The cardiovascular response to acute psychological stress is related to subjectively giving and receiving social support

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Abstract

The pathways linking *giving* and *receiving* emotional and instrumental social support, and cardiovascular reactivity (CVR) are not yet fully understood. Eight-two healthy young adults completed psychometric measures of giving and receiving emotional and instrumental social support and participated in a standardised laboratory stress task. Cardiovascular and hemodynamic parameters were monitored throughout. Both giving and receiving emotional support were positively associated with systolic blood pressure (SBP) and diastolic blood pressure (DBP), such that those reporting giving and receiving more emotional support had higher reactivity. Only receiving instrumental was associated with DBP, with those receiving more instrumental support having higher reactivity. Moreover, while the significant association between giving social support and CVR withstood adjustment for several confounding factors (e.g., BMI, sex) it was abolished when receiving support was controlled for. These findings are novel and extend the literature on social support and CVR. Taken together, these findings suggest that receipt of support, rather than giving, may be more influential in this context.

Key words: blood pressure; cardiovascular reactivity; social support; stress

1. Introduction

The association between social support and cardiovascular mortality is well-established (Hemingway & Marmot, 1999; Kuper, Marmot, & Hemingway, 2002; Mookadam & Arthur, 2004). An individual's experiences within social relationships can significantly predict mortality, with one meta-analysis finding that social isolation increases the risk of cardiovascular mortality (Holt-Lunstad, Smith, & Layton, 2010). One of the proposed pathways underlying this association is the stress buffering hypothesis (Cohen & Wills, 1985; Uchino, Carlisle, Birmingham, & Vaughn, 2011) which suggests that social support reduces cardiovascular responses to stressful situations. In support of this suggestion, a meta-analysis examining over 20 studies of social support on cardiovascular reactivity (CVR) to laboratory stress found that experimental manipulation of social support (e.g., provision of active or passive support compared to no support) reduced hemodynamic reactivity (Thorsteinsson & James, 1999). However, other studies show an increase in CVR in relation to social support, dependant on the sex and social intimacy between the individuals giving and receiving support (Phillips, Gallagher, & Carroll, 2009). Despite this, some have argued that these manipulations of enacted social support in the laboratory lack ecological validity, in that they tend not to reflect social support in real life (Uchino, 2006; Uchino et al., 2011).

In fact, some researchers argue that most disease models linking social support to cardiovascular disease are based on social support in real life and that enacted social support cannot be validly predictive of such negative health outcomes (O'Donovan & Hughes, 2008). Indeed, enacted support manipulations are often confounded by the fact that support providers may be perceived as evaluators, that the support given may not be needed, the support is not matched to the stressor and the influence of body language (e.g, eye gaze, hand gestures) are perceived but are not accounted for (Reader & Holmes, 2016; Uchino, 2009).

Thus, measures of subjective or perceived social support may be a more accurate measure of social support in real life (Uchino, 2009).

In line with this notion, perceived social support in real life resulted in lower cardiovascular response to a stress task (O'Donovan & Hughes, 2008). Similarly, a more recent study found that higher quality, but not quantity, of perceived availability of social support predicting reduced blood pressure reactivity to stress in the laboratory in older adults (Howard, Creaven, Hughes, O'Leary, & James, 2017). In support of this, experimental evidence has also found that simply knowing that support would be made available, if needed, during stress was sufficient for cardiovascular stress adaption in the absence of enacted support (Uchino & Garvey, 1997), implying that perception rather than actual support is what matters. Further, in those living with chronic conditions or dealing with other life stressors, perceived support was found to be more beneficial than actual support with the latter having minimal health benefits (McDowell & Serovich, 2007; Wethington & Kessler, 1986).

Despite this, however, social support is a multidimensional construct that can be understood in terms of structure (e.g., network size), function (i.e., emotional or instrumental) and direction (i.e., giving or receiving) (Uchino, 2009). An underlying assumption in most research on social support is that the person receiving the support benefits whereas the individual providing care and support incurs some cost (Okamura et al., 2018) To date, the CVR research has primarily focused its attention on the *receiving* of social support (Uchino, 2009) with little attention paid to the effects of *giving*. An accumulating body of evidence, however, suggests that *giving* social support is also health protective (Eisenberger, 2013; Inagaki & Orehek, 2017; Poulin, Brown, Dillard, & Smith, 2013). For example, in a study on older adults, mortality was significantly reduced for individuals who reported giving instrumental support to friends, relatives and neighbours, including individuals who reported providing emotional support to their spouse (Brown, Nesse, Vinokur, & Smith, 2003). Other studies have found these effects only in women and not men (Väänänen, Buunk , Kivimäki, Pentti, & Vahtera, 2005). A further study in young adults found that participants with a higher tendency to give social support reported greater received social support, greater self-efficacy, greater self-esteem, less depression, and less stress than participants with a lower tendency to give social support to others (Piferi & Lawler, 2006). In addition, those with a higher tendency to give social support were found to have lower systolic (SBP) and diastolic (DBP) blood pressure (Piferi & Lawler, 2006). While this study suggests that giving support has direct physiological effects, it also suggests that giving support may have implications for stress. In fact, research suggests that humans are hardwired to nurture and care for others which may facilitate stress reduction (Preston, 2013). From a biological perspective, support-giving activates brain regions that are involved in reward processing and inhibits threat-related neural and physiological responses (Eisenberger, 2013; Inagaki & Orehek, 2017). These neurobiological mechanisms have implications for stress attenuation, and are supported by studies in both animals and humans which have found that giving support leads to stress reduction and physiological responding.

In animals, female macaques who gave more support through grooming activities were found to displayed lower stress levels (e.g, lower cortisol responses) compared to those giving less grooming (Shutt, MacLarnon, Heistermann, & Semple, 2007). While in humans, when asked to write a supportive note to a friend (support-giving) compared to when they wrote about their route to school/work (control condition), participants had lower CVR as indexed by reduced SBP, but also had lower salivary alpha-amylase in response to acute psychological stress (Inagaki & Eisenberger, 2016). In older adults with hypertension, those assigned to a condition which involved spending money on others for three-weeks had lower SBP and DBP compared to those assigned to spend money on themselves (Whillans, Dunn, Sandstrom, Dickerson, & Madden, 2016). While subjective stress was not captured in this study, it does highlight the cardiovascular benefits of giving to others. Moreover, the effects of giving have been found to be stronger than receiving social support. For example, while performing a math task, participants who reported giving support showed reduced activation in brain areas related to stress responses, while receiving support was unrelated to activation in stress-related regions (Tristen K. Inagaki et al., 2016). It is also worth noting that receiving support had no effect on mortality once giving support was taken into consideration (Brown et al., 2003). Together these studies suggest that while giving social support may be more effective, the health benefits seen for receiving social support are not independent of giving support.

Important as this work is, it is clear more research is needed, especially given that social support is a multi-dimensional construct including both structural (e.g. networks) and functional (e.g., emotional, instrumental) support (Reader & Holmes, 2016; Shakespeare-Finch & Obst, 2011; Uchino, 2009). In functional terms, instrumental support encompasses aid, advice and information, whereas emotional support refers to empathetic actions that convey caring attitudes (Shakespeare-Finch & Obst, 2011). Further, emotional support is typically viewed as more nurturing and less controlling than instrumental (Trobst, 2000). Moreover, it has been argued that instrumental social support should be most effective for controllable events (e.g., preparing for exams or job interview), whereas emotional support should be most effective for uncontrollable events (e.g., pandemics, job layoff) (Uchino, 2006). In terms of CVR, both types of support have shown stress buffering effects albeit with some nuances. Men receiving instrumental support in a role conflict stress task had lower CVR compared to when they received emotional support (Wilson et al., 1999). In contrast, women when receiving emotional support from male friends had lower CVR, but higher reactivity when receiving emotional support from female friends (Phillips et al., 2009). Thus, while both emotional and instrumental support influence CVR, there are nuances to their effects. Given that these were laboratory manipulations of support they may not reflect support in real life and in some cases may be seen as sources of stress (Birmingham & Holt-Lunstad, 2018). Despite this, the effects of subjectively *receiving* or *giving* emotional or instrumental support in everyday life on CVR are yet to be clarified. This will be the focus of the present study.

In summary, the present study sought to extend previous research in this area and address several gaps in the literature. Specially, it aims to examine the influence of *giving* and *receiving* both emotional and instrumental support in real life on CVR to acute psychological stress. Based on the evidence showing that emotional support is more beneficial for uncontrollable events (Uchino, 2006), like our acute stress task, it is hypothesized first, that both giving and receiving emotional support will be associated with CVR and that these effects will be stronger than instrumental support. Second, it is expected that the effects of giving social support on CVR will be stronger than receiving support. Finally, we also explored whether the effects of receiving social support were still evident after controlling for giving support.

2.Methods

2.1. Participants

Data were collected from 82 healthy young adults (55 % female), recruited from a university setting by means of a course credit system. The present manuscript is part of a larger study observing demographic and psychosocial factors associated with CVR to acute psychological stress. In terms of sample size, for a power of .80, with four predictor variables, to achieve an effect size of .15, which was based on previous work in the area (Howard et al. 2017) a sample of 85 was needed to detect effects(Gpower). Participants' ranged in age from 18-40 (*M* = 22.1, *SD = 6.10)*, with a mean body mass index (BMI) of 24.3kg/m^2 (*SD* = 3.88), the majority were White Irish (90.1%), and 56.5% were single.

Exclusion criteria included being pregnant, currently ill or having any cardiovascular problems, and taking any medication except the contraceptive pill (25% of females said yes). Prior to the testing session, participants were asked to not to drink alcohol, or to do vigorous exercise for 12 hours prior to attending. In addition, they were informed not to smoke (17.2% were current smokers, 4.6% previous smokers) or consume caffeine 2 hours before testing. They were asked whether there was a history of cardiovascular disease in the family (27% said yes). These precautions were to control for confounding and are in line with existing research (Gallagher, O'Riordan, McMahon , & Creaven, 2019). The study was approved by the university's research ethics committee and all participants gave fully informed consent.

2.2. Design

A correlational design was used with the main predictor variables being giving and receiving social support. The dependent variables were measures of CVR including systolic and diastolic blood pressure (SBP, DBP), heart rate (HR), cardiac output (CO), and total peripheral resistance (TPR). CVR scores were the difference between mean baseline and mean task values for each parameter (Gallagher, Meaney, & Muldoon, 2014; Phillips et al., 2009).

2.3. Materials and Apparatus

2.3.1. Demographic and Anthropometric Variables

For calculation of body mass index (BMI) standardised weighing scales and a portable stadiometer were used. Socio-demographic information such as age, gender, ethnicity, relationship status, smoking status and family history of cardiovascular disease were captured using a standardised questionnaire.

2.3.2. Social Support: Giving and Receiving

The original 20-item 2-Way Social Support Scale (SSS) was developed to assess the subjective experience of giving and receiving both emotional and instrumental social support (Shakespeare-Finch & Obst, 2011). Nine items capture *giving support* component (e.g. emotional: 'I give others a sense of comfort in times of need'; instrumental: 'I am a person others turn to for help with tasks') and 11 items *receiving support* (e.g. emotional: 'When I am feeling down there is someone I can lean on'; instrumental: 'I have someone to help me if I am physically unwell'). Participants indicate the frequency of their experience on a six-point scale rated from 0 (*not at all*) to 5 (*always*), with higher scores indicate greater social support given and received. The scale can be summed to two giving and receiving social support scores, the greatest utility are the validated subscales that identify the four aforementioned aspects of social support (Shakespeare-Finch & Obst, 2011). The scale has been validated for both younger and older adults (Obst, Shakespeare-Finch, Krosch, & Rogers, 2019; Shakespeare-Finch & Obst, 2011) and has excellent internal consistency (subscales $\alpha = .81–.92$), and for the present study they ranged between .73-.90.

2.3.3. Stress Task Measures

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

2.3.4. Cardiovascular Assessment

A Finometer Pro hemodynamic cardiovascular monitor (Finapres Medical Systems BV, BT Arnhem, The Netherlands) was used to capture measures of SBP, DBP, HR, CO, and TPR. This monitor takes beat-to-beat continuous non-invasive measurements and meets the validation criteria of the Association for the Advancement of Medical Instrumentation (AAMI, 2020) and has been used in several similar studies (Howard & Hughes, 2012; O'Riordan, Howard, & Gallagher, 2019)

2.3.5. Stress Task

As in previous work (O' Riordan, Howard, & Gallagher, 2019), a maths task and speech task were used as our stressor; the maths task, was the paced auditory serial addition test (PASAT) (Gronwall, 1977). This task used within laboratory-based studies and has been found to successfully perturb the cardiovascular system (Gallagher et al., 2014; Riordan, Howard, & Gallagher, 2019). For this, participants have to listen to a 5-minute audio track where single digit numbers are read aloud via computer. They are required to retain the previous number and add it to the subsequent number called out; numbers are presented at a rate of 2.4 seconds during the first minute with the speed of presentation increasing by .4 seconds for each subsequent minute of the task. The experimenter was sitting behind a screen while recording the answers. Following this, participants had to give a 4-minute speech, where they were given two minutes to prepare and, while in the same position, were instructed to describe and provide real life examples of three of their best and worst characteristics (Bosch et al., 2009; O'Riordain et al. 2019). If participants ceased speaking during the four-minute period, they were prompted to continue. The order of these tasks was counterbalanced. To heighten the sense of stress, our experimenters wore laboratory coats and the testing was done in reduced light with a spotlight illuminating the participant.

2.4. Procedure

Prior to laboratory arrival, participants were sent a study information sheet; those eligible and who agreed to take part attended a 45-minute testing session at our health and psychophysiology laboratory. On arrival, adherence to the inclusion and exclusion criteria were established, those not adhering were rescheduled. Once consented and the completed demographic questionnaire were collated, height and weight for calculation of body mass index (BMI) were completed. The participant was then seated at a desk by the spotlight and to control for unnecessary movement had to place their feet in a box as this may affect cardiovascular measures (Pickering et al., 2005). A 20-minute laboratory and cardiovascular acclimatization period followed and here the social support measures were completed, then formal baseline cardiovascular measures were taken for 10 minutes. During the baseline period, once questionnaires were completed participants were provided reading material, to facilitate a 'vanilla' baseline in which participants engage in minimally demanding tasks during baseline cardiovascular assessment. Following the baseline, and 1-minute before the stress task began, the researcher asked the participant to complete the pre-stress task rating questionnaire then the task began. After completing the task, the post-task stress questionnaire was administered and the blood pressure cuff removed. Finally, participants were thanked and were provided with a debriefing sheet.

2.5. Data analyses

Prior to analyses data were screened for normality and assumptions of fit. Data for all our CVR indices were normally distributed, i.e. all *p*'s for Kolmogorov-Smirnov and Shapiro-tests were > . 08; no outliers were identified; multicollinearity diagnostics were also performed on our predictors and VIF values were all below 1.89. In our initial analyses, tests of difference and Pearson's bivariate correlations checked for age, sex, relationship, smoking, family history of heart disease, BMI and other socio-demographic differences/associations with our outcome variables. This was followed up with repeated measures analysis of variance (ANOVA) to confirm whether our task was physiologically and psychologically stressful. A series of hierarchal linear regressions were used to test our main hypotheses. Each CVR parameter was entered as a dependent variable, with separate analyses run for each parameter. Confounding variables (e.g. gender, BMI, ethnicity and relationship status, baseline blood pressure and heart rate) including task order entered at Step 1 of the model and predictor variables (giving and receiving both emotional and instrumental social support) were each entered separately at Step 2. When testing independent effects of support giving and receiving, support giving variables were entered in Step 2, and receiving variables at Step 3. Partial Eta-squared (η^2), adjusted R^2 were used as an indicators of effect size. For illustrative purposes, and to help create reference groups (Kupper, Denollet, Widdershoven, & Kop, 2015; Sherwood et al., 2017) for future prognostic research, when any, significant associations were observed, we trichotomised social support using percentiles of the total scale with error bars (SE) reflective of the mean of each score.

3. Results

3.1. Descriptive Statistics

Descriptive and correlation statistics for main psychological and cardiovascular variables are reported in Table 1. The means for receiving emotional and instrumental social support and giving instrumental support are similar to normative values for the scale, our mean scores for giving emotional support is slightly higher (Shakespeare-Finch & Obst, 2011). As can be seen from Table 1, all the social support variables were positively correlated with each other. Giving emotional support was positively associated with SBP and DBP mean task values, i.e., those who reporting giving higher support had higher resting values, whereas giving instrumental support was positively associated with both baseline and task values for SBP and DBP. Receiving emotional support was also positively correlated with mean task SBP and DBP and receiving instrumental support correlated with mean SBP to the task.

[Insert Table 1 about here]

3.2. Manipulation check

Repeated measures (baseline, task) ANOVAs confirmed that the stress task increased cardiovascular responses for: SBP, *F*(1, 81) = 191.6, $p < .001$, $\eta_p^2 = .70$; DBP, *F*(1, 81) = 232.9, $p < .001$, $\eta_p^2 = .74$; HR, *F*(1,81) = 110.7, $p < .001$, $\eta_p^2 = .55$; CO, *F*(1,81) = 29.6, $p < .001$, $\eta_p^2 = .27$; TPR, *F*(1,81) = 14.5, $p < .001$, $\eta_p^2 = .15$. Further, repeated measures ANOVAs also revealed a significant increase from pre- to post-task rating of self-reported stress, *F*(1, 81) =56.31, $p < .001$, $\eta_p^2 = .41$. These are illustrated in Figure 1a, 1b and Ic.

[Insert Figure 1a, 1b and 1c About Here]

There were no differences in CVR across stress tasks. There were also sex differences on resting CVR values, such that men had higher SBP, women had higher HR, lower CO and higher TPR. For our social support measures there were no significant sex differences for giving instrumental or receiving social support, women were more likely to give emotional support (22.2 (2.95) vs 20.4 (5.14)) compared to men, *F*(1, 81) = 4.24, *p* = .04. There were no significant associations between age and smoking status and any of our cardiovascular outcomes. BMI was positively associated with resting SBP, *r* = .28,*p* = .03 and CO, *r* = .27,*p* = .04, and negatively associated with resting HR = -.27., *p* = .03. It was also positively associated with SBP reactivity, *r* =. 29, *p* = .009. Whites/Caucasians compared to others, *F*(1, 81) = 4.69, *p* = .03, and those who were in a relationship compared to those who weren't, *F*(1, 81) = 6.22, *p* = .01, had higher resting SBP. Thus, the above confounds were controlled for in relevant analyses.

3.3. Associations between giving social support and cardiovascular reactivity.

In the model for giving emotional support, there were no associations for HR, CO or TPR. However, significant positive associations with SBP, β = .25, 95% CI [0.04, 1.26], t = 2.12, p = .037, ΔR^2 = .05, and DBP, β = .28, 95% CI [0.08, .74], t = 2.49, p = .01, ΔR^2 = .07, such that those who reported giving more emotional support to others had higher SBP and DBP reactions to the stress task (see Figure 2). While for the model on giving instrumental social support, there were no associations with any CVR indices, all *p's* >.10. Finally, we re-ran the analyses but this time we added pre and post subjective task stress ratings and the results above remained the same.

[Insert Figure 2 About Here]

3.4. Associations between receiving social support and cardiovascular reactivity

Those participants who reported receiving emotional support from others had higher, SBP, β = .29, 95% CI [0.11, 1.00], t = 2.53, p = .01, ΔR^2 = .07, and DBP, β = .32, 95% CI [0.11, .57], t = 2.96, p = .004, ΔR^2 = .10, reactivity to the task (see Figure 3). Receiving emotional support was not associated with CO, HR or TPR, all *p's* > .1. In the regression models of receiving instrumental social support, a broadly analogous picture emerged, with DBP β = .27, 95% CI [0.09, .97], t = 2.43, p = .018, ΔR^2 = .07 (see Figure 4), with SBP non-significant, albeit close to the critical value SBP, β = .22, 95% CI [-.02, 1.63], t = 1.93, p = .06, ΔR^2 = .05. No significant associations emerged for HR, CO or TPR, all *p's* >.20. Further, results also withstood adjustment of pre-post task stress ratings.

[Insert Figure 3 & 4 About Here]

3.5. Sensitivity Analysis: Is it better to give or receive emotional or instrumental social support for SBP and DBP reactivity?

A series of hierarchical linear regressions were again conducted with the same confounders entered at Step 1, followed by giving emotional support at Step 2, and receiving emotional support at Step 3. As can be seen in Table 2, giving emotional support was no longer significant for both SBP, and DBP reactivity at Step3. However, receiving emotional social support was still significant in these models, SBP, and DBP, and explained an additional 6% of the variance. A similar regression was performed on receiving instrumental support and here instrumental giving was added at Step 2 and receiving instrumental at Step 3. In this analysis, receiving instrumental, but not giving instrumental social support remained significant for DBP, and explained an additional 9% of the variance (See Table 2).

[Insert Table 2 about here]

4. Discussion

This study sought to build on previous research on giving and receiving social support for CVR to acute psychological stress. Our findings show that while there were no associations between giving and receiving either emotional or instrumental support on HR, CO or TPR reactivity, there were significant effects for SBP and DPB. In particular, we found that both *giving* and *receiving* emotional social support were positively associated with SBP and DPB reactivity to the stress task, such that those reporting giving more support to others or receiving more from others had higher CVR responses to the task; for giving it was SBP/DPB and receiving DPB. While giving instrumental support was not associated with CVR, receiving social support was positively associated with DBP reactivity, insofar as those receiving more instrumental support had higher CVR reactivity. Moreover, these remained significant following adjustment for several confounding factors including, sex, BMI, and baseline blood pressure. While we expected that the effects of giving would be stronger than receiving similar size beta weights were seen for the associations above. Further, we found receiving emotional and instrumental support to be more influential compared to giving as the association between giving emotional and instrumental social support and CVR were abolished after adjusting for receiving social support.

Although not in the expected direction, our results concur with several other studies showing that receiving social support is influential on CVR reactions to acute psychological stress (Howard et al., 2017; Phillips et al., 2009; Thorsteinsson & James, 1999). While these other studies have found a stress-buffering effect of social support, i.e. an attenuation of CVR responses, this study observed an increase in CVR for both SBP and DBP. Although an augmented CVR was evident in females who were supported by female friends' relative to female strangers (Phillips et al., 2009). Moreover, it is worth noting that not all studies find a buffering effect of social support on CVR, rather, some such as this study, find that support, including real life social support, is also associated with higher CVR reactivity (Lee, Suchday, & Wylie-Rosett, 2015; McMahon, Creaven, & Gallagher, 2020; Roy, Steptoe, & Kirschbaum, 1998). In those previous studies they had manipulated support in the laboratory by providing social support to those undergoing a stress task. This was unlike the present study were support was not provided or manipulated. Thus, it could be that support in real life, as assessed in this study, functions as an individual difference variable, which has been suggested by others (Sarason, Sarason, & Shearin, 1986). In addition, some researchers suggest that social support may also facilitate engagement with stressors (Roy et al., 1998) and assist with active coping, which may be the case here. Active stressors (e.g. speech/maths) are those where you may influence an outcome whereas passive (e.g. cold pressor) one you have less ability to influence the outcome(Obrist, 1981). An alternative, would be to consider that under certain conditions acute stress responses compared to coping with prolonged chronic stress are often healthful, for example, acute stress can be immunoenhancing whereas chronic stress is damaging (Segerstrom & Miller, 2004). Thus, perhaps the stress buffering hypothesis is supported. Further, both higher and lower CVR reactions to acute psychological stress have been found to have adverse health effects (Phillips & Hughes, 2011), and what we may be evidencing here is a moderate or optimally healthy response to stress (Lovallo, 2011). Moreover, in terms of clinical significance, it is worth noting that extremely low DBP (−2.4 ± 5.4 mm Hg) and SBP (4±6 mm Hg) have been found to predict CHD mortality (Kupper et al., 2015; Sherwood et al., 2017).

In the present study, emotional support was more likely to be related to SBP and DBP across our analyses than instrumental support. This finding is consistent with laboratory studies where emotional support received from others is associated with CVR (Uchino et al., 2011). Our finding for receiving emotional support in real life is similar to recent evidence suggesting that subjective receipt of affectionate support in real life was associated with increased CVR to acute stress (McMahon et al., 2020). In the present study, and elsewhere (Wilson et al., 1999), there is also evidence that receiving instrumental support is important for CVR, although the present study is the first to investigate the relationship between subjective instrumental support received in real life and CVR, rather than enacted support. More interestingly, however, our findings on giving social support are also consistent with other studies showing that giving support influences CVR reactivity (Inagaki & Eisenberger, 2016; Whillans et al., 2016). However, our results, while showing that both self-reported giving and receiving emotional support independently influences CVR, also suggests that the self-reported effects of giving are abolished after controlling for receiving. Thus, while both giving and receiving social support appear to be health protective (Eisenberger, 2013; Inagaki & Orehek, 2017; Poulin et al., 2013; Shakespeare-Finch & Obst, 2011), the findings of the present study seem to suggest that for CVR (Inagaki et al., 2016), it might be better to receive support.

There are several strengths to our study, including extending on the stress buffering hypothesis and CVR literature, and the robust study design employed. However, there are several limitations that must be acknowledged. First, the cross-sectional observational design means that causation cannot be inferred (Christenfeld, Sloan, Carroll, & Greenland, 2004). Second, this study relied on self-report measures of giving and receiving social support. Although this could be measured in several ways (e.g. enacted, experimental manipulation) our aim was to capture support in real life and these scales are frequently used for this type of assessment. Nonetheless, the limitations of self-report measures, including issues of social desirability bias, are acknowledged. As such our findings are for self-reports of social support, and as such the results may differ according to experimental manipulations of both giving and receiving support. Further, it must be noted that while no significant effects for hemodynamic variables (i.e. TPR, CO) were observed, this may be a result of the stressor employed within the present study which incorporates both active and passive stress components. Both active and passive stress components are known to elicit differing hemodynamic response profiles (O'Suilleabhain, Howard, & Hughes, 2018), which may have resulted in an inability to observe significant associations within the present study. Of course, our findings require replication, in particular with respect to giving social support, which is a relatively novel construct with implications for stress responding.

In conclusion, the present study adds to emerging evidence linking giving social support to health as well as to research investigating associations between perceptions of both *giving* and *receiving* social support and CVR to acute stress. In particular, we have found that giving and receiving emotional social support, in particular, in real life is associated with CVR reactivity. Finally, in the content of CVR, while the concept of giving emotional social support was beneficial, the effects did not withstand adjustment for receiving emotional support.

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5. References

AAMI. (2020). Recommendations and Practical Guidance for performing and reporting validation studies according to the Universal Standard for the validation of blood pressure measuring devices by the Association for the Advancement of Medical Instrumentation/European Society of Hypertension/International Organization for Standardization (AAMI/ESH/ISO): Erratum. *J Hypertens, 38*(3), 561. doi:10.1097/HJH.0000000000002383

Birmingham, W. C., & Holt-Lunstad, J. (2018). Social aggravation: Understanding the complex role of social relationships on stress and health-relevant physiology. *Int J Psychophysiol, 131*, 13-23. doi:10.1016/j.ijpsycho.2018.03.023

Brown, S. L., Nesse, R. M., Vinokur, A. D., & Smith, D. M. (2003). Providing social support may be more beneficial than receiving it: results from a prospective study of mortality. *Psychol Sci, 14*(4), 320-327. doi:10.1111/1467-9280.14461

Christenfeld, N. J., Sloan, R. P., Carroll, D., & Greenland, S. (2004). Risk factors, confounding, and the illusion of statistical control. *Psychosom Med, 66*(6), 868-875. doi:10.1097/01.psy.0000140008.70959.41

Cohen, S., & Wills, T. A. (1985). Stress, social support, and the buffering hypothesis. *Psychol Bull, 98*(2), 310-357. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/3901065

Eisenberger, N. I. (2013). An empirical review of the neural underpinnings of receiving and giving social support: implications for health. *Psychosom Med, 75*(6), 545-556. doi:10.1097/PSY.0b013e31829de2e7

Gallagher, S., Meaney, S., & Muldoon, O. (2014). Social identity influences stress appraisals and cardiovascular reactions to acute stress exposure. *British Journal of Health Psychology, 19*(3), 566-579. doi: 510.1111/bjhp.12056. Epub 12013 Jun 12018.

Gallagher, S., O'Riordan, A., McMahon , G., & Creaven, A. (2019). Evaluating personality as a moderator of the association between life events stress and cardiovascular reactivity to acute stress. *International Journal of Psychophysiology, 126*(52-59. doi: 10.1016/j.ijpsycho).

Gronwall, D. M. (1977). Paced auditory serial-addition task: a measure of recovery from concussion. *Percept Mot Skills, 44*(2), 367-373. doi:10.2466/pms.1977.44.2.367

Hemingway, H., & Marmot, M. (1999). Clinical Evidence: Psychosocial factors in the etiology and prognosis of coronary heart disease: systematic review of prospective cohort studies. *West J Med, 171*(5-6), 342-350. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/18751201

Holt-Lunstad, J., Smith, T. B., & Layton, J. B. (2010). Social relationships and mortality risk: a meta-analytic review. *PLoS Med, 7*(7), e1000316. doi:10.1371/journal.pmed.1000316

Howard, S., Creaven, A. M., Hughes, B. M., O'Leary, E. D., & James, J. E. (2017). Perceived social support predicts lower cardiovascular reactivity to stress in older adults. *Biol Psychol, 125*, 70-75. doi:10.1016/j.biopsycho.2017.02.006

Howard, S., & Hughes, B. M. (2012). Benefit of social support for resilience-building is contingent on social context: examining cardiovascular adaptation to recurrent stress in women. *Anxiety Stress Coping, 25*(4), 411-423. doi:10.1080/10615806.2011.640933

Inagaki, T. K., Bryne Haltom, K. E., Suzuki, S., Jevtic, I., Hornstein, E., Bower, J. E., & Eisenberger, N. I. (2016). The Neurobiology of Giving Versus Receiving Support: The Role of Stress-Related and Social Reward–Related Neural Activity. *Psychosomatic Medicine, 78*(4), 443-453. doi:10.1097/psy.0000000000000302

Inagaki, T. K., & Eisenberger, N. I. (2016). Giving support to others reduces sympathetic nervous system-related responses to stress. *Psychophysiology, 53*(4), 427-435. doi:10.1111/psyp.12578

Inagaki, T. K., & Orehek, E. (2017). On the Benefits of Giving Social Support: When, Why, and How Support Providers Gain by Caring for Others. *Current Directions in Psychological Science, 26*(2), 109-113. doi:10.1177/0963721416686212

Kuper, H., Marmot, M., & Hemingway, H. (2002). Systematic review of prospective cohort studies of psychosocial factors in the etiology and prognosis of coronary heart disease. *Semin Vasc Med, 2*(3), 267-314. doi:10.1055/s-2002-35401

Kupper, N., Denollet, J., Widdershoven, J., & Kop, W. J. (2015). Cardiovascular reactivity to mental stress and mortality in patients with heart failure. *JACC Heart Fail, 3*(5), 373-382. doi:10.1016/j.jchf.2014.12.016

Lee, Y. S., Suchday, S., & Wylie-Rosett, J. (2015). Social support and networks: cardiovascular responses following recall on immigration stress among Chinese Americans. *J Immigr Minor Health, 17*(2), 543-552. doi:10.1007/s10903-013-9955-9

Lovallo, W. R. (2011). Do low levels of stress reactivity signal poor states of health? *Biol Psychol, 86*(2), 121-128. doi:10.1016/j.biopsycho.2010.01.006

McDowell, T. L., & Serovich, J. M. (2007). The effect of perceived and actual social support on the mental health of HIV-positive persons. *AIDS Care, 19*(10), 1223-1229. doi:10.1080/09540120701402830

McMahon, G., Creaven, A. M., & Gallagher, S. (2020). Perceived social support mediates the association between attachment and cardiovascular reactivity in young adults. *Psychophysiology, 57*(3), e13496. doi:10.1111/psyp.13496

Mookadam, F., & Arthur, H. M. (2004). Social support and its relationship to morbidity and mortality after acute myocardial infarction: systematic overview. *Arch Intern Med, 164*(14), 1514-1518. doi:10.1001/archinte.164.14.1514

O'Donovan, A., & Hughes, B. M. (2008). Access to social support in life and in the laboratory: combined impact on cardiovascular reactivity to stress and state anxiety. *J Health Psychol, 13*(8), 1147-1156. doi:10.1177/1359105308095968

O'Riordan, A., Howard, S., & Gallagher, S. (2019). Social Context and Sex Moderate the Association Between Type D Personality and Cardiovascular Reactivity. *Appl Psychophysiol Biofeedback, 44*(4), 321-330. doi:10.1007/s10484-019-09447-x

O'Suilleabhain, P. S., Howard, S., & Hughes, B. M. (2018). Openness to experience and stress responsivity: An examination of cardiovascular and underlying hemodynamic trajectories within an acute stress exposure. *PLoS One, 13*(6), e0199221. doi:10.1371/journal.pone.0199221

Obrist, P. A. (1981). Cardiovascular Psychophysiology A Perspective. *Springer US, Plenum Press, New York*. doi:10.1007/978-1-4684-8491-5

Obst, P., Shakespeare-Finch, J., Krosch, D. J., & Rogers, E. J. (2019). Reliability and validity of the Brief 2-Way Social Support Scale: an investigation of social support in promoting older adult well-being. *SAGE Open Med, 7*, 2050312119836020. doi:10.1177/2050312119836020

Okamura, T., Ura, C., Miyamae, F., Sugiyama, M., Inagaki, H., Edahiro, A., . . . Awata, S. (2018). To give or to receive: Relationship between social support giving/receiving and psychometrics in a large-scale survey. *Int J Geriatr Psychiatry, 33*(5), 798-799. doi:10.1002/gps.4853

Phillips, A. C., Gallagher, S., & Carroll, D. (2009). Social support, social intimacy, and cardiovascular reactions to acute psychological stress. *Ann Behav Med, 37*(1), 38-45. doi:10.1007/s12160-008-9077-0

Phillips, A. C., & Hughes, B. M. (2011). Introductory paper: Cardiovascular reactivity at a crossroads: where are we now? *Biol Psychol, 86*(2), 95-97. doi:10.1016/j.biopsycho.2010.03.003

Pickering, T. G., Hall, J. E., Appel, L. J., Falkner, B. E., Graves, J., Hill, M. N., . . . Public Education of the American Heart Association Council on High Blood Pressure, R. (2005). Recommendations for blood pressure measurement in humans and experimental animals: Part 1: blood pressure measurement in humans: a statement for professionals from the Subcommittee of Professional and Public Education of the American Heart Association Council on High Blood Pressure Research. *Hypertension, 45*(1), 142-161. doi:10.1161/01.HYP.0000150859.47929.8e

Piferi, R. L., & Lawler, K. A. (2006). Social support and ambulatory blood pressure: an examination of both receiving and giving. *Int J Psychophysiol, 62*(2), 328-336. doi:10.1016/j.ijpsycho.2006.06.002

Poulin, M. J., Brown, S. L., Dillard, A. J., & Smith, D. M. (2013). Giving to others and the association between stress and mortality. *American journal of public health, 103*(9), 1649-1655. doi:10.2105/AJPH.2012.300876

Preston, S. D. (2013). The origins of altruism in offspring care. *Psychol Bull, 139*(6), 1305-1341. doi:10.1037/a0031755

Reader, A. T., & Holmes, N. P. (2016). Examining ecological validity in social interaction: problems of visual fidelity, gaze, and social potential. *Culture and Brain, 4*(2), 134-146. doi:10.1007/s40167-016-0041-8

Riordan, A., Howard, S., & Gallagher, S. (2019). Social Context and Sex Moderate the Association Between Type D Personality and Cardiovascular Reactivity. *Applied Psychophysiology Biofeedback., doi: 10.1007/s10484-019-09447-x*

Roy, M. P., Steptoe, A., & Kirschbaum, C. (1998). Life events and social support as moderators of individual differences in cardiovascular and cortisol reactivity. *J Pers Soc Psychol, 75*(5), 1273-1281. doi:10.1037//0022-3514.75.5.1273

Sarason, I. G., Sarason, B. R., & Shearin, E. N. (1986). Social support as an individual difference variable: Its stability, origins, and relational aspects. *Journal of Personality and Social Psychology, 50*(4), 845-855. doi:https://doi.org/10.1037/0022-3514.50.4.845

Segerstrom, S. C., & Miller, G. E. (2004). Psychological stress and the human immune system: a meta-analytic study of 30 years of inquiry. *Psychol Bull, 130*(4), 601-630. doi:10.1037/0033-2909.130.4.601

Shakespeare-Finch, J., & Obst, P. L. (2011). The development of the 2-Way Social Support Scale: a measure of giving and receiving emotional and instrumental support. *J Pers Assess, 93*(5), 483-490. doi:10.1080/00223891.2011.594124

Sherwood, A., Hill, L. K., Blumenthal, J. A., Adams, K. F., Jr., Paine, N. J., Koch, G. G., . . . Hinderliter, A. L. (2017). Blood pressure reactivity to psychological stress is associated with clinical outcomes in patients with heart failure. *American heart journal, 191*, 82-90. doi:10.1016/j.ahj.2017.07.003

Shutt, K., MacLarnon, A., Heistermann, M., & Semple, S. (2007). Grooming in Barbary macaques: better to give than to receive? *Biology letters, 3*(3), 231-233. doi:10.1098/rsbl.2007.0052

Thorsteinsson, E. B., & James, J. E. (1999). A Meta-analysis of the effects of experimental manipulations of social support during laboratory stress. *Psychology & Health, 14*(5), 869-886. doi:10.1080/08870449908407353

Trobst, K. K. (2000). An Interpersonal Conceptualization and Quantification of Social Support Transactions. *Personality and Social Psychology Bulletin, 26*(8), 971-986. doi:10.1177/01461672002610007

Uchino, B. N. (2006). Social support and health: a review of physiological processes potentially underlying links to disease outcomes. *J Behav Med, 29*(4), 377-387. doi:10.1007/s10865-006-9056-5

Uchino, B. N. (2009). Understanding the Links Between Social Support and Physical Health: A Life-Span Perspective With Emphasis on the Separability of Perceived and Received Support. *Perspect Psychol Sci, 4*(3), 236-255. doi:10.1111/j.1745-6924.2009.01122.x

Uchino, B. N., Carlisle, M., Birmingham, W., & Vaughn, A. A. (2011). Social support and the reactivity hypothesis: conceptual issues in examining the efficacy of received support during acute psychological stress. *Biol Psychol, 86*(2), 137-142. doi:10.1016/j.biopsycho.2010.04.003

Uchino, B. N., & Garvey, T. S. (1997). The availability of social support reduces cardiovascular reactivity to acute psychological stress. *J Behav Med, 20*(1), 15-27. doi:10.1023/a:1025583012283

Väänänen, A., Buunk , B., Kivimäki, M., Pentti, J., & Vahtera, J. (2005). When it is better to give than to receive: long-term health effects of perceived reciprocity in support exchange. . *J Pers Soc Psychol, 89*(2), 176-193 doi: doi:10.1037/0022-3514.89.2.176

Wethington, E., & Kessler, R. C. (1986). Perceived support, received support, and adjustment to stressful life events. *J Health Soc Behav, 27*(1), 78-89. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/3711634

Whillans, A. V., Dunn, E. W., Sandstrom, G. M., Dickerson, S. S., & Madden, K. M. (2016). Is spending money on others good for your heart? *Health Psychol, 35*(6), 574-583. doi:10.1037/hea0000332

Wilson, D. K., Kliewer, W., Bayer, L., Jones, D., Welleford, A., Heiney, M., & Sica, D. A. (1999). The influence of gender and emotional versus instrumental support on cardiovascular reactivity in African-American adolescents. *Ann Behav Med, 21*(3), 235-243. doi:10.1007/BF02884840

Table 1

Descriptive statistics and correlational analysis for main study variables

Variables	Mean (SD)		1	2	3	4	5	6	7	8	9	10	11	12	13
1. Give Emotional Support	21.4(4.13)	1.0 – 25.0													
2. Give Instrumental Support	14.8(3.6)	2.0- 20.0	.52**												
3. Receive Emotional Support	30.1(5.53)	10.0-35.0	.30**	.35**											
4. Receive Instrumental Support	16.8(3.19)	8.0 – 20.0	.30**	.32**	.66**										
5. Baseline SBP	125.1(10.95)	102.6 – 147.4	.13	.33**	.19	.04									
6. Baseline DPB	75.6(8.09)	62.1- 111.5	.14	.22*	.11	.11	.70**								
7. Baseline HR	73.9 (10.60)	58.0– 100.5	.05	-.06	-.14	-.01	-.13	.07							
8. Baseline CO	6.1(1.47)	3.6-10.3	-.06	.10	.05	.01	.09	-.36**	.23*						
9. Baseline TPR	1.0 (.29)	0.5- 2.18	.07	.04	.00	.03	.30**	.71**	-.08	-.83**					
10. Task SBP	143.1 (17.06)	105.3 –192.6	.27*	.34**	.34**	.21	.73**	.53**	-.02	.18	.17				
11.Task DBP	86.8(11.33)	66.9 – 129.4	.27*	.24*	.28*	.24*	.52**	.81**	.11	-.27*	.58**	.73*			
12. Task HR	84.8(11.20)	61.4 -110.9	.10	-.06	-.07	-.03	-.07	.11	.90**	0.17	-.01	0.14	.26*		
13. Task CO	6.6(1.93)	2.4-11.9	.02	.09	.08	.06	.03	-.38**	.19	.92**	-.79**	.27*	-.23*	.22*	
14. Task TPR	1.1 (0.48)	.58-5.31	.09	.08	.10	.10	.21	.58**	-.01	-.67**	.80**	0.18	.66**	.02	-.76**

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 2. Hierarchical regressions predicting SBP and DBP reactivity from giving and receiving emotional social support and giving and receiving instrumental support on DBP reactivity

Variables	β	t	p	R^2	ΔR^2
SBP model: Step 1				.13	
Sex	-.06	-.53	.59		
BMI	.20	2.78	.08		
Ethnicity	-.13	-1.15	.25		
Relationship status	.00	0.03	.75		
Task order	-.09	-0.86	.39		
Baseline SBP	.02	0.16	.86		
Step 2				**.20**	**.06**
Giving emotional support	.20	1.72	.09		
Step 3				**.26**	**.06**
Receiving emotional support	.28	2.37	**.02**		
DBP Model: Step 1				.09	
Sex	-.00	-.06	.95		
BMI	.13	1.14	.26		
Ethnicity	-.09	-0.88	.38		
Relationship status	-.03	-0.26	.79		
Task order	.00	0.06	.95		
Baseline DBP	.10	0.89	.38		
Step 2				**.15**	**.06**
Giving emotional support	.10	1.65	.10		
Step 3				**.21**	**.06**
Receiving emotional support	.26	2.17	**.03**		
DBP Model: Step 1				.09	
Sex	.03	-.30	.76		
BMI	.14	1.20	.23		
Ethnicity	-.11	-1.01	.31		
Relationship status	-.01	-0.09	.93		
Task order	.01	0.09	.93		
Baseline DBP	.13	1.10	.27		
Step 2				.09	.00
Giving instrumental support	0.09	-.80	.43		
Step 3				**.18**	**.09**
Receiving instrumental support	.34	2.72	**.008**		

Bold font represents significant models

Figure 1: Baseline and task values for the cardiovascular indices (1a, 1b) and pre-post stress task ratings (1b)

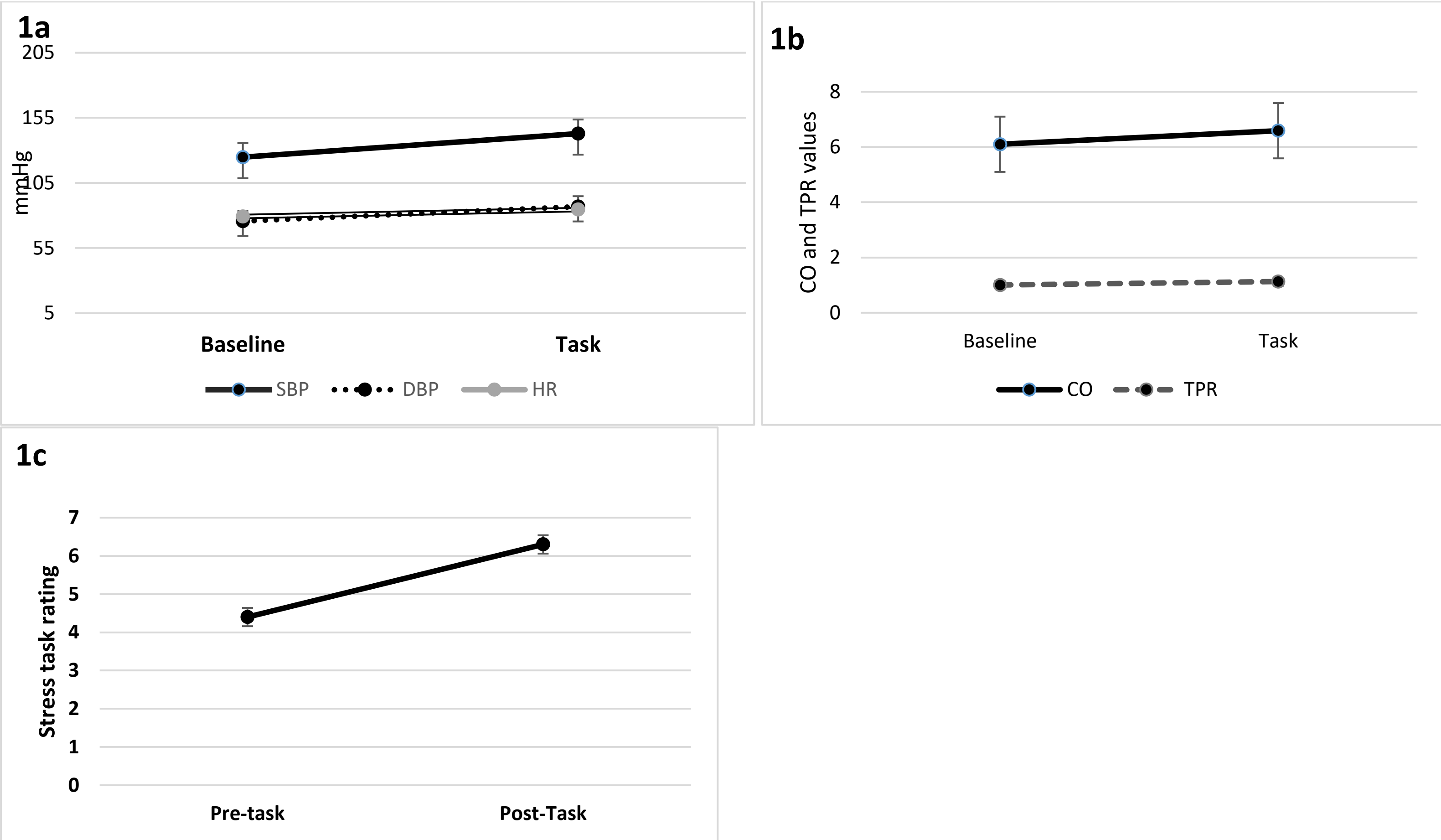

Figure 2. Associations between *giving emotional* social support and CVR reactivity for a) SBP and b) DBP, controlling for confounding variables

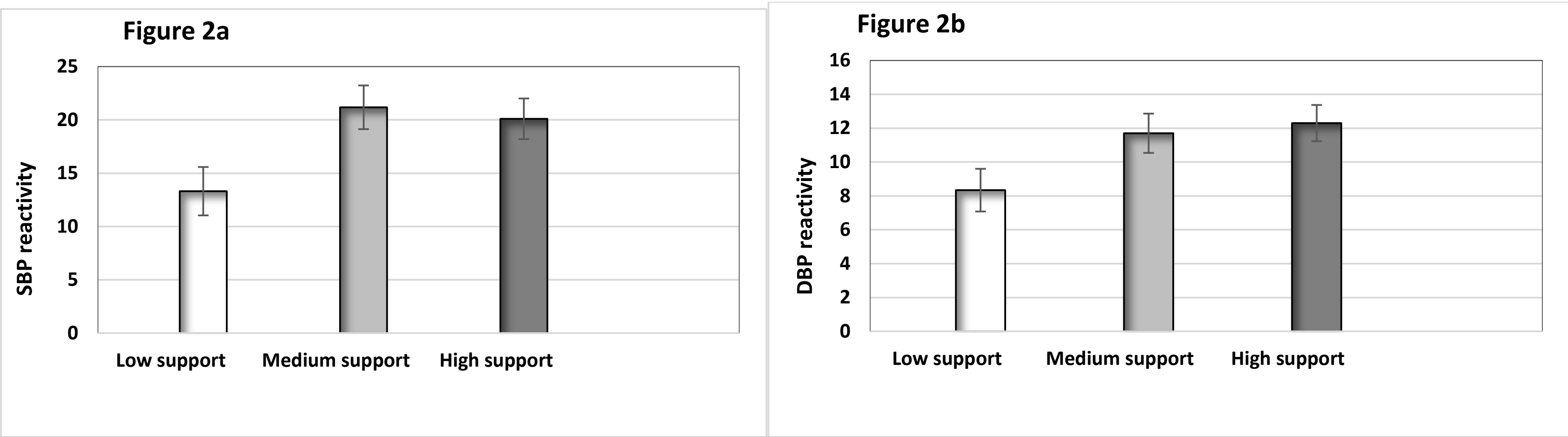

Figure 3. Associations between *receiving emotional* social support and CVR reactivity for a) SBP and b) DBP, controlling for confounding variables

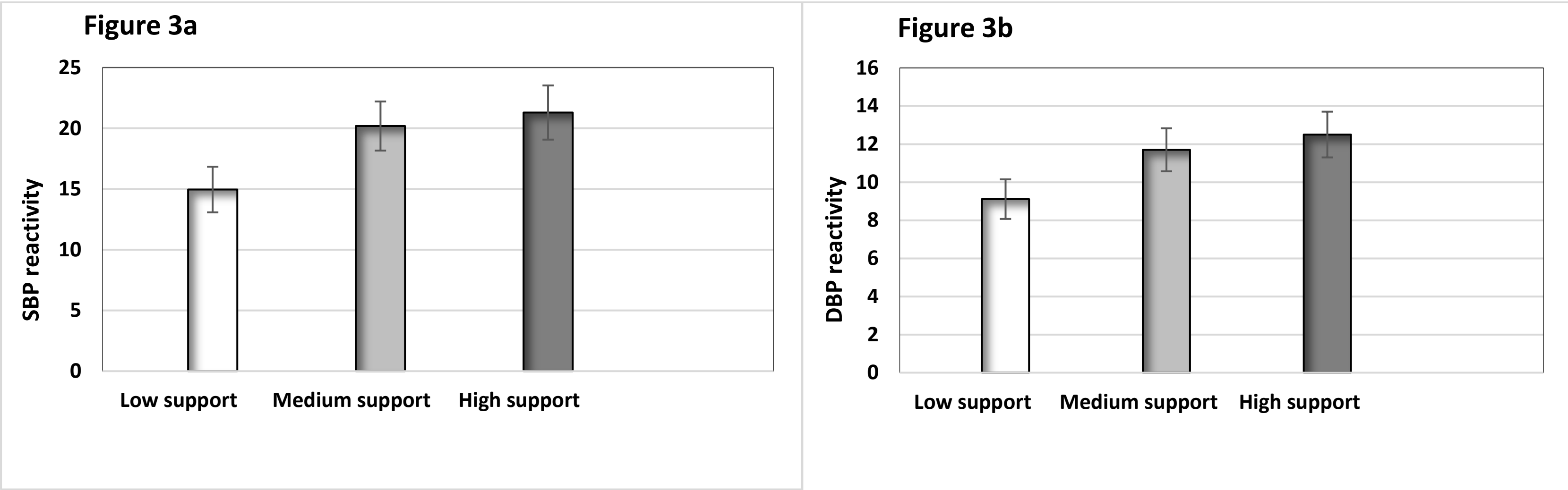

Figure 4. Associations between *receiving instrumental* social support and DBP reactivity, controlling for confounding