The Impact of Physical Proximity and Attachment Working Models on Cardiovascular Reactivity: Comparing Mental Activation and Romantic Partner Presence

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Abstract

Close relationships, especially high-quality romantic relationships, are consistently associated with positive physical health outcomes. Attenuated cardiovascular reactivity is one physiological mechanism implicated in explaining these effects. Drawing on Attachment and Social Baseline theories, this experimental study evaluated two potential affiliative cues as mechanisms through which romantic relationships may attenuate cardiovascular reactivity to a laboratory-based stressor. Prior to a cold pressor task, 102 participants were randomly assigned to either have their partner physically present, call upon a mental representation of their partner, or think about their day during the stressor. Consistent with our preregistered hypotheses, participants in both the partner present and mental activation conditions had significantly lower blood pressure (BP) reactivity during the cold pressor task compared to control participants for both systolic (d = -0.54) and diastolic BP (d = -0.53), but no significant differences emerged for heart rate or heart rate variability. Although participants in the partner present and mental activation conditions had similar BP reactivity to the cold pressor task, those in the partner present condition reported significantly less pain as a result of the task. The difference in BP reactivity by condition was moderated—BP reactivity was greater for people with lower self-reported relationship satisfaction. The results suggest that accessing the mental representation of a romantic partner and a partner's presence each buffer against exaggerated acute stress responses to a similar degree.

Keywords: Attachment Theory, Social Baseline Theory, cardiovascular reactivity, romantic relationships, heart rate variability, heart rate, blood pressure

1. Introduction

Close relationships are central to human health and provide an essential interpersonal context that affects psychological and physical wellbeing (Sbarra & Coan, 2017). People who are married or who have higher social support, for example, live longer than those who are unmarried or have low social support (Holt-Lunstad, Smith, & Layton, 2010; Sbarra, Law, & Portley, 2011; Shor, Roelfs, Bugyi, & Schwartz, 2012). Close relationships, and specifically romantic relationships, can affect health by attenuating responses to stressful stimuli (Butler & Randall, 2012; Cohen, 2004). When facing stressful situations, romantic partners may act as a psychological resource for coping, and these resources can in turn buffer against exaggerated physiological reactivity (Coan, Schaeffer, & Davidson, 2006; Cohen & Wills, 1985; Sbarra & Hazan, 2008). Relatively few experimental studies, however, have directly compared whether different types of affiliative cues, such as a partner's physical presence or drawing on a mental representation of a romantic partner, impact stress buffering to differing degrees.

Attachment Theory (Bowlby, 1982) and Social Baseline Theory (SBT; Beckes & Coan, 2011) provide complementary explanations for how stress buffering may operate on a day-to-day basis. Attachment Theory highlights the central role of early caregiving experiences in shaping the development of attachment styles—the characteristic ways in which people think and behave in relationships. Attachment styles, often referred to as relationship orientations (see Pietromonaco, & Collins, 2017), are typically operationalized along two relatively dimensions: anxiety and avoidance. People who are relatively secure are low on both dimensions and view close others are sources of support and a secure base from which to experience the world; in contrast, people high in avoidance and anxiety, both forms of attachment insecurity, view close others as either unresponsive or unpredictable with respect to their attachment needs, and this can shapes emotion regulatory responding. Importantly, attachment styles are believed to be carried forward into adulthood and impact self-regulatory capacity (Fraley, Roisman, Booth-LaForce, Owen, & Holland, 2013). People's ability to call on *working models* of attachment figures (Collins & Read, 1994), independent of their attachment orientation, can enhance self-regulatory capacity even when partners are not physically present (Collins & Feeney, 2004), which may be a core ingredient of successful stress buffering (Cohen & Wills, 1985). For example, accessing internal representations of more supportive relationship targets appears to attenuate affective and physiological response during subsequent stressors (Bloor, Uchino, Hicks, & Smith, 2004). In a similar study, thinking about a close friend buffered against blood pressure (BP) reactivity to a stressful task compared to thinking about an acquaintance (Smith, Ruiz, & Uchino, 2004). Drawing on the working model of one's partner may shape secondary appraisal processes (Lazarus & Folkman, 1984), providing psychological resources to navigate demanding or threatening situations (Bloor et al., 2004).

Social Baseline Theory (SBT; Beckes & Coan, 2011) complements Attachment Theory and proposes that social proximity and interaction helps people conserve biological resources by sharing the burden associated with environmental risk and threat, which has the potential to improve health over the long term (Beckes & Coan, 2011; Coan & Maresh, 2014; Coan & Sbarra, 2015). Relative to facing a stressful situation alone, SBT suggests that people may perceive less threat when a partner is present and that this effect operate via a primary appraisal of threat. The physical proximity of a romantic partner or other close other allows people to "share the load" associated with threatening stimuli, requiring the deployment of fewer physiological resources. For example, wives' neural response to threat is attenuated when holding the hand of a spouse compared to holding the hand of an opposite-sex stranger or being alone (Coan et al., 2006). Notably, relationship quality moderated this association, such that wives in higher quality marriages had the greatest reduction in their neural responses.

One physiological pathway through which romantic relationships might impact long-term health is cardiovascular reactivity (CVR). Greater CVR is associated with greater disease progression and is a risk factor for cardiovascular disease (Chida & Steptoe, 2010; Treiber et al., 2003). Daily experience of CVR may affect the cardiovascular system by increasing left ventricular mass or higher levels of carotid atherosclerosis, which are associated with increased risk of cardiovascular disease and mortality (Manuck et al., 2005; Matthews, Zhu, Tucker, & Whooley, 2006, Treiber et al., 2003). Laboratory studies using standardized acute stressors, such as the cold pressor task (Menkes et al., 1989) or Trier Social-Stress Test (Kirschbaum, 2015), find that affiliative cues, including the presence of a friend or romantic partner or mentally imagining a close friend, reduce CVR (Bloor et al., 2004; Feeney & Kirkpatrick, 1996; Kamarck, Manuck, & Jennings, 1990; Smith et al., 2004). CVR responses to lab stressors are associated with long-term health outcomes (Treiber et al., 2003). Attenuated CVR to these laboratory tasks may reflect less progression of pre-clinical cardiovascular disease states, such as left ventricular mass and carotid atherosclerosis, and better long-term health outcomes (Treiber et al., 2003).

Although mechanistic models linking relationship quality to health often cite CVR as a candidate pathway of interest (Robles, Slatcher, Trombello, & McGinn, 2014; Uchino, 2006), relatively few well-controlled experimental laboratory studies have directly compared the various affiliative cues that may explain physiological responding. At a broad level, SBT suggests that the presence of a romantic partner should reduce threat appraisals and thereby operate to minimize stress reactivity (Coan and Sbarra, 2015). Attachment Theory, in turn, holds that mentally drawing on one's working model of their partner should increase perceived social support (cf. Collins & Feeney, 2004) and thus provide increased psychological resources for managing task demands. Although prior research has examined physiological reactivity during stressful tasks when people mentally draw on close relationships (Bloor et al., 2004, Smith et al., 2004) and have a spouse physically present (Coan et al., 2006), no work has directly compared the effects on CVR of partner presence versus mentally accessing a working model of one's romantic partner.

1.1 Present Study

Two central questions arise regarding the link between romantic partners and CVR. First, does calling on the mental representation of a romantic partner differentially predict CVR compared to having a partner physically present? Second, to the extent that the presence of a partner and calling on a representation of a partner attenuate CVR, how might these effects operate? To answer these questions, the present study compared cardiovascular responses to a laboratory stressor among undergraduate students in a romantic relationship ($N = 102$) who were randomly assigned to either have a romantic partner present, access the mental representation of their partner, or think about their day as an active control. The preregistered hypotheses and analysis plan for this investigation are available online (https://osf.io/kdt9s). Specifically, we predicted that both participants who called on the representation of their partner and those whose partner were present would have significantly less CVR—in the form of decreased heart rate (HR) and blood pressure (BP), and increased heart rate variability (HRV)—compared to the control condition. Thus, a key part of this prediction is that participants in either affiliative conditions would not differ significantly in their CVR. In addition, as a conceptual replication of Coan et al. (2006), we hypothesized that romantic relationship satisfaction would moderate CVR, with lower CVR for people who reported higher relationship quality among people in either of the affiliative conditions. In exploratory analyses, we also examined whether the type of affiliative cue (partner presence versus mental activation) affected participants' appraisals of the cold pressor task and self-reported pain during the stressful task, but made no specific *a priori* hypotheses about these potential associations.

2. Method

2.1 Participants

A sample of undergraduate students in a romantic relationship (N = 102) at a large university were randomly assigned to one of three conditions, Partner Present, Mental Activation, or Control. The participants were 19.1 years old on average and predominantly female (75.5%), with an average relationship length of 20.6 months (SD = 17.2). The sample was generally diverse, with 46.0% reporting they were Caucasian and non-Hispanic. Additional demographics are included in Table 1. One-way ANOVAs evidenced there were not significant differences by condition in demographics or the baseline cardiovascular measures.

2.2 Procedure

Potentially eligible participants were recruited using screening questions embedded in a larger survey. Participants were eligible if they reported they were in a committed heterosexual romantic relationship of at least one month, their partner was present in the local metro area, they were fluent in English, at least 18 years old, and did not have any uncontrolled medical conditions. Eligible participants were randomized in approximately a 1/3 to 2/3rds ratio to receive an offer to participate in the study either alone (n = 326, 68.9%) or with their romantic partner (n = 147, 31.1%) via email and phone calls, to match the two conditions without a partner present to one condition with partners present. In total, 70 of the 326 participants (21.5%) offered participation alone and 32 of the 147 participants (21.8%) offered participation with their partner expressed interest and were enrolled in the study, the latter making up the Partner Present condition (*n* = 32). Participants who signed up to participate in the study alone were then randomized to either the Control (*n* = 35) or Mental Activation conditions (*n* = 35). Figure 1 outlines participant recruitment and randomization. The University of Arizona Institutional Review Board approved the study protocol.

The full laboratory procedure used by research assistants is available online at https://osf.io/2u9h3/. Once participants arrived, they were informed about the study procedure and completed self-report questionnaires. Participants' height and weight were measured by the research assistants using a digital scale and tape measure, and used to calculate body mass. The research assistants then attached the physiological sensors.

The lab portion of the study, outlined in Figure 2, then began with the participants completing a 10 minute vanilla baseline task (Jennings, Kamarck, Stewart, Eddy, & Johnson, 1992), in which they were asked to observe ten side-by-side nature scenes for 1-min. Once the baseline period was completed, a research assistant informed participants of the upcoming stressful task and asked them to wait for three minutes. Once this task anticipation period ended, participants reported on their appraisals of the upcoming task and were asked to place their foot in the water for four minutes. This limb immersion cold pressor task is used extensively in the literature (Menkes, 1989) and is linked to changes in cardiovascular activity in the peripheral vasculature (Allen, Shelley, & Bouquet, 1992; Mourot, Bouhaddi, & Regnard, 2009). Notably, much of the research in the stress-buffering literature uses psychological stressors, such as the Trier Social Stress Test (Kirschbaum, 2015). In the current study, we chose a physiological stressor to avoid social evaluative differences that occur when performing a psychological stressor in front of a romantic partner, which would occur in the Partner Present condition. The water was 38-40°F and approximately 3” depth. Seven participants either stated they couldn’t continue the cold pressor or took their foot out of the water during the task (Partner Present n = 2; Mental Activation n = 2; Control n = 3) and the data for these participants was collected for the task until this point. After the cold pressor task, participants were asked to wait for a ten minute recovery period, after which they completed an additional set of self-report assessments about the task.

2.2.1 Experimental Manipulations

The basic procedure varied slightly for each condition, resulting in the three randomly assigned experimental conditions.

Control Condition. Control condition participants were told prior to the cold pressor “*During the upcoming task, please think about your day and what has happened or will happen today.*”

Mental Activation Condition. Mental Activation participants were told “*For some people, thinking about their romantic partner can be helpful during tasks like this. So before you begin, I will ask you to close your eyes and take 30-seconds to come up with a detailed image of your romantic partner. Please try to create a careful image of his/her face, of him/her doing something, or of the two of you doing something together that you find supportive. The most important piece is that you concentrate carefully on creating a very vivid image that you can use to support you while you’re completing this task. For now, please take 30 seconds to come up with the image you can call on during the task.*” Then prior to the cold pressor these participants were told “*During this task, please try to focus on that image that you created of your partner and draw on it as if he/she was right here supporting you through the task. If you get distracted, just remember to turn your attention back to that image of your partner.*”

Partner Present Condition. The participant's partner was present in the room sitting quietly next to them during the baseline, anticipation, cold pressor, and recovery tasks. No partner was present at any point for the two other conditions.

2.3 Measures

2.3.1 Self-report measures. Participants completed several self-report measures.

Demographics. Participants reported a variety of demographic information and relationship characteristics, including cohabitation status, marital status and relationship length (in months). Participants were also asked to indicate their sex/gender, age in years, year in school, as well as endorse whether they identified as Asian, Black/African American, Caucasian, Pacific Islander, and Other within individual questions. Participants were then asked whether they identified as Hispanic.

Relationship quality. The Relationship Quality Index (Norton, 1983) was used to assess relationship quality. The scale has five items asking about the quality of the participant's relationship using a 7-point Likert scale with anchors ranging from *"Very strongly disagree"* to *"Very strongly agree."* Higher scores on the scale represented relatively greater relationship quality. The scale demonstrated high internal consistency in the current sample ($\alpha = 0.93$) and reasonable validity when used to assess relationship quality (Norton, 1983).

Task appraisals. Participants completed an adapted Stressor Appraisal Scale (Schneider, 2008) to assess their appraisals (Lazarus & Folkman, 1984) of the cold pressor task both prior to the task and following the recovery period. The original scale had nine total items in a 7-point Likert-scale format, with six items asking about the participant's primary appraisal of the task (e.g. "*How stressful do you think the task will be?")*, and three related to their secondary appraisal of the task (e.g. "*How able do you think you are to cope with the task?")*. We adapted these nine original items to create nine additional items asking about the task once it was completed. Higher scores on the primary appraisal items represent a greater belief in the difficulty of a stressor, whereas higher scores on the secondary appraisal items represent more ability to cope with the stressor. The scales evidenced good internal reliability both before and after the cold pressor task ($0.84 < \alpha s < 0.94$). Pre and post-task appraisals were correlated for primary appraisals ($r = .43$, $p < .001$), but not secondary appraisals ($r = .06$, $p = .530$).

Pain. Pain was assessed using a standard 11-point (0-10) Numeric Rating Scale that has established validity and clinical utility (Williamson & Hoggart, 2005). Participants were asked to "indicate the intensity of your current pain levels on a scale from 0 (no pain) to 10 (worst pain imaginable)" prior to the cold pressor task and following the 10 minute recovery period. A paired t-test indicated that pain increased after the task, $t = 4.09$, $p < .001$, an increase of 1.31 points.

Depressive symptoms. The Center for Epidemiologic Studies Depression Scale (CESD; Radloff, 1977) assessed participants' self-reported symptoms of depression using 10 items. Higher scores on this inventory reflected endorsement of more depressive symptoms and emotional disturbance. The CESD demonstrated high internal consistencies in this sample ($\alpha = .83$) and has established concurrent and predictive validity (Radloff, 1977).

Anxiety symptoms. The Generalized Anxiety Disorder 7-item measure (GAD-7; Spitzer, Kroenke, Williams, & Löwe, 2006) was used to assess participants' self-reported anxiety symptoms. The scale includes seven items on a four point scale anchored by the frequency of anxiety symptoms, with higher scores reflecting endorsement of more frequent anxiety symptoms. The GAD-7 demonstrated high internal reliability in this sample ($\alpha = .89$), and has established validity, including concurrent, divergent, and construct validity (Spitzer et al., 2006).

2.3.2 Cardiovascular Reactivity (CVR). CVR was collected during the laboratory task using a standard laboratory equipment. Task means were created by averaging the valid measurements—the measurements taken each 45 seconds for BP, the 1 minute epochs for HR and HRV—across each task period. For the baseline task, only the last five minutes were used, whereas all valid measurements during the 4-minute cold pressor were used.

Heart Rate (HR), Heart Rate Variability (HRV), and Respiratory Rate (RR). Electrocardiograph (ECG) data and cardiac impedance data was collected using a Mindware psychophysiological system (Mindware Technologies LTD) using a six lead configuration, including the right clavicle and lower left rib. Leads were also placed on the chest at the suprasternal notch and xiphoid process, as well as two leads on the spine located 1-1.5 inches above and below leads placed on the suprasternal notch and xiphoid process. All leads were connected to standard 1.5 inch adhesive electrodes using 7% Chloride wet gel (Mindware Technologies LTD). Data collection used BioLab v. 3.1.2 (Mindware Technologies LTD) and the configuration including a 500 gain for the signals. The Mindware HRV Analysis program v. 3.1.3 was used for post-processing artifact detection and cleaning of R-spikes. A Hamming function was used for windowing during post-processing. After each segment was cleaned, the number of R-spikes during each minute-long epoch were averaged across task to assess mean task HR. Respiratory sinus-arrhythmia (RSA) was used as our measure of HRV and was quantified using the variance in the time series related to respiration (0.12-0.42 Hz). This is the standard method used within the Mindware HRV Analysis 3.1.3 processing software to measure parasympathetic vagal influences on cardiac function. In addition, spectral analysis of the signal was used to assess respiration rate (RR) using the Z0 respiration signal. Both RSA and RR task means were also collected in minute-long epochs during all laboratory tasks. No mean level data across task was excluded for HR, RSA, or RR.

Blood Pressure (BP). BP was assessed using a Carescape V100 Dinamap BP collection device equipped with Critizon Dura-Cuf blood pressure cuffs. Research assistants placed the appropriate sized cuff on the participant's nondominant arm, which the participant then rested on the table in front on them during all lab tasks. The Carescape V100 Dinemap device produces systolic BP (SBP), diastolic BP (DBP), mean arterial pressure, and pulse pressure. SBP measures the peak pressure present in the arteries during the start of the cardiac cycle, whereas DBP measures the lowest pressure during the cycle. Research assistants recorded BP values every 45 seconds during the duration of lab tasks, beginning at the immediate start of the task. BP tasks means were created by averaging valid SBP and DBP across lab tasks. No extreme, biologically implausible BP scores were recorded for any participant during the course of the lab study. A small number of attempted BP recordings (2.2%) did not result in valid BP measurements and were excluded when calculating task means.

2.4 Data Analysis

Data analysis followed the preregistered analytic plan (https://osf.io/kdt9s/) to assess the primary outcomes of interest—SBP, DBP, HR, and RSA—using multiple regression models. We ran each model independently and controlled for baseline cardiovascular activity levels. In cases of RSA, we also included RR as a covariate. We tested our primary hypotheses using a series of contrast codes. We first compared the Partner Present (scored -1) and Mental Activation conditions (scored 1), with Control scored 0, to determine if the conditions differed. We then created an additional contrast combining these two conditions (scored 1) and comparing them to Control (scored -2). The first contrast compared Mental Activation to Partner Present and the second contrast compared Mental Activation and Partner Present to Control. We next tested relationship quality as a moderator of the association between condition and CVR. In cases where contrasting groups did not differ on the moderation effects, we collapsed across conditions. Finally, we conducted exploratory analyses to test for differences in participants' reported pain from during the cold pressor task by condition, whether participants' appraisals might mediate the CVR outcomes, examining whether a variety of alternative variables (sex, age, and minority status) acted as potential moderators of our primary results, and testing change in CVR from baseline and cold pressor to the recovery period to supplement the preregistered results of interest[1]. We used ML estimation in MPLUS version 7.11 (Muthén & Muthén, 2012) when running all models. To account for missing data in our models, we used full likelihood maximum likelihood (FIML) estimation the regression analyses. This method incorporates all available information from all participants with available data and produces unbiased estimates that outperform other missing data treatments, such as listwise deletion (Graham, 2009).

3. Results

Table 1 displays descriptive statistics for the participants by condition.

3.1 Analyses of Preregistered Hypotheses

To test the preregistered hypotheses, we first examined our main effects models to determine whether there were differences by condition in CVR. As predicted, we observed no significant differences between the Partner Present and Mental Activation conditions for SBP, $B = -0.06$, 95% CI [-1.91, 1.79], $p = .950$, or DBP, $B = 0.58$, 95% CI [-0.87, 2.04], $p = .434$.

[1] We also tested additional models to ensure our substantive results did not change based on analytic choices. First, including covariates in our models did not change any of the substantive results of the study. Second, using change scores rather than task means did not affect the substantive results.

Furthermore, Partner Present and Mental Activation participants had significantly lower BP reactivity compared to Control participants for both SBP, B = -1.45, 95% CI [-2.49, -0.40], p = .007, and DBP, B = -1.18, 95% CI [-2.00, -0.36], p = .005, matching our preregistered hypotheses. Figure 3 illustrates the raw reactivity for each condition. Participants assigned to the Partner Present and Mental Activation conditions increased 4.41 mmHg SBP and 3.38 mmHg DBP less from baseline to the cold pressor task compared to Control, effect sizes of d = -0.54 and -0.53, respectively. The full model results are presented in Table 2.

We observed no significant differences in HR between the Partner Present and Mental Activation conditions, B = 0.61, 95% CI [-1.11, 2.33], p = .489, nor between Partner Present and Mental activation compared to Control, B = -0.53, 95% CI [-1.52, 0.45], p = .286. Similarly, there were no significant differences in RSA between the Partner Present and Mental Activation conditions, B = 0.09, 95% CI [-0.08, 0.26], p = .287, or between Partner Present and Mental activation compared to Control, B = -0.02, 95% CI [-0.11, 0.08], p = .742. These results were essentially unchanged when excluding the seven participants who did not complete the cold pressor task.

We next examined if relationship quality moderated the association between condition and the outcomes of interest, specifically when comparing Control participants to those in the Partner Present and Mental Activation conditions. We found no evidence for a significant Condition × Relationship Quality interaction for either HR or RSA. There was, however, a significant interaction for both SBP, B = 1.73, 95% CI [0.66, 2.81], p = .002, and DBP, B = 1.03, 95% CI [0.15, 1.90], p = .021. The simple slopes of the interaction effects by condition were not in the direction of our preregistered hypotheses; in the Control condition, higher relationship quality was associated with lower SBP and DBP reactivity, B = -3.79, 95% CI [-6.35, -1.23], p =

.004, *B* = -2.38, 95% CI [-4.48, -0.28], *p* = .025, whereas there was no association for participants in the Mental Activation or Partner Present conditions, *B* = 1.41, 95% CI [-0.79, 3.61], *p* = .201, *B* = 0.69, 95% CI [-1.09, 2.47], *p* = .439. There was a significant difference between the groups for marital quality below 6.40 and 6.45 points (out of 7) for SBP and DBP on the assessment of relationship quality, which characterized 37.3% and 52.0% of the total sample, respectively[2]. Figure 4 outlines the simple slopes of these interactions. Participants in the Control condition evidenced the lowest BP reactivity at high levels of relationship quality, such that their BP reactivity was similar to the Mental Activation and Partner Present conditions.

3.2 Exploratory Analyses

We conducted a series of exploratory analyses to determine if the observed effects were mediated by differences in appraisals of the cold pressor task. Using a mediational framework, we first assessed whether differences in primary or secondary appraisals prior to or following the task might have explained differences in BP reactivity between the three conditions. There were, however, no significant differences in primary or secondary appraisals by condition, nor did primary or secondary appraisals of the task predict SBP or DBP reactivity. Participants in the Partner Present condition had significantly lower pain ratings after the cold pressor compared to participants in the Mental Activation and Control conditions, *B* = -1.33, 95% CI [-2.41, -0.25], *p* = .016. The effect was medium in size, *d* = -0.57, representing a 1.33 point or 12.1% difference in pain on the 11-point scale. These effects point to a dissociation in self-report and physiology

[2] Removing an outlier in SBP, the interaction effect was no longer significant for SBP, *B* = 0.44, 95% CI [-0.63, 1.50], *p* = .422. This participant's scores were not, however, biologically implausible, and were based on several valid BP readings during both the baseline and cold pressor. We tested this model when windsorizing the outlier in question, matching it to the next highest score. When doing so, the interaction effect remained significant, *B* = 1.28, 95% CI [0.16, 2.30], *p* = .013, though the size of the effect was attenuated.

across conditions: Participants in the Partner Present condition perceived the cold pressor task to be less painful than the Mental Activation and Control participants, but evidenced similar, attenuated BP reactivity to Mental Activation participants.

We also conducted additional exploratory analyses to better understand the current findings, including testing the primary models using cardiac impedance measures as main outcomes, examining if moderators interacted with condition to predict CVR outcomes, and examining whether there were significant differences in the change from baseline and stressor task means to recovery period means by condition. In terms of cardiac impedance outcomes, neither left-ventricle ejection time, stroke volume, cardiac output, nor pre-ejection period evidenced significant differences by condition. There was, however, a significant effect of condition on total peripheral resistance (TPR), $B = -21.21$, 95% CI [-41.95, -0.47], $p = 0.041$, such that participants in the Partner Present and Mental Activation conditions had lower TPR compared to Control participants. These results suggest that control participants experienced greater vasoconstriction in the vascular periphery compared to the other conditions matching the preregistered results reported above. We then examined whether gender, age, or minority status moderated our primary results predicting BP reactivity. None of these variables moderated our primary results. Finally, we also analyzed our primary CVR outcomes from baseline and stressor means to the recovery period means. There were not significant differences by condition in recovery period task means from either baseline or stressor task means.

4. Discussion

In the current study, 102 young adults in a romantic relationship were randomized to either have their partner present, draw on the mental representation of their romantic partner, or think about their day as an active control during a cold pressor task. Consistent with our preregistered hypotheses, participants in the Partner Present and Mental Activation conditions evidenced less BP reactivity from the baseline to the cold pressor task compared to Control participants. These results replicate and extend prior research showing that drawing on a close other can reduce BP reactivity during a stressful task (Bloor et al., 2004, Smith et al., 2004). Also consistent with our preregistered predictions, we observed no significant differences in the BP reactivity effect between the Partner Present and Mental Activation conditions. We acknowledge that it would be reasonable to expect that the physical presence of a romantic partner would reduce CVR more than thinking about a partner alone—as proximity *and* the activation of a working model could both potentially be called on as affiliative cues when a partner is present—but this potential hypothesis was not supported by this study. A key question for future research is whether the Mental Activation and Partner Present conditions yield similar results through similar or different mechanistic routes. The Partner Present condition included a number of affiliative cues—sight, smell, and even the possibility for touch—that may prove to be stress buffering, and a more complete understanding of these processes is needed.

Evidence that drawing on the mental representation of a romantic partner and having a romantic partner physically present attenuates BP reactivity during a physiologically stressful task *to a similar degree* suggests that that physical presence alone is not a key feature of attenuating partners' CVR. Blood pressure reactivity to a cold pressor predicts the development of preclinical disease states (Treiber et al., 2003). To the extent to which these affiliative cues result in reliable effects that generalize outside of the laboratory and persistent in time on a day-to-day basis, CVR may be a critical, health-relevant pathway linking romantic relationships to distal health outcomes. In this sense, the experimental, laboratory-based findings observed here fit well with correlational studies outside of the laboratory. For example, blood pressure is lower when people speak with their romantic partner (Gump, Polk, Kamarck, & Shiffman, 2001) and close others (Holt-Lunstad, Uchino, Smith, Olson-Cerny, & Nealey-Moore, 2003) compared to other people. Routinely drawing on the affiliative cues during times of acute daily stress—thinking about a romantic partner or having a partner with them during their regular commute in heavy traffic, for example—may lessen CVR as a result of those stressors. If maintained across a variety of acute stressors, we would expect long-term health benefits for those in social relationships (cf. Uchino, 2006).

In the present study, we observed no significant differences by condition for HR or HRV. Previous studies have found greater variability in cardiac responses, such as HR and HRV, to limb immersion cold pressor tasks compared to BP reactivity (Mourot et al., 2009). It is possible that high levels of variability in HR and HRV responses to the limb immersion cold pressor task masked group differences by condition. The current sample consisted largely of healthy young adults, who generally evidence less CVR to stress than older adults who have greater variability in their physical health (Treiber et al., 2003). This may both explain the null results for HR and HRV by condition and makes the results for BP reactivity all the more robust. Work in this area would benefit from using older adults drawn from a community sample for a replication and extension of the current study design.

We also found exploratory evidence that partner presence reduced the perception of pain during the cold pressor task. People whose partner was present reported roughly 12% *less pain* during the task compared to people whose partner was not present (d = -0.57). Having a partner present reduced CVR while also reducing the pain associated with a cold, whereas mentally drawing on the working model of romantic partner buffered against CVR, but did not reduce pain. The assessments of primary and secondary appraisals of the task did not, however, differ by condition, nor did they predict people's BP reactivity during the cold pressor task. These results suggest that both affiliative cues studied in this study translated to decreased BP reactivity, and the effects for a partner's presence may operate through reduced perceptions of pain. However, the lack of differences by primary or secondary appraisals make it less clear how drawing on the working model of partner might reduce BP reactivity. The lack of difference in pain ratings between mental activation and control is particularly notably in light of previous evidence that imagining warm touch, but not verbal support, from a partner reduces perception of pain during a stressful task (Jacubiak & Feeney, 2016). Participants were not asked to imagine specific types of support from their romantic partner in this study, however, which may explain these results. One major implication of these results is that having a partner present appears to make a cold pressor less physically painful than drawing on the mental image of a partner—matching well with one potential way that social support can impact cognition (Pietromonaco & Collins, 2017).

The results of this investigation suggest a variety of valuable possible future direction for study. First, the null results in the current study related to appraisals leave the question of how mental activation and physical presence of a partner translate to lower BP reactivity during stress. Testing what alternative mechanisms might explain this effect, as well as different ways to test appraisal processes, would help provide additional information on the pathway by which affiliative cues translate to reductions in CVR. For example, alternative methods of assessing appraisals might better measure differences in participants' perceptions of the cold pressor task. Second, it is important to examine how alternative affiliative cues, including physical touch, might operate compared to physical presence and drawing on the working model of a romantic partner (e.g., Pietromonaco & Collins, 2017). Physical contact—as used in handholding studies (Coan et al., 2006)—is associated with reduced CVR (Grewen, Anderson, Girdler, & Light, 2010), and it is unclear how this might differ from physical presence or drawing on the working model of a romantic partner. Finally, it is an open question whether other types of potential lab stressors (such as the Trier Social Stress Test) would yield similar results.

The main effects of condition were in addition to a significant Condition × Relationship Quality interaction predicting BP reactivity. Participants in the Control condition (but not in the Partner Present and Mental Activation conditions) had a strong negative association between relationship quality and BP reactivity. Partner Present and Mental Activation participants had significantly less BP reactivity at all but the highest levels of relationship quality, and this effect was largest at the lowest levels of relationship quality. The direction of these effects was surprising, as we originally predicted that higher relationship quality would buffer more effectively against reactivity during the stressful task in a similar way to in the study by Coan et al. (2006). Instead, the results suggest that there is not a difference in BP reactivity based on relationship quality when having a partner present or explicitly drawing on a supportive image of a partner. People in the control condition in higher quality relationships, in contrast, were buffered against BP reactivity. We cannot be sure why this pattern of results emerged, but can speculate that people in very high quality relationships may derive the benefit of being in a romantic relationship regardless of whether their partner is present or they are asked to call upon the working model of their partner. In this way, control participants with high relationship quality could “look like” participants in the mental activation and partner present participants in terms of their BP reactivity largely because they spontaneously draw on their romantic partners as a psychological resource during stress tasks. This conjecture could be tested in future studies by using post-task assessments asking participants to describe their thought process for managing the stress of the cold pressor. The interaction also raises a large question about the default responding in the cold pressor task: Are control participants in high-quality relationships uniquely buffered, or is it more probable that control participants in low-quality relationships have few stress buffering capacities? The latter consideration raises the possibility that even people in low-quality relationships can receive effective stress buffering from a partner (from their presence or calling upon/activating an internal working model of that person).

The current study should be understood in the context of its limitations. First, the nature of the three experimental manipulations was such that people may have responded to the three prompts differently. For example, it is possible some participants in the Control condition thought about spending time with their partner as part of thinking about their day. The same is true of the Partner Present condition, who were not provided explicit instructions of what to think about and may have spontaneously drawn on the working mental model of their partner due to their presence. It is possible that changes to the prompts prior to the cold pressor could produce different results. For example, the prompt for the Mental Activation condition stated that drawing on the mental working model of their partner might help them in the task. Telling participants in the control condition that thinking about their day might be helpful with the task could have created an expectation for improvement (cf. Boot, Simons, Stohart, & Stutts, 2013), and changed the results for those participants. Second, the current study used a sample of undergraduate students in romantic relationships. Although the sample was ethnically diverse and participants' relationship lengths averaged over a year and a half, it is possible using community members or married participants may produce different results. Third, the timing and method for assessing task appraisals might have obscured group differences. Future studies should consider more proximal measurement timing (during or immediately following stressors) or additional assessments that might complement self-report, such as fMRI, to more effectively access differences in task appraisals. Finally, the current study assessed CVR, and though CVR is linked to cardiovascular disease states over the long-term (Barnett, Spence, Manuck, & Jennings, 1997; Treiber et al, 2003), the magnitude of influence is an open question (Lovallo, 2015; Manuck, 1994). At the same time, the romantic partner effects are likely not limited to CVR and may include behavioral pathways which are also implicated in disease risk.

4.1 Conclusions

Relative to a control condition, participants who were randomly assigned to draw upon the mental representation of their romantic partner or have their partner physically present in the room evidenced significantly lower BP reactivity during a cold pressor task. There were no significant differences by condition for HR or HRV. The effect on BP reactivity was moderated, such that the difference in BP reactivity for these groups compared to control was larger for participants with lower relationship quality. People assigned to the Partner Present condition also reported less pain during the cold pressor task compared to participants whose partner was not present. The results suggest that accessing the mental representation of a romantic partner and a partner's presence each buffer against BP reactivity to a stressful task to a similar extent, and having a partner present makes this process less painful.

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6. Tables

Table 1

Demographic Characteristics of the Sample by Condition

	Partner Present *n* = 32	Mental *n* = 35	Control *n* = 35	*f*	*p*
Age	19.38 ± 1.72	18.97 ± 1.69	18.97 ± 1.84	0.61	.547
Sex	71.9%	74.3%	80.0%	0.31	.733
Ethnicity	40.6%	45.7%	51.4%	0.39	.681
Cohabitating	14.8%	25.0%	25.8%	0.60	.549
Married	0.0%	6.3%	9.7%	1.31	.276
Relationship quality	6.55 ± 0.59	6.15 ± 0.98	6.12 ± 0.99	2.45	.091
Relationship length	18.60 ± 16.14	21.00 ± 20.83	22.03 ± 14.19	0.34	.710
Depressive symptoms	16.66 ± 4.48	18.02 ± 5.61	17.71 ± 5.14	0.65	.524
Anxiety symptoms	11.28 ± 3.74	12.71 ± 5.34	12.97 ± 4.64	1.27	.286
Body mass	22.38 ± 3.78	22.71 ± 3.25	22.87 ± 3.85	0.16	.850
Baseline systolic BP	107.89 ± 9.23	106.68 ± 7.93	105.61 ± 8.82	0.58	.563
Baseline diastolic BP	61.18 ± 5.63	61.27 ± 5.53	62.07 ± 6.11	0.25	.779
Baseline HR	80.89 ± 9.16	81.80 ± 12.04	79.21 ± 11.13	0.51	.603
Baseline RSA	6.42 ± 0.80	6.31 ± 0.99	6.04 ± 1.06	0.14	.872

Note: Data are means ± standard deviations from all available data unless otherwise noted. *F* statistics and *p* values are the results of one-way ANOVAs comparing the three conditions. Sex is percentage women, ethnicity is % non-Hispanic white. BP = blood pressure, HR = heart rate, RSA = respiratory sinus arrhythmia. Relationship length is measured in months.

Table 2

Model Results for Main Effect Model Preregistered Hypotheses

Outcome: Systolic BP	*B*	95% CI	β
Baseline systolic BP	0.97**	[0.79, 1.14]	0.74**
Contrast 1: MA to PP	-0.06	[-1.91, 1.79]	-0.00
Contrast 2: MA and PP to Control	-1.45**	[-2.49, -0.40]	-0.18**

Outcome: Diastolic BP	*B*	95% CI	β
Baseline diastolic BP	0.87**	[0.66, 1.08]	0.62**
Contrast 1: MA to PP	0.58	[-0.87, 2.04]	0.06
Contrast 2: MA and PP to Control	-1.18**	[-2.00, -0.36]	-0.21**

Outcome: HR	*B*	95% CI	β
Baseline HR	0.84**	[0.71, 0.97]	0.79**
Contrast 1: MA to PP	0.61	[-1.11, 0.33]	0.04
Contrast 2: MA and PP to Control	0.53	[-1.52, 0.45]	-0.07

Outcome: RSA	*B*	95% CI	β
Baseline RSA	0.67**	[0.53, 0.82]	0.66**
Contrast 1: MA to PP	0.09	[-0.08, 0.26]	0.08
Contrast 2: MA and PP to Control	-0.02	[-0.11, 0.08]	-0.02
Cold pressor RR	-0.06	[-0.13, 0.00]	-0.14

Note: 95% CI = 95% confidence interval. MA = mental activation, PP = partner present, BP = blood pressure, HR = heart rate, RSA = respiratory sinus arrhythmia, RR = respiration rate.

* $p < .05$. ** $p < .01$.

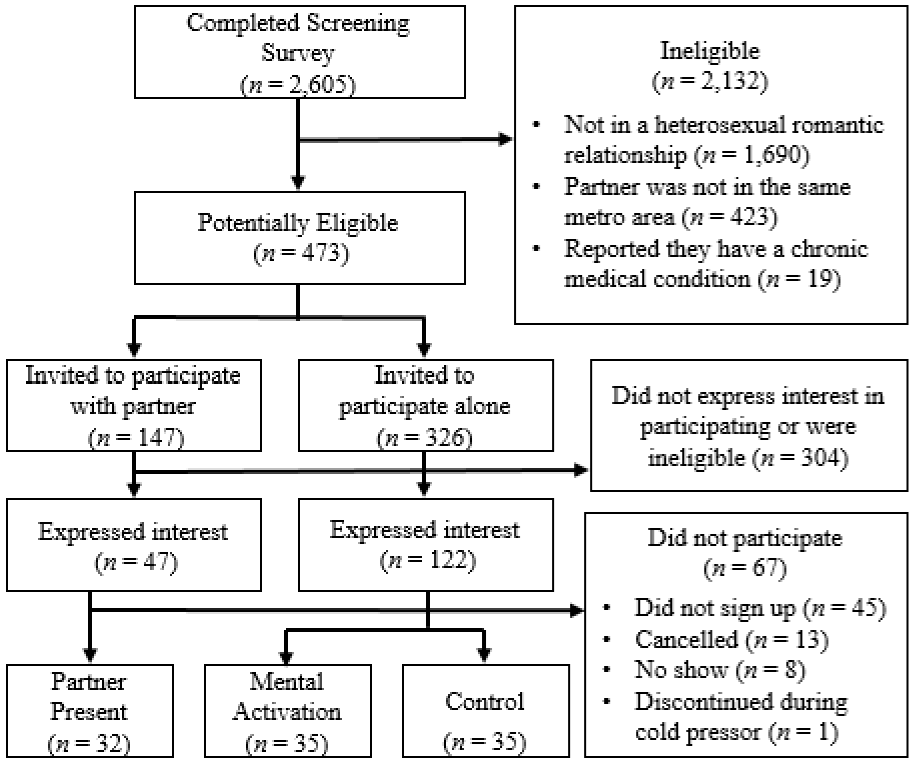

Figure 1. CONSORT diagram outlining the recruitment and randomization of the study participants.

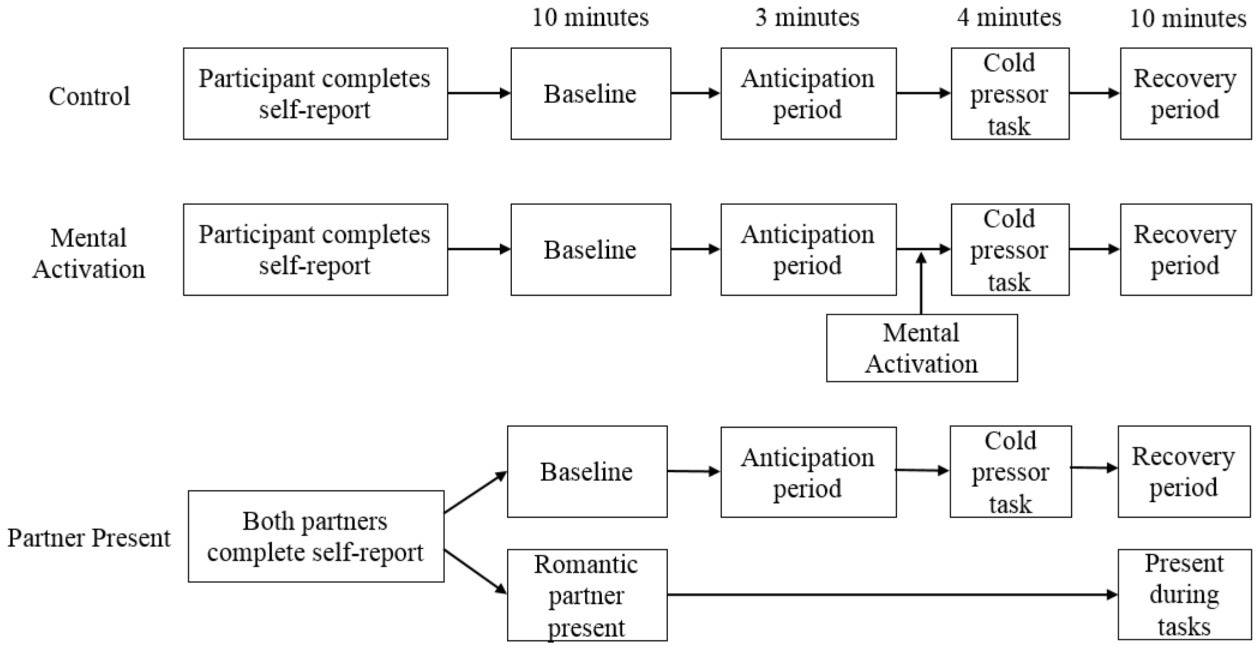

Figure 2. Outline of the study tasks by condition.

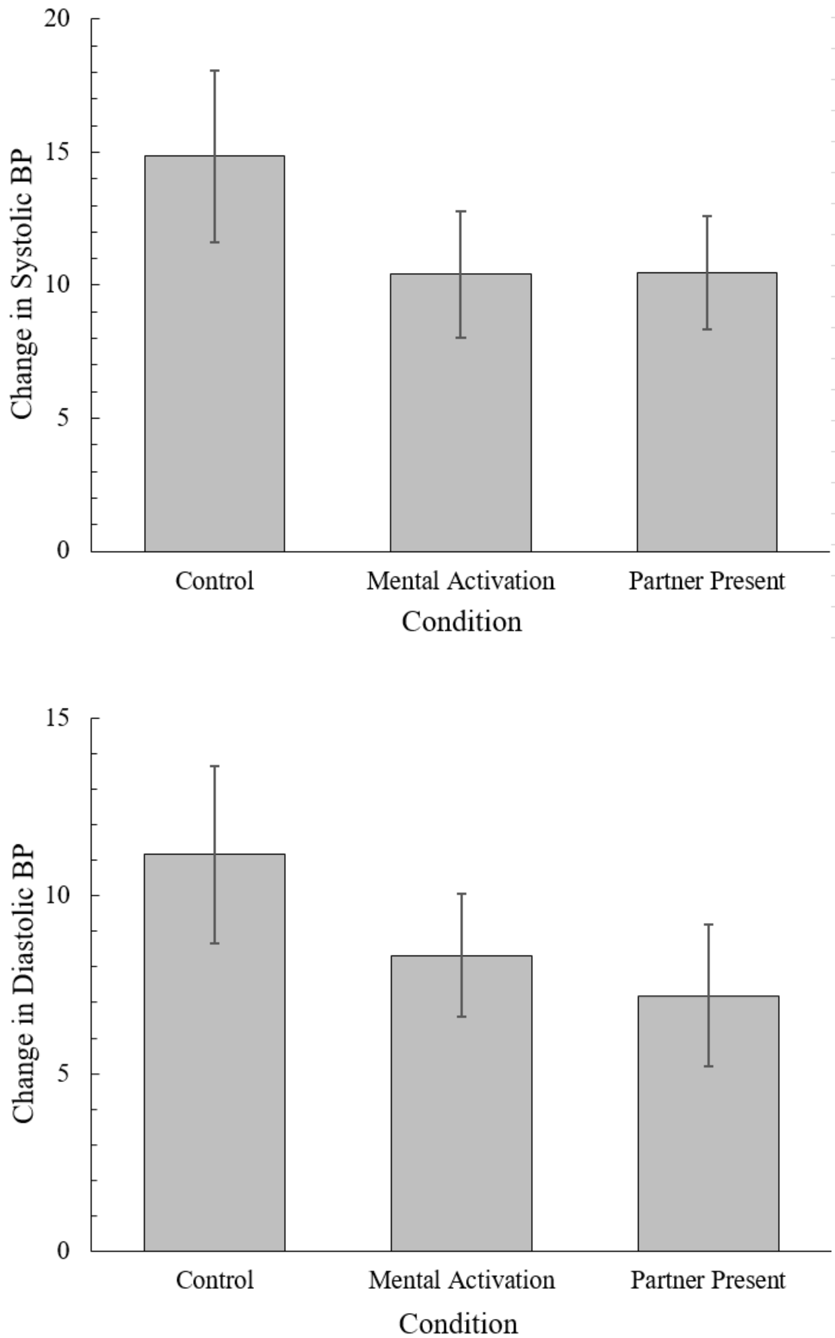

Figure 3. Raw results for systolic and diastolic blood pressure (BP) reactivity from baseline to the cold pressor task averages by condition. Bars represent 95% confidence intervals.

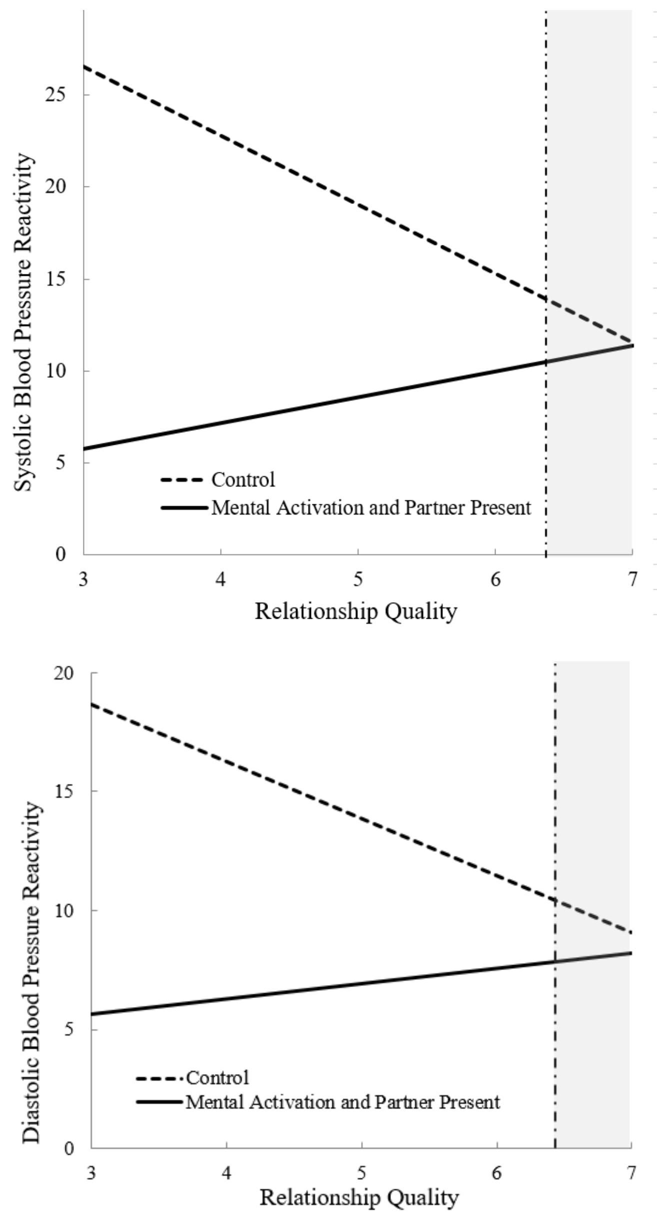

Figure 4. Decomposed simple slopes for the interaction of Relationship Quality × Condition interaction comparing Control to Mental Activation and Partner Present. The shaded area represent the area where the difference between the two groups was not significant. There is a significant negative association for control participants, but no association for participants in the Mental Activation or Partner Present conditions between relationship quality and SBP or DBP.