The Good, the Bad, and the Variable:

Examining Stress and Blood Pressure Responses to Close Relationships

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Author Note

This project was supported by funding from the National Institute on Aging (R24 AG048024), the National Institute of Mental Health (T32 MH019391), and Samsung Research. The content is solely the responsibility of the authors and does not necessarily represent the official views of any of the funding agencies. Correspondence concerning this article should be sent to Brian P. Don: brian.don@auckland.ac.nz or Wendy Berry Mendes wendy.mendes@ucsf.edu. Dr. Brian P. Don is a Lecturer in the School of Psychology at the University of Auckland. Dr. Amie Gordon is an Assistant Professor in the Psychology Department at the University of Michigan. Dr. Wendy Berry Mendes is a Professor in the Department of Psychiatry and Behavioral Sciences at UC San Francisco.

Abstract

Social relationships influence physical health, yet questions remain regarding the nature of this association. For instance, when it comes to predicting health-relevant processes in daily life, few studies have examined (a) the relative importance of both positive *and* negative relational experiences, and (b) *variability* in relational experiences (in addition to mean levels). To address these gaps, we conducted a daily study (N = 4,005; ~ 30,000 observations) examining relationships, stress, and physiology in daily life. Heart rate and blood pressure were assessed using an optic sensor and integrated with an app-based study. Results demonstrated that higher mean levels of positive and lower mean levels of negative relational experiences predicted lower stress, better coping, and better physiological functioning in daily life, such as lower systolic blood pressure reactivity. Greater variability in their negative (but not positive) relational experiences reported *lower* stress, *better* coping, and *lower* systolic blood pressure reactivity.

Keywords: Close relationships; stress; coping; blood pressure; digital platforms.

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An extensive body of research demonstrates that close relationships are an important contributor to physical health (e.g., Holt-Lunstad et al., 2010; Robles et al., 2014). Despite this, a number of questions remain regarding the precise nature of the link between relationships and physical health. For example, prior research has only begun to elucidate how relationships contribute to health-relevant psychological and physiological processes in everyday life (Pietromonaco, & Collins, 2017; Slatcher, & Selcuk, 2017). Moreover, although theorists have stressed the importance of both positive and negative aspects of relationships in contributing to physical health, little research has simultaneously examined how each of these aspects of relationships uniquely contribute to health-relevant processes in everyday life (cf. Uchino et al., 1999), especially in the context of a high-powered study which can adequately simultaneously compare the two. Finally, recent research has demonstrated that variability in relationship functioning contributes to well-being outcomes (even accounting for average levels of relationship functioning; e.g., Eller et al., 2022; Girme et al., 2018; Overall, 2020); however, little work has considered how relational variability contributes to outcomes relevant to physical well-being. In this research, we address these limitations by examining the ways in which mean levels and variability in both positive and negative aspects of individuals' relationships predict stress, coping, blood pressure, blood pressure reactivity, and heart rate reactivity in everyday life.

Close Relationships and Physical Health: Prior Research and Outstanding Questions

How do close relationships influence physical health? Theorists suggest that positive and negative aspects of relationships engender psychological and physiological changes, which can accumulate into long-term physical health consequences (e.g., Pietromonaco, & Collins, 2017;

Slatcher, & Selcuk, 2017; Smith & Weihs, 2019). Some prior research has indeed documented that key facets of relationships contribute to proximal psychological and biological processes (e.g., stress, emotion regulation, immunologic and cardiovascular functioning), thereby contributing more broadly to health, with much of this work focusing on either (a) negative aspects of relationships, like conflict (e.g., Powers et al., 2006; Smith et al., 2020), or (b) social support (Bowen et al., 2014; Uchino, 2004; Uchino et al., 2018).

Despite this prior research, two recent reviews have argued that the existing literature is lacking in a few notable ways (Pietromonaco & Collins, 2017; Slatcher & Selcuk, 2017). First, despite the theoretical importance of *positive relational processes* in contributing to physical health, little research has examined how positive aspects of relationships (e.g., responsiveness, intimacy, and closeness) are associated with proximal psychological (e.g., stress) and physiological processes (e.g., cardiovascular functioning) that contribute to broad physical health functioning. Moreover, among the few studies that do examine how positive aspects of relationships predict biological indicators of physical well-being (e.g., Saxbe et al., 2008), these positive relational processes are often not directly compared to the challenging relational experiences (e.g., relationship conflict) that have received more attention in past literature (see Slatcher et al., 2015 for an exception). Additionally, much of the prior research has focused exclusively on intimate relationships and health; although they have been studied less frequently, other types of close relationships (e.g., friendships, family relationships) also have potential to influence the psychological and biological processes that contribute to physical health (e.g., Lu et al., 2021). Our goal in this work was to address these gaps was to examine the links between relationship experiences and the proximal psychological and physiological processes that impact physical health using a high-powered study, which would be able to detect even small but meaningful effects of both positive and negative relational experiences when they are directly compared.

Relational Variability and Psychological and Physiological Concomitants

In addition to mean levels of relationship functioning, research in relationship science has demonstrated that when it comes to predicting key outcomes, it is important to consider variability in relationships (e.g., Arriaga et al., 2006; Campbell et al., 2010; Girme et al., 2018). For instance, researchers (e.g., Don et al., 2022; Girme et al., 2018) have drawn on the Relational Turbulence Model (Solomon & Knoblock, 2004) to suggest that greater relational variability, including variability in both positive and negative relational experiences (e.g., Don et al., 2022), may create uncertainty in the relationship, such as questions, doubts, or ambiguity about the state of the relationship. This uncertainty, in turn, theoretically contributes to greater irritations and negative emotions, thereby creating a turbulent experience for individuals in the relationship. Indeed, numerous studies have demonstrated that within-person variability (which tends to be operationalized as within-person standard deviations) in constructs such as relationship quality or attachment security tends to predicts key outcomes, even while accounting for mean levels of those same variables (Campbell et al., 2010; Eller, et al., 2022; Girme et al., 2018). Generally speaking, people who report greater relational variability tend to experience maladaptive outcomes (e.g., Girme et al., 2018), although there may be some relationship behaviors or specific relationship contexts where this is not the case, and where variability may be beneficial (especially in *negative* relational contexts; e.g., Don et al., 2022; Overall, 2020). Consistent with this literature, relational variability may have implications for the everyday psychological and physiological responses that contribute to health (e.g., stress or blood pressure reactivity), although little existing research has examined this possibility. A high-powered sample is particularly beneficial when studying variability because the goal is to try to detect the incremental influence of relational variability on key outcomes beyond mean levels of relational experiences.

Health-Relevant Psychological and Physiological Processes

To assess health-relevant psychological and physiological processes, we focused on self-reported and physiological outcomes: stress, coping, blood pressure (mean levels and reactivity), and heart rate reactivity. Stress and coping are well-established contributors to physical well-being (Thoits, 2010), and tend to vary across the course of everyday experiences (e.g., Bolger et al., 1989). Heart rate and blood pressure (a) offer insight into processes that do not rely on self-reported responses and thus are less likely to be contaminated by social desirability responding, and (b) tend to vary across daily life (e.g., Uchino et al., 2006). Additionally, blood pressure and blood pressure reactivity are related to cardiovascular disease and hypertension (e.g., Treiber et al., 2003; Vrijkotte, et al., 2000), and are linked to psychological experiences (e.g., Caroll et al., 2012). While some prior research has linked relational experiences to blood pressure and heart rate (e.g., Cribbet et al., 2020; Holt-Lunstad et al., 2007; Kamarck et al., 1990; Shankar et al., 2011), to our knowledge, no work has done so while simultaneously examining (a) positive and negative relational experiences, and (b) variability as well as mean levels of relational experiences in a high-powered daily study.

The Current Research

In this study, participants completed daily check-ins via their smartphone or smartwatch, which included assessments of their blood pressure, heart rate, stress, coping, and (at selected check-ins) their positive and negative relational experiences, reflecting on their closest relationship.[1] We anticipated that greater mean levels of positive relational experiences and lower mean levels of negative relational experiences would be independently associated with lower stress, better coping, lower heart rate reactivity, and lower blood pressure reactivity. We also expected that relational variability would be maladaptive, such that greater variability in both positive *and* negative relational experiences would predict greater stress, worse coping, greater blood pressure (mean levels and reactivity), and greater heart rate reactivity.

The data and data analytic syntax for this study are available at the corresponding Open Science Framework (OSF) page for this study at the following address: https://osf.io/q4bth/?view_only=91bad24fc94547c8bd458b2dbdd19a2d. Materials for this paper are also available at the OSF page for this study. This study was not preregistered.

Method

Participants and Procedure

We designed an EMA study to measure emotions, stress, and physiology via an app that could be downloaded to smartphones. Here we present results from questions obtained once every three days, so from this point we use the term *daily diary* to emphasize the once-a-day nature of this data, as opposed to multiple momentary assessments. The app leveraged an optic sensor embedded in some Samsung phones and watches (e.g., Galaxy S9) that allowed for measurements of heart rate and blood pressure (see *citation masked*, for validation study). In brief, the validation paper describes lab and field studies comparing blood pressure and heart rate obtained from the optic sensor to estimates from FDA-approved blood pressure monitors (A&D UA-651BLE monitor). In laboratory studies, we observed overall correlations between the optic

[1] Relational variability tends to be examined within the context of one relationship (e.g., Eller et al., 2022; Girme et al., 2018). That is, to what extent do individuals experience variability in a particular relationship across a period of time? We adopt this same approach in this study,

sensor and FDA-approved monitors of *r*=.78 and *r*=.82, for SBP and DBP, respectively, and *r*=.96 for HR. Critically, when comparing two FDA-approved BP monitors to each other in a small sample, we observed comparable but *lower* correlations than with the optic sensor, $r = .75$ and $r = .72$, for SBP and DBP, respectively, and $r = .90$ for HR. In field studies across 3,380 observations, we observed overall correlations of $r = .70$ and $r = .76$, for SBP and DBP, respectively, and $r = .98$ for HR. In contrast, two FDA approved BP monitors showed similar correlations, $r = .77$ and $r = .64$, for SBP and DBP, respectively, and $r = .90$ for HR. In summary, the validity of the sensor was excellent for estimating HR, and showed moderate to strong agreement with FDA-approved BP monitors when estimating SBP and DBP.

Participants were required to be at least 18 years old, and proficient in English. For the purpose of these analyses, participants included 4,005 people (see data cleaning strategy below for information on how we arrived at this final analytic sample). Participants were 48.12 years old on average ($SD = 12.84$). With respect to sex, 34.9 % identified as female, 64.7% identified as male, 0.3% identified as another gender (e.g., transgender, genderfluid). With respect to race, 8.1% identified as Asian, 6.4 % identified as Black or African-American, 3.0% identified as Indian, 8.4% identified as Latino, 2.4% identified as Native American or Alaska native, 0.5% identified as Pacific Islander, 74.5% identified as White or European, and 1.5% declined to provide their race (participants were able to select more than one category, so the percentages do not add to 100%). The study was approved for global use and participants from across the world participated but the largest concentration of participants were from countries where we offered the app on the Google Playstore: USA 68.6%; UK 9.4%; Australia 8.6%; Canada 5.9%; India 1.4%; Hong Kong 0.7%; New Zealand 0.05%; Singapore 1.4%; all other countries 3.5%.

Once enrolled in the study, participants were sent notifications three times each day (7:00am - 10:00am; 10:00am – 4:00pm; and 8:00pm – 11:00pm). During each check-in, participants first provided a sensor reading by placing their finger over the optic sensor for approximately 30 seconds. This provided information to estimate heart rate, systolic and diastolic blood pressure. Following the sensor measurement, participants completed self-report items. At every check-in, participants received questions related to stress and coping. Additionally, participants received a rotating series of additional questions that appeared during a check-in every third day, meaning that across the course of the 21-day study, participants would see each set of these additional questions up to seven times. The questions assessing participants' relational experiences were presented during the evening check-in as part of these additional, rotating questions.

The study was designed to be 21 days long, however participants were allowed to continue completing assessments beyond the 21-day study period if they wished to do so (and some participants did). To encourage participation, participants instantly received their blood pressure and heart rate measurements. At the end of each week, they also received summary reports of their physiological responses and daily psychological experiences (e.g., stress and emotions). Data collection occurred from March 15th, 2019 data to December 31st, 2021. The Human Research Protection Program of [university name masked for review] approved this research.

Measures

Positive and negative relational experiences. Every three days, participants were prompted to think about the person in their life with whom they were the closest, which could have been a spouse, friend, or family member. Positive relational experiences were assessed using four items (e.g., "*To what extent did you feel satisfied with this person today?*"). Negative relational experiences were assessed using three items ("e.g., *Did you experience conflict with this person today?*" (positive α = .94; negative α = .70; $r = -.29$, $p < .001$).[2]

Physiologic measures. At each check-in, systolic blood pressures (SBP), diastolic blood pressure (DBP), and heart rate (HR) were assessed. At the start of the study, to best estimate blood pressure, participants were encouraged to calibrate their BP value using a cuff. Blood pressure levels were only displayed to those who calibrated the sensor to an external device. Participants were able to recalibrate at any time during the study so we offset BP values by their calibration values to make sure they were equated within-person. When predicting overall blood pressure, we only used calibrated values, (81.8% of blood pressure values were calibrated). Finally, to calculate within-person reactivity scores, we approximated baseline by identifying the check-in with the individual's lowest heart rate value, and subtracted the corresponding SBP, DBP, and HR from that check-in from all of their other daily check-in HR, SBP, and DBP scores (see *citation masked* for this strategy).

Stress and coping. At every check-in, participants responded to items about stress and coping. Participants were first presented with a question that assessed whether or not they had experienced any majorly stressful events since the previous check-in ("*Have you experienced any particularly stressful events since your last check-in*"). If participants answered "no" to that question (which included 83.4% of the responses), they were presented with questions that assessed their general stress ("*I feel stressed, anxious, overwhelmed*") and coping ("*I feel in control, coping well, on top things*") in the current moment on a scale from 1 = *not at all* to 5 = *extremely*. Because some prior research and theory emphasizes the importance of examining

[2] These items were drawn from a larger set of items regarding participants relational experiences, and were selected because they were (a) clearly positively or negatively-valenced, and (b) demonstrated good reliability.

people's stress in relation to their perceived ability to cope with the situation (rather than examining the two separately; e.g., Mendes et al., 2007), we also examined the ratio of stress to coping as an outcome. We created a stress to coping ratio by dividing participants' stress scores by their coping scores. As such, greater scores indicated a greater ratio of perceived stress relative to one's ability to cope.[3]

Data Analytic Strategy and Cleaning

Our goal was to examine how mean levels and fluctuations in positive and negative relational experiences predicted participants' stress, coping, SBP, DBP, SBP reactivity, DBP reactivity, and HR reactivity across the check-ins in which they reported those relational experiences**.** We calculated within-person means and standard deviations for positive and negative relational experiences for each individual included in the study. Although standard deviations can technically be calculated with only two values, to include a reasonable range of assessments for calculating relational variability, we required that all participants complete at least 3 relational check-ins in order to be included in final analyses. For the physiological outcomes, we eliminated extreme values for SBP (<80 and > 210), DBP (< 50 and > 180), HR (< 30 and > 200), BMI (<15 and >60), age (>90). We also removed any blood pressure or heart rate values when individuals reported exercising within 30 minutes of the check in.

The data were nested, such that daily check-ins were nested within individuals, and we therefore utilized multilevel modeling to test our hypotheses. In particular, we constructed two-level models in which check-ins were nested within participants. All of the predictors of interest were person-level variables, and so we examined a series of random intercept models for each

[3] Although blood pressure, heart rate, stress, and coping (i.e., the outcomes of interest) were assessed at every check-in (every day), we only utilized outcome data from the same check-ins (i.e., every three days) in which participants completed a relational check-in, in order to ensure that the outcome data would be relevant to testing our hypotheses.

outcome. We first started by testing a model that included only mean levels of positive and negative relational experiences as predictors. We then tested a model that included positive and negative relational variability as additional predictors. Finally, we tested a model that included interactions between mean levels and variability as predictors of each outcome in order to ascertain whether variability had the same effect at differing mean levels. In the models predicting the physiological outcomes, we also included age, BMI, and sex as covariates. For each analysis, we calculated effect sizes in the form of *r* values for each parameter using the *t* to *r* transformation used by Kashdan and Steger (2006): $r = \sqrt{(t^2/t^2+\text{df})}$.

Among participants who completed at least 3 relational check-ins, the average number of check-ins was 65.51 (*SD* = 117.20, Max = 2,804). Mean levels (*r* - .002, *p* = .87) and variability (*r* – .004, *p* = .78) in positive relational experiences were not associated with the number of check-ins participants completed. Participants who had higher levels of negative relational experiences tended to complete fewer check-ins, though the effect size was small (*r* = .05, *p* < .001), but variability in negative relational experiences was not associated with the number of check-ins participants completed (*r* = -.003, *p* = .81). As is the default for multilevel modeling, participants were incorporated into analyses even if they were missing data on an outcome variable at one or more check-ins.

Because of the high degree of variability in the number of check-ins participants completed, for the primary set of analyses presented in this paper, we examined only the first 100 check-ins (or up to a maximum of 14 relational check-ins). To ensure results were largely the same regardless of the number of check-ins we included in the analyses, we also re-examined these same analyses using data in which we examined (a) only the first 63 check-ins (21 days of data, the length of the original study, or up to a maximum 7 relational check ins), and (b) all check-ins participants completed (see OSM Supplemental Tables 17-32 for results, which were largely the same). Because it was necessary to remove extreme values, and filter based on variables like age, BMI, and exercise, the analyses for each outcome variable included a slightly different number of observations (e.g., stress and coping analyses n = 29,807; SBP reactivity n = 30,458).

Additionally, after conducting our primary analyses, we also tested two sets of ancillary analyses. First, we examined whether the number of check-ins that participants completed moderated the results of our primary findings. Specifically, we included number of check-ins as a moderator of the association between both mean levels and variability in positive and negative relational experiences and each of the outcomes of interest. Second, we re-conducted our primary analyses while including a series of demographic covariates, including age, BMI, socioeconomic status, and race.

Results

Descriptive statistics and bivariate correlations are presented in Table 1. As expected, higher mean levels of positive relational experiences were correlated with lower negative relational experiences (r = -.29). Additionally, the higher the average positive relationship experience, the *less* positive relational variability (r =-.44). In contrast, those who reported higher average negative relationship experiences reported greater negative relationship variability (r =.42).

We then examined our primary questions, and results of multilevel models examining how positive and negative relational experiences predict stress, coping, stress to coping ratios, blood pressure, blood pressure reactivity, and heart rate reactivity, are presented in Tables 2-4, and in the OSM in Supplemental Tables 1-3. Greater mean levels of positive relational

Table 1

Descriptive Statistics and Bivariate Correlations for Primary Study Variables

	Variable	*M*	*SD*	1	2	3	4	5	6	7	8	9	10	11	12
1	Age	50.42	12.96	-											
2	Gender	-	-	-.08**	-										
3	BMI	29.27	6.74	.03**	.11**	-									
4	PosRel - Mean	1.72	0.91	.17**	.02*	.01	-								
5	PosRel - SD	0.19	1.91	-.16**	.12**	.05**	-.44**	-							
6	NegRel - Mean	0.00	0.79	-.12**	.07**	.07**	-.29**	.49**	-						
7	NegRel - SD	-0.01	0.68	-.12**	-.04**	-.01	-.60**	.24**	.42**	-					
8	Stress	-0.20	1.43	-.13**	.06**	-.02**	-.23**	.09**	.09**	.27**	-				
9	Coping	3.77	1.02	.16**	-.06**	.02**	.33**	-.12**	-.09**	-.25**	-.52**	-			
10	SBP Reactivity	3.10	31.88	.02*	-.01	-.03**	.01	-.01	-.02**	-.01	.01	.01	-		
11	DBP Reactivity	-1.02	20.38	.02**	.01	-.03**	.03**	-.02*	-.02**	-.03**	.01	.01	.97**	-	
12	HR Reactivity	19.18	15.97	.04**	-.04**	.02*	-.02*	.02**	.03**	.01	.05**	-.03**	.08**	.04**	-

Note. * *p* > .05, ** *p* > .01. PosRel = positive relational experiences. NegRel = negative relational experiences. SD = within-person standard deviation.

Table 2

Results of Analyses Predicting Stress and Coping from Relational Experiences and Variability

Outcome	Parameter	Estimate	*p*	95% CI		*r*
				LL	*UL*	
Stress Model 1	Intercept	1.74	<.001	1.72	1.75	-
	PosRel - Mean	**-0.05**	**<.001**	**-0.06**	**-0.04**	**0.12**
	NegRel - Mean	**0.13**	**<.001**	**0.11**	**0.14**	**0.22**
Stress Model 1	Intercept	1.74	<.001	1.72	1.75	-
	PosRel - Mean	**-0.05**	**<.001**	**-0.06**	**-0.04**	**0.10**
	PosRel - SD	0.01	0.25	-0.01	0.04	0.01
	NegRel - Mean	**0.14**	**<.001**	**0.12**	**0.15**	**0.23**
	NegRel - SD	**-0.06**	**<.001**	**-0.09**	**-0.04**	**0.06**
Stress Model 3	Intercept	1.75	<.001	1.73	1.77	-
	PosRel - Mean	**-0.05**	**<.001**	**-0.06**	**-0.04**	**0.10**
	PosRel - SD	0.02	0.09	-0.003	0.04	0.02
	PosRel Mean * PosRel SD	**0.01**	**0.01**	**0.003**	**0.03**	**0.03**
	NegRel - Mean	**0.14**	**<.001**	**0.12**	**0.15**	**0.22**
	NegRel - SD	**-0.06**	**<.001**	**-0.09**	**-0.04**	**0.06**
	NegRel Mean * NegRel SD	-0.01	0.26	-0.02	0.01	0.01
Coping Model 1	Intercept	3.74	<.001	3.72	3.75	0.98
	PosRel - Mean	**0.16**	**<.001**	**0.15**	**0.17**	**0.30**
	NegRel - Mean	**-0.06**	**<.001**	**-0.08**	**-0.05**	**0.10**
Coping Model 2	Intercept	3.73	<.001	3.71	3.75	0.98
	PosRel - Mean	**0.16**	**<.001**	**0.15**	**0.18**	**0.28**
	PosRel - SD	-0.001	0.92	-0.03	0.03	0
	NegRel - Mean	**-0.07**	**<.001**	**-0.09**	**-0.06**	**0.11**
	NegRel - SD	**0.06**	**<.001**	**0.03**	**0.09**	**0.04**
Coping Model 3	Intercept	3.71	<.001	3.69	3.73	0.97
	PosRel - Mean	**0.16**	**<.001**	**0.15**	**0.17**	**0.28**
	PosRel - SD	-0.01	0.55	-0.04	0.02	0.01
	PosRel Mean * PosRel SD	-0.01	0.07	-0.02	0.001	0.02
	NegRel - Mean	**-0.07**	**<.001**	**-0.08**	**-0.05**	**0.1**
	NegRel - SD	**0.05**	**<.001**	**0.02**	**0.08**	**0.04**
	NegRel Mean * NegRel SD	**0.03**	**0.001**	**0.01**	**0.05**	**0.04**

Note. PosRel = positive relational experiences. NegRel = negative relational experiences. SD = within-person standard deviation. CI = confidence interval. *LL* = lower limit. UL = upper limit. Analyses based on 29,807 observations.

Table 3

Results of Multilevel Analyses Predicting Systolic Blood Pressure Reactivity from Relational Experiences and Fluctuations

Outcome	Parameter	Estimate	*p*	95%CI *LL*	95%CI *UL*	*r*
SBP Reactivity Model 1	Intercept	6.08	<.001	2.94	9.21	0.05
	BMI	-0.01	0.79	-0.09	0.07	0.00
	age	-0.05	0.01	-0.09	-0.01	0.03
	Men	-0.47	0.41	-1.59	0.65	0.01
	Other Gender	3.31	0.48	-5.92	12.54	0.01
	PosRel - Mean	0.34	0.052	-0.002	0.68	0.02
	NegRel - Mean	**0.52**	**0.02**	**0.10**	**0.94**	**0.03**
SBP Reactivity Model 2	Intercept	6.19	<.001	3.05	9.33	0.05
	BMI	-0.01	0.84	-0.08	0.07	0.00
	age	-0.06	0.01	-0.10	-0.01	0.03
	Men	-0.60	0.30	-1.72	0.53	0.01
	Other Gender	2.97	0.53	-6.26	12.19	0.01
	PosRel - Mean	0.37	0.05	-0.003	0.74	0.02
	PosRel - SD	0.16	0.66	-0.56	0.89	0.01
	NegRel - Mean	**0.71**	**0.002**	**0.25**	**1.16**	**0.04**
	NegRel - SD	**-0.87**	**0.04**	**-1.68**	**-0.05**	**0.03**
SBP Reactivity Model 3	Intercept	6.30	<.001	3.14	9.46	0.05
	BMI	-0.01	0.82	-0.09	0.07	0.00
	age	-0.05	0.01	-0.10	-0.01	0.03
	Men	-0.59	0.31	-1.71	0.54	0.01
	Other Gender	2.98	0.53	-6.25	12.20	0.01
	PosRel - Mean	**0.38**	**0.045**	**0.01**	**0.75**	**0.03**
	PosRel - SD	0.31	0.42	-0.44	1.06	0.01
	PosRel Mean * PosRel SD	0.27	0.13	-0.08	0.63	0.02
	NegRel - Mean	**0.68**	**0.004**	**0.22**	**1.14**	**0.04**
	NegRel - SD	**-0.91**	**0.03**	**-1.73**	**-0.09**	**0.03**
	NegRel Mean * NegRel SD	0.08	0.74	-0.39	0.55	0.00

Note. Analyses based on 30,458 observations.

Table 4

Results of Multilevel Analyses Predicting Diastolic Blood Pressure Reactivity from Relational Experiences and Fluctuations

Outcome	Parameter	Estimate	*p*	95%CI		*r*
				LL	*UL*	
DBP Reactivity Model 1	Intercept	1.12	0.28	-0.92	3.15	-
	BMI	-0.02	0.13	-0.05	0.01	0.02
	age	-0.97	0.01	-1.70	-0.25	0.03
	Men	1.22	0.69	-4.76	7.19	0.00
	Other Gender	-0.01	0.75	-0.06	0.04	0.00
	PosRel - Mean	**0.30**	**0.01**	**0.08**	**0.53**	**0.03**
	NegRel - Mean	**0.37**	**0.01**	**0.09**	**0.65**	**0.03**
DBP Reactivity Model 2	Intercept	1.19	0.25	-0.85	3.22	-
	BMI	-0.01	0.79	-0.06	0.04	0.00
	age	-0.02	0.11	-0.05	0.00	0.02
	Men	-1.03	0.01	-1.76	-0.29	0.04
	Other Gender	1.05	0.73	-4.93	7.03	0.00
	PosRel - Mean	**0.30**	**0.02**	**0.06**	**0.54**	**0.03**
	PosRel - SD	-0.001	1.00	-0.47	0.47	0.00
	NegRel - Mean	**0.44**	**0.01**	**0.15**	**0.74**	**0.04**
	NegRel - SD	-0.38	0.16	-0.90	0.15	0.02
DBP Reactivity Model 3	Intercept	1.20	0.25	-0.85	3.25	-
	BMI	-0.01	0.77	-0.06	0.04	0.02
	age	-0.02	0.13	-0.05	0.01	0.03
	Men	1.08	0.01	-1.74	-0.28	0.00
	Other Gender	-0.01	0.72	-4.90	7.06	0.00
	PosRel - Mean	**0.30**	**0.01**	**0.06**	**0.54**	**0.03**
	PosRel - SD	0.08	0.74	-0.40	0.57	0.00
	PosRel Mean * PosRel SD	0.16	0.17	-0.07	0.39	0.02
	NegRel - Mean	**0.44**	**0.01**	**0.14**	**0.74**	**0.04**
	NegRel - SD	-0.42	0.12	-0.95	0.11	0.02
	NegRel Mean * NegRel SD	0.13	0.42	-0.18	0.43	0.01

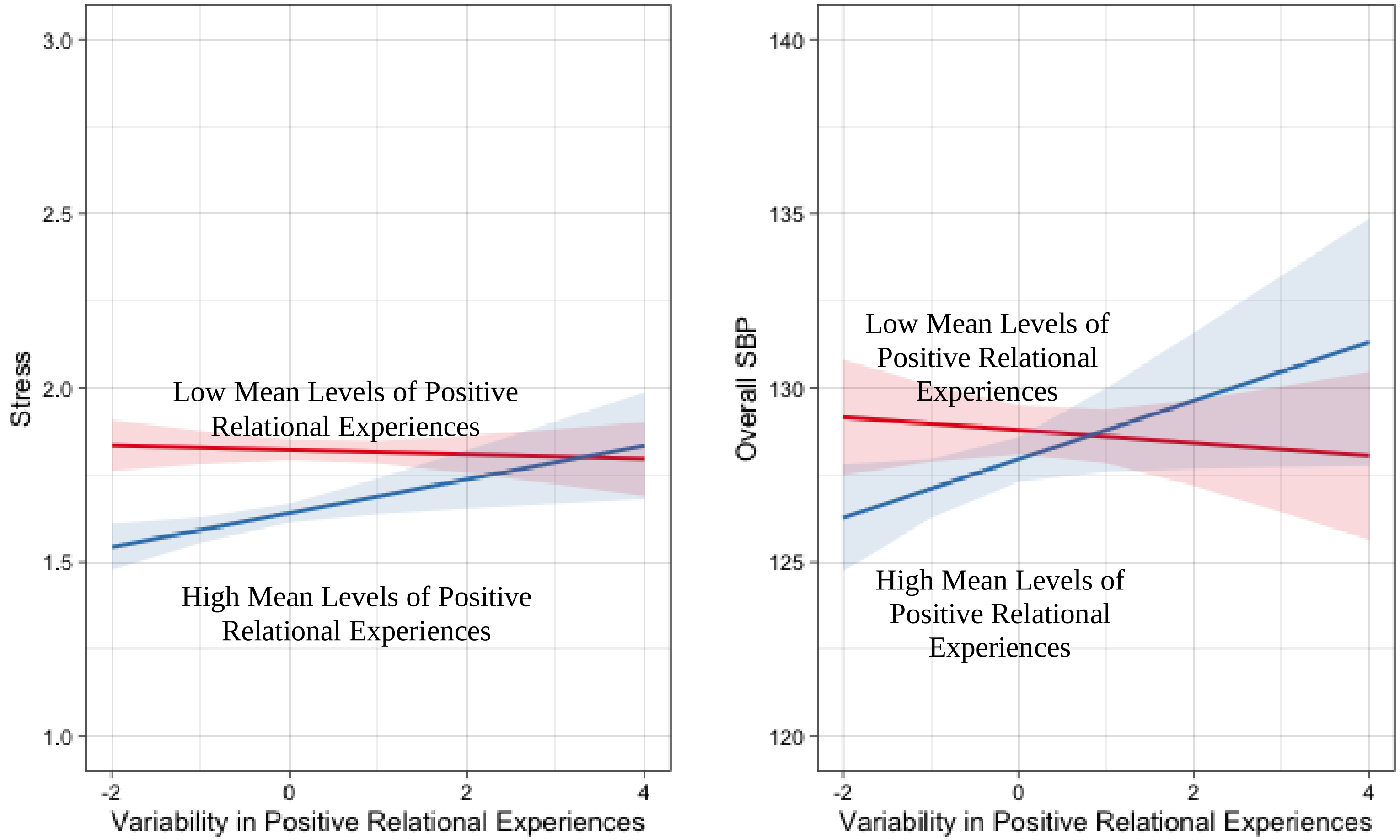
Note. Analyses based on 30,271 observations.

experiences was significantly associated with lower stress, better coping, a lower ratio of stress to coping, greater DBP reactivity, lower overall SBP (but only in the first model tested, which did not include relational variability). Effect sizes for mean levels of positive relational experiences in predicting these outcomes ranged from small to moderate (*r*'s = .03 to .30). With respect to main effects, greater variability in positive relational experiences only predicted a greater stress to coping ratio, but variability was not associated with stress, coping, or any of the physiological outcomes. The interaction between mean levels and variability in positive relational experiences was significant in predicting stress and overall SBP, and the size of this association was small. These interactions are presented in Figure 1. We probed simple slopes by examining the association between variability in positive relational experiences and (a) daily stress and (b) overall SBP at low (-1 *SD*) and high (+1 *SD*) mean levels of positive relational experiences. At high mean levels of positive relational experiences, greater variability in positive relational experiences was associated with greater daily stress (B = .04, 95% CI [0.01, 0.08], p = .007, r = .05) and SBP (B = .83, 95% CI [0.02, 1.66], p = .04, r = .03). By contrast, at low mean levels of positive relational experiences, the association between variability in positive relational experiences and both stress (B = -.01, 95% CI [-0.03, 0.02], p = .65, r = .03) and SBP (B = -.18, 95% CI [-0.82, 0.45], p = .58, r = .01) was not statistically significant. This pattern suggests that when people experienced higher levels of positive relational experiences that were accompanied by more variability (less stable positive relational experiences), they reported more daily stress and experienced greater overall SBP.

Greater mean levels of negative relational experiences were significantly associated with greater stress, worse coping, a greater stress to coping ratio, greater SBP reactivity, greater DBP reactivity, and greater overall DBP. Effect sizes for mean levels of negative relational

Figure 1

The Interactions between Variability and Mean Levels of Positive Relational Experiences in Predicting Stress and Systolic Blood Pressure in Everyday Life



experiences in predicting these outcomes ranged from small to moderate (*r*'s = .03 to .23). Greater variability in negative relational experiences was associated with lower stress, better coping, a lower stress to coping ratio, lower SBP reactivity, and greater heart rate reactivity.

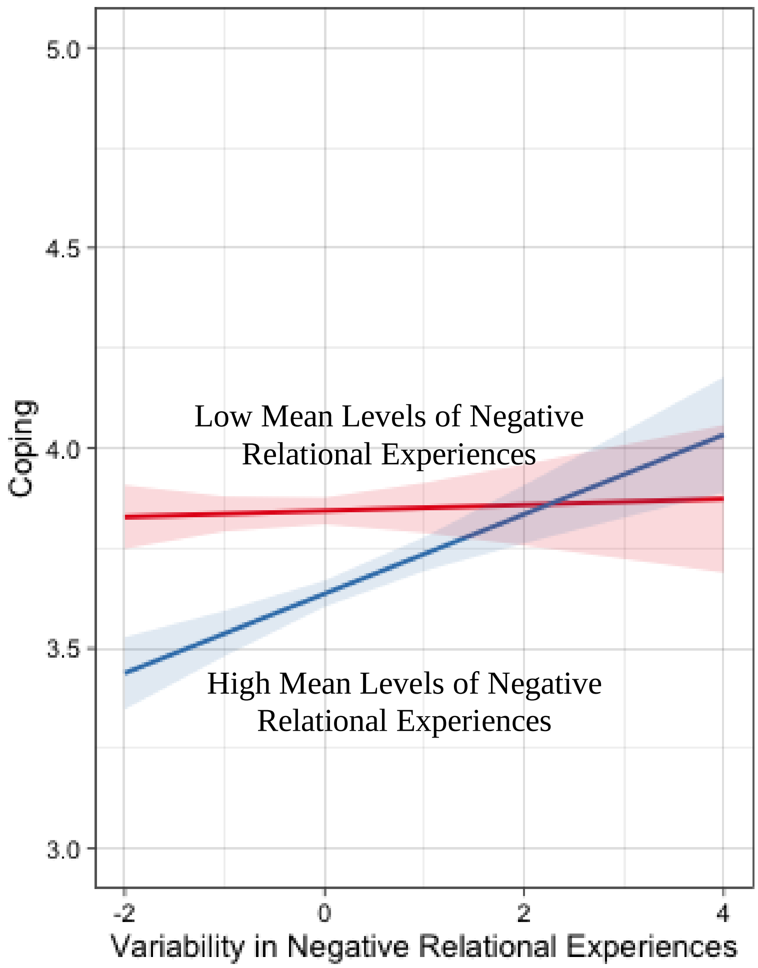
Effect sizes for variability in negative relational experiences in predicting these outcomes were small (*r*'s = .03 to .06). The interaction between mean levels and variability in negative relational experiences was only significant in predicting coping. This interaction is presented in Figure 2, and we probed simple slopes using the same approach as above. When mean levels of negative relational experiences were high, greater variability in negative relational experiences was significantly associated with *better* coping (B = .10, 95% CI [0.06, 0.14], p < .001, r = .06). In other words, higher mean levels of negative experiences were associated with better coping when there was more variability in negative relationship experiences. When mean levels of negative relational experience were low, however, variability in negative relational experiences was not associated with coping (B = .007, 95% CI [-0.03, 0.05], p = .72, r = .001).

Results of analysis which (a) included a different number of check-ins, and (b) included the number of check-ins each participant completed as a moderator are included in the OSM (see Supplemental Tables 4-32. Results of these analyses were largely the same as the ones presented above, suggesting the number of check-ins participants completed did not have a large influence on the overall pattern of findings.

Results of analyses in which we controlled for gender, age, BMI, socioeconomic status, and race for all outcomes are included in Supplemental Tables 33-47. Results of these analyses were nearly identical as those presented in our primary analyses, suggesting that inclusion of demographic covariates did not substantially alter our findings.

Figure 2

The Interaction between Variability and Mean Levels of Negative Relational Experiences in Predicting Coping in Everyday Life



General Discussion

We drew on a highly-powered study that implemented an app-based research approach to examine how positive and negative relational experiences predicted stress, coping, blood pressure, blood pressure reactivity, and heart rate reactivity in daily life. With respect to psychological outcomes, we observed that (a) greater mean-levels of positive and lower negative relational experiences predicted lower self-reported stress and better coping in daily life, and (b) greater variability (i.e., less stability) in negative (but not positive) relational experiences consistently predicted *lower* stress and *better* coping. With respect to physiological outcomes, mean levels of both positive and negative relational experiences were associated with participants' physiological experiences in daily life, such that negative relationship experiees predicted a maladaptive physiological profile (greater SBP reactivity, greater DBP reactivity, and greater overall DBP), whereas positive relational experiences predicted greater SBP reactivity but lower heart rate reactivity. Additionally, we also found evidence of an interaction between mean levels and variability in relational experiences in predicting stress, coping, and overall SBP, such that the influence of variability depended on context. Implications of these results are discussed below.

Numerous researchers have recently called for a better understanding of the mechanisms by which close relationships influence health (e.g., Farrell & Stanton, 2019; Sbarra & Coan, 2018; Slatcher & Selcuk, 2017). In the current research, although we did not directly test for mediation between the health-relevant daily processes and long-term health outcomes (e.g., disease diagnosis or mortality), our results shed light on some unanswered questions in this literature. In particular, our results suggest that (a) mean levels of *both* negative and positive relational contribute to health-relevant psychosocial (stress and coping) and physiological (blood pressure and heart rate) processes in daily life (depending on the specific outcome of interest), but that (b) negative relational variability is more consistently linked with these outcomes in daily life than positive relational variability. Only one prior study, to our knowledge, had included both positive and negative aspects of relational experiences in a study examining health-relevant outcomes (Slatcher et al., 2015), so it was heretofore unclear whether relational positivity or negativity would be most influential. Our results clarify this work by suggesting that both positive and negative relational experiences clearly matter.

One of the primary novel contributions of this research is in extending the nascent research examining relational variability to the domains of stress, coping, and physiology. Critically, prior research examining relational variability was inconsistent, with some studies suggesting relational variability was associated with maladaptive outcomes (Arriaga et al., 2006; Campbell et al., 2010; Girme et al., 2018), while others studies suggesting it was associated with mixed or beneficial outcomes (Don et al., 2022; Overall, 2020). In this work, people who reported greater variability in their negative relational experiences reported *lower* stress, *better* coping, and *lower* SBP reactivity. Consistent with the work of Overall (2020), one possible explanation for this pattern of findings is that variability in negative relational experiences specifically may be beneficial, because negative experiences like conflict can be detrimental if consistent throughout one's life. As such, consistency or stability in negative relational experiences may be maladaptive because it represents an inability to respond flexibly to the demands of the situation (Overall, 2020). More broadly, our work extends the literature by demonstrating that it is not just mean levels of negative relational experiences that contribute to health-relevant processes in daily life, but that relational variability also matters.[4] Given that we

[4] We note additionally our results suggested that mean levels and variability in relational experiences may interact, specifically when predicting stress and coping.

only examined a few outcomes in this work, future research is needed examine how relational variability contributes to other psychosocial, physiological, and behavioral factors that contribute to physical health.

It is important to consider the size of the effects we identified, and whether they are practically meaningful. Generally speaking, the effect sizes for mean levels of relational experiences were stronger in predicting the outcomes of interest than variability in relational experiences. Moreover, relational experiences tended to be a stronger predictor of stress and coping than the physiological outcomes we examined. Despite generally small effect sizes, we believe these findings are practically meaningful. For instance, throughout our analyses, we found a small but consistent effect: that negative relational experiences tended to predict a maladaptive cardiovascular profile in everyday life. Although this effect is small, to the extent that negative relational experiences contribute to elevated blood pressure throughout everyday life, across the course of time this maladaptive cardiovascular profile associated with negative relational experiences may accumulate into long-term physiological harm, or negative health outcomes (e.g., Götz et al., 2022).

Limitations and Constraints on Generality

This study is not without limitations. First, while our sample was drawn from across the world, three-quarters of the participants were White individuals, and over two-thirds were from the United States. As such, our sample is not representative of most relationships globally, and because our goal is to derive conclusions about the general link between relationships and health, this work requires replication among samples with more ethnic, sociodemographic, and geographic diversity. Second, our results are correlational, and bi-directionality is possible in our findings: for instance, prior research demonstrates that stress influences relationships processes (e.g., Neff & Karney, 2009). While the goal of this work was to identify the plausible ways in which relationships connect to health-relevant processes in daily life, future research is needed to causally test (a) directionality, and (b) the precise mechanisms by which relationship influence physical health. Third, participants in this study received feedback on their physiology throughout the course of the study, and it is possible that this type of feedback influenced their behavior or subsequent physiology. We do feel, however, that this type of physiological feedback is unlikely to influence the association between aggregated relational experiences and the outcomes we examined, but this facet of our study design must be considered when generalizing these results to the general population. Finally, we also note that there were large number of people in this study who did a small number of check-ins, although in supplemental analyses we found check-in number did not meaningfully influence the results.

Conclusion

We forged new ground by examining how mean levels and variability in relational experiences predicted psychological and physiological processes in daily life that are relevant to physical health. The quality of our relationships can determine who lives and dies; this research points to some pathways through which relationships may contribute to or undermine physical health.

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