

3-2008

Hostility & Ambulatory Blood Pressure

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Recommended Citation

Vella, E. J., Karmarck, T. W., & Shiffman, S. (2008). Hostility moderates the effects of social support and intimacy on blood pressure in daily social interactions. *Health Psychology, 27*(2, Suppl), S155-S162.
doi:10.1037/0278-6133.27.2

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Hostility Moderates the Effects of Social Support and Intimacy on Blood Pressure in
Daily Social Interactions

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^bThis research was supported by the National Institute of Health Training Grant HL07560 awarded to Dr. Vella and the National Heart, Lung, and Blood Institute Grants HL056346 and HL040962 awarded to Dr. Kamarck, in addition to the Pittsburgh Mind-Body Center Grants HL076852 and HL076858. We thank the entire staff and crew of the Pittsburgh Healthy Heart Project for their efforts in data collection. Some of these data were presented at the 28th annual meeting for the Society of Behavioral Medicine held March, 2007 in Washington, DC.

^cDr. Shiffman is cofounder and Chief Science Officer of Invivodata, Inc., which provides electronic diary methods like those reported here for use in clinical trials.

Abstract

Objective: The current study sought to determine the role of hostility in moderating the effects of positive social interactions on ambulatory blood pressure (ABP). **Design:** Participants (341 adults) completed the Cook Medley Hostility Scale and underwent ABP monitoring, assessed every 45 minutes during waking hours across 6 days. An electronic diary measuring mood and social interactions was completed at each ABP assessment. **Main Outcome Measures:** The dependent variables from the ABP monitor included systolic blood pressure, diastolic blood pressure, and heart rate. **Results:** Different patterns of ambulatory diastolic blood pressure (ADBP) responding to social interactions perceived as intimate or supportive among high vs. low hostile individuals were observed. Higher intimacy ratings were linked to reductions in ADBP among low hostile but not high hostile individuals. Conversely, high hostile, but not low hostile, individuals showed increases in ADBP to situations rated high in social support. Although findings for ambulatory systolic blood pressure were non-significant, the pattern of results was similar to ADBP. **Conclusion:** Hostile individuals may find offers of support stressful and may fail to benefit from intimacy during daily life. The pathogenic effects of hostility may be mediated in part by responses to social interactions, both positive and negative. *Keywords:* ambulatory blood pressure, hostility, social support, intimacy, ecological momentary assessment.

Hostility and Gender Moderate the Effects of Social Support and Intimacy on Blood Pressure in Daily Social Interactions

Trait hostility and social isolation, or lack of social support, have been identified as correlates of coronary heart disease (CHD) risk (Rozanski, Blumenthal, & Kaplan, 1999). Interpersonal models designed to explain the relationship between hostility and CHD posit that these two characteristics may be interrelated, such that hostile individuals may promote social conflict and may be mistrustful of the supportive efforts from others (e.g., Smith, Glazer, Ruiz, & Gallo, 2004). Indeed, evidence suggests that trait hostility and low social support tend to co-occur and may predict disease outcome synergistically (e.g., Scherwitz, Perkins, Chesney, & Hughes, 1991).

Hostile individuals have been found to exhibit exaggerated cardiovascular reactivity (CVR) to interpersonal provocation relative to their non-hostile counterparts (e.g., Davis, Matthews, & McGrath, 2000). To the extent that these responses are frequent and large in magnitude, they are presumed to contribute to a number of pathogenic processes associated with increased CV disease risk (e.g., Treiber et al., 2003). Although there is a considerable literature examining the effects of hostility on physiological responses to interpersonal provocation, less is known about the role of hostility in moderating responses to positive social interactions.

Research suggests that hostile subjects may show more pronounced CVR than non-hostile subjects under laboratory conditions of social support (e.g., Smith, Ruiz, & Uchino, 2004). In a related finding, Lepore (1995) reported a moderating effect of cynicism, derived from the Cook-Medley Hostility Scale (CMHS; Cook & Medley, 1954), on blood pressure (BP) reactivity to experimentally induced social support during

a speech stressor. Results indicated cynically hostile subjects failed to show the stress buffering influence of support on BP responses exhibited by those scoring low on cynicism. One study found that hostile individuals showed significant increases in BP relative to low hostile individuals during self disclosure of personally troubling events (Christensen & Smith, 1993), suggesting that social interactions characterized by intimacy may promote differential physiological responding among hostile individuals.

Since the prevailing models of hostility and CHD presume that the pathogenic effects of hostility unfold in the course of daily life events, field assessments may be expected to provide more relevant information with respect to the mechanisms linking hostility and disease. Ecological momentary assessment (EMA) methods, characterized by repeated assessments of subjects' momentary states in their natural environments (Stone & Shiffman, 1994), can be used in conjunction with ambulatory monitoring of BP and heart rate (HR) to ascertain the influence of individual differences in hostility on behavioral and physiological responses to daily life social interactions.

It remains unknown whether the moderating effects of hostility on CV responses to social interactions of self disclosure and support is apparent in daily living. Previous research using EMA methods among hostile individuals found that CMHS scores predicted more frequent negative and less frequent positive social interactions, and that the intensity of negative interactions was linked to elevations in DBP for high, but not for low, hostile subjects (Brondolo et al., 2003). In this study, CMHS scores did not moderate the BP responses to positive social interactions assessed as pleasant, friendly, or agreeable. It is possible that these social interactions were too broadly defined to detect BP differences as a function of hostility, and that it is necessary to specifically assess

social situations characterized by self disclosure and support (e.g., Christensen & Smith, 1993; Lepore, 1995). Offerings of social support and discussion of personal feelings may serve as an ‘ego threat’ among hostile individuals, eliciting a sense of vulnerability that may be associated with differential CV responses relative to those scoring low on hostility.

The primary aim of the current study was to use EMA methods to determine the role of hostility in moderating the effects of positive social interactions, including social support and intimacy, on ambulatory blood pressure (ABP) in a sample of healthy older men and women. Hostility was predicted to correlate negatively with the frequency and strength of social interactions rated as agreeable, intimate, and supportive. Furthermore, hostile individuals were expected to show significant increases in ABP responses to social support and intimacy relative to those scoring low on hostility. To our knowledge, the present study is the first investigation to explore the moderating influence of hostility on ABP in response to self reported situations of social support and intimacy in daily life. The influence of gender was also considered, since previous studies have suggested that the relationship between hostility and ABP may be stronger among men (e.g., Linden, Chambers, Maurice, & Lenz, 1993; Raikkonen, Matthews, Flory, & Owens, 1999).

Method

Participants

Three hundred forty one healthy adults (168 men, 173 women; $M=60$, $SD=4.71$ yrs) were selected from a larger sample involved in the Pittsburgh Healthy Heart Project, an ongoing prospective investigation of biobehavioral predictors for subclinical CV disease progression. This study received approval from the institutional review board at

the University of Pittsburgh. Recruitment involved targeted mailings and media postings in the Pittsburgh metropolitan area. Participants provided written informed consent to all procedures and were paid US\$200 for completing the assessments involved in this portion of the study. It should be noted that participants also underwent a number of assessments not described in this report (see Kamarck et al., 2004). Previous papers have reported other findings from this sample (e.g., Kamarck et al., 2002; Kamarck, Polk, Sutton-Tyrell, & Muldoon, 2002; Kamarck, Schwartz, Janicki, Shiffman, & Raynor, 2003; Janicki, Kamarck, Shiffman, Sutton-Tyrell, & Gwaltney, 2005; Stewart, Janicki, & Kamarck, 2006).

Inclusion criteria included age (50-70 ys) and peri or post-menopausal status (absence of menses during past 6 months). Primary exclusion criteria included any history of chronic medical disorders, pharmacologic treatment for hypertension or hypercholesterolemia within the past year, current or regular use of any medication with autonomic effects, or excessive alcohol consumption defined as 5 or more drinks at least 3 times per week. Persons with diabetes receiving insulin were also excluded, as were those with mean clinic SBP > 180 mmHg or DBP > 110 mmHg. In addition, individuals whose arm circumference interfered with reliable detection of Korotkoff sounds were not enrolled.

A total of 464 individuals provided written informed consent for participation and were enrolled in the study. From this sample, 13 were found ineligible during the initial data collection period, and an additional 69 individuals dropped out during one of the subsequent visits. For the current study, those with fewer than 30 complete ABP and diary readings for either of the ambulatory assessment period ($n = 34$) or who began

taking antihypertensive medications ($n = 7$) were not included in the analyses. Out of the remaining sample ($n = 341$), 85% was Caucasian, and 14% was African American, with 25% of the sample reporting no more than a high school education and 50% reporting a bachelor's degree or greater.

Measures and Procedures

Initial Visit. The initial study visit included a medical history interview, BP screening, and a blood draw for risk factor assessment. Participants were instructed to abstain from food or caffeine consumption for 12 hours prior to this early morning visit, and they were seated for at least 30 minutes prior to the BP screening, which was performed by a trained research nurse using a standard mercury sphygmomanometer (Vital Signs Model 63154, Country Technology, Gays Mills, WI). Following guidelines from the American Heart Association (Perloff et al., 1993), 3 seated BP readings were taken at 2 minute intervals, with the screening value being designated by the average of the last 2 readings.

A demographics questionnaire was also administered at this visit, which assessed age, gender, race, and education level. Race was coded as a binary (dummy) variable (0 = Caucasian, 1 = Minority). The prevalence of non-African American ethnic minorities in the sample ($n = 5$) was too small to examine these groups separately. Participants were classified into 4 categories according to their education level (1 = high school or less, 2 = some college or technical school, 3 = bachelor's degree, and 4 = graduate degree).

ABP Monitoring. Approximately 1 month following the initial study visits (median of 31 days, range = 3-145), participants were trained to use an automated, auscultatory ABP monitor (Accutacker DX, Suntech, Raleigh, NC, USA), in conjunction

with an EMA electronic diary (see below). The ABP monitor was programmed to inflate every 45 minutes during waking hours. Data collection took place across 3 days during 2 periods separated by approximately 4 months, for a total of 6 days of ABP measurements. Prior to each 3 day period, participants underwent a one day training interval during which they practiced using the equipment and were given feedback on their performance. Invalid ABP readings were deleted using out-of-range and error criteria previously described (Kamarck et al., 2002).

Electronic Diary. The revised Diary of Ambulatory Behavioral States (DABS) used in the current study is a 45 item self-report diary designed for repeated administration in conjunction with ABP (Kamarck et al., 1998). DABS items were presented on a palmtop computer (Palm Pilot Professional, Palm, Santa Clara, CA) programmed specifically for this project (Invivodata, Inc, Pittsburgh, PA). The DABS contains ABP relevant items, such as posture, physical exertion, talking, food consumption, and comfort with ambient temperature. Further, multi-item Likert-type scales from the DABS assess within person fluctuations in mood and social interaction qualities, with intensity responses ranging from 0 to 10. Responses were recorded using a stylus on an 11 point visual analogue scale ranging from ‘no’ to ‘yes’. An auditory prompt was administered 4 minutes following the beginning of cuff inflation, if necessary, as a reminder to complete the DABS. As part of the DABS, participants were asked about currently being in a social interaction (yes or no), which was defined as “a give-and-take exchange with another, which may or may not involve conversation” (Reis & Wheeler, 1991). For this report, observations were not included for analyses unless participants responded in the affirmative to this question.

The following four scales were designed to assess positive qualities of social interactions: Agreeableness (3 items), Intimacy (3 items), Instrumental Support (3 items), and Emotional Support (3 items). Sample items include ‘Pleasant Interaction?’ (Agreeableness); ‘Did you discuss personal feelings?’ (Intimacy); ‘Someone helped you with an errand/task?’ (Instrumental Support); and ‘Someone expressed care/concern for you?’ (Emotional Support). Social interactions rated as high in agreeableness were assessed on average to involve content that was less personal in nature than those rated high on social support or intimacy. Since there were a number of within subject observations for each scale, the observations were averaged within person. When averaged for each 3 day period, the test re-test reliabilities for these scales across the 4 month interval ranged from .69-.83, with internal consistencies from .82-.90, suggesting that these measures may reflect individual differences in social interaction quality that are relatively stable over time.

Use of the electronic diary facilitates data entry and feedback, permitting rapid data downloads and display. The diary precluded missing or out of range entries and the time-stamp associated with each entry provided a check on timely compliance and facilitated merging of data from the electronic diary with that from the ABP monitor. “Delay” and “suspend” software features enable participants to postpone or forgo interviews when necessary (e.g., during church or while driving). Participants are discouraged from overusing these features, however, and their use is recorded, as with other responses (Shiffman, 1999). Compliance data for use of the DABS in this sample has been documented in a recent report (Kamarck et al., in press).

Hostility Assessment. The CMHS consists of 50 true-false items from the Minnesota Multiphasic Personality Inventory (Hathaway & McKinley, 1943). Participants completed the CMHS on a computer during a laboratory visit taking place in between the 2 ABP monitoring periods. The CMHS scale is characterized by both high internal consistency (Cronbach's alpha: .80 - .82; Smith & Frohm, 1985), and high test-retest reliability ($r > .8$ over periods of 1-4 years; Barefoot, Dahlstrom, & Williams, 1983; Schekelle et al., 1983). Sample items include, "It is safer to trust nobody," and "Most people inwardly dislike putting themselves out to help others."

Analytic Strategy

Since the primary aim of this study was to determine the relationship between hostility and positive social interactions in predicting ABP, analyses were restricted to ABP recordings taking place during social interactions. Multilevel modeling (PROC MIXED; SAS Institute, Inc., 1997) was used for most of the analyses in this report. The advantages to this approach over conventional regression analyses include the ability to handle repeated within-subjects measurements of both predictors (e.g., DABS social interaction quality subscales) and dependent (e.g., ABP) variables in conjunction with between-subjects predictors (i.e., demographic variables and CMHS); to model autocorrelation effects; and to handle missing data (Schwartz & Stone, 1998). Maximum likelihood methods were used to obtain solutions for the models. A spatial power function was used to model autocorrelated errors (Polk, Kamarck, & Shiffman, 2002).

Pearson correlation was used (2 tailed) to determine the strength and direction of the relationship between hostility and social interaction frequency, indexed by the proportion of times participants indicated they were in a social interaction during cuff

inflation. Additional correlations were tested to examine the relationship between hostility and the frequency of social interactions characterized by the DABS positive social interaction subscales, with separate correlations for agreeableness, intimacy, and the social support variables. Frequencies of ‘highly’ agreeable, intimate, and supportive social interactions were indexed by proportion of encounters rated above the grand median (sample median of subject means) for agreeableness, intimacy and the social support variables, respectively.

To test the effect of hostility on the mean scores for each of these social interaction scales, multilevel models were conducted treating repeated DABS scales as dependent variables with agreeableness, intimacy, and the social support variables analyzed in separate models. Main effects were estimated for gender and hostility, in addition to the interaction term of gender X hostility, to determine whether the relationship between hostility and social interaction quality varies as a function of gender.

A second set of multilevel models were conducted to determine the main effects of hostility and statistical interactions among gender and the DABS positive social interaction scale scores (e.g., agreeableness, intimacy, and social support) in predicting ABP and ambulatory heart rate (AHR). Main effects for hostility are reported, followed by any significant 2 way or 3 way interaction effects. Separate tests were conducted for SBP, DBP, and HR. Positive social interaction scale scores from the DABS were included as random coefficients so that individual differences in the magnitude of these effects could be taken into consideration with these models. In accordance with recommendations by Aiken and West (1991), significant interactions were followed up by simple slopes analyses. For visual display purposes and analysis of simple slopes,

ABP responding associated with “high” and “low” hostility were plotted at 1 and 2 standard deviations above and below the mean, and “high” and “low” DABS were represented at the mean maximum (i.e., the sample average of the maximum score for each person) and mean minimum scores for the sample.

To calculate the effect sizes associated with significant interaction effects between hostility and DABS variables on ABP, we estimated the between person variance associated with the main effects predictor model (e.g., individual differences in the effects of intimacy as a predictor of ADBP), and we compared this with the between person variance associated with the same model that also included the interaction with hostility (e.g., Intimacy X Hostility added as an additional predictor of ADBP). The percentage reduction in this variance after adding the interaction term (r^2) is a measure of the extent to which hostility accounts for individual differences in ABP changes during these daily social interactions, the square root of which is expressed as r .

The following time-varying covariates were included as fixed effects in each model: posture; physical activity; temperature; recent meal; snack; caffeine or alcohol consumption within the past 45 minutes; antihistamine or decongestant use within the past 4 hours; talking during cuff inflation; cigarette smoking within the past 5 minutes; and number of cigarettes smoked within the past 45 minutes. Age, race, body mass index, education, and gender were also included as fixed effects covariates in all the reported multilevel models in this report. Since significant gender X race effects on ABP and AHR were observed, this interaction term was included in all models (race effects on ABP and AHR were generally present only for women).

Results

Descriptive Statistics

Average CMHS scores were in the low to moderate range, with a mean of 13.27 (SD = 6.47; range: 2-35). Men scored higher on the CMHS than women, $t(338) = 3.088$, $p < .005$. Average ABP and AHR for all participants (averaged by individual) was 128.48 mmHg (SD = 12.01) for SBP, 78.50 mmHg (SD = 7.04) for DBP, and 80.31 (SD = 9.23) beats per minute for HR. Table 1 displays the mean values for ABP, AHR, CMHS, and DABS positive social interaction scale scores by gender. Preliminary analyses revealed men to exhibit significantly greater ASBP ($B = -3.66$, $SE = 1.30$, $df = 36,000$, $t = -2.81$, $p < .01$) and ADBP ($B = -2.71$, $SE = 0.75$, $df = 36,000$, $t = -3.62$, $p < .001$) and women to exhibit significantly greater AHR ($B = 4.08$, $SE = 0.94$, $df = 36,000$, $t = 4.33$, $p < .001$).

Frequency of Social Interactions. Out of an average 113.26 (SD = 11.98; range = 76-165) total electronic diary entries completed by participant, 43.55 (SD = 19.22; range = 1-104; 38.45%) entries took place during social interactions. A marginal negative relationship was observed between CMHS scores and proportion of overall social interactions by participant, $r = -.103$, $p < .06$. Moreover, individuals with higher CMHS scores reported a lower frequency of agreeable interactions, $r = -.164$, $p < .005$, and intimate social interactions, $r = -.109$, $p < .05$. The frequency of social interactions characterized by instrumental or emotional support was not correlated with CMHS scores, $ps > .20$.

Influence of Hostility on Mean DABS Positive Social Interaction Scale Scores

Multilevel models were conducted to observe the influence of CMHS on the mean of positive social interaction scale scores, restricting analyses to social interactions during

cuff inflation. Age, race, education, BMI, and gender were included as fixed effects covariates in each model. Analyses revealed a marginal positive association between CMHS and magnitude of daily instrumental support ratings ($B = 0.024$, $SE = 0.013$, $df = 14000$, $t = 1.87$, $p = .062$), as well as a significant negative association between CMHS and magnitude of agreeable interactions ($B = -0.03$, $SE = 0.008$, $df = 14000$, $t = -4.07$, $p < .0001$). These findings suggest that in addition to reporting fewer social interactions characterized as being high in agreeableness and intimacy, hostile individuals tend to report their social interactions as being higher in instrumental support and as less pleasant. There were no significant gender X hostility interactions for any of the positive social interaction variables.

Influence of Hostility on ABP and AHR

Multilevel models were conducted to determine the association between CMHS and ABP/AHR, with demographic between-subjects variables and within-subjects time varying factors being used as covariates. There was no relationship between CMHS and ABP ($ps > .15$), although a marginal positive association was observed between CMHS and AHR ($B = 0.15$, $SE = 0.08$, $df = 13000$, $t = 1.81$, $p = .07$). CMHS did not interact with gender to predict ABP or AHR.

To determine whether hostility is associated with the magnitude of CV response to social support, intimacy, or agreeable social interactions, the statistical interactions between hostility and these DABS variables were tested. Social interaction variables served as within-subjects random effects predictor variables. Results revealed an interaction between CMHS and instrumental support in predicting ADBP ($B = 0.017$, $SE = 0.007$, $df = 13000$, $t = 2.35$, $p < .05$). Simple slopes analyses revealed that subjects

scoring high on hostility exhibited significant increases in ADBP during social interactions rated high in instrumental support (1 SD above mean: $B = 0.27, p < .001$, 2 SD above mean: $B = 0.38, p < .001$), whereas low hostile subjects displayed non-significant changes in ADBP as a function of increases in instrumental support (1 SD below mean: $B = 0.05$, n.s., 2 SD below mean: $B = -0.06$, n.s.; see Figure 1). Hostility did not interact with emotional support or agreeableness in predicting ABP or AHR ($ps > .2$).

CMHS interacted with intimacy ratings to predict ADBP levels ($B = 0.017$, $SE = 0.008$, $df = 13000$, $t = 2.08$, $p < .05$). Simple slopes analyses revealed low hostile individuals to show significant reductions in ADBP as intimacy ratings increased (1 SD below mean: $B = -0.14, p < .05$, 2 SD below mean: $B = -0.26, p < .05$), whereas high hostile individuals showed non-significant elevations in ADBP as intimacy increased (1 SD above mean: $B = 0.07$, n.s., 2 SD above mean: $B = 0.19$, n.s.; see Figure 2). To calculate the effect sizes associated with these significant interaction effects, we examined the reduction in the (total) variance of the person-specific effects of these psychosocial variables accounted for by the addition of the interaction term. Resulting correlation values were $r = .286, p < .001$ for the Instrumental Support X Hostility interaction, and $r = -.211, p < .001$ for the Intimacy X Hostility interaction effect. These coefficients reflect the magnitude of the relationship between hostility and ADBP during these social interactions. The statistical interactions with CMHS and instrumental support or intimacy were non-significant in predicting ASBP and AHR ($ps > .13$). Moreover, gender was not found to moderate the relationship between hostility and any of the DABS positive social interaction variables, as evidenced by non-significant 3 way interactions in predicting ABP and AHR ($ps > .13$).

Discussion

The purpose of this study was to ascertain the relationships among trait hostility and social interaction qualities in predicting daily BP and HR in an older healthy sample. Hostility was expected to be negatively associated with daily reports of agreeableness, intimacy, and social support. Moreover, hostile individuals were expected to show significant increases in daily CV responses as social support and intimacy increased. Finally, gender differences were examined as potential moderators of these effects.

The findings regarding the first hypothesis of hostility as a predictor of daily social interaction qualities were mixed. Hostile individuals were found to have fewer agreeable and intimate social interactions, and tended to have fewer social interactions overall. However, hostility was not associated with the frequency of encounters characterized by instrumental or emotional support, and was marginally associated with more pronounced ratings of instrumental support. Nonetheless, hostility was negatively associated with agreeableness ratings during social interactions. The inverse relationship between hostility and frequency of social interactions, as well as between hostility and frequency and intensity of agreeable interactions, has been reported elsewhere (e.g., Brondolo et al., 2003) and may reflect behavioral and perceptual influences of a cynical mistrust.

Hostility was only marginally associated with AHR in this study ($p = .064$) and was not associated with average ABP during social interactions. The lack of main effects for the CMHS has been reported in other research (e.g., Brondolo et al., 2003; Enkelmann et al., 2005) and corroborates interpersonal models of hostility that take into account type and intensity of social interaction in predicting CV responses to stress.

In accordance with the second hypothesis of the current study regarding the moderating influence of hostility on ABP responses to the strength of social interactions, hostile individuals were found to show significant increases in ADBP during situations rated high in instrumental support, whereas low hostile subjects showed non-significant decreases in ADBP (see Figure 1). Therefore, although hostility was marginally associated with ratings of higher instrumental support, these instances were characterized by increases in ABP for hostile individuals. Moreover, type of social support seemed to make a difference, since hostility interacted with instrumental support, but not emotional support, in predicting ADBP. These findings suggest that hostile individuals may fail to benefit from situations of instrumental support and may find offers of assistance stressful, as if suggestive of an inability for the hostile person to complete a task alone.

In partial support of the second hypothesis for the current study, a statistical interaction was observed between hostility and intimacy ratings on ADBP, indicating that low hostile participants display significant reductions in ADBP along with increases in intimacy ratings, whereas hostile participants showed non-significant elevations in ADBP to intimate social interactions (see Figure 2). Previous findings in the laboratory have revealed hostile individuals to show significant increases in BP responses to a speech stressor involving self disclosure of a personally troubling event compared to low hostile individuals, suggesting that hostile individuals may find discussing personal feelings with others stressful (Christensen & Smith, 1993).

Unlike this laboratory study, we did not find significant elevations in BP among hostile individuals during intimate interactions. Although hostile participants showed an increase in ADBP with increases in intimacy ratings, the effect was non-significant ($B =$

0.07, n.s., at 1 SD above mean, $B = .19$, n.s., at 2 SD above mean). One explanation for this effect in comparison to Christensen & Smith (1993) concerns the topic of discussion. In their laboratory self disclosure study, participants were instructed to specifically discuss a topic of personal distress, whereas in the current study participants merely reported having discussed personal feelings. It is possible that discussing matters personally distressing is requisite to observe significant elevations in BP responses among hostile individuals. Nonetheless, the current findings are broadly consistent with the laboratory evidence insofar as they suggest hostile individuals fail to benefit from the presence of intimacy in their social interactions.

It should be noted that hostility interacted with instrumental support and intimacy to predict ADBP, whereas these statistical interactions for ASBP were non-significant. However, the general pattern of results for ASBP was similar to that observed with ADBP, whereby hostility was positively associated with ASBP to instrumental support and intimacy. The notion that vascular (i.e., DBP) responses may be differentially sensitive to anger or hostility effects is not unprecedented. For example, meta-analyses have revealed average effect sizes associated with BP reactivity to provocative laboratory stressors among individuals rating high on the CMHS to be stronger for DBP than SBP (Suls & Wan, 1993). Moreover, similar findings have been reported in previous ambulatory research, whereby CMHS interacted with daily experiences of social conflict to predict ADBP, but not ASBP (Brondolo et al., 2003).

On the whole, the current findings provide support for interpersonal models of hostility by suggesting that hostile individuals exhibit significant BP responses to situations of social support and may not appear to be soothed by intimate social

interactions, and corroborate results reported from laboratory studies on social support (e.g., Lepore, 1995; Chen et al., 2005) and self disclosure (Christensen & Smith, 1993). Further, hostility was not found to interact with the agreeableness scale of social interactions characterized as 'pleasant' and 'friendly' in predicting ABP, a null finding which has been reported previously (Brondolo et al., 2003). Perhaps it is only those positive interactions potentially threatening in nature to hostile individuals (e.g., those involving disclosure of personal feelings or receiving offers of help on a task, which could be perceived as intrusive or condescending) that evoke differential physiological responses. Thus, encounters simply characterized as 'pleasant' or 'agreeable' may be too superficial to tap into these effects among hostile individuals, and it may be necessary to inquire about qualities of social interactions that may pose an 'ego threat' or influence a sense of vulnerability.

Although this study makes important contributions to the extant literature, a couple of key limitations need to be noted. First, although hostility was characterized by a single score in the current study, hostility is a multifaceted construct, including affective, behavioral, and cognitive components (e.g., Smith et al., 2004), each of which may be differentially associated with physiological responses to social situations. For example, the cognitive component of hostility (e.g., cynical mistrust) may be especially important for the phenomena observed in this study, insofar as it may relate to an inability to use positive social experiences (e.g., social support, intimacy) as a buffer from daily stressors. To the extent that more sensitive measures of hostility may inform a stronger understanding of psychophysiological contributions to disease processes, future studies may consider pitting different hostility scales against one another to observe which

components of this construct better predict physiological responses to social interactions. A second limitation to the current study concerns the use of only healthy older adults. For example, insofar as normotensives may show smaller BP responses to psychological challenge relative to hypertensives (Georgiades, Lemne, de Faire, Lindvall, & Fredrikson, 1996), this could potentially result in a restriction in range with respect to the observed effects, thereby underestimating the strength of association between hostility and ABP. The generalizability of these results to younger samples cannot be determined from these data, although it should be noted that previous laboratory studies showing similar patterns of results (Lepore, 1995; Christensen & Smith, 1993) have involved younger samples than that represented here.

To our knowledge, the current study represents the first investigation to use EMA methods to assess the moderating influence of hostility on ABP responses to daily situations of social support and intimacy. The findings suggest that social context matters when predicting the influence of hostility on ABP responses in healthy older adults and may have implications for conceptualizations of the social psychophysiology of hostility. Other studies have indicated hostile individuals to show significant ABP responses to interpersonal stressors (e.g., Brondolo et al., 2003). Our findings reveal hostile individuals may also fail to benefit from social situations of a more positive valence, such as social support and intimacy. Use of EMA methods permits a non-invasive assessment of physiological responses to a variety of social situations in real time, which may have important ramifications for understanding individual differences in psychophysiological processes related to hostility.

References

- Aiken, L.S. & West, S.G. (1991). *Interactions between categorical and continuous variables*. In: Multiple Regression: Testing and Interpreting Interactions. Thousand Oaks, CA. Sage Publications. pp 116-138.
- Barefoot, J.C., Dahlstrom, G., & Williams, R.B. (1983). Coronary heart disease incidence and total mortality: A 25 year follow-up study of 255 physicians. *Psychosomatic Medicine*, 45, 59-63.
- Benotsch, E.G., Christensen, A.J., & McKelvey, L. (1997). Hostility, social support, and ambulatory cardiovascular activity. *Journal of Behavioral Medicine*, 20(2), 163-175.
- Brondolo, E., Rieppi, R., Erickson, S.A., Bagiella, E., Shapiro, P.A., McKinley, P., & Sloan, R.P. (2003). Hostility, interpersonal interactions, and ambulatory blood pressure. *Psychosomatic Medicine*, 65, 1003-1011.
- Chen, Y.Y., Gilligan, S., Coups, E.J., & Contrada, R.J. (2005). Hostility and perceived social support: Interactive effects on cardiovascular reactivity to laboratory stressors. *Annals of Behavioral Medicine*, 29(1), 37-43.
- Christensen, A.J., & Smith, T.W. (1993). Cynical hostility and cardiovascular reactivity during self-disclosure. *Psychosomatic Medicine*, 55, 193-202.
- Cook, W.W. & Medley, D. M. (1954). Proposed hostility and pharisaic-virtue scales for the MMPI. *Journal of Applied Psychology*, 238, 414-18.
- Davis, M.C., Matthews, K.A., & McGrath, C.E. (2000). Hostile attitudes predict elevated vascular resistance during interpersonal stress in men and women. *Psychosomatic Medicine*, 62, 17-25.

- Enkelmann, H.C., Bishop, G.D., Tong, E.M.W., Diong, S.W., Why, Y.P., Khader, M., & Ang, J. (2005). The relationship of hostility, negative affect and ethnicity to cardiovascular responses: An ambulatory study in Singapore. *International Journal of Psychophysiology*, 56, 185-197.
- Georgiades, A., Lemne, C., de Faire, U., Lindvall, K., & Fredrickson, M. (1996). Stress-induced laboratory blood pressure in relation to ambulatory blood pressure and left ventricular mass among borderline hypertensive and normotensive individuals. *Hypertension*, 28(4), 641-646.
- Hathaway, S.R., & McKinley, J.C. (1943). *Booklet for the Minnesota Multiphasic Personality Inventory*. New York: The Psychological Corporation.
- Janicki, D.L., Kamarck, T.W., Shiffman, S., Sutton-Tyrrell, K., & Gwaltney, C.J. (2005). Frequency of spousal interaction and 3-year progression of carotid artery intima medial thickness: The Pittsburgh healthy heart project. *Psychosomatic Medicine*, 67, 889-896.
- Kamarck, T.W., Janicki, D.L., Shiffman, S., Polk, D.E., Muldoon, M.F., Liebenauer, L.L., & Schwartz, J.E. (2002). Psychological demands and ambulatory blood pressure: A field assessment approach. *Physiology & Behavior*, 77, 699-704.
- Kamarck, T.W., Muldoon, M.F., Shiffman, S., Sutton-Tyrrell, K., Gwaltney, C., & Janicki, D.L. (2004). Experiences of demand and control in daily life as correlates of subclinical carotid atherosclerosis in a healthy older sample. *Health Psychology*, 23(1), 24-32.
- Kamarck, T.W., Polk, D.E., Sutton-Tyrrell, K., & Muldoon, M.F. (2002). The incremental value of ambulatory blood pressure persists after controlling for methodological

- confounds: Associations with carotid atherosclerosis in a healthy sample. *Journal of Hypertension*, 20(8) 1535-1541.
- Kamarck, T.W., Schwartz, J.E., Janicki, D.L., Shiffman, S., & Raynor, D.A. (2003). Correspondence between laboratory and ambulatory measures of cardiovascular reactivity: A multilevel modeling approach. *Psychophysiology*, 40, 675-683.
- Kamarck, T.W., Shiffman, S., Muldoon, F., Sutton-Tyrrell, K., Gwaltney, C.J., Janicki, D.L., & Schwartz, J. (in press). Ecological momentary assessment as a resource for social epidemiology. In A. Stone, S. Shiffman, A. Atienza & D. Nebeling (Eds.), *The science of real-time data capture: Self report in health research*. New York, NY: Oxford University Press.
- Kamarck, T.W., Shiffman, S., Smithline, L., Goodie, J., Thompson, H., Ituarte, P.H., Yi-Kuan Jong, J., Pro, V., Paty, J.A., Kassel, J.D., Gnys, M., & Perz, W. (1998). The diary of ambulatory behavioral states: A new approach to assessment of ambulatory cardiovascular activity. In D. Krantz & A. Baum (Eds.), *Perspectives in behavioral medicine: Technology and methodology in behavioral medicine* (pp. 163-193). Hillsdale, NJ: Erlbaum.
- Lepore, S.J. (1995). Cynicism, social support, and cardiovascular reactivity. *Health Psychology*, 14(3), 210-216.
- Linden, W., Chambers, L., Maurice, J., & Lenz, J.W. (1993). Sex differences in social support, self deception, hostility, and ambulatory cardiovascular activity. *Health Psychology*, 12, 376-380.

- Perloff, D., Grim, C., Flack, J., Frohlich, E.D., Hill, M., McDonald, M., & Morgenstern, B.Z. (1993). Human blood pressure determination by sphygmomanometry. *Circulation*, 88, 2460-2467.
- Polk, D.E., Kamarck, T.W., & Shiffman, S. (2002). Hostility explains some of the discrepancy between daytime ambulatory and clinic blood pressures. *Health Psychology*, 21(2), 202-206.
- Raikkonen, K., Matthews, K.A., Flory, J.D., & Owens, J.F. (1999). Effects of hostility on ambulatory blood pressure and mood during daily living in healthy adults. *Healthy Psychology*, 18(1), 44-53.
- Reis, H.T., & Wheeler, L. (1991). Studying social interaction with the Rochester Interaction Record. *Advances in Experimental Social Psychology*, 24, 269-317.
- Rozanski, A., Blumenthal, J.A., & Kaplan, J. (1999). Impact of psychological factors on the pathogenesis of cardiovascular disease and implications for therapy. *Circulation*, 99, 2192-2217.
- Schekelle, R.B., Gale, M., Ostfeld, A.A., & Paul, O. (1983). Hostility, risk of coronary heart disease, and mortality. *Psychosomatic Medicine*, 45, 109-14.
- Scherwitz, L., Perkins, L., Chesney, M., & Hughes, G. (1991). Cook-Medley Hostility scale and subsets: Relationship to demographic and psychosocial characteristics in young adults in the CARDIA study. *Psychosomatic Medicine*, 53(1), 36-49.
- Schwartz, J., & Stone, A. (1998). Strategies for analyzing ecological momentary assessment data. *Health Psychology*, 17, 6-16.
- Shiffman, S. (1999). Real-time self-report of momentary states in the natural environment: Computerized ecological momentary assessment. In: A.A. Stone,

- J.S. Turkkan, J. Jobe, C. Bachrach, H. Kurtzman, & V. Cain (Eds.). *Science of Self-Report: Implications for Research and Practice*. Mahwah (NJ): Erlbaum, pp. 277-296.
- Smith, T.W. & Frohm, K. (1985). What's so unhealthy about hostility? Construct validity and psychosocial correlates to the Cook & Medley hostility scale. *Health Psychology, 4*, 503-520.
- Smith, T.W., Glazer, K., Ruiz, J.M., & Gallo, L.C. (2004). Hostility, anger, aggressiveness, and coronary heart disease: An interpersonal perspective on personality, emotion, and health. *Journal of Personality, 72*(6), 1217-1270.
- Smith, T.W., Ruiz, J.M., & Uchino, B.N. (2004). Mental activation of supportive ties, hostility, and cardiovascular reactivity to laboratory stress in young men and women. *Health Psychology, 23*(5), 476-485.
- Stewart, J.C., Janicki, D.L., & Kamarck, T.W. (2006). Cardiovascular reactivity to and recovery from psychological challenge as predictors of 3-year change in blood pressure. *Health Psychology, 25*(1), 111-118.
- Stone, A.A., & Shiffman, S. (1994). Ecological momentary assessment in behavioral medicine. *Annals of Behavioral Medicine, 16*, 199-202.
- Suls, J. & Wan, C.K. (1993). The relationship between trait hostility and cardiovascular reactivity: A quantitative review. *Psychophysiology, 30*(6), 615-626.
- Treiber, F.A., Kamarck, T., Schneiderman, N., Sheffield, D., Kapuku, G., & Taylor, T. (2003). Cardiovascular reactivity and development of preclinical and clinical disease states. *Psychosomatic Medicine, 65*, 46-62.

Table 1

Ambulatory Blood Pressure (ABP), Heart Rate, Social Interaction Subscales, and Hostility by Gender (N = 341)

Variable	Women (n = 173)		Men (n = 168)		t	p	df
	M	(SD)	M	(SD)			
ABP							
Systolic (mmHg)	126.74	(12.00)	130.33	(11.77)	-2.81	.01	36000
Diastolic (mmHg)	77.34	(7.35)	79.74	(6.46)	-3.62	.001	36000
Heart Rate (bpm)	82.74	(8.41)	77.84	(9.36)	4.33	.001	36000
Instrumental Support	3.76	(1.39)	4.24	(1.45)	-1.94	.053	14000†
Emotional Support	3.97	(1.56)	4.65	(1.69)	-2.36	.05	14000†
Intimacy	4.57	(1.25)	4.94	(1.36)	-1.24	.22	14000†
Agreeableness	7.31	(0.91)	7.44	(0.98)	-0.85	.40	14000†
Cook-Medley Hostility	12.22	(6.07)	14.36	(6.69)	-3.88	.005	388

Note. bpm = beats per minute.

†Analyses restricted to social interactions.

Table 2

Ambulatory Blood Pressure (ABP), Heart Rate, and Social Interaction Subscales by Low and High Hostility Quartile

Variable	Cook-Medley Hostility Quartile	
	< 26%	>75%
ABP		
Systolic (mmHg)	127.01 (11.1)	131.10 (13.0)
Diastolic (mmHg)	78.10 (6.5)	79.49 (7.9)
Heart Rate (bpm)	80.61 (7.9)	80.68 (8.9)
Frequency		
Total Observations	113.45 (11.7)	111.30 (10.9)
Social Interactions	43.95 (18.5)	38.59 (21.6)
Instrumental Supp	23.72 (16.5)	22.66 (18.4)
Emotional Support	25.45 (18.9)	22.31 (19.9)
Intimacy ^a	25.25 (17.5)	19.74 (18.2)
Agreeableness ^b	24.78 (17.5)	17.30 (17.4)
Social Interaction Intensity		
Instrumental Supp	4.01 (1.39)	4.17 (1.48)
Emotional Support	4.32 (1.61)	4.48 (1.72)
Intimacy	4.83 (1.23)	4.57 (1.33)
Agreeableness ^c	7.53 (0.87)	7.17 (1.02)

Note. bpm = beats per minute. Numbers are means with standard deviation in parentheses.

^aHostility inversely associated with proportion of observations rated above the sample median of subject means for intimacy, $r = -.109$, $p < .05$

^bHostility inversely associated with proportion of observations rated above the sample median of subject means for agreeableness, $r = -.164$, $p < .005$.

^cIn mixed models regression hostility predicted lower agreeableness ratings during social interactions ($B = -0.03$, $SE = .008$, $df = 14000$, $t = -4.07$, $p < .0001$)

Figure Captions

Figure 1. Interaction between daily reports of instrumental support and Cook-Medley Hostility Scores in predicting ambulatory diastolic blood pressure. Simple slopes reflect predicted values at 1 and 2 standard deviations above and below the centered mean for hostility, and the sample average minimum and maximum values of instrumental support for each person.

Figure 2. Interaction between daily reports of intimacy and Cook-Medley Hostility Scores in predicting ambulatory diastolic blood pressure. Simple slopes reflect predicted values at 1 and 2 standard deviations above and below the centered mean for hostility, and the sample average minimum and maximum values of intimacy for each person.



