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Hostility and Distraction Have Differential Influences on Cardiovascular Recovery From Anger Recall in Women

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This study investigated the relation of dispositional hostility to cardiovascular reactivity during an anger-recall task and of hostility and distraction to posttask recovery in 80 healthy women (ages 18–30). Half were randomly assigned to distraction during recovery. Hostility predicted slower systolic blood pressure and preejection period during recovery. Distraction was related to faster cardiac recovery, higher high-frequency (HF) power, lower low-frequency (LF) power and LF:HF ratios, and lower state anger and rumination during recovery. These results indicate deleterious influences of hostility on cardiovascular recovery but not during anger recall. The findings also show beneficial effects of distraction in expediting cardiovascular recovery, possibly through reducing rumination and anger.

Key words: hostility, distraction, cardiovascular reactivity, poststress recovery, impedance cardiography, heart rate variability

Dispositional hostility has been prospectively associated with cardiovascular morbidity and mortality (Dembroski, MacDougall, Costa, & Grandits, 1989; Everson et al., 1997; Hecker, Chesney, Black, & Frautschi, 1988; Iribarren et al., 2000; Matthews, Glass, Rosenman, & Bortner, 1977; Rozanski, Blumenthal, & Kaplan, 1999; Scherwitz et al., 1992; Sykes et al., 2002). Whereas this relation is fairly consistent in men, the association has been understudied in women (Beckham, Calhoun, Glenn, & Barefoot, 2002). Nevertheless, prospective evidence has suggested that hostility also increases women's risk for hypertension and coronary heart disease (CHD; Adams, 1994; Barefoot, Larsen, Lieth, & Schroll, 1995; Irribarren et al., 2000; Matthews, Owens, Kuller, Sutton-Tyrrell, & Jansen-McWilliams, 1998).

The relation of hostility to cardiovascular disease may be mediated, in part, by enhanced cardiovascular reactivity (Manuck, 1994; Matthews, 1986; McEwen, 1998; Smith, 1992). Hostile individuals have been shown to display greater cardiovascular reactivity responses, particularly in response to social and anger-provoking stressors, as compared with nonhostile individuals (Everson, McKey, & Lovallo, 1995; Smith & Allred, 1989; Suarez, Harlen, Peoples, & Williams, 1993; Suarez & Williams, 1989a, 1989b). Exaggerated cardiovascular reactivity (i.e., acute cardiovascular responses to behavioral challenge) has been implicated as a potential risk factor for hypertension, atherosclerosis and its progression, and CHD (Barnett, Spence, Manuck, & Jennings, 1997; Kamarck et al., 2000; Krantz & Manuck, 1984; Rozanski et al., 1999). Slow poststress cardiovascular recovery (stress-related cardiovascular elevations following a stressor) has also been proposed as a critical factor linking hostility with cardiovascular disease (Brosschot

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& Thayer, 1998; Gerin & Pickering, 1995; Linden, Earle, Gerin, & Christenfeld, 1997).

Relatively little is known about the physiological (e.g., hemodynamic) and psychological (e.g., cognitive, emotional) processes underlying cardiovascular responses and recovery to anger provocation (both in general and among hostile individuals). With respect to hemodynamics, several investigators have found that anger-related tasks tend to elicit a vascular resistance response pattern (Davis, Matthews, & McGrath, 2000; Everson et al., 1995; Prkachin, Mills, Zwaal, & Husted, 2001) or a mixed cardiac and vascular response (Neumann & Waldstein, 2001; Sinha, Lovallo, & Parsons, 1992). The present study further examined hemodyamic mechanisms underlying cardiovascular reactivity and recovery during anger recall by measuring impedance cardiography and heart rate variability (HRV).

With regard to cognition and emotion, distraction and rumination are two opposing emotion regulation processes that individuals may automatically or consciously use following an angry situation and that may vary as a function of hostility. *Rumination* has been described as cognitions that focus attention on a negative event and negative mood (Rusting & Nolen-Hoeksema, 1998). In contrast, *distraction* methods (e.g., active relaxation, reading, and listening to music) focus attention away from negative emotions onto pleasant or neutral stimuli (Nolen-Hoeksema, 1991) and are presumed to offset ruminations (i.e., Haynes, Gannon, Orimoto, O'Brien, & Brandt, 1991; Linden et al., 1997). Distraction has been shown to reduce anger (Rusting & Nolen-Hoeksema, 1998) and to speed cardiovascular recovery from stressful (Patel, 1975) and anger-related laboratory tasks (A. Schwartz, Gerin, Davidson, & Christenfeld, 2000). It is interesting to note that R. E. Thayer, Newman, and McClain (1994) found that men tend to use active distraction to regulate negative emotions, whereas women tend to use rumination. These gender differences in emotion regulation tendencies provided further reason to study women in the present investigation. Thus, distraction was investigated here as a potential psychological mechanism enhancing cardiovascular recovery.

The present study investigated the relations between dispositional hostility and cardiovascular reactivity evoked by a personally relevant anger recall task and hostility and distraction on poststress recovery in healthy young women. The effects of distraction on cardiovascular recovery were measured by comparing a standard recovery period to a recovery involving a distraction technique. It was hypothesized that (a) dispositional hostility would predict greater cardiovascular reactivity and prolonged recovery, (b) distraction would speed cardiovascular recovery and be associated with lower state anger and rumination, and (c) dispositional hostility would interact with the distraction condition such that higher hostile individuals would have the greatest benefit from distraction.

Method

Participants

Eighty[1] female university students (18–30 years old) were recruited from advertisements via flyers and massed screening sessions from introductory psychology courses at the University of Maryland, Baltimore County (UMBC). The sample included persons of Caucasian (54%), African American (34%), and Asian American (12%) ethnicities and approximated the UMBC population base rates. Participants were nonsmokers (by self-report); had a body mass index (BMI) < 30 kg/m^2 (National Heart, Lung, and Blood Institute Expert Panel on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults, 1998); were normotensive (resting systolic blood pressure [SBP] < 140 mmHg and diastolic blood pressure [DBP] < 90 mmHg; Chobanian et al., 2003); and reported no history of hypertension, cardiovascular or pulmonary disease, psychiatric disorder, or use of medications affecting cardiovascular function (including oral contraceptives). Sample characteristics are displayed in Table 1. Participants were asked to refrain from caffeine intake for 12 hr and alcohol for 24 hr prior to the session. Informed consent was obtained in accordance with the UMBC's Institutional Review Board guidelines. Each participant was involved in one 2-hr laboratory session and was compensated with a choice of $10 or two course credits on completion of the study.

Psychosocial Measures

The Cook–Medley Hostility (Ho) Scale (Cook & Medley, 1954) was used to assess dispositional hostility in the present study and has been widely used in examining the link between hostility and cardiovascular reactivity and disease. Although there has been some controversy related to the validity and the multidimensional nature of the Ho scale (see Barefoot, Dodge, Peterson, Dahlstrom, & Williams, 1989; Costa, Zonderman, McCrae, & Williams, 1986), several studies have found that the Ho Scale is significantly correlated with self-reports of anger and other measures of hostility supporting construct validity (e.g., Smith & Frohm, 1985; Smith, Pope, Sanders, Allred, & O'Keeffe, 1988; Woodall & Matthews, 1989). The Ho Scale has also displayed Cronbach's alphas averaging about .80 (Smith & Frohm, 1985) and test–retest correlations of .80 (Smith, 1992).

State anger was measured using the S-Anger subscale of the State–Trait Anger Expression Inventory (Spielberger, 1988). The 10 items of the subscale are rated on 4-point Likert scales and are summed (scores range from 10–40) with higher scores indicating greater state anger. The internal consistency of the subscale is around .84, and validity has been supported by several studies (Spielberger, 1988).

State rumination was assessed by the Revised Impact of Events Scale (IES). The IES assesses two types of cognitive emotion regulation processes, rumination (or intrusive thoughts) and avoidance using a 5-point scale (0 = *never* to 4 = *very often*; Horowitz, Wilner, & Alvarez, 1979). The test–retest reliability was .89, with a Cronbach's alpha of .78 (Horowitz et al., 1979).

A manipulation check questionnaire, written for the present study, evaluated the time spent reading (in the distraction condition only) and time spent thinking about the anger recall task during the recovery period.

[1] A priori power analysis for multiple regression analyses with two main predictors and their interaction on cardiovascular reactivity using GPOWER software (Erdfelder, Faul, & Buchner, 1996) revealed that for power = .80, average medium effect size ($f^2 = .15$; effect sizes were calculated from correlations between hostility scores using the Hostility [Ho] Scale, blood pressure, heart rate [HR], and impedance reactivity measures from Everson et al., 1995), and $\alpha = .05$, 77 participants were needed for this experiment (Erdfelder et al., 1996). However, 80 participants were used in the study to have an even number of participants in the control ($n = 40$) and distraction ($n = 40$) groups. For the HRV reactivity measures with the main predictors and their interaction, a priori power analysis revealed that for power = .80, large effect sizes ($f^2 = .33$; effect size was calculated using high frequency [HF] power reactivity estimates during a speech task from Berntson et al., 1994), and $\alpha = .05$, 37 participants were needed for this experiment (Erdfelder et al., 1996). We collected data on the latter 40 of 80 participants for the HRV measures. An alpha level of .05 was used for all statistical tests, all of which were two-tailed.

Table 1
Sample Characteristics Across All Participants and by Distraction Condition

Characteristic	All ($N = 80$) *M*	All ($N = 80$) *SD*	Control ($n = 40$) *M*	Control ($n = 40$) *SD*	Distraction ($n = 40$) *M*	Distraction ($n = 40$) *SD*
Demographics[a]						
Age (years)	19.0	1.5	19.0	1.6	19.0	1.5
Body mass index (kg/m^2)	23.1	3.3	22.5	3.4	23.6	3.0
Education (years)	12.7	1.3	12.7	1.4	12.7	1.0
Caffeine intake (8-oz [237-ml] drinks/day)	1.1	0.9	1.2	0.9	1.2	0.9
Alcohol intake (drinks/week)	0.8	1.6	0.6	1.2	0.9	1.9
Psychosocial measures						
Hostility	20.8	7.6	21.2	7.9	20.5	7.6
State anger following baseline	10.3	0.8	10.4	0.9	10.3	0.7
State anger during task	18.7	6.1	18.6	5.7	18.8	6.5
State anger during recovery	12.9	4.1	14.1***	4.5	11.8***	3.5
Rumination during task	12.0	4.4	12.4	3.9	11.7	4.8
Rumination during recovery	10.5	5.5	11.5*	5.6	9.5*	5.4
Baseline cardiovascular measures						
Systolic BP (mmHg)	106	7.1	106	5.3	107	8.5
Diastolic BP (mmHg)	57	6.1	58	5.0	56	6.9
Heart rate (bpm)	77	10.7	78	10.9	75	10.5
Preejection period (s)	104	12.3	104	12.0	104	12.3
Cardiac index (L/min/m^2)	4.2	0.9	4.3	0.8	4.2	1.0
Stroke volume index (ml/beat/m^2)	58	15.9	57	14.0	58	17.9
Total peripheral resistance (dynes/cm^5/s)	918	232	917	198	919	264
Root mean square of successive differences (ms)	44.8	27.2	39.0	23.1	51.4	30.3
LF	0.40	0.18	0.44	0.21	0.36	0.14
HF	0.53	0.19	0.50	0.21	0.56	0.16
LF/HF	1.07	1.08	1.37	1.39	0.74	0.41

Note. BP = blood pressure; LF = low frequency; HF = high frequency.
[a] Positive family history of hypertension: all, 41%; control, 36%; distraction, 46%.
* $p < .06$. *** $p < .01$.

The participants rated these questions using a 4-point scale (4 = *all of the time* to 1 = *none of the time*).

Cardiovascular Measures

SBP and DBP were measured oscillometrically using a Model 8100 Critikon Dinamap Vital Signs Monitor (cuff on nondominant arm; Critikon, Tampa, FL). HR was derived from the electrocardiogram (ECG) measured from two electrodes attached bilaterally to the chest. Heart sounds were obtained by a Model 21050A Hewlett-Packard contact transducer (Phillips Medical Systems, Andover, MA) positioned at the second intercostal space on the left sternal border. The ECG and heart sound signals were filtered and amplified by Grass biological amplifiers (Grass Medical Instruments, Quincy, MA). Impedance-derived signals (dZ/dt), measured with a Model 304B IFM Minnesota Impedance Cardiograph (Surcom, Inc., Minneapolis, MN), were used to provide noninvasive estimates of cardiac preejection period (PEP), stroke volume (SV), left ventricular ejection time (LVET), cardiac output (CO), and total peripheral resistance (TPR). A standard four-band electrode placement was used, with two bands placed around the neck and two around the chest (i.e., tetrapolar band–electrode configuration; Sherwood et al., 1990). Four channels of cardiovascular signals—ECG, heart sounds, dZ/dt (first derivative of the change in thoracic impedance), and Zo (basal thoracic impedance)—were acquired continuously, using computerized analog-to-digital conversion at a rate of 1,000 samples/s (Debski et al., 1991).

HRV data were measured continuously using VU-AMS (Groot, Klaver, Sijmons, Bik, & de Vries, 1999; Klaver, de Geus, & de Vries, 1994).[2] Recording methodology, reliability and validity of the VU-AMS have been described previously (de Geus, Willemsen, Klaver, & van Doornen, 1995). A continuous time series of R-wave-to-R-wave intervals were derived online from a three-lead ECG (sampling frequency = 1,000 Hz) during the baseline, task, and recovery periods.

Procedures

The participant was seated in a sound-attenuated, temperature-controlled room and then engaged in a standard 15-min baseline period, a 3-min anger recall task, and a 10-min recovery period. Instructions for the personally relevant anger recall task were a modified version of those used previously (Ironson et al., 1992; Neumann & Waldstein, 2001; Waldstein et al., 2000). Participants were asked to recall and talk about a recent event, occurring within the last year, which continued to make them angry, frustrated,

[2] The reason a separate device (VU-AMS) was used to collect ECG measures for the HRV measures was because of its more advanced functions (i.e., automatic analog signal conversion, R-wave detection, and interbeat interval calculation outputs) in comparison with the other ECG device used for impedance measurement and scoring, which only outputs the analog signal.

irritated, or upset. During recovery, the participants experienced either a distraction technique (i.e., reading a neutral article about the possibility of life in outer space; see Weinberger, Schwartz, & Davidson, 1979) or a standard recovery period (i.e., no reading or implemented distractions) as determined by random assignment. The S-Anger subscale was administered prior to the task. Following recovery, participants provided a retrospective self-report of state anger (S-Anger subscale) and state rumination (revised IES) pertaining to the task and recovery periods. Then, participants completed the Ho Scale ($n = 80$) and manipulation check items ($n = 49$). Blood pressure measures were collected in 90-s intervals during baseline and at 60-s intervals during task and recovery periods ($n = 80$), which is consistent with well-established psychometric criteria (Debski et al., 1991; Kamarck et al., 1992; Kamarck, Jennings, & Manuck, 1993). The ECG and impedance measurements were obtained continuously during the baseline, task, and recovery periods from all participants ($N = 80$). HRV measures were collected on the latter 40 participants (see Footnote 1).

Data Reduction

Blood pressure data (i.e., SBP and DBP) were averaged for the baseline period and the anger-recall task. For the baseline period, the last three blood pressure readings were averaged. For the recall task, the three obtained blood pressure readings were averaged. ECG and impedance waveforms were ensemble averaged and scored in 30-s intervals for the baseline, task, and recovery periods using computer software designed at the University of Pittsburgh (Debski et al., 1991). SV was calculated using a fixed value of 135 ohm*cm for blood resistivity (SV = LVET*dZ/dt*12/Zo2*ρ; Kubicek, Karnegis, Patterson, Witsoe, & Mattson, 1966). CO was computed as (HR*SV)/1,000. To adjust for participant differences in BMI, stroke volume index (SI) and cardiac index (CI) were calculated by dividing SV and CO by body surface area, weight (kg)$^{.425}$ $\times$ height (cm)$^{.725}$ $\times$ .007184. TPR was calculated using the equation mean arterial pressure/CO $\times$ 80. The systolic time intervals, PEP and LVET, were coded in milliseconds as the following intervals: the Q-wave of the digitized ECG to the β-point of the dZ/dt waveform; the β-point to X-wave of the dZ/dt waveform (i.e., coincident with the closure of the aortic valve—the second heart sound). The measures collected from the impedance cardiography data were averaged for the baseline, task, and recovery periods.

For the HRV data, time and frequency domain analyses were performed using a custom HRV package. Artifactual and arrhythmic intervals were substituted with a preprocessing algorithm, with estimates based on interpolation from the two preceding and two succeeding valid intervals (J. F. Thayer, Friedman, & Borkovec, 1996). Time domain analysis provided root mean square of successive differences (r-MSSD) in R-wave-to-R-wave intervals and HR. Then, an autoregressive algorithm computed the autoregressive coefficients that define the power spectra for the time series. The best statistical estimate to represent the time series was selected by the program for the model. The program then provided power values for each spectral component in the model. Specifically, using guidelines of the Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology (1996), spectral analyses using the autoregressive algorithm described above were performed on these data to obtain both low-frequency (LF; 0.04–0.15 Hz) and high-frequency (HF; 0.15–0.40 Hz) components. LF and HF power are thought to measure differential autonomic nervous system influences. Briefly, HF power primarily reflects respiratory-modulated parasympathetic (vagal) outflow, whereas LF power is thought to reflect baroreceptor-mediated regulation of blood pressure (Friedman & Thayer, 1998) that is influenced by substantial sympathetic control and varying amounts of parasympathetic influences. It is important to note, however, that the relative contribution of these autonomic components to LF power has been a topic of debate (see Friedman & Thayer, 1998; Pagani, Rimoldi, & Malliani, 1992). Because LF power may be influenced by parasympathetic activity, the LF:HF ratio, an index of relative balance of sympathovagal influences on the heart (Malliani, Lombardi, Pagani, & Cerutti, 1990), was also computed. Higher LF:HF ratio values point to relative increases in sympathetic activity and imply functional decreases in the vagal control of HR. Spectral estimates of power were computed on single epochs for the baseline (15-min epoch), task (3-min epoch), and recovery (10-min epoch) periods and were then logarithmically transformed (ln) to normalize the distribution of scores. Normalized values for the spectral estimates of power were used in the final analyses, that is, LF and HF power/(total power − direct current components), and are regarded as reliable estimates of autonomic balance (Malliani, Pagani, & Lombardi, 1994).

Arithmetic change scores (task mean value − baseline mean value) were calculated as an index of SBP, DBP, HR, PEP, SI, CI, TPR, r-MSSD, LF power, HF power, and LF–HF reactivity during the recall task. These physiological change scores were used in the final analyses for the task period. For recovery, excursions were used to estimate the area under the recovery curve minus the baseline for each participant and each cardiovascular measure (i.e., SBP, DBP, HR, PEP, CI, SI, TPR). Excursions were calculated using the following equation: Excursion = 0.5 * fixed time interval [(cardiovascular measure @ Time 1) + (2*cardiovascular measure @ Time 2) + (2*cardiovascular measure @ Time 3) + $\cdots$ + (cardiovascular measure at last time point)] − (baseline cardiovascular measure * the fixed time interval), where fixed time interval = 60-s averages for blood pressure and 30-s averages for HR and impedance measures, and each time point (e.g., Time 1) represents a blood pressure value taken every 60 s, or for HR and impedance measures, corresponds to 30-s averages until the end of the 10-min recovery period (Protter & Morrey, 1970). Spectral estimates of power (a single data point representing all relevant data for a specified period) estimating HRV components do not lend themselves to excursion computation and are the standard for assessing HRV (Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology, 1996).

Results

Preliminary Analyses

Sample characteristics are provided in Table 1. The distraction and control conditions did not differ with respect to sample characteristics, hostility, or baseline cardiovascular measures (see Table 1). The manipulation of experiencing a standard versus a distraction recovery appeared to be effective according to self-reports. Namely, analyses of variance (ANOVAs) revealed a significant main effect of the distraction condition on time spent thinking, $F(1, 46) = 8.60$, $p < .005$, such that the distraction group reported less time spent thinking than the standard recovery group (*M*s = 1.7 vs. 2.3). Higher levels of state anger were associated with more time spent thinking about the angry event, $r(49) = .54$, $p < .001$, and with less reading time, $r(33) = -.49$, $p < .004$. Similarly, higher levels of rumination during recovery were related to more time spent thinking about the angry event, $r(49) = .55$, $p < .001$, and less reading time, $r(33) = -.53$, $p < .001$.

Repeated measures ANOVAs showed significant changes from baseline to task for all cardiovascular measures except PEP: significant increases for SBP, $F(1, 79) = 302.22$, $p < .0001$; DBP, $F(1, 79) = 333.45$, $p < .0001$; HR, $F(1, 77) = 214.17$, $p < .0001$; TPR, $F(1, 77) = 115.01$, $p < .0001$; and LF, $F(1, 36) = 70.63$, $p < .0001$; and significant decreases for r-MSSD, $F(1, 39) = 5.61$, $p < .02$; CI, $F(1, 77) = 4.74$, $p < .03$; SI, $F(1, 77) = 134.87$, $p < .0001$; and HF, $F(1, 37) = 80.60$, $p < .0001$ (see Table 2).

Table 2
Baseline, Task, and Recovery Means and Standard Deviations for Cardiovascular Measures

Measure	Baseline	Task	Recovery (min) 1	2	5	10
Systolic BP (mmHg)						
M	106	122**	111	109	107	107
SD	7	10	10	8	7	7
Diastolic BP (mmHg)						
M	57	72**	59	56	55	53
SD	6	9	8	7	8	8
Heart rate (bpm)						
M	77	91**	83	89	78	79
SD	11	12	15	14	11	10
Preejection period (s)						
M	104	103	101	103	104	105
SD	12	13	14	13	13	13
Cardiac index (L/min/m^2)						
M	4.2	4.1**	4.0	4.1	4.2	4.2
SD	0.9	1.0	1.1	1.1	1.1	1.0
Stroke volume index (ml/beat/m^2)						
M	58	45**	50	55	55	54
SD	16	13	15	16	17	14
Total peripheral resistance (dynes/cm^5/s)						
M	918	1,191**	1,037	989	950	924
SD	231	379	317	301	300	246
Root mean square of successive differences (ms)						
M	44.8	37.0**	—	—	—	42.3
SD	27.2	20.6	—	—	—	25.0
LF						
M	0.40	0.66**	—	—	—	0.45
SD	0.18	0.18	—	—	—	0.20
HF						
M	0.53	0.25**	—	—	—	0.47
SD	0.19	0.15	—	—	—	0.20
LF/HF						
M	1.07	4.83**	—	—	—	1.57
SD	1.08	5.66	—	—	—	1.91

Note. Dashes indicate that the values for these measures are shown for the average of the entire 10-min recovery period. BP = blood pressure; LF = low frequency; HF = high frequency.
** $ps < .05$ when task means are compared with respective baseline means.

State Anger and Rumination

Multiple regression analyses were conducted on retrospective self-reports of state anger and rumination experienced during the task and recovery, with hostility as the predictor variable for the task and hostility, the distraction condition, and their interaction as the predictors for recovery. Distraction was independently associated with significantly lower reports of state anger ($\beta = -0.27$, $p < .01$, $r^2 = .07$) and marginally lower rumination ($\beta = -0.19$, $p < .07$, $r^2 = .04$) during recovery compared with controls (see Table 1).

Cardiovascular Reactivity

Multiple regression analyses were performed on SBP, DBP, HR, PEP, SI, CI, TPR, r-MSSD, LF power, HF power, and LF:HF ratio arithmetic change scores, with hostility as the predictor and controlling for BMI (except for CI and SI, because they were already adjusted for BMI). No significant associations were noted for hostility on the reactivity change scores.

Cardiovascular Recovery

Multiple regression analyses examined hostility, distraction condition, and their interaction as predictors of cardiovascular recovery (i.e., SBP, DBP, HR, PEP, SI, CI, and TPR excursions and r-MSSD, LF power, HF power, and LF:HF ratio), controlling for respective cardiovascular reactivity means and BMI (except for CI and SI). Results revealed that hostility independently predicted slower SBP ($\beta = 0.47$, $p < .02$, $r^2 = .06$) and PEP ($\beta = -.45$, $p < .03$, $r^2 = .05$) poststress recovery (see Table 3). In addition, the distraction condition independently predicted faster HR recovery ($\beta = .35$, $p < .003$, $r^2 = .10$; see Table 3) and predicted lower LF power ($\beta = -0.39$, $p < .057$, $r^2 = .10$) and LF:HF ratios ($\beta = -0.54$, $p < .02$, $r^2 = .16$) and higher HF power ($\beta = -0.45$, $p < .03$, $r^2 = .14$) during recovery (see Table 4). No significant findings were noted with respect to the Hostility × Distraction Condition interaction. Although the means and standard deviations for the cardiovascular recovery measures are presented in Table 3 for descriptive purposes, the reader is reminded that excursion

Table 3
Cardiovascular Recovery Means and Standard Deviations

Group	Minute 1		Minute 2		Minute 5		Minute 10	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Systolic BP (mmHg)								
Low Ho**	110	7.4	107	6.4	107	7.3	106	5.8
High Ho**	113	11.0	110	8.7	108	7.4	108	7.4
Control	114	9.1	110	7.0	107	8.2	107	6.1
Distraction	110	9.9	108	8.7	107	8.7	107	7.5
Diastolic BP (mmHg)								
Low Ho	58	7.4	55	7.6	53	7.2	52	8.4
High Ho	60	7.5	57	7.4	56	7.6	54	8.0
Control	61	7.8	58	6.7	56	7.4	54	7.5
Distraction	57	6.7	54	7.9	54	7.8	52	8.8
Heart rate (bpm)								
Low Ho	79	18.8	76	11.8	76	12.5	77	11.6
High Ho	81	10.7	82	9.6	82	8.9	83	7.7
Control**	85	12.9	79	10.9	80	10.3	81	12.9
Distraction**	80	11.9	77	10.8	79	10.6	79	12.7
Preejection period (ms)								
Low Ho**	100	15.0	102	14.5	104	13.5	105	14.3
High Ho**	105	13.1	104	14.9	105	14.6	107	13.6
Control	100	16.5	103	16.9	105	15.8	105	16.2
Distraction	102	12.7	104	12.0	105	11.7	106	11.0
Cardiac index (L/min/m^2)								
Low Ho	4.21	1.1	4.20	0.9	4.20	1.0	4.34	0.9
High Ho	4.06	1.1	4.18	1.0	4.26	1.1	4.05	1.0
Control	4.30	1.0	4.39	0.9	4.45	1.0	4.40	0.9
Distraction	4.00	1.1	4.02	0.9	4.49	1.2	4.02	1.0
Stroke volume index (ml/beat/m^2)								
Low Ho	53.7	15.3	54.9	13.3	54.7	15.1	55.0	12.8
High Ho	53.1	17.7	54.1	17.6	54.5	16.4	53.2	15.3
Control	59.5	16.8	61.4	15.2	60.6	16.0	59.6	13.5
Distraction	48.2	14.4	48.7	13.3	49.5	13.7	49.4	12.8
Total peripheral resistance (dynes/cm^5/s)								
Low Ho	1063	336	961	222	943	310	900	218
High Ho	1008	321	1006	370	943	295	943	269
Control	950	294	910	235	897	267	879	226
Distraction	1107	340	1047	343	996	338	957	256

Note. High and low hostility groups were created based on the median of Hostility Scale (Ho) scores—*mdn* = 21: Low Ho < 21 ($n = 36$), High Ho ≥ 21 ($n = 44$)—solely for descriptive purposes. The cardiovascular recovery means and standard deviations presented here are for descriptive purposes only, and excursion values were used to represent cardiovascular recovery in the statistical analyses. BP = blood pressure.
** $p < .05$.

values were used to represent cardiovascular recovery in the statistical analyses.

Discussion

The present study investigated the relation of dispositional hostility and distraction to poststress recovery using both impedance cardiography and HRV measures. Hostility was not significantly related to cardiovascular reactivity during the anger recall task. However, consistent with our hypotheses, hostility predicted slower SBP and PEP recovery, whereas distraction was associated with faster HR recovery, lower LF power and LF:HF ratios, and higher HF power. These findings are discussed below.

Table 4
Spectral Power Estimate Means and Standard Deviations During Recovery

	Hostility				Condition			
	Low (n = 20)		High (n = 20)		Control (n = 20)		Distraction (n = 20)	
Measure	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
LF	0.46	0.23	0.43	0.22	0.49*	0.23	0.41*	0.15
HF	0.46	0.18	0.48	0.23	0.43**	0.22	0.51**	0.16
LF/HF	1.33	1.00	1.80	2.53	2.08**	2.45	0.99**	0.74

Note. LF = low frequency; HF = high frequency.
* $p < .06$. ** $p < .05$.

Task-Induced Cardiovascular Responses

Consistent with several other studies using anger provocation tasks (Davis et al., 2000; Everson et al., 1995; Prkachin et al., 2001), the anger-recall task used here elicited a vascular resistance response pattern implying relative increases in alpha-adrenergic sympathetic activity. In addition, the increases in LF power and LF:HF ratios and decreases in HF power during the task suggest a reduction in parasympathetic activity and a shift toward sympathetic activation. However, contrary to the study hypotheses, hostility did not potentiate cardiovascular reactivity or state anger during the anger recall task. Davis et al. (2000) also found comparable cardiovascular reactivity and self-reported anger for low and high hostile women during a speech task, although the task did not specifically target anger. In general, the present results contrast with the results of several prior studies noting greater self-reported anger and enhanced cardiovascular reactivity among harrassed, hostile men and women (Earle, Linden, & Weinberg, 1999; Everson et al., 1995; Powch & Houston, 1996; Smith & Allred, 1989; Suarez et al., 1993; Suarez & Williams, 1989a, 1989b). Harassment may thus be critical in engaging anger and evoking exaggerated cardiovascular responses among hostile persons. It is possible that personally relevant anger recall is similarly potent among hostile and nonhostile persons, but these tasks need to be directly compared.

Poststress Recovery

As anticipated, hostility was independently related to slower SBP and PEP recovery. Although significant associations were not noted between hostility and the HRV components, the trend of higher LF:HF ratio means shown in Table 4 with lower PEP recovery suggests the possibility of prolonged sympathetic activation and decreased vagal control of the heart. These findings were also supported by nonsignificant trends indicating slower CI and TPR recovery for hostile individuals (see Table 3). Because the effect sizes for CI and TPR were small, these interpretations should be considered with caution. A more powerful research design may be warranted to uncover statistically significant relations between hostility and impedance cardiography measures. However, hostility was unrelated to state anger or rumination during the recovery period. Suarez and colleagues (Suarez et al., 1993; Suarez & Williams, 1989a, 1989b) similarly found that high hostile participants maintained greater SBP levels during recovery as compared with their low hostile counterparts, especially after they were harassed. It is possible that more robust findings may be elicited in relation to hostility and recovery if a more extreme form of anger provocation (e.g., harassment, social conflict) were used.

Select dimensions of myocardial recovery were enhanced by distraction, which is partially consistent with the study hypotheses. Specifically, distraction was associated with expedited HR recovery, lower LF power and LF:HF ratios, and higher HF power, potentially via diminished beta-adrenergic activation and enhanced vagal tone. It is important to note that the distraction group retrospectively endorsed lower state anger and state rumination during recovery as compared with the control group. Thus, distraction seemed to be effective in reducing rumination and anger across all participants. Other more engaging or pleasurable distractions might have had an even more potent effect on expediting cardiovascular recovery. In contrast to the present investigation, prior studies of distraction and poststress recovery have found enhanced blood pressure recovery (Patel, 1975; A. Schwartz et al., 2000). These inconsistencies in recovery patterns may be partially attributable to the different methodologies used to measure blood pressure recovery (i.e., continuous vs. intermittent) or the type of distraction used (e.g., visual pictures used in A. Schwartz et al., 2000).

Although dispositional hostility and distraction were independently related to several autonomic cardiac recovery measures in the present study, the hypothesized interaction between hostility and distraction on cardiovascular recovery was not found. It is possible that use of more antagonizing anger provocation tasks (e.g., harassment) or a more engaging distraction task may have been needed to elicit the hypothesized hostility by distraction interactive effects.

Study Strengths and Limitations

With respect to strengths of the present study, our sampling of minority women (i.e., 34% African American and 12% Asian American) is rather distinctive.[3] This study also used a task considered to be more "real life" than those used previously, requiring that participants verbally express their emotions about a personally relevant event rather than using scripts or imagery (G. E. Schwartz, Weinberger, & Singer, 1981; Sinha et al., 1992). Another strength is that this study provided an in-depth investigation of differential autonomic influences in regulating blood pressure and HR. The present study also improved on prior research by evaluating poststress recovery using an excursion measure (i.e., area under the recovery curve minus the baseline). This technique has several advantages: (a) It can provide a more reliable estimate of cardiovascular recovery based on all of the relevant data points rather than an arbitrary subset or a single point as with other statistical

[3] We further examined whether the significant findings pertaining to blood pressure and HR recovery were comparable for Whites and non-Whites. Specifically, regression models for SBP and HR recovery were recomputed with ethnicity (White vs. non-White groups) and its interactions with hostility and distraction included. Interactions of interest (Ethnicity × Hostility on SBP or Ethnicity × Distraction on HR) were not significant. Thus, the cardiovascular recovery findings of the present study were consistent across White and non-White groups.

techniques; (b) excursions can be made independent of the level of reactivity by covarying the level of reactivity in the final analyses; and (c) this technique accounts for the rate of change from the end of the task to the end of the recovery period.

The present study also has several limitations. First, this study included only young, healthy women. Although there has been a general paucity of research examining the role of hostility and other psychosocial factors in eliciting exaggerated cardiovascular reactivity in women, this method limits the generalizability of our findings. Second, the anger-recall task has not been contrasted with other anger-provoking tasks and may be a milder form of anger provocation as compared with harassment or social conflict tasks (Davis et al., 2000). Third, the effect sizes noted in the present study tended to be small to medium, suggesting that hostility and distraction may have a limited impact on cardiovascular recovery from anger recall. However, more extreme anger provocation tasks may have elicited larger effect sizes. Additionally, more engaging or pleasant types of distraction may have resulted in more robust findings. Thus, studying several different types of distraction varying in engagement and affective valence and arousal may be a fruitful area of future research. Fourth, the participants in the standard recovery condition may have been engaging in their own distraction or avoidance techniques (although not formally implemented) as well as rumination. Hence, to more purely measure rumination during recovery, future studies could include a rumination condition (e.g., directing participants to think about the anger-recall task or imagine the angry event during recovery) to prevent natural avoidance and distraction tendencies and compare it with a distraction and a standard recovery condition.

Conclusions

In conclusion, the results of the present study suggest that dispositional hostility influences cardiovascular recovery from, but not cardiovascular reactivity to, anger recall among young women. This highlights the importance of studying both cardiovascular reactivity and poststress recovery as potential mediators of the relation between psychosocial factors and cardiovascular disease. Our findings suggest that greater levels of dispositional hostility prolong cardiovascular recovery. The results also indicate benefits of distraction on expediting cardiovascular recovery following an anger-provoking situation across all participants, possibly by reducing cognitive rumination and state anger. The use of distraction, as conceptualized here, or other even more engaging and pleasurable distractions (e.g., reading a very interesting book or listening to a favorite CD) as an intervention to facilitate cardiovascular recovery from angry emotions may possibly defend against pathogenic processes contributing to cardiovascular disease. It would also be useful to further investigate whether distraction may be more beneficial in expediting cardiovascular recovery among persons with high levels of hostility when exposed to more extreme forms of anger provocation.

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