

Social Relationships and Ambulatory Blood Pressure: Structural and Qualitative Predictors of Cardiovascular Function During Everyday Social Interactions

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Healthy normotensive men and women ($N = 102$) underwent a 3-day ambulatory blood pressure (BP) assessment in which a BP reading was taken 5 min into each social interaction. After each interaction, participants completed a diary that included structural categorization of the relationship and ratings of the quality of the relationship with the interaction partner. Random regression analyses revealed that interactions with family members and spouses were associated with lower ambulatory BP. Interactions with ambivalent network members (characterized by both positive and negative feelings) were associated with the highest ambulatory systolic BP, an effect that was independent of the familial effects on BP. Although there were psychological correlates associated with both structural and functional aspects of relationships, no evidence was found that these mediated the primary findings involving ambulatory BP. These data highlight the influence of both structural and qualitative aspects of relationships on ambulatory BP and possibly health.

Key words: ambulatory blood pressure, social relationships, cardiovascular functioning, diary study, ambivalence, health

Relationships with others occupy a central role in people's everyday lives, and evidence suggests that these relationships have positive effects on physical health (Berkman, 1995; Cohen, 1988; House, Landis, & Umberson, 1988). Reviews of prospective studies indicate that people who are socially isolated are at increased mortality risk from a number of causes (Berkman, 1995) and that the effects of social relationships are comparable with standard risk factors such as smoking, exercise, and diet (House et al., 1988). In fact, both structural (e.g., type of relationship or size of social network) and qualitative (e.g., perceived helpfulness) aspects of social relationships are inversely related to the incidence of the most common cause of death in industrialized nations—coronary heart disease (CHD; Berkman, Leo-Summers, & Horow-

itz, 1992; Cohen, 1988; Orth-Gomer, Rosengren, & Wilhelmsen, 1993). One relatively unexplored pathway by which relationships may influence CHD is through their impact on blood pressure (BP) during daily life (Uchino, Cacioppo, & Kiecolt-Glaser, 1996). Thus, the major aim of this study was to examine the association of ambulatory BP levels with differing aspects of social relationships.

Studies of ambulatory BP are important because this index is a predictor of cardiovascular outcomes. Although studies have confirmed that the risk of cardiovascular disease rises in a linear fashion with increases in resting BP assessed in the clinic (MacMahon et al., 1990), clinic BP may not represent an individual's usual level or capture important fluctuations. Ambulatory assessments may more closely characterize an individual's BP because a number of representative measurements are taken during everyday life (see Stone & Shiffman, 1994). Importantly, studies suggest that elevated ambulatory BP may be a stronger predictor of cardiovascular outcomes, including severity of complications in essential hypertension, organ damage such as left ventricular wall thickness or hypertrophy, and overall morbidity and mortality than are clinic BP readings (Perloff, Sokolow, & Cowan, 1983; Pickering, Harshfield, Devereux, & Laragh, 1983; Prisant, Carr, Wilson, & Converse, 1990; Sokolow, Werdeger, & Hinman, 1966).

Although there has been research on how psychosocial variables such as mood (e.g., Gellman et al., 1990; Kamarck et al., 1998) and personality (e.g., Porter, Stone, & Schwartz, 1999; Raikkonen, Matthews, Flory, Owens, & Gump, 1999) may influence ambulatory BP, very little attention has been paid to whether characteristics of social relationships predict ambulatory BP (Uchino et al.,

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1996). This is surprising considering social relationships have been linked to significant physical health outcomes including endpoints directly related to CHD (Berkman, 1995). Of the few studies that have examined such an association, several do suggest its importance in predicting ambulatory BP. For example, in an examination of more structural aspects of relationships (e.g., with family, with friends, or with strangers), Spitzer et al. (1992) found that ambulatory BP levels were lowest when with a family member and highest when with a stranger (also see Guyll & Contrada, 1998).

Although these few studies provide preliminary evidence of an association between social relationships and ambulatory BP, many important questions are raised by these data. First, Spitzer et al. (1992) only provided a limited sampling of different relationship types (i.e., family, friends, strangers). It was unclear if the BP effects attributed to these higher order social contexts were due to more specific interactions with spouses, coworkers, and others. Thus, a comparison between other structural categories of relationships (e.g., coworkers, romantic relationships) is an important unexplored issue. It should be noted that direct comparisons between more diverse structural aspects of social networks have been difficult in prior research. Of the few studies that exist, all have used a standard interval-contingent sampling that takes a BP reading during a certain time point (e.g., once every 15–20 min or every hour). Unless extended over several days, it is unclear as to whether such a method would adequately capture a comprehensive assessment of daily social interactions. Even if a social interaction was assessed, there may be significant variability in how long into it that BP was taken using a random sampling procedure. Therefore, in the present study, we capitalized on a well-established method of sampling (i.e., event-contingent sampling; Reis & Wheeler, 1991) used in social interaction research that has not thus far been used in ambulatory BP studies. Event-contingent sampling method uses explicit criteria to define an event (in our case, a social interaction) that can then be linked to ambulatory BP. This sampling method may provide an alternative test of whether differing social contexts predict ambulatory BP because any social interaction that meets predefined criteria can potentially be sampled. Consistent with the results of Spitzer and colleagues, we predicted that interactions with family members would be associated with the lowest ambulatory BP. We further hypothesized that interactions with spouses would also predict lower ambulatory BP than interactions with others, given prior research on the protective effects of marital relationships (Kiecolt-Glaser & Newton, 2001; Stroebe & Stroebe, 1996).

A second major limitation of the existing studies is that no study that we are aware of has assessed the effects of the quality of the relationship on ambulatory BP during social interactions. General views or schemas about specific relationships provide an important cognitive lens through which the behaviors of others are encoded and interpreted (Dunkel-Schetter & Bennett, 1990). However, there appears to be considerably more heterogeneity in the quality of individuals' relationships than has been examined in prior research. Most prior research has examined the positive and negative aspect of individuals' social relationships from a bipolar perspective, implicitly assuming that social relationships are characterized as either primarily positive or primarily negative. Positive and negative aspects of social relationships, however, tend to be separable dimensions (Finch, Okun, Barrera, Zautra, & Reich, 1989; Fiore, Becker, & Coppel, 1983; Kiecolt-Glaser, Dyer, &

Shuttleworth, 1988; Ruehlman & Karoly, 1991), and many individuals construe their relationships as having a mix of positive and negative feelings (Uchino, Holt-Lunstad, Uno, & Flinders, 2001). The implications of this ambivalence within relationships have not been adequately considered in social support theory or research (Coyne & DeLongis, 1986; Major, Zubek, Cooper, Cozzarelli, & Richards, 1997; Uchino et al., 2001).

We have argued that the separability of positive and negative aspects of social relationships may have significant conceptual implications for their joint study (Uchino et al., 2001). As illustrated in Figure 1, such data suggest that any given social network member may differ in his or her underlying positive and negative basis (Cacioppo & Berntson, 1994). As depicted in the high-positivity/low-negativity corner of Figure 1, there may be social network members that are primarily sources of social support or other pleasant interpersonal experiences (e.g., enjoyable friends). The low-positivity/high-negativity corner reflects a network tie that is primarily a source of negativity or what we label a socially aversive tie (e.g., an unreasonable work supervisor). The low-positivity/low-negativity corner would be a socially indifferent tie and may represent network members who are characterized by relatively low levels of social interactions (e.g., casual coworkers or neighbors). A unique aspect of this conceptualization for the social relationships and health literature is represented in the high-positivity/high-negativity corner of Figure 1. We label such a network member as a source of *ambivalence*. This refers specifically to network members who are a source of both positivity and negativity (e.g., overbearing parent, volatile romance, competitive friend). Unfortunately, the implications of ambivalent relationships have not been adequately examined as most of the prior research on social support has ignored the negative aspects that may co-occur with the positive aspects of relationships (Coyne & DeLongis, 1986; Rook & Pietromonaco, 1987; Uchino et al., 2001).

We have found in our prior research that ambivalent ties, compared with supportive ties, were associated with (a) greater interpersonal stress and (b) higher cardiovascular reactivity during acute stress in older adults (Uchino et al., 2001). Based on these data, we predicted that interactions with ambivalent network members during everyday life would be associated with the highest ambulatory BP levels. Consistent with the literature linking more

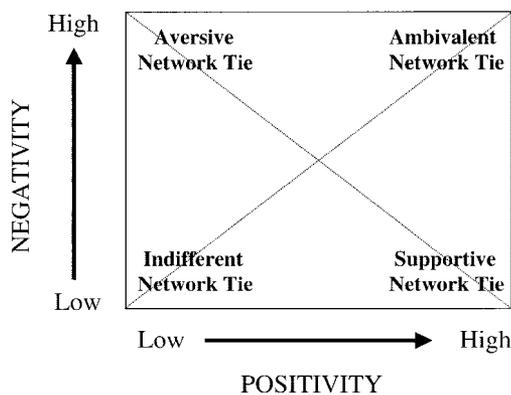


Figure 1. General conceptual framework incorporating the positive and negative aspects of social relationships on health.

positive aspects of relationships to better health outcomes, we also predicted that daily interactions with supportive network members (i.e., primarily positive relationships) would be associated with the lowest ambulatory BP.

Social relationships presumably influence ambulatory BP by means of relevant psychological processes. For instance, prior research suggests that supportive relationships are associated with a more positive psychological profile (Sarason, Pierce, & Sarason, 1990). In the present study, we examined a variety of psychosocial factors that may be responsible for the association between social relationships and these physiological processes. First, we were interested in how the structural and qualitative relationship variables predicted experienced psychological states. On the basis of prior research, we first predicted that supportive relationships would be associated with increases in self-disclosure, intimacy, and positive affect and decreases in negative affect compared with the other relationship categories depicted in Figure 1. Our prior work with older adults further suggests that interactions with ambivalent ties would predict increases in negative affect. Second, we were interested in whether these factors then served as mediators of any obtained results. We thus examined if any significant associations detected in our first set of analyses could account for the observed associations between social relationships and ambulatory BP.

Method

Participants

Forty-nine healthy men and 53 healthy women participated in this study. Volunteers were recruited from introductory psychology courses and through paid advertisement. Our participants were between the ages of 18 and 46 years ($M = 24$ years), and 86% were employed.¹ Participants were given extra credit or paid \$50 for their time. Consistent with our prior research (e.g., Cacioppo et al., 1995), the following self-reported inclusion criteria were used to select healthy participants: no existing hypertension, no cardiovascular prescription medication use, no past history of chronic disease with a cardiovascular component (e.g., diabetes), no recent history of psychological disorder (e.g., major depressive disorder), and no consumption of more than 10 alcoholic beverages a week.

Procedure

Participants volunteered to participate in a 3-day study in which an ambulatory BP measurement was to be initiated 5 min into every social interaction. Each participant wore an ambulatory BP monitor and carried a folder with a number of diary sheets throughout the study. To get a broader sampling of an individual's social interaction, we assessed 2 working or school days and 1 nonworking or nonschool day. On each day, participants arrived at the lab in the morning, and the monitor was attached by a trained assistant. Participants returned to the lab each evening (after 8 p.m.), the monitor was removed, completed diary sheets were collected, and protocol accuracy for the day was assessed (i.e., diary accuracy scale; see below).

On the 1st day, participants received detailed instructions. They were told to initiate a BP reading approximately 5 min into all social interactions that lasted a minimum of that duration. Participants were also told that in the event they forgot to initiate a BP reading after 5 min, they should still take a reading and estimate how long into the interaction it was assessed. Criteria for a social interaction were defined as any activity in which participants were mutually engaged with another individual, such as a conversation (Reis & Wheeler, 1991). The mere presence of another individual was neither necessary (e.g., telephone conversations) nor suffi-

cient (merely being in the same room without an interaction). Diary sheets were then explained, and participants were told to fill out one diary sheet immediately following each social interaction.

On the final day of the protocol, all of the participants were compensated, debriefed, and thanked for their participation. Because of the potentially sensitive nature of these interpersonal assessments, strict assurances of confidentiality were given to all participants. They were also given the opportunity at the end of the study to withdraw and take their diaries with them without any penalty, although no participant in the present study chose this option.

Measures

Ambulatory BP monitor. The Accutracker II (Suntech Medical Instruments, Raleigh, NC) was used to estimate ambulatory readings of systolic blood pressure (SBP), diastolic blood pressure (DBP), and heart rate (HR). The Accutracker II was designed specifically for ambulatory assessments and is well-validated as readings correspond with intra-arterial BP assessments during rest, isometric exercise, and bicycle exercise (White, Lund-Johansen, & Omvik, 1990; also see Light, Obrist, & Cubeddu, 1988). The Accutracker II assessed HR by means of three electrocardiogram sensors attached to the chest, whereas SBP and DBP were assessed with the auscultatory method using a microphone and occluding cuff. The sensors and the cuff were worn under the participants' clothing, and only a small control box (approximately 5.0 in. \times 3.5 in. \times 1.5 in., or 12.7 cm \times 8.89 cm \times 3.81 cm) attached to the participant's belt was partially exposed.

Participants were instructed to press an easily identified start button on the monitor to initiate a BP reading. The monitor recorded and saved all BP and HR readings, as well as the times and the date they were taken in memory. Each evening a trained research assistant downloaded the data that was obtained during the day.

The Accutracker II uses a number of codes that may signify problems with the estimation of the ambulatory cardiovascular assessment. On the basis of prior research (see Kamarck et al., 1998), we deleted readings associated with test codes 2 (weak Korotkoff sounds), 3 (microphone difficulties), and 4 (air leaks). Outliers associated with artifactual readings were also identified using the criteria by Marler, Jacobs, Lehoczy, and Shapiro (1988). These included the following: (a) SBP less than 70 mm Hg or greater than 250 mm Hg, (b) DBP less than 45 mm Hg or greater than 150 mm Hg, (c) HR less than 40 beats per minute (bpm) or greater than 200 bpm, and (d) SBP/DBP less than $1.065 + (.00125 \times \text{DBP})$ or greater than 3.0. Compared with prior research, 17% of the ambulatory cardiovascular readings were deleted on the basis of the above criteria, resulting in 1,568 valid ambulatory readings (e.g., Raikkonen et al., 1999). These criteria resulted in the loss of 4 participants who started with few readings. As a result, our final sample included 98 participants.

Ambulatory diary. Participants were instructed to complete a one-page diary sheet with each ambulatory cardiovascular assessment. It was designed to be easy to complete (about 1–2 min) to maximize cooperation and was divided into four general sections. The first consisted of general information, such as the date and time of the interaction. It also assessed the duration of the interaction when the cuff was inflated. The second section assessed information on basic variables that might influence cardiovascular function (see Guyll & Contrada, 1998; Kamarck et al., 1998). These include items such as posture (lying down, sitting, standing); activity level (1 = *no activity*, 4 = *strenuous activity*); location (work, home, other); talking (yes, no); temperature (too cold, comfortable, too hot); prior consumption of nicotine, caffeine, alcohol, or a meal; and prior exercise (no, yes). The third section of the ambulatory diary was adapted from the Rochester interaction record (see Reis & Wheeler, 1991). Participants were

¹ The University of Utah is a commuter school and comprises many nontraditional students; therefore, many of our participants may have been working and attending school.

asked to list the initials of the primary person they were interacting with and their relationship to the person (e.g., friend, mother). This section also included assessments of perceived characteristics of the interaction, including positive affect, negative affect, intimacy, self-disclosure, and social influence (1 = *not at all*, 6 = *extremely*). The final section of the diary was adapted from our social relationship index (Uchino et al., 2001) and assessed how generally positive and negative the participant typically felt toward the primary interaction partner (1 = *not at all*, 6 = *extremely*).

Diary Accuracy Scale. The Diary Accuracy Scale (DAS) was created on the basis of interview questions used extensively in prior research (Cutrona, 1986; Hodgins & Zuckerman, 1990; Reis, Senchak, & Solomon, 1985; Reis & Wheeler, 1991) as an indication of accuracy with the diary procedure. The DAS was completed at the end of each monitoring day and was used to estimate the participants' difficulty and accuracy associated with the ambulatory protocol. Participants rated the difficulty in remembering to inflate the cuff or record the interaction (1 = *no difficulty*, 7 = *very much difficult*). They also estimated the percentage of interactions in which they did not inflate the cuff and did not record the interaction in the diary. Finally, participants rated the extent to which cuff inflation and diary recordings interfered with the interaction (1 = *none*, 7 = *a great deal*).

Results

Preliminary Analyses

We first examined participants' ratings of the difficulty and accuracy associated with the protocol as assessed by the end-of-day DAS. Mixed-model analyses of variance were performed using time (Day 1, Day 2, Day 3) as a repeated variable. Gender was also examined as a between-participant variable. Results revealed no significant gender main effects on any of these items. Furthermore, no significant changes occurred over time on any of these measures, and no Gender × Time interactions approached significance. Average levels of these ratings are summarized in Table 1 and suggest that participants (a) did not view the protocol as particularly difficult, (b) were relatively accurate in their ratings, and (c) missed recording a relatively small proportion of the potential interactions. These findings are relatively consistent with prior studies that use event-contingent sampling of social interactions (Reis & Wheeler, 1991). Nevertheless, because of the retrospective nature of these ratings, it is possible that participants may have overestimated their adherence. In addition to reports of accuracy, we also examined the number of BP readings that did not have a corresponding diary. Our participants were missing an average of 1.04 diary record(s) per day,² which is only slightly higher than their self-reported accuracy assessment.³

We next examined the number and nature of the social interactions that occurred during the study. Participants had a mean of 18.8 interactions during the 3-day recording period ($M = 6.3$

Table 1
Mean Diary Rating Scale Items

Item	<i>M</i>	<i>SD</i>
Difficulty remembering to inflate cuff	1.96	1.04
Difficulty remembering to record diary	2.24	1.20
Accuracy in recorded diary	2.28	0.91
Interactions cuff not inflated (%)	10.42	14.03
Interactions not recorded in diary (%)	7.73	10.32
Cuff interfered with interaction	2.26	1.30
Diary interfered with interaction	1.94	1.17

Table 2
Frequency and Percentage of Interactions With Different Relationships

Category and relationship type	Frequency	%	Mean no. of interactions per individual
1. Father	42	2.28	0.35
2. Mother	94	5.11	0.69
3. Sister	50	2.72	0.40
4. Brother	42	2.28	0.37
5. Relative other	114	6.20	0.75
6. Husband	49	2.66	0.38
7. Wife	104	5.66	0.74
8. Girlfriend	49	2.66	0.44
9. Boyfriend	57	3.10	0.41
10. Friend	548	29.80	4.50
11. Roommate	29	1.58	0.25
12. Coworker	241	13.10	2.14
13. Boss	68	3.70	0.62
14. Neighbor	7	0.38	0.03
15. Client or customer	20	1.09	0.13
16. Classmate	40	2.18	0.32
17. Other	285	15.50	2.42

interactions/day). As shown in Table 2, many of these interactions occurred with friends (29.8%), immediate family (20.7%), or coworkers (13.1%). Importantly, as evidenced by Table 2, we appear to have a broad sampling of participants' interactions with their social network.

Do Different Categories of Relationships Predict Characteristics of the Interaction?

Before examining if more structural aspects of relationships influence ambulatory BP, we first examined the psychological processes associated with these different structural categories. To have an adequate number of readings in each relationship category, we divided relationships into the higher order categories of familial relationships (Categories 1 to 7; see Table 2) versus nonfamilial relationships (Categories 8 to 16), romantic relationships (Categories 6 to 9) versus nonromantic relationships (Categories 1 to 5 and 10 to 16), spousal relationships (Categories 6 and 7) versus nonspousal relationships (Categories 1 to 5 and 8 to 16), and work relationships (Categories 12, 13, and 15) versus nonwork relationships (Categories 1 to 11 and 14, 16). In the present analysis, Category 17 (other) presented problems as the nature of these relationships was not known. As a result, these data were excluded from the analyses.

We used Proc Mixed (SAS Institute; Littell, Milliken, Stroup, & Wolfinger, 1996) to examine the diary ratings of positive affect, negative affect, intimacy, self-disclosure, and influence (see Schwartz & Stone, 1998). Proc Mixed uses a random regression model to derive parameter estimates both within and across indi-

² This is equivalent to 16% over the 3-day study.

³ It is possible that some BP readings without corresponding diary sheets may have been due to erroneously hitting the start button or initiating a BP reading out of curiosity in nonsocial situations. Therefore, it is unclear if participants were overestimating their compliance.

Table 3

Primary Results of Interactions Between Structural and Functional Aspects of Social Relationships, Psychological Factors, and Cardiovascular Functioning

Dependent variable	Structural aspects											
	Familial vs. nonfamilial			Romantic vs. nonromantic			Spousal vs. nonspousal			Work vs. nonwork		
	<i>b</i>	<i>t</i>	<i>df</i>	<i>b</i>	<i>t</i>	<i>df</i>	<i>b</i>	<i>t</i>	<i>df</i>	<i>b</i>	<i>t</i>	<i>df</i>
Psychological												
Positive affect	0.23**	2.80	1,169	0.21*	1.96	1,169	0.31*	2.33	1,169	-0.53***	-5.87	1,169
Negative affect	0.01	0.11	1,169	-0.04	-0.39	1,169	-0.15	-1.06	1,169	0.33***	3.48	1,169
Intimacy	0.80***	7.70	1,169	1.04***	7.98	1,169	0.97***	5.72	1,169	-1.27***	-11.36	1,169
Disclosure	0.29**	3.00	1,163	0.47***	3.86	1,163	0.44**	2.77	1,163	-0.58***	-5.40	1,163
Influence	-0.05	-0.63	1,168	0.09	0.93	1,168	0.14	1.16	1,168	0.10	1.19	1,168
Ambulatory cardiovascular assessment												
SBP	-3.42*	2.30	1,141	-2.07	-1.16	1,141	-3.48	-1.61	1,386	3.14	1.44	1,141
DBP	-2.46**	3.13	1,099	-1.93*	-1.99	1,099	-3.02*	-2.55	1,336	0.20	0.24	1,099
HR	-0.84	-0.97	1,110	-1.01	-0.94	1,110	-1.25	-0.93	1,342	0.14	0.15	1,110

Note. SBP = systolic blood pressure; DBP = diastolic blood pressure; HR = heart rate.

* $p < .05$. ** $p < .01$. *** $p < .001$.

viduals (Singer, 1998). In the present study, the intercept was treated as a random variable (see Singer, 1998). By default, Proc Mixed also treats the unexplained variation within individuals as a random factor. The unstructured variance-covariance matrix was specified in this model and allowed the intercept and variation within individuals to be estimated from the data. Unless otherwise noted, all other factors were treated as fixed variables to reduce the complexity of the model.⁴ In these analyses, gender and relationship categorization were first centered at their grand mean before inclusion into the model (Singer, 1998). Because of the overlap inherent in these categorizations (e.g., spouses are included in familial ties), we performed separate analyses for each relationship categorization.

In these analyses, we first examined the psychological correlates of interacting with familial versus nonfamilial relationships. As shown in Table 3, results revealed that interactions with familial ties were associated with greater levels of positive affect, intimacy, and self-disclosure. Of interest, familial interactions did not differ from nonfamilial interactions in terms of negative affect ($p > .90$) or influence ($p > .50$). Analyses involving spousal and romantic relationships were consistent with the above findings as spousal interactions were associated with higher positive affect, intimacy, and self-disclosure. Again, no significant differences were found for negative affect and influence.

Finally, analyses of interactions with work relationships revealed that these were viewed more negatively than interactions with nonwork relationships. Work relationships were associated with lower positive affect, greater negative affect, lower intimacy, and lower self-disclosure.

Do Different Categories of Relationships Predict Ambulatory Cardiovascular Assessments?

The preceding analyses suggested that interactions with familial, spousal, romantic, and nonwork relationships were viewed more positively than their counterparts. In our first analyses of BP, we

examined the association between the structural categories of relationships and ambulatory BP. However, before proceeding to these analyses we examined the potential contribution of extraneous factors such as posture that might need to be statistically controlled (Schwartz, Warren, & Pickering, 1994). In these analyses, time (first reading, second reading, etc.) was also included as a random factor, whereas gender, body mass index, time passed before cuff inflation, posture (lying-sitting, sitting-standing), activity level, talking, location (home-work, home-other), and temperature (comfortable-too cold, comfortable-too hot) were treated as fixed factors in the model. In addition, exercise and consumption of nicotine, caffeine, alcohol, and a meal since the last reading were treated as fixed factors and examined because of their potential influence on ambulatory BP. All variables were first centered at their grand mean before inclusion into the model (Singer, 1998) and were analyzed using Proc Mixed.

Results of this initial model revealed that time, prior nicotine use, home-work location, and home-other location were independent predictors of higher ambulatory SBP, whereas lying-sitting posture, sitting-standing posture, prior nicotine use, talking, and home-other location independently predicted higher ambulatory DBP. In analyses of HR, women had higher ambulatory HR than men. Likewise, lying-sitting posture, sitting-standing posture, activity level, prior nicotine, prior meal, and home-other location predicted greater ambulatory HR. No other variable approached significance.

In our main analyses, the covariates ($p < .10$) from our first analyses were included in the equation to provide a test of the independent effects of relationship categories on ambulatory cardiovascular function. Results of these analyses converged some-

⁴ To take a more conservative approach, we also performed our analyses treating the major structural and qualitative relationship assessments as random factors in the model. Results of these analyses were comparable with those reported later.

Functional aspects								
General positivity			General negativity			Positivity × Negativity		
<i>b</i>	<i>t</i>	<i>df</i>	<i>b</i>	<i>t</i>	<i>df</i>	<i>b</i>	<i>t</i>	<i>df</i>
0.36***	12.63	1,378	-0.21***	-5.63	1,378	0.04	1.71	1,378
-0.09**	-2.96	1,378	0.45***	10.56	1,378	-0.08***	-3.80	1,378
0.61***	16.68	1,376	0.17***	3.37	1,376	-0.00	-0.17	1,376
0.35***	9.86	1,373	-0.10*	-2.05	1,373	-0.08**	-3.18	1,373
0.02	0.61	1,377	0.04	1.01	1,377	0.00	0.06	1,377
0.42	0.80	1,342	0.74	1.04	1,342	0.73*	2.03	1,342
0.05	0.18	1,289	0.22	0.58	1,289	0.44*	2.20	1,289
0.16	0.49	1,302	0.01	0.01	1,302	0.07	0.32	1,302

what with the findings regarding the psychological correlates of relationship categories (see Table 3). Consistent with Spitzer and colleagues (Spitzer et al., 1992), familial interactions were associated with lower levels of ambulatory SBP (for nonfamily, $M = 138.98$; for family, $M = 135.84$) and DBP (for nonfamily, $M = 81.05$; for family, $M = 78.79$). In addition, DBP was lower when interacting with romantic (for nonromantic, $M = 77.28$; for romantic, $M = 75.86$) and spousal relationships (for nonspouse, $M = 77.39$; for spouse, $M = 75.79$). Interactions with work versus nonwork relationships did not predict ambulatory SBP, DBP, or HR ($ps > .15$).

Finally, we examined whether the psychological variables mediated the effects of these structural aspects of relationships on ambulatory BP. We focused on familial versus nonfamilial relationship as it had the most consistent associations with ambulatory BP. Analyses reveal that statistically controlling for these psychological factors did not alter the effects for familial versus nonfamilial relationships on ambulatory SBP ($\beta = -4.03$, $p = .007$) or DBP ($\beta = -3.03$, $p = .0002$). These analyses suggest that these psychological factors do not account for the observed effects of relationship type on ambulatory BP.

Does the Quality of the Relationship Predict Characteristics of the Interaction?

The second major aim of this study was to investigate whether the quality of the relationship (i.e., how positive and negative participants typically felt toward the primary interaction partner) predicted ambulatory cardiovascular function. As in the prior analyses, we first examined more specific psychological processes potentially associated with these qualitative measures. Gender, normally perceived positivity, and normally perceived negativity were treated as fixed factors and centered at their grand mean. These variables, along with the normally perceived positivity and negativity cross-product term, were entered simultaneously into

the random regression models predicting positive affect, negative affect, intimacy, self-disclosure, and influence. These analyses revealed several main effects that replicated prior research on social relationships and psychological outcomes. Consistent with prior research on supportive relationships, results revealed that normally perceived positivity was associated with higher levels of positive affect, lower levels of negative affect, greater ratings of intimacy, and greater self-disclosure (see Table 3). In comparison, perceived negativity toward the primary person with whom participants interacted predicted less positive affect, higher negative affect, and lower levels of self-disclosure. Surprisingly, normally perceived negativity toward the person predicted greater ratings of intimacy.⁵

Of greater interest for the conceptual framework depicted in Figure 1 were the statistical interactions between ratings of normally perceived positivity and negativity that emerged for ratings of self-disclosure and negative affect. The form of these interactions was examined by computing predicted values one standard deviation above and below the mean for perceived positivity and negativity. These predicted values revealed that self-disclosure was highest when interacting with more supportive ties (high positivity, low negativity) and lowest when interacting with indifferent (low positivity, low negativity) and aversive (low positivity, high negativity) ties. Interactions with ambivalent ties were associated with a moderate level of self-disclosure. Predicted negative affect score also revealed that negative affect was highest when interacting with aversive ties, moderate when interacting with ambivalent ties, and lowest when interacting with supportive and indifferent ties.

⁵ Although it is difficult to explain this finding, we suspect that it may be a statistical artifact as no other ratings paralleled this perceived negativity main effect.

Does the Quality of the Relationship Predict Ambulatory Cardiovascular Assessments?

In our main analyses, we again used Proc Mixed to investigate if the quality of the relationships predicted ambulatory cardiovascular assessments. In the random regression model, the covariates ($p < .10$) from our first analyses were again included in the equation to provide a test of the independent effects of relationship quality. These covariates were entered along with measures of normally perceived positivity, normally perceived negativity, and the cross-product term for positivity and negativity to test the utility of the model depicted in Figure 1. All main effect variables were again centered at the grand mean before inclusion in the model (Singer, 1998).

No main effects of normally perceived positivity and negativity emerged for ambulatory SBP, DBP, and HR. However, significant statistical interactions between normally perceived positivity and negativity emerged in predicting ambulatory SBP and ambulatory DBP ($ps < .05$). The form of these statistical interactions were examined by plotting predicted values for SBP and DBP one standard deviation below and above the mean for perceptions of relationship positivity and negativity (Aiken & West, 1991). As shown in Figure 2, individuals interacting with social ties about which they normally felt relatively high levels of both positivity and negativity (ambivalent) had elevated levels of ambulatory SBP compared with the other relationship categories. Similar to the pattern for SBP, interactions with ambivalent ties were associated with the highest levels of ambulatory DBP. No significant statistical interactions were found in analyses of HR.⁶ Overall, these data provided evidence for the potential detrimental influence of interactions with ambivalent ties on ambulatory BP.

One potential alternative explanation for these findings on ambulatory BP is that the relationship ratings were biased by current levels of affect during the interaction. To address this issue, we examined the statistical interaction between rated positive and negative affect during the actual interaction on ambulatory BP. If characteristics of the interaction significantly biased the relationship ratings, then the same patterns of association should be evident using the mood ratings of the interactions. Inconsistent with this possibility, results of these ancillary analyses revealed that none of the statistical interactions between positive and negative affect approached significance ($ps > .25$). In addition, statistically controlling for the main effects and cross-product term for state positive and negative affect did not alter the significance

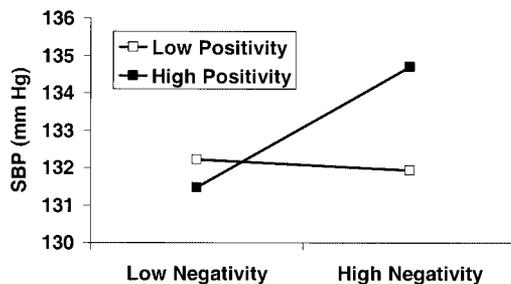


Figure 2. Predicted systolic blood pressure (SBP) levels during social interactions as a function of normally perceived relationship positivity and negativity (one standard deviation above and below the mean).

levels of the association between relationship quality and ambulatory BP. Therefore, it appears that state measure of affect did not influence the ambulatory BP effects we found for relationship quality.

In more conceptually interesting analyses, we examined whether the psychological variables mediated the effects of social relationships on ambulatory BP. Although the statistical interactions between positivity and negativity for self-disclosure and negative affect did not evidence the same pattern as those for ambulatory BP, nevertheless we examined these as potential mediators of our observed results. The interaction of positive and negative relationship quality remained significant for SBP ($\beta = 0.73, p < .05$) and DBP ($\beta = 0.44, p < .05$) when statistically controlling for these factors, suggesting that these psychological processes did not account for the effects of relationship quality on ambulatory BP.

What Is the Independent Contribution of Structural Versus Qualitative Aspects of Relationships in Predicting Ambulatory BP?

Results of this study suggest that both structural and qualitative aspects of social relationships predict ambulatory BP. An important question raised by these data is the independent contribution of these factors. For instance, is the effect of the quality of the relationship simply an artifact of its overlap with familial versus nonfamilial interactions? Or more interesting, given data linking both structural and qualitative aspects of relationships to health outcomes, are these independent pathways by which relationships may influence ambulatory BP? To address this question, we duplicated the analyses in the last section but included the familial versus nonfamilial category into the random regression equation. The familial category was used because it was the only significant predictor of both ambulatory SBP and DBP. Results of these analyses for SBP revealed that both the familial categorization ($p < .03$) and the normally perceived Positivity \times Negativity interaction ($p < .02$) remained significant. These data suggest that the elevated ambulatory SBP seen when interacting with ambivalent ties was independent of the familial categorization, and vice versa. However, analyses of DBP revealed that only the familial categorization main effect remained significant ($p < .001$).

Discussion

The primary aims of this study were to examine the prediction of ambulatory cardiovascular function by (a) different structural categories of relationships and (b) their quality. Results not only replicated and extended prior research on the BP correlates of structural social network classifications but also demonstrated the potential importance of the conceptual framework depicted in Figure 1. As noted earlier, prior research has examined positivity and negativity in social relationships from a bipolar perspective. This perspective would not have captured the synergistic effects of positivity and negativity (ambivalence) for ambulatory SBP, an

⁶ We also conducted ancillary analyses in which we examined the three-way interaction among gender, normally perceived positivity, and normally perceived negativity. Results did not suggest that gender moderated our main results ($ps > .13$). However, the sample size in the present study may have limited the power to test this three-way interaction.

effect that was independent of the structural categorization. These results are particularly interesting in light of research emphasizing the prognostic importance of SBP in predicting cardiovascular disorders (Lloyd-Jones, Evans, Larson, O'Donnell, & Levy, 1999).

Consistent with Spitzer et al. (1992), familial ties proved to be a strong, independent predictor of ambulatory SBP and DBP. Importantly, we were able to rule out some of the alternative explanations suggested by Spitzer and colleagues, such as physical activity and talking. However, an important unanswered question relates to why familial relationships are associated with lower levels of ambulatory cardiovascular assessments. The self-reported ratings of positive affect, negative affect, self-disclosure, and intimacy differed by the relationship categorizations but did not statistically mediate the effects on ambulatory BP. One possible explanation for these findings is that increased familiarity associated with familial ties may have a calming effect on the cardiovascular system. If this familiarity is indeed shaped by years of contact, then self-reported affect rating taken at the time of the interaction may not tap into this more automatic process. However, we only examined a limited set of psychological and behavioral processes. Therefore, although our failure to demonstrate mediation may appear to challenge the idea that psychological factors can have a direct impact on physiology, there may be other psychological factors mediating this relationship or perhaps our specific methodology was not sensitive enough. Future research should expand on the set of psychological states that we have included.

The ambulatory BP effects of interacting with supportive ties were weak in the present study. Of course, whether these data generalize to other populations (e.g., older adults) and contexts (e.g., times of high stress) remain questions for further research as we have found that social support is a stronger predictor of BP in older adults (e.g., Uchino, Holt-Lunstad, Uno, Betancourt, & Garvey, 1999). These data, nonetheless, are consistent with a meta-analysis that showed familial sources of support appeared to be particularly important predictors of resting BP (Uchino et al., 1996). The consistency of the effects reported for the familial categorization highlight the potential importance of interventions aimed at fostering familial social support.

We also found that interactions with ambivalent network members were associated with the highest levels of ambulatory SBP, independent of the familial categorization. We should emphasize that these results were not found for measures of ambulatory DBP or HR. These null results notwithstanding, these data combined with our earlier laboratory research (Uchino et al., 2001) suggest that ambivalent ties may be associated with negative effects on cardiovascular outcomes. One reason for this effect may be due to the increased interpersonal stress associated with ambivalent network members. Individuals can cope with aversive ties by discounting or withdrawing from such interactions. However, ambivalent ties are more complex, less readily avoided or discounted, and relatively less predictable, requiring heightened attention and effort during social interactions, processes that may be associated with potentiated cardiovascular responses (e.g., Smith, Ruiz, & Uchino, 2000). In addition, the negativity in ambivalent relationships may be more impactful because people care about these relationships at some level. Although the analyses of psychological processes again did not reveal a pattern that could explain the BP effect, perhaps more specific measures of vigilance, controllabil-

ity, or interpersonal stress would provide stronger tests of these mechanisms.

Overall, the data on ambivalence and ambulatory BP may have implications for the conceptualization and assessment of social relationships in the health domain. Much of the prior research on relationship quality and health has only assessed one dimension (typically positivity or social support). Even in studies in which both dimensions were assessed, researchers have typically examined the effects of one dimension by statistically controlling for the other (e.g., Finch et al., 1989; Fiore et al., 1983). As outlined in Figure 1, however, high negativity includes both social aversion and social ambivalence, whereas high positivity includes both social support and social ambivalence. Thus, examining either positive or negative dimensions of social networks in isolation (i.e., by assessing only a single dimension or statistically controlling for one dimension) may mask the different health effects of these network types and obscure reliable associations between social relationships and health-related outcomes. For instance, the adverse effects attributed to negative aspects of relationships in prior research may be specifically due to the influence of ambivalent ties. Future research will be needed to examine the implications of our framework for the links between social relationships and health outcomes.

There are several limitations of the present study that should be discussed. First, we used a cross-sectional design and a young, healthy sample. Although ambulatory BP appears to be a strong predictor of future cardiovascular disorders (Perloff et al., 1983; Verdecchia et al., 1994), whether these BP differences in our young sample would result in cardiovascular risk needs to be determined. Longitudinal studies will be necessary to clarify the health significance of short-term fluctuations in ambulatory BP as seen during mood states (e.g., Kamarck et al., 1998) or, in our case, during social interactions. The nature of the relationships sampled in this study (e.g., family, friends, significant other, coworkers) does suggest that such BP-altering interactions occur regularly, which may increase its long-term implications for health.

We also do not know in any objective sense how compliant participants were in sampling their social interactions. Although the DAS suggests adequate compliance, future studies that carefully compare event-sampling with interval-contingent sampling will be needed. In addition, we are unsure to what extent the social situation influenced the participant's compliance or the extent to which having to monitor an interaction influenced the nature of the interaction.⁷ It should also be noted that we did not explicitly compare BP readings during social interactions with alone conditions. Prior research does suggest that structural measures of social interactions (e.g., family, spouses) predict lower levels of ambulatory BP compared with being alone (Gump, Polk, Kamarck, & Shiffman, 2001; Spitzer et al., 1991). Nevertheless, the present study can only draw conclusions about the relative differences in ambulatory BP during different types of social interactions.

⁷ For instance, noncompliance may not be random (e.g., participants may be less likely to monitor negative interactions than positive interactions). Likewise, it is possible that because the participants knew they must monitor the interaction, they may have been less likely to get into a heated argument than if they were not wearing the monitor.

Compared with laboratory paradigms in which interactions with specific relationships are more tightly controlled (e.g., Gerin, Pieper, Levy, & Pickering, 1992; Kamarck, Manuck, & Jennings, 1990; Lepore, 1992), the nature of the interactions were also less specified in the present study. However, in this ambulatory paradigm with event-contingent sampling, this loss of specificity and experimental control was offset by increased generalizability because we were able to sample a wide variety of relationships and interactions. Furthermore, the ability to measure cardiovascular function in the everyday life of participants may better capture their cardiovascular risk (e.g., Perloff et al., 1983). Hence, in constructing a social psychophysiology of cardiovascular risk and response (Smith & Gerin, 1998), laboratory and ambulatory approaches provide complementary methodologies.

Despite possible limitations, there are a number of strengths of this study that are worth repeating. As noted, the effects of both the structural and qualitative aspects of one's social relationships on cardiovascular functioning were examined in a naturalistic context. This study is also unique in that it extended prior research on social relationships and health by using event-contingent ambulatory monitoring over multiple recording days to increase the reliability and generalizability of these findings. With rare exceptions, most prior research has used shorter (24 hr) interval-contingent sampling approaches to ambulatory BP monitoring. This approach may be influenced by atypical days, especially among college students, because each day may have different structure (e.g., particular classes, work, social events, weekend dates) that affects social interactions (Reis & Wheeler, 1991). Although event-contingent sampling may be more prone to noncompliance than interval-contingent sampling, it can be a useful complement to more traditional methods because it can provide a more controlled assessment of the event of interest. Finally, the conceptual model of relationships underlying this research helped to derive more specific predictions about associations between the quality of the relationship and physiological outcomes. Further research on this framework may prove helpful in developing a more complete understanding of the impact of relationships on health and guide the design of appropriate interventions to promote positive health outcomes.

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