Locus of Control Predicts Appraisals and Cardiovascular Reactivity to a Novel Active Coping Task

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ABSTRACT These two studies investigated the influence of dispositional locus of control (LOC) on subjective and physiological responses to a novel laboratory stressor task. Across two studies, 64 healthy undergraduate students, ages 18–22, completed Levenson's (LOC) scales for internal, powerful others, and chance prior to performing a video-game

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task. Participants rated pretask and posttask stressfulness and coping ability (i.e., measures of primary and secondary appraisal). Cardiovascular measures (heart period, HP; preejection period, PEP; respiratory sinus arrhythmia, RSA; cardiac output, CO; systolic blood pressure, SBP; diastolic blood pressure, DBP & total peripheral resistance, TPR) were recorded during 4-minute baseline and 4-minute stressor task periods. The internal LOC factor predicted pretask reports of coping ability as well as posttask reports of stressfulness. In contrast, the powerful-others LOC factor predicted cardiac changes (HP, PEP, and RSA) during the task but not cardiac output or any other vascular change measure. These results underscore the importance of using the three subscales of the Levenson LOC to assess relationships between dispositional LOC and the response to stressors because self-reported appraisals of a task are predicted by a different component of dispositional LOC than are task-related cardiovascular functions.

Locus of control (LOC) is a dispositional variable that describes an individual's expectancies regarding whether events are under their personal control, the control of powerful others, or chance. In Rotter's (1966) original formulation, LOC was defined as a single dimension ranging from internal (events under personal control) to external (events controlled by powerful others or chance). However, Levenson (1973, 1981) argued that internal and external control were not necessarily orthogonal, created a new measure of dispositional LOC that both separated internal from external LOC, and acknowledged that different sources of external LOC (i.e., powerful others or chance) may be associated with different thoughts and behaviors. Levenson's measure includes three separate subscales that represent three dimensions: internal LOC, powerful-others LOC, and chance LOC. Three similar subscales were later adapted for health-related LOC in the form of the Multidimensional Health Locus of Control Scale (MHLC; Wallston, Wallston, & DeVellis, 1978). Thus, there has been a theoretical shift away from the assumption that dispositional internal and external patterns of LOC form the ends of a single continuum and toward the idea that internal and external LOC are partly separable aspects of dispositional LOC.

The locus of control construct has been a major focus of research, and the literature suggests that when compared to externals, internals show, for example, more active search of the environment, higher levels of academic achievement, and better emotional adjustment (Crandall & Crandall, 1983). In addition, evidence suggests that a high internal locus of control may reduce the impact of stressful events on mental and physical health (Cohen & Edwards, 1989; Denney & Frisch, 1981; Lefcourt & Davidson-Katz, 1991; Lefcourt, Miller, Ware, & Sherk, 1981). Indeed, LOC has been postulated to play an important role in the stressor-appraisal process. Appraisal theory proposes that an appraisal process occurs with the perception of a potentially stressful stimulus and is modified over time as one's perception of the situation changes (Lazarus & Folkman, 1984). Cognitive appraisals consist of both primary appraisals (Is the event impactful?) and secondary appraisals (Do I have the resources to cope with this impactful event?). Recently, some investigators have begun assessing self-report measures of primary and secondary appraisal processes using Likert-scale ratings of stressfulness and coping ability, respectively (Quigley, Feldman Barrett, & Weinstein, 2002; Tomaka & Blascovich, 1994; Tomaka, Blascovich, Kelsey, & Leitten, 1993; Tomaka, Blascovich, Kibler, & Ernst, 1997; Weinstein, Quigley, & Mordkoff, 2002). Although such self-reported appraisals may not capture all facets of appraisal, they do provide a way of assessing reportable aspects of appraisal to test theoretical propositions about stressor appraisals.

Several groups have postulated specific relationships between dispositional LOC and stressor appraisals. For example, Lefcourt and Davidson-Katz (1991) hypothesized that persons with an internal LOC would be both less likely to appraise a stressor as threatening and more likely to believe that they possessed adequate resources for coping with a threatening event. Thus, in this framework, an internal LOC would be associated with lower reported stressfulness (i.e., primary appraisals) and higher reported coping ability (i.e., secondary appraisals). Folkman (1984) similarly postulated that dispositional beliefs about control, such as LOC, would be associated with primary appraisals, such that a high internal LOC would result in lowered reported stressfulness. She further hypothesized that secondary appraisals usually would be influenced more by situational than by dispositional beliefs about control because appraisals of coping ability require an assessment of the current situation. However, based on Rotter's (1966) proposition that dispositional expectancies of control would have a greater impact in situations that are novel or ambiguous, Folkman (1984) further hypothesized that LOC would be more likely to affect secondary appraisals in ambiguous situations. Therefore, when there are few cues regarding controllability or when the situation is novel, an individual with an internal LOC is predicted to be more likely to perceive the situation as controllable than the person with an external LOC. According to Folkman's reasoning, a high internal LOC should be associated with both reduced primary and increased secondary appraisals in novel situations or those where controllability is ambiguous, but mostly with primary appraisals when the situation is not ambiguous or novel. Two studies have provided supporting evidence for the relationship between LOC and appraisals of stressfulness predicted by Lefcourt and Davidson-Katz (1991) and Folkman (1984). Vitaliano, Russo, and Maiuro (1987) reported that medical students with an external LOC (based on Rotter's scale) were more likely to perceive a personally relevant performance stressor as a threat than those with an internal LOC. Similarly, Anderson (1977) reported that business owners with an external LOC (Rotter's scale) reported their experience with a major hurricane to be more stressful than those with an internal LOC. The relationship between LOC and perceived coping ability (secondary appraisals) has not been investigated. Instead, researchers have assessed the relationship between LOC and coping behaviors, such as problem solving (Anderson, 1977; Parkes, 1984; Vitaliano et al., 1987). Thus, a link between LOC and secondary appraisals remains to be shown.

Another important facet of the stress response that may be moderated by dispositional LOC is the cardiovascular response to stressors. Stress researchers often focus on the cardiovascular system, because of its prominent role in the initial response to stressors and the postulated effects of repeated or chronic activation of cardiovascular stress responses on cardiovascular disease risk (Lovallo & Gerin, 2003). In one of the few studies to investigate the effects of LOC on cardiovascular stress responses, Houston (1972) found that participants with an internal LOC (Rotter's scale) had significantly greater increases in heart rate from rest to a cognitive stressor task completed under the threat of shock than those with an external LOC. Conversely, Williams, Poon, and Burdette (1977) found that those with an internal LOC (Rotter's scale) instead had a reduced forearm blood flow (FBF) to a speeded reaction time task requiring sensory intake than those with an external LOC. These same participants did not differ on their heart rate response to the task, although the trend paralleled the FBF results. Finally, Muller and colleagues (1998) asked participants who were defined as internal or external, based on scores on the Levenson LOC subscales, to perform active or passive coping tasks.[1] There were no significant differences in heart period (inverse of heart rate) or pulse wave velocity between those with internal or external LOC. Thus, there is little consistent evidence to guide predictions about how LOC may be related to cardiovascular stressor reactivity.

The aim of the present studies was to examine how dispositional LOC, assessed using Levenson's multidimensional LOC instrument, was related to cognitive appraisals and cardiovascular reactivity associated with a novel, stressful video-game task. These studies extend previous work not only by using a multidimensional LOC scale but also by using internal, powerful-others external, and chance external LOC as continuous variables rather than using an arbitrary cut-off score for group assignment. In addition, these two studies expand the range of cardiovascular measures to address not only overall cardiac function but also the autonomic mediation of the cardiac stress responses and a greater range of vascular stress responses in relation to dispositional LOC. Based on the work of appraisal theorists, we predicted that high scores on internal and low scores on the powerful-others or chance scales would be associated with lower perceptions of stressfulness as well as higher perceptions of coping ability (i.e., they would predict both primary and secondary appraisals). Based on previous mixed results, we did not have explicit a priori hypotheses about expected relationships between LOC and cardiovascular stress responses or basal cardiovascular function. Two studies were conducted to assess these relationships and because the studies differed only by the addition of measures of vascular reactivity in Study 2, they are reported together with differences noted where relevant.

1. Those who also scored low on the external scales were classified as internals, and those who scored high on one or both of the external scales were classified as externals. In the active coping task, participants were told that they had control over aversive tones, whereas in the passive coping task, participants were told that they could not control the aversive tones.

METHOD

Participants

Participants were 33 students (19 females) for Study 1 and 32 students (22 females) for Study 2 recruited from psychology classes at the Pennsylvania State University and compensated with extra credit and $5 for their participation. Participants were excluded if they reported a family history of high blood pressure, asthma, or other cardiovascular or respiratory illnesses. Participants had at least 5 hours of sleep prior to the testing day and had abstained from alcohol for at least 12 hours prior to the session. Cardiovascular data for 16 of 33 participants in Study 1 were unusable due to movement artifact. Thus, results from cardiovascular variables are reported for a total of 49 participants.[2] Further cardiovascular results from Study 2 are reported in Weinstein, Quigley, and Mordkoff (2002).

Physiological Measures

In Study 1 we recorded heart period (HP; the inverse of heart rate), preejection period (PEP; an estimate of sympathetic effects on the heart), respiratory sinus arrhythmia (RSA; an estimate of parasympathetic effects on the heart), and cardiac output (CO; the amount of blood pumped from the heart per minute). We used heart period because it has a more linear relationship with the autonomic neural inputs driving changes in the timing of the beats than does heart rate (Berntson, Cacioppo, & Quigley, 1995). Preejection period and respiratory sinus arrhythmia are estimates of sympathetic and parasympathetic effects on the heart that have been validated with laboratory tasks like those used here. In this context, a shortening of preejection period indicates an increase in sympathetic activity and vice versa; an increase of respiratory sinus arrhythmia indicates an increase in parasympathetic activity, and vice versa. For more information on the limits to interpretation of these two autonomic variables, see Weinstein et al. (2002), and Berntson et al. (1995). In Study 2 we also obtained the following measures: systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP), and total peripheral resistance (TPR; an estimate of the total resistance to blood flow by the systemic vasculature).

2. There were no significant differences between participants with cardiovascular data and those without cardiovascular data on pretest stress and coping appraisals, posttask stress and coping appraisals, or internal, powerful others or chance LOC scores.

EKG and impedance cardiographic signals were recorded using a Minnesota Impedance Cardiograph (Model 304B: Instrumentation for Medicine). Aluminum-mylar electrode bands were placed in a tetrapolar configuration using the method outlined by Sherwood et al. (1990). Respiration was recorded using a respiration belt (EPM Systems, Midlothian, VA) around the waist. Physiological signals were digitized (12 bit A/D) and stored for offline processing. ECG and dZ/dt were sampled at 500 Hz and respiration and Zo at 250 Hz. One-minute ensemble averaged values for heart period, stroke volume (for deriving CO), and preejection period were obtained from the ECG and ZCG signals (Kelsey & Gwethlein, 1990). Respiratory sinus arrhythmia was estimated for each minute using the method of Porges and Bohrer (Porges & Bohrer, 1990; Mxedit, ver. 2.01, Delta-Biometrics, Bethesda, MD). For Study 2, blood pressure measurements were recorded once each minute during the baseline and task periods using a Dinamap blood pressure monitor (Model 1846 SX; Criticon, Inc., Tampa, FL). Total peripheral resistance was calculated for each minute using the formula (MAP/CO) * 80.

Self-Report Measures

Locus of Control (LOC). LOC was measured using Levenson's LOC scales (Levenson, 1973), modified by removing items that did not reflect significant variance on the respective scales and that decreased reliability of the subscales (Brosschot, Gebhardt, & Godaert, 1994; Presson, Clark, & Benassi, 1997). The measure includes three subscales that correspond to beliefs about control from (1) personal actions and characteristics (i.e., internal), (2) powerful others, and (3) chance or fate. The internal scale (five items) includes items such as "When I make plans, I am certain to make them work." The powerful-others scale (six items) includes items such as "I feel like what happens in my life is mostly determined by powerful people." The chance scale (seven items) includes items such as "When I get what I want, it is usually because I am lucky." Levenson's LOC scales use a 6-point, Likert-type scale ranging from 1 = *Strongly Disagree* to 6 = *Strongly Agree* with anchors for all six points. Previously reported internal consistency (Cronbach's alpha) for the shorter subscales is 0.58 for internal, 0.71 for powerful others and 0.67 for chance (Brosschot et al., 1994). The internal consistency of the scales for our combined sample was 0.71 for internal, 0.69 for powerful others, and 0.70 for chance. The test-retest reliability of these scales in a sample of male high school teachers was 0.67 for internal, 0.64 for powerful others, and 0.66 for chance over 6 months (Brosschot et al., 1994).

Appraisals. Appraisals were assessed prior to and following each task with two questions. Pre- and posttask stress appraisals were assessed by asking, respectively, ‘‘How stressful do you expect the upcoming task to be?’’ and ‘‘How stressful was the preceding task?’’ Pre- and posttask coping appraisals were assessed by asking, respectively, ‘‘How well do you think you can cope with the upcoming task?’’ and ‘‘How well do you think you coped with the preceding task?’’ Stressfulness was rated on a scale of 1 (*Not at all stressful*) to 5 (*Very stressful*) and coping ability was rated on the same scale where 1 = *I cannot cope at all with the task* and 5 = *I can cope very well with the task*.

Video-Game Task

The stressor was a video-game computer task. The object of the game was to ‘‘catch,’’ with an on-screen paddle, small blue squares that dropped from the top of the video screen. The participant controlled the paddle with two response buttons (force keys; PCB Piezotronics). Each button was placed 2.5 cm from the end of a 3 cm diameter wooden dowel that was 19.5 cm long. Participants held one dowel in each hand and used their thumbs to press the buttons. Their performance level was held constant at 50% accuracy using a staircase tracking method. The tracking algorithm worked by varying the task so that when participants made several catches in a row, the difficulty level increased, and when they missed catching several squares in a row, the difficulty level decreased. Thus, for individuals who did not initially perform well, the software slowed the pace so they were able to catch 50% of the squares. For those who initially did well, the software speeded the pace, again so that they were able to catch only 50% of the squares. The pace was adjusted up and down throughout the task to maintain an average 50% success rate. The minimum force required to move the paddles in the task reported here was set at 50% of the individual’s maximum voluntary force (see below). The actual force used by participants during the task was measured in A-D units and used as a measure of effort in the analyses of cardiovascular measures. During the task, the participant sat upright in an upholstered chair.

Procedure

The participant was seated in a testing room adjacent to the control room where the physiological data were collected. The experimenter first described the procedure to the participant, who then gave informed consent and completed a health questionnaire. Band electrodes were placed around the neck and torso, a blood pressure cuff was placed on the participant’s nondominant arm, and a respiration belt was placed around the waist. Next, the participant completed the LOC scales while the electrodes stabilized for at least 10 minutes. Following stabilization, the participant sat quietly for a 4-min resting baseline. Following the baseline, the experimenter entered the testing room and collected measures of the participant's maximum voluntary force on the response buttons by asking the participant to press on both buttons as hard as possible with both thumbs at the sound of a tone. This procedure was followed three times and the maximum voluntary force was calculated by averaging the six values. Following maximum force determination, an experimenter explained the task and then asked the appraisal questions (via an intercom from the control room). Participants were told to work as hard as possible on the video-game task and informed that they would receive $1 for the task as long as they reached a preset criterion of performance. Following the initial task, the participant completed other versions of the video-game task and was compensated. The results of the remaining tasks are reported in Weinstein et al. (2002).

Data Analyses

Physiological measures. In order to remove the effects of baseline physiological state from each dependent variable, regressions were performed using the baseline scores to predict task scores. The resulting unstandardized residuals were used for all analyses. For blood pressure measurements in Study 2, we examined the 4 minutes of the task and observed that blood pressure changes were almost always sustained over all 4 minutes. In order to maximize the reliability of the vascular variables by aggregating over multiple measures (Llabre et al., 1988), we calculated the mean over the 4 task minutes and the mean over the 4 baseline minutes for SBP, DBP, MAP, TPR, and CO. Residualized change scores were calculated using these means. Data for each participant were used in these analyses only if the person contributed at least two blood pressure measurements for each task and baseline period. All participants met this criterion, and for 94% of the participants, the means for each 4-minute task or baseline comprised three or more readings. In contrast to vascular changes, cardiac and autonomic responses tended to peak at the beginning of the task. Thus, in order not to miss any potential changes elicited by the task, residualized change scores were calculated by regressing the 1st minute of the task on the final minute of the baseline for heart period, preejection period, and respiratory sinus arrhythmia, which is common in laboratory tasks such as the game used in the present study (Kelsey et al., 1999).

Because effort is known to influence cardiovascular responding, we included a measure of effort (average force used to move the paddles during the task in A-D units) in the regressions that involved cardiovascular measures. We also assessed whether we could combine the data from both studies for analyses of self-report and cardiac data. To do this, we performed stepwise regression models that included main effects of study (Study 1 or Study 2), internal, powerful others, and chance LOC and effort at Step 1, and interaction terms of study with each LOC variable and effort at Step 2. We then assessed whether there was a significant change in R^2 from Step 1 to Step 2. When there was no significant change in R^2 across these two steps, we did the follow-up analyses by combining data across studies. In all cases, there were nonsignificant increments in R^2 with the second step; therefore, all relevant analyses are reported using data from both studies. We did not follow this procedure for blood pressure because there were no blood pressure data for Study 1. Because we had no a priori hypotheses about how the LOC factors would be related to the cardiovascular variables, we tested the full model that included effort in the first step and the three LOC factors in the second step. We report unadjusted R^2 for all analyses.

RESULTS

LOC and Appraisals

Two participants in Study 1 and one in Study 2 did not complete the LOC scales. Therefore, the *N*s were 31 and 31, or a total of 62 across both studies. The model that included all three LOC scales as predictors was significant for posttask stress, $F(3, 58) = 3.20$, $p < .05$, $R^2 = .14$, marginally significant for pretask coping , $F(3, 58) = 2.66$, $p = .056$, $R^2 = .12$, and not statistically significant for either pretask stress, $F(3, 58) = 1.25$, *ns*, or posttask coping, $F\ (3, 58) = 1.86$, *ns*. Scores on internal LOC predicted both pretask coping ratings ($\beta = .34$, $p < .01$) and posttask stress ratings ($\beta = -.38$, $p < .01$) such that those who scored high on internal LOC were more likely to report higher pretask coping ratings and lower posttask stress ratings than those who scored low. Neither scores on powerful others nor scores on chance significant predictor of either pretask coping or posttask stress. Thus, in the combined samples, having a more internal LOC was related to greater self-reported coping ability prior to the task (but not after) and lower self-reported stressfulness following the task (but not before). Internal LOC was related to appraisals made at specific times relative to a performance task and did not simply relate to appraisals more globally.

Table 1
Summary of Regression Analysis for Variables Predicting Pretask Coping and Posttask Stress

	Pretask Coping			Posttask Stress		
Variable	B	SE B	β	B	SE B	β
Internal	.07	.03	.34#	– .10	.03	– .38*
Powerful Others	– .003	.03	– .02	– .01	.04	– .05
Chance	– .005	.03	– .03	.01	.03	.03

Pretask coping $R^2 = .12$, Posttask stress $R^2 = .14$.
#$p = .06$. *$p < .05$.

LOC and Basal Cardiovascular Function

LOC data were missing for 2 of the 49 participants for whom we had cardiovascular data. Thus, the total *N* for the cardiovascular analyses that included participants from both studies is 47. The total *N* for the analysis of blood pressure data, which was only collected in Study 2, is 31 with the exception of mean arterial pressure for which we were missing data for an additional 2 participants for a total *N* of 29.

The variable effort was not included in any of the analyses of basal cardiovascular function because these measures were recorded during a rest period in which participants made no explicit effort. The model that included all three LOC factors as predictors for basal preejection period was significant ($F\ (3,\ 43) = 4.02$, $p < .05$, $R^2 = .22$). Chance was a significant predictor of basal preejection period ($\beta = -.54$, $p < .01$) and powerful others was a marginally significant predictor ($\beta = .29$, $p = .07$). Thus, lower scores on powerful-others LOC and higher scores on chance LOC were associated with shorter preejection period (higher basal sympathetic nervous system activity). The models including all three LOC factors revealed no significant effects on baseline cardiac output, $F\ (3,\ 43) = 1.47$, *ns*, heart period, $F(3,\ 43) = 1.20$, *ns*, respiratory sinus arrhythmia, $F(3,43) = .19$, *ns*, systolic blood pressure, $F(3,\ 27) = 1.27$, *ns*, diastolic blood pressure, $F(3,27) = 1.29$, *ns*, mean arterial pressure, $F(3,\ 25) = 1.04$, *ns*, or total peripheral resistance, $F(3,\ 27) = .95$, *ns*.

LOC and Cardiovascular Reactivity

We tested models that controlled for the possible influence of effort using stepwise regression that included effort as the first step in the model with all three LOC scales added in the second step. There was no significant effect of effort on heart period reactivity (F (1, 45) = 1.23, *ns*), but the model that included all three LOC scales was significant (F (4, 42) = 2.47, $p < .05$, $R^2 = .19$) after controlling for the effect of effort. Only the powerful-others scale significantly predicted heart period reactivity ($\beta = .43$, $p < .01$).

Similarly, there was no significant effect of effort on preejection period reactivity (F (1, 45) = 1.12, *ns*), but the model that included all three LOC scales was marginally significant (F (4, 42) = .2.20, $p = .10$, $R^2 = .16$) after controlling for effort. Again, however, only powerful others was a significant predictor of preejection period reactivity ($\beta = .61$, $p < .05$).

Effort was a significant predictor of respiratory sinus arrhythmia reactivity, (F (1, 45) = 5.89, $p < .05$), and the three LOC factors were also significant predictors of respiratory sinus arrhythmia after controlling for effort (F (4, 42) = 3.52, $p < .05$, $R^2 = .29$). Within this model only effort ($\beta = -.35$, $p < .05$) and powerful-others LOC ($\beta = .40$, $p < .05$) were significant predictors of respiratory sinus arrhythmia reactivity. Greater effort was related to greater decreases in respiratory sinus arrhythmia, and a stronger powerful-others LOC was related to smaller decreases, or even increases, in respiratory sinus arrhythmia. There was no significant effect of effort on cardiac output, F(1, 45) = 3.10, *ns*, and no effect of the LOC factors after controlling for effort, F (4, 42) = 1.71, *ns*.

Together, these results indicate that participants who reported that powerful others had more control in their lives were more likely to show smaller task-related decreases, or even increases, in heart period, preejection period, and respiratory sinus arrhythmia from baseline than those with lower powerful-others LOC scores (see Figure 1 and Table 2). This suggests that for participants scoring high on powerful others, heart period decreased less (or even increased more), sympathetic nervous system activity increased less (reflected by either small decreases or even increases in preejection period), and parasympathetic nervous system activity decreased less (reflected in smaller decreases or even increases in respiratory sinus arrhythmia) during the 1st minute of the task than for those scoring low on powerful others.

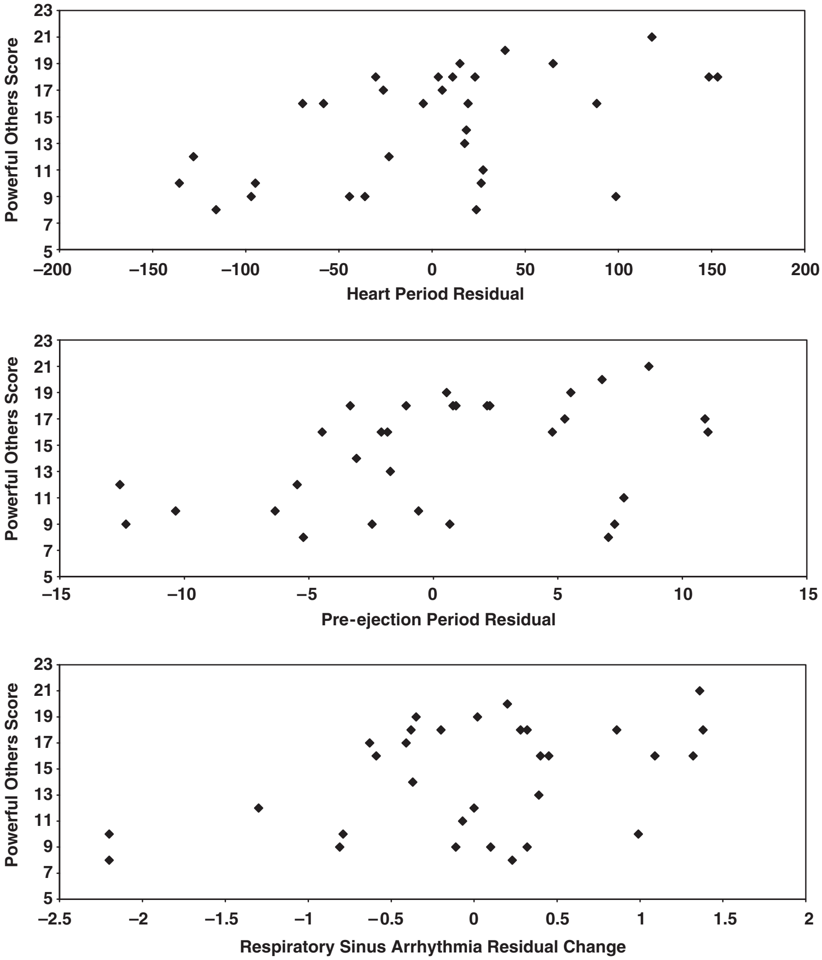

Figure 1

Powerful-others LOC predicts cardiac reactivity. Those with a stronger powerful-others LOC were more likely to have smaller decreases, or even increases, in heart period, preejection period, and respiratory sinus arrhythmia than those with a weaker powerful-others LOC.

Blood pressure measures were collected only for Study 2. Using the same process of entering effort into the model first and then entering the locus of control scales in a second step, we found that effort had a significant effect on systolic blood pressure ($F(1, 29) = 5.56$, $p < .05$, $R^2 = .18$) and a marginal effect on mean arterial pressure ($F(1, 29) = 3.47$, $p = .07$, $R^2 = .24$). Higher effort predicted

Table 2
Summary of Regression Analysis for Variables Predicting Cardiac Reactivity

	Heart period			Preejection period			Respiratory sinus arrhythmia		
Variable	B	SE B	β	B	SE B	β	B	SE B	β
Internal	−4.32	3.08	−.19	−.29	.28	−.15	−.05	.04	−.20
Powerful Others	8.31	3.08	.43*	.57	.28	.61*	.10	.04	.40*
Chance	−3.02	2.75	−.18	−.11	.25	−.08	−.02	−.04	−.10

Heart period $R^2 = .19$, preejection period $R^2 = .16$, respiratory sinus arrhythmia. $R^2 = .29$. $^*p < .05$.

larger increases in systolic blood pressure and mean arterial pressure. However, the LOC scales did not predict any of the blood pressure measures over and above the effect of effort, systolic blood pressure, F (4, 26) = .2, *ns*, diastolic blood pressure, F (4, 26) = 1.9, *ns*, mean arterial pressure, F (4, 26) = 2.10, *ns*, or total peripheral resistance, F (4, 26) = .05, *ns*.

We considered the possibility that our failure to see a relationship between the LOC scales and vascular change was due to our using the average of all 4 minutes of baseline and 4 minutes of task for the vascular measures in order to increase reliability of these measures. This could have resulted in an apparently smaller response to the task if the peak response occurred early in the task. Therefore, in a post hoc analysis, we also conducted regression analyses using the three LOC scales to predict the unstandardized residuals of the regressions using the mean of all 4 minutes of baseline to predict the 1st minute of the task for all vascular measures. There were no statistically significant effects of any of the LOC scales on any of the vascular measures, suggesting that the failure of the LOC subscales to predict vascular measures was not due to our choice of when to measure the response.

DISCUSSION

The results of the present studies show that individuals with higher scores on Levenson's internal LOC scale are more likely to report higher pretask coping ability as well as lower posttask stressfulness during a laboratory stress task than those who score low on the internal scale. In addition, higher scores on Levenson's powerful-others scale were associated with reduced cardiac reactivity but unrelated to vascular reactivity or cognitive appraisals. A belief that one's life events are mostly determined by chance was associated with higher basal sympathetic nervous system activity, whereas a belief that life events were determined by powerful others was associated with lower basal sympathetic nervous system activity.

The present results are consistent with the theories of Lefcourt and Davidson-Katz (1991) and Folkman (1984), which predicted relationships between internal LOC and both primary and secondary appraisals. However, neither of these theoretical accounts predicts how LOC will be related to the temporal sequence of appraisals and potentially stressful events, and the current data suggest that the temporal course matters. The internal LOC scale predicted primary (i.e., stressor) appraisals following the task, but not prior to the task. This result is consistent with findings of Vitaliano et al. (1987) and Anderson (1977), who found a negative relationship between internal LOC and postevent primary appraisals of real-life stressors, such as performance in medical school (Vitaliano et al., 1987) or having experienced a significant business loss due to a hurricane (Anderson, 1977). However, because neither study measured preevent appraisals, we cannot know if our findings would generalize to other situations where appraisals are made prior to the event.

The present results also support our hypothesis regarding a positive correlation between internal LOC and coping ability that was based on Lefcourt and Davidson-Katz (1991). Folkman (1984) also hypothesized there would be a relationship between internal LOC and coping ability, but only if the situation is novel or ambiguous with respect to control. Although the level of ambiguity of the task in this study was not directly manipulated or assessed, the task used here was the first of a series of five similar tasks and therefore novel. Therefore, although the study was not designed to test Folkman's hypothesis directly, the results are consistent with it. As with stressor appraisals, the temporal course of the coping appraisal process appears important, with only higher pretask coping ability related to higher scores on internal. This suggests that those with a more internal LOC approach an upcoming unknown task with greater confidence in their ability to cope, although they are no more likely than those without a strong internal orientation to think that they coped well when asked to report their appraisals after the task.

The fact that internal LOC consistently predicted pretask coping ratings and posttask stress ratings suggests that the impact of LOC on stress ratings may be mediated by its impact on perceived coping ability. When faced with an impactful and relatively novel event, an individual with a higher internal score may consider his/her ability to cope with the situation to be relatively high, regardless of the expected stressfulness. This perception may influence new appraisals during the task and ultimately result in a lower posttask stress rating. Thus, while primary and secondary appraisals may be quite independent theoretically, they may be related under experimental or real-world situations, especially when changing circumstances lead to changes in these appraisals. For example, in a previous study (Quigley et al., 2002), we found that individuals who had greater cardiac reactivity during the latter part of a math task and who performed the task more poorly were more likely to change their appraisals from relatively low stress and high coping before the task to appraisals of relatively high stress and low coping after the task. These data suggest that some individuals use changing circumstances (in this case, their own physiology and performance) to alter their cognitive appraisal of the situation, whereas other individuals are less likely to do this. In our previous study, however, we combined stress and coping appraisals into a single construct in keeping with older literature, and we did not directly address the possibility that these primary and secondary appraisals may not be related (i.e., appraisals of low stress may not always accompany appraisals of high coping). Further studies will be needed in order to delineate situations and individuals in which primary and secondary appraisals either are or are not related. However, the pattern of relationships with the three LOC factors observed here suggests that it will be important to separately analyze primary and secondary appraisals.

Although the internal LOC was consistently related to aspects of cognitive appraisal, it was not associated with any of the cardiovascular measures. Furthermore, chance LOC and powerful-others LOC were each associated with different aspects of cardiovascular functioning. Basal sympathetic nervous system activity was significantly related to both chance and powerful-others LOC orientations with higher scores on chance associated with higher basal sympathetic nervous system activity (shorter preejection period) and higher levels of powerful others associated with lower levels of sympathetic nervous system activity (longer preejection period). This finding suggests that for individuals who feel that events in their lives are a matter of fate, the sympathetic nervous system is more active compared to individuals who don't believe that life events are controlled by chance or fate. Thus, the sympathetic branch of the autonomic nervous system, which is relatively quiescent at rest and more active under stressful circumstances, may be more tonically active under resting conditions in those who believe that their lives are controlled by chance. In contrast, basal sympathetic nervous system activity appears to be lower for individuals with a high powerful-others orientation than those who score low on powerful others.

Cardiac reactivity measures during the task were predicted by scores on powerful-others LOC. Individuals who reported that those in power often control events in their lives showed either smaller decreases or even increases in heart period, preejection period, and respiratory sinus arrhythmia during the 1st minute of the videogame task than those with low powerful-others LOC. Recall that a decrease in heart period indicates increased heart rate, a decrease in preejection period indicates increased sympathetic nervous system activity, and a decrease in respiratory sinus arrhythmia indicates reduced parasympathetic nervous system activity. Thus, these results suggest that a higher score on powerful-others LOC predicts an overall less robust cardiac response to the task. These results are comparable to those of Houston (1972), who found that participants defined as externals (Rotter's scale) showed smaller increases in heart rate during a cognitive task performed under threat of shock than internals. Houston explained his finding by suggesting that those who believe that external forces are responsible for their fate are more likely to resign themselves to a situation, and therefore show less reactivity, whereas those with an internal LOC are likely to work harder to achieve control. Results by Muller, Gunther, Habel, and Rockstroh (1998) suggest a different possible interpretation of the relationship between LOC and cardiovascular reactivity. In that study, externals were defined as those who scored relatively high on powerful others and/or chance (as well as moderate on internal). Externals showed smaller heart rate increases than internals following a task in which they experienced an aversive tone indicating poorer performance. Muller et al. (1998) suggested that the emotional impact of negative feedback may not be as great for a person who believes that powerful others, which could include the researchers, control the outcome, compared to someone who believes that he or she controls the outcome. However, in the present study, there was no relationship between stress ratings, which could be viewed as a measure of emotional impact, and powerful others prior to or following the 4-minute task. In addition, each participant experienced the same number of negative feedback experiences (i.e., missing a square) because the accuracy of the task was set to remain on average at 50%. Differences in the methods of defining LOC and the tasks used across the Houston (1972), Muller et al., (1998), and present studies make it difficult to draw definitive conclusions outside of the current experimental context. However, the relationship between a powerful-others LOC and cardiovascular reactivity should be further investigated given the importance of individual differences in cardiovascular reactivity for the risk of cardiovascular diseases (e.g., Treiber et al., 2003).

These data should be interpreted with caution due to the limitations of this study. The fact that we had no a priori hypothesis regarding how LOC would be related to CV measures resulted in a number of exploratory analyses, which increases the chance of Type II errors. Replication of these results will be necessary to increase our confidence that they are not simply chance findings. In addition, further theorizing and empirical exploration into why a powerful-others LOC may be associated with lower cardiac reactivity is warranted.

In summary, the results of the present study provide further support for Levenson's assertion (1973) that subdividing the LOC construct into three components will provide a richer understanding of relationships between different aspects of the stress response (e.g., subjective and physiological) and LOC. Internal LOC scores predicted cognitive appraisals, but not cardiovascular responding, such that those with a more internal LOC reported a greater ability to cope with an upcoming mildly stressful task and reduced posttask stress than those with a lower internal LOC. In contrast, powerful-others LOC scores predicted cardiac reactivity but not vascular responding or cognitive appraisals during the same task. Here, those with a higher powerful-others LOC score showed reduced reactivity compared to those who did not believe that powerful others control outcomes in their life. Finally, a higher score on chance LOC was associated with higher basal sympathetic nervous system activity, whereas a higher score on the powerful-others LOC predicted lower basal sympathetic nervous system activity.

The results reported here also suggest the existence of a stress-response buffering profile reminiscent of Kobasa's (1979) hardy personality. Kobasa theorized that individuals who feel a sense of control and commitment and have the ability to perceive stressors as a challenge are less likely to suffer from stress-related illness. An individual with a high internal, high powerful-others, and low chance LOC profile may be less susceptible to the negative effects of stress because he or she is likely to have lower basal sympathetic nervous system activity, less cardiac reactivity, and the propensity to view events as less stressful and their own coping ability as strong. Continued investigation of the relationships between dispositional LOC and aspects of the stress response could have important implications for a society seeking relief from the negative effects of exposure to a stressful environment.

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