Momentary Work Worries, Marital Disclosure, and Salivary Cortisol Among Parents of Young Children

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Objective: To investigate whether worries about work are linked to people's own cortisol levels and their spouses' cortisol levels in everyday life and whether marital factors may moderate these links. Although research has shown that satisfying marriages can buffer the physiological effects of everyday stress, the specific mechanisms through which marriage influences the processing and transmission of stress have not yet been identified. **Methods:** Thirty-seven healthy married couples completed baseline measures and then provided saliva samples and indicated their worries about work for six times a day from a Saturday morning through a Monday evening. **Results:** Wives' cortisol levels were associated positively with their own work worries ($p = .008$) and with their husbands' work worries ($p = .006$). Husbands' cortisol levels were associated positively only with their own work worries ($p = .015$). Wives low in both marital satisfaction and disclosure showed a stronger association between work worries and cortisol compared with wives reporting either high marital satisfaction and/or high marital disclosure. **Conclusions:** These results suggest that momentary feelings of stress affect not only one's own cortisol levels but affect close others' cortisol levels as well. Furthermore, they suggest that, for women, the stress-buffering effects of a happy marriage may be partially explained by the extent to which they disclose their thoughts and feelings with their spouses. **Key words:** cortisol, marriage, stress, couples, work, self-disclosure.

HPA = hypothalamic-pituitary-adrenal; **EMA** = Ecological Momentary Assessment; **NA** = negative affect; **PSS** = Perceived Stress Scale; **APIM** = actor-partner interdependence model; **CAR** = cortisol awakening response.

INTRODUCTION

The word "family" often conjures up images of a stable, restorative place where people can come home to recuperate from life's daily worries. In reality, the family is a dynamic system, existing not in a vacuum but rather shaped by outside experiences, including stressful ones. It is now well known that reactions to daily stressors can persist after an event has occurred, with individuals carrying home the residue of stressful experiences from work and school into the home—affecting not only peoples' own mood but the mood of other family members as well (1). For example, research has shown that negative mood at work predicts day-to-day changes in angry marital behavior (2), and more stressful experiences at work predict greater distraction and less responsiveness to spouses at home (3).

Although it is clear that experiences at work affect family dynamics at home, the physiological consequences of work-family spillover are less well known. Preliminary findings (4) suggest that stressful experiences at work can affect people physiologically at home, and that satisfying marriages can buffer these effects. However, the specific mechanisms through which marriage influences the processing and transmission of stress on a daily basis have not yet been identified. In this article, we examine the links between short-term changes in a common daily stressor—worry about work—and salivary cortisol among working parents. We also address how between-couple variation in an important marital process—self-disclosure—may moderate the links between work worries and cortisol.

A large number of human and non-human animal studies have documented the effects of stress exposure on the hypothalamic-pituitary-adrenal (HPA) axis. The HPA axis influences other peripheral physiological systems and ultimately health via cortisol, its principal hormonal product (5,6). Over the past two decades, there has been an increased focus on the effects of stress and mood on cortisol in everyday life, with an estimated 38 naturalistic cortisol studies (7) having been conducted. Although these studies (8–10) have demonstrated links between stress and cortisol in naturalistic settings, remarkably few studies have investigated how daily stress might affect close others' cortisol levels. One study (11) showed that greater work hours are positively associated with one's own and one's spouse's cortisol. However, no studies to our knowledge have examined how fluctuations in concerns about work that people carry home with them (which we term "work worries") affect cortisol.

The strength of within-day associations between work worries and cortisol at home may depend, in part, on the quality of the marital relationship. For example, among married working mothers, evening cortisol declines most sharply for those highest in marital satisfaction (4). Furthermore, higher daily levels of intimacy are linked to lower same-day cortisol levels among dual-earner couples (12). However, very little is known about the specific elements of marital quality that may moderate the effects of stress on the HPA axis. One possible candidate is marital disclosure—the extent to which people open up to their spouses about their thoughts and feelings.

There has been growing interest in self-disclosure in daily life, particularly in the context of close relationships (13–15). For example, higher daily levels of self-disclosure in romantic relationships are associated with increased intimacy in those relationships (14,15). Surprisingly, the effects of self-disclosure in relationships on stress physiology have largely been overlooked. Actively holding back thoughts, emotions, or behaviors can exacerbate a number of adverse biological pro-

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Received for publication October 1, 2009; revision received July 29, 2010.

Portions of this research were funded, in part, by Grants MH52391 and MH015750, graduate research assistantship, and postdoctoral fellowship (R.B.S.) from the National Institutes of Health.

DOI: 10.1097/PSY.0b013e3181f60fcc

0033-3174/10/7208-0001

cesses, such as increased cortisol production and immune suppression (16). A large body of experimental evidence has shown that disclosing one's thoughts and feelings through expressive writing results in improvements in physical health (17,18) and HPA axis functioning (19,20). This evidence suggests that disclosures in everyday life—such as marital disclosure—may also have health benefits. Based on previous findings, we expected marital disclosure to buffer the effects of work worries on cortisol.

The major aim of this work was to investigate how work worries when people are at home with their families are linked to one's own cortisol and spouses' cortisol. To our knowledge, no published studies have examined the effects of one person's psychological state on another person's cortisol (e.g., one's spouse) in everyday life. The second aim was to investigate whether marital disclosure moderates the links between momentary work worries and cortisol. Although previous studies have reported effects of written emotional disclosure on biological processes, none to our knowledge has examined the effects of disclosure to close others on biology.

In this study, couples completed Ecological Momentary Assessment (EMA) (21) questionnaires assessing work worries and provided saliva samples six times per day from a Saturday morning through a Monday evening, which captured the days of the week (weekends) that families typically spend the bulk of their time together as well as the often stressful transition from leisure to work (Mondays) (22). We conducted dyadic analyses (23) to assess the effects of one's own feelings of work worries and the effects of spouses' work worries on cortisol.

Based on previous findings, we hypothesized: 1) Momentary work worries would be positively associated with one's own cortisol and spouses' cortisol over the 3 days of the study. 2) Higher overall levels of marital disclosure would moderate the association between momentary work worries and cortisol. In other words, we expected the effects of momentary work worries on cortisol to be attenuated among individuals who were more self-disclosing with their spouses.

METHODS

Participants

Fifty-one families from Austin, Texas, were recruited for a larger study of everyday family life. All families included a mother and a father who were married or cohabitating for at least 2 years and had at least one child between the ages of 3 years and 5 years. Analyses were restricted to those couples who indicated that they both worked at least part-time outside the home. Because of known effects of pregnancy on the HPA axis (24), five couples in which the wife was pregnant were excluded from the analyses. Based on these criteria, 37 complete couples were included in the final sample. Data were collected for this study from August 2006 through May 2007 under approval from the University of Texas at Austin Institutional Review Board.

The average age of participants was 35.6 years (standard deviation [SD] = 4.6) for husbands and 34.5 years (SD = 4.1) for wives. The average length of marriage in the study was 7.4 years (SD = 3.9). Wives worked 30.0 hours (SD = 14.4) per week on average, whereas husbands worked 41.4 hours (SD = 17.3) on average. The ethnic make-up of the sample was 73.0% white/Caucasian, 17.6% Hispanic/Latino, 5.4% black/African American, and 4.0% indicating other ethnicity. The median annual family income was $87,000, ranging from $20,000 to $500,000. Each family was paid $250 for participating in the study.

Procedure

Families initially came to the laboratory on a weekday evening to complete baseline questionnaires and receive an overview of the study. During the following Saturday morning through Monday evening, participants completed momentary questionnaire assessments and provided saliva samples six times per day.

Baseline Measures

Marital Disclosure

Marital disclosure was assessed with a two-item scale developed for this study in which participants were asked, on a 7-point Likert-type scale (1 = very little; 7 = a great deal), "To what extent do you disclose your deepest thoughts and feelings to your spouse?" and "To what extent do you say what's on your mind to your spouse." The α reliability for the current sample was 0.77; mean scores were 5.68 for wives and 4.51 for husbands.

Marital Satisfaction

The Marital Adjustment Test is a well-validated 16-item measure of marital satisfaction (25). The α reliability in this study was 0.79 for wives and 0.75 for husbands. In this sample, the mean score was 104 (range, 47–145) for wives and 105 (range, 40–140) for husbands. This measure was included as a covariate to determine the unique moderating effects of marital disclosure on the links between momentary work worries and cortisol—above and beyond marital satisfaction—and marital disclosure × marital satisfaction × work worries interaction effects. In this sample, correlations between the Marital Adjustment Test and marital disclosure were 0.46 for husbands (p = .004) and 0.26 for wives (p = .12).

Health-Related Variables

To control for possible confounds in the cortisol data, we asked participants to provide information about nicotine habits, caffeine intake, body mass index, and birth control medication.

Ecological Momentary Assessment Measures

Cortisol Collection

From the Saturday morning through Monday evening when families participated in the study, spouses were instructed to self-collect saliva samples and report collection times at six time points: immediately on wakening, 45 minutes later (before any eating, drinking, or exercise), at three semirandom beeped time points in the early evening (approximately 5 PM, 7 PM, and 9 PM), and then at bedtime. The timing of these samples corresponds to recommendations by the MacArthur Research Network on Socioeconomic Status and Health (26). Spouses were each given a signaling device (Casio DataBank DBC-60 programmable watch, Casio USA, Dover, New Jersey), which was preprogrammed to emit signals during the three semirandom times each day. Saliva was collected using a Salivette (Sarstedt 1534, Sarstedt Inc., Newton, North Carolina), consisting of a sterilized cotton swab that the participant placed in his/her mouth for 2 minutes and then stored in a small beaker contained in a plastic tube.

Substantial efforts were made to emphasize the importance of compliance with the study's procedures, particularly with regard to the timing of saliva sampling immediately on waking (27). These efforts included having participants take a practice sample at the outset of the study, explaining to participants why exact timing of the samples is essential, and asking participants to note any sampling issues that occurred. Participants were asked to refrigerate Salivette samples at the end of each day and placed them in plastic bags provided by the experimenter. On returning the Salivettes to the laboratory the following week, samples were stored in a −20°C freezer.

Cortisol levels were determined by time-resolved immunoassay with fluorometric end point detection (28) at the Biological Psychology laboratory directed by Dr. Clemens Kirschbaum at the Technical University of Dresden in Dresden, Germany. The test used 50 μL of saliva and had average intraand interassay coefficients of variation of <8%. To correct for positive skewness, a natural $\log_{10}$ transformation was performed on the cortisol data before analyses. A constant of 1 was added to cortisol values before transformation so that all transformed values would be positive.

Momentary Work Worries

At the six points each day that they provided saliva samples, participants completed an EMA measure of work worries adapted from previous research (29,30). At each sampled moment, participants were given three paired descriptors indicating how they felt about their job at that moment: "Worried about/Not worried at all" (reverse-scored), "Relaxed about/Tense toward," and "In Control of/Controlled by." The descriptors were rated on a 7-point Likert-type scale (range, −3 to +3), standardized to a mean of 0 and an SD of 1, and then averaged together to form a work worries composite. The α reliability for the scale in the current sample was 0.85, with mean scores of 0.08 (SD = 0.63) for wives and −0.09 (SD = 0.59) for husbands.

Momentary Negative Affect

To rule out the possibility that any effects of momentary work worries on cortisol were simply due to overall negative affect (NA), a well-validated 13-item measure of momentary NA (29) was completed at each time point. In response to the question, "How are you feeling right now?" the respondent rated words, such as "frustrated," "worried," and "irritable" on a 4-point Likert-type scale (0 = not at all; 3 = very much), standardized to a mean of 0 and an SD of 1, and then averaged together to form a composite measure of NA. The α reliability for this scale in the current sample was 0.87, with mean scores of 0.00 for wives (SD = 0.38) and −0.04 for husbands (SD = 0.36).

Daily Perceived Stress

To rule out the possibility that any effects of momentary work worries were due to higher overall levels of stress that day, participants completed a short form of the Perceived Stress Scale (PSS) (31) each night. The short form PSS consists of four items that ask respondents how they felt over the past 24 hours (e.g., "In the past 24 hours, how often have you felt that you were unable to control the important things in your life?"). Responses were provided on a 5-point Likert-type scale (0 = never; 4 = fairly often). the α reliability for the current sample for this measure was 0.74, with mean scores of 1.30 for wives (SD = 0.70) and 1.25 for husbands (SD = 0.61).

Overview of Data Analytic Strategy—The Actor-Partner Interdependence Model (APIM)

A unique characteristic of marital data is that the data from spouses are not independent. For example, people who are satisfied in their marriage tend to have spouses who also are satisfied; people who are optimistic tend to have optimistic spouses, and so on. To account for this data interdependence in statistical analyses, researchers in recent years have begun to frame their analyses in the APIM (32). The APIM is a technique designed to address interdependence in dyadic (couple) data. This technique allows researchers to estimate, for example, the influence of one person's momentary work worries on his/her own cortisol—called *actor* effects—as well as the effects of his/her momentary work worries on his/her spouse's cortisol—called *partner* effects. We illustrate this basic APIM design in Figure 1.

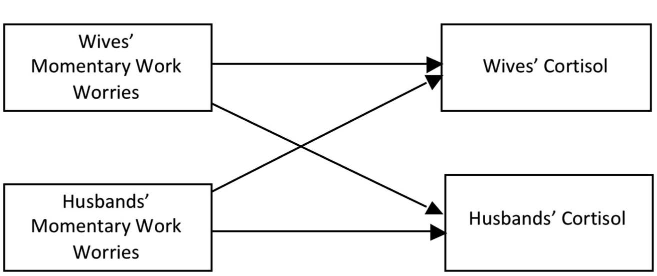

Figure 1. Actor-Partner Interdependence Model used to estimate the association between momentary experiences and cortisol.

APIM analyses in this study were conducted using hierarchical linear modeling (HLM) (33). Because of the strong diurnal rhythm of cortisol, HLM is ideal for its analysis (34). Furthermore, HLM can estimate slopes and intercepts even with missing data.[1] All APIM analyses were conducted using the longitudinal dyadic analysis model proposed by Laurenceau and Bolger (35). With this type of model, data from husbands and wives are on separate lines in the data files, nested within couple-level IDs. Separate intercept and slope terms are created for husbands and wives, with spouses denoted by dummy variables used to calculate intercepts. Using this type of statistical technique, one can model, for example, the effects of wives' work worries on their own cortisol levels and on their husbands' cortisol levels and the effects of husbands' work worries on their own cortisol levels and on their wives' cortisol levels, simultaneously estimating all four of these effects.

A three-level multilevel growth-curve analysis (36) was used. Variables that change with each cortisol sample, such as momentary work worries, are Level 1 variables; day-to-day experiences, such as daily perceived stress and weekends versus weekdays, are Level 2 variables; person-level variables, such as marital disclosure and marital satisfaction, are Level 3 variables. We included both same-sampling moment and prior-sampling moment NA and work worries as Level 1 predictors. This allowed us to examine whether cortisol at each moment was more strongly associated with one's own experiences and spouses' experiences at the prior sampling moment versus sampling moment concurrent with cortisol sampling. Effect sizes were computed from t values (effect size $r = \text{sqrt}[t^2/t^2 + \text{df}]$) and are reported in tables in the results (37).

Because of the large lag between the second and third sampling occasions (from early morning to early evening), the second sampling occasion was not included as a prior-moment predictor in analyses. However, we were still able to incorporate the second-sampling occasion work worries as a same-moment predictor of cortisol (just not as a prior-moment predictor). Additionally, only same-moment experience data were available for the first sampling occasion of each day. Prior-moment work worries and NA were assessed, on average, 1.37 hours earlier, with 93% of the assessments no more than 2 hours earlier (SD = 1.01).

First, a Level 1 (moment-level) model was fit to provide estimates of the parameters defining each person's diurnal cortisol rhythm:

$$\begin{aligned}\text{Level 1: Cortisol} = {} & \text{Husband} (\pi 1_i \text{ Intercept} + \pi 3_i \text{ Time Since Waking}_{ij} \\ & + \pi 5_i \text{ Time Since Waking}^2_{ij} + \pi 7_i \text{ Cortisol Awakening Response}_{ij}) \\ & + \text{Wife} (\pi 2_i \text{ Intercept} + \pi 4_i \text{ Time Since Waking}_{ij} + \pi 6_i \text{ Time Since Waking}^2_{ij} \\ & + \pi 8_i \text{ Cortisol Awakening Response}_{ij}) + \varepsilon_{ij} \quad \text{[Eq. 1]}\end{aligned}$$

Salivary cortisol shows a strong basal diurnal rhythm, with levels typically high in the morning on waking, sharply increasing in the first 30 to 45 minutes after awakening, dropping rapidly over the next few hours, and then declining more slowly across the day. Thus, we modeled cortisol values as a function of the time of each sample, scaled as hours since time waking each day, such that Level 1 intercepts reflected an estimate of each person's average wakeup cortisol level across the days of testing. Both linear and quadratic terms for time of day ("Time Since Waking" and "Time Since Waking^2," respectively, in the above equation) were included to account for curvilinear nature of diurnal cortisol slopes. In line with previous research (10), the 45-minute after awakening cortisol sample was indicated with a dummy variable (0, 1), with the coefficient on that variable ($\pi 7_i$ for husbands and $\pi 8_i$ for wives) representing an estimate of participants' cortisol awakening response (CAR). Previous research indicated that a higher CAR is associated with greater psychological stress (38) and perceived work overload (39) and is greater on weekdays compared with weekends (39,40).

Second, we estimated Level 2 (day-level) effects of daily perceived stress and the effects of weekend days versus Mondays on cortisol:

[1]Altogether, 89 cortisol observations, or 6.5% of the 1332 sampling occasions (n = 74) were missing from the data set, either because the saliva collection was skipped or the saliva was sampled incorrectly (e.g., the timing of the sample was unknown).

$$\text{Level 2: } \pi 1 \text{ to } \pi 8 = \beta_{i0} \text{ to } \beta_{ij} \times \text{Day-Level Variables} + r_{ij} \text{ [Eq. 2]}$$

Third, we estimated Level 3 (person-level) effects of variables known to influence cortisol. These variables included health-related variables (nicotine and caffeine intake, body mass index, age, and birth control medication) and other relevant person-level variables (average number of hours worked each week, annual income, and time married):

$$\text{Level 3: } \beta_{i0} \text{ to } \beta_{ij} = \gamma_{ij0} + \gamma_{ijk} \times \text{Person-Level Controls} + \mu_{ij} \text{ [Eq. 3]}$$

Fourth, momentary predictors (NA and work worries) were entered at Level 1, simultaneously estimating actor and partner effects of both prior sampling-moment and same sampling-moment experiences (e.g., NA and work worries at each moment). The example of momentary NA is used here:

$$\begin{aligned}\text{Level 1: Cortisol} = {} & \pi 1 + \ldots \pi 8 + \text{Husband } (\pi 9_i \text{ Husband Same-Moment NA}_{ij} \\ & + \pi 10_i \text{ Husband Prior-Moment NA}_{ij} + \pi 11_i \text{ Wife Same-Moment NA}_{ij} \\ & + \pi 12_i \text{ Wife Prior-Moment NA}_{ij}) + \text{Wife } (\pi 13_i \text{ Wife Same-Moment NA}_{ij} \\ & + \pi 14_i \text{ Wife Prior-Moment NA}_{ij} + \pi 15_i \text{ Husband Same-Moment NA}_{ij} \\ & + \pi 16_i \text{ Husband Prior-Moment NA}_{ij}) + \varepsilon_{ij} \text{ [Eq. 4]}\end{aligned}$$

Finally, the moderating effects of the marital variables (marital disclosure and marital satisfaction) were included at Level 3:

$$\text{Level 3: } \beta_{i0} \text{ to } \beta_{ij} = \gamma_{ij0} + \gamma_{ijk} \times \text{Marital Variables} + \mu_{ij} \text{ [Eq. 5]}$$

RESULTS

Initial Models of Diurnal Cortisol With Effects of Time, Time^2, CAR, and Day-Level Predictors

We first ran an HLM model with time, time^2, and CAR as predictors (Eq. 1); all effects were significant and are displayed in Table 1. As illustrated in Figure 2, cortisol levels showed a decline across the day (effect of time) and a slight end-of-day increase (effect of time^2). Next, we entered Level 2 (day-level) predictors into the model (a combination of Eqs. 1 and 2); results are displayed in Table 2. Based on criteria from previous EMA cortisol research (8), variables with effects of $p < .20$ were included as covariates in all subsequent analyses. Using these criteria, higher wives' daily perceived stress (PSS) was associated with husbands' flatter cortisol slopes (effect of time) and flatter cortisol increases at the end of the day (effect of time^2). Husbands' perceived stress was associated with a smaller CAR for wives. The only significant day-level effects were the effects of weekends versus Mondays, with both husbands and wives showing greater CARs on Mondays compared with weekends.

TABLE 1. Initial Model of Diurnal Cortisol

Fixed Effect	Coefficient (Standard Error)	T Ratio	p
Husbands' intercept, $\pi 1$	1.024 (0.031)	33.21	.001
Wives' intercept, $\pi 2$	0.963 (0.036)	26.53	.001
Husbands' average slope of time since waking, $\pi 3$	−0.076 (0.006)	−12.84	.001
Wives' average slope of time since waking, $\pi 4$	−0.070 (0.009)	−8.04	.001
Husbands' average slope of time since waking^2, $\pi 5$	0.002 (0.000)	4.90	.001
Wives' average slope of time since waking^2, $\pi 6$	0.002 (0.000)	3.27	.003
Husbands' average CAR, $\pi 7$	0.067 (0.026)	2.27	.01
Wives' average CAR, $\pi 8$	0.037 (0.022)	2.97	.006

Intercepts indicate average cortisol values at wake up; average slopes of time since waking indicate change in cortisol per 1-hr change in time; average slopes of time since waking^2 indicate change in cortisol per 1-hr change in time^2; CAR = cortisol awakening response, indicating amount of change in cortisol during the 45 mins after waking.

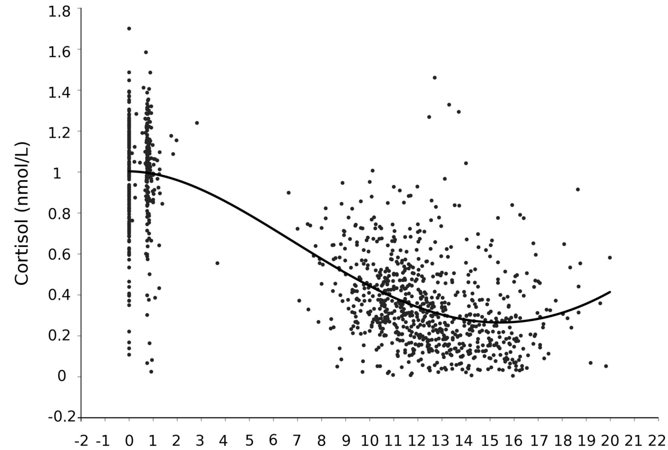

Figure 2. Cortisol values for all participants over the 3 days of the study.

Analyses to Determine Inclusion of Person-Level Covariates

We next added Level 3 (person-level) health covariates and work, marital and financial covariates to the model (a combination of Eqs. 1–3). The results of these analyses are shown in Tables 3 and 4, respectively. Notable effects ($p < .05$) in these analyses included: 1) greater wives' hours worked per week was related to lower wives' wake-up cortisol, a less steep end-of-the-day cortisol increase, and lower husband's wake-up cortisol; 2) greater wives' hours per week was related to flatter wives' cortisol slope; and 3) greater length of marriage was related to higher wives' wake-up cortisol. Together, these findings indicate that wives' greater work hours are associated with less "healthy" diurnal cortisol profiles for both husbands and wives, and, to a lesser extent, that length of marriage seems to be associated with a healthier cortisol profile for wives.

Analysis to Determine Inclusion of Momentary NA as a Covariate

We next entered momentary NA as a Level 1 predictor (combination of Eqs. 1–4). As shown in Table 5, there was a significant partner effect of wives' prior sampling-moment NA predicting husbands' cortisol. Thus, when wives reported higher NA, their husbands showed higher cortisol levels approximately 1 hour to 1½ hours later on average. There were no other actor or partner affects of NA on cortisol that met our $p < .20$ cutoff for inclusion in subsequent analyses.

TABLE 2. Effects of Day-Level Predictors

Fixed Effect	Coefficient (Standard Error)	T Ratio	Effect Size r	p
Husbands' intercept, $\beta10$	1.041 (0.031)	33.51		.001
Weekends versus Mondays, $\beta11$	−0.047 (0.060)	−0.79	.13	.44
Wives' daily perceived stress, $\beta12$	−0.046 (0.042)	−1.08	.18	.83
Husbands' daily perceived stress, $\beta13$	−0.016 (0.057)	−0.28	.05	.78
Wives' intercept, $\beta20$	0.950 (0.043)	21.89		.001
Weekends versus Mondays, $\beta21$	0.042 (0.046)	0.92	.15	.36
Wives' daily perceived stress, $\beta22$	−0.031 (0.039)	−0.78	.13	.43
Husbands' daily perceived stress, $\beta23$	−0.014 (0.053)	−0.26	.04	.79
Husbands' average slope of time since waking, $\beta30$	−0.076 (0.006)	−12.87		.001
Weekends versus Mondays, $\beta31$	0.000 (0.013)	0.03	.00	.98
Wives' daily perceived stress, $\beta32$	**0.026 (0.014)**	**1.82**	**.29**	**.08**
Husbands' daily perceived stress, $\beta33$	0.012 (0.013)	0.91	.15	.37
Wives' average slope of time since waking, $\beta40$	−0.066 (0.009)	−6.95		.001
Weekends versus Mondays, $\beta41$	−0.015 (0.012)	−1.20	.20	.24
Wives' daily perceived stress, $\beta42$	0.015 (0.013)	1.10	.18	.28
Husbands' daily perceived stress, $\beta43$	−0.011 (0.019)	−0.58	.10	.56
Husbands' average slope of time since waking^2, $\beta50$	0.001 (0.000)	4.05		.001
Weekends versus Mondays, $\beta51$	0.001 (0.001)	0.94	.15	.35
Wives' daily perceived stress, $\beta52$	**−0.002 (0.001)**	**−1.91**	**.30**	**.06**
Husbands' daily perceived stress, $\beta53$	−0.001 (0.001)	−0.92	.15	.36
Wives' average slope of time since waking^2, $\beta60$	0.001 (0.001)	2.42		.02
Weekends versus Mondays, $\beta61$	**0.001 (0.001)**	**1.46**	**.24**	**.15**
Wives' daily perceived stress, $\beta62$	−0.001 (0.001)	−0.85	.14	.40
Husbands' daily perceived stress, $\beta63$	0.001 (0.001)	0.60	.10	.55
Husbands' average CAR, $\beta70$	0.011 (0.029)	0.37		.71
Weekends versus Mondays, $\beta71$	**0.189 (0.071)**	**2.66**	**.40**	**.01**
Wives' daily perceived stress, $\beta72$	0.038 (0.050)	0.76	.13	.45
Husbands' daily perceived stress, $\beta73$	−0.018 (0.082)	−0.22	.04	.83
Wives' average CAR, $\beta80$	0.040 (0.028)	1.40		.16
Weekends versus Mondays, $\beta81$	**0.090 (0.040)**	**2.28**	**.36**	**.03**
Wives' daily perceived stress, $\beta82$	0.051 (0.040)	1.25	.21	.21
Husbands' daily perceived stress, $\beta83$	**−0.136 (0.068)**	**−1.99**	**.32**	**.06**

Intercepts indicate average cortisol values at wakeup; average slopes of time since waking indicate change in cortisol per 1-hr change in time; average slopes of time since waking^2 indicate change in cortisol per 1-hr change in time^2; CAR = cortisol awakening response, indicating amount of change in cortisol during the 45 mins after waking. Bolded rows indicate covariates that were included in subsequent analyses ($p < .20$).

Hypothesis 1: Associations Between Momentary Work Worries and Cortisol

We then tested the effects of momentary work worries on cortisol (combination of Eqs. 1–4, including the addition of wives' prior-moment NA).[2] As shown in Table 6, there was an actor effect of husbands' prior sampling-moment work worries predicting their own cortisol; husbands' cortisol levels were unaffected by their wives' work worries. Greater levels of wives' cortisol were positively associated with their own same sampling-moment work worries (an actor effect) and independently associated with their husbands' prior sampling-moment work worries (a partner effect). Thus, whereas husbands were physiologically reactive only to their own work worries, wives were physiologically reactive to their own work worries as well as to their husbands' work worries.

[2]We also ran separate analyses for same-moment and prior-moment work worries. The effects of work worries on cortisol were nearly identical to (and not statistically different from) the combined analyses reported here, with the effects slightly stronger when separate analyses were run. The combined analyses are reported here because they are the more conservative of the two types of analyses and allowed us to test the unique contributions of same-moment and prior-moment experiences in predicting cortisol.

The effects of work worries were moderated by the day of the week. As illustrated in Figure 3, for wives—but not husbands—the link between their own work worries and their own cortisol levels was stronger on Mondays compared with weekends ($\gamma1410 = 0.097$, SE = 0.032, $t = 3.05$, effect size $r = .45$, $p = .003$).

Hypothesis 2: Moderation of Effects of Work Worries on Cortisol by Marital Disclosure

We next tested whether marital disclosure moderated the effects of momentary work worries on cortisol. This analysis was identical to the earlier model used to test the effects of same- and prior-sampling moment work worries on cortisol, but with marital disclosure and marital satisfaction and a marital disclosure × satisfaction interaction term added at Level 3; marital disclosure and marital satisfaction were both standardized before computing their interaction term. We found a significant two-way (cross-level) interaction between wives' marital disclosure and their own same-moment work worries ($\gamma_{1401} = -0.35$, SE = 0.16, $t = -2.29$, effect size $r = .36$, $p = .022$), indicating that wives who reported low

TABLE 3. Effects of Person-Level Health Predictors

Fixed Effect	Coefficient (Standard Error)	T Ratio	Effect Size r	p
Husbands' intercept, γ100	1.0227 (0.0305)	33.49		.001
BMI, γ101	0.0010 (0.0037)	0.29	.05	.78
Tobacco/nicotine, γ102	**−0.0150 (0.0100)**	**−1.51**	**.25**	**.14**
Caffeine, γ103	−0.0073 (0.0270)	−0.27	.12	.79
Age, γ104	−0.0043 (0.0065)	−0.66	.11	.51
Wives' intercept, γ200	0.9727 (0.0376)	25.82		.001
BMI, γ201	0.0038 (0.0068)	0.56	.09	.58
Birth control, γ202	−0.0826 (0.1110)	−0.77	.13	.46
Caffeine, γ203	−0.0192 (0.0423)	−0.46	.08	.65
Age, γ204	0.0020 (0.0089)	0.23	.04	.82
Husbands' average slope of time since waking, γ300	−0.0745 (0.0061)	−12.03		.001
BMI, γ301	−0.0004 (0.0007)	−0.54	.09	.59
Tobacco/nicotine, γ302	**0.0051 (0.0020)**	**2.50**	**.39**	**.02**
Caffeine, γ303	−0.0056 (0.0057)	−0.99	.16	.33
Age, γ304	−0.0010 (0.0013)	−0.77	.13	.45
Wives' average slope of time since waking, γ400	−0.0718 (0.0086)	−8.29		.001
BMI, γ401	**−0.0037 (0.0016)**	**−2.29**	**.36**	**.03**
Birth control, γ402	0.0120 (0.0270)	0.45	.07	.66
Caffeine, γ403	**0.0144 (0.0098)**	**1.47**	**.24**	**.15**
Age, γ404	−0.0013 (0.0021)	−0.66	.11	.51
Husbands' average slope of time since waking^2, γ500	0.0016 (0.0004)	4.30		.001
BMI, γ501	0.0000 (0.0000)	0.72	.12	.48
Tobacco/nicotine, γ502	**−0.0002 (0.0001)**	**−1.81**	**.29**	**.08**
Caffeine, γ503	0.0003 (0.0004)	0.89	.15	.39
Age, γ504	−0.0000 (0.0000)	−0.51	.08	.61
Wives' average slope of time since waking^2, γ600	0.0016 (0.0005)	3.29		.003
BMI, γ601	**0.0002 (0.0000)**	**2.51**	**.39**	**.02**
Birth control, γ602	0.0000 (0.0015)	0.02	.00	.99
Caffeine, γ603	**−0.0009 (0.0005)**	**−1.63**	**.26**	**.11**
Age, γ604	0.0001 (0.0001)	0.80	.13	.43
Husbands' average Cortisol Awakening Response, γ700	0.0650 (0.0282)	2.31		.03
BMI, γ701	−0.0020 (0.0035)	−0.60	.09	.55
Tobacco/nicotine, γ702	−0.0017 (0.0111)	−0.16	.03	.88
Caffeine, γ703	0.0181 (0.0252)	0.72	.13	.48
Age, γ704	−0.0016 (0.0061)	−0.26	.04	.78
Wives' average CAR, γ800	0.0530 (0.0245)	2.16		.04
BMI, γ801	0.0037 (0.0045)	0.81	.13	.42
Birth control, γ802	**0.1256 (0.0747)**	**1.67**	**.27**	**.10**
Caffeine, γ803	−0.0001 (0.0281)	−0.01	.00	.99
Age, γ804	−0.0031 (0.0059)	−0.53	.09	.60

None of the women in this sample reported tobacco or nicotine usage. Intercepts indicate average cortisol values at wake-up; average slopes of time since waking indicate change in cortisol per 1-hr change in time; average slopes of time since waking^2 indicate change in cortisol per 1-hr change in time^2; CAR = cortisol awakening response, indicating amount of change in cortisol during the 45 mins after waking. Bolded rows indicate covariates that were included in subsequent analyses ($p < .20$).

levels of marital disclosure showed a stronger positive association between work worries and cortisol than those who were highly disclosing. The interaction between wives' marital satisfaction and work worries was not significant ($\gamma_{1402} = -0.17$, SE = 0.11, $t = -1.60$, effect size $r = .26$, $p = .11$), but there was a significant marital disclosure × satisfaction × work worries three-way interaction ($\gamma_{1403} = 0.49$, SE = 0.18, $t = 2.65$, effect size $r = .40$, $p = .009$). As shown in Figure 4, for those wives who indicated that they were either highly disclosing or highly satisfied with their spouses, there was essentially no association between momentary work worries and cortisol (and no significant differences between the slopes). However, for wives who indicated that they were both low in marital disclosure and low in marital satisfaction, there was a strong positive association between work worries and cortisol (simple slope = 0.56, SE = 0.14, $t = 4.03$, effect size $r = .56$, $p < .0003$). In other words, wives who were unsatisfied in their relationship and were not open about their thoughts and feelings with their husbands were very physiologically reactive to their own work worries. For husbands, neither marital disclosure nor marital satisfaction moderated the association between momentary work worries and cortisol.

DISCUSSION

We found that momentary changes in work worries had a physiological impact on both the person experiencing the worry as well as on the person's spouse. Greater work worries were related to one's own cortisol levels for both husbands

TABLE 4. Effects of Person-Level Work, Marital and Financial Predictors

Fixed Effect	Coefficient (Standard Error)	T Ratio	Effect Size *r*	*p*
Husbands' intercept, γ100	1.0297 (0.0218)	47.21		.001
Hours per week that wife works, γ101	**−0.0036 (0.0015)**	**−2.36**	**.37**	**.03**
Hours per week that husband works, γ102	0.0005 (0.0014)	0.43	.07	.67
Length of marriage, γ103	**0.0007 (0.0005)**	**1.54**	**.25**	**.13**
Annual household income, γ104	−0.0232 (0.0221)	−1.05	.17	.30
Wives' intercept, γ200	0.9669 (0.0283)	34.11		.001
Hours per week that wife works, γ201	**−0.0045 (0.0020)**	**−2.22**	**.35**	**.03**
Hours per week that husband works, γ202	**0.0028 (0.0018)**	**1.55**	**.19**	**.13**
Length of marriage, γ203	**0.0014 (0.0006)**	**2.18**	**.34**	**.04**
Annual household income, γ204	**−0.0503 (0.0297)**	**−1.69**	**.27**	**.10**
Husbands' average slope of time since waking, γ300	−0.0785 (0.0049)	−15.90		.001
Hours per week that wife works, γ301	−0.0004 (0.0003)	−1.22	.20	.22
Hours per week that husband works, γ302	0.0003 (0.0003)	1.06	.17	.29
Length of marriage, γ303	**−0.0001 (0.0001)**	**−1.81**	**.29**	**.07**
Annual household income, γ304	−0.0000 (0.0052)	−0.01	.00	.99
Wives' average slope of time since waking, γ400	−0.0699 (0.0055)	−12.64		.001
Hours per week that wife works, γ401	**0.0013 (0.0003)**	**3.47**	**.50**	**.001**
Hours per week that husband works, γ402	0.0004 (0.0004)	1.11	.18	.27
Length of marriage, γ403	**−0.0001 (0.0001)**	**−1.48**	**.24**	**.14**
Annual household income, γ404	0.0048 (0.0048)	1.00	**.16**	.32
Husbands' average slope of time since waking^2, γ500	0.0018 (0.0003)	5.90		.001
Hours per week that wife works, γ501	**0.0000 (0.0000)**	**1.95**	**.31**	**.05**
Hours per week that husband works, γ502	**−0.0000 (0.0000)**	**−1.64**	**.26**	**.10**
Length of marriage, γ503	**0.0000 (0.0000)**	**1.60**	**.26**	**.11**
Annual household income, γ504	0.0001 (0.0004)	0.53	.09	.59
Wives' average slope of time since waking^2, γ600	0.0016 (0.0004)	3.90		.001
Hours per week that wife works, γ601	**−0.0001 (0.0000)**	**−2.11**	**.33**	**.04**
Hours per week that husband works, γ602	**−0.0000 (0.0000)**	**−1.46**	**.24**	**.15**
Length of marriage, γ603	0.0000 (0.0000)	0.85	.14	.40
Annual household income, γ604	−0.0000 (0.0003)	0.13	.02	.90
Husbands' CAR, γ700				
Hours per week that wife works, γ701	**0.0025 (0.0018)**	**1.43**	**.23**	**.15**
Hours per week that husband works, γ702	−0.0005 (0.0015)	−0.35	.06	.73
Length of marriage, γ703	**−0.0008 (0.0005)**	**−1.54**	**.25**	**.12**
Annual household income, γ704	0.0048 (0.0249)	0.19	.03	.85
Wives' CAR, γ800				
Hours per week that wife works, γ801	**0.0027 (0.0017)**	**1.58**	**.25**	**.11**
Hours per week that husband works, γ802	0.0014 (0.0016)	0.91	.15	.36
Length of marriage, γ803	0.0001 (0.0006)	0.35	.06	.73
Annual household income, γ804	0.0107 (0.0246)	0.43	.07	.66

Intercepts indicate average cortisol values at wakeup; average slopes of time since waking indicate change in cortisol per 1-hr change in time; average slopes of time since waking^2 indicate change in cortisol per 1-hr change in time^2; CAR = cortisol awakening response, indicating amount of change in cortisol during the 45 mins after waking. Bolded rows indicate covariates that were included in subsequent analyses ($p < .20$).

and wives—actor effects. Husbands' work worries also independently predicted wives' cortisol levels—a partner effect. Among wives, lower marital disclosure augmented the association between momentary work worries and cortisol levels, with wives who were both low in disclosure and low in marital satisfaction showing a strong positive relationship between work worries and cortisol.

Our work worry findings are novel in several respects. First, although prior EMA studies have investigated the links between mood and cortisol in everyday life (8,41,42), none to our knowledge has examined the effects of specific types of worries. It is notable that neither negative affect nor daily levels of perceived stress were associated with cortisol after taking into account the effects of stressful feelings about work. A number of studies (3,43,44) have shown that stressful experiences earlier in the day at work can spill over into everyday family life and negatively influence mood at home. Our findings suggest that worries about work when employed individuals are home with their families can affect physiology as well.

Second, this is the first study, to our knowledge, to demonstrate that one person's momentary feelings of stress are related to another person's cortisol levels in daily life. Husbands' work worries affected wives' cortisol levels, but wives' feelings of work stress did not affect husbands' cortisol levels. This is in line with previous laboratory research suggesting that wives are more physiologically reactive to marital interactions than husbands (45,46) as well as naturalistic work

TABLE 5. Effects of Momentary Negative Affect on Cortisol

Fixed Effect	Coefficient (Standard Error)	T Ratio	Effect Size *r*	*p*
Momentary effects on husbands' cortisol				
Actor effects (effects of own NA)				
Same-moment NA, π900	0.026 (0.231)	1.14	.19	.26
Prior-moment NA, π1000	0.020 (0.021)	0.95	.16	.34
Partner effects (effects of wives' NA)				
Same-moment NA, π1100	−0.003 (0.021)	−0.13	.02	.90
Prior-moment NA, π1200	**0.046 (0.019)**	**3.39**	**.49**	**.02**
Momentary effects on wives' cortisol				
Actor effects (effects of own NA)				
Same-moment NA, π1300	0.018 (0.022)	0.80	.13	.42
Prior-moment NA, π1400	0.004 (0.020)	0.18	.03	.85
Partner effects (effects of husbands' NA)				
Same-moment NA, π1500	0.006 (0.023)	0.26	.04	.78
Prior-moment NA, π1600	−0.003 (0.021)	−0.15	.03	.88

Bolded rows indicate covariates that were included in subsequent analyses ($p < .20$). Additionally, all variables in bolded rows from Tables 2 through 4 are included as covariates in this analysis.

TABLE 6. Effects of Momentary Work Worries on Cortisol

Fixed Effect	Coefficient (Standard Error)	T Ratio	Effect Size *r*	*p*
Momentary effects on husbands' cortisol				
Actor effects (effects of own work worries)				
Same-moment work worries, π1000	−0.004 (0.019)	−0.19	.03	.85
Prior-moment work worries, π1100	0.048 (0.020)	2.44	.38	.02
Partner effects (effects of wives' work worries)				
Same-moment work worries, π1200	0.016 (0.020)	0.80	.13	.42
Prior-moment work worries, π1300	−0.000 (0.019)	−0.00	.00	.99
Momentary effects on wives' cortisol				
Actor effects (effects of own work worries)				
Same-moment work worries, π1400	0.059 (0.022)	2.70	.41	.008
Prior-moment work worries, π1500	0.013 (0.021)	0.64	.11	.52
Partner effects (effects of husbands' work worries)				
Same-moment work worries, π1600	−0.022 (0.020)	−1.07	.17	.29
Prior-moment work worries, π1700	0.053 (0.019)	2.80	.42	.006

All variables in bolded rows from Tables 2 through 5 are included as covariates in this analysis.

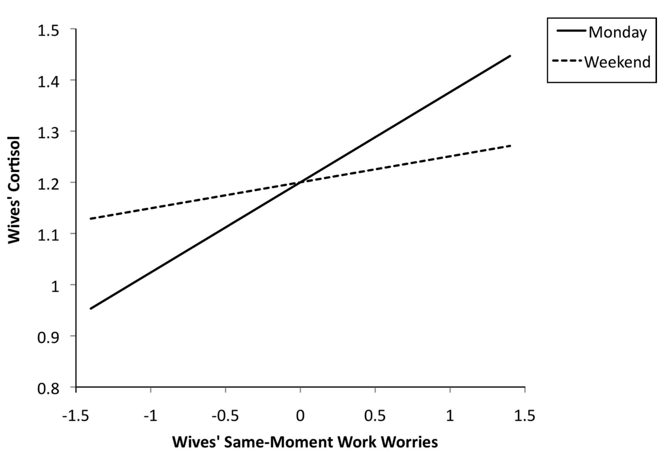

Figure 3. Wives' same-moment work worries predicting wives' log-transformed cortisol, as moderated by Mondays versus weekends. All variables in bolded rows from Tables 2 through 5 are included as covariates in this analysis.

showing that couples' cortisol levels covary (47). Although previous research has shown effects of interpersonal stress on physiology, these findings suggest that, for women at least, partner effects on physiology also extend to nonrelationship stressors.

By incorporating both same and prior sampling-moment psychological measures, we were able to explore the timing of the links between momentary work worries and cortisol in a naturalistic setting. The differences in the time course of stress-cortisol links for husbands and wives—with husbands' cortisol levels influenced by prior-moment work worries and wives' cortisol levels influenced by same-moment work worries—were unexpected. In laboratory studies (48), acute stressors typically lead to an increase in salivary cortisol levels in approximately 20 minutes. At home, when mood can change over time depending on situational cues and other factors, the timing of psychological states on cortisol is likely to be more variable. Unlike the laboratory, in everyday life, measuring the exact onset and offset of stressors is difficult. Furthermore, there may be systematic differences in men's and women's cognitive and emotional processing of stress that lead to a greater time lag among men than women.

In addition to momentary effects of work worries on cortisol, we found person-level effects of marital disclosure moderating the links between momentary work worries and

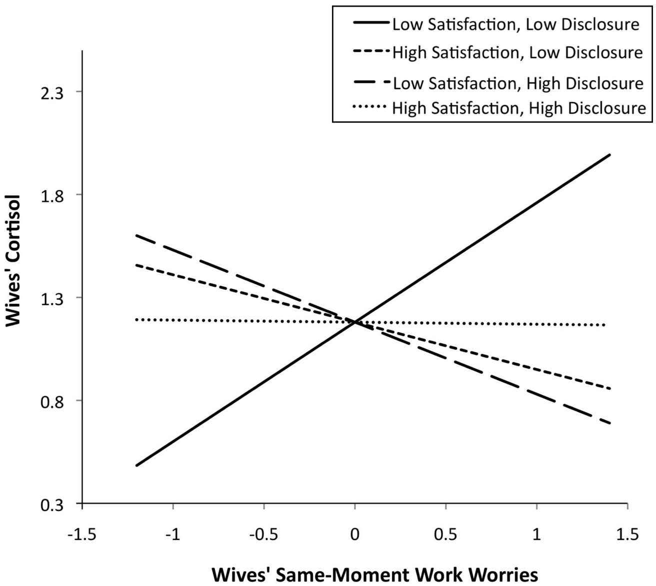

Figure 4. Wives' same-moment work worries predicting wives' cortisol, as moderated by wives' marital satisfaction and marital disclosure, with high and low values plotted at +1 standard deviation (SD) and −1 SD from the mean, respectively (54). All variables in bolded rows from Tables 2 through 5 are included as covariates in this analysis.

cortisol among wives: wives who reported low levels of marital disclosure showed a much stronger association between work worries and cortisol than those who were highly disclosing. This effect was especially pronounced among wives reporting both low marital disclosure and low marital satisfaction. Wives who were either disclosing to their husbands or satisfied in their marriages did not seem to be physiologically reactive to their own work worries.

The marital disclosure findings reported here suggest that, for wives at least, the stress-buffering effects of a happy marriage on HPA activity (4) may be partially explained by the extent to which they are able to be open and expressive with their spouses. The benefits of written emotional disclosure for health have been documented (17). This finding suggests that disclosure in the context of close relationships—the context that affords the greatest opportunities for self-disclosure—is beneficial as well.

There are limitations of this study that should be noted. The first is statistical power. Using Cohen's criteria of $r = .10$ for small effects, $r = .30$ for medium effects, and $r = .50$ for large effects (49), post hoc power analyses (23) showed that we had very little power for detecting small effects (power = 0.13), reasonable power for detecting medium effects (power = 0.74), and excellent power for detecting large effects (power = 0.90). Attempts at replication with larger probability samples would determine the robustness of these findings and evaluate their generalizability. For example, it would be worthwhile to investigate whether the effects reported here vary as a function of stage of life and an absence of children in the home. It may be that the effects of work-related stressors are especially strong during the early years of parenthood and one's career compared with later years.

Second, the uneven spacing of sampling moments throughout each day was not ideal for the type of lag momentary analyses conducted here. Future studies should consider additional assessments (e.g., 60 minutes and 20 minutes before each saliva-sampling occasion) to estimate more precisely the time course of the effects of everyday feelings of stress on cortisol. The trade-off of additional participant burden in this type of design is also a consideration.

Despite these limitations, this study represents an important step in furthering our understanding of how everyday feelings of stress influence one's own physiology and the physiology of close others. We were able to test simultaneously the within-couple effect of momentary work worries and the between-couple stress-buffering effect of marital disclosure on cortisol. HPA axis dysregulation has been linked to negative health consequences—including mortality (50)—through wear and tear brought on by chronic stress (51). The findings reported here indicate that taking into consideration the perspectives of close others will be vital to our understanding of daily stress processes. Although a growing number of researchers are going beyond the individual to examine the impact of the quality of relationships—especially marriage—on health (52,53), very little is known about the precise aspects of relationships that confer health benefits. Examining specific relationship processes, such as marital disclosure and their buffering effects on stress-health associations, will lead ultimately to a deeper and more complex understanding of the health benefits of social relationships.

We thank James Pennebaker for his guidance on this project and Leah Dickenson, Jacqui Sperling, Shu-wen Wang, and Stephanie Young for their helpful comments on a previous draft of this article.

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