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Psychological Vulnerability and Stress: The Effects of Self-Affirmation on Sympathetic Nervous System Responses to Naturalistic Stressors

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Objective: Everyday stressors can threaten valued aspects of the self. Self-affirmation theory posits that this threat could be attenuated if individuals affirm alternative self-resources. The present study examined whether self-affirmation would buffer cumulative stress responses to an ongoing academic stressor. ***Design:*** Undergraduate participants provided 15-hr urine samples on the morning of their most stressful examination and baseline samples 14 days prior to the examination. Participants were randomly assigned to the self-affirmation condition where they wrote two essays on important values over the 2-week period prior to exam, or a control condition. ***Main Outcome Measures:*** Samples were analyzed for urinary catecholamine excretion (epinephrine, norepinephrine), an indicator of sympathetic nervous system activation. Participants also indicated their appraisals of the examination experience. ***Results:*** Participants in the control condition increased in cumulative epinephrine levels from baseline to examination, whereas participants in the self-affirmation condition did not differ from baseline to examination. The buffering effect of self-affirmation was strongest among individuals most concerned about negative college evaluation, those most psychologically vulnerable. ***Conclusion:*** The findings demonstrate that sympathetic nervous system responses to naturalistic stressors can be attenuated by self-affirmation. Discussion centers on psychological pathways by which affirmation can reduce stress and the implications of the findings for health outcomes among chronically stressed participants.

Keywords: academic stressors, catecholamines, self-affirmation, stress, stress interventions

Midterm examinations for a student, job performance evaluations for an employee, and medical tests for a patient are all regularly occurring stressful events. The anticipation of and preparation for these events can be stressful, in part, because being a good student, a valued employee, or a healthy person are central aspects of how many individuals see themselves, and the outcome of the exam, evaluation, or medical test can affect both one's standing on the domain, as well as how one is perceived by others. Because stress increases one's susceptibility to a wide range of pathological medical conditions such as hypertension and myocardial infarction (e.g., Lundberg, 2006; Marmot, Bosma, Hemingway, Brunner, & Stansfeld, 1997), as well as increased incidence of common ailments such as colds (S. Cohen, Tyrrell, & Smith, 1993), identifying psychological means by which individuals can cope adaptively to stressful situations is a topic of historical and contemporary research interest (see Carver, 2007; Lazarus & Folkman, 1984; Miller & S. Cohen, 2001 for reviews).

Self-affirmation theory posits that affirming valued sources of self-worth such as important personal qualities, values, or relationships can buffer threats to the self, reducing the impact that these threats have on both physiological and psychological responses (see Sherman & G. L. Cohen, 2006 for a review). The self-affirmation approach begins with the premise that people are motivated to maintain the perceived worth and integrity of the self (Steele, 1988). When information or events threaten a valued self-image, people attempt to maintain a *global* sense of self-integrity, rather than their perceived worth in a specific domain or in particular situations. Thus, if people can "affirm" an unrelated domain of self-worth, their self-evaluation will be less contingent on a particular focal stressor, which will be experienced, consequently, as less physiologically taxing. Consistent with this model, one study (Creswell et al., 2005) found that self-affirmation attenuated cortisol responses to the Trier

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Social Stress Task (Kirschbaum, Pirke, & Hellhammer, 1993), a common laboratory stress challenge task. Suggestive correlational evidence is also provided by a study showing that individuals with greater perceived self-resources have reduced cardiovascular reactivity during a laboratory stressor (Taylor, Lerner, Sherman, Sage, & McDowell, 2003). Although these findings strongly suggest that drawing on self-resources can buffer stress responses and reduce the physiological impact of threatening and stressful events, they have been confined to laboratory investigations of stress. In the present paper, we examine the effects of an experimental self-affirmation manipulation on cumulative stress responses to a naturalistic academic stressor.

Stressful events are known to trigger fight-or-flight responses due to activation of the sympathetic-adrenomedullary (SAM) axis. The SAM axis response is characterized by a cascade of events resulting in cells of the adrenal medulla (and to a lesser extent, the kidney) releasing catecholamines, namely epinephrine and norepinephrine, into the bloodstream, and by norepinephrine being released from granules of sympathetic nerve fibers (Bellinger et al., 2001; Weiner, 1992). The release of these catecholamines is important in that they mobilize energy and coordinate host tissues and organs for a fight-or-flight response to a stressor (Lundberg, 2000; Weiner, 1992). These endocrine responses facilitate fight-or-flight responses during stress, but excessive or prolonged activation of the sympathetic nervous system is known to increase one's susceptibility to negative mental and physical health outcomes (S. Cohen, Janicki-Deverts, & Miller, 2007; Young & Breslau, 2004). The release of catecholamines can be caused by both psychological stress and physical activity. Epinephrine secretion is stimulated by both distress from anticipation as well as the actual experience of stressful events, whereas norepinephrine secretion is stimulated in response to psychological stress as well as to changes in physical activity (Rogers et al., 1991; Steptoe, 1987; Weiner, 1992).

Increased catecholamine levels have been observed among people who are experiencing a wide range of naturalistic stressors including familial health risks (James, van Berge-Landry, Valdimarsdottir, Montgomery, & Bovbjerg, 2004) and occupational job strain (Brown, James, & Mills, 2006). Examination stress can also lead to increased SAM activation as assessed by cardiovascular reactivity (Loft et al., 2007) and such naturalistic stressors can suppress cellular immunity (Segerstrom & Miller, 2004) and increase vulnerability to diseases such as cancer (Antoni & Lutgendorf, 2007; Reiche, Morimoto, & Nunes, 2005). For example, Glaser et al. (1985) found that during final exams, medical students showed a decrease in natural killer cells and an increase in psychological distress relative to a baseline period 6 weeks earlier.

Reliable measurement of catecholamines has historically been difficult, given their relatively short half-life (1–3 minutes). Instead of measuring catecholamines in the blood, investigators are increasingly measuring cumulative levels of free epinephrine and norepinephrine in the urine, using 15-hr and 24-hr cumulative samples (Baum & Grunberg, 1997; Janicki-Deverts, Zilles, S. Cohen, & Baum, 2006). Urinary measures of epinephrine have been most closely linked to cumulative psychological stress and anticipation of threat (see Baum, Lundberg, Gruenberg, Singer, & Gatchell, 1985; Dimsdale & Moss, 1980). In contrast, urinary measures of norepinephrine do not appear to be as strongly coupled with stress, likely due to the confounding effects of norepinephrine's sensitivity to changes in physical activity (Rogers et al., 1991), and the constant slow release of norepinephrine from sympathetic nerve fibers into circulation, among other factors (for reviews, see Steptoe, 1987; Weiner, 1992).

In the present paper, we examine whether providing people with opportunities to affirm a valued aspect of their self-image can buffer cumulative catecholamine responses to naturalistic examination stressors. Although most research has examined the short-term effects of self-affirmations, recent research has shown that self-affirmations can exert long-term effects on the academic grades of minority students (G. L. Cohen, Garcia, Apfel, & Master, 2006) and increase acceptance of threatening health information for up to 1 month (Harris & Napper, 2005). The present study examines whether a self-affirmation manipulation, writing two essays on different values on separate occasions, in the 2-week period preceding an examination could affect cumulative stress responses during the examination period. We furthermore explore a psychological pathway by which the affirmation could reduce stress. Previous research has found that self-affirmations can reduce rumination about academic failure (Koole, Smeets, van Knippenberg, & Dijksterhuis, 1999). The stress of difficult events can be exacerbated when people become preoccupied with meta-level concerns (e.g., "what if I fail this test?"). Thus, by having participants complete appraisals of the stressful examination, we examine whether the affirmation can attenuate these concerns.

We predict that enabling individuals to draw on alternative self-resources during a period of heightened stress, via a self-affirmation activity, will buffer stress responses associated with an important academic examination. A second prediction concerns the potential moderating role of psychological vulnerability. Previous research has found that the effects of self-affirmation are strongest for those who are most vulnerable to a potential threat, be it threatening health information (Sherman, Nelson, & Steele, 2000) or information that threatens a valued identity (G. L. Cohen et al., 2007). In the present investigation, we tested whether those students who are most concerned about being evaluated negatively, and thus most psychologically vulnerable during the midterm examination period, would be the most responsive to the stress-protective effects of self-affirmation.

Method

Participants

Fifty-four undergraduates (38 female and 16 male; 65% Caucasian, 15% Asian American, 20% other ethnicities; mean age = 20.11 years) participated in the study for $50. During recruitment, participants (who were enrolled in a wide range of classes) were excluded from the study if they were high caffeine users or did not have an in class midterm examination. Participants were asked to refrain from caffeine use or excessive exercise during the 24 hours prior to, and during, the 15-hr urinary sampling periods, due to

their known effects on urinary catecholamines (Steptoe, 1987)[1]. Five participants were excluded from physiological data analyses because of improper urine collection or analysis ($n = 2$) or because they were outliers on baseline levels of epinephrine (>3 *SD*) ($n = 3$). Thus, the final sample consisted of 49 participants (see Figure 1 for CONSORT Diagram; Moher, Schulz, & Altman, 2001).

Background Measures

Prior to the experimental manipulation, participants completed a series of psychosocial and health screening questionnaires at a baseline assessment session. Participants identified their most stressful class for the quarter and the midterm date for that class and completed a four-item measure of college concerns designed to assess both academic and social concerns. They indicated their agreement with items on a scale from 1 (very much disagree) to 6 (very much agree). The four items were, "In college, I worry that people will think I'm unintelligent if I do poorly," "In college, I sometimes worry that people will dislike me," "In college, I am usually confident that others will have a good impression of my ability (reverse scored)," and "In college, I often get nervous and worried when I talk to people" ($\alpha = .68$; G. L. Cohen & Garcia, 2005; Heatherton & Polivy, 1991). Participants completed the values ranking component of the self-affirmation manipulation. Participants selected their two most important and two least important values from a list of 11 values (Artistic skills, Athletics, Business/earning money, Creativity, Independence, Musical ability/appreciation, Politics, Relations with friends or family, Religious Values, Sense of Humor, Spontaneity/living life in the moment).

Urine Collection

Figure 2 presents a timeline for the 15-day experimental study, which was determined individually for participants based on their midterm examination date. Exactly 2 weeks prior to their examination, participants completed the first overnight urine assessment. Participants collected all urine, beginning (on Day 1) 15 hours prior to their regular wake-up time with the final sample collected after waking (on Day 2); 15-hr urinary catecholamine assessments are effective and reliable means for assaying cumulative sympathetic nervous system activation during naturalistic stressors (Steptoe, 1987; Janicki-Deverts et al., 2006).

The samples were collected in plastic containers (that contained 25 mL of 50% acetic acid as a preservative), and participants were instructed to refrigerate the container at all times. Participants began their second urine collection on the day prior to the midterm exam (Day 14) and completed collection on the morning of the exam (Day 15).

Self-Affirmation Manipulation

Participants were randomly assigned to a self-affirmation condition or a no-affirmation control condition. The self-affirmation procedure was based on the materials used in previous field experiments (G. L. Cohen et al., 2006; see McQueen & Klein, 2006 for a methodological review) and is theorized to bring online important self-resources unrelated to the focal academic stressor. Students logged on to the study web page in response to email notifications on Day 3 and Day 10, and completed 10-min writing exercises. For the first writing exercise, participants in the self-affirmation condition wrote about the value they had ranked as most important, why this value was important to them and a time in their life that this value was particularly important. Participants in the no-affirmation condition wrote about the value that they had ranked as least important, and why this value might be important to the typical student at their university.[2] For the second writing exercise, participants in the affirmation condition wrote about their second most important value, whereas those in the control condition wrote about their second least important value. As in Cohen et al. (2006), students also indicated their level of agreement with statements concerning the focal value, such as "I care about this value" (in the affirmation condition) or "The typical university student cares about this value" (in the control condition). The purpose of these statements was to reinforce the affirmation (or no-affirmation) writing exercise.

Post-Examination Stress Appraisals

After participants completed their examination, they were instructed to log on that day to the experimental web page and complete questions assessing their postexamination stress appraisals. One item assessed a tendency to be distracted by thoughts of failure during the examination, "During the exam I often thought about what would happen if I fail." A second item examined the tendency not to ruminate on difficult problems, "When taking the exam I had the attitude, "If I don't know it now, there is no point in worrying about it." Participants responded to both items in terms of how they felt while taking the exam on a scale from 1 (never felt like this) to 4 (always felt like this).

Catecholamine Analysis

All urine samples were assayed at the Mayo Medical Laboratories in Rochester, MN, following established procedures (see

[1] To examine compliance with our requests not to exercise or consume caffeine, participants completed a brief questionnaire when they turned in each urine sample, where they reported on their behavior for the previous 24 hours. Although compliance with these requests was not perfect, most participants complied, and crucially, this did not vary significantly by condition. More specifically, prior to the first urine collection, 75.5% did not consume caffeine, and this did not differ by condition $\chi^2(1, N = 49) = 1.18, p = .33$. Prior to the first urine collection, 65.4% did not exercise, and this did not differ by condition, $\chi^2(1, N = 49) = 1.42, p = .27$. Prior to the second urine collection, 55.1% did not did not consume caffeine, and this did not differ by condition, $\chi^2(1, N = 49) = .15, p = .78$. Prior to the second urine collection, 65.3% did not exercise, and this did not differ by condition, $\chi^2(1, N = 49) = 1.42, p = .27$. Although it is possible that restricting caffeine use or exercise may have contributed to the stress of the time period, it did not systematically vary across conditions. Finally, this low rate of compliance may be due to the population of undergraduate students utilized in the study; future research would profit from samples more likely to yield higher compliance.

[2] In the literature, many different no-affirmation conditions have been used, and they have all produced analogous null effects relative to the self-affirmation conditions (McQueen & Klein, 2006). We adopted the Cohen et al. (2006) manipulation because this very carefully conducted study showed that the participants in the no-affirmation condition did not differ from historical norms (in their case, grades; in our case, historical norms of catecholamine levels were not available), and thus the no-affirmation condition was unlikely to have threatened or otherwise affected participants.

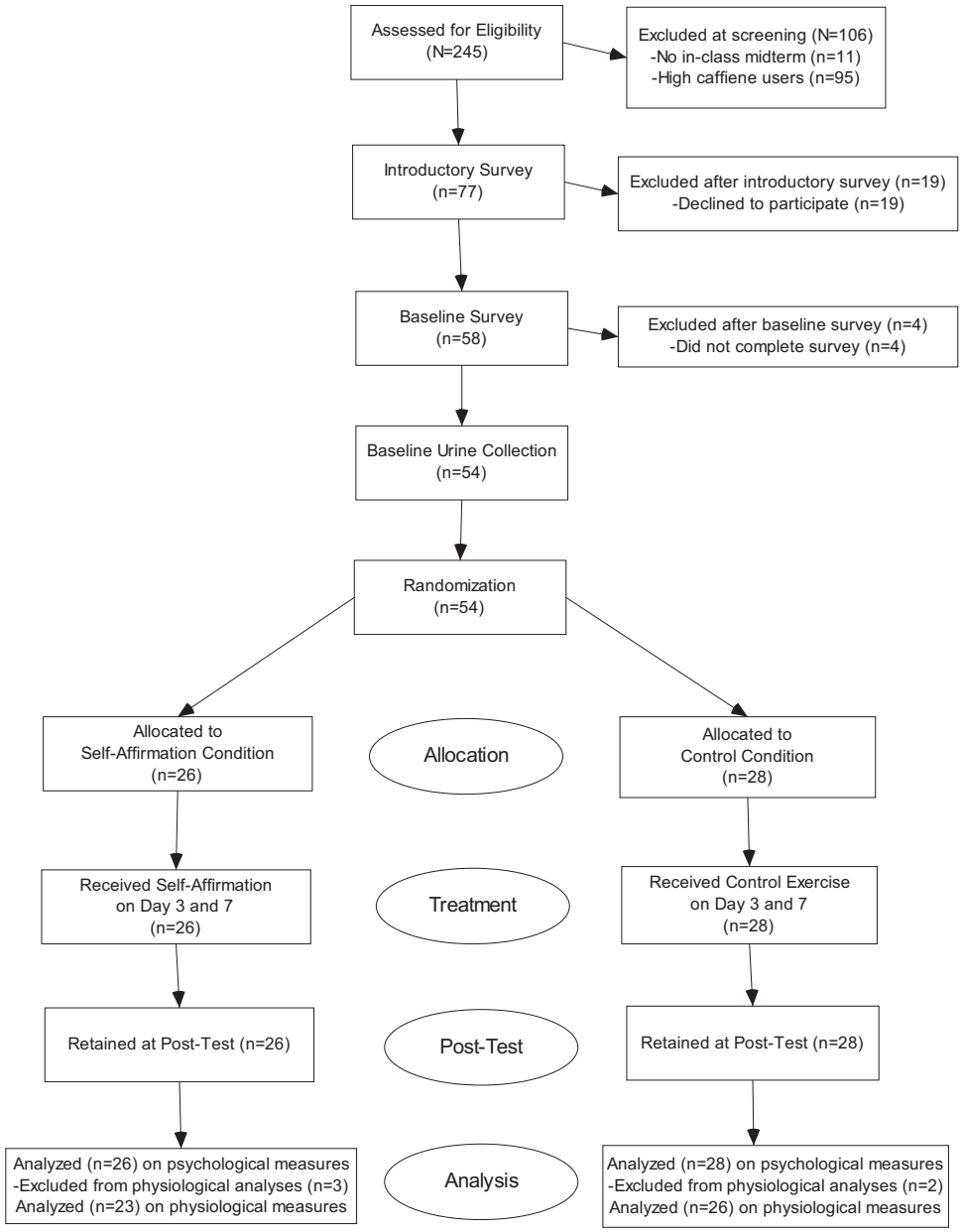

Figure 1. CONSORT Diagram.

Jiang & Machacek, 1987). An aliquot of the 15-hr urine collection preserved in acid was extracted with ethyl acetate to remove acidic metabolites. A 1.0 mL aliquot of the extracted urine was absorbed on aluminum oxide at an alkaline pH and eluted with acid. The catecholamines were removed by washing with boric acid. An aliquot of the boric acid eluate was injected onto a high-performance reverse-phase paired ion-chromatography column where the catecholamines were resolved into individual components.

Results

Covariates

In our biological analyses, we controlled for two variables known to affect urinary catecholamine levels, minutes exercised (the day before the pretest) and oral contraceptive use (Lundberg, 2000). Both variables were assessed prior to the administration of the independent variable, and were entered as covariates in all catecholamine analyses.

Effect of Self-Affirmation on Catecholamines

First, we conducted a repeated measures analysis of covariance (ANCOVA), with baseline epinephrine and midterm exam epinephrine as the repeated measure, minutes of exercise and oral contraceptive use as the covariates, and affirmation status as the between-subjects variable. The results revealed a significant within-subjects main effect. Overall, epinephrine levels were higher (adjusted $M = 1.40$, $SE = .23$) at midterm exam than at

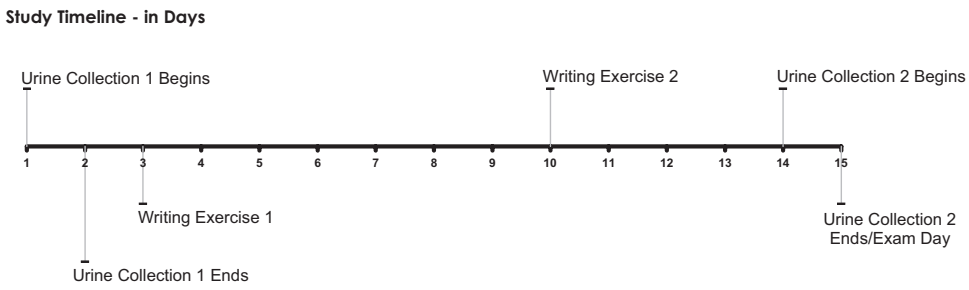

Figure 2. Study timeline.

baseline (adjusted $M = 1.03$, $SE = .14$), $F(1, 45) = 11.12$, $p = .002$, $\eta_p^2 = .20$. Thus, participants overall experienced an increase in their epinephrine levels on the day of their midterm exam relative to 2 weeks prior.

However, this increase was moderated by self-affirmation condition assignment, as there was a significant Time × Treatment interaction, $F(1, 45) = 5.63$, $p = .02$, $\eta_p^2 = .11$. As can be seen in Figure 3, planned comparisons reveal that those in the no-affirmation condition showed a significant increase in epinephrine levels from baseline (adjusted $M = .77$, $SE = .19$) to the midterm exam (adjusted $M = 1.66$, $SE = .31$), $p = .004$. By contrast, those in the self-affirmation condition did not differ from baseline (adjusted $M = 1.28$, $SE = .20$) to midterm exam (adjusted $M = 1.15$, $SE = .33$), $p = .66$.

We conducted the same analysis examining changes in norepinephrine from baseline to the midterm exam. Overall, norepinephrine levels were higher (adjusted $M = 16.24$, $SE = 1.04$) at baseline than at midterm exam (adjusted $M = 12.42$, $SE = .75$), $F(1, 45) = 4.85$, $p = .03$, $\eta_p^2 = .10$, indicating a significant decrease in norepinephrine levels. The pattern of findings for norepinephrine were consistent with the stress buffering effects observed with epinephrine, but the × Treatment interaction was not significant: $F(1, 45) = 1.85$, $p = .18$, $\eta_p^2 = .04$). Planned comparisons revealed significant decreases in cumulative norepinephrine in the self-affirmation participants from baseline (adjusted $M = 17.84$, $SE = 1.54$) to midterm exam (adjusted $M = 12.62$, $SE = 1.10$), $p = .001$. The decrease in cumulative norepinephrine levels from baseline (adjusted $M = 14.65$, $SE = 1.45$) to the midterm exam (adjusted $M = 12.22$, $SE = 1.04$), $p = .09$ in the control participants was only marginally significant. In sum, across both catecholamine measures, the self-affirmation appeared to buffer the students during the stressful midterm examination period.[3]

Moderating Role of Psychological Vulnerability

We predicted that the effects of the self-affirmation manipulation would be most pronounced among those who had the greatest concern about negative college evaluation, and thus were the most psychologically vulnerable during the period prior to the examination. To examine this hypothesis, we conducted a hierarchical multiple regression where midterm exam epinephrine was the outcome, and college concerns (the pretest assessment of concern for negative college evaluation), affirmation condition, baseline epinephrine, birth control usage, minutes exercised (Step 1), and the interaction between college concerns and affirmation condition (Step 2) were the predictors. All continuous predictors were mean-centered before inclusion in the regression analyses. The predictors at Step 1 explained 26% of the variance in midterm exam epinephrine, $F(5, 43) = 4.28$, $p = .009$, $R^2 = .26$. Furthermore, the interaction between college concerns and affirmation condition explained an additional 7.5% of the variance in midterm exam epinephrine, $b = -.96$, $F(1, 42) = 5.31$, $p = .026$, $\Delta R^2 = .075$ (see Figure 4). Overall, college concerns predicted posttest epinephrine levels, $b = .83$, $t(42) = 2.50$, $p = .016$. Simple slopes analyses (Aiken & West, 1991) reveal that for those who were most concerned about college evaluation (one *SD* above the mean on college concerns), the self-affirmation exerted the strongest effects ($b = -1.83$, $t(42) = -3.10$, $p = .003$); by contrast, the self-affirmation made virtually no difference for those who were not as concerned about college evaluation (one *SD* below the mean on college concerns; $b = .11$, $t(42) = .19$, $p = .85$). The affirmation manipulation had greatest impact among individuals who were most psychologically vulnerable.

We also conducted simple slopes analyses to examine the relationship between college concerns and posttest epinephrine for each of the two conditions. In the no affirmation condition, college concerns predicted increased midterm exam epinephrine levels ($b = .83$, $t(42) = 2.50$, $p = .02$). However, participants in the self-affirmation condition showed no significant relationship between college concerns and midterm exam epinephrine ($b = -.13$, $t(42) = -.51$, $p = .62$). In sum, college concerns predicted increases in epinephrine levels, but writing about an important value attenuated this effect.

We conducted the same regression analysis to predict posttest norepinephrine. The predictors at Step 1 explained 29.5% of the variance in midterm exam norepinephrine, $F(5, 43) = 3.60$, $p = .008$, $R^2 = .295$. Moreover, the interaction between college concerns and affirmation condition once again explained a significant amount of additional variance, $b = -2.90$, $F(1, 42) = 4.25$, $p = .045$, $\Delta R^2 = .065$. Overall, college concerns did not significantly

[3] One alternative explanation for these findings is that the relatively higher levels of catecholamines in the no-affirmation condition may reflect increased effort and not stress; self-affirmation may have reduced engagement. Participants reported their midterm grades. Looking at the full sample of 54 participants, there was no difference in midterm performance between those in the self-affirmation condition ($M = 78.8\%$, $SE = 3.2\%$), and those in the no affirmation condition ($M = 79.7\%$, $SE = 3.0\%$), $F(1, 52) = .05$, $p = .83$, $\eta_p^2 = .001$. Participants appear to have been just as engaged, and performed just as well, in the self-affirmation condition.

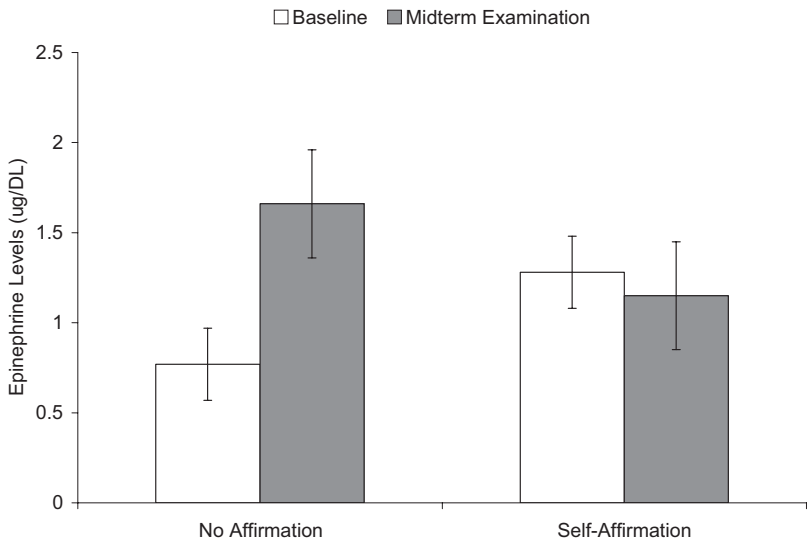

Figure 3. 15-hr urinary epinephrine levels as a function of affirmation status at baseline and at midterm exam. Note. Error bars represent standard error for the mean; means are adjusted for pretest exercise and birth control use.

predict posttest norepinephrine levels, $b = 1.62$, $t(42) = 1.46$, $p = .15$. Simple slopes analyses reveal that for those who were most concerned about college evaluation, the self-affirmation exerted the strongest effects, $b = -3.40$, $t(42) = -1.71$, $p = .094$, although this effect was only marginally significant; by contrast, the self-affirmation made less difference for those who were not as concerned about college evaluation, $b = 2.48$, $t(42) = 1.23$, $p = .23$.

We also conducted simple slopes analyses to examine the relationship between college concerns and posttest norepinephrine for each of the two conditions. In the no affirmation condition, college concerns predicted increased midterm exam norepinephrine levels $b = 1.62$, $t(42) = 1.46$, $p = .15$, albeit nonsignificantly. However, participants in the self-affirmation condition showed a negative relationship, again nonsignificantly, between college concerns and midterm exam epinephrine, $b = -1.28$, $t(42) = -1.45$, $p = .15$.

In sum, for both epinephrine and norepinephrine, the effects of the self-affirmation at reducing stress were strongest for those who were most psychologically vulnerable to the threat posed by the midterm examinations.

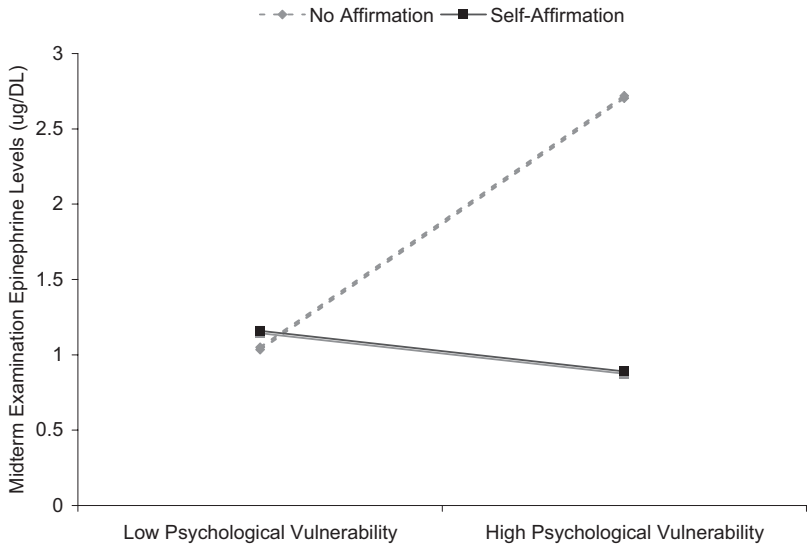

Figure 4. Midterm examination 15-hr urinary epinephrine levels as a function of affirmation status and psychological vulnerability. Note. Midterm exam epinephrine means are estimated based on one *SD* above and below the mean on college concerns, controlling for baseline epinephrine levels, pretest exercise and birth control use.

Post-Examination Stress Appraisals

To examine how participants were thinking and feeling about the focal stressor, and whether this was affected by the affirmation manipulation, we conducted analyses on the stress appraisal measures that participants completed after their exam. We conducted moderated regression analyses to examine whether there was a main effect of condition, and whether this main effect was moderated by college concerns as was the epinephrine measure (we used the full data set, $n = 54$, in the following analyses as we were not examining physiological responses). The two items, "During the exam I often thought about what would happen if I fail" and, "When taking the exam I had the attitude, 'If I don't know it now, there is no point in worrying about it,'" were not correlated, $r(54) = .09$, $p = .52$, suggesting that they corresponded to different potential appraisals participants experienced during the test, and so we analyzed them separately.

For both regression analyses, the stress appraisal item was the outcome, college concerns, affirmation condition, (Step 1), and the interaction between college concerns and affirmation condition (Step 2) were the predictors. For the item assessing thinking about failure during the exam, the model at Step 2 explained 28% of the variance, $F(3, 50) = 6.43$, $p = .001$, $R^2 = .28$. College concerns was a significant predictor, $b = .58$, $t(50) = 3.54$, $p = .001$, as students who were more psychologically vulnerable had greater concerns about failure. Most important, affirmation condition was also a significant predictor, $b = -.46$, $t(50) = -2.20$, $p = .03$, as those in the affirmation condition (estimated $M = 1.48$) had reduced concerns about failure relative to those in the no affirmation condition (estimated $M = 1.95$). College concerns did not interact with condition, $b = -.30$, $t(50) = 1.43$, $p = .16$.

For the item assessing worrying during the exam, the results were similar as the model at Step 2 explained 16% of the variance, $F(3, 50) = 3.09$, $p = .035$, $R^2 = .16$. College concerns was not a significant predictor, $b = -.07$, $t(50) = -.38$, $p = .71$, but, importantly, affirmation condition was a significant predictor, $b = .53$, $t(50) = -2.30$, $p = .03$, as those in the affirmation condition (estimated $M = 2.52$) were more likely *not* to worry if they did not know information relative to those in the no affirmation condition (estimated $M = 1.99$). College concerns did not interact with condition, $b = -.27$, $t(50) = 1.16$, $p = .25$.

Finally, there was some evidence for reduced stress appraisals being a pathway to explain the self-affirmation effects on epinephrine. Overall there was a positive correlation between thinking about the possibility of failure during the examination and posttest epinephrine, $r(49) = .34$, $p = .02$ and a marginal negative correlation between having the attitude that if you don't know it, there is no point worrying, and posttest epinephrine, $r(49) = -.24$, $p = .098$. However, mediational analyses examining whether stress appraisals account for either the effect of affirmation or the interaction between college concerns and affirmation in predicting posttest epinephrine were not significant.[4] Taken together, these postexamination stress appraisals support the stress-buffering hypothesis; it appears that the self-affirmation enabled participants to be less stressed and worried during this most stressful midterm examination.

Discussion

The present study provides the first experimental evidence demonstrating that brief self-affirmation exercises can buffer cumulative stress responses to real world academic examination stressors. Participants who completed two brief self-affirmations in the weeks prior to their midterm had reduced epinephrine responses during the difficult midterm examination period relative to those who completed a matched control activity. By affirming themselves on their important values, these students were physiologically buffered during this stressful examination period. In combination with a previous laboratory study (Creswell et al., 2005), the present study indicates that self-affirmation can buffer neuroendocrine and sympathetic nervous system responses to real world stressors. As these hormone effectors have been linked to a variety of negative health and disease outcomes (S. Cohen et al., 2007), self-affirmation provides a promising new direction for reducing stress in stressed patient populations and for improving the efficacy of stress management interventions.

This study joins a body of research showing that self-affirmations can buffer stress and improve performance outcomes in evaluative and threatening settings. In one demonstration, a self-affirmation intervention among minority middle school students led to improved academic performance, reducing the race achievement gap in end of semester performance by 40% (Cohen et al., 2006). The present study, by demonstrating that self-affirmation buffers cumulative stress responses among those most vulnerable to the potential threat posed by academic evaluation, provides one possible explanation for this finding. Our findings suggest that in the absence of affirmation, those who are most psychologically vulnerable, either because of minority status or concern about negative evaluation more generally, may perceive that their self-worth and social status is to some extent contingent upon their academic performance, providing additional concerns when they face evaluation. Writing about valued qualities may serve to secure students' perception that they would still be "a good person" and valued by others regardless of their performance, reducing stress and these additional concerns. In the Cohen et al. (2006) study, then, the self-affirmation may have buffered minority students from the additional arousal and stress they may have experienced in academic settings when their poor performance could confirm a negative group stereotype, stress that could undermine their preparation and performance (O'Brien & Crandell, 2003; Steele, Spencer & Aronson, 2002).

Psychological Pathways

The present study raises important questions about the potential pathways by which self-affirmation buffers stress. Based on their retrospective stress appraisals, the self-affirmation appears to have changed the way participants experienced the examination stressor. The participants in the self-affirmation condition reported

[4] The two stress appraisal measures were uncorrelated with posttest norepinephrine, $r(49) = -.02$, $p = .89$ for "if I don't know it now . . ." and $r(49) = -.02$, $p = .89$ for thinking of failure. Also, on the mediation analyses, thinking of failure, for example, was not associated with posttest epinephrine when entered into Step 1 ($b = .18$, $p = .59$) or Step 2 ($b = .10$, $p = .77$) of the regression analysis.

being less concerned about failure and being quicker to move on cognitively if they did not know an answer. Thus, the affirmation seemed to reduce the additional concerns that often lead people to exacerbate stressors. Moreover, there was correlational evidence of a relationship between being concerned with failure and posttest epinephrine, suggesting that allaying these meta-level concerns may be a pathway by which self-affirmation reduced stress.

These findings suggest that when people are given the opportunity to write about important values, it may put the stressor into a different context. They may be more secure in their self-worth, and thus, less concerned about what the potential failure would represent in terms of their overall self-image. It was important that the self-affirmation did not reduce performance, but it seemed to reduce the stress associated with performing poorly on an important exam. Consistent with the possibility that the self-affirmation can reduce concerns about the implications of failure, other research has found that experimentally induced self-affirmations can lead to the cessation of rumination about academic failures (Koole et al., 1999). Examination time is often stressful for students because they continually reprocess what could happen to them if they do not obtain the desired grade, and in particular, focus on past events when they did not do as well as they had hoped. The self-affirmation appears to have changed how participants experienced and thought about the stressor, attenuating the psychological and physiological stress responses.

Limitations

There are several limitations and unanswered questions raised by this study. First, it is important to note that the study was conducted with college students. Although these students were confronting a real and meaningful daily stressor in their examinations, it is important to conduct similar studies with other, more chronically stressed populations.[5] Second, although we did observe a consistent stress buffering effect of self-affirmation on both epinephrine and norepinephrine levels during the examination period, and consistent interactions with psychological vulnerability, it is important to note that the norepinephrine levels did decrease overall from baseline to the examination stress period. One explanation for this decrease centers on the role of exercise and physical activity on urinary levels of norepinephrine. It is well-established that norepinephrine is also released during exercise or physical activity as well as during stress (Rogers et al., 1991; Steptoe, 1987; Weiner, 1992). We believe that this overall decrease in norepinephrine is partially explained by decreases in physical activity levels during the academic examination period, as students were likely exercising less as they were studying more.[6] Thus, the stronger decrease in norepinephrine in the self-affirmation condition relative to the control condition may be due to decreases in exercise and physical activity as well as the stress-buffering effects of self-affirmation.

Implications for Chronically Stressed Patient Populations

The present findings have implications for improving health outcomes in patient populations. As stress has been linked to increased disease progression in cancer patients and in particular through changes in sympathetic nervous system and hypothalamic—pituitary—adrenocortical activation (Antoni & Lutgendorf, 2007; Sephton & Spiegel, 2003) it is possible that interventions with these populations that include self-affirmation components could lead to improved health. We have shown in the present study that a brief affirmation activity can buffer cumulative catecholamine responses to a real-world stressor, providing initial experimental evidence for the efficacy of self-affirmation in stressful real world contexts (cf. Creswell et al., 2005; Keough & Markus, 1999). This finding is consistent with recent research in patient samples, where self-affirmation writing was associated with reduced self-reported distress and physical symptoms in breast cancer survivors (Creswell et al., 2007). The present study suggests that interventions that enable vulnerable individuals to draw on alternative self-resources can reduce sympathetic nervous system responses to naturalistic stressors. Taken together with these other studies on self-affirmation, stress, and health, the present findings highlight the translational potential of self-affirmation in stress and health contexts, and hopefully encourage further studies testing the efficacy of self-affirmation interventions in patient populations.

[5] Furthermore, within college students, we only sampled those who were not heavy caffeine consumers, as we omitted those who said that had they consumed more than 14 caffeinated beverages per week or who indicated that they would not restrict their caffeine consumption during the study. This sampling limits our ability to generalize to higher caffeine consumers.

[6] Supporting this explanation, we examined reports of exercise. Seventeen participants reported exercising the night before each urine sample was collected. Of those 17, there was a decrease in number of minutes exercised from the pretest ($M = 61.18$, $SE = 11.94$) to the posttest ($M = 30.88$, $SE = 7.74$), $F(1, 16) = 5.67$, $p = .03$, $\eta_p^2 = .26$, suggesting that in general students were reducing their exercise during the midterm examination period (although this may have been due to the repeated reminders to restrict exercise usage during the period of the study).

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