Individual Differences in Repressive-Defensiveness Predict Basal Salivary Cortisol Levels

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Prior studies assessing the relation between negative affective traits and cortisol have yielded inconsistent results. Two studies assessed the relation between individual differences in repressive-defensiveness and basal salivary cortisol levels. Experiment 1 assessed midafternoon salivary cortisol levels in men classified as repressors, high-anxious, or low-anxious. In Experiment 2, more rigorous controls were applied as salivary cortisol levels in women and men were assessed at 3 times of day on 3 separate days. In both studies, as hypothesized, repressors and high-anxious participants demonstrated higher basal cortisol levels than low-anxious participants. These findings suggest that both heightened distress and the inhibition of distress may be independently linked to relative elevations in cortisol. Also discussed is the possible mediational role of individual differences in responsivity to, or mobilization for, uncertainty or change.

Glucocorticoid hormones mediate or modulate a number of important processes. For example, unpredictability, uncontrollability, and related factors reliably elicit glucocorticoid secretion (e.g., Gunnar, Marvinney, Isensee, & Fisch, 1988), and glucocorticoids facilitate optimal coping with threat (e.g., Takahashi & Rubin, 1993). Glucocorticoids also have modulatory effects on perception, learning, and memory (e.g., McEwen

et al., 1992) and on immunological, cardiovascular, and metabolic functioning (for reviews, see, e.g., Cupps & Fauci, 1982; McEwen et al., 1992). Finally, high levels of glucocorticoids, due to various abnormalities of hypothalamic-pituitary-adrenal (HPA) axis function, have been implicated in depression and other disorders (e.g., Murphy, 1991).

Given the broad range of functions affected by glucocorticoids and the response of glucocorticoids to psychological stimuli, it is not surprising that a number of studies have assessed whether specific personality dimensions predict levels of cortisol (the primary glucocorticoid in humans). Consistent with the long-standing emphasis on the relation between the HPA axis and stress, one major focus has been the relation between cortisol and anxiety, distress, or other indicators of a broad dimension of negative affect (NA; e.g., Watson & Clark, 1984). Studies in this area have yielded inconsistent results.

One set of studies has found that, among individuals exposed to short-term (e.g., Benjamins, Asscheman, & Schuurs, 1992; Hellhammer, Hubert, & Rolf, 1985; Kagan, Reznick, & Snidman, 1988; Lundberg & Frankenhaeuser, 1980) or long-term (e.g., Antoni et al., 1990; Davidson & Baum, 1986; Vickers, 1988) stressors, heightened subjective or behavioral signs of anxiety or distress are associated with heightened cortisol responses or levels. Related findings have indicated a linkage between heightened basal cortisol levels and traits characterized by proneness to anxiety and distress (e.g., Bell et al., 1993; Kagan et al., 1988; Montagner et al., 1978). Additionally, administration of glucocorticoids has been associated with increased self-reported fear or anxiety (e.g., Persky, Smith, & Basu, 1971).

In contrast, other studies have found the opposite relation, that is, a linkage between decreased negative affect and (a) increased cortisol responses to stressors (e.g., Dorn, Susman, &

Petersen, 1993; Manyande et al., 1992; Miyabo, Asato, & Mizushima, 1979) and (b) increased basal levels of cortisol (e.g., Bell et al., 1993; Brändtstädter, Baltes-Götz, Kirshbaum, & Hellhammer, 1991; Mattsson, Gross, & Hall, 1971). Consistent with this evidence are infrahuman findings showing that glucocorticoid administration has anxiolytic effects (McEwen et al., 1992) and that elimination of glucocorticoids amplifies fear responsivity (Weiss, McEwen, Silva, & Kalkut, 1970) and symptoms of learned helplessness (Edwards, Karkins, Wright, & Henn, 1990). Finally, other studies have failed to find any significant or replicable relations between negative affect and cortisol (e.g., Bohnen, Nicolson, Sulon, & Jolles, 1991; Kirschbaum, Bartussek, & Strasburger, 1992).

The primary goal of the present studies was to examine the relation between cortisol and a personality typology that may help resolve at least some of these inconsistencies. Using criteria first developed by Weinberger, Schwartz, and Davidson (1979), several studies have classified participants on the basis of responses to the Marlowe-Crowne Inventory (MC; Crowne & Marlowe, 1964) and the Manifest Anxiety Scale (MAS; Taylor, 1953) or other measures of negative affect (e.g., neuroticism). Three groups have typically been formed: repressors (low MAS, high MC scores), low-anxious (low MAS, low MC scores), and high-anxious (high MAS, low MC scores). Repressive and low-anxious participants typically have reported low levels of negative affect when compared to high-anxious participants. However, relative to low-anxious participants, repressors have demonstrated greater responsivity to stressors on autonomic measures (e.g., Newton & Contrada, 1992; Weinberger et al., 1979) and elevated resting systolic blood pressure (e.g., King, Taylor, Albright, & Haskell, 1990).

Evidence suggests that repressors and high- and low-anxious individuals might demonstrate differences in HPA activation that parallel the differences in autonomic activity found in prior studies. These findings lead to the prediction that low-anxious individuals would demonstrate lower cortisol levels than both repressors and high-anxious individuals. For example, individuals who use flexible-accommodative coping strategies have lower basal cortisol levels than those who use a more rigid, less adaptable style (Brändtstädter et al., 1991; Knight et al., 1979). Low-anxious individuals commonly describe themselves as flexible and adaptive (Weinberger, 1990). Other studies have indicated an association between the tendency to use avoidant coping strategies (e.g., denial and reaction formation) and heightened cortisol levels (Knight et al., 1979; Vaernes, Ursin, Darragh, & Lambe, 1982; Ursin, 1987). Although such effects have not been found in all studies (e.g., Wolff, Hofer, & Mason, 1964), they are relevant because repressors demonstrate an avoidant coping style that may inhibit the experience of negative affect (for a review, see Weinberger, 1990). Finally, several studies have shown that two characteristics of high-anxious individuals, heightened distress and a ruminative coping style, are often associated with heightened cortisol levels (e.g., Davidson & Baum, 1986).

Both repressors and low-anxious individuals report low negative affect. If repressors have higher cortisol levels than low-anxious participants, failure to classify them as two separate groups might at least partially account for the weak and inconsistent findings concerning the relation between trait indexes of negative affect and cortisol yielded by prior studies. In addition,

repressive-defensiveness studies and related research (e.g., Gross & Levenson, 1993) have shown that inhibition of distress is often associated with elevated sympathetic nervous system activity. Evidence of elevated cortisol levels in repressors relative to low-anxious participants would suggest that such inhibition is also associated with heightened HPA activation.

We tested our hypotheses by assessing basal cortisol levels in repressive, high-anxious, and low-anxious participants. We focused on basal cortisol because (a) previous repressor studies have found differences on basal measures of physiological systems that are influenced by glucocorticoids, and (b) differences on basal measures are likely to reflect long-term patterning and have greater long-term consequences. We measured cortisol in saliva because it can be reliably assayed and offers several advantages over other measures (e.g., Kirschbaum & Hellhammer, 1989). First, it is noninvasive. Second, plasma measures assess both physiologically active (i.e., free) and inactive (i.e., protein-bound) cortisol, whereas saliva cortisol provides an index of only physiologically active free cortisol.

In the first experiment, we studied male undergraduates classified as repressors, high-anxious, or low-anxious. We predicted that repressors and high-anxious participants would have significantly higher cortisol levels than low-anxious participants.

Experiment 1

Method

Participants

Participants were 39 male undergraduates (age range = 18–22 years) enrolled in Introductory Psychology at the University of Wisconsin—Madison. They completed the short form of the Weinberger Adjustment Inventory (WAI; Weinberger, 1991; Weinberger & Schwartz, 1990) during a mass testing session at the beginning of the school term (n = 1060). A portion of those who met inclusion criteria based solely on the Repressive-Defensiveness and Distress scales of the WAI were chosen at random and invited to attend experimental sessions (n = 78). During these sessions, participants completed the MC and the short form of the MAS (Bendig, 1956). Cortisol assays were performed only on those participants who met second-stage inclusion criteria based on their MC and MAS scores and the overall pattern of scores on the WAI Restraint, Repressive-Defensiveness, and Distress scales (n = 39).

Measures

Marlowe-Crowne Inventory. This 33-item scale assesses both the tendency to deny negative characteristics that are likely to be common and the tendency to ascribe to oneself positive characteristics that are thought to be rare. The MC has appropriate internal consistency reliability (K-R 20 = 0.88) and test–retest stability (1-month test–retest r = 0.88) for a trait measure (Crowne & Marlowe, 1964).

Manifest Anxiety Scale. The 20-item short form of the MAS was used to measure trait anxiety. Coefficient alphas of 0.76 (Bendig, 1956) and 0.89 (Sincoff, 1992) have been reported in adult samples. The MAS is highly correlated with other measures of trait anxiety and negative affectivity (Watson & Clark, 1984).

Weinberger Adjustment Inventory. The short form of the WAI (Weinberger 1991) assesses superordinate dimensions of distress, restraint, and repressive-defensiveness. The 12-item Distress scale is significantly correlated with other indicators of a broad negative affect dimension. The 12-item Restraint scale assesses the tendency to inhibit immediate impulses or emotions in the interest of more long-term

goals. The 11-item Repressive-Defensiveness scale assesses extreme restraint and the tendency to deny negative characteristics that are likely to be common in the general population. All three short-form scales have acceptable internal consistency reliability (coefficient alphas in the 0.79–0.86 range) and test–retest reliability (2-week test–retest rs in the 0.75 to 0.88 range) (Weinberger 1991). The construct validity of these scales has been indicated by patterns of convergent and discriminant validity with external measures (Weinberger, 1991; Weinberger & Schwartz, 1990). There are empirical linkages between the MAS and WAI Distress scale and between the MC and both the WAI Repressive-Defensiveness scale and specific facets of the WAI Restraint scale (Weinberger, 1990, 1991; Weinberger & Schwartz, 1990).

Coping Style Classifications

We used a selection procedure based on patterns of scores on both the WAI scales and on the MC and MAS. A two-stage, multiple-criterion procedure was used because it could potentially maximize the validity of the classifications formed (Wiggins, 1973).

Repressors. Participants were classified as repressors if they met the following criteria: (a) WAI Distress and MAS scores below the median of their respective distributions of scores; (b) WAI Repressive-Defensiveness and MC scores in the top quartile of their distributions of scores; and (c) a pattern of WAI Distress, Repressive-Defensiveness, and Restraint scores that met Weinberger's (1991) criteria for the repressive category. Table 1 shows the means and *SDs* on these measures for this group and the other groups discussed below.

Low-anxious/self-assured group. Participants were classified as low-anxious if they met the following criteria: (a) WAI Distress and MAS scores below the median of their respective distributions of scores; (b) WAI Repressive-Defensiveness and MC scores in the bottom quartile of their distribution of scores; and (c) a pattern of WAI Restraint and Distress scores that met Weinberger's criteria for the self-assured category (see Table 1).

High-anxious/reactive group. The major features of participants classified as high-anxious or reactive were (a) scores on the anxiety indices that were higher than those of both repressors and low-anxious participants; and (b) scores on the defensiveness indexes that were lower

than those of repressors but comparable to those of low-anxious participants. The following criteria were used: (a) WAI Distress and MAS scores above the median of their respective distributions of scores; (b) WAI Repressive-Defensiveness and MC scores in the bottom quartile of their distribution of scores; and (c) a pattern of WAI Restraint and Distress scores that met Weinberger's criteria for the reactive category (see Table 1). For the sake of brevity, we refer to the low-anxious/self-assured group as low-anxious and we refer to the high-anxious/reactive group as high-anxious.

Procedure

Participants were informed in advance that the study involved collection of saliva samples and completion of several health and personality questionnaires. To limit variability due to circadian variations in cortisol, all participants came to the laboratory on a weekday at 3:30 PM. To limit the effects of transient stressors, participants were scheduled at a time during the school term when midterm or final exams were not typically administered. Participants were studied in small groups of approximately 8–12 individuals. After arriving at the laboratory, participants were instructed to deposit an amount equal to 2 ml of saliva into test tubes. All participants collected an adequate amount of saliva within 2–3 min. Samples were obtained at 3:45 PM, 4:10 PM, and 4:35 PM and were immediately frozen at $-20°$ C until the time of analysis. In addition to providing saliva samples, participants completed the MC and the MAS and several brief questionnaires not directly relevant to the goals of the present study.

Cortisol Analysis

Salivary cortisol concentrations were determined by radioimmunoassay using a commercially available kit (Du Pont Co., Billerica, MA) adapted for use with saliva. After centrifugation, duplicate 200-μl samples of unextracted supernatant were incubated with anti-cortisol serum for 30 min at room temperature. ^{125}I-labeled cortisol was then added and assay tubes were incubated at 4°C overnight. On the following day, standard second antibody techniques were used to separate free from bound cortisol. Commercially prepared samples of between 42 and 389 ng/ml yielded an average intraassay coefficient of variation of 3.8% and an average interassay coefficient of variation of 6.0%.

Design and Analysis

An omnibus, mixed-model Coping Style (repressor/low-anxious/high-anxious) × Time (1/2/3) analysis of variance (ANOVA) was performed to test for group differences in cortisol (ng/ml) averaged across each of the three time points. Because we hypothesized that both repressors and high-anxious participants would have higher cortisol values than low-anxious participants, we also conducted a planned contrast that assessed whether the pooled repressor and high-anxious groups had higher mean cortisol levels (averaged across time points) than the low-anxious group. We adopted the decision rules that (a) we would only conduct post-hoc tests assessing pairwise differences between the low-anxious group and the high-anxious and repressor groups if the planned contrast yielded significant differences, and (b) we would only conduct a post-hoc test assessing differences between the repressor and high-anxious groups if a significant effect for Coping Style was determined by the omnibus ANOVA. Fisher least significant difference (LSD) tests were used for such post-hoc analyses.[1]

Table 1
Group Means on Measures Used to Classify Participants in Experiment 1

	Coping style group					
	High-anxious		Low-anxious		Repressor	
Scale	M	SD	M	SD	M	SD
Marlowe–Crowne Inventory	6.13	3.09	9.50	2.37	22.43	3.18
Manifest Anxiety Scale	9.00	2.00	2.40	1.43	2.14	1.79
WAI Distress	39.53	5.10	18.90	3.25	17.64	3.82
WAI Restraint	37.13	4.31	46.30	2.83	53.29	3.41
WAI Repressive-Defensiveness	15.87	3.14	16.00	3.71	37.71	4.58
n	15		10		14	

Note. WAI = Weinberger Adjustment Inventory. The short forms of the Manifest Anxiety Scale and the WAI Distress, Restraint, and Repressive-Defensiveness scales were used. Potential ranges: Marlowe–Crowne Inventory = 0–33; Manifest Anxiety Scale = 0–20; Distress = 12–60; Restraint = 12–60; Repressive-Defensiveness = 11–55.

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[1] In the case of three groups when only pairwise post-hoc contrasts are conducted, the LSD test is the optimal post-hoc procedure. Its familywise Type I error rates correspond to nominal levels and its power is typically superior to that of other procedures (for a review, see Levin, Serlin, & Seaman, 1994).
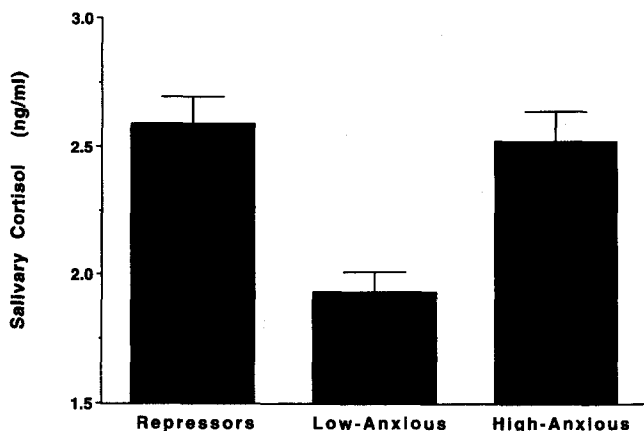
Figure 1. Mean salivary cortisol levels (ng/ml) across three time-points in Experiment 1. Error bars equal one-half standard error of the mean.

Results and Discussion

Figure 1 shows the mean cortisol values, averaged across the three assessment times, of the Coping Style groups. Consistent with predictions, the repressive and high-anxious groups had higher mean cortisol values than the low-anxious group. Although the omnibus ANOVA yielded only a marginally significant main effect for Coping Style, $F(2, 36) = 2.38, p < .10$, the more powerful omnibus Welch test (Welch, 1951) indicated a significant Coping Style main effect, $F(2, 24) = 4.16, p < .05$.

Perhaps more importantly, as predicted, both the Welch and ANOVA-based (i.e., pooled variance) planned comparisons indicated significant differences between the low-anxious group and the pooled repressor and high-anxious groups (Welch $t[29.28] = 2.88, p < .01$, pooled-variance $t[36] = 2.17, p < .05$). Subsequent follow-up contrasts indicated that low-anxious participants had significantly lower cortisol values than repressors, Welch $t(21) = 2.57, p < .025$, LSD $t(36) = 2.04, p < .05$. In addition, the Welch procedure indicated that the low-

A Levene's test conducted on cortisol pooled across time points indicated significant heterogeneity of variance among the three groups, $F(2, 36) = 3.39, p < .05$ (high-anxious $SD = 0.923$, low-anxious $SD = 0.459$, repressor $SD = 0.784$). The ANOVA can become overly conservative when, as in the present case, the group with the largest sample size has the largest variance and the group with the smallest sample size has the smallest variance (e.g., Tomarken & Serlin, 1986). Therefore, we additionally performed an omnibus test and planned and post-hoc contrasts using procedures developed by Welch (1947, 1949, 1951) that do not assume variance homogeneity. Under variance heterogeneity, the Welch procedure provides excellent control of Type I errors and superior power relative to the ANOVA or other commonly used ANOVA alternatives (e.g., Tomarken & Serlin, 1986). We present both the Welch and the ANOVA-based results because the most conventionally accessible applications of the Welch procedures only allow for tests of between-group effects, while the ANOVA allows for tests of both between-group and within-subjects effects (e.g., effects of time of assessment).[2] All within-subjects effects in Experiments 1 and 2 were Greenhouse-Geisser corrected for potential sphericity violation (Geisser & Greenhouse, 1958).

anxious group had significantly lower cortisol values than the high-anxious group, Welch $t(21) = 2.09, p < .05$, LSD $t(36) = 1.83, p < .08$. No significant differences were observed on comparisons between the high-anxious group and repressors, $ps > .80$. Overall, these findings are consistent with the notion that both heightened negative affectivity and heightened defensiveness may be linked to heightened basal cortisol levels, or, conversely, that low levels of both negative affectivity and defensiveness may be linked to processes that serve to inhibit basal cortisol secretion.

The omnibus ANOVA also yielded a significant main effect for Time, $F(2, 72) = 9.28, p < .001$, attributable to progressively declining cortisol values across the three assessment points, linear trend $t(36) = 3.46, p < .002$ (Time 1 $M = 2.73$ ng/ml, Time 2 $M = 2.40$ ng/ml, Time 3 $M = 2.06$ ng/ml). Such declines are consistent with known diurnal variations in cortisol. The Coping Style × Time interaction was nonsignificant, $F(4, 72) < 1, p > .50$.

Experiment 2

Experiment 2 was designed to replicate and extend the findings of Experiment 1 and to address potential ambiguities associated with the procedure used in our initial experiment. Rather than assessing cortisol on only one occasion, we did so on nine occasions. We collected saliva at three fixed times (8:00 AM, 3:00 PM, and 9:00 PM) on each of 3 days. This procedure had several advantages. First, measures aggregated across multiple occasions have greater temporal stability (e.g., Epstein, 1979) and stronger relations with personality indices (e.g., Rushton, Brainerd, & Pressley, 1983) than measures assessed on a single occasion. Basal salivary cortisol averaged across both days and times of day demonstrates acceptable temporal stability for a measure of individual differences (e.g., intraclass $r = .84$ for 3-day averages; Tomarken, Brown, Orth, & Loosen, 1996).

Assessments of cortisol on more than one occasion also allowed us to address whether the results of Experiment 1 reflected group differences in basal cortisol or in cortisol responsivity to the laboratory environment. Although the procedure used in Experiment 1 would not appear to be stressful, exposure to novel environments can elicit increased cortisol secretion (e.g., Levine, Coe, & Wiener, 1989). By requiring participants to attend multiple laboratory sessions, the procedure used in Experiment 2 allowed us to: (a) assess possible habituation to the novelty of the laboratory, and (b) assess whether group differences were moderated by time of assessment (i.e., Day 1 vs. Day 3). The multiple-session procedure used in Experiment 2 also allowed us to assess whether the effects observed in Experiment 1 were generalizable across times of day. Basal cortisol has a circadian rhythm that normally peaks in the morning

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[2] We performed supplementary analyses on log-transformed cortisol values in both Experiments 1 and 2. We present only the results of analyses performed on the nontransformed values because in one or both studies: (a) the log-transformed and nontransformed analyses yielded identical results; (b) some variance heterogeneity was evident even on log-transformed cortisol; and (c) the distribution of nontransformed cortisol in the three groups did not deviate significantly from normality (all $ps > .05$).

hours at about the time of awakening and reaches its nadir early in sleep. Time of day can moderate the relation between personality measures and cortisol (e.g., Brändtstädter et al., 1991).

In Experiment 1, we also did not control for several biomedical and behavioral factors that might affect cortisol secretion. For this reason, in Experiment 2 we excluded potential participants on the basis of several such factors and instituted stricter procedural criteria (see *Method* section). Finally, in Experiment 2, we made two changes that pertained to participant selection and classification. Whereas Experiment 1 used only male participants, both men and women participated in Experiment 2. In Experiment 2, we also selected participants according to criteria that were different from those used in Experiment 1. In Experiment 1, to qualify for the high-anxious group, participants not only had to meet MAS and MC criteria but also had to score extremely low on the WAI Repressive-Defensiveness and Restraint scales. It is likely that a higher proportion of high-anxious participants in previous repressive-defensiveness studies scored in the moderate range on the MC or similar measures (e.g., Weinberger et al., 1979). More generally, the use of the WAI as well as the MC and MAS to classify participants raises questions about the relation between our findings and those of previous repressive-defensiveness studies, the majority of which have used only the latter two measures to classify participants. For this reason, and because of the smaller pool of potential participants relative to Experiment 1, we selected participants using only the MC and MAS in Experiment 2.

Method

Participants

Male and female undergraduates were recruited from the Introductory Psychology course pool at Vanderbilt University. From 620 students who were administered the MC and the 50-item long version of the MAS in small groups, 140 potential participants were identified who met criteria for inclusion in either low-anxious, high-anxious, repressor, or defensive high-anxious groups. Low-anxious participants scored in the lower third of the distribution of scores on both the MC and MAS (MC ≤ 12, MAS ≤ 11). High-anxious participants scored in the lower third on the MC (MC ≤ 12) and the upper third on the MAS (MAS ≥ 21). Repressors scored in the upper third on the MC (MC ≥ 19) and the lower third on the MAS (MAS ≤ 11), and defensive high-anxious subjects scored in the upper third on both the MC and the MAS (MC ≥ 19, MAS ≥ 21). These cutoff points were consistent with those used in Experiment 1 and in several prior studies.

During a telephone interview, potential participants were screened for a set of exclusionary criteria assessing factors that could potentially affect cortisol levels. Participants were not included if they reported (a) a history of any endocrine abnormalities; (b) other chronic medical conditions or recent injuries or illnesses in the past 6 months; (c) recent use of prescription or nonprescription medications; (d) excessive alcohol intake (i.e., an average of > two drinks per day); and (e) more than occasional use of cigarettes (i.e., a pack per week or more). Women were excluded if they reported that they were pregnant or that they used oral contraceptives (Meulenberg, Ross, Swinkels, & Benraad, 1987). Finally, to minimize the effects of transient elevations in cortisol due to academic stressors (see Kirschbaum & Hellhammer, 1989), we required participants to schedule laboratory days when they had no examinations, papers, or class presentations.

One hundred and twenty-two of the 140 potential participants agreed to the initial telephone interview. The remainder had fulfilled Introduc-

tory Psychology participation credits by other means. Of the 122, 83 potential participants met the criteria noted above. Seventy-one of these participants (41 men and 30 women; age range = 18–22) attended all 9 experimental sessions and consistently adhered to the procedural criteria described below. The major reason that participants were dropped from the study was failure to attend all 9 sessions. Drop-out rates were not differential across the coping style groups (*ps* > .50). Only 3 men and 3 women met criteria for the defensive high-anxious group. Because of these small *n*s, we eliminated this group from analyses. Thus, 65 participants were in the sample used for analyses. The means on the MC and MAS for the three remaining groups follow: high-anxious: MC *M* = 8.10, MAS *M* = 28.65; low-anxious: MC *M* = 8.56, MAS *M* = 8.16; repressors: MC *M* = 21.99, MAS *M* = 7.91.

Procedure

Participants were asked to schedule three separate weekdays for laboratory sessions. Most participants scheduled sessions within a 2-week period. On each of these three days, participants came to the laboratory at three separate times, between 7:45 AM and 8:15 AM, 3:00 PM and 3:30 PM, and 9:00 PM and 9:30 PM, for a total of nine laboratory sessions.[3]

Participants were instructed not to eat or exercise for at least 2 hours prior to laboratory sessions and to refrain from any alcohol use beginning on the evening prior to a laboratory day and until the final assessment of that day. When participants arrived at the laboratory, the experimenter first assessed their adherence to procedural criteria. Participants were asked to reschedule laboratory days if they failed to meet the procedural or exclusionary criteria noted above. If a session was missed, the entire day was rescheduled and repeated. In addition, for the majority of participants (*n* = 45), we recorded the self-reported time of falling asleep on the previous night, time of awakening that morning, and total sleeping time. We also assessed height and weight, measures subsequently used to compute body-mass index (BMI) (kilograms/meter^2). Coping Style (repressor/high-anxious/low-anxious) × Sex ANOVAs revealed no significant main effects or interactions involving Coping Style on these measures. The only significant effects that emerged were the expected sex differences in height, weight, and BMI (*ps* < .001).[4] After these assessments, participants used polypropylene transfer pipettes to collect at least 1 ml of saliva. Saliva samples were transferred directly into polypropylene tubes and frozen until the time of analysis.

Cortisol Analysis

To accommodate the lower concentration of cortisol that we expected to find in the evening samples, we developed an in-house radioimmunoassay optimally sensitive for the measurement of cortisol in saliva. Although it is not uncommon for different endocrinology laboratories to use different assay methods, secondary advantages of using an in-house method included lower cost and the potential to demonstrate generalizability across different settings. Briefly, we incubated triplicate tubes of either unextracted salivary supernatant or appropriately diluted reference standard at 4°C for 18 hours with 100 μl each of ^{125}I-cortisol

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[3] The number of participants present at any given time ranged from 1 to 4. The modal number was 1. There was no relation between group size and salivary cortisol levels.

[4] Due to administrative error, 20 participants were not administered these measures. Consistent with the absence of any trends for Coping Style on analyses of these measures, power analyses indicated that Coping Style effects would have remained clearly nonsignificant had sample sizes been increased. In addition, correlations computed between these measures and average cortisol levels indicated no significant relations (all *ps* > .05).

(Diagnostic Products Corp., Los Angeles, CA) and rabbit anti-cortisol serum (developed in the laboratory of David N. Orth). Forty to 100 μl of saliva were used per assay tube, depending upon the time of day that the sample was collected. Phase separation was achieved by adding 100 μl of goat anti-rabbit serum (Calbiochem, La Jolla, CA) and incubating the assay tubes for an additional 3 hours at 4°C. The reaction mixture was then diluted with 1.6 ml of an ice-cold 4% w/v solution of polyethylene glycol in assay buffer and centrifuged at 4°C for 30 min. Supernates were decanted and antibody-bound radioactivity was assessed in a gamma scintillation counter. The intraassay coefficient of variation was 4.8% (n = 20) using a pooled saliva control sample (7.8 ng/ml). Using an additional pooled saliva control sample (5.75 ng/ml), the interassay coefficient of variation was 7.7% (n = 31).

Design and Analysis

The structure of analyses was consistent with that used in Experiment 1. We performed an omnibus mixed-model Coping Style (repressor/high-anxious/low-anxious) × Sex (male/female) × Time of Day (8:00 AM/3:00 PM/9:00 PM) × Day (1/2/3) ANOVA on cortisol concentration. Due to the unequal cell ns, between-group effects were appropriately conservative least-squares solutions (Kirk, 1982). In addition to the omnibus ANOVA, and consistent with Experiment 1, a planned analysis was conducted to test the a priori prediction that the pooled repressor and high-anxious groups would demonstrate higher overall cortisol levels than the low-anxious group. This prediction was tested by the Contrast main effect of a Contrast × Sex × Time of Day × Day ANOVA. We adopted decision rules identical to those specified in Experiment 1 for follow-up analyses of any significant effects yielded by the ANOVA or planned contrast. Because our a priori predictions had already been supported by the results of Experiment 1, one-tailed criteria were used for the planned contrast and its two pairwise follow-ups. Two-tailed criteria were used for all other effects and contrasts.

A Levene's test comparing the six Coping Style × Sex cells on mean cortisol levels (i.e., averaged across days and times of day) indicated significant variance heterogeneity, $F(5, 59)$ = 3.00, p < .025. Among men, the variability within the high-anxious group (SD = 1.05) tended to be larger than that of the other two groups (repressor SD = 0.64; low-anxious SD = 0.38). Therefore, we also conducted supplementary Welch tests. We did not conduct Welch analogues to the omnibus ANOVA because the conventionally used Welch omnibus test (Welch, 1951) is only applicable to one-way designs. Using the formula derived by Welch (1947; see also Kirk, 1982), we did, however, conduct a 1-df Welch planned contrast comparing the mean daily cortisol (averaged across days and time of day) of the low-anxious group and the pooled high-anxious and repressor groups. For this contrast, male and female cell means were equally weighted within each of the three coping style groups. In other cases, we conducted Welch contrasts testing effects with 1 df (e.g., main effect of Sex) or testing orthogonal components of effects with more than 1 df. In all cases, the Welch contrasts yielded results that were identical to those of the ANOVA. Below, we present both sets of results for the analyses of primary interest but only the ANOVA-based results for analyses of secondary interest.

Results

Coping Style Effects

Table 2 shows mean cortisol values at each time of day and Figure 2 shows mean daily cortisol levels averaged across both days and times of day for each of the groups. As shown by Figure 2, among both men and women, repressors and high-anxious participants had higher overall cortisol levels than low-anxious participants. Consistent with this observation, the omnibus

Table 2

Mean Salivary Cortisol (ng/ml) by Time of Day in Experiment 2

Time of day	High-anxious		Low-anxious		Repressor	
	M	SD	M	SD	M	SD
			Men			
8:00 A.M.	4.41	2.61	3.70	1.43	5.65	2.00
3:00 P.M.	1.37	0.77	1.19	0.59	1.55	0.48
9:00 P.M.	1.09	0.78	0.66	0.44	0.71	0.43
n	13		12		13	
			Women			
8:00 A.M.	6.28	2.16	5.55	1.50	6.99	2.33
3:00 P.M.	1.62	0.87	1.22	0.70	1.66	0.41
9:00 P.M.	0.85	0.38	0.75	0.25	0.91	0.35
n	12		6		9	

Note. Means are averaged across the 3 days of assessment.

Coping Style × Sex × Time of Day × Day ANOVA yielded a significant main effect for Coping Style, $F(2, 59)$ = 4.51, p < .025. In addition, the planned contrast indicated that the low-anxious group had significantly lower cortisol levels than the combined repressor and high-anxious groups, pooled variance $t(59)$ = 2.70, p < .005, Welch $t(16.29)$ = 3.10, p < .005. For both the omnibus and planned analyses, all two-way and higher order interactions involving Coping Style and Sex, Coping Style and Time of Day, and Coping Style and Day were nonsignificant, all ps > .10.

Pairwise contrasts following up the significant Coping Style effects indicated highly significant differences between the repressor and low-anxious groups, pooled variance $t(59)$ = 3.00, p < .005, Welch $t(18.4)$ = 3.61, p < .001. In addition, high-anxious participants had significantly higher cortisol levels than low-anxious participants, pooled variance $t(59)$ = 1.80, p < .05, Welch $t(25)$ = 1.82, p < .05. No significant differences were observed between the repressor and high-anxious groups, both ps > .15.

Additional Effects

The omnibus Coping Style × Sex × Time of Day × Day analyses yielded several additional significant effects. First, a significant main effect for Time of Day, $F(2, 118)$ = 218.77, p < .0001, is consistent with well-known circadian variation in rates of cortisol secretion (see Table 2). Post-hoc contrasts indicated significant differences in cortisol levels between each pair of time points, all ps < .0001. In addition, women tended to have higher cortisol levels than men, particularly at 8:00 AM (see Table 2). Consistent with this observation, the ANOVA indicated a significant main effect for Sex, $F(1, 59)$ = 10.40, p < .005, and a significant Sex × Time of Day interaction, $F(2, 118)$ = 7.56, p < .01. Follow-up, simple effects analyses indicated significant differences between men and women at 8:00 AM, $F(1, 59)$ = 9.73, p < .01, but not at 3:00 PM or 9:00 PM, ps > .40.
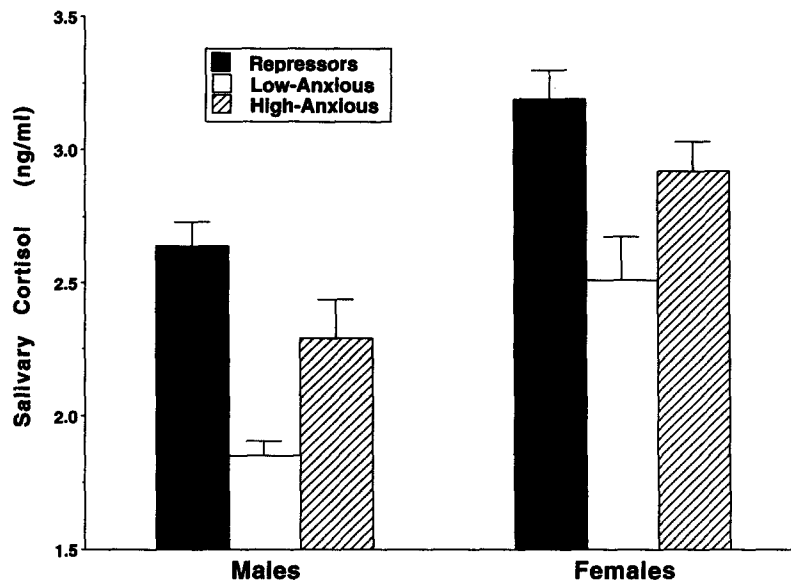
Figure 2. Mean salivary cortisol levels (ng/ml) across all nine assessments in Experiment 2. Error bars equal one-half standard error of the mean.

Discussion

The results of Experiment 2 parallel those of Experiment 1. The pooled repressor and high-anxious group demonstrated significantly higher basal cortisol levels than the low-anxious group. On pairwise comparisons, repressors demonstrated notably higher cortisol levels than low-anxious participants. In addition, differences between the high-anxious and low-anxious groups were significant, although only according to the one-tailed criteria used. While such criteria could be justified, it appears that the differences between high- and low-anxious participants are not as robust as those between repressors and low-anxious participants.

The results of Experiment 2 also extended those of Experiment 1 in several respects. First, while only men participated in Experiment 1, the Coping Style effects observed in Experiment 2 were generalizable across both sexes (i.e., Coping Style × Sex interactions were nonsignificant). Second, according to statistical criteria, the effects of Coping Style were not conditional on day of assessment or time of day. Finally, the use of stricter exclusionary and procedural criteria indicates that these findings are not spurious.

In Experiment 2 women had significantly higher cortisol levels than men during the morning (8:00 AM) assessments. These results are consistent with prior findings using participants in age ranges comparable to those of the college students used in our experiment (e.g., Lundberg & Frankenhaeuser, 1980). Although other studies have failed to find sex differences (for a review, see Kirschbaum & Hellhammer, 1989) or have found opposite effects (Laudat et al., 1988), participants in these latter studies were older than the participants in the present study. Notably, Brändtstädter et al. (1991) found that salivary cortisol values declined with age among women, but not men. Most importantly, the overall pattern of differences among the coping style groups was the same for men and women.

General Discussion

Prior studies of the relation between personality and cortisol have yielded inconsistent results. The differences that we found between repressors and low-anxious participants suggest that some inconsistencies may have been due to heterogeneity among individuals who report low levels of negative affect. In our studies, if we had assessed only trait anxiety and thus pooled repressors and low-anxious participants, the means of this composite group would not have differed significantly from those of the high-anxious group ($ps > .30$).

Perhaps, then, inconsistencies among previous studies were due at least partially to differences across studies in: (a) proportions of repressors, low-anxious, and high-anxious participants, or (b) the degree to which experimental contexts elicited coping responses characteristic of those typically used by these groups. As noted above, prior evidence indicates linkages between (a) increased cortisol levels and both heightened negative affect and heightened denial, attributes characteristic of high-anxious individuals and repressors, respectively, and (b) lowered cortisol levels and increased flexibility, an attribute characteristic of low-anxious individuals (e.g., Weinberger, 1990; Weinberger et al., 1979).

Differential Mobilization for Uncertainty as a Potential Mediator of Effects

One question raised by our findings is precisely why low-anxious participants should have lower basal cortisol levels than repressors and high-anxious participants. One approach to this question is to identify factors that (a) stimulate cortisol secretion, and (b) might be shared by high-anxious individuals and repressors and differentiate both groups from low-anxious individuals. One such factor may be responsivity to, or mobilization

for, unpredictability, uncertainty, novelty, or change. Exposure to such factors reliably elicits heightened basal cortisol secretion and activation of the HPA axis as a whole (e.g., Gunnar et al., 1988). Perhaps, then, low-anxious individuals are less responsive to, or less threatened by, uncertainty, unpredictability, or change than other groups. Such individuals commonly describe themselves as flexible and adaptive (Weinberger et al., 1979). These self-descriptions suggest that low-anxious individuals are relatively unperturbed by uncertainty or change.

In contrast, heightened anxiety has been linked to the tendency to appraise stimuli as unpredictable, uncertain, or uncontrollable and/or to heightened responsivity to stimuli with such characteristics (e.g., Barlow, 1988; Kagan et al., 1988). In addition, anxiety has been linked to a lowered threshold for activation of neural systems specialized for behavioral inhibition in response to uncertainty or novelty (e.g., Gray, 1982; Kagan et al., 1988). Glucocorticoids modulate the functioning of structures (e.g., hippocampus) that are major components of such systems. Such interactions may account for the linkages between activation of the HPA axis and behavioral inhibition (e.g., Kagan et al., 1988; Takahashi & Rubin, 1993).

Repressors may also be more threatened by uncertainty or change than low-anxious individuals. Relative to low-anxious participants, repressors demonstrate many of the cardinal features (e.g., heightened conformity to social norms, heightened self-control, suppression of aggression) of high scorers on the constraint dimension that has been identified by Tellegen and his associates (e.g., Tellegen & Waller, in press). This dimension has strong parallels to Weinberger's (1990) restraint dimension. High-constraint individuals report decreased tolerance for uncertainty or change (Tellegen & Waller, in press). Such intolerance might account for many characteristics of high-constraint individuals (e.g., a tendency to plan activities in advance) and, in the present context, for the higher cortisol levels of repressors relative to low-anxious participants.[5]

It is likely that our experimental context did not elicit notable uncertainty, especially in Experiment 2 during which participants came to the laboratory nine times and experienced essentially the same simple, repetitive, noninvasive procedure. Thus, it is more likely that our effects reflect group differences in reactivity to, or anticipation of, daily naturalistic events. If repressors and high-anxious individuals are more threatened by uncertainty or change than low-anxious individuals, they may be more tonically mobilized to cope with future uncertainty or change. Anticipatory mobilization for unpredictable events can be associated with cortisol elevations (Lundberg & Frankenhaeuser, 1980; Sapolsky, 1992). Future studies should assess whether specific appraisal dimensions (e.g., unpredictability) and coping responses mediate the relation between the repressive-defensive typology and cortisol levels.

We should also note another perspective that could account for elevated cortisol levels among repressors relative to low-anxious participants. Both prior repressive-defensiveness studies and related investigations (e.g., Gross & Levenson, 1993) have indicated an association between the inhibition of negative affect and heightened activation of the sympathetic nervous system. The present findings imply that chronic inhibition of negative affect might also elicit heightened activation of the HPA axis. Munck, Guyre, and Holbrook (1984) proposed that glu-

cocorticoids serve primarily to inhibit or dampen the activity of physiological systems that constitute the body's primary response to stress. Such counter-regulatory effects might also serve to promote inhibition of negative affect or the perception of threat under certain conditions or in specific individuals (for a more extended discussion, see Tomarken & Davidson, 1994).

Relations with Health Outcomes

Elevated cortisol levels might also account in part for the linkage between the repressive-defensive typology and health status. Several studies have shown that repressors (Esterling, Antoni, Kumar, & Schneiderman, 1993; Jamner, Schwartz, & Leigh, 1988) and, in some cases, high-anxious participants (Esterling et al., 1993) show decreases on certain measures of immunological functioning relative to low-anxious participants. Although the relation between the HPA axis and the immune system is extremely complex, cortisol is often immunosuppressive (e.g., Cupps & Fauci, 1982). Thus, between-group differences in cortisol might at least partially mediate the immunological effects found in previous studies. The cortisol effects observed in the present study may also be proximal mediators of repressors' elevated serum glucose (Jamner et al., 1988), serum cholesterol (Weinberger, 1990), and blood pressure (King et al., 1990). More generally, the present results add to the growing evidence that when participants are jointly classified on the basis of measures of negative affectivity and the Marlowe-Crowne Inventory, or similar measures, linkages between personality traits and physiological systems that can influence health status are revealed.

Additional Conceptual and Methodological Issues

We should note several additional ambiguities and limitations concerning our findings. First, it is necessary to assess individuals who are both high in defensiveness and high in anxiety. Second, it is necessary for future studies to account for the greater variance heterogeneity demonstrated by high-anxious participants in both of our studies. Third, we should caution that conclusions drawn from basal cortisol levels are not necessarily generalizable to cortisol responses to discrete stimuli (e.g., Gunnar et al., 1988). Finally, it could be argued that 24-hour urinary cortisol measures, assessing the integrated cortisol secretion over time, are optimal for the assessment of basal cortisol. In an initial pilot study in which participants were self-instructed to collect saliva samples at multiple time points over the course of several days, a minority (15%) did not consistently comply. As a result, we decided that all subsequent sample collections would be conducted in our laboratory. This restriction did not afford reasonable conditions for collection of total 24-hour urine samples. Nevertheless, a desirable goal for future research is assessment of whether the present findings are replicable with urinary-free cortisol measures.

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[5] Consistent with this argument is the evidence that constraint is linked to increased functional activity of serotonergic pathways (Depue & Spoont, 1986). Serotonergic systems have excitatory effects on the HPA (Chaouloff, 1993) and promote behavioral withdrawal from unpredictable or novel stimuli (e.g., Depue & Spoont, 1986).

Summary and Conclusions

In two studies, repressors and high-anxious participants demonstrated higher basal salivary cortisol levels than low-anxious participants. Our findings may account for inconsistencies among prior studies on the relation between personality and cortisol. Future studies should assess the relation between our findings and (a) appraisals of, and mobilization for, uncertainty and unpredictability, and (b) differences in immunological functioning and health status among repressors and other groups.

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