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Autonomic characteristics of defensive hostility: Reactivity and recovery to active and passive stressors

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Abstract

The autonomic characteristics of hostility and defensiveness were assessed in 55 male undergraduates based on composite Cook Medley Hostility (Chost) and Marlowe Crowne Social Desirability (MC) scores to create 4 groups: Defensive Hostile (DH; high MC, high Chost), High Hostile (HH; low MC, high Chost), Defensive (Def; high MC, low Chost) and Low Hostile (LH; low MC, low Chost). All subjects engaged in a video game (VG) and hand cold pressor (CP) task. Cardiovascular responses in DH subjects were predicted to show enhanced sympathetic α and β-adrenergic activity and the least vagal control compared to others across tasks. DH and LH men showed significant heart rate reactivity to the CP task compared to HH men. LH men showed significant reductions in high frequency power (vagal assessment) to the tasks compared to HH men. Future studies may employ harassment techniques and include the factors of gender and ethnicity in their assessments.
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Considerable research has implicated hostility as a risk factor for coronary heart disease (CHD) (see Miller et al., 1996 for a review). Hostility has been defined as a trait that involves the devaluation of, opposition to, a tendency to blame, and a desire to harm others (Smith, 1994). Hostility is linked with cynicism and mistrust, which may provoke frequent angry feelings and associated behaviors. Situations requiring anger inhibition are likely more prevalent in contemporary daily life than encounters permitting anger expression (Brosschot and Thayer, 1998). Although numerous studies have indicated that hostility associated with anger inhibition entails a greater risk of CHD than hostility coupled with anger expression (e.g., Dembroski et al., 1985; Atchison and Condon, 1993), many conflicting findings have also emerged (e.g., Angerer et al., 2000; Mendes de Leon, 1992; Siegman et al., 1987).

The trait of *defensiveness* fosters anger inhibition through the restraint of anger recognition and expression in the service of social desirability (Crowne and Marlowe, 1964; Weinberger, 1990; Jamner et al., 1991). Hostility coupled with defensiveness creates an approach–avoid conflict between the desire for social approval and distrust of those who can provide such support. Hostile defensiveness has been related to both increased cardiovascular (CV) reactivity to stress and CHD (Helmers and Krantz, 1996; Helmers et al., 1995; Jorgenson et al., 1995; Larson and Langer, 1997). The rumination resulting from anger suppression may partially explain these relationships by prolonging CV activity associated with anger (Glynn et al., 2002).

Hostility may involve a chronic tendency to perceive daily life experiences as threatening. By impeding the dissipation of anger, defensiveness may sustain heightened sympathetic and diminished parasympathetic activity associated with the persistent perception of threat (Brosschot and Thayer, 1998; Thayer and Friedman, 2002). Moreover, autonomic nervous system (ANS) activity may vary as a function of trait hostility (Schuler and O'Brien, 1997). The Cook and Medley (1954) Hostility Scale (Ho) is perhaps the most widely used hostility measure in CV reactivity research. Individuals who score high on this scale tend to respond to everyday stressors with elevated CV reactivity, and also reinforce negative social interactions through cynicism, thereby increasing the probability of subsequent stressful interactions (Smith and Pope, 1990).

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The inclination to express or inhibit anger may be a potent mediator of the hostility-CHD link. The idea that chronic anger suppression generates inner conflict linked with CHD and hypertension is rooted in psychodynamic notions of catharsis (e.g., Alexander, 1939; see Hokanson, 1970 for review). As noted above, contemporary investigations have generally yielded conflicting findings on the relationship between anger expression/inhibition and CV outcomes. A common way to assess the tendency to suppress hostile feelings is by use of the Marlow–Crowne Social Desirability Scale (MC; Crowne and Marlowe, 1964) in conjunction with the Ho scale. The MC scale depicts defensiveness as the likelihood of attitude change in response to social pressure. Individuals with high MC scores tend to deny or suppress socially undesirable characteristics of self, and so may inhibit anger expression (McCrae and Costa, 1983; Paulhus, 1984).

Both lab and field investigations have shown that men who have high Ho and MC scores (i.e., defensive hostile; DH) exhibit both elevated CV baseline levels and greater CV reactivity to stress in comparison to high Ho, low MC (LH) men (Helmers and Krantz, 1996; Houston et al., 1989; Jorgenson et al., 1995; Jamner et al., 1991). Furthermore, in a sample of male CHD patients, defensive hostility has been associated with longer and more frequent episodes of ischemia during daily life activities and more severe ischemia in response to stressors (Helmers et al., 1995). Congruent findings emerged from a study of DH male patients who showed significantly more coronary artery blockage than those scoring low on both scales (Jorgenson et al., 2001).

1. Methodological considerations

In addition to person variables, the type of stressor used in CV reactivity studies has likely contributed to divergences in the hostility-reactivity-CHD literature. A frequently applied distinction to CV laboratory stressors is that between *active* and *passive* coping. The primary difference between active and passive tasks is the degree of psychological engagement required for performance completion (Obrist, 1981). For example, the cold pressor task, which involves hand or foot immersion in iced water, is often viewed as a prototype passive coping task because it is an endurance stressor that requires relatively little continuous mental effort. In contrast, active coping tasks such as reaction time and mental arithmetic involve feedback for performance completion and require considerable mental effort. Active tasks are also characterized by cardiac sympathetic beta-adrenergic activation and vagal withdrawal (Obrist, 1981), and passive coping tasks such as cold pressor are often depicted as involving more vascular sympathetic alpha-adrenergic activity (Saab et al., 1993).

According to the *transactional model* of the CHD-hostility relationship, heightened CV reactivity is most likely to be provoked in hostile people when they are engaged by an active stressor (Smith, 1994). Consistent with this notion, some studies have found active coping tasks to be more sensitive to hostility-related differences in CV reactivity. For example, an inverse relationship between cardiac vagal tone (as assessed by high frequency heart period variability (HF-HPV)) and hostility has been found for active (mental arithmetic and Stroop task) but not passive (orthostatic tilt) stressors (Sloan et al., 2001). In contrast, greater sympathetic reactivity (faster respiration rate and shorter pre-ejection period (PEP), a contractility measure derived from impedance cardiography) to a passive coping task (cold pressor) has also been reported in hostile subjects (Ruiz et al., 2006). Thus, a direct test of the transactional model in a defensively hostile population would compare CV reactivity to both active and passive stressors.

An additional methodological concern is the contrast of CV reactivity to vs. recovery from stress. Recovery data may provide particular insights into the pathogenic processes whereby DH individuals engage in hostile rumination after stressor removal, maintaining elevated CV reactivity (Brosschot and Thayer, 1998). Hostile individuals have been known to display both larger and longer lasting blood pressure (BP) responses to anger provoking situations (Fredrickson et al., 2000), as well as greater post-stressor elevations in heart rate (HR) and systolic blood pressure (SBP) following the cold pressor task (Demaree and Harrison, 1997; Demaree et al., 2000). Delayed CV recovery to stress may be a risk factor for hypertension as well as a critical factor in the hostility-CHD link (Brosschot and Thayer, 1998; Schuler and O'Brien, 1997).

The present study was designed to simultaneously assess these important individual difference and methodological factors that have been prominent in the CV reactivity literature. This aim was achieved by investigating the relationship between CV reactivity and recovery to active and passive coping tasks in defensive-hostile subjects. The *composite hostility scale* (Chost), comprised of hostile affect, cynicism, and aggressive responding subscales from the Ho scale was used as the hostility assessment for the current study, since it has been found to be a better predictor of mortality (Barefoot et al., 1989), myocardial ischemia (Helmers et al., 1993), and CV stress reactivity (Christensen and Smith, 1993; Larson and Langer, 1997) compared to the total Ho score. In general, men have been reported to demonstrate more CV reactivity to lab stressors than women (e.g., Guyll and Contrada, 1998). To control for gender, only male subjects were studied. These individuals engaged in an active and passive coping task while CV activity was assessed.

The Chost and MC scales were used to create four groups: (a) defensive hostile (DH: high defensive-high hostile), (b) high hostile (HH: low defensive-high hostile), (c) defensive (Def: high defensive-low hostile), and (d) low hostile (LH: low defensive-low hostile). The combination of defensiveness and hostility was predicted to reflect depressed parasympathetic and elevated sympathetic responsivity to laboratory stress. Also, DH subjects were expected to experience the most pronounced carry-over effect from lab stress reactivity manifested in delayed CV recovery. Specifically, DH subjects were predicted to show the (a) least cardiac vagal control, as reflected in low HF-HRV, (b) the most cardiac sympathetic beta-adrenergic activity, as reflected in decreased PEP from impedance cardiography, and (c) the most elevated alpha-adrenergic activity, as reflected in BP. These findings are predicted to appear in elevated reactivity (change from baseline) and attenuated recovery (return to baseline).

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2. Method

2.1. Subjects

Subjects were 55 right-handed male undergraduate psychology students at Virginia Polytechnic Institute and State University (mean age: 19.6, SD = 1.64; range: 18–27 years.) These men were selected from a screening of 158 subjects on the basis of Chost and MC scores and information obtained from a health questionnaire. Exclusionary criteria included a positive smoking status and/or use of medications that may alter CV activity. In accordance with Larson and Langer (1997), classification as high vs. low hostile and defensive vs. non-defensive was based on Chost scores at or above 15 and MC scores at or above 16, respectively. Based on this classification, the following groups were created: 15 DH, 16 HH, 16 Def, and 8 LH (see Table 1 for means and standard deviations of Chost and MC scores across groups). Subjects were instructed to abstain from caffeine, alcohol, and strenuous exercise for 12 h before the study, and received extra credit in a psychology course for participation.

2.2. Materials

2.2.1. Questionnaires

Chost is derived from the Ho scale, which consists of 50 true–false items from the Minnesota Multiphasic Personality Inventory (Hathaway and McKinley, 1943). The Ho scale is characterized by both high internal consistency (Cronbach's alpha: 0.80–0.82; Smith and Frohm, 1985), and high test–retest reliability ($r > 0.8$ over periods of 1–4 years; Barefoot et al., 1983; Schekelle et al., 1983). Sample items include, "It is safer to trust nobody," "I am not easily angered," and "I have at times had to be rough with people who were rude or annoying." The MC social desirability scale, a 33 item true–false questionnaire designed to assess avoidance of disapproval, is reported to be reliable (alpha coefficient = 0.88; 1 month test–retest correlation = 0.88; Crowne and Marlowe, 1964). Scores range from 0 to 33, with higher scores indicating a need for approval and social defensiveness (Weinberger, 1990).

2.2.2. Stimuli

A three-minute segment of a multicultural documentary video entitled *Powaqqatsi: Life in Transformation* (Reggio, 1988) was shown to all subjects during their baseline periods as a neutral visual stimulus to control for psychological engagement prior to exposure to the experimental stimuli. The video portrays daily life events in various countries and contains no words.

Table 1
Mean Chost and MC scores by group

Group	*N*	Chost	MC
DH	15	*M* = 18.53, SD = 3.00	*M* = 18.53, SD = 2.77
HH	16	*M* = 20.56, SD = 3.31	*M* = 10.13, SD = 2.80
Def	16	*M* = 9.94, SD = 2.35	*M* = 21.19, SD = 3.80
LH	8	*M* = 10.38, SD = 2.88	*M* = 11.25, SD = 2.38

A car race game task (Test Drive 4, Accolade, Inc., 1997) was used in the active coping procedure. This game has been reported as activating and engaging and also has been shown to elicit cardiac sympathetic beta-adrenergic activity and parasympathetic withdrawal (Friedman and Santucci, 2003; Santucci and Friedman, 2001).

2.2.3. Recording equipment

The electrocardiogram (ECG) and impedance cardiography (ICG) were recorded with the Ambulatory Monitoring System (AMS) v 4.4, using Ag–AgCl electrodes attached to the torso in accordance with configuration guidelines in the user manual (Vrije Universiteit Amsterdam, the Netherlands; Groot et al., 1998). The validity and reliability of this device has been established (Willemsen et al., 1996). BP was monitored by usage of the Vasotrac (Medwave, Inc.) system, a non-invasive semi-continuous blood pressure recording device placed over the radial artery and held in place by a Velcro wrist strap, providing a BP reading approximately every 15 heart beats. This device has been found not to produce significant discomfort or distraction to subjects during extended use (Friedman et al., 2004). The reliability and validity of the Vasotrac has been demonstrated in clinical settings (Belani et al., 1999a,b).

2.3. Dependent variables

Heart rate (mean number of beats per minute) and heart period (HP; mean time interval in ms between successive *R* spikes) were derived from the ECG. ECG was analog filtered (high pass 17 Hz) at acquisition and subjected to online auto trigger level *R*-wave detection resulting in a HP resolution of 1 ms. The HP time series was spectral analyzed (SAS for Win98, v.8.2, 2001). Differences between adjacent HP values were computed and subjected to an ordinary least squares regression procedure for detrending. Output residuals were used to create power spectral density units ($ms^2\ Hz^{-1}$). Low frequency (LF) (0.04–0.15 Hz) and HF (0.15–0.40 Hz) ranges were extracted from the power spectral density units, with the HF component serving as a measure of cardiac vagal activity. The autonomic underpinnings of the slower, LF component are more controversial with respect to relative contributions of sympathetic and parasympathetic influence (Friedman and Thayer, 1998b). However, a number of studies suggest that LF power can estimate cardiac sympathetic influences under certain conditions (e.g., Friedman et al., 1996; Kamada et al., 1992; Snidman et al., 1995). A natural logarithm procedure was employed (SPSS, v.10, 2001) to correct for skewed raw score distributions in the spectral data. PEP was derived through ICG, yielding an index of cardiac sympathetic contractility (Sherwood et al., 1990). SBP and diastolic BP (DBP) were obtained from the Vasotrac BP monitoring device.

2.4. Procedure

Each subject signed an informed consent and was determined by a screening form to be non-smoking and in good health. Upon arrival at the lab, each subject had six thoracic

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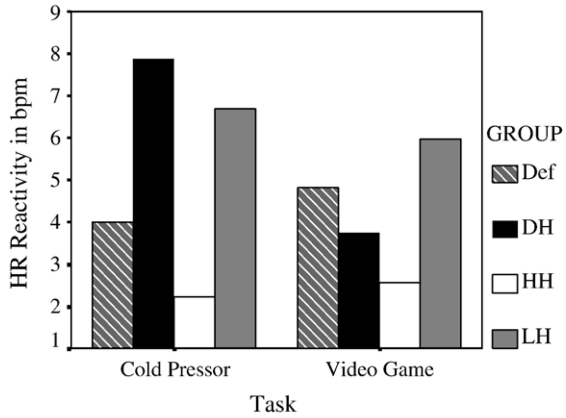

Fig. 1. Mean HR reactivity by group for CP and VG.

electrodes applied to the torso to record ECG and ICG in accord with configuration guidelines described in the AMS user manual v 1.2 (Groot et al., 1998). The BP cuff was placed on the wrist of the non-dominant (left) hand so that the right hand may be used for the video game.

Instructions were given prior to each of the following 3-minute conditions (the ordering of condition 2 and 5 was equally counterbalanced across groups):

(1) Baseline 1 (B1): sitting quietly in a comfortable lounge chair while observing a video screen showing a neutral segment of *Powaqqatsi*.
(2) Video Game (VG): playing the previously described video game.
(3) Recovery (RC1): sitting quietly in the lounge chair.
(4) Baseline 2 (B2): identical to B1.
(5) Hand cold pressor (CP): this passive coping task entailed placing the right hand in a bucket of iced water (0–3°C). The hand was removed from the water after 1.5 min, and then re-immersed after 10 s to allow immersion to be maintained for 3 min with minimal discomfort.
(6) RC2: identical to RC1.

Recording equipment was removed after completion of these procedures.

2.5. Design and analyses

The sequence of conditions was as follows: baseline, task, recovery period, baseline 2, task 2, and recovery 2, with the order of active and passive tasks counterbalanced across subjects. Change scores, task minus baseline for reactivity and post-stress minus baseline for recovery, were calculated for all physiological measures and compared between groups.

The design for this study was a 2 × 2 × 6 (Hostility × Defensiveness × Condition) mixed design, with condition as the within subjects factor.

Although the order of task presentation was counterbalanced across subjects with equal representation per group, the task order was treated as a covariate in all analyses to control for the potential influence of order effects on CV responses to the stressors. A series of multivariate analyses of covariance (MANCOVA's) on repeated measures were conducted to test significant differences in CV activity by trait and condition. A 2 × 2 × 2 (Hostility × Defensiveness × Baseline) MANCOVA assessed baseline differences in CV activity across traits and baseline period. A 2 × 2 × 2 (Hostility × Defensiveness × Condition) MANCOVA was conducted on reactivity difference scores to evaluate CV responses to the stressors by trait. A 2 × 2 × 2 (Hostility × Defensiveness × Condition) MANCOVA assessed significant changes in recovery difference scores by trait. Multiple comparison Bonferroni procedures were used as post-hoc tests to control for error rates.

3. Results

3.1. Baseline tests

The 2 × 2 × 2 MANCOVA on baseline data yielded non-significant main effects and interaction terms, indicating that the CV activity did not differ as a function of baseline period, defensiveness, or hostility.

3.2. Reactivity scores

The 2 × 2 × 2 MANCOVA on reactivity scores (task minus baseline) revealed a significant Hostility × Defensiveness interaction, $F(6, 45) = 2.85$, $p = 0.019$. Univariate analyses showed significant Hostility × Defensiveness interaction effects for HR, $F(1, 50) = 8.35$, $p = 0.006$ and HF power, $F(1, 50) = 16.97$, $p < 0.001$. Post-hoc analyses showed that DH and LH men displayed significantly more HR reactivity to CP compared to HH men (see Fig. 1 for HR reactivity scores by group and task). The reduction in HF power by LH men in response to CP was significantly lower than the increases shown by Def and HH men. Moreover, the decrease in HF power by LH men during VG was significantly lower than that shown by HH men. All p values for multiple comparisons using Bonferroni procedures were <0.05. Fig. 2 displays natural log HF power reactivity by group and task. Reactivity analyses on BP and PEP were non-significant.

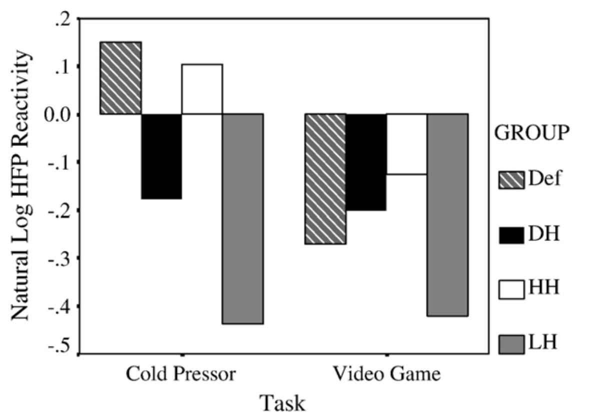

Fig. 2. Mean natural log HFP reactivity by group for CP and VG.

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3.3. Recovery scores

The 2×2×2 MANCOVA on recovery scores yielded non-significant main effects and interaction terms, indicating that the CV activity exhibited by the groups did not differ as a function of recovery period, defensiveness, or hostility.

4. Discussion

On the whole, the present findings regarding the relationship of defensive hostility to CV stress reactivity and recovery are mixed. DH men did display significantly larger HR reactivity to CP than HH men, consistent with findings of elevated CV responsivity to this task in DH men (Mente and Helmers, 1999). Reports of greater HR but not BP reactivity among Chost/MC-assessed anger repressors (Siegman, 1994) were also replicated. Indeed, in the present study, no CP reactivity differences related to defensive hostility were found on any CV variable other than HR, and no differences at all were found at baseline or in response to the active task. These findings conflict with those that show elevated levels of CV activity in DH men at baseline and during active tasks (e.g., Helmers and Krantz, 1996; Jorgenson et al., 1995; Houston et al., 1989; Larson and Langer, 1997), but are consistent with reports of no unusual CV responses to active stressors without harassment in hostile men (Suarez and Williams, 1989). Finally, no group differences in CV recovery to the stressors were detected in the present study.

Somewhat curious findings emerged relevant to LH subjects. Like the DH group, this group showed significantly larger HR reactivity to CP than did HH men. Others have also reported increased CV reactivity to CP in LH men (Mente and Helmers, 1999). LH men also exhibited marked suppression of HF power in response to both stressors, showing a significant difference from HH on VG, and both HH and Def on CP (to which the latter responded with increases in HF power). Although the HF reactivity displayed by LH men was not in accordance with the predictions in this study, the suppression of cardiac vagal activity during stress is appropriate and could be viewed as adaptive physiological responsiveness (Friedman and Thayer, 1998a; Thayer and Friedman, 2002). In contrast, defensiveness and hostility were marked by less variability and lower reactivity of HF power to these tasks, suggesting less vagal involvement and lower cardiac response flexibility (Thayer and Friedman, 2004).

The present findings suggest that the active vs. passive distinction may not be the key task variable in differentiating CV reactivity as a function of hostility and defensiveness. The *psychosocial vulnerability model* of hostility holds that it is necessary to annoy hostile individuals to evoke sufficient anger and consequent CV reactivity (e.g., Suarez and Williams, 1989). Some studies have found larger CV reactivity in hostile individuals exposed to active stressors that include the factor of "harassment" (e.g., Jorgenson et al., 1995), which may be a more crucial task feature than the active vs. passive distinction (Suls and Wan, 1993). Tasks that elicit anger in an interpersonal context may connect more effectively with critical elements of hostility. Hence, a possible cause of low reactivity to the VG active stressor in the hostile groups in this study was the lack of harassment. However, others report that harassment can provoke angry feelings with minimal CV increases in hostile individuals (e.g., Felston, 1995). Future studies may compare active stressors with and without interpersonal frustration to clarify the relationship between defensive hostility and CV reactivity.

It is also possible that the VG and CP tasks differed in negative affect, which has also been found to affect CV reactivity (Enkelmann et al., 2005; Sirois and Burg, 2003). Self-reported affect was not collected in this study, and so this question cannot be addressed directly. However, previous work in our lab showed that these two tasks do not differ on negative affect (both evoke minimal levels), although VG elicits somewhat more positive affect (Santucci and Friedman, 2001). Future research may be directed at manipulating affective valence in conjunction with the active/passive distinction to systematically examine these task features.

Brosschot and Thayer (1998) argued further that psychometric treatment is alone insufficient to detect CV recovery differences related to anger inhibition. Regardless of expressive style, social realities typically preclude the open expression of anger. Hence, even those predisposed to vent their hostility are not often afforded the opportunity to do so. A more powerful and ecologically valid comparison of the effects of anger expression and inhibition on CV recovery requires experimental, rather than psychometric manipulation of these factors. In general, it seems that the factors of interpersonal harassment and opportunity to express anger are more relevant to hostility studies (particularly those directed at expression vs. suppression) than the more traditional classification of CV 'active' and 'passive' coping tasks.

The psychometric approach also presents convergent validity problems for the construct of anger inhibition. The use of MC scores was initially used in conjunction with anxiety measures, and presumes that "repressive copers" tend to suppress negative affect in general (Weinberger, 1990). However, anger and anxiety repression may be less than perfectly correlated (Siegman, 1994). It is not known how such results map onto other measures of anger inhibition, such as the Anger-In subscale of Spielberger's Anger-Expression Scale (Spielberger et al., 1985). Future studies might clarify the relationship between such measures, and compare their respective abilities to predict CV reactivity and recovery in response to tasks that include critical features such as interpersonal stress and the blocking of anger expression.

Another important issue is the assessment of CV recovery. The procedure used in the present study was to subtract mean baseline values from mean post-stress values for each dependent variable. Although this is a commonly employed method to assess recovery (e.g., Glynn et al., 2002), an alternate approach is to assess time to return to baseline (Linden et al., 1997). However, both of these methods have been found to show relatively low test–retest reliability, as well as non-independence from reactivity measures (Christenfeld et al., 2000). Rather, these investigators recommended a multiparameter curve-fitting technique to capture the dynamic nature of CV recovery, which may be a more sensitive and reliable method.

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However, this method requires continuous beat-to-beat BP assessment, which was not available in the present study.

The present findings are also limited to young adult men. In view of well-known gender differences in both CHD and CV reactivity, it will be important to extend the present findings to women (Stoney, 2003). Moreover, ethnicity has been shown to be a factor in cold pressor responsivity (Anderson et al., 1988) as well as susceptibility to hostility, perseverative thinking, and avoidant coping (Thayer and Friedman, 2004). Although ethnicity was not formally assessed in the present study, the authors report anecdotally that the majority of the subjects were white. Race and gender are clearly crucial factors to address in future research. Finally, the current study was limited by incidental difficulties regarding laboratory space that inadvertedly led to unequal cell sizes, reflected in the relatively low number of LH subjects.

In sum, the present findings yield limited evidence for enhanced CV reactivity among defensively hostile men. The results are likely more important in pointing toward future refinements in this line of research. First, the active vs. passive distinction may not be the most operative context in which to select tasks. Rather, factors such as interpersonal harassment coupled with manipulation of anger expression/inhibition may be more relevant. The latter goes beyond static psychometric categorization in capturing the dynamic CV activity of actual anger processing. Finally, recovery assessment with more sophisticated methods such as curve fitting may enhance the sensitivity and reliability required to detect differences associated with traits such as defensive hostility.

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