Differential Effects of Avoidant and Approach-Related Negative Personality Traits on Stress Cardiovascular Response Patterns

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Abstract

This study examined the effects of avoidant and approach negative traits on cardiovascular responses to repeated exposure to psychosocial stressors of varying intensities, post-stress cardiovascular recovery, and repeated stress cardiovascular reactivity, and investigated the role of stress cognitive appraisal therein. One hundred sixty-seven college student participants were randomly assigned to moderate- or high-intensity stress conditions, with cardiovascular response data continuously collected across four phases: baseline, initial stress exposure, recovery, and repeated stress exposure. The results revealed: (1) Regardless of stress intensity, avoidant negative traits predicted lower (blunted) cardiovascular responses during both initial and repeated stress and poorer post-stress recovery, whereas approach negative traits predicted greater cardiovascular responses and poorer post-stress recovery. (2) Perceived personal resources for repeated stress mediated the association between avoidant negative traits and repeated stress heart rate responses. Therefore, avoidant negative traits are associated with persistently lower (blunted) stress cardiovascular responses and poorer post-stress recovery, while approach negative traits are associated with greater stress cardiovascular responses and poorer post-stress recovery, indicating that both types of negative traits exhibit maladaptive rigid patterns of stress cardiovascular reactivity. This may constitute the physiological mechanism through which these two distinct negative traits increase the risk of developing cardiovascular disease.

Full Text

Preamble

Differential Effects of Avoidance and Approach Negative Personality Traits on Patterns of Stress Cardiovascular Responses

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Abstract

This study examined the distinct influences of avoidance versus approach negative traits on cardiovascular responses to repeated exposure to psychosocial stressors of varying intensity, post-stress cardiovascular recovery, and repeated stress cardiovascular responses, while exploring the role of stress cognitive appraisal in these relationships. One hundred sixty-seven undergraduate participants were randomly assigned to moderate- or high-intensity stress conditions, with cardiovascular data continuously collected across four phases: baseline, initial stress exposure, recovery, and repeated stress exposure. Results revealed: (1) Regardless of stress intensity, avoidance negative traits predicted lower (blunted) cardiovascular responses during both initial and repeated stress, along with poorer post-stress recovery, whereas approach negative traits predicted greater cardiovascular responses and poorer post-stress recovery. (2) Perceived personal resources for repeated stress mediated the relationship between avoidance negative traits and heart rate responses to repeated stress. Thus, avoidance negative traits are associated with persistently low (blunted) stress cardiovascular responses and poor recovery, while approach negative traits are associated with greater stress cardiovascular responses and poor recovery. Both types of negative traits exhibit maladaptive rigid stress cardiovascular response patterns, which may constitute distinct physiological mechanisms through which different negative traits increase cardiovascular disease risk.

Keywords: avoidance negative trait; approach negative trait; stress cardiovascular response pattern; cognitive appraisal

Introduction

The relationship between personality traits and cardiovascular health and disease has long been a focal topic in psychosomatic medicine research. Previous studies have demonstrated that negative emotionality-centered personality traits such as neuroticism, trait anxiety, trait depression, Type D personality, Type A personality, trait anger, and trait hostility are closely associated with the incidence and mortality of cardiovascular diseases including coronary heart disease and hypertension, representing high-risk personality traits for cardiovascular disease (e.g., for review, Chida & Steptoe, 2010; Huang, Yao, Huang, Guo, & Yang, 2008). Research has also explored the link between negative traits and stress cardiovascular response patterns to elucidate the physiological mechanisms through which negative traits influence cardiovascular disease development. These studies have found that neuroticism, trait anxiety, and trait depression are associated with blunted stress cardiovascular responses (e.g., Peng, Wu, Sun, Guan, & Luo, 2018), whereas trait anger and trait hostility are associated with greater stress cardiovascular responses (e.g., Brydon et al., 2010). The motivational dimensional model of emotion posits that depression and anxiety belong to motivationally avoidant negative emotions, while anger belongs to motivationally approach negative emotions (Carver & Harmon-Jones, 2009). Therefore, based on motivational direction, negative traits can be divided into two distinct types: avoidance negative traits such as trait depression and trait anxiety, and approach negative traits such as trait hostility and trait anger. Gray's behavioral motivational systems theory (Carver & White, 1994) suggests that avoidance negative traits manifest as behavioral inhibition or withdrawal, whereas approach negative traits manifest as behavioral activation or aggression. This implies that avoidance and approach negative traits may have different—or even opposite—relationships with stress cardiovascular response patterns, leading to distinct physiological mechanisms that increase cardiovascular disease risk, yet previous research has not systematically examined these issues from this perspective. The present study addresses this gap by integrating a repeated stress exposure paradigm.

Stress cardiovascular response patterns, including the magnitude of cardiovascular responses during stress onset, the degree of cardiovascular recovery after stress offset, and cardiovascular responses to repeated stress presentations, are closely linked to cardiovascular disease risk. McEwen' s (1998) allostatic load theory posits that adaptive physiological stress responses constitute a dynamic process: the organism produces moderate physiological responses when stress emerges, followed by rapid return to baseline after stress offset, thereby maintaining homeostasis. Conversely, maladaptive responses increase physiological wear and produce allostatic load, with persistent allostatic load leading to disease onset. Regarding the relationship between stress cardiovascular response magnitude and cardiovascular disease, the early cardiovascular reactivity hypothesis (Obrist, 1981) suggested that excessive stress cardiovascular responses increase risk for hypertension and coronary heart disease (for review, Hughes & Lü, 2017; Treiber et al., 2003). More recently, accumulating evidence indicates that excessively small stress cardiovascular responses (blunted responses) also predict adverse cardiovascular health outcomes (for review, Ginty, Kraynak, Fisher, & Gianaros, 2017). Research has also demonstrated that delayed post-stress cardiovascular recovery increases risk for conditions such as coronary atherosclerosis (Heponiemi et al., 2007). Furthermore, when organisms repeatedly encounter the same or similar stressors (i.e., repeated stress), reduced cardiovascular responses to repeated stress (habituation) benefit cardiovascular health, whereas cardiovascular responses equivalent to or greater than initial stress (sensitization) predict higher cardiovascular disease incidence and mortality (Eisenstein, Eisenstein, & Smith, 2001; Hughes, Lü, & Howard, 2018). Thus, excessively large or small (blunted) stress cardiovascular responses, poor post-stress recovery, and persistently large or small responses to repeated stress reflect an inability to respond dynamically to the duration of stress stimulation —manifesting as rigid or inflexible stress cardiovascular response patterns that increase cardiovascular disease risk.

Regarding the relationship between personality traits and stress cardiovascular responses, numerous previous studies have employed single stress exposure paradigms to examine stress cardiovascular response patterns in individuals with different negative traits such as neuroticism, trait depression, trait anxiety, Type D personality, trait hostility, and trait anger. Some research found that high trait anxiety individuals exhibited greater systolic blood pressure responses during social stress tasks (public speaking, Feldman, Cohen, Hamrick, & Lepore, 2004), though more studies found blunted blood pressure and heart rate responses in high trait anxiety individuals during social stress (Gramer & Sprintschnik, 2008; Peng et al., 2018; Souza et al., 2015). Studies on trait depression found that high trait depression individuals reported high subjective stress experience during public speaking tasks yet exhibited blunted stress cardiovascular responses (Puig-Perez, Villada, Pulopulos, Hidalgo, & Salvador, 2016; Rooij, Schene, Philips, & Roseboom, 2010) and poor heart rate recovery post-stress (Gordon, Ditton, & Antono, 2012). Research on Type D personality, characterized by negative affectivity and social inhibition, found blunted heart rate responses during speech tasks (Kupper, Denollet, Widdershoven, & Kop, 2013), though other studies found greater stress cardiovascular responses in Type D individuals under social evaluation conditions (Bibbey, Carroll, Ginty, & Phillips, 2015). A meta-analysis on neuroticism and stress cardiovascular responses indicated that high neuroticism is associated with blunted stress cardiovascular responses (Chida & Hamer, 2008), with subsequent empirical studies consistently finding blunted heart rate responses during public speaking tasks in high neuroticism individuals (Bibbey, Carroll, Roseboom, Phillips, & Rooij, 2013) and delayed blood pressure recovery after interpersonal conflict (Hutchinson & Ruiz, 2011). Additionally, early research on Type A personality found that Type A individuals exhibited greater heart rate responses during psychological stress (tone memory task, Juszczak & Andreassi, 1987), and greater systolic and diastolic blood pressure responses (mirror tracing task, Contrada, 1989; mental arithmetic interference task, Sundin, Ohman, Palm, & Ström, 1995). Studies also found that high trait aggression individuals with anger tendencies exhibited greater blood pressure responses during speech tasks (Betensky & Contrada, 2010). Research on trait hostility showed that high trait hostility individuals exhibited greater mean arterial pressure, systolic, and diastolic blood pressure responses during social stress (public speaking task, Brydon et al., 2010; interpersonal conflict task, Davis, Matthews, & Mcgranth, 2000) and delayed systolic blood pressure recovery post-stress (Brydon et al., 2010), though some studies showed smaller diastolic blood pressure responses during social conflict tasks in high trait hostility individuals (Hernandez, Larkin, & Whited, 2009).

These studies indicate that individuals with negative traits such as high trait anxiety, trait depression, Type D personality, and high neuroticism tend to exhibit blunted cardiovascular responses during psychosocial stress, accompanied by poor post-stress cardiovascular recovery, whereas individuals with high trait hostility, trait anger, and Type A personality tend to exhibit greater stress cardiovascular responses with poor recovery. However, previous research has not systematically examined the effects of avoidance versus approach negative personality traits on stress cardiovascular response patterns from a motivational classification perspective. Since trait anxiety, trait depression, Type D personality, and neuroticism belong to motivationally avoidant negative traits, while trait hostility, trait anger, and Type A personality belong to motivationally approach negative traits, we can infer that avoidance negative traits may be associated with blunted stress cardiovascular responses and poor recovery, whereas approach negative traits may be associated with greater stress cardiovascular responses and poor recovery—potentially constituting different physiological mechanisms through which these two types of negative traits increase cardiovascular disease risk. Therefore, this study uses trait anxiety and trait depression as indicators of avoidance negative traits, and trait hostility and trait anger as indicators of approach negative traits, to further explore the differential effects of avoidance versus approach negative personality traits on stress cardiovascular responses and recovery.

Notably, previous studies have only examined the effects of different negative personality traits on stress cardiovascular responses and post-stress recovery during single stress exposure. No research has investigated how these two types of negative traits differentially affect cardiovascular responses to repeated stress exposure in a dynamic process. Moreover, most previous laboratory studies created low- or moderate-intensity stress contexts. As stress intensity increases, greater cardiovascular responses benefit the organism in coping with more demanding situations, yet responding to high-demand stress contexts with rigid (persistently large or small) cardiovascular responses is also maladaptive, increasing allostatic load and cardiovascular disease risk. Recent evidence shows that individuals with low cardiovascular disease risk personality traits (high extraversion) can exhibit flexible cardiovascular response patterns according to stress intensity demands, producing moderate responses to moderate stress and increasing responses with higher stress intensity, while maintaining rapid cardiovascular recovery after stress regardless of intensity (Lü, Xing, Hughes, & Wang, 2018). Whether the differential effects of avoidance versus approach negative traits on repeated stress cardiovascular response patterns are moderated by stress intensity has not been addressed in previous research.

Additionally, Lazarus and Folkman’ s (1984) cognitive appraisal theory posits that physiological stress responses depend on individuals’ cognitive evaluation of their relationship with the stress environment, including primary and secondary appraisals. Similarly, the biopsychosocial model of challenge and threat (BPS; Blascovich, 2008) suggests that whether individuals perceive a situation as challenging or threatening depends on their perception of personal resources and situational demands. When perceived personal resources exceed situational demands, individuals appraise the situation as challenging; when perceived demands exceed resources, they appraise it as threatening (Blascovich, 2008). Whether these two types of negative traits influence stress cardiovascular responses through stress cognitive appraisals has not been examined. Therefore, this study also investigates whether avoidance and approach negative traits affect stress cardiovascular responses through the mediating variable of stress cognitive appraisal (situational demands, personal resources, threat index).

In summary, this study employs a mock interview task to induce psychosocial stress using a 2×4 mixed design, with stress intensity (moderate vs. high) as a between-subjects factor and experimental phase (baseline, initial stress, recovery, repeated stress) as a within-subjects factor, using heart rate, systolic blood pressure, and diastolic blood pressure as cardiovascular response indices (e.g., Bibbey et al., 2013; Hughes, Howard, James, & Higgins, 2011; Lü et al., 2018). The study examines the relationships between avoidance negative traits (indexed by the common factor of trait anxiety and trait depression), approach negative traits (indexed by the common factor of trait anger and trait hostility), and cardiovascular responses, recovery, and repeated stress cardiovascular responses under different stress intensity conditions, while preliminarily exploring the role of stress cognitive appraisals. Based on literature review, we propose the following hypotheses: (1) Regardless of stress intensity, avoidance negative traits will be associated with blunted cardiovascular responses, delayed post-stress cardiovascular recovery, and blunted cardiovascular responses to repeated stress. (2) Regardless of stress intensity, approach negative traits will be associated with greater cardiovascular responses, poor post-stress cardiovascular recovery, and greater cardiovascular responses to repeated stress. (3) Components of stress cognitive appraisal (situational demands, personal resources, threat index) will mediate the relationships between avoidance/approach negative traits and cardiovascular responses to initial or repeated stress.

2.1 Participants

Prior to data collection, a priori power analysis using G*Power was conducted for hierarchical regression analyses (main effects, two-way interactions) and mediation analyses. To achieve a medium effect size ($f^2 = 0.15$) with statistical power of 0.80, the minimum required sample size was 77 participants. During actual data collection, we aimed to collect as much data as possible to test our effects. We recruited 109 undergraduate students from universities in Xi' an, including 58 males, aged 17–25 years (mean age = 19.23 ± 1.13 years; mean body mass index = 21.02 ± 2.68 kg/m²). All participants were physically healthy with normal baseline blood pressure, no history of cardiovascular disease, and no smoking or alcohol abuse behaviors within the past six months. All participants provided informed consent before the formal experiment and received monetary compensation upon completion.

2.2 Stress Intensity Manipulation

Different intensities of psychosocial stress were induced using a standardized mock interview task (Lü et al., 2018). (1) **Moderate-intensity psychosocial stress**: Two interviewers entered the laboratory and informed participants, "You will now participate in an interview for a middle school head teacher position. You have 30 seconds to prepare, followed by 5 minutes to present your qualifications for this job. The clarity and fluency of your verbal expression will be evaluated face-to-face by the two interviewers, and the entire interview process will be video-recorded." After 30 seconds of preparation, participants delivered their 5-minute presentation. If pauses exceeded 10 seconds, interviewers prompted them to continue. If participants had difficulty continuing, one interviewer asked standardized questions (e.g., "Do you have previous experience in this type of work?" , "What are your plans if you obtain this position?"). The repeated stress exposure task followed the same procedure as the initial stress exposure, but the presentation topic was "applying for an office secretary position." (2) **High-intensity psychosocial stress**: Two interviewers entered the laboratory and informed participants, "You will now participate in an interview for a middle school head teacher position. You have 30 seconds to prepare, followed by 5 minutes to present your qualifications for this job. The clarity and fluency of your verbal expression will be evaluated face-to-face by the two interviewers, and your interview performance will be video-recorded for evaluation by three additional professionals. All five professionals will score your interview performance, and these scores will be recorded." After 30 seconds of preparation, participants delivered their 5-minute presentation. At 2 minutes, one interviewer provided first negative feedback: "Your interview performance is lagging behind other participants; you need to try harder." At 3 minutes, interviewers provided second negative feedback: "Your interview performance is still lagging behind other participants; please do your best in the remaining 2 minutes." If pauses exceeded 10 seconds, interviewers prompted them to continue. If participants had difficulty continuing, interviewers asked 1–2 standardized questions. The repeated stress exposure task followed the same procedure as the initial stress exposure, but the presentation topic was "applying for an office secretary position."

2.3 Experimental Procedure

The formal experiment was conducted during fixed time periods (2:30–5:30 PM). Participants were informed by telephone the night before the experiment to rest well, avoid vigorous exercise on the experimental day, and refrain from taking any medications or stimulant beverages (e.g., coffee, Red Bull). Before the experiment, all participants reported compliance with these requirements. Upon arrival at the laboratory, participants first rested quietly for 20 minutes to adapt to the environment and completed personality scales. The experimenter then attached physiological data collection equipment (SOMNOtouch™ RESP) and brought participants into the stress laboratory to begin the formal experiment (experimental flow and data collection timeline shown in Figure 1 [Figure 1: see original paper]).

Baseline phase (5 minutes): Participants were instructed to sit quietly on a sofa, maintain steady breathing, and view a neutral picture (a book, selected from the International Affective Picture System, IAPS; Lang, Bradley, & Cuthbert, 2005) presented on a computer screen directly in front of them. After the rest period, instructions prompted participants to rate their current emotional valence and arousal.

Initial stress exposure phase (5 minutes): Following the baseline phase, participants were randomly assigned to either moderate- or high-intensity psychosocial stress conditions to complete the corresponding task (see Section 2.2 for stress intensity manipulation details). After the stress task, instructions prompted participants to provide immediate cognitive appraisals and subjective emotional experience reports about the completed task.

Recovery phase (5 minutes): Instructions prompted participants to sit quietly on a sofa, maintain steady breathing, and view a neutral picture (a cup, IAPS; Lang et al., 2005) presented on a computer screen directly in front of them. After the rest period, instructions prompted participants to rate their current emotional valence and arousal.

Repeated stress exposure phase (5 minutes): The moderate- or high-intensity repeated psychosocial stress task followed the same procedure as the initial stress exposure, but the presentation topic was "applying for an office secretary position" (to avoid order effects, presentation topics for the two stress exposures were counterbalanced across participants). After the stress task, instructions prompted participants to provide immediate cognitive appraisals and subjective emotional experience reports about the completed task.

2.4.1 Personality Trait Scales[3]

Trait Anxiety Scale: The Chinese revised version of the Spielberger Trait Anxiety Inventory (Wang, Wang, & Ma, 1999) was used. The scale contains 20 items, with 11 describing negative emotions and 9 describing positive emotions. Items are rated on a 4-point scale (1 = "almost never" to 4 = "almost always"), with positive emotion items reverse-scored. Scale scores range from 20 to 80, with higher scores indicating higher anxiety levels. The scale has demonstrated good reliability and validity in Chinese samples (Jin, Guo, & Zheng, 2015). In this study, the internal consistency coefficient was 0.89.

Trait Depression Scale: The Chinese version of the Spielberger Trait Depression Scale (Lei, Xu, Deng, & Luo, 2011) was used. The scale contains 16 items rated on a 4-point scale (1 = "almost never" to 4 = "almost always"), with scores ranging from 16 to 64. Higher scores indicate stronger trait depression. The scale has demonstrated good reliability and validity in Chinese samples (Lei et al., 2011). In this study, the internal consistency coefficient was 0.91.

Trait Anger Scale: The Spielberger Trait Anger Scale (Luo, Zhang, Liu, & Liu, 2011) was used. The scale contains 10 items rated on a 4-point scale (1 = "almost never" to 4 = "almost always"), with total scores ranging from 10 to 40. Individuals with higher trait anger scores experience anger more frequently and intensely. The scale has demonstrated good reliability and validity in Chinese samples (Luo et al., 2011). In this study, the internal consistency coefficient was

0.85.

Trait Hostility Scale: The Cook & Medley Hostility Scale (CMHS; Cook & Medley, 1954) was used. The scale consists of 50 items with "yes/no" response options, with total scores ranging from 0 to 50. Higher scores indicate higher hostility levels. The internal consistency coefficient in Chinese samples is 0.78 (Gu et al., 2000). In this study, the internal consistency coefficient was 0.81.

2.4.2 Subjective Stress Reports

Emotional experience subjective reports: After each experimental phase, participants rated their emotional valence (1 = extremely unpleasant, 9 = extremely pleasant) and arousal (1 = extremely calm, 9 = extremely tense) on 9-point scales (Lü et al., 2018).

Stress cognitive appraisal: Immediately after each stress task, participants appraised the speech task they had just completed, including perceived situational demands (primary appraisal) and perceived personal resources (secondary appraisal). Primary appraisal contained 6 items (e.g., "The speech task just completed was very demanding"). Secondary appraisal contained 5 items (e.g., "I am very good at completing this type of task [speech]"). Participants rated each item on a 7-point scale (1 = strongly disagree, 7 = strongly agree), and mean scores were calculated for primary and secondary appraisals. Threat index was calculated as situational demands divided by personal resources, with larger ratios indicating higher perceived threat (Mendes, Blascovich, Major, & Seery, 2001).

2.5 Cardiovascular Data Collection

Throughout the experiment, physiological data were continuously recorded using a portable physiological recorder (SOMNOtouch™ RESP, SOMNOmedics, Germany). Offline data processing was conducted using DOMINO light software version 1.4.0, with artifacts removed and average physiological values calculated for each research phase (baseline, initial stress exposure, recovery, repeated stress exposure) for each participant. Electrocardiogram (ECG) data were collected via a single-channel ECG sensor, with three silver-silver chloride (Ag-AgCl) electrodes placed on participants' left and right supraclavicular areas and left lower rib area, at a sampling frequency of 1024 Hz. Heart rate (HR) data were derived from ECG R-R intervals. Continuous non-invasive beat-to-beat blood pressure data were monitored by synchronously recording ECG and finger photoplethysmography (using a pulse oximeter sensor on participants' non-dominant finger). Blood pressure values were calculated using pulse transit time, a validated indirect blood pressure measurement method that meets the European Society of Hypertension International Protocol revision 2010 standards (Bilo et al., 2015). This method is widely used in experimental and clinical research (Gesche, Grosskurth, Küchler, & Patzak, 2012; Qin, Lü, Hughes, & Kaczmarek, 2019). Systolic and diastolic blood pressure values were calculated for each minute throughout the experiment, then averaged across minutes within each research phase to obtain phase-specific means.

2.6 Data Processing and Statistical Analysis

This study used change scores to analyze stress cardiovascular responses and recovery (Deltas; Llabre, Spitzer, Saab, Ironson, & Schneiderman, 1991). Specifically: cardiovascular reactivity = mean cardiovascular value during stress phase -mean cardiovascular value during baseline; cardiovascular recovery = mean cardiovascular value during recovery phase -mean cardiovascular value during baseline; cardiovascular response adaptation = cardiovascular reactivity during initial stress -cardiovascular reactivity during repeated stress. Larger change scores indicate greater cardiovascular responses during stress; larger recovery change scores indicate poorer post-stress cardiovascular recovery. Positive adaptation scores indicate reduced responses to repeated stress compared to initial stress (i.e., habituation), with larger positive values indicating better adaptation. Zero or negative adaptation scores indicate no significant change or increased responses to repeated stress compared to initial stress (i.e., sensitization) (Lü, Wang, & Hughes, 2016).

(1) **Confirmatory factor analysis**: AMOS 21.0 was used for second-order confirmatory factor analysis with maximum likelihood estimation to test model fit (Hu & Bentler, 1999) and verify the theoretical hypothesis of a two-dimensional structure of negative traits. With satisfactory model fit, common factor scores from trait anxiety and trait depression were used as the avoidance negative trait index, and common factor scores from trait anger and trait hostility were used as the approach negative trait index for subsequent correlation and hierarchical regression analyses.

(2) **Manipulation checks**: One-way repeated measures ANOVA was used to test the effectiveness of initial and repeated stress manipulations, examining whether subjective emotional experience and cardiovascular indices showed quadratic or cubic trends across research phases (baseline, initial stress exposure, recovery, repeated stress exposure). Bonferroni post-hoc comparisons analyzed whether initial and repeated stress exposures significantly elicited psychophysiological responses relative to baseline. Independent samples t-tests tested stress intensity manipulation effectiveness by comparing whether high-intensity psychosocial stress elicited greater psychophysiological responses than moderate-intensity stress.

(3) **Correlation analysis**: Stress intensity (dummy-coded: 0 = moderate, 1 = high) was treated as a continuous variable. Pearson correlations examined relationships among stress intensity, trait anxiety, trait depression, trait anger, trait hostility, avoidance negative trait, approach negative trait, baseline cardiovascular values, stress cardiovascular reactivity (change scores), post-stress cardiovascular recovery (change scores), and adaptation between the two stress exposures (change scores).

(4) **Hierarchical regression analysis**: Predictor variables were centered. Hierarchical regression analyses examined: (a) predictions of stress cardiovascular reactivity and adaptation by stress intensity and avoidance negative trait (main effects in Step 1, interaction effects in Step 2). Additionally, with stress cardiovascular reactivity entered as a control variable in Step 1 (to exclude potential effects of reactivity magnitude on recovery), main effects of stress intensity and avoidance negative trait entered in Step 2, and their interaction entered in Step 3, to further examine predictions of post-stress cardiovascular recovery. (b) Predictions of stress cardiovascular reactivity, recovery, and adaptation by stress intensity and approach negative trait (same steps).

(5) **Mediation analysis**: PROCESS SPSS Macro (Preacher & Hayes, 2008) was used to preliminarily examine whether stress cognitive appraisals mediated associations between avoidance/approach negative traits and stress cardiovascular responses. Bootstrapped resampling was set to 10,000 iterations. Significant indirect effects were determined by bootstrapped 95% confidence intervals; mediation was significant when the confidence interval did not contain zero. All path coefficients are reported as unstandardized ordinary least squares (OLS) regression coefficients (Jiang & Li, 2015).

All statistical tests were two-tailed with significance level set at 0.05. Effect sizes for small, medium, and large effects were: t-test Cohen' s d = 0.2/0.5/0.8; ANOVA partial ^{2} = 0.04/0.25/0.64; hierarchical multiple regression f^2 = 0.02/0.15/0.35.

3.1 Confirmatory Factor Analysis of the Two-Dimensional Structure of Negative Personality Traits

Based on the theoretical hypothesis of a two-dimensional structure of negative personality traits, AMOS 21.0 was used for second-order confirmatory factor analysis. Trait anxiety, trait depression, trait anger, and trait hostility served as four first-order factors with their respective items as observed variables, while avoidance negative trait (comprising trait anxiety and trait depression) and approach negative trait (comprising trait anger and trait hostility) served as two second-order factors. The second-order factor model showed adequate fit: ^{2}(4379, N = 167) = 7664.28 ($p < 0.001$), ^{2}/df = 1.75, GFI = 0.93, NFI = 0.92, NNFI = 0.93, RMSEA = 0.067 (90% CI = 0.065–0.070), CFI = 0.96. Therefore, trait anxiety and trait depression can be extracted as avoidance negative trait, and trait anger and trait hostility can be extracted as approach negative trait, supporting the theoretical hypothesis of a two-dimensional structure of negative personality traits.

Descriptive statistics for subjective experiences (valence, arousal) and cardiovascular indices (heart rate, systolic blood pressure, diastolic blood pressure) across the four research phases (baseline, initial stress exposure, recovery, repeated stress exposure) under different stress intensities (moderate, high) are presented in Table 1 .

One-way repeated measures ANOVA indicated that in the moderate-intensity psychosocial stress condition, significant main effects of experimental phase were found for heart rate, systolic blood pressure, diastolic blood pressure, and emotional arousal, all showing a cubic trend of increase-decrease-increase (see Figure 2 [Figure 2: see original paper]): $F(1,80) = 221.35$, $p < 0.001$, partial $^2 = 0.74$; $F(1,79) = 243.48$, $p < 0.001$, partial $^2 = 0.76$; $F(1,81) = 207.22$, $p < 0.001$, partial $^2 = 0.66$; $F(1,81) = 136.12$, $p < 0.001$, partial $^2 = 0.63$. Emotional valence showed a decrease-increase-decrease trend (see Figure 2): $F(1,82) = 12.96$, $p = 0.001$, partial $^2 = 0.14$. Bonferroni post-hoc comparisons indicated that emotional arousal, heart rate, systolic blood pressure, and diastolic blood pressure during both initial and repeated stress were significantly higher than corresponding baseline values, while emotional valence was significantly lower ($ps < 0.001$). Similarly, in the high-intensity psychosocial stress condition, significant main effects of experimental phase were found for heart rate, systolic blood pressure, diastolic blood pressure, emotional arousal, and valence, all showing cubic trends (see Figure 2): $F(1,81) = 253.51$, $p < 0.001$, partial $^2 = 0.76$; $F(1,81) = 257.11$, $p < 0.001$, partial $^2 = 0.76$; $F(1,82) = 318.37$, $p < 0.001$, partial $^2 = 0.80$; $F(1,81) = 261.09$, $p < 0.001$, partial $^2 = 0.76$; $F(1,77) = 216.50$, $p < 0.001$, partial $^2 = 0.74$; $F(1,80) = 48.23$, $p < 0.001$, partial $^2 = 0.38$. Bonferroni post-hoc comparisons indicated that heart rate, systolic blood pressure, diastolic blood pressure, and emotional arousal during both initial and repeated stress were significantly higher than corresponding baseline values, while emotional valence was significantly lower ($ps < 0.001$).

Independent samples t-tests indicated that during both initial and repeated stress exposures, high-intensity psychosocial stress elicited greater heart rate responses than moderate-intensity stress: $t(164) = 3.44$, $p = 0.001$, $d = 0.54$; $t(162) = 4.17$, $p < 0.001$, $d = 0.66$. Similarly, greater systolic blood pressure responses: $t(163) = 2.09$, $p = 0.039$, $d = 0.33$; $t(161) = 3.62$, $p < 0.001$, $d = 0.57$; greater diastolic blood pressure responses: $t(163) = 2.57$, $p = 0.011$, $d = 0.40$; $t(164) = 2.23$, $p = 0.027$, $d = 0.35$; greater emotional arousal responses: $t(162) = 1.92$, $p = 0.057$, $d = 0.30$; $t(163) = 2.62$, $p = 0.010$, $d = 0.41$; and lower emotional valence: $t(163) = 2.93$, $p = 0.004$, $d = 0.46$; $t(164) = 2.63$, $p = 0.009$, $d = 0.41$. Regarding stress cognitive appraisals, participants in the high-intensity condition perceived higher task demands than those in the moderate-intensity condition during both initial and repeated stress: $t(165) = 2.73$, $p = 0.007$, $d = 0.43$; $t(165) = 2.13$, $p = 0.035$, $d = 0.33$; fewer personal resources: $t(165) = 2.31$, $p = 0.022$, $d = 0.36$; $t(165) = 1.98$, $p = 0.049$, $d = 0.31$; and higher threat: $t(165) = 3.05$, $p = 0.003$, $d = 0.48$; $t(165) = 2.55$, $p = 0.012$, $d = 0.40$.

These results demonstrate that regardless of stress intensity, both initial and repeated stress tasks significantly elicited psychophysiological responses, with high-intensity stress producing significantly greater responses than moderate-intensity stress, confirming the effectiveness of both stress exposures and stress intensity manipulation.

3.2 Correlation Analysis

Correlations among stress intensity, trait anxiety, trait depression, trait anger, trait hostility, avoidance negative trait, approach negative trait, baseline cardiovascular indices, stress cardiovascular reactivity, recovery, and adaptation between the two stress exposures are presented in Table 2 . Core correlation results for all study variables are also presented as scatterplots in Figure 3 [Figure 3: see original paper].

As shown in Table 2, trait anxiety, trait depression, trait anger, trait hostility, avoidance negative trait, and approach negative trait were not significantly correlated with baseline cardiovascular indices ($ps > 0.05$). Stress intensity was significantly positively correlated with initial and repeated stress cardiovascular (heart rate, blood pressure) responses, indicating that physiological responses increased with stress intensity. Trait anxiety, trait depression, and avoidance negative trait were negatively correlated with stress cardiovascular responses, whereas trait anger, trait hostility, and approach negative trait were positively correlated with stress cardiovascular responses and post-stress cardiovascular recovery.

3.3 Hierarchical Regression Analysis

Correlation analyses revealed overall relationships between personality variables and cardiovascular indices without distinguishing stress intensity. Building on these correlations, hierarchical regression analyses further examined predictions of stress cardiovascular reactivity, recovery, and adaptation by stress intensity (dummy-coded) and avoidance/approach negative traits.

As shown in Table 3 , avoidance negative trait significantly negatively predicted initial stress heart rate reactivity ($= -0.21$, $t = -2.81$, $p = 0.006$), systolic blood pressure reactivity ($= -0.24$, $t = -3.14$, $p = 0.002$), diastolic blood pressure reactivity ($= -0.32$, $t = -4.36$, $p < 0.001$), and repeated stress diastolic blood pressure reactivity ($= -0.30$, $t = -4.02$, $p < 0.001$). Stress intensity and avoidance negative trait interactively predicted repeated stress heart rate reactivity ($= -0.18$, $t = -2.45$, $p = 0.015$); other interactive predictions were not significant. Avoidance negative trait did not significantly predict adaptation between the two stress exposures. As shown in Table 4 , after controlling for stress reactivity, avoidance negative trait significantly positively predicted post-stress heart rate recovery ($= 0.17$, $t = 2.23$, $p = 0.027$). The interaction between stress intensity and avoidance negative trait was not significant. These results indicate that regardless of stress intensity, avoidance negative trait is associated with blunted stress cardiovascular reactivity, poor post-stress cardiovascular recovery, and blunted cardiovascular responses to repeated stress.

As shown in Table 5 , approach negative trait significantly positively predicted initial stress heart rate reactivity (= 0.31, t = 4.20, $p < 0.001$), systolic blood pressure reactivity (= 0.21, t = 2.73, p = 0.007), repeated stress heart rate reactivity (= 0.25, t = 3.39, p = 0.001), and repeated stress systolic blood pressure reactivity (= 0.20, t = 2.67, p = 0.008). The interaction between stress intensity and approach negative trait was not significant. Approach negative trait did not significantly predict adaptation between the two stress exposures. As shown in Table 6 , after controlling for stress reactivity, approach negative trait significantly positively predicted post-stress heart rate recovery (= 0.25, t = 3.24, p = 0.001) and diastolic blood pressure recovery (= 0.16, t = 2.31, p = 0.022). The interaction between stress intensity and approach negative trait was not significant. These results indicate that regardless of stress intensity, approach negative trait is associated with greater stress cardiovascular reactivity, poor post-stress cardiovascular recovery, and greater cardiovascular responses to repeated stress.

3.4 Mediation Analysis of Cognitive Appraisal

Correlation analyses between avoidance/approach negative traits and stress emotional experience and cognitive appraisals showed that avoidance negative trait was positively correlated with emotional valence reactivity during initial and repeated stress (r = 0.23, p = 0.003; r = 0.18, p = 0.024); positively correlated with perceived task demands during initial and repeated stress (r = 0.24, p = 0.002; r = 0.25, p = 0.001); negatively correlated with perceived personal resources during initial and repeated stress (r = -0.19, p = 0.013; r = -0.17, p = 0.027); and positively correlated with perceived threat during initial and repeated stress (r = 0.23, p = 0.003; r = 0.20, p = 0.009). Approach negative trait was not significantly correlated with stress emotional experience or cognitive appraisals. Additionally, perceived personal resources for repeated stress were significantly positively correlated with repeated stress heart rate reactivity (r = 0.24, p = 0.002) and diastolic blood pressure reactivity (r = 0.16, p = 0.044). Further mediation analysis (see Figure 4 [Figure 4: see original paper]) showed that the direct effect of avoidance negative trait on repeated stress heart rate reactivity was significant (effect = -1.64, SE = 0.78, t = -2.09, p = 0.038, 95% CI [-3.19, -0.09]), and the indirect effect of avoidance negative trait on repeated stress heart rate reactivity through perceived personal resources for repeated stress was also significant (effect = -0.38, SE = 0.22, 95% CI [-0.95, -0.03]), indicating that perceived personal resources for repeated stress mediated the relationship between avoidance negative trait and repeated stress heart rate reactivity, with the indirect effect explaining 18.66% of the total effect.

4 Discussion

This study examined healthy undergraduate participants using a repeated stress exposure paradigm to investigate the effects of avoidance versus approach negative traits on cardiovascular (heart rate, systolic blood pressure, diastolic blood pressure) responses and recovery during initial and repeated moderate- and high-intensity psychosocial stress exposures. Results showed that regardless of stress intensity, avoidance negative trait consistently predicted blunted stress heart rate, systolic blood pressure, and diastolic blood pressure reactivity, whereas approach negative trait consistently predicted greater stress heart rate and systolic blood pressure reactivity. After stress offset, avoidance negative trait predicted poor heart rate recovery, while approach negative trait predicted poor heart rate and diastolic blood pressure recovery. During repeated stress exposure, avoidance negative trait continued to predict blunted diastolic blood pressure reactivity, while approach negative trait continued to predict greater heart rate and systolic blood pressure reactivity.

These findings indicate that avoidance negative traits are associated with blunted stress cardiovascular reactivity and poor post-stress recovery, supporting numerous previous studies on depression and anxiety traits. Previous research has found that trait anxiety is associated with blunted blood pressure and heart rate responses during psychosocial stress (mock interview, speech tasks; Gramer & Sprintschnik, 2008; Peng et al., 2018; Souza et al., 2015), and trait depression is associated with blunted psychosocial stress cardiovascular responses (Puig-Perez et al., 2016; Rooij et al., 2010) and poor heart rate recovery post-stress (Gordon et al., 2012). However, these studies were conducted under single stress exposure conditions. The present study extends these findings by demonstrating that avoidance negative traits remain associated with blunted stress cardiovascular reactivity during repeated stress exposure. Moreover, this study reveals that the association between avoidance negative traits and blunted cardiovascular reactivity to both initial and repeated stress, as well as poor post-stress recovery, is not moderated by stress intensity. That is, avoidance negative traits such as trait anxiety and trait depression are associated with persistently blunted cardiovascular responses and poor post-stress recovery across different intensities of repeated psychosocial stress. Research suggests that motivational dysregulation, such as motivational deficits in coping with stress events or attenuated conscious psychological engagement, may lead to physiological disengagement during stress, resulting in blunted stress cardiovascular responses (Carroll, Ginty, Whittaker, Lovallo, & Rooij, 2017). Motivational deficits and avoidance/behavioral withdrawal tendencies are core features of avoidance negative traits. Thus, the association between avoidance negative traits and persistently blunted cardiovascular responses across different intensities of repeated psychosocial stress may result from insufficient motivational system engagement. Persistently blunted cardiovascular responses may trigger compensatory increases in other physiological systems, leading to allostatic load and increased cardiovascular disease risk (McEwen, 1998; McEwen & Gianaros, 2011).

This study also found that approach negative traits are associated with greater stress cardiovascular reactivity and poor post-stress recovery, consistent with previous research on anger and hostility traits. Studies have found that high trait aggression individuals with anger tendencies exhibit greater blood pressure responses during psychosocial stress (speech tasks; Betensky & Contrada, 2010). High trait hostility individuals also show greater mean arterial pressure, systolic, and diastolic blood pressure responses during psychosocial stress (speech, interpersonal conflict tasks; Brydon et al., 2010; Davis et al., 2000) and delayed systolic blood pressure recovery post-stress (Brydon et al., 2010). Building on these studies, the present research further demonstrates that approach negative traits are also associated with greater cardiovascular responses to repeated psychosocial stress. Moreover, the association between approach negative traits and greater cardiovascular responses to both initial and repeated stress, as well as poor post-stress recovery, is not moderated by stress intensity. That is, approach negative traits such as trait hostility and trait anger are associated with persistently greater cardiovascular responses and poor post-stress recovery across different intensities of repeated psychosocial stress. Research indicates that approach-motivated negative emotions (e.g., anger) involve a state of action readiness (Carver & Harmon-Jones, 2009) accompanied by autonomic activation (Qin et al., 2019). Thus, the association between approach negative traits and persistently greater stress cardiovascular reactivity may relate to this action readiness and accompanying sustained cardiovascular activation. This persistently greater cardiovascular reactivity in approach negative traits is particularly evident in heart rate and systolic blood pressure. Sustained elevated heart rate reduces vascular compliance and accelerates coronary atherosclerosis progression (Custodis et al., 2010), while sustained elevated blood pressure, particularly systolic blood pressure, is an independent risk factor for coronary artery disease, hypertension, myocardial infarction, and mortality (Kannel, 2000; Rodriguez et al., 2014).

In summary, these results demonstrate that across both moderate- and high-intensity and initial and repeated psychosocial stress contexts, avoidance negative traits such as trait depression and trait anxiety are associated with blunted stress cardiovascular reactivity and delayed post-stress recovery, whereas approach negative traits such as trait hostility and trait anger are associated with greater stress cardiovascular reactivity and delayed post-stress recovery. As discussed, excessively large or small (blunted) stress cardiovascular responses, poor post-stress recovery, and persistently large or small responses to repeated stress reflect an inability to respond dynamically to the duration and intensity of stress stimulation—manifesting as rigid stress cardiovascular response patterns. Therefore, both avoidance negative traits (trait depression, trait anxiety) and approach negative traits (trait hostility, trait anger) are associated with rigid stress cardiovascular response patterns. Such rigid patterns that fail to change with stress intensity or novelty (i.e., initial vs. repeated stress exposure)—whether persistently blunted or persistently large—represent maladaptive stress cardiovascular response patterns that increase allostatic load and cardiovascular disease risk (Heponiemi, 2007; Hughes et al., 2018; McEwen, 1998; McEwen & Gianaros, 2011).

Furthermore, this study preliminarily examined the mediating role of subjective cognitive appraisals in the associations between avoidance/approach negative traits and cardiovascular responses to repeated psychosocial stress of different intensities. We found that perceived personal resources for repeated stress mediated the relationship between avoidance negative trait and heart rate reactivity to repeated stress. Specifically, higher levels of avoidance negative trait were associated with perceptions of fewer personal resources for coping with stress, thereby reducing physiological mobilization and resulting in blunted stress cardiovascular reactivity. These findings provide empirical support for Lazarus and Folkman' s (1984) cognitive appraisal theory and the biopsychosocial model of challenge and threat (BPS; Blascovich, 2008), suggesting that subjective perceptions of stress stimuli may constitute a potential mechanism linking negative personality traits to maladaptive stress physiological response patterns. The different motivational nature (avoidance vs. approach) of negative traits may influence how stress stimuli are cognitively appraised, thereby affecting the magnitude of stress physiological responses. These results offer insights for clinical intervention and treatment, suggesting that cognitive therapy targeting stress cognitive appraisals in individuals with negative personality traits may help alleviate their maladaptive stress physiological responses.

This study is the first to categorize negative personality traits into avoidance and approach types, innovatively creating moderate- and high-intensity psychosocial stressors in laboratory conditions and combining them with a repeated stress exposure paradigm to systematically examine the relationships between avoidance/approach negative traits and cardiovascular responses/recovery during initial and repeated stress exposures of different intensities. This provides a theoretical framework and empirical support for clarifying inconsistencies in previous findings and deepening understanding of the characteristics of these two types of negative traits and their relationships with cardiovascular disease risk. However, this study has several limitations: (1) Although using personality traits as continuous variables in a normal undergraduate sample provides good statistical power and minimal parameter estimation bias (Markon, Chmielewski, & Miller, 2011), the conclusions require further investigation in clinical personality samples. (2) This study focused primarily on cardiovascular activity changes; future research should extend these questions to other physiological systems involved in stress responses (e.g., cortisol). (3) Chronic stress such as recent life events may influence baseline and acute stress responses and warrants further examination and control. (4) This study preliminarily explored potential mechanisms linking negative traits to maladaptive stress cardiovascular responses from a cognitive appraisal perspective; future research should further investigate the psychophysiological mechanisms underlying these associations from perspectives of motivational engagement, cognitive perception, and emotional meaning.

5 Conclusion

This study found that regardless of stress context intensity, both avoidance and approach negative traits are associated with rigid stress cardiovascular response patterns. Specifically, avoidance negative traits are primarily associated with persistently blunted stress cardiovascular reactivity and poor post-stress cardiovascular recovery, whereas approach negative traits are primarily associated with persistently greater stress cardiovascular reactivity and poor post-stress cardiovascular recovery.

References

Betensky, J. D., & Contrada, R. J. (2010). Depressive symptoms, trait aggression, and cardiovascular reactivity to a laboratory stressor. *Annals of Behavior Medicine, 39*, 184-191.

Bibbey, A., Carroll, D., Ginty, A. T., & Phillips, A. C. (2015). Cardiovascular and cortisol reactions to acute psychological stress under conditions of high versus low social evaluative threat: Associations with the Type D personality construct. *Psychosomatic Medicine, 77*, 599-608.

Bibbey, A., Carroll, D., Roseboom, T. J., Phillips, A. C., & Rooij, S. R. D. (2013). Personality and physiological reactions to acute psychological stress. *International Journal of Psychophysiology, 90*, 28-36.

Bilo, G., Zorzi, C., Munera, J. E., Torlasco, C., Giuli, V., & Parati, G. (2015). Validation of the SOMNOtouch-NIBP noninvasive continuous blood pressure monitor according to the European Society of Hypertension International Protocol revision 2010. *Blood Pressure Monitoring, 20*, 291-294.

Blascovich, J. (2008). Challenge and Threat. In Elliot, A. J. (Ed.), *Handbook of approach and avoidance motivation* (pp. 431-445). New York.

Brydon, L., Strike, P. C., Bhattacharyya, M. R., Whitehead, D. L., McEwan, J., Zachary, I., & Steptoe, A. (2010). Hostility and physiological responses to laboratory stress in acute coronary syndrome patients. *Journal of Psychosomatic Research, 68*, 109-117.

Carroll, D., Ginty, A. T., Whittaker, A. C., Lovallo, W. R., & Rooij, S. R. d. (2017). The behavioural, cognitive, and neural corollaries of blunted cardiovascular and cortisol reactions to acute psychological stress. *Neurosience and Biobehavioral Reviews, 77*, 74-86.

Carver, C. S., & Harmon-Jones, E. (2009). Anger is an approach-related affect: evidence and implications. *Psychological Bulletin, 135*, 183-204.

Carver, C. S., & White, T. L. (1994). Behavioral inhibition, behavioral activation, and affective responses to impending reward and punishment: The BIS/BAS scales. *Journal of Personality and Social Psychology, 67*, 319-333.

Chida, Y., & Hamer, M. (2008). Chronic psychosocial factors and acute physiological responses to laboratory-induced stress in healthy populations: A quantitative review of 30 years of investigations. *Psychological Bulletin, 134*, 829-885.

Chida, Y., & Steptoe, A. (2010). Greater cardiovascular responses to laboratory mental stress are associated with poor subsequent cardiovascular risk status: A meta-analysis of prospective evidence. *Hypertension, 55*, 1026–1032.

Contrada, R. J. (1989). Type A behavior, personality hardiness, and cardiovascular responses to stress. *Journal of Personality & Social Psychology, 57*, 895–903.

Cook, W. W., & Medley, D. M. (1954). Proposed hostility and pharisaic-virtue scales for the MMPI. *Journal of Applied Psychology, 38*, 414–418.

Custodis, F., Schirmer, S. H., Baumhäkel, M., Heusch, G., Böhm, M., & Laufs, U. (2010). Vascular pathophysiology in response to increased heart rate. *Journal of the American College of Cardiology, 56*, 1973–1983.

Davis, M. C., Matthews, K. A., & Mcgrath, C. E. (2000). Hostile attitudes predict elevated vascular resistance during interpersonal stress in men and women. *Psychosomatic Medicine, 62*, 17–25.

Eisenstein, E. M., Eisenstein, D., & Smith, J. C. (2001). The evolutionary significance of habituation and sensitization across phylogeny: A behavioral homeostasis model. *Integrative Physiological & Behavioral Science, 36*(4), 251–265.

Feldman, P. J., Cohen, S., Hamrick, N., & Lepore, S. J. (2004). Psychological stress, appraisal, emotion and Cardiovascular response in a public speaking task. *Psychology & Health, 19*, 353–368.

Gesche, H., Grosskurth, D., Küchler, G., & Patzak, A., (2012). Continuous blood pressure measurement by using the pulse transit time: Comparison to a cuff-based method. *European Journal of Applied Physiology, 112*, 309–315.

Ginty, A. T., Kraynak, T. E., Fisher, J. P., & Gianaros, P. J. (2017). Cardiovascular and autonomic reactivity to psychological stress: Neurophysiological substrates and links to cardiovascular disease. *Autonomic Neuroscience, 207*, 2–9.

Gordon, J. L., Ditto, B., & D'Antono, B. (2012). Cognitive depressive symptoms associated with delayed heart rate recovery following interpersonal stress in healthy men and women. *Psychophysiology, 49*, 1082–1089.

Gramer, M., & Sprintschnik, E. (2008). Social anxiety and cardiovascular responses to an evaluative speaking task: The role of stressor anticipation. *Personality & Individual Differences, 44*, 371–381.

Gu, D., Xin, X., Gao, J., Zhu, Y., Wang, H., Zheng, R., ···Chen, S. (2000). Hostility behavior as risk factor of coronary heart disease. *Chinese Journal of Epidemiology, 21*, 441–444. [顾东风, 辛雪, 高玖鸣, 朱燕, 汪红, 郑润平, ···陈绍建. (2000). 敌意行为与冠心病危险因素联系的横断面研究. 中华流行病学杂志, 21, 441–444.]

Heponiemi, T., Elovainio, M., Pulkki, L., Puttonen, S., Raitakari, O., & Keltikangas-Järvinen, L. (2007). Cardiac autonomic reactivity and recovery in predicting carotid atherosclerosis: The cardiovascular risk in young Finns study. *Health Psychology, 26*, 13–21.

Hernandez, D. H., Larkin, K. T., & Whited, M. C. (2009). Cardiovascular response to interpersonal provocation and mental arithmetic among high and low hostile young adult males. *Applied Psychophysiology & Biofeedback, 34*, 27-35.

Hu, L. T., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling, 6*(1), 1–55.

Huang, Y., Yao, S., Huang, R., Guo, R., & Yang, X. (2008). Type D personality as a risk factor in patients with coronary heart disease. *Chinese Journal of Clinical Psychology, 16*, 305–308. [黄彦科, 姚树桥, 黄任之, 郭锐, 杨晓来. (2008). 冠心病的新危险因素-D 型人格. 中国临床心理学杂志, 16, 305–308.]

Hughes, B. M., Howard, S., James, J. E., & Higgins, N. M. (2011). Individual differences in adaptation of cardiovascular responses to stress. *Biological Psychology, 86*(2), 129–136.

Hughes, B. M., & Lü, W. (2017). Blood pressure reactivity or responses. In: Gellman, M.D., Turner, J.R. (Eds.), *Encyclopedia of Behavioral Medicine, 2nd edition.* Springer, New York.

Hughes, B. M., Lü, W., & Howard, S. (2018). Cardiovascular stress-response adaptation: Conceptual basis, empirical findings, and implications for disease processes. *International Journal of Psychophysiology* (special issue: stress & adaptation), *131*, 4–12.

Hutchinson, J. G., & Ruiz, J. M. (2011). Neuroticism and cardiovascular response in women: Evidence of effects on blood pressure recovery. *Journal of Personality, 79*, 277–302.

Jiang, C., & Li, S. (2015). Mediation analysis and the application of bootstrap in mediation analysis. *Psychological Exploration, 35*, 458–463. [江程铭, 李纾.(2015). 中介分析和自举 (bootstrap) 程序应用. 心理学探新,35, 458–463.]

Jin, Y., Guo, Z., & Zheng, X. (2015). Predictability bias of neutral stimuli in college students with trait anxiety. *Chinese Journal of Clinical Psychology, 23*, 213–217. [金艳, 郭展鹏, 郑希付.(2015). 特质焦虑大学生对中性刺激的预测偏向. 中国临床心理学杂志,23, 213–217.]

Juszczak, N. M., & Andreassi, J. L. (1987). Performance and physiological responses of Type A and Type B individuals during a cognitive and perceptual-motor task. *International Journal of Psychophysiology, 5*, 81–89.

Kannel, W. B. (2000). Elevated systolic blood pressure as a cardiovascular risk factor. *The American Journal of Cardiology, 85*, 251–255.

Kupper, N., Denollet, J., Widdershoven, J., & Kop, W. J. (2013). Type D personality is associated with low cardiovascular reactivity to acute mental stress in heart failure patients. *International Journal of Psychophysiology, 90*, 44–49.

Lang, P. J., Bradley, M. M., & Cuthbert, B. N. (2005). *International affective picture system (IAPS): Affective rating of pictures and instruction manual*. University of Florida Center for Research in Psychophysiology, Gainesville, FL.

Lazarus, R. S., & Folkman, S. (1984). *Stress, appraisal, and coping*. Springer publishing company.

Lei, Z., Xu, R., Deng, S., & Luo, Y. (2011). Reliability and validity of the Chinese version of state-trait depression scale in college students. *Chinese Mental Health Journal, 25*, 136–140. [雷智慧, 徐蕊, 邓森碧, 罗跃嘉.(2011). 状态特质抑郁问卷中文版在大学生中的信效度. 中国心理卫生杂志,25, 136–140.]

Llabre, M. M., Spitzer, S. B., Saab, P. G., Ironson, G., Schneiderman, N. (1991). The reliability and specificity of delta versus residualized change as measures of cardiovascular reactivity to behavioral challenges. *Psychophysiology, 28*, 701–711.

Lü, W., Wang, Z., & Hughes, B. M. (2016). Openness and physiological responses to recurrent social stress. *International Journal of Psychophysiology, 106*, 135–140.

Lü, W., Xing, W., Hughes, B. M., & Wang, Z. (2018). Extraversion and cardiovascular responses to recurrent social stress: Effect of stress intensity. *International Journal of Psychophysiology* (special issue: stress & adaptation), *131*, 144–151.

Luo, Y., Zhang, D., Liu, Y., & Liu, Y. (2011). Reliability and validity of the Chinese version of trait anger scale in college students. *Chinese Mental Health Journal, 25*, 700–704. [罗亚莉, 张大均, 刘云波, 刘衍玲.(2011). 特质愤怒量表中文版在大学生人群应用的信度和效度. 中国心理卫生杂志,25, 700–704.]

Markon, K. E., Chmielewski, M., & Miller, C. J. (2011). The reliability and validity of discrete and continuous measures of psychopathology: A quantitative review. *Psychological Bulletin, 137*, 856–879.

Mendes, W. B., Blascovich, J., Major, B., & Seery, M. D. (2001). Challenge and threat responses during downward and upward social comparisons. *European Journal of Social Psychology, 31*, 477–497.

McEwen, B. S. (1998). Stress, adaptation, and disease: Allostasis and allostatic load. *Annals of the New York Academy of Sciences, 840*, 33–44.

McEwen, B. S., & Gianaros, P. J. (2011). Stress and allostasis induced brain plasticity. *Annual Review of Medicine, 62*, 431–445.

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

Peng, H., Wu, J., Sun, X., Guan, Q & Luo, Y. (2018). Trait anxiety predicts the response to acute psychological stress. *Acta Psychologica Sinica, 50*, 73–82.

[彭惠妮, 吴健辉, 孙小方, 关青, 罗跃嘉. (2018). 特质焦虑对急性心理性应激反应的预测. 心理学报, 50, 73-82.]

Preacher, K. J., & Hayes, A. F. (2008). Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. *Behavior Research Methods, 40*, 879-891.

Puig-Perez, S., Villada, C., Pulopulos, M. M., Hidalgo, V., & Salvador, A. (2016). How are neuroticism and depression related to the psychophysiological stress response to acute stress in healthy older people? *Physiology & Behavior, 156*, 128-136.

Qin, Y., Lü, W., Hughes, B. M., & Kaczmarek, L. D. (2019). Trait and state approach-motivated positive affects interactively influence stress cardiovascular recovery. *International Journal of Psychophysiology, 146*, 261-269.

Rodriguez, C. J., Swett, K., Agarwal, S. K., Folsom, A. R., Fox, E. R., Loehr, L. R., …& Chang, P. P. (2014). Systolic blood pressure levels among adults with hypertension and incident cardiovascular events: The atherosclerosis risk in communities study. *JAMA Internal Medicine, 174*, 1252-1261.

Rooij, S. R. D., Schene, A. H., Phillips, D. I., & Roseboom, T. J. (2010). Depression and anxiety: Associations with biological and perceived stress reactivity to a psychological stress protocol in a middle-aged population. *Psychoneuroendocrinology, 35*, 866-877.

Souza, G. G. L., Mendonça-de-Souza, A. C. F., Duarte, A. F. A., Fischer, N. L., Souza, W. F., Coutinho, E. S. F., . . . Volchan, E. (2015). Blunted cardiac reactivity to psychological stress associated with higher trait anxiety: A study in peacekeepers. *BMC Neuroscience, 16*, 81-89.

Sundin, O., Ohman, A., Palm, T., & Ström, G. (1995). Cardiovascular reactivity, Type A behavior, and coronary heart disease: Comparisons between myocardial infarction patients and controls during laboratory-induced stress. *Psychophysiology, 32*, 28-35.

Treiber, F. A., Kamarck, T., Schneiderman, N., Sheffield, D., Kapuku, G., & Taylor, T. (2003). Cardiovascular reactivity and development of preclinical and clinical disease states. *Psychosomatic Medicine, 65*, 46-62.

Wang, X., Wang, X., & Ma, H. (1999). *Handbook of mental health assessment scales*. Beijing, China: Chinese Journal of Mental Health. [汪向东, 王希林, 马宏.(1999). 心理卫生评定量表手册. 北京: 中国心理卫生杂志社.]

Zhou, H., & Long, L. (2004). Statistical Remedies for Common Method Biases. *Advances in Psychological Science,12*(6), 942-950. [周浩, 龙立荣.(2004). 共同方法偏差的统计检验与控制方法. 心理科学进展,12(6), 942-950.]

Appendix: Sample Items from Personality Trait Scales

Trait Depression Scale

Instructions: Below are some statements that people often use to describe themselves. Please read each statement and then check the appropriate number on the right to indicate how you generally feel. There are no right or wrong answers. Do not spend too much time on any single statement, but your responses should reflect your usual feelings.

1. I enjoy life
2. I am depressed
3. I am happy
4. I have no motivation
5. I am excited

Trait Anxiety Scale

Instructions: Below are some statements that people often use to describe themselves. Please read each statement and then check the appropriate number on the right to indicate how you generally feel. There are no right or wrong answers. Do not spend too much time on any single statement, but your responses should reflect your usual feelings.

1. I feel pleasant
2. I feel nervous and uneasy
3. I feel satisfied
4. I wish I could be as happy as others
5. I feel drained

Trait Anger Scale

Instructions: The following sentences describe how people feel and react to their emotions in daily life. Please indicate the degree to which each statement describes you by checking the appropriate box. There are no right or wrong answers; please respond based on your first impression after reading each sentence.

1. I lose my temper easily
2. I have a hot temper
3. I am quick-tempered

4. I get angry when others' mistakes delay my work

5. I feel annoyed when my excellent performance is not recognized

Trait Hostility Scale

Instructions: The following sentences describe how people feel and react to their emotions in daily life. Please indicate the degree to which each statement describes you by checking the appropriate box. There are no right or wrong answers; please respond based on your first impression after reading each sentence.

3. I would rather keep my distance from school friends or people I know but haven' t seen for a long time, unless they speak to me first

Note: Figure translations are in progress. See original paper for figures.

Source: ChinaXiv —Machine translation. Verify with original.