State, but not trait gratitude is associated with cardiovascular responses to acute psychological stress

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Abstract

Recent research suggests that gratitude is associated with better cardiovascular health. Here, we investigated whether trait and/or state gratitude was associated with cardiovascular responses to acute stress. Eighty-six young adults completed measures of gratitude and had their cardiovascular responses monitored throughout a standardised stress testing protocol. Trait gratitude was not associated with cardiovascular reactivity, i.e systolic or diastolic (SBP, DBP) or heart rate (HR). However, while state gratitude was not associated with HR or DBP reactivity, it was negatively associated with SBP reactivity, such that those who reported higher state gratitude during the past week displayed lower SBP to the stressor. Moreover, this association was robust to withstand adjustment for several potential founds, such as sex, depression and body mass index. These findings are novel and highlight that gratitude, in particular state gratitude, is one potential mechanism underlying the protective benefits of gratitude on cardiovascular health.

Key Words: Blood pressure; cardiovascular reactivity; gratitude; stress.

1. Introduction

Cardiovascular diseases (CVD) such as coronary heart disease (CHD) and strokes remain a serious health concern worldwide, accounting for 31% of all global deaths. Of these 17.5 million heart disease- related deaths, 7.4 million are estimated to be due to CHD specifically (WHO, 2016). In addition to the established risk factors including smoking, obesity, diabetes, family history of heart disease and low physical activity (Helfand et al., 2009), there is an increasing literature suggesting that psychological factors may significantly contribute to CHD. In particular, the reactivity hypothesis posits that exaggerated or prolonged cardiovascular reactivity (CVR) to psychological stress may promote the development of cardiovascular disease (Obrist, 1981; Phillips & Hughes, 2011). This hypothesis has received substantial support with prospective studies finding that heightened reactivity to stress is associated with adverse cardiovascular outcomes including hypertension (Carroll, Ginty, Painter, et al., 2012), atherosclerosis (Barnett, Spence, Manuck, & Jennings, 1997; Matthews et al., 1998) and mortality (Carroll, Ginty, Der, et al., 2012). Moreover, affective states and personality traits such as depression and neuroticism have been shown to negatively impact CVR to acute stress (Chida & Hamer, 2008), while positive factors such as social support and optimism have been found to buffer against stress and are cardio protective (Gallagher, Meaney, & Muldoon, 2014; Howard & Hughes, 2012; Puig-Perez, Hackett, Salvador, & Steptoe, 2017). One positive psychological factor that has not received much attention in this literature is gratitude.

Gratitude has been conceptualized as an emotion, an affective disposition and is part of a broad dispositional orientation towards perceiving and appreciating the positive in life (Wood, Froh, & Geraghty, 2010). At the trait level, gratitude is often operationalized by assessing individual differences in the average rate with which gratitude as an emotion is experienced on a daily basis, while at a state level it is viewed as feeling thankful and appreciative for favours received (Wood, Maltby, Stewart, Linley, & Joseph, 2008). Additionally, at the trait level, disposition gratitude is usually assessed by the GQ-6 with no specified time limits, whereas as a state it can be captured by the gratitude adjective checklist (GAC) by using a more limited timeframe (Froh et al., 2011; McCollough et al., 2002). For example, Froh and colleagues (2009) assessed emotion as a mood by asking participants to rate feeling grateful, thankful, and appreciative since yesterday, while others asked participant to rate these emotions over the past week (Waters, 2012). Moreover, a grateful response to life circumstances is considered a fundamental process by which everyday experiences are positively interpreted by people (Emmons & McCullough, 2003).

Although the social and psychological benefits of gratitude are well documented (Wood et al., 2010), emerging studies are now evidencing that gratitude may serve a protective and predictive role in physical health (Hill, Allemand, & Roberts, 2013). For example, heart failure patients who participated in a gratitude intervention had reduced inflammation and increased parasympathetic heart rate variability scores compared to those in a control group (Redwine et al., 2016). Similarly, gratitude journaling has also been found to reduce stress and reduce cortisol, a stress hormone, in pregnant women (Matvienko-Sikar & Dockray, 2017). While in a sample of healthy young women, completing gratitude diaries for two-weeks was associated with reduced blood pressure relative to a control group (Jackowska, Brown, Ronaldson, & Steptoe, 2016). Despite this, to our knowledge no study has examined whether gratitude influences cardiovascular stress reactivity. Moreover, given that cardiovascular stress reactivity is one established pathway underling CHD and with gratitude buffering against the negative effects of stress on health (B. O'Connell & Killeen-Byrt, 2018), this study is clearly warranted. In fact, a call by researchers to examine the pathways underlying the gratitude-health link have been made (Hill et al., 2013; Park et al., 2014; Wood et al., 2010).

In terms of health protection, when a person is faced with negative situations or stress gratitude may facilitate coping, reduce negative emotions and restore cognitive flexibility (Fredrickson, 1998); a notion consistent with the cognitive model of stress (Lazarus & Folkman, 1984). According to this model one's internal resources and traits influence how one copes and manages stress, thus gratitude may be one such resource. In fact, one recent study task found that gratitude was associated with increased positive and lower negative mood following exposure to a cold pressor task (Hirshberg et al., 2018); although cardiovascular reactivity was not assessed in this study, it does show that gratitude can influence responses to acute stress exposure. Moreover, given the role emotions play in the onset of heart disease (Pressman & Cohen, 2005; Sirois & Burg 2003), investigating health protective emotions is a worthwhile line of enquiry.

In summary, based on the above evidence and the lack of research on gratitude and cardiovascular stress reactivity the present sought to fill this gap in knowledge. Further, while there are links between gratitude, stress and health, the pathways underlying biological processes are still being elucidated. Despite this, however, given that gratitude has been shown to buffer against stress we are predicting that it will attenuate the CVR responses to acute stressors. However, we did not have any predictions in relation to trait or state gratitude on CVR responses to the stressor; thus these particular hypotheses will be exploratory.

2. Materials and methods

2.1. Participants

Eighty-six healthy young adults (65% female), from our local university participated in this study. Based on previous research and power calculations, a minimum sample size of 68 participants was needed to detect a significant effect ($p < .05$, standardized regression coefficient =0.15). Participants were recruited by means of a course credit system within the university, by word of mouth, and the advertisement of the study throughout the campus. Participants ranged in age from 18-28 (*M* = 20.7, *SD* = 2.69) with a mean body mass index (BMI) of 24.7kg/m^2 (*SD* = 3.33) and the majority were White Irish, (95%).

Participants with a diagnosis of cardiovascular disease, or were ill or women who were pregnant, were also excluded in order to minimize the possibility of confounding variables. In preparation for the testing session they were asked to refrain from alcohol and vigorous exercise 12 hours prior to testing, as well as smoking and consuming caffeine 2 hours before testing. These precautions were to control for confounding and are in line with existing research (Creaven & Hughes, 2012; Riordan, Howard, & Gallagher, in press). This study was approved by the university's research ethics committee. All participants provided consent and the study was approved by our local research ethics board.

2.2 Design

A within-subjects correlational design was used with the main predictor variables being trait and state gratitude. The dependent variables were measures of CVR including systolic and diastolic blood pressure (SBP, DBP) and heart rate (HR). These reactivity scores were computed as the difference between mean baseline and mean task values for each cardiovascular parameter, in line with previous research (e.g., (Brown, Creaven, & Gallagher, 2019; Gallagher, O'Riordan, McMahon , & Creaven, 2019). Given the well-established association between depression and heart disease (Chida & Hamer, 2008) and gratitude negative association with depression (Wood et al., 2010) we controlled for depression in our main analyses. Depression was assessed by well-validated 7-item scale on the Hospital Anxiety and Depression Scale (HADS) (Zigmond & Snaith, 1983).

2.3. Materials and Apparatus

2.3.1 Demographic and Anthropometric Variables

A weighing scales and portable stadiometer were used to measure height and weight. Socio-demographic information such as age, gender, ethnicity, relationship status, smoking status and family history of cardiovascular disease were gathered using a standardised demographic questionnaire.

2.3.2 Trait Gratitude

This was assessed using the Gratitude Questionnaire-Six Item Form (GQ-6;(McCullough, Emmons, & Tsang, 2002). This self-report scale examines general thankfulness and gratitude, under four facets of grateful tendencies- intensity, density, span, and frequency). Respondents are asked to indicate how much they agree with six statements, for example 'I have so much in life to be thankful for', two of which are reverse scored, for example, 'When I look at the world, I don't see much to be grateful for'. Respondents provide their answer on a 7-point scale ranging from '*Strongly disagree'*= 1 to '*Strongly agree'* = 7. All items are summed to produce a total gratitude score with higher scores indicating higher gratitude. The scale has high internal consistency, Cronbach's alpha = .82 (McCullough et al., 2002). Similar alpha coefficients were found in the current study, 0.78.

2.3.3 State Gratitude

This was assessed by the 3-item Gratitude Adjective Checklist (GAC) - 3 Item Measure (GAC) (McCullough et al., 2002). The GAC is a Likert scale including three adjectives 'Grateful', 'Thankful' and 'Appreciative' with participants asked to rate the extent to which they have experienced these feelings during the past week using a 5-point scale ranging from 'Not at all' = 1 to 'Extremely' = 5 with higher scores indicating greater experiences of feelings of gratitude. This assessment of other emotional states over the past week is consistent with those that capture depressive states like in the HADS above. Internal consistency is high, with Crobach's alpha =.86 (McCullough et al., 2002) and this was confirmed in the current study, α =.82.

2.3.4 Stress Task Measures

Immediately before and after the stress task, participants were asked to indicate how stressful they expected to find the task and how stressful they found it. These items were scored on a 7-point Likert scale 0 (*Not at all*) to 6 (*Extremely*) and were used to confirm that the task was psychologically stressful.

2.3.5 Cardiovascular Assessment

Participant's SBP, DBP and HR were all measured using a GE DINAMAP PRO 300 V2 Monitor. These were recorded consistently every two minutes, on the non-dominant arm of each participant, from baseline through to task. The GE DINAMAP PRO 300 V2 Monitor has been used in many other psychophysiological related studies (Gallagher et al., 2014; Vahlkvist & Pedersen, 2009) and is recommended by the British Heart Foundation.

2.4 Stress Task

A math task was used to elicit a stress response. This task is an adaption of the Trier Social Stressor Task (Kirschbaum, Pirke, & Hellhammer, 1993) and was chosen as reliably perturbs the cardiovascular system (Creaven & Hughes, 2012; Nater et al., 2005). Participants were instructed to serially subtract the number 13 from the number 1022. They were asked to work as quickly and accurately as possible. The task lasted for 6 minutes. Further as in previous stress protocols, to heighten feeling of stress, during testing, the lights were switched off and a leader board was placed in front of the participants showing "last week's scores; participants were told that their score would be reviewed by a panel of judges and they might be on the leader board next month. Participants were asked to start again if they said the wrong number. At 1 minute and 30 seconds, the researcher said “you’re going too slowly, please start again from the number 5066”. Three minutes in they were told “ I expected you to do better, start again from the number 6190”.

2.5 Procedure

Prior to arrival at the laboratory, participants were sent a study information sheet Those who agreed to take part and were deemed eligible were asked to attend a 45-minute testing session at our health and psychophysiology laboratory. Upon arrival, participants were greeted and screened again to confirm they adhered to the health behaviour protocol (e.g. no caffeine and exercise prior to attending). Once consent was taken, they completed a demographic questionnaire, and were heighted and weighted for calculation of body mass index (BMI). Participants were then seated at a desk on which a spotlight was lit and they were requested to place their feet in a box to control for unnecessary movements that may affect cardiovascular measures (Pickering et al., 2005). Following a 20-minute acclimatization period, the gratitude scales were completed and cardiovascular acclimatisation measuring took place, then baseline cardiovascular measures were recorded for 10 minutes. Here cardiovascular assessments were taken every two minutes. *Following the formal baseline,* and 1-minute before the stress task began, the researcher asked the participant to compete the pre-stress task questionnaire. They were then given instructions on how to perform the task and informed the task would begin shortly. The main laboratory lights were turned off immediately before the task began and participants were left to complete the stress task in the spotlight. The researcher remained in the testing room and was dressed in a white laboratory coat and asked the participant to speak aloud for the task as their results were being scored. After the stress task, the participant completed the post task stress questionnaire, had the blood pressure cuff removed and were thanked, and were provided with a debriefing sheet.

2.6 Data analyses

Prior to analyses data were screened for normality and assumptions of fit. Data was normally distributed and no outlier were identified. First, tests of differences and correlations checked for sex and sociodemographic associations with our outcome variables. This was followed by repeated measures analysis of variance to confirm whether our task perturbed the cardiovascular system and if it was psychologically stressful. This was then followed by a series of hierarchal linear regressions to test our main hypotheses where confounding factors were entered as Step 1, followed by the predictor variables at Step 2.

3. Results

3.1 Descriptive Statistics

Descriptive statistics for study psychological and cardiovascular variables are reported in Table 1. Trait gratitude scores are within the normal range, albeit they are slightly lower that previously found in an Irish sample (B. H. O'Connell, O'Shea, & Gallagher, 2017). Our average score for the state gratitude scale was slightly above the normal range of 10.95 found elsewhere(Froh et al., 2011). There was a moderate positive correlation between trait and state gratitude, $r = .33$, $p = .003$, $n = 86$. Neither trait or state gratitude were associated with pre or post task stress ratings.

[Insert Table 1 about here]

3.2 Manipulation check

A series of repeated measures (baseline, task) ANOVAs confirmed that the stress task increased cardiovascular responses for: SBP, F(1, 85) = 264.22, p < .001, η_p^2 = .78; DBP, F(1, 85) = 254.20, p < .001, η_p^2 = .75; HR, F(1,85) = 102.12, p < .001, η_p^2 = .55. Further, repeated measures ANOVAs also revealed a significant increase from pre- to post-task rating of self-report stress, F(1, 85) =29.88, p < .001, η_p^2 = .26.

There was no difference on trait or state gratitude by gender. However, men were more likely to have higher resting SBP, F(1, 85) = 122.03, p < .001, η_p^2 = .59. Further, there were no associations between age, family history of cardiovascular disease, smoking or relationships status and any of our variables of interest. Moreover, trait or state gratitude were not associated with baseline SBP, DBP or HR. However, BMI was positively associated with resting SBP, r = .34, p = < .001, n = 86. Thus, the above confounds were controlled for in relevant analyses.

3.3 Associations between trait and state gratitude and cardiovascular reactivity.

A series of hierarchical linear regressions, where baseline SBP, DBP, HR, gender and BMI were added at Step 1, and each predictor variable individually at step 2, were conducted. In these analyses, there were no associations between trait gratitude and SBP, DBP or HR reactivity to acute stress, see Table 2. Further, there were no significant associations between state gratitude and DBP and HR reactivity. However, there was a significant association between state gratitude and SBP reactivity, β = -.23, 95% CI [-1.93, -.60], t = -2.11, p = .03, which added an additional 6% to the variance in explaining SBP reactivity. For those who reported feeling more thankful, grateful and appreciative during the week of the stress testing session had lower SBP reactivity to the psychological stressor. We followed these regressions up, by entering both predictors simultaneously in step 2, and the same patterns was evident.

See table 2. This association was robust to withstand adjustment for sex, BMI and baseline SBP. Finally, we ran a similar regression but this time we controlled for depression and performance scores and again, the results remained, β = -.26, 95% CI [-2.03, -.22], t = -2.48, p = .01. In fact, the effect became stronger.

[Table 2 about here]

4. Discussion

The present study sought to evaluate whether trait and state gratitude predicted CVR to acute stress. We did not find any association between trait gratitude and SBP, DBP or HR reactivity and a similar pattern was evident for state gratitude and DBP and HR. However, we did find a negative association between SBP reactivity such that those who reported feeling more grateful, thankful and appreciative during the week of testing had lower SBP reactivity to the stressor. While we did not have directional hypotheses in relation to trait and state gratitude,i.e. which would be the strongest predictor, we did expect a buffering effect of gratitude on CVR. Moreover, given that we controlled for several confounding factors most notably depression make these findings particularly noteworthy. To our knowledge, this is the first study to show that gratitude, in particular state, influences CVR responses to acute psychological stress.

Previous studies have also found health protective effects of positive psychological factors on health (Chida & Steptoe, 2008). For example, factors such as optimism and social support have been previously shown to buffer the effect of stress on cardiovascular responses to stress (Bajaj et al., 2019; Gallagher et al., 2014), here however we find it was state gratitude attenuated SBP responses to stress. Further, while optimism and social support have received a lot of attention in the CVR literature, none has been paid to gratitude. Moreover, given that it was state gratitude, i.e., feelings of gratefulness and thankfulness during the week of testing, that was the key predictor of cardiovascular reactivity it seems likely that gratitude as a positive emotional states has important stress buffering effects. In fact, the link between emotions and health is well known (Chida & Steptoe, 2008) and positive emotion states are central to the stress process (Folkman, 2008) as such our findings are theoretically coherent with this line of research. Further, according to Pressman and Cohen (2005) based on the circumplex model of emotion one should see activated emotions (e.g. excitement and joy) associated with increases in HR and BP, whereas low-activation emotions like calmness and pleasantness, which are more akin to gratitude, to be associated with a dampening of cardiovascular response; this latter pattern was evident here. Albeit most of this evidence comes from induced emotional states which may also be one reason why trait gratitude was not associated with CVR. It could be that mood induction in close proximity to, or during times of stress is what is important and given our state gratitude scale asked about recent feelings then perhaps this may have led to greater induction of grateful emotions at the time of testing. This possibility would need to be tested to validate this speculation.

The implications are not only theoretical they also have clinical implications. For example, from a theoretical perspective. A call by researchers to help clarify the pathways that underlie the gratitude/positive emotion-physical health link has been made several times (Hill et al., 2013; Park et al., 2014). One pathway already identified was the moderation of vagal tone by positive emotions, whereby an increase in positive emotions lead to an increase in vagal tone, which is cardio-protective (Kok et al., 2013). Here we identify another pathway through CVR reactions to acute psychological stress, which has been associated with cardiovascular health (Carroll, Ginty, Painter, et al., 2012; Chida & Hamer, 2008). Moreover, it also extends our knowledge of the stress-buffering effects of positive emotions to show how gratitude when experienced during times of stress can have cardio-protective effects. Further, in terms of clinical utility, several studies have found that cardiac patients who write about grateful experiences have better cardiovascular health and cardiovascular-related health outcomes in comparison to those who do not (Mills et al., 2015; Redwine et al., 2016). Thus, our results extend on this to show that feeling grateful and thankful can attenuate CVR to acute stress, implying that this could also be a point of intervention to improve cardiovascular health.

The limitations of the present study include, first, the use self-report measures were used to assess both trait and state gratitude; thus, it is possible that social desirability concerns influenced our findings. However, self-report measures for these constructs are widely used and also enable comparisons with prior research in this area. Second, we assessed state gratitude as in the past week it would be worth looking at more recent experiences such as on the day or just before the task to see if these emotions are important for coping with stress in real time. Third, given a lack of previous research evaluating gratitude on CVR we adopted an exploratory approach to hypothesis-testing. Although this is a significant limitation, future research is well-positioned to adopt a confirmatory approach. While DBP and HR were not associated with state gratitude the effect was in the same direction. Further, while we suggest that our findings are in line with gratitude as an emotion, we did not measure positive effect here as this may have shed some light on other mediating pathways. Thus, we suggest future research explore these ideas further. Fourth, cardiovascular recovery from acute stress has important cardiovascular implications (Steptoe & Marmot, 2005), thus, future research should examine the role of gratitude here. Although, a recent literature review found insufficient evidence on the role of positive emotional states to speeds physiological recovery (Cavanagh, & Larkin, 2018). Nonetheless, given that this study is the first to examine the role of gratitude, both trait and state we suggest continuing this line of enquiry. Finally, our observational design means that causal relationships between state gratitude and stress responses cannot be established. However, a strength of our study is the comprehensive measurement of cardiovascular responses. Our findings require replication and point particularly to state gratitude as an important construct with implications for stress responding.

In conclusion, the present study established as association between gratitude and CVR to acute psychological stress. Further, it appears that state but not trait gratitude was important in this context, in particular feelings of gratefulness and thankfulness during the week of testing were associated with attenuated SBP reactivity. While this finding appears consistent with the influence of emotions on stress processes we are the first to demonstrate that feelings of gratitude can buffer against the negative effects of stress on cardiovascular responses to acute stress. Moreover, this adds a better understanding of how gratitude influences our physical health (Park et al., 2014).

Conflict of interest: The authors report no competing interests

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Table 1
Descriptive statistics of gratitude and CVR variables

Variables	Range	Mean	Standard Deviation
Trait Gratitude	21 - 36	29.9	2.92
State Gratitude	6 - 15	11.8	2.23
Baseline SBP	80.4 -140.2	111.6	11.28
Baseline DBP	49.6 – 94.0	65.6	6.19
Baseline HR	47.2 – 96.2	73.2	11.48
Task SBP	75.6 – 177.3	128.6	15.45
Task DBP	56.0 – 96.3	75.3	8.01
Task HR	51.0 -151.0	87.7	18.49
Pre Task Stress	0 -6	2.7	1.56
Post Task Stress	1-7	5.1	1.62

Table 2. Summary of hierarchical regressions of trait and state gratitude predicting SBP, DBP and HR reactivity

Variables	β	t	p	95%CI	95%CI
Step 1 –SBP Reactivity					
Baseline SBP	.05	-0.33	.74	-.19	.27
Sex	-.08	-0.64	.52	-6.8	3.4
BMI	-.02	-0.17	.8.686	-.73	.61
Step 2					
Trait Gratitude	.15	1.35	.18	-.24	1.27
State Gratitude	**-.28**	**-2.46**	**.01**	**-2.12**	**-.23**
Step 1 DBP Reactivity					
Baseline DBP	.08	- 0.80	.42	-.27	.12
Sex	-.06	-0.54	.59	-3.24	1.86
BMI	.12	1.07	.27	-.16	.57
Step 2					
Trait Gratitude	.19	1.64	.11	-.08	.81
State Gratitude	-.20	-1.71	.09	-1.06	.08
Step1 HR Reactivity					
Baseline HR				-.11	.41
Sex	-.07	-.62	.53	-9.99	2.37
BMI	.12	.81	.40	-1.14	.60
Step 2					
Trait Gratitude	.08	.66	.51	-.71	1.45
State Gratitude	-.12	-1.01	.31	-2.08	.67