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A brief positive psychological intervention prior to a potentially stressful task facilitates more challenge-like cardiovascular reactivity in high trait anxious individuals

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Abstract

When confronted with stress, anxious individuals tend to evaluate the demands of an upcoming encounter as higher than the available resources, thus, indicating threat evaluations. Conversely, evaluating available resources as higher than the demands signals challenge. Both types of evaluations have been related to specific cardiovascular response patterns with higher cardiac output relative to peripheral resistance indicating challenge and higher peripheral resistance relative to cardiac output signaling threat. The aim of this research was to evaluate whether a brief positive psychological exercise (best possible selves intervention) prior to a potentially stress-evoking task shifted the cardiovascular profile in trait anxious individuals from a threat to a challenge type. We randomly assigned 74 participants to either a best possible selves or a control exercise prior to performing a sing a song stress task and assessed their level of trait anxiety. Cardiac output (CO) and total peripheral resistance (TPR) were continuously recorded through baseline, preparation, stress task, and recovery, respectively, as well as self-reported affect. Trait anxiety was related to higher CO in the best possible selves group and lower CO in the control group. While high trait anxious individuals in the control group showed increasing TPR reactivity, they exhibited a nonsignificant change in the best possible selves group. Moreover, in the latter group a stress-related decrease in positive affect in high trait anxious participants was prevented. Findings suggest that concentrating on strengths and positive assets prior to a potentially stressful encounter could trigger a more adaptive coping in trait anxious individuals.

KEYWORDS

best possible selves, biopsychosocial model, CO, TPR, trait anxiety

1 | INTRODUCTION

High anxious individuals are characterized by showing elevated anxiety symptoms, including cognitive (e.g., worry, confusion) and emotional (e.g., feeling nervous, agitated) signs of anxiety in diverse negative situations (Endler & Kocovski, 2001; Spielberger, 1985). Of note, the stronger affective stress experience in high anxious individuals might be rooted in cognitive evaluations of the stressor (O'Donovan et al., 2013). Specifically, previous research has shown that anxious individuals appraise an upcoming stressor as more threatening and rate their coping resources as limited as compared to low anxious individuals (Blascovich, 2008; Jerusalem, 1990), thus, suggesting a neurobiological sensitivity for threat (Mogg & Bradley, 2018; O'Donovan et al., 2013; Schwerdtfeger, 2006). It might thus be assumed that a positive psychological exercise aiming at strengthening resources could ameliorate the intensified threat processing in anxious individuals, a notion that was tested in this study.

The amount of available resources and the demands imposed by the context constitute major foundations of evaluating an upcoming encounter as challenge or threat (Jamieson, 2018). Specifically, according to the biopsychosocial model (e.g., Blascovich, 2008), challenge results when available resources outweigh demands and threat results when demands outweigh resources. It should be noted that both challenge and threat have been considered cognitive appraisals playing a major role in the coping process as outlined by Lazarus and Folkman (1984). They differentiate challenge from threat appraisals as part of the primary appraisal process contributing to the self-relevance of a given situation. Deviating from this view, the biopsychosocial model of challenge and threat emphasizes that challenge or threat represents the outcome of the coping process when the individual is engaged in a task of high self-relevance (Blascovich, 2008; Seery, 2011, 2013). Therefore, it has been suggested to use the term evaluations rather than appraisals when referring to challenge and threat as related to the biopsychosocial model (Seery, 2011). Of note, challenge and threat evaluations have been considered to reflect rather dynamic and mostly unconscious processes sensitive to various intrapersonal and contextual aspects (e.g., novelty or familiarity with the task, safety vs. danger cues, skill level, ability, and expertise; Blascovich, 2008; Seery, 2011). Thus, challenge and threat evaluations can be modified rather than representing stable trait-like differences, although a habitual tendency toward either challenge or threat evaluations may exist (Moore et al., 2019).

Importantly, the biopsychosocial model suggests that challenge and threat evaluations could modulate cardiac and vascular reactivity in response to stress, particularly in situations of high self- or goal-relevance requiring active instrumental responding (so-called motivated performance tasks, like public speaking or mental stress). In general, engagement in these stress tasks, independent of cognitive evaluations is accompanied by increases in sympathetic and decreases in parasympathetic nervous system activity, as indicated by increases in heart rate (HR) and shortening of the time elapsed between the depolarization of the left ventricle and ventricular ejection (i.e., pre-ejection period; e.g., Jamieson et al., 2017; Seery, 2011). While this response allows the individual to engage in the respective task, the subjective evaluations of the demands posed by a motivated performance situation and the available intraindividual resources may considerably modify this response.

Precisely, according to (Dienstbier, 1989), activation of the sympathetic adrenal medullary axis (SAM) enhances cardiac performance with elevated left ventricular contractility, increased cardiac output (CO; liters of blood pumped by the heart in 1 min, also referred to as cardiac efficiency) and reduced vascular resistance (total peripheral resistance, TPR; resistance of peripheral arteries, which determines the amount of oxygenated blood in the periphery). This response has been referred to as "toughness" and is characterized by high-quality task performance, emotional stability, and low anxiety. According to Obrist (1981), this response could also be labeled active coping and corresponds to evaluating aversive situations as challenge rather than threat. Hence, when perceived resources outweigh demands a challenge response could be expected with comparably high CO and lower TPR. On the contrary, coactivation of the SAM and the hypothalamic-pituitary adrenal axis inhibits decreases in systematic peripheral resistance due to sensitizing effects of cortisol on the artery walls (Rogers et al., 2002; Walker, 2007). This response pattern has been associated with threat evaluations. More specifically, when perceived demands outweigh available resources the resulting stress response is dominated by a vascular profile, that is a higher vasoconstriction (i.e., TPR) relative to CO. It should be emphasized that challenge and threat evaluations and their cardiovascular concomitants have been suggested to represent two anchors of a bipolar dimension, implying that relative rather than absolute differences are important (Blascovich, 2008).

Previous research found robust evidence for this model. For example, a cardiovascular challenge profile has been associated with better task performance (Behnke & Kaczmarek, 2018; for a review, see Hase et al., 2019), thus, substantiating the behavioral concomitants of challenge appraisals. Other studies examined associations between psychological concepts and cardiovascular indicators of challenge and threat. For example, individuals with stable high self-esteem showed a challenge-type cardiovascular response to failure feedback while those with unstable high self-esteem exhibited a threat-type cardiovascular response (Seery et al., 2004).

Importantly, correlational evidence for the validity of the biopsychosocial model is further advanced by experimental studies manipulating resource and threat appraisals and analyzing their relative impact on the cardiovascular indices of challenge and threat, respectively (e.g., Porter & Goolkasian, 2019; Tomaka et al., 1993; Turner et al., 2014). For example, manipulating resource and threat appraisals via brief instructions led to cardiovascular challenge and threat patterns, respectively (Turner et al., 2014). Furthermore, a cardiovascular challenge profile could be triggered by a positive performance feedback, which also resulted in enhanced visual attention toward gains (Frings et al., 2014). In a study by Streamer et al. (2017), reflecting on an upcoming self-relevant speech task using non-first-person language (self-distancing) resulted in a challenge-type cardiovascular response pattern as compared to using first-person language.

Conversely, a cardiovascular threat profile could be provoked by threat appraisals, stigma, stereotype threat (Blascovich, 2008), and benevolent sexism (Lamarche et al., 2020), among others. Furthermore, when social status got threatened and the status was unlikely to change, a cardiovascular threat pattern emerged, which changed to challenge, when instability was expected (Scheepers, 2009). Taken together, while challenge evaluations seem to benefit adaptive behavior and adaptive cardiovascular reactivity, thus, suggesting salutogenic effects, threat evaluations seem to foster vulnerability (Seery, 2011).

Of note, high anxiety proneness and related traits like neuroticism may be accompanied by subjective evaluations of threat rather than challenge (e.g., O'Donovan et al., 2013; Schneider, 2004; Schneider et al., 2012; Seery, 2013) and by elevated cardiac stress reactivity and exaggerated vascular stress responses (e.g., Egloff et al., 2002; Gramer & Saria, 2007; Sanchez-Gonzalez et al., 2015). Correspondingly, in a study on social anxiety, Shimizu et al. (2011) could show that socially anxious women (scoring high on trait social anxiety) exhibited a cardiovascular threat response (i.e., higher TPR as compared to CO) during a social interaction task relative to their low socially anxious counterparts. It could thus be assumed that high anxious women confronted with a motivated performance task tend to evaluate their resources as lower and the demands as higher, thus, resulting in a cardiovascular pattern indicating threat.

Due to the modifiable nature of challenge and threat evaluations, previous research examined if brief instructions and manipulations prior to a stress task could modify cardiovascular reactivity from a threat-type response to a challenge-type response and performance, respectively. Specifically, reminding participants of their personal resources and evaluating a task as less demanding could shift the individual's evaluation from threat to challenge (Jamieson et al., 2017; 2018). In line with this reasoning, reappraising anxious arousal prior to "Karaoke" singing, public speaking, or a math performance task resulted in more challenge-oriented behavior and better performance (Brooks, 2014). A similar challenge-inducing effect of a brief arousal reappraisal manipulation was reported by Moore et al. (2015). Consequently, brief instructions and low-threshold interventions could prove useful to foster a positive, challenge-oriented mindset.

Strategies focusing on individual's strengths and resources are the main focus of positive psychological interventions, which have begun to attract attention among researchers for several years (Bolier et al., 2013). A prominent example of a positive intervention is the best possible selves exercise (King, 2001). This kind of intervention asks participants to elaborate on their best possible future outcomes, thus, facilitating personalized representations of life goals (King, 2001). Meta-analyses and narrative reviews have shown that best possible selves interventions increase positive affect, optimism, and life satisfaction (e.g., Bolier et al., 2013; Layous et al., ; Meevissen et al., 2011; Sheldon & Lyubomirsky, 2007).

Importantly, although such interventions have been designed as repeated exercises to foster an individual's well-being chronically, research also suggests that the immediate effects of a brief positive psychological intervention (so-called micro-intervention) are quite robust (Elefant et al., 2017; Lopes et al., 2016; Meinlschmidt et al., 2016; Peters et al., 2010). In particular, following a best possible selves session, individuals have been found to exhibit increases in happiness, positive affect, and subjective well-being (Elefant et al., 2017; Lopes et al., 2016; Meinlschmidt et al., 2016). However, the mechanisms involved in the effectiveness of a best possible selves intervention remain largely speculative (Loveday et al., 2016). It has been hypothesized that writing about life goals may enable individuals to actively engage and pursue these goals, which requires visualization, self-awareness, and self-regulation (King, 2001). Other research identified reduced goal ambivalence (Heekerens et al., 2019) and—depending on the context—more approach-oriented behavior (Oyserman et al., 2015) as key mechanisms of a best possible selves intervention.

Grounding on the biopsychosocial model of challenge and threat, Jones et al. (2009) identified several antecedents of challenge and threat evaluations. Specifically, increased self-efficacy, perceived control, and achievement-related/approach-oriented goals may all contribute to evaluating resources as higher than demands, potentially resulting in a cardiovascular challenge response. Hence, it could be assumed that a best possible selves intervention is particularly well-suited to trigger more challenge-oriented than threat-oriented evaluations, ultimately leading to the respective cardiovascular response patterns. More specifically, a best possible selves intervention may facilitate self-regulation, optimism, and active coping, and may thus shift an individual's evaluation in a motivated performance task toward challenge rather than threat. It should be noted in this respect that both optimism (e.g., Baumgartner et al., 2018) and life satisfaction (e.g., Schwerdtfeger et al., 2017) have been associated with a challenge-type instead of a threat-type cardiovascular stress profile to a motivated performance task.

It could be assumed that a brief best possible selves intervention could be particularly beneficial for individuals with elevated anxiety, who have been found to show compromised possible selves and future outlook (Eysenck et al., 2006). In accordance with this, Ng (2016) found—among others—that individuals scoring high in neuroticism seemed to benefit more from a best possible selves intervention relative to controls. Specifically, writing about personalized life goals buffered individuals high in neuroticism from decreases in happiness. Thus, the positive effects of a best possible selves exercise are expected to be particularly pronounced in individuals showing a tendency toward threat evaluations, such as emotionally unstable, high anxious individuals. Correspondingly, Strack and Esteves (2015) could observe that anxious individuals, who interpreted anxiety as facilitative appraised an upcoming exam as challenging rather than threatening. Even more, Jamieson et al. (2013) found that socially anxious individuals who were instructed to reframe stress arousal as functional evidenced higher CO and lower TPR to a social-evaluative stress task, thus, suggesting that instructing high anxious individuals in positive coping could lead to a more challenge-oriented cardiovascular stress response.

Hence, the aim of this research was to evaluate the effects of a brief best possible selves intervention on cardiovascular markers of challenge and threat in individuals with different levels of trait anxiety. In accordance with previous research, we expected that while high trait anxious relative to low trait anxious individuals should show a cardiovascular response profile associated with threat rather than challenge following an active control task (i.e., writing about their furniture), they were supposed to exhibit a challenge-type rather than threat-type response after performing a brief best possible selves writing task (i.e., higher CO relative to TPR).

2 | METHOD

2.1 | Participants

Sample size calculation was grounded on the assumption of medium effect sizes of micro-interventions on psychological indicators of health (Bolier et al., 2013; Loveday et al., 2016; Sin & Lyubomirsky, 2009) as well as medium-to-large sized effects of a brief arousal manipulation on cardiovascular indicators of challenge and threat in socially anxious individuals (Jamieson et al., 2013). As power calculation in mixed effects models is difficult to ascertain when assumptions about random variances, slope variances, and intraclass correlations, among others, are lacking solid foundations, power analysis was conducted using a 2 × 4 mixed analysis of variance with medium effect size ($f = 0.25$) using GPower (Faul et al., 2007). The resulting sample size was $N = 62$. Overall, 82 individuals took part in the study, of whom eight were excluded due to excessive artifacts or multiple ectopic beats. Participants were recruited via oral communication, flyers at the university campus and the surroundings, and email announcements. The final sample for analysis comprised of 74 individuals (49 women, 25 men). Their mean age was 23.27 years ($SD = 4.42$) and the mean waist to hip-ratio (WHR) was 0.81 ($SD = 0.10$). Participants were eligible for study entry if they were free of physical and psychological medication and free of chronic and acute illnesses. Exclusion criteria were verified prior to the start of the experiment. Ethical approval by the institutional review board (GZ. 39/25/63 ex 2018/19) was obtained.

2.2 | Experimental manipulation

The study examined the effects of the best possible selves intervention in an experimental between subjects' design. Participants were randomly assigned to either a best possible selves intervention group ($n = 36$) or a control intervention group (active control, writing about their furniture; $n = 38$). Randomization was accomplished by assigning odd and even numbers to participants. Precisely, odd numbers were assigned to the best possible selves condition and even numbers to the active control condition.

In accordance with King (2001), the best possible selves condition was introduced as follows: "*Now, please think about what your life will look like in the future (5–10 years from now). Imagine that everything went as great as possible. You have worked hard and successfully achieved all your life goals, both professionally as well as privately. Imagine that all your dreams have come true and that you live the best possible life. Write down this scenario as detailed as possible*." After 10 min, they were further asked to elaborate in detail on the actions necessary to reach the goals for 5 min ("*Now, please list concrete ideas that help to realize your goals. For example, activities that you could tackle, contacts you could make, ways in which you could use your time as efficiently as possible. There are no limits to your creativity here*").

The active control group was instructed to describe the furniture of their apartment in detail (from entering the door to each room). After 10 min participants were further asked to elaborate on the changes and adaptations in furniture since their moving in (for 5 min; the instructions are available upon request). Following the brief best possible selves or active control intervention, state affect was assessed.

2.3 | Stress task

The sing-a-song stress test (Brouwer & Hogervorst, 2014) was introduced as potentially stressful task, which requested participants to (a) prepare and (b) sing a song in front of a camera for 3 min each. It should be noted that a similar "Karaoke" task proved sensitive in response to an arousal reappraisal intervention (Brooks, 2014). A second informed consent was obtained asking about permission of video recording. During the preparation phase of 3 min the song ("Hollywood Hills" by "Sunrise Avenue") was delivered via a loudspeaker while the lyrics were presented on the computer screen. Subsequently, participants were asked to rate their affective well-being and how threatening and challenging the upcoming task was perceived (i.e., threat and challenge appraisal on a 4-point Likert scale ranging from 1 = "not at all" to 4 = "very much"). Then, participants were instructed to sing along to the song (stress phase of 3 min.). They were informed about their behavior being evaluated with respect to their performance, self-confidence, and talent. Importantly, the time-course of the BSP and the active control group was identical and the experimental procedure was administered fully automatized by means of the software PsychoPy (Peirce, 2007).

2.4 | Variables and Instruments

2.4.1 | Manipulation check

In order to analyze if the best possible selves intervention was conducted as per instruction, transcripts of the written elaborations in the best possible selves and active control group were made and analyzed with the linguistic word inquiry software LIWC (vers. 2015; Tausczik & Pennebaker, 2010). The total number of words, positive emotion words, positive feeling words, future-related words, and achievement-related words, among others, were analyzed.

2.4.2 | Trait anxiety

Trait anxiety was assessed using the trait version of the State-Trait Anxiety and Depression Inventory (STADI; Renner et al., 2018). The STADI aims to assess both state and trait aspects of anxiety and depression. It is based on the State-Trait Anxiety Inventory (STAI; Spielberger, 1983), but allows a reasonable separation of anxiety and depression symptoms. The trait version asks for anxiety and depression symptoms on a 4-point frequency scale ranging from 1 (= almost never) to 4 (= nearly always). Anxiety is assessed via 10 items, which can be further subdivided into worry (five items; e.g., "I think of the worst") and emotionality (five items; e.g., "I am bustling"). The STADI has proven reliable and valid in previous research as could be shown in healthy and clinical populations (Renner et al., 2018). The mean across the 10 items was calculated. Reliability of the scale was good (Cronbach's alpha = 0.87).

2.4.3 | State affect

Positive affect (PA) and negative affect (NA) were assessed via the German version of the Positive and Negative Affect Schedule (PANAS; Krohne et al., 1996; Watson et al., 1988). PA and NA is assessed via 10 adjectives each (PA: e.g., active, strong, excited, inspired, enthusiastic; NA: e.g., guilty, upset, scared, nervous, ashamed) to be rated on a 5-point Likert scale ranging from 1 (not at all) to 5 (extremely). The mean score across the 10 items was calculated for both dimensions. PA and NA were assessed at baseline, post-intervention, immediately before the stress task and at recovery, respectively. Reliability coefficients (Cronbach's alpha) varied between .84 and .92 for PA and .62–.85 for NA.

2.4.4 | Self-reported challenge and threat

We assessed ratings of challenge ("How challenging do you consider the upcoming task?") and threat ("How threatening do you consider the upcoming task?") via unipolar items ranging from 1 = not at all to 4 = very much so. It should be noted that previous research examining the subjective indicators of challenge and threat used multiple items of task demands (e.g., uncertainty, low skills, and perceived danger) and resources (e.g., confidence, ability, familiarity; Blascovich, 2008). The present research did not follow this convention, making the calculation of a challenge/threat-ratio not feasible. Although the single items-approach applied in this study does not have existing evidence that it is related to differentiating cardiovascular patterns of challenge and threat, it was applied on an exploratory basis as an alternative approach.

2.4.5 | Cardiovascular indicators of challenge and threat

CO and TPR were continuously recorded on a beat-to-beat basis using the hemodynamic cardiovascular monitor Finometer® PRO (FMS, Finapres Medical Systems, Amsterdam, The Netherlands). The Finometer records blood pressure continuously via finger and height sensors (vascular unloading technique; Peňáz, 1973). Initially, absolute accuracy of the brachial artery blood pressure is calibrated by a well-validated (Schutte et al., 2004) procedure (i.e., return-to-flow calibration; e.g., Bos et al., 1996) using an upper arm cuff. The continuous brachial artery blood pressure is reconstructed by an initial calibration procedure using an upper arm cuff (i.e., return-to-flow calibration; e.g., Bos et al., 1996). Importantly, the Finometer® has an additional on board "Physiocal" calibration feature (Wesseling et al., 1995), which accounts for potential drifts in the data by an automatized and repeated application (max. every 70 beats). The Finometer® finger cuff was attached at participant's middle finger of the nondominant hand and the upper arm cuff was attached on the same side. CO (via modelflow estimate; Wesseling et al., 1993) and TPR were analyzed offline using BeatScope software (vers. 2.10), by considering individual's gender, age, body mass, and weight. CO is quantified as liters per minute and TPR as the ratio of the mean arterial pressure to cardiac output and is expressed as centimeter-gram-second units (dyn.s/cm^5).

HR was assessed via an electrocardiogram applying a chest lead (modified Eindhoven II-lead; AccuSync® 72), which was recorded with a Biopac MP150 amplifier system (1,000 Hz). HR was analyzed offline via Kubios premium software (vers. 3.2; Tarvainen et al., 2014) applying artifact correction (automatic artifact correction algorithm) if necessary.

2.5 | Procedure

Upon arrival at the laboratory, participants signed informed consent. Then, their waist and hip circumferences were measured. Subsequently, the electrodes were attached and the devices calibrated. Participants then worked on questionnaires to assess demographic variables and trait anxiety. Then, baseline recording started (3 min). In order to obtain basal resting values, participants viewed different landscape photographs during baseline (for a similar approach, see Piferi et al., 2000), which was followed by an affective state questionnaire. Subsequently, the instruction for the best possible selves group or the active control group was presented and participants engaged in writing for 15 min. Handwriting was required in both groups. Thereafter, state affect was assessed. Following the preparation period (3 min), the sing-a-song task was initialized (3 min), after which state affect was assessed again. Finally, the recovery period was followed (5 min), during which participants were instructed to fixate a green dot in the center of the computer screen. We aimed for a 5 min recovery period in order to account for the comparably slow recovery in cardiovascular measures (e.g., Linden et al., 1997). Presentation of a fixation cross was implemented during this period in order to standardize participants' attention, thus, mirroring a vanilla baseline approach (e.g., Jennings et al., 1992). Then, state affect was assessed and subsequently the electrodes were detached and participants debriefed. The procedure is visualized in Figure 1.

Participants were tested individually in a separated quiet room. Each intervention was conducted for 15 min prior to the stress task. The experiment lasted up to 1 hr and 15 min, and participants received course credit if applicable. Participants were instructed to refrain from intense physical activity and alcohol for 4 hr and from nicotine (if smokers) for 2 hr prior to the scheduled time.

2.6 | Data parametrization and analyses

Beat-to-beat values of CO and TPR were aggregated for each period. Values were visually checked for artifacts and outliers, which were removed if necessary (baseline: 0.28%, preparation: 0.38%, stress: 0.36%, recovery: 0.28%). Due to a skewed distribution TPR was logarithmized prior to analysis (lnTPR).

Mixed effects models were calculated accounting for random factors. We specified a random intercept model, thus, accounting for individual differences in intercepts. Several predictor variables were entered as follows.

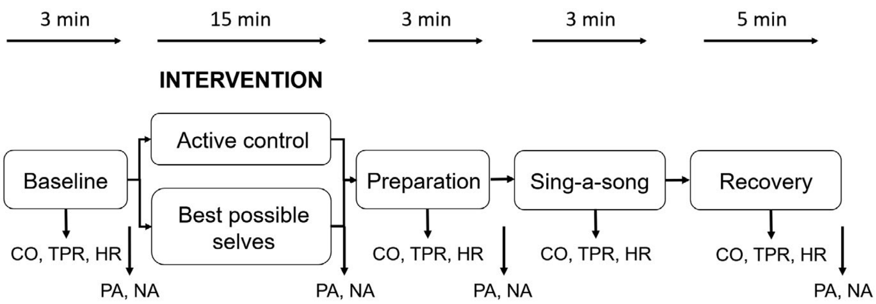

FIGURE 1 Study procedure with the main study phases and the main variables. CO, cardiac output; HR, heart rate; NA, negative affect; PA, positive affect; TPR, total peripheral resistance

2.6.1 | Effects of the best possible selves versus active control exercise on cardiovascular indicators of challenge and threat

For predicting CO and TPR, trait anxiety (grand mean centered) was entered as a continuous predictor variable and group (active control vs. best possible selves) as a dichotomous variable. Task period (0 = baseline, 1 = preparation, 2 = stress, 3 = recovery) served as a factorize variables and the three-way interaction between group, task period and trait anxiety was entered. Additional models including covariates (sex age, WHR, physical activity, and smoking) were also calculated, but did not reveal different findings. Hence, we report the more parsimony models in order to avoid model over-specification.

2.6.2 | Effects of best possible selves versus active control exercise on psychological indicators of state affect

For predicting PA and NA, trait anxiety (grand mean centered) was entered as a continuous predictor variable and group (active control vs. best possible selves) as a dichotomous variable. Task period (0 = baseline, 1 = post-intervention, 2 = stress, 3 = recovery) served as factorized predictor variable and the three-way interaction between group, task period and trait anxiety was entered in a final step.

In case of significant interactions involving trait anxiety or group, references were changed accordingly in order to allow for simple slope analyses. Specifically, trait anxiety was centered at the standard deviation (±1 *SD*) to allow separating trajectories for both low and high anxious participants. The reference for group was changed to 0 and 1 in order to explore both groups separately. Significance (*p*-)values were derived using Satterthwaite's degrees of freedom method (Luke, 2017). Models were analyzed using the statistical computing software R (vers. 3.5.3; R Core Team, 2019) with the packages lme4 (vers. 1.1-21; Bates et al.,2015) and lmer.Test (vers. 3.1-0; Kuznetsova et al., 2017). The level of significance was fixed at $p < .05$ (two-tailed). Of note, in order to evaluate the robustness of the effects, we also applied post hoc power simulations using the R package simr (Green & MacLeod, 2016), applying 10,000 Monte Carlo simulations.

3 | RESULTS

3.1 | Sample characteristics

Participants of the active control and the best possible selves group were compared on a number of measures (Table 1). Of note, both groups did not differ in trait anxiety, age, sex, WHR, smoking status, alcohol intake, regular physical exercise, baseline HR, CO, and lnTPR, thus, ensuring comparability between groups.

3.2 | Manipulation checks

Importantly, the total number of words in the writing tasks was comparable between groups (active control: $M = 270.11$, $SD = 60.17$; best possible selves: $M = 252.78$, $SD = 50.88$; $t(72) = 1.33$, $p = .186$). However, positive emotion words and positive feeling words were significantly more prevalent in the best possible selves as compared to the control

TABLE 1 Comparisons between the best possible selves group and the active control group on demographic, lifestyle and cardiovascular baseline variables

	Best possible selves ($n = 36$)			Active control ($n = 38$)			
	%	*M*	*SD*	%	*M*	*SD*	*p*
Sex (women)	63.9			68.4			.68
Age		22.83	3.53		23.68	5.14	.41
WHR		0.81	0.07		0.81	0.12	.91
Trait anxiety		19.82	5.98		19.79	4.24	.96
Smoker	22.2			10.5			.19
Alcohol consumption	86.1			84.2			.82
Reg. physical activity	77.8			81.6			.68
HR (BPM)		76.36	11.50		76.10	10.99	.92
CO (L/min)		5.83	1.07		5.72	1.22	.67
TPR (dyn.s/cm^5)		1,357.59	326.81		1,419.14	388.77	.47

Abbreviations: CO, cardiac output; DBP, diastolic blood pressure; HR, heart rate; SBP, systolic blood pressure; TPR, total peripheral resistance; WHR, waist to hip-ratio.

group (positive emotion – best possible selves: $M = 4.84$, $SD = 2.03$; positive emotion – control: $M = 0.66$, $SD = 0.52$; $t(39.37) = -12.00$, $p < .001$; positive feelings – best possible selves: $M = 0.20$, $SD = 0.35$; positive feelings – control: $M = 0.01$, $SD = 0.06$; $t(39.37) = -3.15$; $p = .003$). Relative to the control group, the best possible selves group also evidenced a higher number of I-related words, future-related words, social words, achievement-related words, occupational words, insight words, communication-related words, and cognitive mechanism words, among others (Bonferroni-adjusted p's < .0006; data available upon request). The active control group, on the contrary, scored higher on home-related words, physical words, as well as up and down-related words (Bonferroni-adjusted p's < .0006; data available upon request). Taken together, individuals in both groups performed the tasks in accordance with instructions.

Subjective threat ratings did not differ significantly between groups as analyzed via t tests for independent samples ($t(72) = 0.71$, $p = .944$). However, subjective challenge ratings were significantly higher in the active control ($M = 3.29$, $SD = 0.61$) as compared to the best possible selves group ($M = 2.86$, $SD = 0.76$; $t(72) = 2.68$, $p = .009$). Subjective threat ratings were significantly positively associated with trait anxiety in the active control ($r = .41$, $p = .012$), but unrelated to anxiety in the best possible selves group ($r = .26$, $p = .126$). Subjective challenge ratings were unrelated to trait anxiety in both groups (active control: $r = .26$, $p = .109$; best possible selves: $r = .23$, $p = .178$). Finally, across groups subjective challenge ratings were significantly positively associated with CO reactivity to stress ($r = .27$, $p = .021$) and unrelated to TPR reactivity ($r = -0.10$, $p = .402$), while no significant relationships emerged between subjective threat ratings and both TPR reactivity ($r = .01$, $p = .943$) and CO reactivity ($r = .08$, $p = .524$).

In order to verify the motivated performance nature of the sing-a-song stress task, the change from baseline to stress was evaluated for HR using an analysis of variance with repeated measures (baseline vs. stress) and group as a between-subjects factor (active control vs. best possible selves). There was a significant and large-sized main effect for task period ($F(1, 72) = 124.69$, Wilk's $\Lambda = .366$, $p < .001$, $\eta_p^2 = .63$), documenting a significant increase in HR to the sing-a-song task. Descriptive data are reported in Table 2. Importantly, there was no significant two-way interaction between task period and group ($F(1, 72) = 1.70$, Wilk's $\Lambda = .977$, $p = .197$, $\eta_p^2 = .02$). Together these findings suggest that the sing-a-song task resulted in significant cardiac stress reactivity, thus, justifying its use as a motivated performance task for both groups.

3.3 | Predicting cardiovascular indicators of challenge (CO) and threat (TPR)

The mixed effects models for predicting CO and lnTPR are depicted in Table 3. In general, CO increased from baseline to both preparation ($b = 0.782$, $p < .001$) and stress ($b = 1.022$, $p < .001$) and returned to baseline levels during recovery ($b = -0.068$, $p = .505$), thus, documenting an effective stress response. Importantly, a significant three-way interaction between group, trait anxiety and stress ($b = 0.070$, $p = .001$) emerged and suggested group-related differences in the relationship between CO reactivity and trait anxiety.

TABLE 2 Comparisons between the best possible selves group and the active control group on cardiovascular and affective variables across task periods

	Baseline		Preparation		Stress		Recovery	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Best possible selves								
HR (BPM)	76.36	11.50	84.59	12.31	90.50	12.95	76.06	11.26
CO (ltr/min)	5.83	1.07	6.61	1.40	6.87	1.37	5.80	0.90
TPR (dyn.s/cm^5)	1,357.59	326.81	1,448.80	353.07	1,493.78	377.61	1,546.56	342.82
PA (1–5)	2.66	0.70	3.11	0.85	2.70	0.91	2.75	0.86
NA (1–5)	1.14	0.21	1.19	0.25	1.64	0.59	1.50	0.63
Active control								
HR (BPM)	76.10	10.99	85.94	15.10	93.99	17.12	76.13	11.83
CO (ltr/min)	5.32	1.22	6.50	1.70	6.72	1.93	5.61	1.34
TPR (dyn.s/cm^5)	1,419.14	388.77	1,565.55	573.91	1,677.40	722.06	1,727.32	636.06
PA (1–5)	2.75	0.47	2.75	0.67	2.61	0.65	3.04	0.73
NA (1–5)	1.17	0.19	1.16	0.24	1.64	0.57	1.24	0.30

Abbreviations: CO, cardiac output; HR, heart rate; NA, negative affect; PA, positive affect; TPR, total peripheral resistance.

TABLE 3 Linear mixed effects models for predicting cardiac output (CO; left side) and total peripheral resistance (TPR, logarithmized units; right side) in the course of the experiment

	CO			ln TPR		
Variable	b^a	*SE*	*t*	b^a	*SE*	*t*
Intercept	5.776	0.164	35.35***	7.207	0.032	227.71***
Trait anxiety	−0.021	0.034	−0.64	0.005	0.007	0.78
Group (−1 = control, 1 = best possible selves)	0.057	0.163	0.35	−0.018	0.032	−0.57
Preparation (vs. baseline)	0.782	0.103	7.62***	0.071	0.018	3.86***
Stress (vs. baseline)	1.022	0.103	9.95***	0.113	0.018	6.17***
Recovery (vs. baseline)	−0.068	0.103	−0.67	0.154	0.018	8.39***
Group × Preparation	0.0002	0.103	0.002	−0.008	0.018	−0.43
Group × Stress	0.016	0.103	0.16	−0.020	0.018	−1.14
Group × Recovery	0.037	0.103	0.36	−0.022	0.018	−1.20
Trait anxiety × Preparation	0.019	0.021	0.88	−0.003	0.004	−0.90
Trait anxiety × Stress	−0.008	0.021	−0.40	−0.001	0.004	−0.16
Trait anxiety × Recovery	−0.006	0.021	−0.29	0.003	0.004	0.76
Group × Trait anxiety	0.009	0.034	0.26	−0.002	0.007	−0.30
Group × Trait anxiety × Preparation	0.023	0.021	1.09	−0.001	0.004	−0.28
Group × Trait anxiety × Stress	0.071	0.021	3.33**	−0.008	0.004	−2.10*
Group × Trait anxiety × Recovery	0.011	0.021	0.53	−0.001	0.004	−0.22

[a]Unstandardized regression estimates; active control group = writing about one's furniture, best possible selves group = writing about one's best possible selves.

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

Consequently, post hoc simple slope analyses were conducted by changing reference levels for both groups (active control as reference vs. best possible selves as reference) and trait anxiety (±1 *SD*) and rerunning the models. For the control group, the interaction between stress (vs. baseline) and trait anxiety was significantly negative ($b = -0.079$, $p = .022$), thus, suggesting lower CO increases with increasing trait anxiety. Of note, this relationship was reversed in the best possible selves group ($b = 0.062$, $p = .014$). Hence, anxiety was associated with lower CO reactivity in the active control and with higher CO reactivity in the best possible selves group. Further analyses documented that high trait anxious participants showed a lower CO in the active control as compared to the best possible selves group (interaction of group and stress: $b = 0.376$, $p = .012$), whereas for low anxious individuals this effect was reversed ($b = -0.343$, $p = .022$), thus, indicating a lower CO increase in the best possible selves relative to the control group. Taken together, these results suggest that trait anxiety significantly moderated the effects of the best possible selves intervention such that with increasing levels of anxiety CO reactivity became stronger in the best possible selves relative to the control group. A power simulation applying $p < .05$ resulted in a power of 91%, thus, suggesting a relatively robust effect.

For lnTPR there were significant increases from baseline to preparation ($b = 0.071$, $p < .001$), stress ($b = 0.113$, $p < .001$) and recovery ($b = 0.154$, $p < .001$), respectively. These findings document that the stress task resulted in elevated peripheral resistance, which endured into the recovery period. Moreover, a significant three-way interaction between group, trait anxiety and stress was found ($b = -0.008$, $p = .037$), which showed a similar descriptive trend when analyzing the raw untransformed variable ($b = -12.19$, $t = -1.67$, $p = .097$). Again, post hoc simple slope analyses were conducted to further elucidate this effect. Importantly, while for the control group the interaction between stress reactivity and trait anxiety was not significant ($b = 0.007$, $p = .231$), it was marginally significant for the best possible selves group ($b = -0.009$, $p = .057$), indicating a nonsignificant but potentially meaningful descriptive trend that with increasing anxiety levels peripheral resistance reactivity tended to be lower relative to the control group. Further analyses showed that for low trait anxious participants (−1 *SD*) lnTPR significantly increased from baseline to stress in both groups (active control: $b = 0.097$, $p = .018$; best possible selves: $b = 0.135$, $p < .001$). However, for high trait anxious participants, lnTPR significantly increased from baseline to stress in the control

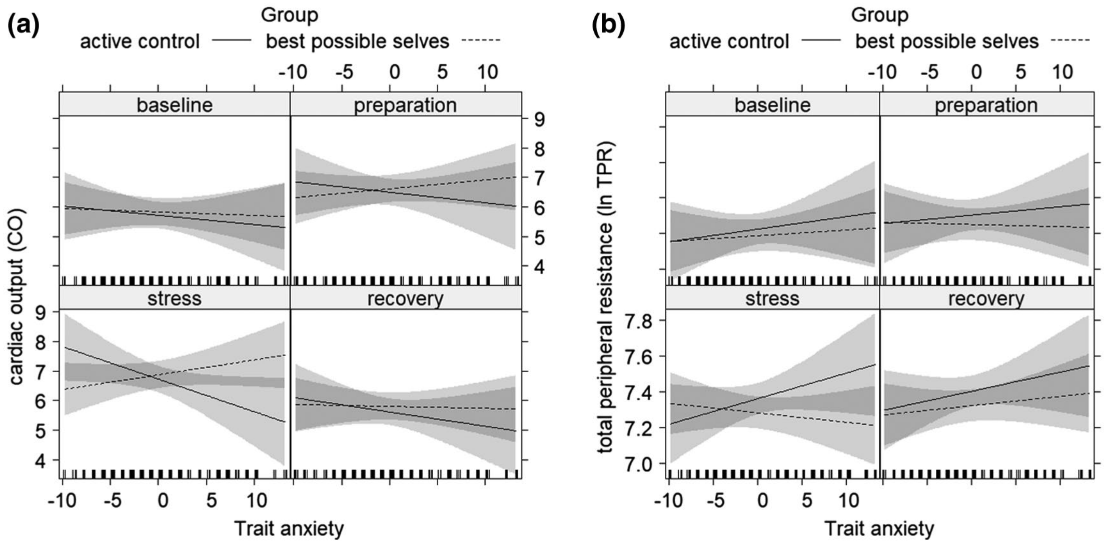

FIGURE 2 Slopes (and confidence intervals) for cardiac output (a, left side) and total peripheral resistance (b, right side) for each period of the experiment. Slopes are derived from the mixed effects models

group only (b = 0.171, p < .001), while it was virtually unchanged in the best possible selves group (b = 0.049, p = .163). Together these findings suggest that the best possible selves relative to the active control group resulted in lower peripheral resistance reactivity in high anxious individuals, thus, indicating a negative relationship in the best possible selves group in contrast to the expected positive relationship in the active control group with a noneffective treatment. Of note, a power analysis resulted in a power of 56%, thus, suggesting a rather fragile effect. The slopes for both models (CO and lnTPR) throughout the experimental periods in both conditions are depicted in Figure 2a (CO) and b (ln TPR).

Of note, because previous studies often restricted analyses to the last minute of the baseline period and the first minute of the motivated performance task (e.g., Jamieson et al., 2013; Scheepers, 2009; Seery et al., 2009), we reanalyzed the outcome measures accordingly. In brief, analyses confirmed the findings presented above. In particular, the three-way interactions of group, trait anxiety and stress were significant for both CO (b = 0.086, t = 3.55, p < .001) and lnTPR (b = −0.01, t = −2.61, p = .01), thus, supporting the reliability of the effects.

3.4 | Predicting state affect (PA and NA)

The mixed effects model for the prediction of PA and NA is depicted in Table 4. For PA there was a significant interaction of group and post-intervention (b = 0.221, p = .004). Follow-up analyses indicated that the control intervention resulted in a nonsignificant change in PA relative to baseline (b = 0.0005, p = .996). However, for the best possible selves group a significant increase in PA relative to baseline could be observed (b = 0.442, p < .001), thus, suggesting efficacy of the experimental manipulation. Moreover, there were significant three-way interactions between group, trait anxiety and stress (b = 0.036, p = .023) and group, trait anxiety and recovery (b = 0.048, p = .002), respectively. Post hoc simple slope-analyses documented that the interaction between trait anxiety and stress (vs. baseline) was not significant in the best possible selves (b = 0.025, p = .175), but tended to be negative in the active control group (b = −0.046, p = .067). Hence, trait anxiety tended to be negatively associated with PA only in the control group. When comparing high (+1 *SD*) versus low trait anxious individuals (−1 *SD*) it turned out that high trait anxious individuals showed a significant decrease in PA from baseline to stress in the control (b = −0.374, p = .024) and no significant change in the best possible selves group (b = 0.164, p = .253). Moreover, in the latter group high trait anxious participants showed a significant increase in PA during recovery (b = 0.295, p = .040), but they evidenced no change in recovery relative to baseline in the control group (b = 0.004, p = .981). Low trait anxious individuals, on the contrary, showed a significant increase in PA during recovery (relative to baseline) in the active control (b = 0.573, p < .001), but no such change in the best possible selves group (b = −0.115, p = .421). Taken together, the best possible selves intervention prevented a decline in PA relative to the active control group and led to a significant increase in PA during recovery among high trait anxious individuals, while low trait anxious individual appeared to be relatively unaffected by the best possible selves intervention.

For NA, there were significant main effects for stress (b = 0.484, p < .001) and recovery (b = 0.216, p < .001), respectively, documenting elevated NA relative to baseline.

TABLE 4 Linear mixed effects models for predicting positive affect (PA; left side) and negative affect (NA; right side) in the course of the experiment

	PA			NA		
Variable	b^a	*SE*	*t*	b^a	*SE*	*t*
Intercept	2.707	0.084	33.38***	1.156	0.045	25.88***
Trait anxiety	−0.020	0.017	−1.17	0.023	0.009	2.46*
Group (−1 = control, 1 = best possible selves)	−0.044	0.084	−0.52	−0.011	0.045	−0.25
Post-Intervention (vs. baseline)	0.222	0.075	2.94**	0.021	0.047	0.45
Stress (vs. baseline)	−0.050	0.075	−0.67	0.484	0.047	10.26***
Recovery (vs. baseline)	0.189	0.075	2.52*	0.216	0.047	4.57***
Group × Post-intervention	0.221	0.075	2.93**	0.029	0.047	0.61
Group × Stress	0.087	0.075	1.16	0.017	0.047	0.36
Group × Recovery	−0.099	0.075	−1.32	0.140	0.047	2.96**
Trait anxiety × Post-intervention	0.004	0.016	0.24	−0.013	0.010	−1.30
Trait anxiety × Stress	−0.011	0.016	−0.69	0.030	0.010	3.12**
Trait anxiety × Recovery	−0.008	0.016	−0.50	0.004	0.010	0.46
Group × Trait anxiety	0.008	0.017	0.49	−0.003	0.009	−0.29
Group × Trait anxiety × Post-Intervention	0.020	0.016	1.28	0.003	0.010	0.34
Group × Trait anxiety × Stress	0.036	0.016	2.29*	−0.009	0.010	−0.88
Group × Trait anxiety × Recovery	0.048	0.016	3.09**	−0.006	0.010	−0.59

[a]Unstandardized regression estimates; control group = writing about one's furniture, best possible selves group = writing about one's best possible selves.

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

Moreover, trait anxiety was associated with elevated levels of NA ($b = 0.023$, $p = .015$), which however, was dependent on stress (two-way interaction between trait anxiety and stress: $b = 0.030$, $p = .002$). Hence, the relationship between trait anxiety and NA was stronger during stress as compared to baseline. A significant interaction between group and recovery ($b = 0.140$, $p = .003$) further suggested that recovery values in NA were not significantly different from baseline in the active control ($b = 0.076$, $p = .249$), but significantly higher in the best possible selves group ($b = 0.356$, $p < .001$). There were no interactions involving group, trait anxiety and stress or recovery, respectively.

4 | DISCUSSION

The aim of this research was to examine if trait anxiety moderates the efficacy of a well-evaluated positive psychological micro-intervention on cardiovascular indicators of challenge and threat. Specifically, in accordance with the biopsychosocial model (Blascovich, 2008) and previous research on brief instructions to facilitate challenge-type cardiovascular responses (e.g., Jamieson et al., 2013), we expected a shift to a more challenge-like cardiovascular response consisting of relatively higher CO and/or lower TPR in trait anxious individuals following a brief best possible selves exercise as compared to a group following a neutral writing exercise, during which anxiety was supposed to be associated with an increased vascular responding. Importantly, the findings confirmed expectations. The relationship between trait anxiety and CO increase from baseline to stress was positive in the best possible selves and negative in the active control group. In line with this, the relationship of trait anxiety with TPR reactivity was negative in the best possible selves and positive in the active control group. Correspondingly, trait anxiety was positively associated with subjective threat ratings in the control group only and affective responding was more positive following the best possible selves writing task in high anxious individuals as compared to the control writing task. Specifically, the decrease in PA reactivity to the stress task in high trait anxious participants could be prevented by the best possible selves exercise and they evidenced elevated PA during recovery in the best possible selves group only. Hence, this study complements previous research, which suggested that neuroticism (a more generalized concept of negative affectivity, including trait anxiety) moderated the effects of a best possible selves intervention on psychological outcomes (Ng,2016).

Importantly, the finding that a brief positive psychological exercise could change cardiovascular indicators of stress-related evaluations from threat and behavioral inhibition to a more approach-oriented, challenge type in high trait anxious individuals complements previous research suggesting that brief instructions regarding reappraisal of emotional arousal (e.g., Jamieson et al., 2012), positive performance feedback (e.g., Frings et al., 2014), mindfulness practice (Daubenmier et al., 2019), focusing on gains rather than losses (e.g., Seery et al., 2009), or even nasal oxytocin application (Kubzansky et al., 2012) could facilitate a challenge-type response profile.

Deviating from several previous studies, however, we aimed to identify trait anxiety as a possible moderator of the effectiveness of a brief positive intervention on cardiovascular indicators of challenge and threat. Of note, the findings confirm results of Jamieson et al. (2013), who found that socially anxious individuals who were instructed to reframe stress arousal as a positive coping tool evidenced a challenge-type cardiovascular stress response as compared to those receiving no instruction. Thus, in line with Turner et al. (2014) it seems that focusing on resource appraisals like self-efficacy, perceived control, and approach-oriented goals facilitates a challenge-type stress response at least in a subset of individuals (namely those scoring high on (trait) anxiety).

The findings of the present research were restricted to cardiovascular indices of challenge and threat and were not entirely supported by subjective ratings of challenge and threat. Although we failed to show that anxiety is positively associated with subjective challenge ratings in the best possible selves condition, there was a positive association between trait anxiety and subjective threat ratings in the control group, thus, supporting previous findings of a close connection between anxiety and threat sensitivity (e.g., Blascovich, 2008; Jerusalem, 1990; O'Donovan et al., 2013; Schwerdtfeger, 2006). Moreover, while both groups did not differ in subjective threat ratings, the control group exhibited higher challenge ratings than the best possible selves group. This finding seems to contradict the assumption that focusing on positive assets and life goals should facilitate challenge rather than threat evaluations. However, it should be noted that challenge may have different meaning for different individuals. Challenge might be more closely associated with stress than threat, especially among young adults. Nonetheless, at least for subjective challenge ratings there was evidence for validity as became evident by the positive correlation with CO reactivity. It should be noted though that subjective challenge and threat evaluations as defined by the biopsychosocial model were not directly assessed as representing resources and demands, respectively, but rather via single items. Consequently, our approach to assess subjective indicators of challenge and threat did not allow a more fine-grained and broad-banded assessment of task demands and resources as suggested by Blascovich (2008).

Importantly, the best possible selves exercise was particularly effective in individuals with elevated trait anxiety, but failed to benefit low anxious individuals on both the subjective and cardiovascular level. Of note, low anxious participants appeared to show the opposite response pattern than high anxious individuals, namely the expected more challenge-oriented response following the control writing task (i.e., higher CO reactivity and PA during recovery), but a relative threat-type response in the best possible selves writing task (i.e., lower CO). These findings are somehow challenging to interpret. Fritz and Lyobomirsky (2018) have extensively elaborated on how and why positive psychological activities could backfire in some individuals. They note that activity overdose, overvaluing happiness, person-activity misfit, failed mediators, and social costs of positive activities could all contribute to adverse effects of positive psychological interventions. The unexpected findings in low anxious individuals could possibly be attributed to an overdose or ceiling effect in the best possible selves group. Low anxious individuals tend to evaluate upcoming stressors as less threatening and more controllable (Endler & Kocovski, 2001) as became evident in this study by stronger CO reactivity and elevated PA during recovery in the control group. A further increase of approach motivation via the best possible selves micro-intervention could have led to an overly high allocation of resources to this exercise, thus, undermining motivational approach to the forthcoming motivated performance task. Certainly, further studies are needed to analyze when and for whom positive psychological interventions might have detrimental effects.

Importantly, manipulation checks suggested validity of the interventions. Specifically, positive, future- and achievement-related words were more prevalent in the best possible selves than in the control group. Moreover, PA increased more strongly following the best possible selves as compared to the control intervention. Some other findings warrant further discussion. First, both groups evidenced significant increases in HR from baseline to stress with a comparably large effect size, thus, suggesting that the sing-a-song task constituted a motivated performance situation as a necessary prerequisite for analyzing cardiovascular indicators of challenge and threat. Second, TPR increased consistently from baseline to preparation and stress, and further increased during recovery, thus, documenting a failure to return to baseline levels. Further research seems warranted to analyze the consequences of this failure to recover in such a young, healthy sample. Third, NA increased during recovery relative to baseline in the best possible selves group only, thus, documenting an increase in negative feeling states toward the end of the study. This finding may indicate a contrast effect following a positive psychological exercise or a kind of disillusion. As mentioned previously, there is increasing awareness about detrimental effects of positive psychological interventions (Fritz & Lyobomirsky, 2018), and given the novelty of the field and evidence for publication bias (Bolier et al., 2013; White et al., 2019), this issue definitely warrants further research.

Although findings provide preliminary support for beneficial effects of a brief best possible selves intervention in trait anxious individuals, some limitations should be mentioned. First, replication of the results utilizing larger sample sizes is certainly warranted before further implications can be drawn. Although power simulations showed a comparably high power for the analysis of CO, associations with TPR appeared rather fragile and results must be regarded preliminary. Second, a major limitation constitutes the compromised assessment of subjective indicators of challenge and threat. Although we found some evidence for the validity of the single-time challenge rating, researchers are advised to assess the subjective perceptions of task demands and intraindividual coping resources in more detail and in accordance with the suggestions derived from the biopsychosocial model (Blascovich, 2008; see also Moore et al., 2012, 2013 for examples). Third, this study was not designed to evaluate stress-related long-term effects of a best possible selves exercise. Previous research could show that the effects of positive psychological micro-interventions diminish in the long range (e.g., Elefant et al., 2017) . Thus, further research is warranted to analyze the timeline of the effects as well as the generalizability to other motivated performance tasks. Fourth, the sample comprised of rather young and healthy adults. Hence, findings cannot be generalized to older populations or clinical (anxious) individuals and potential clinical implications remain speculative. Finally, findings are restricted to subjective and particularly physiological (i.e., cardiovascular) indicators of stress and coping and behavioral consequences of the intervention were not evaluated, although important (Behnke & Kaczmarek, 2018). For example, there is evidence that vocal indicators of confidence and a more confident and dominant behavior are associated with a challenge-type stress response (e.g., Brimmell et al., 2018; Weisbuch et al., 2009). Hence, it would be worthwhile to verify if anxious participants manifest more behavioral signs of motivational approach behavior (and possibly better performance) during the stress task following the best possible selves exercise.

4.1 | Conclusion

Notwithstanding the abovementioned limitations, the results of this study may inform about the efficacy of positive psychological interventions in trait anxious individuals exposed to diverse motivated performance situations. In particular, a brief positive psychological exercise prior to a stressful encounter could shift a cardiovascular response profile in high trait anxious individuals from a threat-related pattern with elevated TPR and lower CO to a challenge-type pattern with elevated CO and attenuated TPR. Thus, findings suggest that high trait anxious individuals could engage in a more adaptive coping when elaborating on personal life goals and positive assets prior to a stressful encounter. Using the well-established biopsychosocial model of challenge and threat, this study contributes to previous research indicating that brief instructions or interventions could reliably modify subjective and cardiovascular concomitants of coping. Future studies should analyze the health-related long-term effects of such interventions and why some individuals (e.g., low trait anxious) seem to not benefit from positive interventions.

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AUTHOR CONTRIBUTIONS

Andreas Richard Schwerdtfeger: Conceptualization; Formal analysis; Investigation; Methodology; Resources; Supervision; Validation; Visualization; Writing-original draft; Writing-review & editing. **Christian Rominger:** Conceptualization; Data curation; Methodology; Project administration; Supervision; Writing-review & editing. **Bernhard Weber:** Data curation; Methodology; Project administration; Software; Visualization; Writing-review & editing. **Isabella Aluani:** Conceptualization; Data curation; Project administration; Writing-review & editing.

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REFERENCES

Bates, D., Mächler, M., Bolker, B., & Walker, S. (2015). Fitting linear mixed-effects models using lme4. *Journal of Statistical Software*, *67*(1). https://doi.org/10.18637/jss.v067.i01

Baumgartner, J. N., Schneider, T. R., Capiola, A. (2018). Investigating the relationship between optimism and stress responses: A biopsychosocial perspective. *Personality and Individual Differences*, *129*, 114–118. http://dx.doi.org/10.1016/j.paid.2018.03.021

Behnke, M., & Kaczmarek, L. D. (2018). Successful performance and cardiovascular markers of challenge and threat: A meta-analysis. *International Journal of Psychophysiology*, *130*, 73–79. https://doi.org/10.1016/j.ijpsycho.2018.04.007

Blascovich, J. (2008). Challenge and threat. In A. J. Elliot (Ed.), *Handbook of approach and avoidance motivation* (pp. 431–445). Psychology Press.

Bolier, L., Haverman, M., Westerhof, G. J., Riper, H., Smit, F., & Bohlmeijer, E. (2013). Positive psychology interventions: A meta-analysis of randomized controlled studies. *BMC Public Health*, *13*, 119. https://doi.org/10.1186/1471-2458-13-119

Bos, W. J., van Goudoever, J., van Montfrans, G. A., van den Meiracker, A. H., & Wesseling, K. H. (1996). Reconstruction of brachial artery pressure from noninvasive finger pressure measurements. *Circulation*, *94*(8), 1870–1875. https://doi.org/10.1161/01.cir.94.8.1870

Brimmell, J., Parker, J. K., Furley, P., & Moore, L. J. (2018). Nonverbal behavior accompanying challenge and threat states under pressure. *Psychology of Sport and Exercise*, *39*, 90–94. https://doi.org/10.1016/j.psychsport.2018.08.003

Brooks, A. W. (2014). Get excited: Reappraising pre-performance anxiety as excitement. *Journal of Experimental Psychology: General*, *143*, 1144–1158. https://doi.org/10.1037/a0035325

Brouwer, A.-M., & Hogervorst, M. A. (2014). A new paradigm to induce mental stress: The Sing-a-Song Stress Test (SSST). *Frontiers in Neuroscience*, *8*, 224. https://doi.org/10.3389/fnins.2014.00224

Daubenmier, J., Epel, E. S., Moran, P. J., Thompson, J., Mason, A. E., Acree, M., Goldman, V., Kristeller, J., Hecht, F. M., & Mendes, W. B. (2019). A randomized controlled trial of a mindfulness-based weight loss intervention on cardiovascular reactivity to social-evaluative threat among adults with obesity. *Mindfulness*, *10*(12), 2583–2595. https://doi.org/10.1007/s12671-019-01232-5

Dienstbier, R. A. (1989). Arousal and physiological toughness: Implications for mental and physical health. *Psychological Review*, *96*(1), 84–100. https://doi.org/10.1037/0033-295X.96.1.84

Egloff, B., Wilhelm, F. H., Neubauer, D. H., Mauss, I. B., & Gross, J. J. (2002). Implicit anxiety measure predicts cardiovascular reactivity to an evaluated speaking task. *Emotion*, *2*(1), 3–11. https://doi.org/10.1037/1528-3542.2.1.3

Elefant, A. B., Contreras, O., Muñoz, R. F., Bunge, E. L., & Leykin, Y. (2017). Microinterventions produce immediate but not lasting benefits in mood and distress. *Internet Interventions*, *10*, 17–22. https://doi.org/10.1016/j.invent.2017.08.004

Endler, N. S., & Kocovski, N. L. (2001). State and trait anxiety revisited. *Journal of Anxiety Disorders*, *15*(3), 231–245. https://doi.org/10.1016/S0887-6185(01)00060-3

Eysenck, M., Payne, S., & Santos, R. (2006). Anxiety and depression: Past, present, and future events. *Cognition & Emotion*, *20*(2), 274–294. https://doi.org/10.1080/02699930500220066

Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G*power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, *39*(2), 175–191. https://doi.org/10.3758/BF03193146

Frings, D., Rycroft, N., Allen, M. S., & Fenn, R. (2014). Watching for gains and losses: The effects of motivational challenge and threat on attention allocation during a visual search task. *Motivation and Emotion*, *38*(4), 513–522. https://doi.org/10.1007/s11031-014-9399-0

Fritz, M. M., & Lyobomirsky, S. (2018). Whither happiness? When, how, and why might positive activities undermine well-being. In J. P. Forgas & R. F. Baumeister (Eds.), *The social psychology of living well* (pp. 101–115). Psychology Press.

Gramer, M., & Saria, K. (2007). Effects of social anxiety and evaluative threat on cardiovascular responses to active performance situations. *Biological Psychology*, *74*(1), 67–74. https://doi.org/10.1016/j.biopsycho.2006.07.004

Green, P., & MacLeod, C. J. (2016). SIMR: An R package for power analysis of generalized linear mixed models by simulation. *Methods in Ecology and Evolution*, *7*(4), 493–498. https://doi.org/10.1111/2041-210X.12504

Hase, A., O'Brien, J., Moore, L. J., & Freeman, P. (2019). The relationship between challenge and threat states and performance: A systematic review. *Sport, Exercise, and Performance Psychology*, *8*(2), 123–144. https://doi.org/10.1037/spy0000132

Heekerens, J. B., Eid, M., & Heinitz, K. (2019). Dealing with conflict: Reducing goal ambivalence using the best-possible-self intervention. *The Journal of Positive Psychology*, *42*, 1–13. https://doi.org/10.1080/17439760.2019.1610479

Jamieson, J. P. (2018). Challenge and threat appraisals. In A. Elliot, C. Dweck, & D. Yeager (Eds.), *Handbook of Motivation and Cognition* (2nd ed.). Guilford Press.

Jamieson, J. P., Crum, A. J., Goyer, J. P., Marotta, M. E., & Akinola, M. (2018). Optimizing stress responses with reappraisal and mindset interventions: An integrated model. *Anxiety, Stress, and Coping*, *31*(3), 245–261. https://doi.org/10.1080/10615806.2018.1442615

Jamieson, J. P., Hangen, E. J., Lee, H. Y., & Yeager, D. S. (2017). Capitalizing on appraisal processes to improve affective responses to social stress. *Emotion Review*, *10*, 30–39. https://doi.org/10.1177/1754073917693085

Jamieson, J. P., Nock, M. K., & Mendes, W. B. (2012). Mind over matter: Reappraising arousal improves cardiovascular responses to stress. *Journal of Experimental Psychology: General*, *141*, 417–422. https://doi.org/10.1037/a0025719

Jamieson, J. P., Nock, M. K., & Mendes, W. B. (2013). Changing the conceptualization of stress in social anxiety disorder. *Clinical Psychological Science*, *1*(4), 363–374. https://doi.org/10.1177/2167702613482119

Jennings, J. R., Kamarck, T., Stewart, C., Eddy, M., & Johnson, P. R. S. (1992). Alternate cardiovascular baseline assessment techniques: Vanilla or resting baseline. *Psychophysiology*, *29*, 742–750. https://doi.org/10.1111/j.1469-8986.1992.tb02052.x

Jerusalem, M. (1990). Temporal patterns of stress appraisals for high- and low-anxious individuals. *Anxiety Research*, *3*(2), 113–129. https://doi.org/10.1080/08917779008248747

Jones, M., Meijen, C., McCarthy, P. J., & Sheffield, D. (2009). A theory of challenge and threat states in athletes. *International Review of Sport and Exercise Psychology*, *2*(2), 161–180. https://doi.org/10.1080/17509840902829331

King, L. A. (2001). The health benefits of writing about life goals. *Personality and Social Psychology Bulletin*, *27*(7), 798–807. https://doi.org/10.1177/0146167201277003

Krohne, H. W., Egloff, B., Kohlmann, C.-W., & Tausch, A. (1996). Untersuchungen mit einer deutschen Version der "Positive and Negative Affect Schedule" (PANAS) [Investigations with a German version of the Positive and Negative Affect Schedule (PANAS)]. *Diagnostica*, *42*(2), 139–156.

Kubzansky, L. D., Mendes, W. B., Appleton, A. A., Block, J., & Adler, G. K. (2012). A heartfelt response: Oxytocin effects on response to social stress in men and women. *Biological Psychology*, *90*(1), 1–9. https://doi.org/10.1016/j.biopsycho.2012.02.010

Kuznetsova, A., Brockhoff, P. B., & Christensen, R. H. B. (2017). lmerTest package: Tests in linear mixed effects models. *Journal of Statistical Software*, *82*(13). https://doi.org/10.18637/jss.v082.i13

Lamarche, V. M., Seery, M. D., Kondrak, C. L., Saltsman, T. L., & Streamer, L. (2020). Clever girl: Benevolent sexism and cardiovascular threat. *Biological Psychology*, *149*, 107781. https://doi.org/10.1016/j.biopsycho.2019.107781

Lazarus, R. S., & Folkman, S. (1984). *Stress, appraisal, and coping*. New York: Springer.

Linden, W., Earle, T. L., Gerin, W., & Christenfeld, N. (1997). Physiological stress reactivity and recovery: Conceptual siblings separated at birth? *Journal of Psychosomatic Research*, *42*, 117–135. https://doi.org/10.1016/S0022-3999(96)00240-1

Lopes, M. P., da Palma, P. J., Garcia, B. C., & Gomes, C. (2016). Training for happiness: The impacts of different positive exercises on hedonism and eudaemonia. *SpringerPlus*, *5*(1), 744. https://doi.org/10.1186/s40064-016-2407-y

Loveday, P. M., Lovell, G. P., & Jones, C. M. (2016). The Best Possible Selves intervention: A review of the literature to evaluate efficacy and guide future research. *Journal of Happiness Studies*, *74*(1), 267. https://doi.org/10.1007/s10902-016-9824-z

Luke, S. G. (2017). Evaluating significance in linear mixed-effects models in R. *Behavior Research Methods*, *49*(4), 1494–1502. https://doi.org/10.3758/s13428-016-0809-y

Meevissen, Y. M. C., Peters, M. L., & Alberts, H. J. E. M. (2011). Become more optimistic by imagining a best possible self: Effects of a two week intervention. *Journal of Behavior Therapy and Experimental Psychiatry*, *42*(3), 371–378. https://doi.org/10.1016/j.jbtep.2011.02.012

Meinlschmidt, G., Lee, J.-H., Stalujanis, E., Belardi, A., Oh, M., Jung, E. K., Kim, H.-C., Alfano, J., Yoo, S.-S., & Tegethoff, M. (2016). Smartphone-based psychotherapeutic micro-interventions to improve mood in a real-world setting. *Frontiers in Psychology*, *7*, 1112. https://doi.org/10.3389/fpsyg.2016.01112

Mogg, K., & Bradley, B. P. (2018). Anxiety and threat-related attention: Cognitive-motivational framework and treatment. *Trends in Cognitive Sciences*, *22*(3), 225–240. https://doi.org/10.1016/j.tics.2018.01.001

Moore, L. J., Freeman, P., Hase, A., Solomon-Moore, E., & Arnold, R. (2019). How consistent are challenge and threat evaluations? A generalizability analysis. *Frontiers in Psychology*, *10*, 1778. https://doi.org/10.3389/fpsyg.2019.01778

Moore, L. J., Vine, S. J., Wilson, M. R., Freeman, P. (2012). The effect of challenge and threat states on performance: An examination of potential mechanisms. *Psychophysiology*, *49*(10), 1417–1425. http://dx.doi.org/10.1111/j.1469-8986.2012.01449.x

Moore, L., Vine, S., Wilson, M., & Freeman, P. (2015). Reappraising threat: How to optimize performance under pressure. *Journal of Sport and Exercise Psychology*, *37*, 339–343. https://doi.org/10.1123/jsep.2014-0186

Moore, L. J., Wilson, M. R., Vine, S. J., Coussens, A. H., Freeman, P. (2013). Champ or Chump?: Challenge and Threat States During Pressurized Competition. *Journal of Sport and Exercise Psychology*, *35*(6), 551–562. http://dx.doi.org/10.1123/jsep.35.6.551

Ng, W. (2016). Use of positive interventions: Does neuroticism moderate the sustainability of their effects on happiness?. *The Journal of Positive Psychology*, *11*(1), 51–61. http://dx.doi.org/10.1080/17439760.2015.1025419

Obrist, P. A. (1981). *Cardiovascular psychophysiology: A perspective*, New York: Plenum Press.

O'Donovan, A., Slavich, G. M., Epel, E. S., & Neylan, T. C. (2013). Exaggerated neurobiological sensitivity to threat as a mechanism linking anxiety with increased risk for diseases of aging. *Neuroscience and Biobehavioral Reviews*, *37*(1), 96–108. https://doi.org/10.1016/j.neubiorev.2012.10.013

Oyserman, D., Destin, M., & Novin, S. (2015). The context-sensitive future self: Possible selves motivate in context, not otherwise. *Self and Identity*, *14*(2), 173–188. https://doi.org/10.1080/15298868.2014.965733

Peirce, J. W. (2007). Psychopy—Psychophysics software in Python. *Journal of Neuroscience Methods*, *162*(1–2), 8–13. https://doi.org/10.1016/j.jneumeth.2006.11.017

Peňáz, J. (1973). *Photoelectric measurement of blood pressure, volume and flow in the finger*. In Digest of the 10th International Conference on Medical and Biological Engineering, Dresden.

Peters, M. L., Flink, I. K., Boersma, K., & Linton, S. J. (2010). Manipulating optimism: Can imagining a best possible self be used to increase positive future expectancies? *The Journal of Positive Psychology*, *5*(3), 204–211. https://doi.org/10.1080/17439761003790963

Piferi, R. L., Kline, K. A., Younger, J., & Lawler, K. A. (2000). An alternative approach for achieving cardiovascular baseline: Viewing an aquatic video. *International Journal of Psychophysiology*, *37*, 207–217. https://doi.org/10.1016/S0167-8760(00)00102-1

Porter, A. M., & Goolkasian, P. (2019). Video games and stress: How stress appraisals and game content affect cardiovascular and emotion outcomes. *Frontiers in Psychology*, *10*, 967. https://doi.org/10.3389/fpsyg.2019.00967

R Core Team. (2019). *R: A language and environment for statistical computing*, Vienna, Austria: [Computer software]. : Author. http://www.R-project.org/

Renner, K.-H., Hock, M., Bergner-Köther, R., & Laux, L. (2018). Differentiating anxiety and depression: The State-Trait Anxiety-Depression Inventory. *Cognition & Emotion*, *32*(7), 1409–1423. https://doi.org/10.1080/02699931.2016.1266306

Rogers, K. M., Bonar, C. A., Estrella, J. L., & Yang, S. (2002). Inhibitory effect of glucocorticoid on coronary artery endothelial function. *American Journal of Physiology-Heart and Circulatory Physiology*, *283*(5), H1922–H1928. https://doi.org/10.1152/ajpheart.00364.2002

Sanchez-Gonzalez, M. A., Guzik, P., May, R. W., Koutnik, A. P., Hughes, R., Muniz, S., Kabbaj, M., & Fincham, F. D. (2015). Trait anxiety mimics age-related cardiovascular autonomic modulation in young adults. *Journal of Human Hypertension*, *29*(4), 274–280. https://doi.org/10.1038/jhh.2014.72

Scheepers, D. (2009). Turning social identity threat into challenge: Status stability and cardiovascular reactivity during inter-group competition. *Journal of Experimental Social Psychology*, *45*(1), 228–233. https://doi.org/10.1016/j.jesp.2008.09.011

Schneider, T. R. (2004). The role of neuroticism on psychological and physiological stress responses. *Journal of Experimental Social Psychology*, *40*(6), 795–804. https://doi.org/10.1016/j.jesp.2004.04.005

Schneider, T. R., Rench, T. A., Lyons, J. B., & Riffle, R. R. (2012). The influence of neuroticism, extraversion and openness on stress responses. *Stress and Health*, *28*(2), 102–110. https://doi.org/10.1002/smi.1409

Schutte, A. E., Huisman, H. W., van Rooyen, J. M., Malan, N. T., & Schutte, R. (2004). Validation of the Finometer device for measurement of blood pressure in black women. *Journal of Human Hypertension*, *18*(2), 79–84. https://doi.org/10.1038/sj.jhh.1001639

Schwerdtfeger, A. (2006). Trait anxiety and autonomic indicators of the processing of threatening information: A cued S1–S2 paradigm.

Biological Psychology, *72*(1), 59–66. https://doi.org/10.1016/j.biopsycho.2005.07.008

Schwerdtfeger, A., Gaisbachgrabner, K., & Traunmüller, C. (2017). Life Satisfaction and Hemodynamic Reactivity to Mental Stress. *Annals of Behavioral Medicine*, *51*(3), 464–469. https://doi.org/10.1007/s12160-016-9858-9

Seery, M. D. (2011). Challenge or threat? Cardiovascular indexes of resilience and vulnerability to potential stress in humans. *Neuroscience and Biobehavioral Reviews*, *35*(7), 1603–1610. https://doi.org/10.1016/j.neubiorev.2011.03.003

Seery, M. D. (2013). The biopsychosocial model of challenge and threat: Using the heart to measure the mind. *Social and Personality Psychology Compass*, *7*(9), 637–653. https://doi.org/10.1111/spc3.12052

Seery, M. D., Blascovich, J., Weisbuch, M., & Vick, S. B. (2004). The relationship between self-esteem level, self-esteem stability, and cardiovascular reactions to performance feedback. *Journal of Personality and Social Psychology*, *87*(1), 133–145. https://doi.org/10.1037/0022-3514.87.1.133

Seery, M. D., Weisbuch, M., & Blascovich, J. (2009). Something to gain, something to lose: The cardiovascular consequences of outcome framing. *International Journal of Psychophysiology*, *73*(3), 308–312. https://doi.org/10.1016/j.ijpsycho.2009.05.006

Sheldon, K. M., & Lyubomirsky, S. (2007). Is it possible to become happier? (And if so, how?). *Social and Personality Psychology Compass*, *1*(1), 129–145. https://doi.org/10.1111/j.1751-9004.2007.00002.x

Shimizu, M., Seery, M. D., Weisbuch, M., & Lupien, S. P. (2011). Trait social anxiety and physiological activation: Cardiovascular threat during social interaction. *Personality & Social Psychology Bulletin*, *37*(1), 94–106. https://doi.org/10.1177/0146167210391674

Sin, N. L., & Lyubomirsky, S. (2009). Enhancing well-being and alleviating depressive symptoms with positive psychology interventions: A practice-friendly meta-analysis. *Journal of Clinical Psychology*, *65*(5), 467–487. https://doi.org/10.1002/jclp.20593

Spielberger, C. D. (1983). *Manual for the state-trait anxiety inventory (form Y): ("Self-Evaluation-Questionnaire")*. Consulting Psychologists Press.

Spielberger, C. D. (1985). Anxiety, cognition and affect: A state-trait perspective. In A. H. Tuma & J. D. Maser (Eds.), *Anxiety and the anxiety disorders* (pp. 171–182). Lawrence Erlbaum Associates Inc.

Strack, J., & Esteves, F. (2015). Exams? Why worry? Interpreting anxiety as facilitative and stress appraisals. *Anxiety, Stress, and Coping*, *28*(2), 205–214. https://doi.org/10.1080/10615806.2014.931942

Streamer, L., Seery, M. D., Kondrak, C. L., Lamarche, V. M., & Saltsman, T. L. (2017). Not I, but she: The beneficial effects of self-distancing on challenge/threat cardiovascular responses. *Journal of Experimental Social Psychology*, *70*, 235–241. https://doi.org/10.1016/j.jesp.2016.11.008

Tarvainen, M. P., Niskanen, J.-P., Lipponen, J. A., Ranta-Aho, P. O., & Karjalainen, P. A. (2014). Kubios HRV – heart rate variability analysis software. *Computer Methods and Programs in Biomedicine*, *113*, 210–220. https://doi.org/10.1016/j.cmpb.2013.07.02

Tausczik, Y. R., & Pennebaker, J. W. (2010). The psychological meaning of words: LIWC and computerized text analysis methods. *Journal of Language and Social Psychology*, *29*(1), 24–54. https://doi.org/10.1177/0261927X09351676

Tomaka, J., Blascovich, J., Kelsey, R. M., & Leitten, C. L. (1993). Subjective, physiological, and behavioral effects of threat and challenge appraisal. *Journal of Personality and Social Psychology*, *65*(2), 248–260. https://doi.org/10.1037/0022-3514.65.2.248

Turner, M. J., Jones, M. V., Sheffield, D., Barker, J. B., & Coffee, P. (2014). Manipulating cardiovascular indices of challenge and threat using resource appraisals. *International Journal of Psychophysiology*, *94*(1), 9–18. https://doi.org/10.1016/j.ijpsycho.2014.07.004.

VanderKaay Tomasulo, M. M., Scanlin, M. C., & Patterson, S. M. (2017). The effects of nicotine and nicotine abstinence on stress-induced cardiovascular reactivity. *Journal of Psychophysiology*, *31*(3), 116–133. https://doi.org/10.1027/0269-8803/a000174

Walker, B. R. (2007). Glucocorticoids and cardiovascular disease. *European Journal of Endocrinology*, *157*(5), 545–559. https://doi.org/10.1530/EJE-07-0455

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology*, *54*(6), 1063–1070. https://doi.org/10.1037//0022-3514.54.6.1063

Weisbuch, M., Seery, M. D., Ambady, N., & Blascovich, J. (2009). On the correspondence between physiological and nonverbal responses: Nonverbal behavior accompanying challenge and threat. *Journal of Nonverbal Behavior*, *33*(2), 141–148. https://doi.org/10.1007/s10919-008-0064-8

Wesseling, K. H., de Wit, B., van der Hoeven, G. M. A., van Goudoever, J., & Settels, J. J. (1995). Physiocal, calibrating finger vascular physiology for finapres. *Homeostasis in Health and Disease*, *36*(2–3), 67–82.

Wesseling, K. H., Jansen, J. R., Settels, J. J., & Schreuder, J. J. (1993). Computation of aortic flow from pressure in humans using a nonlinear, three-element model. *Journal of Applied Physiology*, *74*(5), 2566–2573. https://doi.org/10.1152/jappl.1993.74.5.2566

White, C. A., Uttl, B., & Holder, M. D. (2019). Meta-analyses of positive psychology interventions: The effects are much smaller than previously reported. *PLoS One*, *14*(5), e0216588. https://doi.org/10.1371/journal.pone.0216588

Wolfe, L. A., & Cunningham, D. A. (1982). Effects of chronic exercise on cardiac output and its determinants. *Canadian Journal of Physiology and Pharmacology*, *60*(8), 1089–1097. https://doi.org/10.1139/y82-157

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