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Mental Activation of Supportive Ties, Hostility, and Cardiovascular Reactivity to Laboratory Stress in Young Men and Women

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In addition to actual social interactions, internal representations of supportive ties could affect mechanisms linking relationships and health. Undergraduates (41 men, 41 women) wrote about supportive ties or casual acquaintances. Supportive ties were rated as warmer and less controlling than acquaintances, and writing about them evoked reductions in negative affect, especially for low-hostile participants. Compared with the acquaintance condition, the supportive tie condition resulted in reduced heart rate and blood pressure response during a subsequent speech stressor. Among women, the supportive tie condition reduced blood pressure response among low- but not among high-hostile participants. Hence, mental activation of supportive ties altered effects of laboratory stress and might be relevant to the effects of social relations on health.

Key words: social support, hostility, cardiovascular reactivity, interpersonal circumplex

Social isolation and low social support confer increased risk of coronary heart disease (CHD) in initially healthy populations and are associated with recurrent coronary events among persons with established CHD (Berkman, 1995). These effects have been found when social support is assessed as the individual's number of social network ties or participation in social activities and when it is assessed as subjective reports of the availability and adequacy of various types of support (e.g., emotional vs. instrumental support). Some models suggest that support influences health through behavioral mechanisms (e.g., more exercise, less smoking), but the effects of support on health are significant even when health behaviors are controlled (Uchino, 2004). Other models suggest that psychophysiological mechanisms might link support and CHD (S. Cohen, Kaplan, & Manuck, 1994). Specifically, heart rate, blood pressure, and related responses to stressors have been found to predict atherosclerosis and CHD in some, but not all, studies (Smith & Ruiz, 2002; Treiber et al., 2003), and social support might reduce CHD risk by attenuating such reactivity (Uchino, Cacioppo, & Kiecolt-Glaser, 1996).

Several paradigms have been used to test the hypothesis that social support reduces psychophysiological reactivity (Kamarck, Peterman, & Raynor, 1998; Lepore, 1998). Individual differences in social support are inversely associated with cardiovascular reactivity (CVR) to laboratory stressors (e.g., Uchino, Holt-Lunstad, Uno, & Flinders, 2001) and with levels of ambulatory blood pressure (Linden, Chambers, Maurice, & Lenz, 1993). Supportive comments from friends and strangers have been found to reduce CVR to laboratory stressors (Lepore, Allen, & Evans, 1993), as has the simple presence of a supportive companion (Christenfeld et al., 1997). Finally, ambulatory blood pressure levels are lower when individuals are in the presence of supportive network members (Holt-Lunstad, Uchino, Smith, Olson-Cerny, & Nealey-Moore, 2003). Some studies have failed to replicate these effects (e.g., Roy, Steptoe, & Kirschbaum, 1998), perhaps reflecting the wide range of conceptualizations, measures, and manipulations of support used in these studies. Despite such inconsistencies, measured and manipulated social support have generally been found to be associated with the attenuated physiological responses described in prevailing models (for a review, see Uchino, in press).

Not all individuals respond to social support with reduced CVR. Lepore (1995) found that low- but not high-hostile persons displayed lower CVR to a laboratory stressor when a confederate provided supportive comments, and we have replicated this effect using pairs of friends (Smith, Uno, Uchino, & Ruiz, 2000). Hostility confers risk of CHD, perhaps through the mechanism of heightened reactivity to interpersonal stressors (Smith & Ruiz, 2002). Yet hostile persons also have less supportive personal relationships (Smith, Pope, Sanders, Allred, & O'Keefe, 1988), and their failure to benefit physiologically from social support may contribute to the effects of hostility on health.

Traditionally, social support is seen as a property of the environment, where people provide comfort and assistance (G. R. Pierce, Lakey, Sarason, Sarason, & Joseph, 1997). However, actual enacted support may have less effect on health than the general expectation that support is available (Krause, 1997; Sabin, 1993). Further, several perspectives suggest that support could have an impact on physiological responses and ultimately on health that is independent of actual supportive transactions. Both attachment theory (Bowlby, 1969) and social–cognitive perspectives (Baldwin, 1992) suggest that through recurring patterns of social interaction, individuals develop knowledge structures or

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internal representations (i.e., relational or support schemas) that reflect regularities in their important social relationships. In this way, persons with a history of repeated warm and supportive relationships may interpret current relationships through a positive lens and expect such experiences in the future. In contrast, individuals with a social history involving repeated isolation and conflict might interpret current relationships more negatively and expect little support in the future.

Such internal representations, schemas, or knowledge structures can be activated in a wide variety of ways, from subliminal priming to more obvious, conscious reminders (Bargh & Chartrand, 2000). When activated, these knowledge structures could function similarly to the presence of supportive companions, by altering appraisals of threat or coping ability (T. Pierce, Baldwin, & Lydon, 1997; Sarason et al., 1991). Of course, these relational or support schemas and their activation cannot be observed directly. However, a wide variety of methods (e.g., priming, interference tasks, etc.) have been used to support both the general view that such social knowledge structures influence cognition, emotion, and behavior (Bargh & Chartrand, 2000) and the specific view that personal relationships and social support are represented internally in this way (Baldwin, 1999; Lakey & Drew, 1997).

Mental activation of supportive relationship schemas through subliminal priming, structured writing, or recall exercises reduces negative affect and social cognition (T. Pierce et al., 1997). However, as described previously, individuals vary in their current relationships or interpersonal histories in ways that influence the content and effects of these representations (Lakey & Drew, 1997). Basic theory and research have increasingly adopted the view that individual differences in the internal representations of social ties are at least as important as actual interpersonal events in understanding the nature and effects of support (G. R. Pierce et al., 1997). However, literature on the social psychophysiology of social support and social support as a CHD risk factor is only beginning to include this evolving perspective.

Our primary purpose was to test the hypothesis that mental activation of supportive ties would attenuate heart rate (HR), systolic blood pressure (SBP), and diastolic blood pressure (DBP) responses to a subsequent evaluative speech stressor. Studies using similar stressors have found effects of other types of social support (e.g., presence of companions) on cardiovascular response (Kamarck et al., 1998; Lepore, 1998). To manipulate the activation of representations of supportive ties, we used a structured exercise in which participants wrote and thought about a supportive person in their life or a casual acquaintance. Second, we tested the hypothesis that the beneficial effects of mental activation of supportive ties would be more evident among low- than among high-hostile persons. Hostility is associated with low support and high conflict in personal relationships and with negative social cognition (Smith & Gallo, 2001). Hence, hostile persons' internal representations of support may be less positive (Gambone & Contrada, 2002), rendering the mental activation of supportive ties less effective. Finally, there are sex differences in the use of social support (Ptacek, Smith, & Dodge, 1994), benefits of supportive relationships in general (Kiecolt-Glaser & Newton, 2001), and effects of supportive behavior on CVR in particular (Glynn, Christenfeld, & Gerin, 1999). Therefore, we also attempted to determine if the main effects of mental activation of supportive ties on CVR or the moderation of these effects by trait hostility differed for men and women.

To evaluate the effectiveness of the support manipulation and assess individual differences in these representations, we used a measure based on the interpersonal circumplex (IC; Wiggins, 1996) (see Figure 1). In social psychophysiological studies testing the effects of manipulated or measured interpersonal factors on CVR, it is essential to confirm the nature of these often complex variables—preferably through standardized procedures that permit comparisons across studies. We have found that given its general applicability in social research and the availability of established measures, the IC is useful in this regard (Gallo, Smith, & Kircher, 2000; Smith, Gallo, & Ruiz, 2003). The IC describes social behavior as varying along two main dimensions—dominance versus submissiveness and friendliness versus hostility. In conceptual and empirical analyses within the IC framework, social support generally involves friendly actions from others but also varying degrees of dominance (Trobst, 2000). For example, acceptance clearly reflects friendliness but some submissiveness as well. In contrast, advice or other instrumental support is less warm and more dominant or controlling. We also assessed the initial emotional impact of thinking about supportive (versus neutral) social ties, again as a check on this manipulation and to assess individual differences in this activation.

Method

Participants

The Hostility subscale of Buss and Perry's (1992) Aggression Questionnaire (AQ) was administered to 670 undergraduate men and women in introductory psychology classes at the University of Utah. We initially recruited for laboratory sessions 46 men and 46 women from among the participants scoring in the upper and lower quartiles of this distribution (<

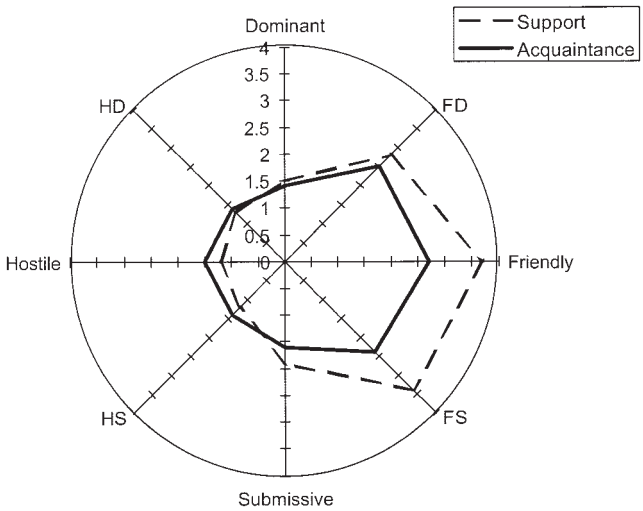

Figure 1. Impact Message Inventory octant scale scores for supportive tie and acquaintance conditions, plotted in the interpersonal circumplex. In separate analyses of variance, significant differences were obtained on Hostile, Hostile–Submissive (HS), Submissive, Friendly–Submissive (FS), Friendly, and Friendly–Dominant (FD) octant scales (all *p*s $< .05$).

13, > 21). Participants were randomly assigned to write and think about either a supportive tie (supportive tie condition) or a casual acquaintance (acquaintance condition). To form stable hostility groups, we retained for analysis only participants whose hostility scores upon readministration of the scale at the end of the laboratory session were in the expected half of the distribution (i.e., above or below the median of the initial distribution). This resulted in a final sample of high-hostile participants with mean hostility scores approximately 1 standard deviation above the mean in published norms (Buss & Perry, 1992) and a low-hostile group with scores approximately 1.5 standard deviations below the mean of these norms (see below for actual scale means). There were 21 high-hostile men (11 support, 10 acquaintance), 22 high-hostile women (10 support, 12 acquaintance), 20 low-hostile men (11 support, 9 acquaintance), and 19 low-hostile women (9 support, 10 acquaintance). Of this sample, 89% identified their ethnicity as Caucasian, 6.6% as Asian or Pacific Islander, 1.1% as Hispanic, 1.1% as Native American, and 2.2% as "other." Their mean age was 21.2 years, and they reported a mean of 13.5 years of education.

Measures

Individual differences. In the initial mass testing, participants completed the Hostility subscale of the AQ. During the laboratory session, participants completed the full 29-item AQ, which also contains scales for trait anger, verbal aggression, and physical aggression. In prior research, we have found the subscales and total AQ score to have adequate internal consistencies (alphas ranging from .70 to .89). The subscales also demonstrate theoretically consistent associations with measures of hostility and interpersonal behavior—such as correlations of .6 with the Cook and Medley (1954) Hostility (Ho) Scale (Ruiz, Smith, & Rhodewalt, 2001), as well as associations with CVR and negative cognition during social interaction (Smith & Gallo, 1999). Although the Ho scale has been used in several prospective studies of CHD, it has a complex internal structure and strong associations with measures of traits outside the typical conceptual definition of hostility (Smith & Gallo, 2001). The AQ Hostility scale has comparatively stronger psychometric properties but has not been used in studies of CHD incidence. Scores reported here reflect the sum of items for each subscale and the total scale.

In the laboratory session, participants also completed the Interpersonal Support Evaluation List (ISEL; S. Cohen, Mermelstein, Kamarck, & Hoberman, 1985). This 48 Likert-item inventory assesses appraisal support (i.e., availability of confidants), tangible support (i.e., material aid), self-esteem support (i.e., favorable comparisons or feedback from others), and belonging support (i.e., affiliation with social groups). Prior research has provided substantial evidence of internal consistency and temporal stability of the subscale and total scores, factor structure, and construct validity (Brookings & Bolton, 1988; S. Cohen & Hoberman, 1983; Heitzman & Kaplan, 1988). ISEL scores reported here reflect the average item score for the total scale.

State anxiety and anger. After the baseline period, participants completed a 12-item state affect measure, which asked how they felt at that moment. After the support manipulation and the preparation and speaking periods of the speech stressor, parallel forms asked how they felt during those activities. Participants responded on 4-point rating scales (1 = *not at all,* 4 = *extremely*). On the basis of their obvious content validity, 6 items (i.e., 4 positively worded items reflecting greater tension, anxiety, nervousness, and worry, and 2 negatively worded items reflecting calmness and relaxation) were taken from the State Anxiety scale of the State–Trait Personality Inventory (STPI; Spielberger, 1980), with a possible range from 6 to 24. Cronbach's alpha coefficients for the State Anxiety scale for the four assessment periods ranged from .69 (baseline) to .89 (speaking period). Similarly, 4 items (i.e., worded positively, reflecting greater anger, annoyance, irritation, and aggravation) were taken from the State Anger scale of the STPI. However, the lack of negatively worded items often produces a skewed distribution of State Anger scale scores (Spielberger, 1980) and could have prevented sensitive measurement of reductions in anger following the support manipulation (i.e., floor effects). Therefore, using dimensional models of anger (cf. Plutchik & Conte, 1997), we added two negatively worded items (i.e., *friendly; kind and warm-hearted*) to this scale. This scale also had a possible range from 6 to 24. Alpha coefficients for the four assessment periods ranged from .69 (baseline) to .83 (speaking period) for this 6-item anger scale. In each case, the item-total correlations for the two new, reverse-scored anger items equaled or exceeded those for the four positively worded items from the original scale.

Impact Message Inventory—Circumplex (IMI–C). After the support manipulation, participants completed a 32-item version of the IMI–C (Kiesler, Schmidt, & Wagner, 1997), which asked them to describe what the target (i.e., supportive tie, acquaintance) communicates in their typical interactions. Four items, rated on 4-point scales, correspond to each octant of the interpersonal circumplex (cf. Figure 1). Examples of friendliness and hostility items are "He/she makes me feel appreciated by them," and "He/she makes me feel distant from them." Examples of dominance and submissiveness items are "He/she makes me feel bossed around," and "He/she makes me feel in charge." Octant scores reported here are average ratings on the four, 4-point items per scale. Octant scores were also combined in weighted averages to form friendliness (warmth) versus hostility (coldness) and dominance (control) versus submissiveness (compliance) dimension scores (Kiesler et al., 1997). Several studies support the reliability, circumplex structure, and validity of the IMI–C octant and dimension scores (Kiesler et al., 1997; Schmidt, Wagner, & Kiesler, 1999; Wagner, Kiesler, & Schmidt, 1995).

Physiological measures. A Dinamap Model 8100 oscillometric monitor (Critikon, Tampa, FL) was used to assess SBP and DBP. The SBP and DBP readings for the last 3 min of the baseline period were averaged to form baseline values. Three values were averaged within both the preparation and the speaking periods. The electrocardiogram output from a Minnesota Impedance Cardiograph Model 304B (Surcom, Inc., Minneapolis, MN) was used to measure HR, defined as the number of cardiac cycles per minute. Average HR was calculated for the last 3 min of the baseline period, preparation period, and three speaking periods.[1]

Procedure

Laboratory sessions were conducted in a room divided by a partition, with a lounge chair for participants on one side and recording equipment on the other. On arrival, participants listened to an audiotape introducing the study as examining cardiovascular responses to cold stimulation and everyday social activities. They were told that after brief exposure to forehead cold stimulation, their responses would be recorded while they wrote and thought about a friend or an acquaintance and while they took turns discussing a current events topic with a partner recorded on audiotape. To avoid participants' initial apprehension about being evaluated, we did not mention the evaluative nature of the discussion task until after the mental activation manipulation. Following the initial informed consent, mylar bands were placed at the base of the neck and at the xiphisternal junction and were connected to an impedance cardiograph. A BP cuff was placed on the upper portion of the nondominant arm. Prior to the initiation of the baseline period described below, participants underwent an initial 5-min adaptation period, an initial 10-min resting baseline period, a 3-min forehead cold pressor task, and a second 5-min adaptation period. Throughout this 23-min portion of the experimental session, all participants underwent

[1] Determinants of HR and BP reactivity were assessed via impedance cardiography (Sherwood et al., 1990). However, due to concerns about low power to detect effects on these measures because of the combination of a small sample size and the greater variability of volume-based measures, we report related findings in footnotes and consider them to be exploratory.

precisely identical procedures described elsewhere (Ruiz, Uchino, & Smith, 2003). The cold stimulation data are not pertinent to the social support manipulation and are reported elsewhere (Ruiz et al., 2003).

Baseline period. The 10-min baseline prior to the support manipulation used a minimally involving task (i.e., "vanilla baseline"; Jennings, Kamarck, Stewart, Eddy, & Johnson, 1992), in which participants viewed a pair of outdoor photographs (e.g., national parks) for 1 min, indicated their preference, and then—as instructed on an audiotape recording—turned to the next pair. Blood pressure was measured once per minute; HR was recorded continuously. At the conclusion of the baseline period, participants completed a state affect measure.

Social support manipulation. Participants were randomly assigned (within initial hostility groups and gender) to the supportive tie or acquaintance condition. This task was intended to have participants bring clearly to mind a specific support person and their associated thoughts and feelings or a specific casual acquaintance and the parallel thoughts and feelings associated with that individual. The task was introduced as assessing physiological responses while participants first wrote and then thought about a person they knew. In the supportive tie condition, participants were asked to select "someone who has been supportive and helpful to you in important ways. . . . a specific person you are currently close to, who you can rely on or turn to when you need help, advice, or encouragement." They were informed that their responses would be confidential. An audiotape then led the participants through a structured exercise in which they wrote answers to four questions during 30-s periods:

1. Briefly describe what you value or appreciate most about this person.

2. Briefly describe what this person values or appreciates most about you.

3. Describe what this person does for you that is supportive or helpful.

4. Describe how you feel when you see this person, after being away from them for a few hours or days.

After this 2-min task, participants described their typical interactions with the target on the IMI–C. The audiotape then led them through the final 1-min portion of the task, when they silently reviewed their answers to each of the four questions for 15 s.

On a second affect measure, participants indicated how they felt while thinking about their answers. Those assigned to the acquaintance condition followed a nearly identical procedure (i.e., writing, IMI–C, review, state affect) but were asked to select someone "you know well enough to say hello to when you see them, but not well enough to think of them as a real friend . . . someone you see fairly often . . . with whom you are cordial or friendly, . . . but not a close friend." The four questions were as follows:

1. Briefly describe how you know this person and what they seem like to you.

2. Describe what you think this person thinks about you, what you seem like to them.

3. Describe what this person does when you see them. . . . What do they usually talk about?

4. When you see this person after not seeing them in a while, how do you feel? . . . What do you say?

Evaluative speech stressor. All participants then underwent a speech stressor with evaluative instructions. In a prior study involving a similar speech task, these evaluative instructions were found to produce significant increases in cardiovascular responses and negative affect (Smith, Nealey, Kircher, & Limon, 1997). Participants were told that the remarks of a student were recorded earlier. One of two topics was introduced (i.e., requiring uniforms in public schools to discourage participation in gangs; raising the social security retirement age). Participants were told that in order to make the discussion engaging, their speech would be recorded and evaluated to "judge whether or not your remarks were as clear, organized, and effective as those of the tape-recorded remarks of the other student in the discussion." After securing their agreement to continue, participants were assigned to either a "pro" or "con" position on one of the topics and were given a set of discussion notes. Assigned topics and assigned pro versus con positions were counterbalanced across support condition, hostility, and sex in order to decrease the likelihood that minor irrelevancies (e.g., particularly involving topics) would influence the findings. Analyses of topic and position revealed no significant effects on CVR. At the conclusion of the 3-min preparation period, participants completed a third state affect questionnaire.

One of four audiotape recordings then presented a 1-min speech reflecting the side of the topic opposite that to which the participant had been assigned. Instructions then asked the participant to respond for 1 min and led them through two additional turns of listening and responding to the tape-recorded, opposing view. Blood pressure was measured once during each minute of the preparation period and each of the three speaking periods; HR was recorded continuously. At the conclusion of the speech stressor, participants completed a final state affect questionnaire. They were then debriefed and given partial course credit for their participation.

Overview of Analyses

Analyses of variance (ANOVAs) generally followed the three-way, between-groups design: 2 (social support condition: supportive tie vs. acquaintance) $\times$ 2 (hostility group: high vs. low) $\times$ 2 (men vs. women). In the primary analyses, a repeated factor with two levels reflected responses to the two phases of the speech stressor (e.g., change from baseline to preparation period; change from baseline to speaking period). In evaluations of the overall stressfulness of this task, the repeated factor had three levels (e.g., baseline, preparation, speaking), with appropriate adjustment of statistical tests (Greenhouse & Geisser, 1959). Consistent with prior recommendations (Llabre, Spitzer, Saab, Ironson, & Schneiderman, 1991), change scores for physiological measures were calculated for the preparation and speaking periods (e.g., average task minus average baseline). Change scores within periods were used as dependent variables. Because baseline levels can alter subsequent change (Benjamin, 1967), respective baseline values were included as covariates in analyses of covariance (ANCOVAs) of emotional and physiological reactivity.

The prediction concerning the effects of social support on SBP, DBP, and HR responses to the speech stressor was tested as the support condition main effect in the ANCOVA model described previously. Effect sizes are presented as eta squared, interpreted as the proportion of variance in the dependent variable attributable to the treatment group or level (Winer, Brown, & Michels, 1991). Eta-squared values of .04, .25, and .64 refer to small, medium, and large effects, respectively (J. Cohen, 1992). The rate and loudness of speech can alter physiological responses (Friedman, Thomas, Kulick-Ciuffo, Lynch, & Suginohara, 1982), creating the possibility that support main effects could reflect the impact of this manipulation on speech parameters (i.e., slower or quieter speaking). Therefore, even in the absence of significant Support Manipulation $\times$ Task Period interactions, we followed predicted significant main effects of the support manipulation with directional tests within the preparation and speaking periods, separately. These comparisons (Bernhardson, 1975) use the appropriate error term from the overall ANCOVA model, and the test statistic is distributed as *t*.

Table 1
Levels of Affect and Physiological Responses During Baseline, Preparation, and Task Periods

Variable	Baseline	Preparation	Speaking	$F(2, 136)$	η^2
State anxiety	7.7_a (0.22)	14.1_b (0.47)	15.5_c (0.50)	161.3	.66
State anger	9.6_a (0.27)	11.2_b (0.37)	13.1_c (0.43)	60.3	.42
SBP (mmHg)	112.3_a (1.22)	118.8_b (1.37)	132.3_c (1.41)	172.0	.66
DBP (mmHg)	65.9_a (0.70)	70.2_b (0.80)	78.0_c (0.90)	146.8	.63
HR (bpm)	69.8_a (1.06)	75.7_b (1.14)	89.0_c (1.34)	259.4	.76

Note. Based on one-way analyses of variance, Greenhouse–Geisser adjusted. Within rows, means with different subscripts differ at $p < .05$ (Bernhardson, 1975). Standard errors are in parentheses. SBP = systolic blood pressure; DBP = diastolic blood pressure; HR = heart rate; bpm = beats per minute.

The prediction that hostility group would moderate the effects of support was tested as the Support Condition × Hostility Group two-way interaction, again with directional follow-up comparisons (i.e., supportive tie vs. acquaintance conditions within hostility groups). When predicted effects were qualified by higher order interactions (e.g., Support × Hostility × Sex), simple main effects and two-way interaction tests with directional follow-up tests were conducted within levels of the unexpected, interacting factor. In follow-up comparisons of means within unpredicted effects, nondirectional tests were used.[2]

Finally, in exploratory mediational analyses (Baron & Kenney, 1986), we evaluated whether changes in negative affect during the speech stressor accounted for effects of the support manipulation of cardiovascular responses during the stressor. To accomplish this, we used affect changes as an additional covariate in the ANCOVA of cardiovascular responses. In this way, we determined (a) if affect changes were associated with cardiovascular responses (i.e., significance of the additional covariate) and (b) if the addition of this covariate rendered otherwise significant effects of the support manipulation on cardiovascular responses to the speech stressor nonsignificant. It should be noted that because ANCOVA is based on the general linear model (SPSS Version 10.0), this procedure is equivalent to the regression-based procedure typically used in mediational analyses.

Results

Baseline Equivalence of Groups and Classification and Manipulation Checks

Three-way (Support × Hostility × Sex) ANOVAs of baseline SBP, DBP, HR, state anxiety, state anger, age, and years of education revealed only one significant effect. Men displayed higher baseline SBP than did women (117.5 mmHg vs. 105.4 mmHg; *SE*s = 1.71, 1.67), $F(1, 76) = 27.1$, $p < .01$. To verify that high- and low-hostility groups differed on the construct of interest and that conditions did not differ on psychosocial characteristics, we conducted three-way (Support × Hostility × Sex) ANOVAs of the Hostility, Anger, Physical Aggressiveness, and Verbal Aggressiveness AQ subscale scores and the ISEL total scores obtained during the laboratory session, which revealed only expected significant main effects for the hostility grouping factor. As expected, a large effect occurred for the AQ Hostility scale, in which the high-hostility group reported more hostility than did the low-hostility group (26.7 vs. 12.2; *SE*s = 0.56, 0.58), $F(1, 74) = 324.0$, $p < .01$, $\eta^2 = .81$. Similar but smaller effects emerged on the following scales of the AQ: Anger (16.2 vs. 10.9; *SE*s = 0.67, 0.68), $F(1, 74) = 31.4$, $p < .01$, $\eta^2 = 0.29$; Physical Aggression (19.3 vs. 14.2; *SE*s = 0.98, 1.01), $F(1, 74) = 13.1$, $p < .01$, $\eta^2 = .15$; and Verbal Aggression (16.1 vs. 13.4; *SE*s = 0.60, 0.62), $F(1, 74) = 9.4$, $p < .01$, $\eta^2 = .11$. On the ISEL total support scores, low-hostile participants reported more support than did high-hostile participants (3.5 vs. 3.1; *SE*s = 0.04, 0.04), $F(1, 74) = 43.8$, $p < .01$, $\eta^2 = .37$.

Results of one-way, repeated measures ANOVAs on baseline, preparation period, and speaking period SBP, DBP, HR, state anxiety, and state anger are presented in Table 1. For each measure, the speech stressor preparation period evoked a significant change from baseline, and the speaking period evoked an additional increase over the preparation period. Effect sizes ranged from moderate to large. Hence, the speech stressor clearly evoked affective and physiological stress responses.

A three-way (Support × Hostility × Sex) ANOVA of the IMI–C friendliness factor scores revealed the expected moderate-to-large effect of support, $F(1, 76) = 62.9$, $p < .01$, $\eta^2 = .45$. As expected, participants described supportive ties as clearly friendly and much more so than casual acquaintances. An ANOVA of IMI–C dominance factor scores revealed a significant but smaller effect for support, $F(1, 76) = 6.2$, $p < .02$, $\eta^2 = .08$. Participants described supportive ties as less dominant or controlling than casual acquaintances. The individual IMI–C octant scores are presented in Figure 1.

The three-way ANOVAs of IMI–C friendliness and dominance factor scores also revealed significant, albeit small, Support × Hostility interactions, $F(1, 76) = 5.87$, $p < .02$, $\eta^2 = .07$, and $F(1, 76) = 4.41$, $p < .04$, $\eta^2 = .06$, respectively. For both hostility groups, supportive ties were rated as friendlier than casual acquaintances. However, supportive ties of low-hostile participants were rated as friendlier than those of high-hostile participants (5.54 vs. 4.52; *SE*s = 0.28, 0.29), $t(76) = 2.4$, $p < .05$, whereas ratings of acquaintances did not differ (2.50 vs. 2.91; *SE*s = 0.31, 0.29). For dominance ratings, low-hostile participants rated supportive ties as less dominant than casual acquaintances (−1.16 vs. −0.01; *SE*s = 0.24, 0.26), $t(76) = 3.18$, $p < .01$, whereas high-hostile participants rated supportive ties and acquaintances similarly (−0.45 vs. −0.35; *SE*s = 0.25, 0.24). Low-hostile participants also rated supportive ties as less dominant than did high-hostile participants, $t(76) = 2.02$, $p < .05$.

A three-way ANCOVA of state anxiety responses during the support manipulation revealed no significant effects. The ANCOVA

[2] Degrees of freedom vary with missing data, most commonly because of HRs that cannot be scored. Missing data are equally distributed across hostility group, support condition, and sex of participant.

of state anger revealed a significant Support × Hostility interaction, $F(1, 74) = 18.95$, $p < .01$, $\eta^2 = .20$. As depicted in Figure 2, after the support manipulation, low-hostile participants in the supportive tie condition reported a larger decrease in state anger from baseline levels than did those in the casual acquaintance condition, $t(74) = 3.32$, $p < .01$. In the supportive tie condition the decrease in state anger reported by low-hostile participants differed from the small increase reported by high-hostile participants, $t(74) = 3.91$, $p < .01$. High-hostile participants actually reported a larger decrease in state anger in the casual acquaintance than in the supportive tie condition, $t(74) = 2.35$, $p < .05$, and in the casual acquaintance condition high-hostile participants reported a larger decrease in state anger than did the low-hostile group, $t(74) = 2.16$, $p < .05$.

Cardiovascular Responses to Speech Stressor

Consistent with predictions, in 2 (support condition) × 3 (hostility group) × 2 (sex) × 2 (preparation, speaking) mixed ANCOVAs, the supportive tie condition resulted in smaller increases in HR from baseline levels during the speech stressor, compared with the acquaintance condition (11.0 beats per minute [bpm] vs. 14.2 bpm; *SE*s = 1.11, 1.14), $F(1, 67) = 4.12$, $p < .05$, $\eta^2 = .06$. As noted previously, the possible influence of speech artifacts on CVR makes it important to examine this effect during both the preparation and the speaking periods, even though the main effect of the support condition was not qualified by an interaction with the periods factor ($p > .20$). As presented in Table 2, this effect was significant during speaking but not during preparation. The effects of hostility, sex, and their interactions with the support conditions were not significant.

A similar mixed ANCOVA of SBP responses indicated that participants in the supportive tie condition also displayed smaller increases in SBP during the subsequent speech stressor, as compared with the casual acquaintance condition (11.0 mmHg vs. 15.3 mmHg; *SE*s = 1.46, 1.47), $F(1, 73) = 4.22$, $p < .05$, $\eta^2 = .06$. As shown in Table 2, this effect was significant during speaking but not during preparation. The effects of hostility, sex, and their interactions with support conditions on SBP reactivity were not significant, nor was the Period × Support Condition interaction. In a similar mixed ANCOVA, the supportive tie condition also resulted in smaller increases in DBP (6.9 mmHg vs. 9.8 mmHg; *SE*s = 0.80, 0.80), $F(1, 73) = 6.27$, $p < .02$, $\eta^2 = .08$. Also as shown in Table 2, this effect was significant during both preparation and speaking, and the Period × Support Condition interaction was not significant.

For DBP reactivity, the Hostility × Support, Hostility × Sex, and Support × Sex two-way interactions were not significant. However, the three-way Support × Hostility × Sex interaction was significant, $F(1, 73) = 4.97$, $p < .03$, $\eta^2 = .06$. To explicate this effect, we tested the predicted Support × Hostility two-way interaction separately for men and women. Among the men, only the expected support main effect approached significance, $F(1, 36) = 3.46$, $p = .07$, $\eta^2 = .09$, such that men in the supportive tie condition displayed smaller increases during the speech stressor than did those in the acquaintance condition (7.7 mmHg vs. 10.2 mmHg; *SE*s = 1.09, 1.17). For women, the predicted Support × Hostility interaction was significant, $F(1, 36) = 4.94$, $p < .04$, $\eta^2 = .12$. As depicted in Figure 3, among low-hostile women, those in the supportive tie condition displayed a smaller increase in DBP than did those in the acquaintance condition, $t(36) = 2.78$, $p < .01$; among high-hostile women, the supportive tie condition displayed nonsignificantly greater increases. Within the supportive tie condition, low-hostile women displayed smaller increases in DBP than did high-hostile women, $t(36) = 1.87$, $p < .03$. The high- and low-hostility groups did not differ in the acquaintance condition, $t(36) = 1.23$. Adjustment via ANCOVA for body mass did not alter any of the CVR findings.[3]

Emotional Responses to Speech Stressor

In a 2 (support condition) × 2 (hostility group) × 2 (sex) × 2 (preparation, speaking) mixed ANCOVA, the support manipulation had no effect on state anger during the speech. However, the effect of support on changes in state anxiety approached significance, $F(1, 70) = 3.20$, $p < .08$, $\eta^2 = .04$; participants in the supportive tie condition tended to report smaller increases in state anxiety during the speech stressor than did those in the acquaintance condition (6.2 vs. 7.8; *SE*s = 0.65, 0.65). This difference was not significant during preparation but was significant during speaking (6.8 vs. 8.9; *SE*s = 0.74, 0.74), $t(70) = 2.13$, $p < .025$.

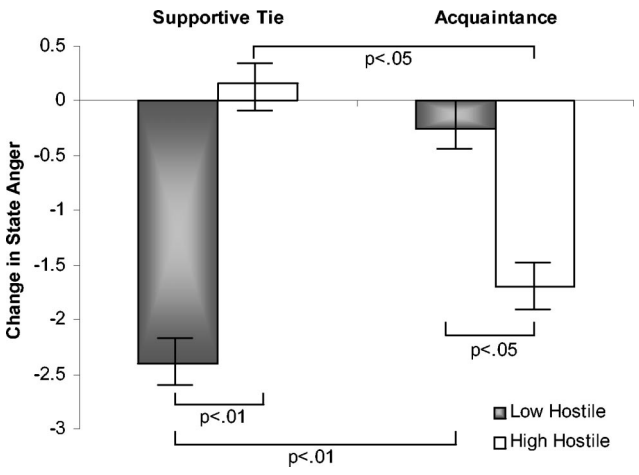

Figure 2. Changes in state anger from baseline to the mental activation task, for high- and low-hostility groups in the supportive tie and acquaintance conditions.

[3] The support manipulation had a significant effect on cardiac sympathetic activation (i.e., preejection period [PEP]). Participants in the supportive tie condition showed a smaller decrease in PEP during the discussion task (i.e., less sympathetic activation) than did those in the casual acquaintance group (−10.2 ms vs. −16.4 ms; *SE*s = 1.99, 2.05), $F(1, 61) = 4.57$, $p < .04$, $\eta^2 = .07$. This effect was significant during both the preparation and the speaking periods, $t(61) = 1.74$, $p < .05$, and $t(61) = 2.08$, $p < .02$, respectively. Effects of the support manipulation on other impedance-derived measures (i.e., cardiac output, total peripheral resistance, respiratory sinus arrhythmia) did not approach significance.

Table 2
Mean Changes in Heart Rate and Blood Pressure During the Preparation and Speaking Periods of the Speech Task

	Preparation			Speaking		
Variable	Supportive tie	Acquaintance	*t*(73)	Supportive tie	Acquaintance	*t*(73)
HR (bpm)	4.5 (1.0)	7.1 (1.1)	1.46	17.5 (1.4)	21.3 (1.5)	2.13**
SBP (mmHg)	5.2 (1.4)	7.9 (1.3)	1.17	16.8 (1.9)	22.6 (1.9)	2.51***
DBP (mmHg)	3.3 (0.7)	5.7 (0.8)	1.75*	10.5 (1.2)	13.9 (1.2)	2.48***

Note. Standard errors are in parentheses. HR = heart rate; SBP = systolic blood pressure; DBP = diastolic blood pressure; bpm = beats per minute.
* $p < .04$. ** $p < .02$. *** $p < .01$.

Exploratory Analyses

As noted earlier, when compared with the casual acquaintance condition, the supportive tie condition produced a nonsignificant reduction in overall state anxiety responses to the stressor, but this effect was significant during the speaking portion of the stressor. Further, in mediational analyses (Baron & Kenny, 1986), changes in state anxiety during the speaking period were related to speaking period changes beyond the effects of the support manipulation: HR, $F(1, 66) = 3.2$, $p < .08$; SBP, $F(1, 72) = 7.2$, $p < .01$; DBP, $F(1, 72) = 4.6$, $p < .04$. Further, statistical control of changes in state anxiety rendered the otherwise significant effects of the support manipulation on each of these physiological responses nonsignificant (all *p*s $> .09$). Hence, there is some evidence that the supportive tie manipulation reduced CVR during the speech stressor through the mechanism of reduced state anxiety.[4]

Discussion

Consistent with predictions based on models of internal representations of social relationships (Baldwin, 1992) and recent models of the nature of social support (e.g., Lakey & Drew, 1997), thinking and writing about supportive ties attenuated CVR to a subsequent psychological stressor. This conclusion is bolstered by aspects of our methods and results. First, participants' ratings of supportive ties differed from casual acquaintances in expected ways on basic dimensions of social behavior. Further, the evaluative speech stressor evoked significant increases in negative affect and cardiovascular responses, confirming that it was stressful. Most important, the support manipulation attenuated CVR for HR, SBP, and DBP during the speech task. Finally, for DBP the support manipulation reduced reactivity while participants silently prepared for and then engaged in the stressor. Therefore, behavioral effects of the support manipulation (e.g., speech rate or volume) cannot account for all of the effects on CVR.[5]

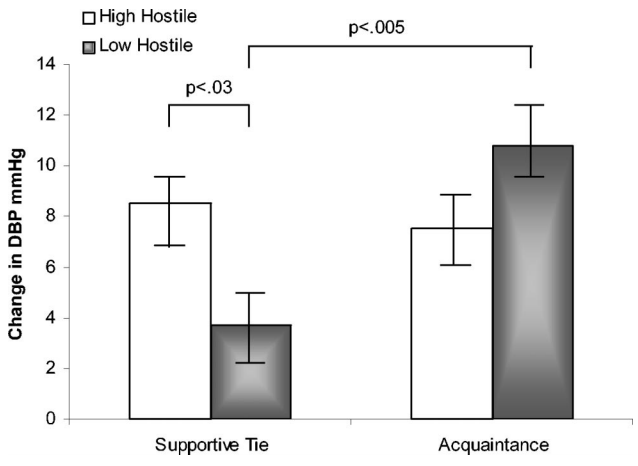

Figure 3. Diastolic blood pressure reactivity (DBP; mean values across preparation and speaking) for high- and low-hostile women in the supportive tie and acquaintance conditions.

These findings extend prior research indicating that individual differences in social support are associated with reduced CVR even in the absence of supportive companions (Uchino et al., 2001) and that knowledge of available support can attenuate CVR without its actual implementation (Uchino & Garvey, 1997). If the well-documented effects of social support on CHD involve the mechanism of CVR, conceptual models of social relations and health could be usefully extended to include theory and research on the internal representation of relationships in general (Baldwin, 1992, 1999) and representations of social support in particular (Lakey & Drew, 1997; T. Pierce et al., 1997). The present results also have implications for investigations of social support and CVR. Experimental manipulations of support should be evaluated for possible mental activation of internal representations. For example, conditions in which the participant is accompanied by a supportive companion throughout the session and one in which the accompanying companion is seated elsewhere during reactivity testing might produce weak differences because both conditions activate mental representations of support.

In contrast to the effects of activation of supportive ties, the prediction that trait hostility would moderate these effects received

[4] Changes in state anxiety during the speaking portions of the task also accounted for PEP reactivity during speaking, $F(1, 60) = 5.1$, $p < .03$, and statistical control of changes in state anxiety rendered the otherwise significant effect of mental activation of support on cardiac sympathetic activity nonsignificant.

[5] This conclusion is supported by the results for PEP (see Footnote 3), as the support manipulation attenuated the stress-induced reduction in PEP (i.e., less cardiac sympathetic activation) during both the preparation and speaking periods (both *p*s $< .05$).

less support. The expected pattern in which effects of support emerged among low- but not among high-hostile participants did not occur for HR or SBP reactivity. It emerged for DBP responses, but only among women. However, the pattern of DBP responses among women corresponded closely to predictions. Further, the support manipulation clearly differed in expected ways for high- and low-hostile participants. The supportive ties of low-hostile participants were rated as friendlier and as less controlling compared with those of high-hostile participants. Also as expected, the supportive tie condition produced a significant decrease in state anger among low- but not among high-hostile participants.

Unexpectedly, writing and thinking about a casual acquaintance produced a decrease in state anger scores among high-hostile participants. It may be that high-hostile persons' experience of conflict in close relationships (Smith et al., 1988; Smith, Sanders, & Alexander, 1990) promotes a pattern in which they tend to turn to more superficial social ties to draw emotional benefits. Overall, although the expected effects on CVR in response to a subsequent stressor were certainly not as expected, it is clear that the process of writing and thinking about supportive ties had very different psychological effects in the high- and low-hostile groups.

Finally, the differing effects of the support manipulation on DBP among high- and low-hostile men and women were the only cases of sex differences in the results. Hence, the support manipulation generally had similar effects on subsequent CVR for men and women.

Limitations and Qualifications

Other aspects of the study warrant caution. First, our sample was young, well-educated, largely Caucasian, and of middle and upper socioeconomic backgrounds. Replications in more diverse groups are clearly needed. Second, as we noted earlier, the mental activation of supportive ties cannot be accomplished or observed directly, and hence the validity of the writing and thinking procedure as a manipulation of this construct must be viewed with caution. For example, this version of a mental activation manipulation was obvious and broad. Mental activation of relationship schema can have effects with far less obvious manipulations (e.g., subliminal priming; T. Pierce et al., 1997). Conceptual replications of our findings with such methods would be useful, as would confirmation of such manipulations with methods other than self-reports (e.g., reaction time; Bargh & Chartrand, 2000). Also, some research suggests that support from partners has larger beneficial effects on the recipient's adjustment if delivered without their awareness (Bolger, Zuckerman, & Kessler, 2000), perhaps because awareness of receiving support also conveys information about the recipient's need for help or comfort—a communication that could raise concerns about competence. Hence, more subtle manipulations of mental representations of support could produce larger effects on CVR to subsequent stressors by activating positive associations without making potentially negative concerns salient.

It is possible that our results reflect the effects of a mood induction rather than the activation of support representations per se. Positive mood inductions have been found to attenuate CVR to stressful stimuli (Fredrickson & Levenson, 1998). As noted previously, exploratory mediational analyses indicated that the effects of the supportive tie manipulation in reducing state anxiety responses to the subsequent speech stressor accounted for the effects of this manipulation on CVR. Therefore, unlike prior studies of social support and CVR (Kamarck et al., 1998) but consistent with prior suggestions regarding mechanisms linking support and health (S. Cohen, 1988), the effects of mental activation of support on CVR may be mediated by mood.

It is also possible that effects of support on stressor appraisals are responsible for both the mood and the CVR effects. Of course, the fact that moods can be manipulated by this interpersonal exercise with beneficial effects on CVR does not reduce the potential implications of our findings for the health effects of support. Mental activation of support can attenuate CVR, even though the precise mechanism is not clear. Nonetheless, future studies should also include measures of other possible mediators of the effects of mental activation of support on CVR, such as appraisals of threat posed by subsequent stressors.

The results for DBP reactivity suggest that the expected moderation by hostility of the effect on mental activation of support on CVR may differ for men and women. The small cell sizes associated with this three-way interaction may have reduced statistical power sufficiently as to preclude additional evidence of this sex difference. Hence, additional research with larger samples is needed. Also, although the AQ Hostility scale is a valid measure, it has not been used in studies of CHD outcomes. Further, although considerable evidence supports the hypothesis that CVR contributes to the development of CHD, this effect is best seen as only tentatively supported (Treiber et al., 2003). There is also little direct evidence that this mechanism underlies the well-established association between social support and CHD. Even if this mechanism were clearly established, it is important to recognize that the present effects of mental activation of supportive ties on CVR, though consistent and reliable, were small. Hence, although our results have clear conceptual implications, their practical importance is unknown.

Also, the support manipulation may have reduced CVR by altering speech during the stressor (Friedman et al., 1982). That is, considering a supportive tie may have led participants to speak more slowly or quietly, and this artifact rather than processes described in models of social support (e.g., appraisals of threat) could be responsible for the effects on cardiovascular responses to the speech stressor. However, the manipulation altered DBP reactivity during the preparation period. Hence, not all of the effects on CVR are open to this interpretation (see also Footnote 3). Nonetheless, mechanisms beyond traditional models of support (e.g., lower task engagement) rather than more accepted mechanisms (e.g., altered appraisals, reduced negative affect) could have contributed to the effects. Finally, the discussion task did not produce main effects of hostility on CVR, even though interpersonal stressors typically do (for a review, see Smith & Gallo, 2001). However, the use of a taped rather than a live debate partner and the emphasis on evaluative threat may have altered this social stressor in such a way as to make it less relative to the motives that typically evoke heightened CVR among hostile persons.

Conclusions and Future Directions

These limitations notwithstanding, the present study provides additional evidence that social support may attenuate cardiovas-

cular stress responses without actual supportive transactions. Individual differences in general perceptions of support and knowledge of the situational availability of support can attenuate CVR even when support is not enacted (Uchino & Garvey, 1997; Uchino et al., 2001). The present results suggest that activation of internal representations of supportive relationships may also have beneficial effects. Of course, actual supportive exchanges are important influences on physiological responses, and some actual supportive transactions may reduce stress without the recipient's awareness (Bolger et al., 2000). However, a full account of support and health will likely include both cognitive–social characteristics of persons (e.g., support schemas) and social networks (G. R. Pierce et al., 1997). Although this view is consistent with current models of social support and personality, to date there has been little attention to such effects on the physiological mechanisms possibly linking support and health. Mental activation of supportive ties during periods of stress may be more common than the actual presence of supportive companions. Hence, these processes may represent an important aspect of the effects of support on health.

Future research should examine activation manipulations that are less intrusive, including those that operate outside of conscious awareness. Perhaps internal representations of supportive ties—or the relative lack of them—are important influences on physiological responses in daily life because many different stimuli (e.g., photographs of family) activate their beneficial effects. Ultimately, research on social support, CHD, and underlying mechanisms guides the development of risk-reducing interventions. To date, most interventions are based on the assumption that actual supportive transactions are the critical influence on health (Lakey & Lutz, 1996). The present findings suggest that techniques based on social–cognitive models that address internal representations of social support might have at least short-term benefits.

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