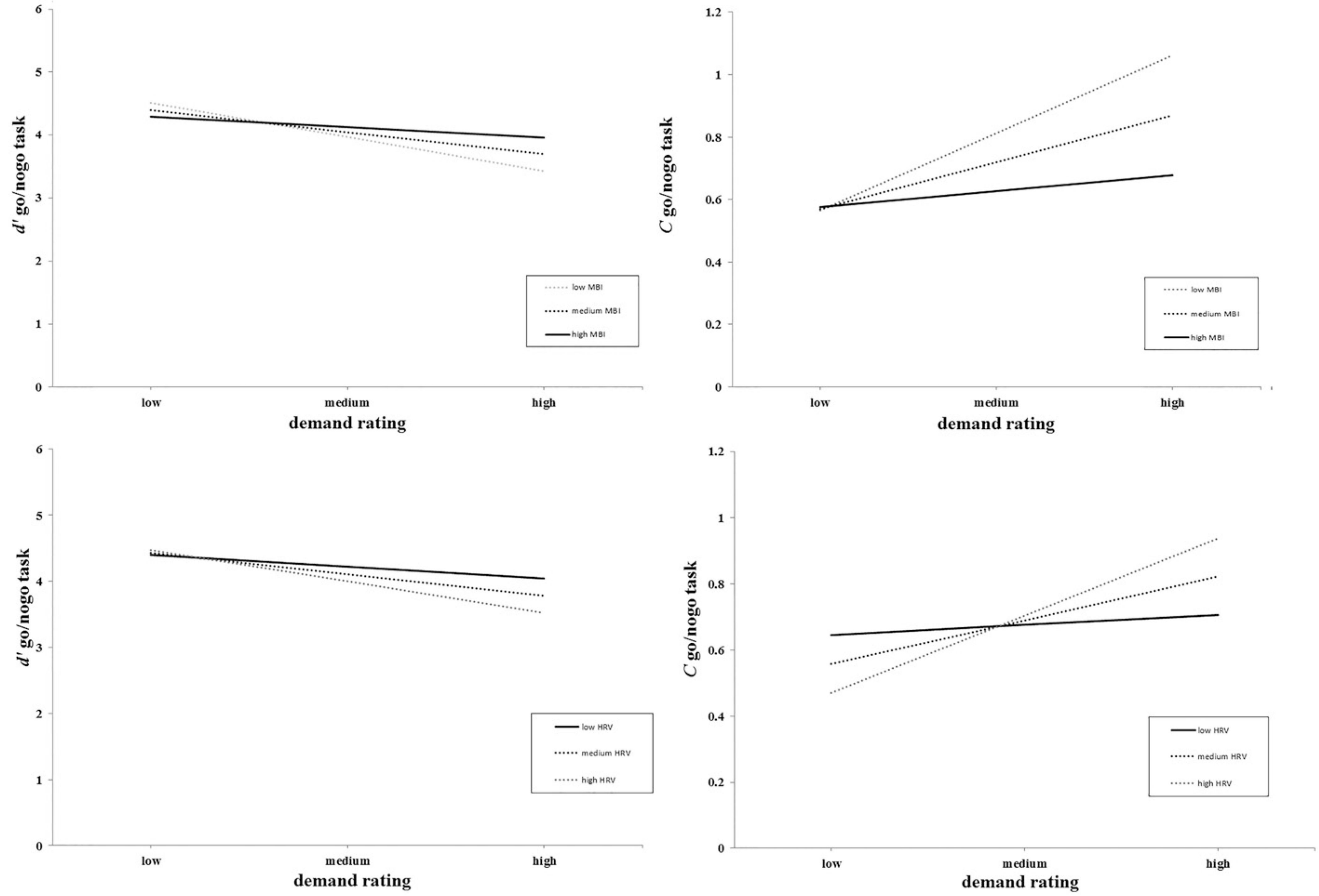

Figure 1.

Simple slopes of demand ratings predicting respective d′ and C performance parameter of the go/nogo task for high, mean, and low levels of the MBI total score respectively heart rate variability (HRV) at rest (root mean square of successive differences between heart beats [RMSSD], logarithmized). High levels represent the mean +1 SD, low levels represent the mean – 1 SD.

Table 1.

Sample characteristics for individuals with high and low burnout symptomatology (median split).

	Low burnout (N = 32)	High burnout (N = 33)	Group comparison
Age, years (mean, SEM)	42.42 (1.58)	44.13 (1.92)	$F(1,63) = 0.47$, $p = 0.50$
Sex, male (N, %)	5 (15.2)	10 (31.3)	$\chi^2(1) = 1.97$, $p = 0.16$
BMI (mean, SEM)	24.34 (0.67)	25.12 (0.79)	$F(1,63) = 0.57$, $p = 0.46$
Smoking (N, % yes)	3 (9.1)	3 (9.4)	$\chi^2(1) = 0.00$, $p = 1.0$
Caffeine consumption (N, % yes)	30 (90.1)	23 (71.9)	$\chi^2(1) = 2.74$, $p = 0.10$
Medication intake (N, % yes)	15 (45.5)	13 (40.6)	$\chi^2(1) = 0.25$, $p = 0.61$
MBI (mean, SEM)	0.90 (0.09)	3.44 (0.13)	$F(1,63) = 259.00$, $p < 0.001$
PHQ-9 (mean, SEM)	3.47 (0.42)	11.91 (0.87)	$F(1,63) = 75.88$, $p < 0.001$
HRV (mean, SEM)	31.66 (3.19)	29.66 (3.46)	$F(1,63) = 0.48$, $p = 0.49$

Cell values indicate group means. In low burnout and high burnout columns, values in parentheses are SEM (percentages). BMI: body mass index (kg/m^2); HRV: root mean square of successive differences between heart beats (RMSSD) at rest; MBI: Maslach burnout inventory – general survey total score; PHQ-9: patient health questionnaire sum score.

Table 2.

Means, standard errors, and range of values the participants scored on the cognitive variables for individuals with high and low burnout symptomatology (median split).

	Low burnout (*N* = 32)	High burnout (*N* = 33)	Range
Number-letter task			
Switch			
v	0.12 (0.01)	0.11 (0.01)	−0.18 to 0.25
a	0.16 (0.004)	0.16 (0.004)	0.09 to 0.23
No switch			
v	0.13 (0.01)	0.12 (0.01)	−0.18 to 0.27
a	0.18 (0.01)	0.18 (0.004)	0.12 to 0.27
Go/nogo task			
d′	4.17 (0.11)	4.04 (0.11)	2.55 to 5.31
C	0.76 (0.06)	0.61 (0.05)	−0.03 to 1.36
2-back task			
d′	2.40 (0.25)	2.14 (0.23)	−1.11 to 4.35
C	0.11 (0.38)	0.08 (0.05)	−0.70 to 0.53

Cell values indicate group means. In low burnout and high burnout columns, values in parentheses are SEM.

Table 3.

Pearson's correlation between the MBI total score, HRV, cognitive performance parameters, and demand ratings.

			Performance parameters							
			Number–letter task							
			Switch		No switch		Go/nogo task		2-back task	
	MBI	HRV	v	a	v	a	d′	C	d′	C
MBI	–	–	−0.11	0.04	−0.11	−0.08	−0.13	−0.21	−0.19	−0.05
HRV	−0.10	–	−0.07	0.14	−0.08	0.05	−0.07	0.15	−0.05	0.03
Demand ratings										
Number–letter task	0.34**	−0.03	−0.34**	0.02	−.28*	−0.17	<−0.01	<−0.01	−0.20	<0.01
Go/nogo task	0.32**	0.01	−0.07	−0.12	−0.10	−0.08	−0.51**	0.30*	−0.06	0.03
2-back task	0.32*	−0.10	−0.18	−0.08	−0.14	−0.11	−0.04	−0.07	−0.32*	−0.21

HRV: root mean square of successive differences between heart beats (RMSSD) at rest, logarithmized; MBI: MBI total score.

* $p < 0.05$

** $p < 0.01$.

Table 4.

Moderation models of demand rating and MBI total score respectively HRV predicting cognitive performance.

	Go/nogo task				2-back task			
	d'		C		d'		C	
Outcome Moderator	MBI	HRV	MBI	HRV	MBI	HRV	MBI	HRV
Age	−0.003 (0.01)	−0.01 (0.01)	−0.01 (0.003)*	−0.01 (0.004)	−0.04 (0.02)*	−0.05 (0.02)*	−0.002 (0.003)	−0.003 (0.004)
Sex	−0.16 (0.16)	−0.16 (0.16)	0.05 (0.08)	0.07 (0.08)	−0.03 (0.37)	−0.001 (0.36)	0.17 (0.07)*	0.14 (0.07)
PHQ-9	−0.01 (0.02)	−0.01 (0.01)	0.003 (0.01)	−0.01 (0.01)	−0.02 (0.05)	−0.03 (0.03)	−0.01 (0.01)	0.001 (0.005)
Demand rating	−0.16 (0.03)**	−0.14 (0.03)**	0.07 (0.02)**	0.06 (0.02)**	−0.10 (0.07)	−0.06 (0.11)	−0.03 (0.02)	−0.03 (0.01)
MBI	0.02 (0.08)	–	−0.06 (0.04)	–	−0.04 (0.20)	–	0.05 (0.04)	–
HRV	–	−0.16 (0.13)	–	0.03 (0.06)	–	−0.33 (0.29)	–	−0.03 (0.06)
Demand rating × moderator	0.07 (0.02)*	−0.15 (0.06)*	−0.03 (0.01)*	0.08 (0.03)*	0.004 (0.05)	−0.06 (0.11)	0.01 (0.01)	−0.04 (0.02)

	Number–letter task							
	Switch				No switch			
	v		a		v		a	
Outcome Moderator	MBI	HRV	MBI	HRV	MBI	HRV	MBI	HRV
Age	−0.002 (0.001)*	−0.003 (0.001)*	−0.001 (0.0003)	−0.001 (0.0003)	−0.002 (0.001)*	−0.003 (0.001)*	−0.001 (0.0003)*	−0.001 (0.0003)**
Sex	−0.01 (0.02)	−0.002 (0.02)	0.01 (0.01)	0.01 (0.01)	−0.01 (0.02)	−0.001 (0.002)	0.01 (0.01)	0.01 (0.01)
PHQ-9	0.005 (0.003)	0.002 (0.002)	−0.001 (0.001)	−0.0002 (0.001)	0.004 (0.003)	0.001 (0.002)	0.001 (0.001)	0.0002 (0.001)
Demand rating	−0.01 (0.005)*	−0.01 (0.005)*	0.001 (0.001)	0.001 (0.001)	−0.01 (0.005)*	−0.01 (0.005)*	−0.001 (0.002)	−0.001 (0.002)
MBI	−0.01 (0.01)	–	0.005 (0.003)	–	−0.01 (0.01)	–	−0.001 (0.004)	–
HRV	–	−0.02 (0.02)	–	0.001 (0.005)	–	−0.03 (0.02)	–	−0.01 (0.01)
Demand rating × moderator	−0.002 (0.003)	−0.01 (0.01)	−0.001 (0.001)	−0.001 (0.002)	−0.001 (0.004)	−0.01 (0.01)	−0.001 (0.001)	−0.003 (0.002)

HRV: root mean square of successive differences between heart beats (RMSSD) at rest, logarithmized; MBI: Maslach burnout inventory – general survey total score; PHQ-9: patient health questionnaire sum score; cells indicate unstandardized beta values with standard errors in parentheses.

* $p < 0.05$

** $p < 0.001$.